Received Signal Strength AnalysisAnd Optimization Measurement Of Wireless Access Point PlacementsAt The University Of Benin

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Abstract- **Academia has peculiar networking needs that must be satisfied for the effective dissemination of knowledge. The main purpose of a campus network is efficient resource sharing and access to information among its users. A key issue with designing and implementing such Wireless Local Area Networks (LAN) is its performance and accessibility under ever-increasing network traffic, and how this is affected by various network metrics such as Signal Strength, latency, and end-to-end delay. Implementation of network systems is a complex and expensive task; hence network measurement and optimization have become essential and have proven to be highly useful for analyzing performance and accessibility under different scenarios. As well as providing a useful prognosis of future network performance based on current expansion dynamics. We present in this paper the analysis and optimization of the University of Benin campus Wireless Access Points Placement.**

Keywords—Measurement, Optimisation, Wireless Access Points, Networking, Local Area Network, WLAN, Signal Strength, IEEE, TCP/IP, RSSI, Wi-Fi.

1. INTRODUCTION

Advances in communication technology and the proliferation of lightweight, hand-held devices with built-in, high-speed radio access are making access to the Internet the common case rather than an exception. Communication is a necessity in all settings be it social or professional. For tasks to be accomplished, people need to work together to solve problems and create resources

for the institution. For easy sharing and access of information among users, the computers involved must be interconnected. This interconnection of computers to form a network with the objective of information communication and optimization of resource sharing is referred to asLocal Area Network (LAN). LAN installations based on IEEE 802.11 technology are emerging as an attractive solution for providing network connectivity in corporations and universities, and in public places like conference venues, airports, shopping malls, etc. – places where individuals spend a considerable amount of their time outside of home and work. In addition to the convenience of untethered networking, contemporary Local Area Networks provide relatively high data connectivity at about7 Mb/s and are easy to deploy in public settings. Wireless technologies are very popular for the flow of information. IEEE 802.11 technologies have started to spread rapidly, enabling consumers to set up their own wireless networks[1][3]. Also, with the increasing use of mobile computing devices such as PDAs, laptops, and an expansion of Wireless Local Area Networks (WLAN), there is growing interest in optimizing the WLAN infrastructure so as to increase productivity and efficiency in various collegesand office campuses with carrying out a cost-effective infrastructure model [8]. So, it has become essential to understand the propagation characteristics for a proposed WLAN before deployment. One of the most important reasons for this is security. Predicting how far a signal can go before installation will ensure that a connection cannot be made in areas where it is not desired. The strength, range and coverage area of an access point is strongly affected by its positioning in reference to its environment. Mechanisms desired connection in places where it should

not be made, it is necessary to carefully predict the signal strength, range, coverage and the correct placement of base stations [2]. Various mechanisms like reflection, diffraction, refraction, scattering & absorption also affect the strength of the signal [3][4]. The strength of our existing WLAN for indoor &

outdoor access points can be analyzed by statistical field measurements. This project demonstrates the analysis of the existing wireless network in indoor & outdoor environments by examining the field measurements of received signal strength (RSS). The data taken for the analysis is used to calculate the path loss exponent & standard deviation of the location [3]. Thefrequency of the radio signal analyzed is 2432 MHz. The received signal levels were monitored from the access point (AP) or base station (BS) manually. Total coverage area chosen for the measurement campaign consisted of a mixture of significantly different propagationenvironments [4].

1.1 AIM AND OBJECTIVES OF THE STUDY

The aim is to measure and optimize wireless access points in the University of Benin, Nigeria using received signal strength.

With the objectives as follows:

1. To measure the performance of the Wireless Local Area Network in UNIBEN.

2. To measure the performance of the Wireless Access Points using received signal strength.

3. To optimize the physical layout of the Wireless Access Points in UNIBEN

4. To assess the area of coverage and accessibilityof the Wireless Local Area Network in the University.

5. To assess the efficiency of Access Points beingused in the University.

Fig 1.0: Areas with access to the Uniben WLAN in the University.

1.2 THEORETICAL FRAMEWORK

The methodologies to be adopted in this research are as follows:

1. Using the Acrylic Wi-Fi software for Windows, we are going to acquire following data from Wireless Access Points (WAPs) in the University through the Ralink RT5390 802.11b/g/n Wi-Fi Adapter on a HP laptop:

- The SSID (Service Set Identifier) or the name ofeach WAP.
- The MAC (Media Access Control) address of each WAP.
- The RSS (Received Signal Strength) of each WAP.
- The IEEE standards for each WAP.
- The channels in which each WAP is broadcastingon.
- The Maximum Speed of each WAP.

2. Using the Wi-Fi Scanner for Android, we are going to run analysis on the WAP's performance and quality through the QCOM RT60 wireless card.

