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Coverage and Data Rate Analysis of Indoor Positioning System Using Ekahuartls.

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ABSTRACT: *There has been tremendous successes in detection for devices or peoplein a given spaceusing the GPS technology or radio frequency (RF) systems. This is widely experienced in GSM location service, navigational services,mapping and GPS location tracking. Unfortunately, research shows that theGPS and RF technologies fail in interior spaces due to lack of visual contact with the GPS satellites and the effects of RF signal degradation in indoor deployments. As the result of this, there is need for theIndoor Positioning System (IPS) to utiliseother positioning methods.In this paper, coverage potential of an indoor positioning system based on Ekahau's Real Time Location System (RTLS) is investigated and analysed. The experiments were conducted on selected test beds with their corresponding maps calibrated with the Ekahau site survey application. The experimental results demonstrated howthe environmental test characteristics affected some research metrics such as data rate and location coverage.The coverage analysis showed worst results in areas of high electromagnetic interferences such as laboratories and equipment rooms and a high signal loss on areas with no walkthrough due to wall penetration losses.*

KEYWORDS: *Access Points (APs), Ekahau, Wi-Fi, Ekahau site survey, positioning engine.*

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I. INTRODUCTION

The growth of wireless networking has generated commercial and research interests in real-timetracking methods of people or objects. Research has proven that the Global Position System (GPS) fails in identifying or tracking objects in some scenarios. These include; inside stores, hospitals, warehouses, and factories. In such scenario where the GPS fails, the Indoor Positioning Systems (IPS) appears to be the option. The IPS provides location estimates for wireless devices suchas laptopcomputers,handhelddevices,andelectronicbadges.The proliferation of "Wi-Fi" (IEEE802.11b) wireless Internet access in cafes, college campuses, airports, hotels, and homes has generated particular interest in indoor positioning systems that utilize physical attributes of Wi-Fi signals [1]. Typical applications include tracking equipment and personnel in hospitals, providing location specific information in supermarkets, museums, and libraries, and location-based access control [2]. In the last few years, there have been global attention and research on positioning techniques and technologies capable of indoors and outdoors location.Particularly, real-time positioning systems have generated strong attention given the high impact they might have on the broad spectrum of applications where ubiquitous information and services are predominant.

The GPS is one of the most common and accepted technologies for outdoor positioning. Nevertheless, for indoors, GPS technology becomes infertile given its highly degraded or blocked satellite signal inside of buildings [3]. GPS receivers need to 'see' at least three (3) satellites which are relatively well distributed in the sky to calculate its 2D position. Hence in environments where the sky is blocked, positioning becomes difficult and in most cases, impossible. This setback of the GPS has given Wi-Fi positioning much attentionas itseems to have to be effective in indoor positioning where the GPS fails.

IPS are increasingly becoming part of our daily lives, in communication networks, they enable mobile devices determine their positions and make such positioning data available for position-based services such as navigating, tracking and monitoring thereby improving the performance of wireless network for network planning, network adaptation and load balancing. Position-based indoor tracking systems have also been used in hospitals, where expensive equipment needs to be tracked to avoid theft, and the patients can get guidance to efficiently use the limited medical resources inside complex environments of the hospitals. Indoor navigation systems are also needed in a large public area to provide position indications for the users. For example, tourists need indoor navigation services in some large museums to see the artefacts in different places in sequence. In addition, position information brings benefits to self-organization and self-formation of ad hoc networks in communications systems.

An IPS consists of a number of elements. These include location sensing module, positioning algorithm module and display module. The location sensing module receives the Radio Frequency(RF) signal from the device, extracts the location metrics such asAngle of Arrival(AOA), Time of Arrival(TOA), Received Signal Strength(RSS), etc. from the indoor propagation channel and passes it to the positioning algorithm module. With a certain accuracy, the positioning algorithm block produces the (x, y, z) location co-ordinates using the parameters fed into it. The algorithm receives the measured metrics from the indoor channel with a certain error and tries to improve the positioning accuracy. The display module simply presents the calculated location of the object to the user through a Graphical User Interface [4] as depicted in Figure 1.1.

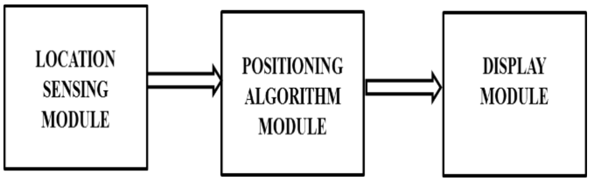

Figure 1.1: A functional block of an Indoor Positioning System

II. IPS TECHNOLOGIES

IPS technologies have evolved over the last two decades and a lot of achievements recorded, full implementations of some of the developed technologies are now available in the market.

