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CHARACTERIZATION OF HOTSPOT COVERAGE PLAN IN 2.4/ 5GHZ FREQUENCY BAND

(NNAMDI AZIKIWE UNIVERSITY, NIGERIA, AS A CASE STUDY)

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ABSTRACT

Research and tertiary institutions today uses wireless connectivity owing to the benefits of mobility flow-aware communication and flexibility advantages generally. In this case, mobility computing involving the use of smart devices, laptops, wifi-desktops, etc, largely depends on a deployed hotspot infrastructure. In particular, the physical position of the mobile system (and hence of the user) and the hotspot infrastructure design layout are fundamental considerations for service efficiency. While previous works have focused on user position estimation, signal strength quality and network QoS, this work leverages the contemporary challenges of network connectivity in tertiary institutions in Nigeria with respect to optimal coverage and cost minimization. Using Nnamdi Azikiwe University-Unizik, Awka as testbed, we carried out a study on hotspot/WLAN IEEE 802.11 deployments while devising a cost effective coverage plan in 2,4/5GHz frequency band. A mathematical model on cost optimization for WLAN Hotpot project processes was developed using Linear programming, the installation procedure, coverage plan based on specifications of the deployment hardware, and data security were covered in this work. Consequently, from the model, we argue that with careful selection of optimization criteria in the deployment, an efficient design cost plan, and QoS, could eliminate possible trade-offs in the deployment contexts by over 95%.

Keywords: Mobility, Flow-aware, Hotspot, Infrastructure, Optimization, Design, Minimization

1. INTRODUCTION

With the success of wired local area networks (LANs), the local computing market is moving toward wireless LAN (WLAN) with the same speed of current wired LAN, Vijay K. G, (1999). WLAN-Hotspots are flexible data communication systems that can be used for applications in which mobility is required publicly. WLAN-Hotspot as a flexible data communications system serves as an extension or as an alternative for wired LANs. Since in the tertiary indoor business environment, mobility is perceived as an absolute requirement, as such, WLAN-Hotspots provide more flexibility than that achieved by the wired LAN. Besides, WLANs-Hotspots are designed to operate in industrial, scientific, and medical (ISM) radio bands (see Table 21.1) and unlicensed-national information infrastructure (U-NII) bands, Vijay K. G, (1999). Using radio frequency (RF) technology, WLANs transmit and receive data over the air, minimizing the need for wired connections.

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Thus, WLANs combine data connectivity with user mobility FCC (2001), Gorday, P., et al., (2001),Gilb, J. P. K, (2001),Gutierrez, J. A.,et al, (2007), Intanagonwiwat, C., et al, (2000), Li, L.,(2001), Mandke, K., et al, (2003). Currently, WLANs can provide data rates up to 250Mbps, though the industry is making intensified moves toward high-speed WLANs. As such manufacturers are developing WLANs to provide data rates up to 500 Mbps or higher. According to Udeze C.C, et al , (2012), the emergence of wireless networking technologies for large enterprises, operators (service providers), small-medium organizations, has made hotspot solutions for metropolitan area networks (MAN), last mile wireless connectivity, mobile broadband solutions, IP-based cellular phones (VOIP) and other event-based wireless solutions in very high demand. The key WLANs include IEEE 802.11a (WiFi-5), IEEE 802.11b (WiFi), IEEE 802.11g and IEEE 802.11n (see Table1). Table 2 shows the lists all subgroups of IEEE 802.11.

Consequently, excellent characterization and deployment of WLAN-Hotspots can provide connectivity in institutions, homes, factories, and hot-spots. In this work, a contribution in the context of design, planning, deployment in a most optimized scenario forms our basis for this work. The rest of this work is organized as follows, Section I -presents the introduction as well as capturing advantages of WLAN-Hotspot deployment, and WLAN-Hotspot consideration metrics, Section II- Presents the existing literature review, Section IV- Presents the methodology which covered a developed mathematical model on cost optimization for WLAN characterization, the installation procedure, coverage plan based on specifications of the deployment hardware, and data security, Section V- Discussed the performance evaluations with respect to optimization criteria in the deployment, design cost plan, localization error minimization, signal coverage maximization, and QoS testing plan.

Table 1: Industrial, Scientific, and Medical (ISM) bands, Vijay K. G, (1999)

S/N	Band (GHz)	Bandwidth(MHz)	Power Level	Spread Spectrum
1	0.902-0.928	26	1W	FHSS,DSSS
2	2.4-2.4835	83.5	1W	FHSS,DSSS
3	5.725-5.850	125	1W	FHSS,DSSS
4	24.0-24.5	250	50Mw/m@3m	Not Applicable

Table 2: IEEE 802.11 subgroups Vijay K. G, (1999)

IEEE-802.11 subgroups	Characterization Domain
802.11a	High Speed physical layer in 5GHz band
802.11b	High Speed physical layer extension of wireless in 2.4GHz band
802.11d	Local and Metropolitan Area Wireless
802.11g	Broadband Wireless
802.11i	Security
802.11n	Wideband Service

1.1 Advantages of WLAN-Hotspot Deployments

The following are a few advantages of deploying WLAN-Hotspots:

(i) Mobility improves productivity with real-time access to information, regardless of worker location, for faster and more efficient decision making Cost-effective network setup for hard-to-wire locations such as older buildings and solid wall structures
(ii) Reduced cost of ownership, particularly in a dynamic environment requiring frequent modification due to minimal wiring and installation costs per device and per user.

1.2 Operational Considerations in deploying the WLAN-Hotspot

In this paper, the following are the identified operational considerations for WLAN-Hotspot deployment, viz:

i. Frequency allocation: Operation of a Hotspot wireless network requires that all users operate in a common frequency band. The frequency band must be approved by Nigeria Communications Commission, (NCC) Nigeria.

ii. Interference and reliability.: This is very peculiar with WLAN environments only. In a WLAN, interference is caused by simultaneous transmission of information in the shared frequency band and by multipath fading. The reliability of a communication channel is measured by bit error rate (BER). Automatic repeat request (ARQ) and forward error correction (FEC) techniques. These are used to increase reliability in WLAN-Hotspots generally.

iii. Security: Since radio waves are not confined to the boundary of buildings or campuses, there exists the possibility of eavesdropping and intentional interference. Data privacy over a radio medium is usually accomplished by using encryption, (64 or 128bits DES or AES).

iv. Power consumption: WLANs are typically related to mobile applications. In these applications, battery power is a scarce resource. Therefore, the devices must be designed to be energy efficient.

v. v.Mobility: One of the advantages of a WLAN is the freedom of mobility. The devices should accommodate handoff at transmission boundaries to route data calls to mobile users.

vi. vi.Throughput: To support multiple transmissions simultaneously, spread spectrum techniques are often used. The more flexible the design context, the higher throughput which contributes to the overall efficiency.