3. Using measuring tape to measure the radius of the area covered by the wireless access points.

As there are many factors affecting the received signal strength, this project scope is based on the analysis of the Wireless Access Points (WAPs) analyzed using RSSI as a metric limited to the radial distance covered by the WAPin the various faculties in the University of Benin. The WAPs in all the faculties will be analyzed and the results used to optimize the WAP placement. Faculty of Engineering will be taken as the case study for WAPlocation optimization.

Anticipated Contribution to Knowledge

It is expected that at the end of this research work that an optimized model is developed for the Local Area Network in University of Benin that can be assessed and used for reference purpose to the network engineers and administrators. This model will also stand as a benchmark to know why and how certain segments of the existing network should be improved upon.

2. LITERATURE REVIEW

Works on the measurement and optimization of Wireless Access Points Placement are widely recorded in literature. Although the WLAN is designed to provide LAN connections to the area where the premises wiring systems are not available for the conventional wired LAN service, it begins to support mobile computers throughout a building or a campus. In general, WLANs operate in the unlicensed industrial, scientific, and medical (ISM) bands at 915 MHz, 2.4 GHz, and 5 GHz. The first version of WLAN specification, IEEE 802.11, provides only up to 2 Mbps, which allows direct sequence or frequency-hopping spread spectrum to be used in 2.4 GHz or operation at the infrared frequencies. However, the IEEE 802.11b standard has emerged to provide high-rate WLAN service up to 11 Mbps in 2.4 GHz, which uses the modified version of IEEE 802.11 direct sequence spread spectrum. Recently, a new version of high-rate WLAN standard, IEEE 802.11a, can provide up to 54 Mbps at the 5 GHz band.

WLANs consists of mobile computers with network adapters (NAs) and access points (APs) which are connected to high speed wired LANs. While WLANs have been considered to be used in the indoor environment such as in a building, their usage has been extended to the Internet access service in the outdoor environment like within a campus or on the street. In designing WLAN services, the most important problem is to determine where APs should be located so that the coverage and the throughput of the service area are maximized.

WLAN

Computer technology has rapidly growth over the past decade. Much of this can be attributed to the internet as many computers now have a need to be networked together to establish an online connection. As technology continues to move from wired to wireless, the wireless LAN (local area network) has become one of the most popular networking environments. Companies and individuals have interconnected computers with local area networks (LANs). The LAN user has at their disposal much more information, data and applications than they could otherwise store by themselves. In the past all local area networks were wired together and in a fixed location. Wireless technology has helped to simplify networking by enabling multiple computer users simultaneously share resources in a home or business without additional or intrusive wiring. The increased demands for mobility and flexibility in our daily life are demands that lead the development.

To know WLAN, we need first to know the definition of LAN, which is simply a way of connecting computers together within a single organization, and usually in a single site (Franklin, 2010). According to Cisco report in 2000 wireless local-area network (WLAN) does exactly what the name implies: it provides all the features and benefits of traditional LAN technologies such as Ethernet and Token Ring without the limitations of wires or cables. Obviously, from the definition the WLAN is the same as LAN but without wires. (Clark et al, 1978) defined WLAN as a data communication network, typically a packet communication network, limited in geographic scope.' A local area network generally provides high-bandwidth communication over inexpensive transmission media. While (Flickenger, 2005) see it as a group of wireless access points and associated infrastructure within a limited geographic area, such as an office building or building campus, that is capable of radio communications. Below are some of the reasons why anyone would want a WLAN:

1- An increasing number of LAN users are becoming mobile. These movable users require that they are connected to the network regardless of where they are because they want simultaneous access to the network. This makes the use of cables, or wired LANs, impractical if not impossible.

2- Wireless LANs are very easy to install. There is no requirement for wiring every workstation and every room. This ease of installation makes wireless LANs inherently flexible. If a workstation must be moved, it can be done easily and without additional wiring, cable drops or reconfiguration of the network.

3- Another advantage is its portability. If a company moves to a new location, the wireless system is much easier to move than ripping up all of the cables that a wired system would have snaked throughout the building. Most of these advantages also translate into monetary savings.

Wireless Access Points (WAP)

One of the main components to establish a wireless network is Wireless Access Point (WAP). WAP is a wireless router or bridge that has a function for transmitting the data that was connected with the WLAN network. In computer networking, a wireless access point (WAP) is a networking hardware device that allows a Wi-Fi compliant device to connect to a wired network.

The WAP usually connects to a router (via a wired network) as a standalone device, but it can also be an integral component of the router itself. Prior to wireless networks, setting up a computer network in a business, home or school often required running many cables through walls and ceilings in order to deliver network access to all of the network-enabled devices in the building. With the creation of the wireless access point, network users are now able to add devices that access the network with few or no cables. A WAP normally connects directly to a wired Ethernet connection and the WAP then provides wireless connections using radio frequency links for other devices to utilize that wired connection. Most WAPs support the connection of multiple wireless devices to one wired connection. Modern WAPs are built to support a standard for sending and receiving data using these radio frequencies [7]. Those standards, and the frequencies they use are defined by the IEEE. Most APs use IEEE 802.11 standards.