Indoor positioning technologies have been classified using threecriterions in [5] namely; (1) the kinds of signals deployed, (2) the use of internally embedded information, and (3) depending on if the mobile devices or tags are active or passive devices in the localization effort. In the first criterion, the authors looked at possible types of signals that can be used in the localization of an object to include radio frequency (RF), example Wi-Fi, Bluetooth [6], [7] and Zigbee [8],light [9], sound [10] and magnetic field [11]. In the second criteria, they classified the IPS based on the activity of the mobile devices, if they generate signals, they are said to be active [12] otherwise they are inactive if they only receive the signals. The third criteria take into consideration the information content of the transmitted signal used for location, if it contains intentionally added pattern which is generated at the source and reconstructed at the receiving end. All of these classes support many applications, for example Wi-Fi, Bluetooth and Zigbee are widely used in the healthcare industry [13], [14], [15] with a recorded accuracy of about 1 meter [16]. The ultrawideband technology deploys the method called triangulation to estimate the distances between static anchors and the mobile nodes byanalysing the signal traveling time [17], [18]. This work concentrated on the evaluation of the Ekahua IPS systems coverage and received data rates when deployed in environments with different electromagnetic interferences, manmade noise and human traffic.

III. RESEARCH METHODOLOGY

3.1 Experiment Setup and Test-bed

The method deployed in the research was based on the components of Ekahua RTLS as depicted in Figure 3.1.

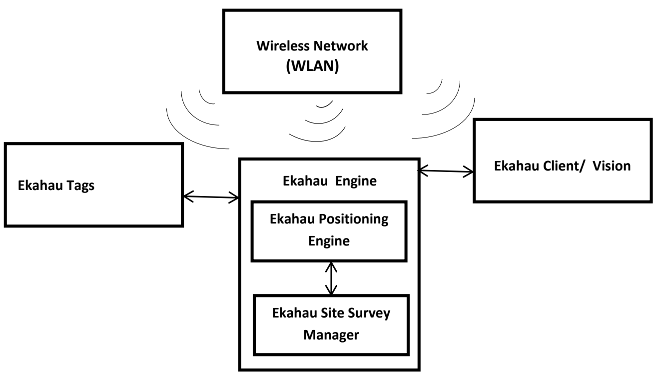

Figure 3.1: The Block Diagram of Ekahau RTLS System [19]

The design of the various units of the Ekahau RTLS was based on the components and wireless LAN requirements of the Ekahau Kits, as shown in Figure 2.1. The planning, implementation and controls of the system was within the Ekahua Engine while the tags are devices used in remote detection and of which sends the received signal strength indication (RSSI) information to the Engine over the Wi-Fi network. Ekahua client are software installed on PCs and PDAs.

3.2Test Beds

The test beds selected for this work included the First Floor Lecture Hall 3 (FL3), Computer Laboratory and the Engineering Workshop; all located within the permanent site of the University of Uyo in Akwa Ibom state of Nigeria. The test beds were selected to provide environment with different sources of electromagnetic interferences (EMI) andhuman and material traffic subjecting the signals to reflection, diffraction and scattering while the other provided a clean open floor with relative separation from human generated noise.

3.2.1Site Measurementsand Characteristicsof Individual Test Beds

Measurements were carried out in three locations in the University of Uyo in Akwa Ibom State of Nigeria namely:

a. First Floor Lecture Hall 3 (FL3)

TheFL3*is 11.04 x 9.01* m^2 in size using a scale of 1:100. It also consisted of sources of EMI such as 8 ceiling fans and fluorescent bulbs, it has less human traffic and as such less associated acoustic noise and not close to machine populated areas.

b. Computer Laboratory

The Computer Laboratoryis of size: *14.39 x 10.70* $m^2$when adopting the same scale of 1:100, it has 6 No ceiling fans and fluorescent bulbs, inverters, Computer systems, monitors (CRTs), and Voltage Regulators. Apart from the computers and its accessories, it is relatively far from heavy machines workshop and well separated from dense human traffic areas, except for students carrying undergoing practical.

c. *Workshop*

The Engineering Workshopsize is 20.45 x 13.02 m^2 on a scale of 1:100. It is loaded with EMI sources like Lathe machines, heavy wattage bulbs, Guillotine Shear machine, Drilling machine, Welding machines, Power Inverters, Metallic Vices, Iron-benders and other machineries. It is the most populated machine area in the campus although has limited human traffic therefore characterized by machine generated industrial noise, human traffic is experienced only when there is a practical session.