1.3 Motivation/ Contribution of the Research

We observed that information exchange through the internet/intranet, drives today's learning process; hence most world leading higher institutions are completely networked and hooked to the internet through the deployment of WLAN backbone because of inherent limitations of using cable technology for the same purpose. It is equally observed that higher institutions in Nigeria are still trying to deployment WLAN technology for similar reason above, but the effort in some cases is marred by poor planning which most times results to waste of resources and funds and overtime leads to abandoning the project entirely.

Having observed that Unizik is making effort towards deployment of wireless LAN, we believe that through careful planning and calculated deployment of access point, wireless network can be installed and managed effectively at a bearable and comparative cost advantage in the Institution by consulting this research work, thereby saving the cost of engaging the services of external vendors. Consequently, we believe that other institutions in Nigeria can benefit from our contributions in this work.

Our contribution is then summarized as follows:

- To present a characterize and develop a workable coverage plan for the deployment of a WLAN-Hotspot in a University Campus using Nnamdi Azikiwe University permanent site as a model
- To illustrate through the use of conceptual diagrams showing the envisaged coverage plan that will be cost effective
- Finally, the demonstrate the deployment context as well as the infrastructural requirements.

2. RELATED WORKS

We shall discuss on the characterization of Hotspot Coverage Plan in 2.4/ 5GHz Frequency Band by first beginning with review of related works. The objective in this section is to explain the motivation for seeking a new and better way to accomplish mobility and planning, and thereby provide a backdrop for a deeper investigation of general performance optimization. The Wi-Fi Hotspot networks we are considering are similar to the public cellular telephone networks in that they are formed of many radio transmitters, each covering a relatively small area, and provide coverage over large areas, numbering from a few to thousands of transmitters in a network. Roberto.B.,et al (2003) presented a new approach to wireless access point placement by integrating coverage requirements with the reduction of the error of the user position estimate. In particular, the paper proposes a mathematical model of user localization error based on the variability of signal strength measurements. Also the proposed error model is used by local search heuristic techniques, such as local search, a prohibition-based variation and simulated annealing.

Amit P. J. et al (2005) focused on congestion estimation using point-to-point link layer reliability on a WLAN IEEE 802.11b. Raffaele B. et al (2008), specifically, developed Markov chain models to compute the distribution of the number of active stations in an IEEE 802.11 WLAN when long-lived Transmission Control Protocol (TCP) connections compete with finite-load User Datagram Protocol (UDP) flows. The work derived its TCP and UDP throughput expressions while validating the model accuracy through performance tests carried out in a real WLAN for a wide range of configurations. David T. A.(2003), presented and discussed an optimal approach to throughput enhancement using ultra compact diversity antennas covering a 3-step evaluation procedure viz: 1) in-situ antenna range measurement (measuring the antennas mounted onto the device housing), 2) multipath modelling, and 3) throughput mapping. Mohammad S.& Soumen.K. (2007) considered radio propagation models in WLANs as well as its obstacles in the propagation environment. Consequently, key performance parameters were quantified viz: throughput, and packet received attenuation. A representative sample of related works was studied a White paper, Hetal Jasani, Yu Cai,(2008) Salam A. Najim, et al, Kritika S. et al (2011), S. Vasudevan, et al (2005), and David Lang (2012).

From the literature review carried out, no work has carried out an investigation on the characterization of Hotspot Coverage Plan in 2.4/ 5GHz Frequency Band mainly. In this paper, we seek achieve mobility and planning for general performance optimization. This work will then focus on a typical WLAN scenario context- Nnamdi Azikiwe University, where we intend to deploy an efficient WLAN-Hotspot that will serve as a generic template for other institutions in the South-Eastern part of Nigeria. Apart from the cost optimization model proposed, the network will be implemented with a normal site bandwidth saving tools:

- HTTP caching proxy (squid)
- Block streaming sources (DNS redirects to a placeholder page)
- QOS traffic shaping to allocate bandwidth between users ('users' being wireless users vs registration vs keynote streaming video, etc.)

3. METHODOLOGY

3.1 Structural Analysis

In this paper, we first carried out a comprehensive study on what is existing on ground considering the various departments, faculties, etc. Again, we noted from a field study carried out in UNIZIK, that there has not been a coordinated attempt to cover the university environment (WLAN-Hotspot), hence, the existing network seem to be limited to faculty or department LANs only. Also the existing system appears to use too many access points AP and no amplification for the signal, this appears to be marred by power problem and poor bandwidth management which makes the service very epileptic. The university master plan cannot be displayed entirely in this work without taking a sizeable space in this work, therefore for simplicity of the coverage plan; the University environment has been divided into five major WLAN Hotspot location areas shown in the figure below. This represents the target areas intended for coverage.