Received Signal Strength

In telecommunications, received signal strength indicator (RSSI) is a measurement of the power present in a received radio signal. RSSI is usually invisible to a user of a receiving device. However, because signal strength can vary greatly and affect functionality in wireless networking, IEEE 802.11 devices often make the measurement available to users. RSSI is often done in the intermediate frequency (IF) stage before the IF amplifier. In zero-IF systems, it is done in the baseband signal chain, before the baseband amplifier. RSSI outputis often a DC analog level. It can also be sampled by an internal ADC and the resulting codes available directly or via peripheral or internal processor bus. In an IEEE

802.11 system, RSSI is the relative received signal strength in a wireless environment, in arbitrary units. RSSIis an indication of the power level being received by the receive radio after the antenna and possible cable loss. Therefore, the higher the RSSI number, the stronger the signal.

RSSI can be used internally in a wireless networking card to determine when the amount of radio energy in the

channel is below a certain threshold at which point the network card is clear to send (CTS). Once the card is clear to send, a packet of information can be sent. The end-user will likely observe a RSSI value when measuring the signal strength of a wireless network through the use of a wireless network monitoring tool like Wireshark, Kismet or Insider. As an example, Cisco Systems cards have a RSSI Max value of 100 and will report 101 different power levels, where the RSSI value is

0 to 100. Another popular Wi-Fi chipset is made by Atheros. An Atheros based card will return an RSSI value of 0 to 127 (0x7f) with 128 (0x80) indicating an invalid value.

Network Architecture

The institutions of higher learning need to reap the benefits of internet revolution through integrating ICT into the learning environment. The focus is to improve the quality of education and laying a good foundation at the higher learning institution and encourage the institution and its affiliated colleges to share the resources, knowledge content, promotion and implementation of e- governance, faculty development and exchange of skills. All the IT resources and content should be available to the faculty and students from their desk as well as anywhere- anytime basis over the campus. To achieve the same, the universities need to establish Campus network at their campuses. It is very helpful for the universities to work from any block/building and receive the same speed of data transfer. The University of Benin Network is a computer network made up of an interconnection of local area networks (LANs) within a limited geographical area. The networking equipment (switches, routers, firewalls, IPSs) and transmission media (optical fiber, copper cable) are used to interconnect & communicate among all devices connected.

In the University, its area network interconnects (although not sufficiently) a variety of campus buildings, including administrative buildings, academic buildings, university libraries, campus or student centers, hostels, guest house, gymnasiums, and other outlying structures, like conference centers, technology centers, stadiums, and training institutes. The Campus network are interconnected with high-speed Ethernet links operating over optical fiber such as Gigabit Ethernet and 10 Gigabit Ethernet [7]. A tiered hierarchal architecture is used to establish Campus network with core, distribution & access segments for efficient flow of information & data traffic. All buildings, blocks, centers, hostels, residential complexes, hostels are connected through high-speed fiber optical cable and all nodes inside a building are connected through UTP copper cable support gigabits speed. Seminar halls, conference rooms and common areas in the campus are Wi-Fi enabled through deployment of secured 802.11 based wireless access points with centralized authentication to allow secure network access through laptops and Wi-Fi enabled devices. The Internet & all applications/services are deployed at central locations from where faculty, staff and students access

them using their desktops & laptops anytime from anywhere on the campus.

The Wireless Access Points are structured in a Star-Tree Hybrid topology emanating from the University's ICT department located at the main auditorium outward. This Signal is transmitted to other areas in the university using two methods: Via a Radio and Via Optic Fiber. When the signal is received at a faculty, it is sent to a switch that transmits the signal to the various wireless access points in that faculty.