3.3 Equipment and their Set-up procedure for Ekahua RTLS

According to [5], the process used in setting up the Ekahau RTLS consists of the following steps:

1 Set up of the Cisco Access Point
2 Set up of the Cisco 2950 Switch
3 Configuration of virtual LAN
4 Assignment of IP addresses to constituent devices
5 Activation and association of the tags
6 Conduction ofsite survey and calibration

In order to investigate how the RTLS tags communicated with the Ekahau Positioning Engine (EPE), the tags were assigned static IP addresses so they can be tracked and their protocols of operation sniffed with the use of Omnipeek Wild Packet Software using ideas gotten from [20]. Determining the performance and accuracy of the tag required that random locations be sampled for analysis with two different calibrations made to investigate the effect of a poorly calibratedmap, the results of the investigation is as reported in section 4.

IV. RESULT PRESENTATION

4.1 Data Rate Analysis Report

The Site MAPs were imported into the Ekahausite survey application and scaled to match the physical dimensions of the site. The scaled Site Maps were calibrated and site survey metrics were obtained and analyzed. The site survey metrics such as data rate and location coverage captured for each test bed were analyzed as shown.

4.1.1 FL3 Test Bed

Figure 4.1 gives the data rate of FL3 with all portions on the map indicating a green legend depicting that the test bed’s data rate was strong and approaches 150Mb/s.

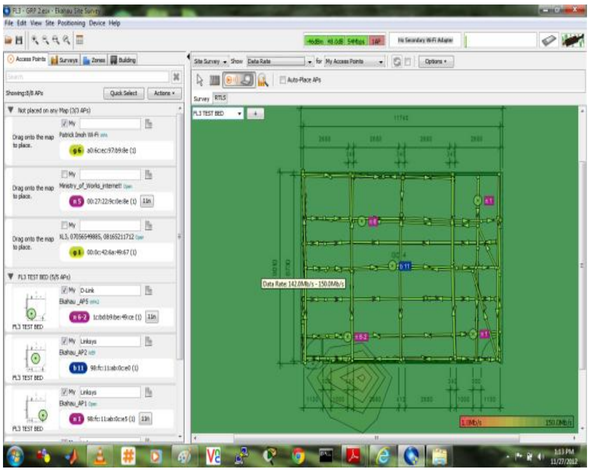

Figure 4.1: Data Rate – FL3

3.1.2Computer Laboratory Test Bed

The signal strength for the computer lab was similar to that of FL3 as shown in Figure 4.2 with data rate approaching 150Mb/s everywhere within the tested field.

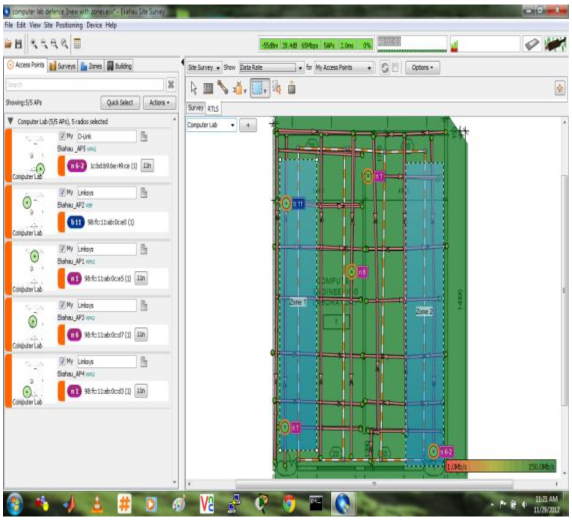

Figure 4.2: Data rate – Computer Laboratory

4.1.3 Workshop – Data Rate

Figure 4.3 shows the data rate in the measured area of the workshop and unlike the other test beds of FL3 and Computer laboratory, not all portions of the map indicated good data rates as some parts on the map are yellowish indicating low data rate. This could be as a result of high EMI interference experienced in and around the workshop and obstructions to signals by heavy machines and the no walkthrough areas which constitute blockages to the signal. It was also noticed that the interferences in repeated scenario showed increase when students were actively operating the machines.