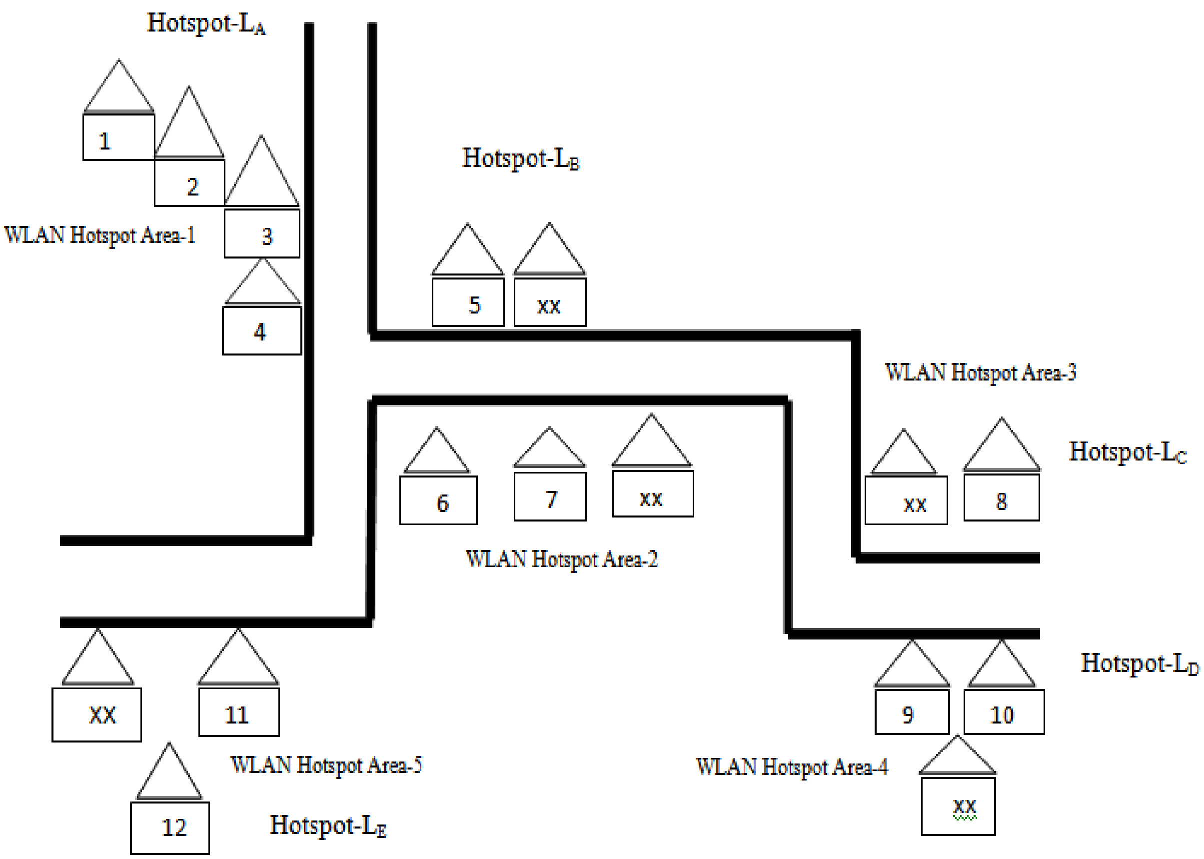

Figure 1: Block Diagram Representation of Target Areas

Legend-Key:
1,2&3=Business Admin& Marketing Block
4=Afrihub
5=Central bank building
6=Utility building
7=Engineering Block
8=Administrative Block
9=Natural Science
10=Science Village
11=Social Science
12=Law Faculty
xx= Other Buildings/Departments around

We shall focus on the hardware equipment specifications and software intended to be used to actualize the coverage plan later in this work.

4. DESIGN DESCRIPTION

The target areas have been designated as WLAN-Hotspot areas. In our characterization, the distance of separation between one hotspot to another is estimated to be on an average of about 8KM (Obtained by driving around the hotspot with a car-[drive test technique]).The line of sight distance between the hotspot is estimated at much lesser distance of about 4KM (Without Obstacles). Fortunately, the equipment to be deployed in the coverage is rated by the manufactures to have a range of about 10-20KM on amplification depending on the topology of the location. Hence, the key to effective coverage lies on proper deployment of the Access Point in the WLAN-Hotspot in other to cover the estimated distance between the hotspot. Bearing this in mind, we calculated that since the distance between the hotspot is less than the line of sight distance between the equipment to the deployed, very effective coverage could be ensured if the base stations are located in the hotspot in a way that obstacles are avoided.

Hence the need for the use of altimeter to determine the best location for the installation of the base station emerged, this was resolved via a GSM vendor whose services were used to determine the best location. Consequently three locations were map out to give the best immediate coverage. Details are shown in figure 3.1 were the coverage plan was presented. Also ability to easily and cheaply provide power supply to the base stations and security of the base station were also put into consideration in selecting these locations. The height recommended overcoming adverse topography and avoiding unnecessary obstacle is about 160M.Thus, the height of the mast to be used in mounting the directional antennae is about 160M.

4.1 Design Specifications

4.1.1 System specification

In this work, the network being deployed in the coverage plan will have a capacity of 1500 users simultaneously and can be expanded by software upgrade. The system specification for the coverage plan is divided into two parts: the hardware and the software specification. This session begins by showing detail of hardware specification and later concludes with software specification which comprises of the operating system (OS) to be installed at the server to ensure maximum data security, billing software for billing, value added services and bandwidth management to optimize the speed of the network. The key to the success of this coverage plan is to have a few number of base stations in other to ensure easy maintenance and amplify the signal from the base to maximum power possible so that reception is ensured at all parts of the campus environment and beyond and then use power full bandwidth management software to optimize the speed of the network. The primary advantage of this approach is that it is easier to provide regular power, security and regular maintenance to less number of base stations (AP) than to many; hence the overall cost of providing the service is drastically reduced.

Consequently, the design approach will be as follows: a primary or main base station will be situated at the same location with the V-SAT (where the internet connection is made), Three or Four amplified secondary or repeater base station will be situated in the different “hotspot” (location where coverage is required) as extension of the main connection point.

4.1.2 Hardware Specification

From the foregoing, The Main base station or Access Point (AP) will ultimately consist of the following equipment:

A. Main or Primary Base Station
i. System Unit and Monitor
ii. Wireless Router Board
iii. 350mW Wireless Radio Card
iv. 3 Way Splitter
v. Jumper Cable/ Coaxial Cable With F connectors
vi. A Coil of RJ45 networking cable
vii. Wireless Amplifier Radio
viii. 500W Uninterruptible Power Supply
ix. 12V/200Ah Battery
x. 160M Mast
xi. 3x120" Sector Antennae and accessories
xii. A broadband V-SAT link to the Internet
xiii. Coaxial Surge arrestor kit
xiv. Power Over Ethernet Adapter (PoE) Power Injector
xv. Bandwidth Management Software

While the secondary or repeater base station will consist of the following:

- Repeater or Secondary Base Station
i. Wireless Router Board
ii. 350mW Wireless Radio Card
iii. 3 Way Splitter
iv. Jumper Cable/Coaxial Cable With F connectors
v. A Coil Of RJ45 Networking Cable
vi. Wireless Amplifier Radio
vii. 500W Uninterruptible Power Supply
viii. 12V/200Ah Battery
ix. 160M Mast
x. 3x120" Sector Antennae
xi. Power Over Ethernet Adapter (PoE) Power Injector
xii. Coaxial Surge Arrester Kit

Below are the details of the technical specifications of some of the hardware mentioned above.