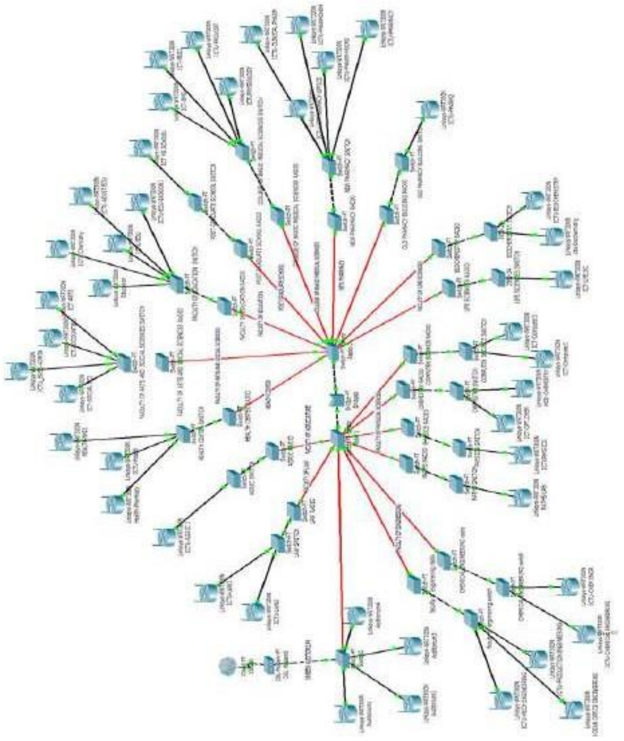

Fig 1.2 University of Benin Network Model

3. METHODS

The design of a wireless local area network (WLAN) has an important issue of determining the optimal placement of access points (AP) and assignment of channels to them. WLAN services in the outdoor as well as indoor environments should be designed in order to archive the maximum coverage for WLAN service areas, AP shouldbe installed such that the sum of signal measured at each traffic demand point is maximized. However, as users connected to an AP shares wireless channel bandwidth with others in the same AP, AP placement should be carefully decided to maximize the throughput by considering load balancing among AP and channel interference and coverage for the user traffic demand. The optimization objective is to reallocate WAPs to area with less coverage, which qualitatively represents congestion at the hotspot in WLAN service areas. The proposed method finds the optimal AP placement utilization using the Received Signal Strength intensity. There are various factors affecting the received signal for both indoor and outdoor localization which are spatial (distance), temporal, environmental, hardware, and

human presence. The case study here is the OptimalRadial Distance.

3.1ToolsHardware

For this project, off the shelf commercially available stamped and approved by the Wi-Fi alliance equipment were used. Each faculty on campus were studied taking into consideration the different Wireless Access Points installed as well as taking measurements and analysis on each available Access Points. A laptop with Dell's 1370 WLAN mini-PCI card and an android mobile phone were used to perform the measurements. A tape rule was also used to measure the distance at every instance corresponding to the RSS indicator on both the laptop and android device.

Software

The methodology used in this project is based on a comparative study, which the execution of this research is to obtain the data according to directly (primary data) which is the data is processed to compare a variable between different subjects. The location of the research was carried out in all the faculties on campus. A data variable of the signal strength from each WAP was determined using network analysis software, such as Acrylic Wi-Fi Home and Wi-Fi Analyzer. These programs were selected because of their easy use and installation, the program runs on the Windows platform. Acrylic Wi-Fi Home software can be used to view channels, SSIDs and the filter from the detected network. There can be found indicator colors like green, yellow, and red who functioneddescribe the quality of the network. SNR of each network can also be seen every minute during the Acrylic Wi-Fi Home enabled. Meanwhile on the Wi-Fi Analyzer android application, it is not much different from Acrylic Wi-Fi Home where at this application can be see SNR, frequency, and other parameters.

Acrylic Wi-Fi Analyzer and Wi Fi site survey software Acrylic Wi-Fi is an innovative WLAN Scanner thatperforms detailed security and coverage analysis for Wi-Ficommunications networks in a very short time and at anunbeatable cost. It has a clear and intuitive interface where to display the existing communications devices,how they behave, what are the existing security options and generate reports automatically. This software displaysReal-Time WLAN information of available WAPs in anetwork location and was used for network analysis including signal strength and quality of an AP. The Wi-Fi scanner displays Wi-Fi access points and connecteddevices, shows information of the security mechanisms and obtains generic Wi-Fi passwords. It is able to gather informationfrom802.11/a/b/g/n/acnetworks.The software was used to capture information such as: SSID,MAC Address, Broadcast Channel etc. from the APs.

With Acrylic Wi-Fi Analyzer you can identify problemssuch as the coexistence of devices with old standards thatdegrade the signal, the security risks of WEP, WPA or

WPS passwords, the existence of unauthorized access points or the spread of a corporate Wi-Fi network.

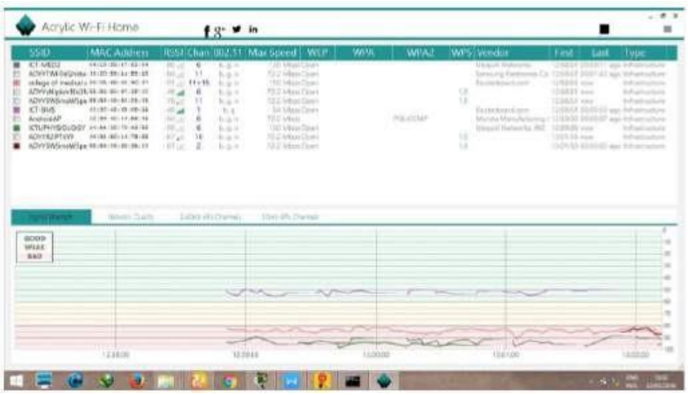

Fig 1.3 Acrylic Wi-Fi being used to analyze WAPs in a certain area.