4.1.3 Computer System Unit and Monitor:

A laptop computer is usually preferred for low power consumption and portability. It should have the following configurations at minimum:

- A Pentium III or its equivalence and above with minimum of:
  Clock Frequency : 1GHZ
  RAM : 256MB
  Hard disc : 2GB free (standard ATA interface controller and drive)
  VGA Monitor : 1200 Resolution

4.1.4 Wireless Router board

Wireless router board with level 5 license (Mikrotic is the preferred manufacturer). The Level 5 license implies that the board has a capacity of 500simultenous users The board is shown below with its technical specifications:

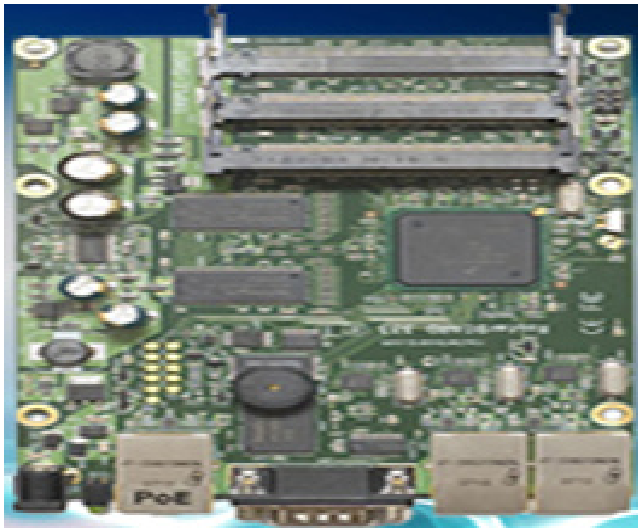

Figure 2: Router board

The specifications of figure 2 are detailed below:

- Frequencies:
802.11b/g 2.312 – 2.497 (5 MHz step);
802.11a 4.920 – 6.100 (5 MHz step)

- Chipset: Atheros AR5414

- Security: Hardware 64 and 128 bit WEP; Hardware TKIP and AES-CCM, Encryption; 802.1x WPA authentication

- Modulation: 802.11b+g: DSSS, OFDM for data rate >30Mbps, 802.11a: OFDM

- Host Interface: Mini-PCI form factor; Mini-PCI Version 1.0 type 3B suggested only for motherboards that are produced after 2004

- Power requirements: 3.3V +/- 10% DC; 400mA max (300mA typ.)

Output Power / Receive Sensitivity: IEEE 802.11a: 17dBm/-88dBm @ 6Mbps, 13dBm/-71dBm @ 54Mbps
IEEE 802.11b: 19dBm/-95dBm @ 1Mbps, 19dBm/-90dBm @ 11Mbps. IEEE 802.11g: 18dBm/-90dBm @ 6Mbps, 15dBm/-73dBm @ 54Mbps

Transfer Data Rate: 802.11b:11,5.5,2,1 Mbps, auto-fallback
802.11g (Normal mode):54, 48, 36, 24,18,12,9,6 Mbps, auto-fallback
802.11g (Turbo mode):108, 96,72,48,36,24,18,12 Mbps, auto-fallback
802.11a (Normal mode):54, 48, 36, 24,18,12,9,6 Mbps, auto-fallback
802.11a (Turbo mode):108, 96,72,48,36,24,18,12 Mbps, auto-fallback

Supported OS Mikrotik RouterOS, Windows XP

Operation Temp.: 0°C to 50

Humidity range: Operating 5% to 95% (non-condensing)

Protocol: CSMA/CA with ACK architecture 32-bit MAC

Connectors: Two U.fl connectors

Weight: 20 grams

Watt Wireless Radio Amplifier:
2.4Ghz/5.0Ghz wireless radio amplifier from Hyperlinks It is shown in figure 3 with its technical specifications in table 3.1

Figure 3: Wireless Amplifier

Table 3: Wireless Amplifier Specifications

Receive Gain	**20 dB nom.**
Frequency	2400 - 2500 MHz/5000MHz
Max. Input Power	400mW (20 dBm)
Operating Mode	Bi-directional, half-duplex Time Division Duplex. Senses RF carrier from transmitter and automatically switches from receive to transmit mode
Water Resistant Rating (Outdoor Models)	IEC 60529 IPX7
Operating Temperature	-40°C to 50°C (-40°F to 122°F)
Dimensions	5.9 x 2.5 x 1.3 (inches) 150 x 64 x 33 (mm)
Weight	.95 lbs. (.44 Kg)
Current Draw	1.25A Peak Tx and 0.14A Peak Rx
Supply Voltage	12VDC -0.5V / +1V

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4.1.5 350mW Wireless Radio Card:

This works with the router board to generate the electromagnetic signal fed into the Antennae through the Wireless Amplifier radio. The 350mW rating is sufficient since the signal will undergo amplification. The card is capable of generating signal in the 2.4 GHz and 5 GHz frequency band. Shown in figure 4 is the wireless card attached to the router board. The card with the protruding wire is the wireless card. The terminal end connects to the antenna through the amplifier. The wireless card is rated 350mW.

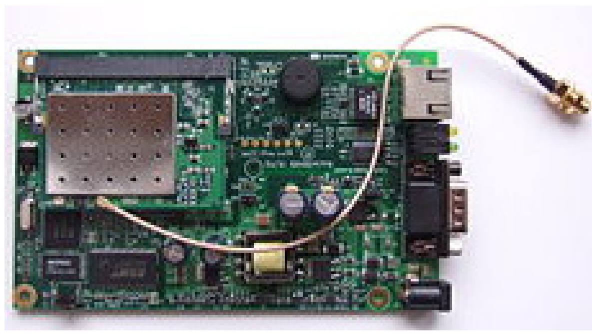

Figure 4: Wireless Card connected to router board

4.1.6 500W Inverter Power Supply:

The base station equipment mentioned above do not consume much power as can be seen from their technical data, consequently, a 500W Inverter power supply be sufficient to power the base station. However the inverter should be able to provide up to 20hrs of power supply to the base station in the event of power failure from the public supply therefore it recommended that up to four 12/200AH battery be connected to ensure the expected long duration supply. In addition if solar panels are available, they can also be connected to charge the batteries as alternative energy source.

4.1.7 4x90" Sector Antennae and accessories:

The antennae are critical in ensuring very good coverage within the campus environment. Their sample and technical specifications are shown in figure 5.

Figure 5: Sector Antenna

Table 4: Sector Antenna Specifications

Model	**HK5817-090**
Frequency	5725 - 5850 MHz
Antenna Gain	17 dBi*
Polarization	Vertical
Horizontal Beam Width (Individual antenna)	90°
Vertical Beam Width (Individual antenna)	8°
Lightning Protection	DC Ground
Power Rating (Individual antenna)	100 Watts

4.1.8 Broadband V-SAT link to the Internet

Since there is an existing V-SAT link in Afrihub-NAU owned by the university, it may no longer be necessary to provide a different link in this coverage plan. The site survey shows a mast located close to the V-SAT link bearing apparently, a WLAN installation. All that is required to do here is to make use of the mast, link the WLAN to the existing V-SAT link, then expand the V-SAT bandwidth from the internet service provider (ISP). If the bandwidth is too narrow for the expected traffic from WLAN network, then an installation of bandwidth manager with the billing system in the server is indispensible.

4.1.9 Client Equipment

Wireless Client adapter connects users via an access point to the rest of the LAN. The user will require one or two of the following;

(i) PCMCIA wireless card for laptop in cases where the laptop does not contain an onboard wireless adapter
(ii) PCI Wireless Card for desktop user since most desktop do not contain an onboard card.
(iii) Outdoor radio if there is no signal or the quality of the signal received is poor.

5. SOFTWARE SPECIFICATION

Operating System: Linux (Fedora) may be preferable as the operating system for the sever, Its Primary advantage includes (i) immunity to virus attack apparently due to the fact that many scammers concentrate attack to Windows base OS. (ii) Ability to provide device driver for many hardware is also an additional advantage. Incompatibility with many value added software pack is the main drawback of this OS. Nevertheless, windows based OS (XP and Vista), especially, windows Vista can equally prove formidable to virus attack when supported with a reliable anti virus software and regularly updated. Optionally, Mikrotik provides OS for Router board they manufacture called Mikrotik RouterOS; the only problem with this is incompatibility with other software which may be installed in the server to provide value added services such as Voice over WLAN. However, the Mikrotik RouterOS comes with its own value added package though this may not contain all the features present in other third party value added software pack.

- **Bandwidth Management Software:** Solaris is a popular band width manager recommended by experts its features include; (i) Incoming and outgoing traffic is managed, based on traffic type (telnet, FTP, E-mail, NFS™, etc.), end-user source or destination address, or organization source Or destination address, (ii) Bandwidth management rules can be configured to map organization, systems, or geographical layouts. (iii) Java-based graphical user interface makes it easy to specify bandwidth allocation policies, and enables remote monitoring and configuration. It works by sorting traffic into classes based on the application type, source and destination addresses, URL, and type-of-service field. It then schedules the traffic according to the minimum and maximum bandwidth defined for each class. There is also Easy browsing hotspot billing software and bandwidth manager which offers very wide range of billing options

6. SYSTEM IMPLEMENTATION

Using the V-SAT link already exiting, the main or primary base station is to be connected to the V-SAT link and then to the internet, via the modem of the V-sat or via the wired router. From the indoor modem, it is then fed to the DC injector of the WLAN (see figure 6), from the DC injector, the connection is linked to outdoor radio amplifier (located in the mast) via coaxial cable where the signal is amplified in power and fed to the antennae of the Primary base station Figure 4.1 explains the above description.

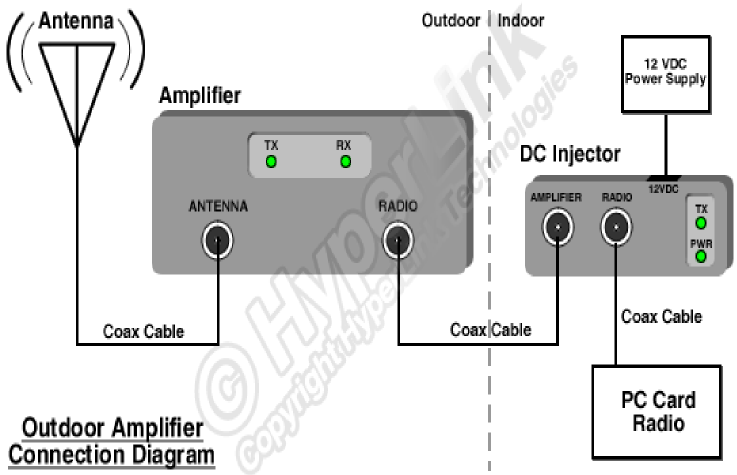

Figure 6: Block diagram of hardware connection

7. COVERAGE PLAN BLOCK DIAGRAM

The block diagram of the coverage plan in figure 1 is further expanded in figure 6 showing the five area coverage plan. From figure 6, the antennae will radiate signal up to 10KM (line of sight from) from AfriHub to Business Admin, Utility Building, faculty of Engineering and to other parts of the campus, the signal will be picked by the antennae of the secondary base station in Administrative block. The router in base station will be configure as a repeater for the network and will recognize the SSID and the MAC address of the signal from the primary base station, hence it will send the signal to the outdoor amplifier in the mast for further amplification from where the signal is fed to back to the antenna which works in full duplex mode (Transmitter and Receiver).

This is radiated further again 10kM (line of sight) bridging any gap between it and the primary base. Any of the signal could be received by the secondary base station in law faculty but will be radiated again 10KM (after undergoing similar process as the base station in Administrative building) for all the department within it. By the manufacturer specification the signal will all interlink to ensure no gap between coverage hence ensuring a near perfect coverage of the campus and beyond. It is noteworthy to mention, here that any of the secondary or repeater base station can be a made a primary base station by providing a V-SAT link to it. The hardware installation block diagram is as shown in figure 7.