Wi-Fi Analyzer

This is an android application that displays WLAN information received by a WLAN mini-PCI card of the mobile phone. It was used to measure the RSS at every distance taken away from the Access Point's location. TheWifi Analyzer sends a probe to intercept the beacons transmitted by the access points at a frequency equal to the frequency of the transmitted beacons.

Fig 1.4 Wi-Fi analyzer being used in detecting signal strength of a WAP.

Fig 1.5 Wi-Fi analyzer showing a graphical representation of the WAPs in a certain area.

Methodology Algorithm

1. At each location in the faculty, the WAPs available were analyzed with both the mobile phone (using Wi-Fi Analyzer software) and the laptop (using Acrylic Wi-Fi software) in order to compare its WLAN information such as the RSS and Link Speed.

2. The RSS was recorded at the WAP's location at

first i.e., at distance = 0ft

3. Then the distance was increased from zero to the certain value, at which instance, the RSS was measured to ensure the signal received by the wireless card of both the phone and the computer were at the desired RSS level shown by the RSSI. Desired RSS level in this context means the minimum signal strength in which stable connection can be made by the devices.

4. At all Wireless Access Point locations in the designated Faculties, the above steps were repeated, andeach measurement was recorded.

5. Faculty of Engineering was chosen as the case study for result analysis and optimization. An analysis of the data gathered in engineering was carried out to compute the optimal radial distance at which RSS will be best for easy access to the users.

6. Relocation of access points in each faculty was done with Google maps to expand the coverage area. The areas with highest activities in each faculty were noted in this regard and subsequently WAPs relocation were done using the optimized radial distances from each access point.

7. A model of the optimized location of the WAPs was realized using Google Maps taking into consideration all the access points radial distance.

Fig 1.7 G-Map view of readings taken at Faculty of Agriculture Building. The black circles show the

approx. distance covered by the access point inside the building on the ground floor.

4. RESULTS

This section provides the result of our research and a brief discussion for each data collection. In the following discussion we will divide the result into two test environments.

Indoor Area

The Indoor Area measurements were taken inside the halls of various buildings (corridors and offices) since it was a conveniently placed for acquired the data. There are no obstacles in this area except enclosed with concrete wall. The result of data collected is shown in table 1 below. Figures in the table 1 represent the average results from each experiment received from measurements using the two devices. From table 1 was shown the maximum distance of wireless router signal that can be maintain the connection between the WAP and the observer. The lowest signal strength means when the signal strength stated the maximum distance between WAP and observer. As a comparison with the result of the research and the RSSI of wireless WAP, in table 1 and the maximum distance covered by the WAP is related in such a way that as you move away from the WAP, the signal strength drops until finally the network cannot be seen anymore. Therefore, we can analyze the maximum distance of the wireless AP specification cannot be fully analyzed in this situation due to wall obstructions which hinder the flow of the signals of the WAPs. Wireless access points placed in offices exhibit a lower distance compared with the ones given placed in the corridors. However, due to the superior signal strength of some wireless access points, a WAP placed in an office can be suitable enough to cover a large radial area despite obstructions.

Outdoor Area

The measurements were taken in the parking area of Campus without obstacles. We analyzed using the Acrylic Wi-Fi software to ensure the area is free from other access point signals. The wireless AP was stationary, while the observer was rotated around the wireless router at a fixed distance of 10 FT in order to measure the signal strength. There are three different conditions, such as theantenna of WAP with vertical direction, the antenna of WAP with horizontal direction, and by adding some brickswith a thickness of 6 centimeters surrounding the WAP. From the sampled readings from all locations, we have obtained the wireless access point information of each location. It was observed that the signal strength of theWAPs obtained was the same whether vertical or horizontal. Although the same cannot be said about theRSS of the WAP when a brick was placed as anobstruction. This further proves that the distance covered by the WAPs is reduced due to obstructions between the access point and the observer, which is the case inaccess point locations in all the faculties analyzed.

Data Collected

Various data collected from all the faculties were presented in a table and shown below in Table 1. The table contains Access Point SSID, Model, Signal Strength, Link/WAP Speed and Distance Values for Different Wireless Access Points at the various faculties in theuniversity (Indoor and Outdoor).