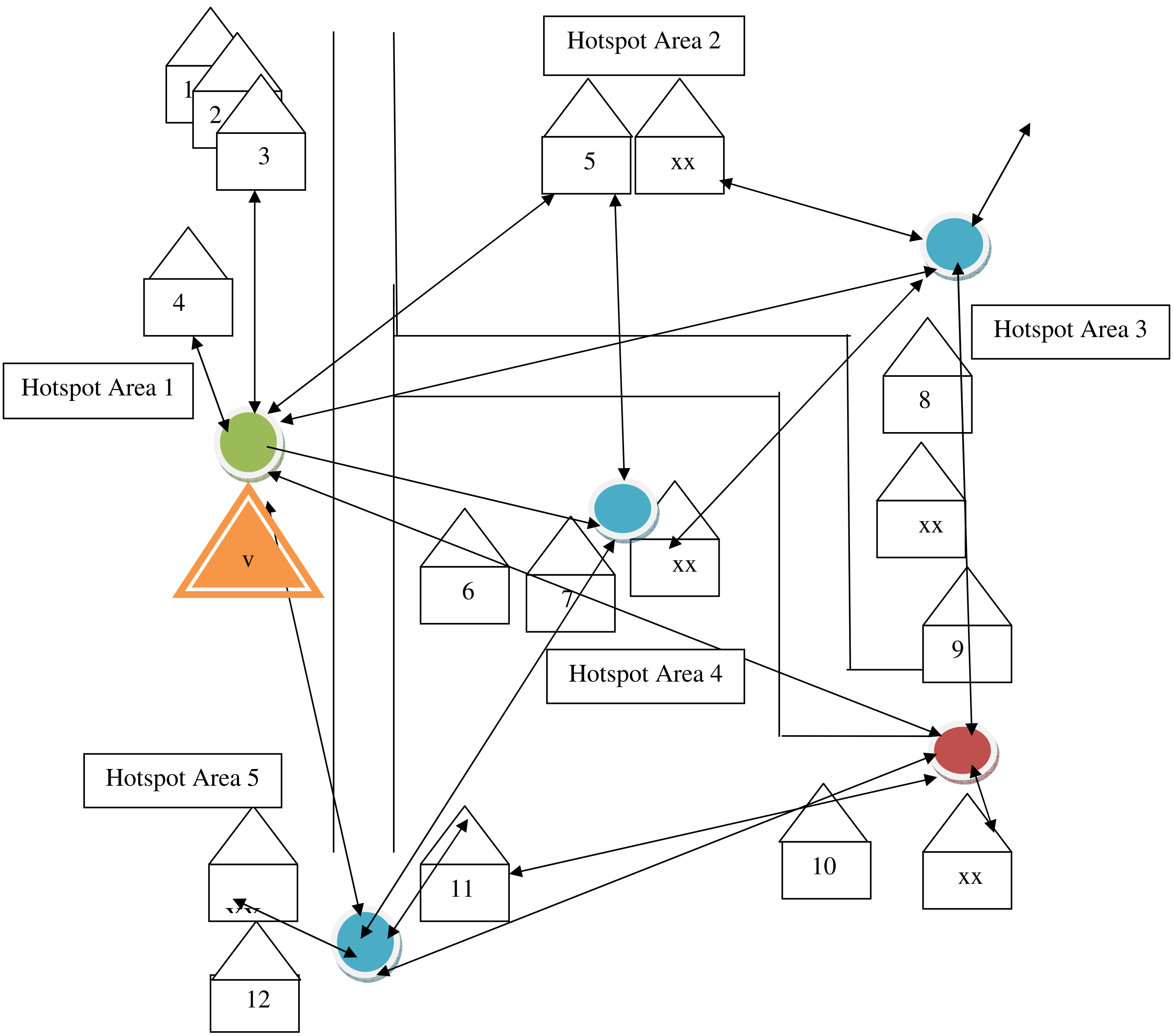

Figure 7: Block diagram of the WLAN Hotspot Coverage plan

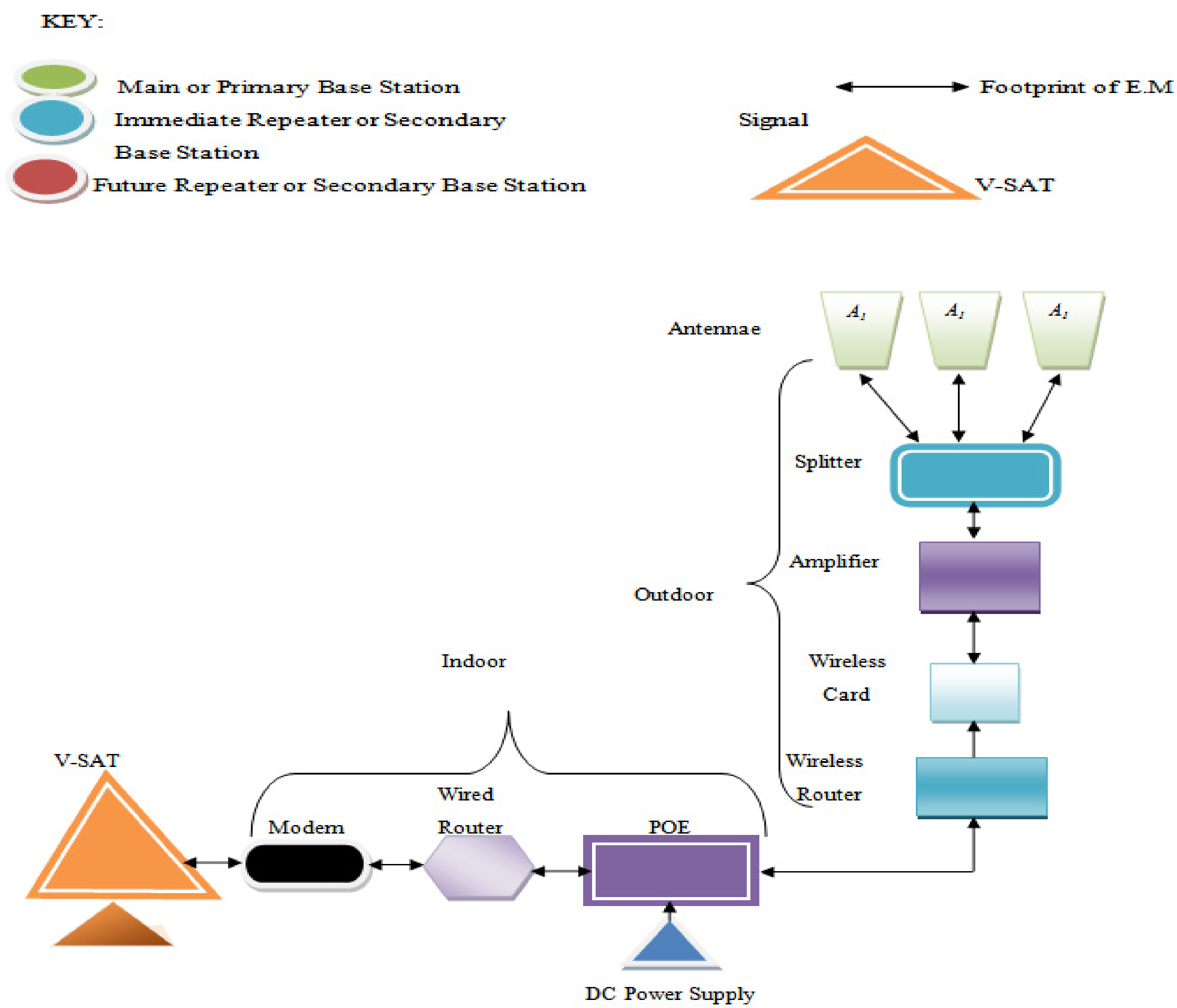

Figure 8: Block diagram of Primary base connection

7. MATHEMATICAL MODELING FOR COST DESIGN

7.1 Cost Optimization Formulation

Given that the strategic planning of UNIZIK WLAN Hotspot infrastructural development involves two sets of processes; Project process and Operation process, a cost of Five million Naira(N5m) and Three Million Naira(3m) can be allocated for them respectively. In our strategy, Four (4) project engineers and Five (5) Operation engineers are proposed to be used for the development of a Cost of Eight million Naira(8m). We then formulate the linear programming model as shown below:

Let the Project process be K_1

Let the Project operation process be K_2

The Objective function is, thus, **Min (Z)** = $5K_1 + 3K_2$
Subject to: $4K_1 + 5K_2 \leq 8$
$5K_1 + 2K_2 \leq 6$
$3K_1 + 8K_2 \leq 9, \quad K_1, K_2 \geq 0$

The above can be solved, thus,
Min Z $-5K_1 + 3K_2 = 0$
Subject to : $4K_1 + 5K_2 + S_1 = 8$
$5K_1 + 2K_2 + S_2 = 6$
$3K_1 + 8K_2 + S_3 = 9,$
$K_1, K_2 \geq 0$

Basic	*Z*	K_1	K_2	S_1	S_2	S_3	*Solution*
Z	*1*	*-5*	*-3*	*0*	*0*	*0*	*0*
S_1	*0*	*4*	*5*	*1*	*0*	*0*	*8*
S_2	*0*	*5*	*2*	*0*	*1*	*0*	*6*
S_3	*0*	*3*	*8*	*0*	*0*	*1*	*9*
Z	*1*	*-3.1/8*	*0*	*0*	*0*	*3/8*	*27/8*
S_1	*0*	*17/8*	*0*	*1*	*0*	*-5/8*	*19/18*
S_2	*0*	*17/4*	*0*	*0*	*1*	*-1/4*	*15/4*
K_2	*0*	*3/8*	*1*	*0*	*0*	*1/8*	*9/8*
Z	*1*	*0*	*0*	*0*	*31/34*	*5/34*	*23.1/34*
S_1	*0*	*0*	*0*	*1*	*-1/2*	*-1/2*	*1/2*
K_1	*0*	*1*	*0*	*0*	*4/17*	*-1/17*	*15/17*
K_2	*0*	*0*	*1*	*0*	*-3/34*	*5/34*	*27/34*

Thus K_1 = 15/17 million = ₦882,353 and K_2 = 27/34 million = ₦794,118
This implies that from the available resources, the total cost available within the constraints is Z = 23.1/34 million = ₦6,794,118 out of which the amount available for training of one worker for project process K_1 = ₦882,352 while for amount available for training of one worker for maintenance process is K_2 = ₦794,118. From the above consideration, it could be deduced that an additional cost of five million (₦5M) and two million naira (₦2M) will be required for additional expansion for cloud computing scalability and maintenance after a period of time. Though available funds for these, is six million naira (₦6M). Unizik infrastructural development which is involved with WLAN Hotspot infrastructure, may need to train three (3) skilled men for the project process and eight (8) skilled men for the operation process at cost of nine million (₦9M). The question is how the funds should be distributed for the various cost to be able to make the best of the available funds? and how does these translate to optimized WLAN Hotspots setup?

7.2 Approaches to Optimizing WLAN Hotspots to Support Wi-Fi Enabled Devices

The following steps are outlined which will help to optimize QoS in Unified Wireless Network deployment:

1. Configure 2.4-GHz for 20-MHz and three Non-overlapping channels: In the WLAN Hotspots, it is recommend that the 2.4-GHz frequency remain configured for 20-MHz and three non-overlapping channels. This provides greater flexibility for access point placement and WLAN design. Maintaining three 20-MHz channels helps enterprise deployments better optimize wireless capacity and coverage.
2. By implementing Cisco ClientLink to improve client reliability and coverage in mixed mode client WLAN Hotspot environments
3. By disabling lower data rates in 2.4GHz frequency band

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4. By enabling Cisco Band Select to encourage clients to use 5-GHz which have large spectrum of 2.4GHz for effective congestion management
5. By Utilizing all of the available 5-GHz Spectrum with Dynamic Frequency Selection (DFS)
6. By enabling Cisco CleanAir for detecting and mitigating wireless RF interference with
7. By Implementing Radio Resource Management (RRM)
8. By enabling Cisco Video Stream technology to order to improve multimedia and video traffic over Wifi enterprise-class that is reliable, synchronized manner without disruption.
9. By properly configure high-density wireless deployments: For areas with a large number of end users or devices simultaneously accessing the WLAN, it is important to properly design and configure the wireless network for high-density usage. The following RF design best practices are recommended to help properly deploy a high-density wireless network:
10. By accurately assessing end-user bandwidth requirements
11. By determining the total bandwidth for each access point
12. By assessing available access point channels for each Wi-Fi spectrum (2.4- and 5-GHz)
13. By performing a thorough site survey which helps in defining the contours of RF coverage for each area within a building and on campus. By performing a thorough site survey, organizations can discover building regions where multipath distortion is occurring and uncover campus areas where RF interference is high.
14. By accurately defining access point placement in site RF environment.
15. By Properly configuring Wi-Fi enabled devices in the context of security, congestion management, coverage, etc.