Location	Access Point SSID	WAP Vendor	Highest RSS	Lowest RSS	Coverage Radius	WAP Speed
1. College of Medical Sciences	ICTUPHYSIOLOGY	Ubiquiti Networks. INC	-30dBm	-64dBm	48ft	65MBPS
	ICT-MED2	Routerboard.com	-34dBm	-86dBm	65FT	54MBPS
	college of medical sciences base	Routerboard.com	-32dBm	-86dBm	35ft	150MBPS
	ICT-BMS	Routerboard.com	-29dBm	-87dBm	178FT	54 Mbps
	ICTU-PROVOST	Routerboard.com	-39dBm	-87dBm	40FT	54MBPS
2. Faculty of Agriculture	ICTU AGRIC 2	ROUTERBOARD	-40dBm	-66dBm	125FT	11MBPS
	ICTU AGRIC 3	TP LINK	-38dBm	-74dBm	60FT	40MBPS
	ICTU AGRIC 4	TPLINK TECHNOLOGIES CO LTD.	-30dBm	-73dBm	75FT	54MBPS
	ICTU AGRIC 6		-22dBm	-73dBM	93FT	65MBPS
	ICTU AGRIC 7	Ubiquiti Networks		-73dBM	113FT	65MBPS
3. Faculty of Engineering	New 1000LT (ENGINE 1)-ICTU 2.4G	Senao Network	-31dBm	-61dBm	110FT	39MBPS
	New 1000LT (ENGINE 2)-ICTU 2.4G	Senao Network	-32dBm	-72dBm	100FT	65MBPS
	New 1000LT (ENGINE 3)-ICTU 2.4G	Senao Network	-24dBm	-73dBm	110FT	65MBPS
	ICTU-Computer Engineering	Ubiquiti Networks	-17dBm	-70dBm	138FT	65MBPS
	ICTU-Electrical Engineering	Senao Network	-23dBm	-73dBm	171FT	65MBPS
	ICTU-Civil Engineering	Senao Network	-22dBm	-73dBm	190FT	65MBPS
	ICTU-DEAN OFFICE Engineering	TP-Link	-26dBm	-73dBm	80FT	58MBPS
	ICTU-MECH Engineering	Senao Network	-26dBm	-73dBm	80FT	65MBPS
	ICTU-PRODUCTION	Senao Network	-28dBm	-73dBm	75FT	65MBPS
	ICTU-Chemical Engineering	Ubiquiti Networks	-33dBm	-69dBm	39FT	65MBPS
	ICTU PET-ENG	TP Link	-42dBm	-73dBm	141FT	108MBPS
4. Faculty of Law	ICTU-LAW 1	Routerboard.com	-30dBm	-72dBm	35FT	54MBPS
	ICTU-LAW 2	Routerboard.com	-39dBm	-73dBm	35FT	54MBPS
	ICTU-LAW 3	Ubiquiti Networks	-40dBm	-75dBm	75FT	19MBPS
5. Faculty of Physical Sciences	Math-Lab	Ubiquiti Networks	-19dBm	-69dBm	75FT	65MBPS
	MATH LAB	TP-LINK	-48dBm	-73dBm	70FT	65MBPS
	Computer-Lab Annex		-41dBm	-74dBm	65FT	65MBPS
	ICTU-Chemistry	Routerboard	-45dBm	-72dBm	75FT	65MBPS
	ICT-OPT-CHEM	Ubiquiti Networks	-28dBm	-69dBm	70FT	65MBPS
	ICTU PHYSICS	Routerboard	-26dBm	-72dBm	70FT	54MBPS

	HOD CHEM	Ubiquiti Networks	-39dBm	-70dBm	75FT	65MBPS
	Chemistry-Annex	Ubiquiti Networks	-41dBm	-73dBm	75FT	26MBPS
	ICTU-Biological Annex	Senao Networks	-28dBm	-74dBm	50FT	58MBPS
6. Faculty of Life Sciences	ICT-LIFE SCIENCE	Ubiquiti Networks	-28dBm	-73dBm	75FT	65MBPS
	ICT-Life Science	Routerboard	-38dBm	-70dBm	60FT	54MBPS
	ICTU-Pharm2	Ubiquiti Networks	-39dBm	-73dBm	75FT	65MBPS
7. New Pharmacy Building	ICTU-PHARM	ALFA	-36dBm	-70dBm	100FT	11MBPS
	ICTU biochemistry	CISCO LINKSYS	-36dBm	-72dBm	71FT	54MBPS
	ICTU-BIOCHEMISTRY	Ubiquiti Networks	-28dBm	-70dBm	89FT	26MBPS
	ICTU-CLINICAL-PHARM	Ubiquiti Networks	-21dBm	-73dBm	75FT	65MBPS
	ICTU-PHARMCHEM	Ubiquiti Networks	-28dBm	-72dBm	50FT	54MBPS
	ICTU-PHARMACY	Routerboard	-39dBm	-73dBm	75FT	135MBPS
	ICTU-PHARM-MICRO	Ubiquiti Networks	-36dBm	-70dBm	80FT	65MBPS
	ICTU-PHARMACY-OFFICE	Ubiquiti Networks	-28dBm	-73dBm	75FT	65MBPS
8. Faculty of Education	ICTU-ADULT EDU	CISCO LINKSYS	-31dBm	-72dBm	60FT	135MBPS
	ICTU-EDU-INDOOR	CISCO LINKSYS	-36dBm	-73dBm	60FT	65MBPS
	ICTU-EDU-INDOOR1	TP LINK	-40dBm	-70dBm	60FT	135MBPS
	ICTU-HEK	TP LINK	-40dBm	-73dBm	54FT	135MBPS
	ICTU-EDUCATION	TP LINK	-28dBm	-73dBm	75FT	135MBPS
9. Faculty of Arts and Social Sciences	ICT ARTS	Ubiquiti Networks	-39dBm	-72dBm	35FT	54MBPS
	ICTU BUSS-ADMIN	Routerboard	-31dBm	-70dBm	35FT	54MBPS
	ICT SOCIAL SCI	Ubiquiti Networks	-36dBm	-72dBm	35FT	54MBPS
	ICTU ACCOUNTING	Routerboard	-28dBm	-70dBm	35FT	54MBPS