These steps will help IT engineers maintain a robust high-performance wireless network for all mobile users - especially those early adopters who bring new and exciting Wi-Fi enabled devices on to the enterprise WLAN and expect them to just work.

8. CONCLUSION

8.1 Summary of Achievement:

This research has presented a workable coverage plan for the deployment of wireless LAN in 2.4 and 5Ghz frequency band based on IEEE 802.11 b&g standard in Nnamdi Azikiwe University Awka Permanent site.The network so designed will be able to accommodate video streaming and voice over internet facility. It is noteworthy to mention that project and operational processes are very important in cost optimization for WLAN Hotspot deployment. Organizations will continually experience the introduction of new wireless client devices that bring innovative collaboration and communication opportunities to businesses. The robust nature of any good planning and implementation makes it easy for organizations to smoothly integrate new devices, such as the Apple iPad, Apple iPhone 4, Cisco Cius, laptops and Android-enabled devices, onto the secure enterprise wireless environment.

8.2 Problems encountered.

The following problems were encountered in the course of this work

(i) The ability of the wireless LAN to connect to the internet depends entirely on the reliability of the v-sat link located at AfriHub which in turn depends on the efficiency of the internet service provider I.S.P, hence if the I.S.P. is not very efficient, internet Access via the WLAN will seriously be impeded
(ii) It has not been easy to predict the demand staff and students will place on the network since a user doing video streaming will require more bandwidth than a user checking E-Mail, reading paper or downloading a text book, consequently, network congestion may be inevitable if application such as video streaming and voice over W-LAN is on high demand
(iii) There is currently no way of testing the manufacturer claims as per range of equipment prior to installation. One has to trust on the sincerity of the test carried out by the manufacture and adapt a conservative approach while planning the network then make adjustment after the installation if the manufactures rating are not truly realistic.

8.3 Recommendations:

(i) As a solution to (i) above, it may be necessary to have more than one link to the internet from different I.S.P, the initial cost may be discouraging but this can be split down to the user as part of the initial subscription fee, since this will ensure efficient service which is what the user desires.

(ii) Adequate provision for expansion of the network should be made as part of the preventive maintenance. This should be done as far as possible without disrupting the network. The flexibility of upgrading the router board from level 5 to 6 e.t.c. using the same hardware has made this easy but there will always be situations when entirely new installation may be desired especially as demand for services increases. Areas Suggested for further studies.

(i) Improvement of speed and video streaming ability of a wireless network
(ii) Ways of simulating wireless network performance and verifying manufacturers claims with respect to equipment range prior to installation

REFERENCES

1. Vijay K. Garg (2007). Wireless Communications and Networking", 2007 by Elsevier Inc.
2. FCC, First Report and Order 02-48, February 2002.
3. Gorday, P., et al (2001).IEEE 802.15.4 Overview." IEEE 802.15-01/509r0, November 12, 2001.
4. Gilb, J. P. K.(2001).Overview of Draft Standard 802.15.3." IEEE 802.15-01/509r0, November 14, 2001.
5. Gutierrez, J. A. et al,. *IEEE 802.15.4 Low-rate Wireless Personal Area Networks: Enabling Wireless Sensor Network.* Standard Information Network, IEEE Press, ISBN 0-7381-3557-7.
6. Intanagonwiwat, C., et al (2000). Directed-Diffusion: A Scalable and Robust Communication Paradigm for Sensor Networks. Proceedings of ACM MobiCom '00*,* Boston, MA, 2000, pp. 56–67.
7. Li, L., and Halpern, J,(2001).Minimum-Energy Mobile Wireless Network Revisited. ICC '01, Helsinki, Finland, June 2001.
8. Mandke, K., et al (2003). The Evolution of Ultra Wide Band Radio for Wireless Personal Area Network. *High Frequency Electronics*, September 2003.
9. Udeze C.C, et al (2012), " A Conceptual Design Model for High Performance Hotspot Network Infrastructure (GRID WLAN), *International Journal of Advanced Computer Science and Applications, (IJACSA), Vol. 3, No. 1, 2012 Pp.* 93-99.
10. Roberto.B.,et al(2003). Optimal Wireless Access Point Placement for Location-Dependent Services, Technical report DIT-03-052, Universit`a di Trento, October 2003
11. Amit P. J. et al (*2005*).Understanding Link-Layer Behavior in Highly Congested IEEE 802.11b Wireless Networks", *SIGCOMM 2005 Workshops,* August 22–26, 2005, Philadelphia, PA, USA.
12. Raffaele B. et al (2008), " Throughput Analysis and Measurements in IEEE 802.11 WLANs with TCP and UDP Traffic Flows", IEEE Transactions On Mobile Computing, Vol. 7, No. 2, February 2008, Pp.171-1186.
13. David T. A.(2003).Maximizing Throughput with Ultra-Compact Diversity Antennas, IEEE VTC 2003 FALL",
14. Mohammad S.& Soumen.K. (2007), "Performance of Modeling wireless networks in realistic environment", International Journal of Computer Networks (IJCN), Volume (2): Issue (1),Pp.62-79
15. White paper- ProCurve Networking by HP-Planning a Wireless Network
16. Hetal Jasani, Yu Cai,(2008) " Performance Evaluation of Wireless Networks", IEEE Xplore, 2008.
17. Salam A. Najim, et al.Performance Evaluation of Wireless IEEE 802.11b used for E-Learning Classroom Network", IAENG International Journal of Computer Science,
18. Kritika S. et al (2011).Performance Evaluation of 802.11 WLAN Scenarios in OPNET Modeler", International Journal of Computer Applications (0975 – 8887) Volume 22, No.9, May 2011,Pp.30- 35.
19. S. Vasudevan, et al (2005).Facilitating Access Point Selection in IEEE 802.11 Wireless Networks, USENIX Association, Internet Measurement Conference 2005.
20. David Lang (2012)– Intuit, Building a Wireless Network for a High Density of Users, USENIX Association, 26th Large Installation System Administration Conference (LISA '12) 247

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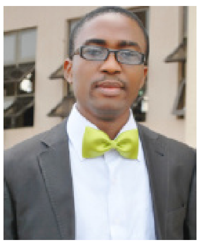

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