Table 1: Signal Strength, Distance and Link Speed Values for Different WAPs available in all faculties in the university.

After getting and recording our data for all the faculties in the school, Faculty of Engineering was taken as a case study. Data analysis and WAP optimization were done on the results recorded for the faculty. An optimized model was created for WAP placement to improve WAP coverage in the faculty using the optimal radial distance as a metric. The Optimization was done with Google maps to show the radial distance of coverage graphically. A total of eleven WAPs were analyzed in the faculty of engineering, each with its radial distance of coverage, RSS, link/WAP speed etc. All the factors in consideration were recorded in a table. The table below shows the data recorded for our case study which contains Access points SSID, Model, Signal Strength, Speed and Distance Values for Different Wireless Access Points at Faculty of Engineering.

S/N	SSID	RSS close to the WAP	RSS when farthest from WAP	Radial distance covered by WAP
1.	New 1000LT (ENGINE 1)-ICTU 2.4G	-31dBm	-61dBm	110FT
2.	New 1000LT (ENGINE 2)-ICTU 2.4G	-32dBm	-72dBm	100FT
3.	New 1000LT (ENGINE 3)-ICTU 2.4G	-24dBm	-73dBm	110FT
4.	ICTU-Computer Engineering	-17dBm	-70dBm	138FT
5.	ICTU-Electrical Engineering	-23dBm	-73dBm	171FT
6.	ICTU-Civil Eng	-22dBm	-73dBm	190FT
7.	ICTU-DEAN OFFICE Engineering	-26dBm	-73dBm	80FT
8.	ICTU-MECH Engineering	-26dBm	-73dBm	80FT
9.	ICTU-PRODUCTION	-28dBm	-73dBm	75FT
10	ICTU-Chemical Engineering	-33dBm	-69dBms	39FT
11.	ICTU PET-ENG	-42dBm	-73dBm	141FT

Table 2. Signal Strength, Distance and Link Speed Values for Different WAPs available in Faculty of Engineering.

Chart

The RSS (dBm) and the radial distance values were taken as a metric for data analysis. A chart was created to show a graphical view of the relationship between RSS (dBm) and the radial distance (Ft.). There is a linear relationship between RSS and the radial distance. The RSS received by the devices decreases as the distance increases. i.e. Increasing Distance from the WAP means decreasing RSS received by the devices.

Below shows the graphical view we talked about above.

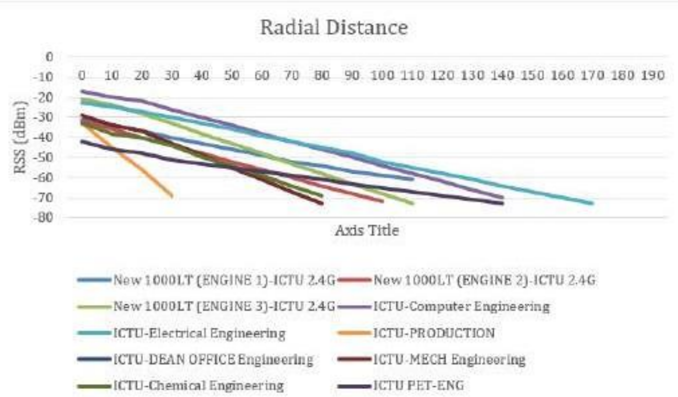

Fig 1.8 Graph showing the relationship between RSS and distance covered by the WAP.

Optimizing Wireless Access Point Placement in theFaculty of Engineering

Optimization of wireless access point placement in the faculty of Engineering was done graphically using Google maps and optimizing radial distance of coverage by relocating the WAPs available to areas with no coverage. A Google map image is shown below in fig 1.9 showing the current locations of WAPs in the Faculty.

All areas with circles were the covered area. Users can access the internet in this region. We noted the Lecture theaters were not covered i.e., LT1, LT2, LT3, and LT4 while some areas have redundant WAPs.

Fig 1.9 current Model of the WAPs placement in the Faculty of Engineering

Optimization Model

The optimization model developed is shown graphically using a Google map image of the Faculty of Engineering. In this image, areas marked as uncovered area in figure were covered through relocation of WAPs from areas withredundant WAPs. The uncovered area was marked as a, b and c which were Lecture theatres 1 to 4 and Petroleum Engineering Department. The steps taken to achieve our objective are outlined below:

1. An access point named ICTU-Elect/elect engineering was relocated to the lecture theatres 1-4.

2. An access point named ICTU-computer engineering was relocated to the Civil Engineering Laboratory

3. An access point named New 1000LT (ENGINE1) was relocated to the Petroleum EngineeringDepartment.

The optimized model graphical view is shown below in fig

2. Also in our proposed model, the RSS to be received at the optimized locations was analyzed and placed in table

3. The table consists of Optimized Location, SSID of Access Point Used, RSS before optimization, and RSS after optimization.

A chart was created to show how our optimized model provides better WAP coverage and the proposed signal received signal received at each new location.

Fig 2.0 Proposed optimized model of the wireless access point placements in the Faculty of Engineering.

Optimized Location	SSID of Access Point Used	RSS before optimization	RSS after optimization
LT1,LT2,LT3,LT4,Production 400lvl class and Board Room	ICTU-Electrical Engineering	0dbm	-23dbm to -73dbm
Civil Engineering Laboratory	ICTU-Computer Engineering	0dbm	-17dbm to -70dbm
Petroleum Engineering LTs	New 1000LT(PNG 3-ICTU 2.4G)	-92dbm(From ICTU PET-ENG)	-24dbm to -73dbm

Table 3. optimized locations and RSSI values

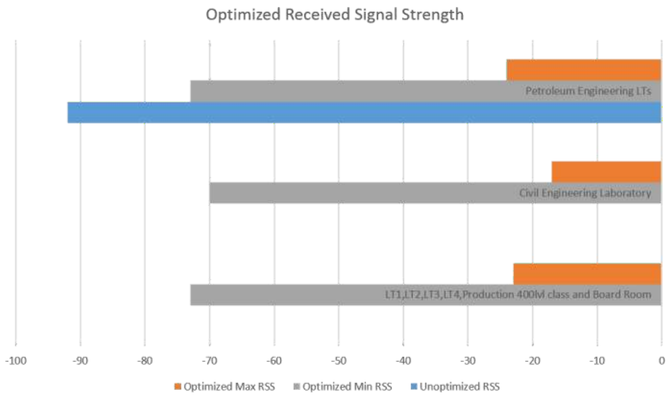

Fig 2.1. A chart showing the optimized model.

5.RECOMMENDATION

This project was carried out using the faculty of engineering as a case study. For future references it is advised that the method used in optimizing the WAPs placement of Faculty of Engineering be adopted to optimize the various WAPs placement in the university.

REFERENCES

[1] K. Kagome, “Analyzing wireless network coverage at National”, 2004.

[2] F. Li, R. Lu, M. Li, H. Wu, M. Claypool, and R. Kincki, “Measuring the Queue Sizes of IEEE 802.11 Wirelessaccess points”, 2006.

[3] Y. Chapre and S. Jha, “RSSI and its analysis in a typical WLAN system”, 1998.

[4] G. Adekunle, B. Aladeyelu, “Image Classification of Automobile using Deep Learning in TensorFlow”, Journal of Multidisciplinary Engineering Science and Technology (JMEST), Vol. 10 Issue 3, ISSN: 15818-15822, March2023.

[5] K Ogunjemilua, J. N. Davis, V Grout, and R. Picking, “An Ivestigation into Signal Strength of Wireless Access Point”, 1995.

[6] M. Travere, “Analysis of wireless signal strength at different distances”, 2001.

[7] G. Adekunle, “Automating data retention from a website using an application programming interface”, Journal of Multidisciplinary Engineering Science and Research (JMESR), Vol. 2 Issue 5, ISSN: 220-226, May 2023.

[8] H. F. Mohsin, K. A. Kadhim, Z. N. Khudhier “Study and performance analysis of received signal strength indicator (RSSI) in wireless communication systems”, IJET, 6 (4) (2017) 195-200.

[9] K. Kaemarungsi and P. Krishnamurthy, “Analysis of WLAN’s received signal strength indication for indoor location fingerprinting”, Pervasive and Mobile Computing, vol. 8, issue 2, April 2012. Pages 292-316.

[10] B. Alathari, M. R. Radi, F. Kadhim, N. S. Ali, and Z. A.

A. Alyasseri, “An Optimization for Access Point Placement in Indoor Communication”, Proceedings of the 9th Internatuinal Conference on Computational Science and Technology Conference paper. Pp 615-629, 2022.