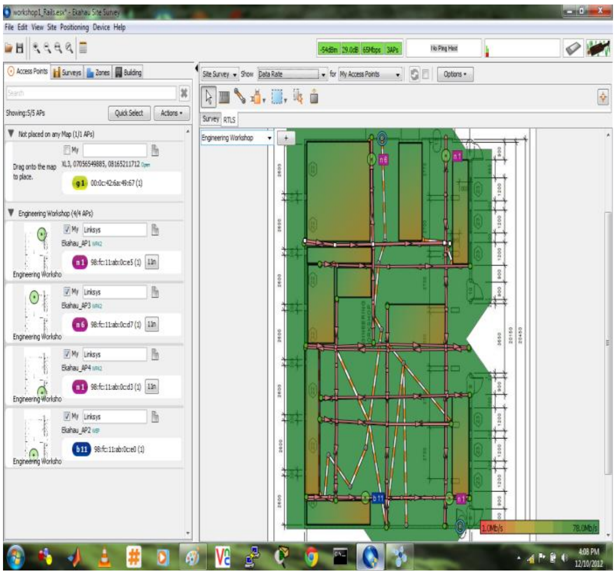

Figure 4.3: Data Rate – Workshop

4.2 Location Coverage Analysis Report

To properly analyze the best position for devices such as the APs (Access Points) for maximum and rationalized coverage distance, we carried out the location coverage analysis to determine the reachof the network. Figure 4.4 presents the coverage map of FL3.

4.2.1 FL3 – Location Coverage

All portions on the map in Figure 4.4 indicated good coverage of between -63dBm and -75dBm when considering APs 1 or 2 respectively. Bad coverage was seen outside the test bed region indicating the need for proper network planning to ascertain best radio locations for the transceivers if coverage must cover the outside region, from the legend, the map indicates good location coverage.

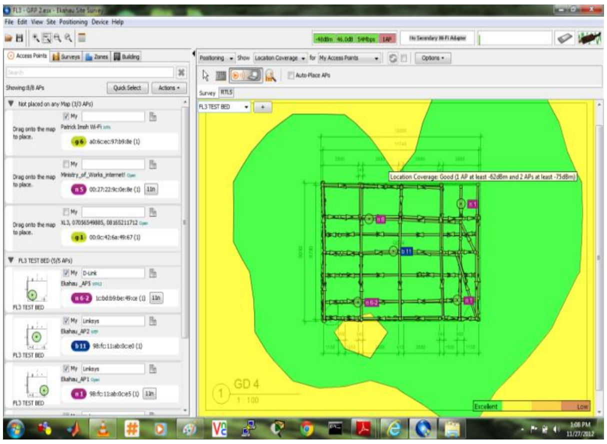

Figure 4.4: FL3 – Coverage Map

4.2.2 Computer Laboratory – Location Coverage

The entire map of Figure 4.5 depicting the coverage of the computer laboratory also indicated green coloration similar to FL3 test bed and from the legend; the test bed's location coverage was excellent.

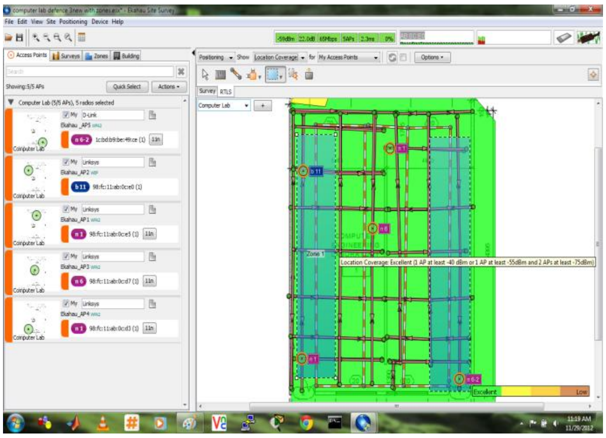

Figure4.5: Location Coverage – Computer Laboratory

4.2.3 Workshop – Location Coverage

In Figure 4.6 not all portions on the map indicated good signal strength. Some are green while more portions were yellowish. The green fields interpret excellent location coverage while the yellow fields interpret fair location coverage. There existed a gradient from yellow to light-brown in some areas which indicated a poor coverage within the workshop.

It can be observed that the yellow portions are machine areas, restricted portions and no walkthroughs areas of the workshop, and these regions exhibit more EMI than other regions.

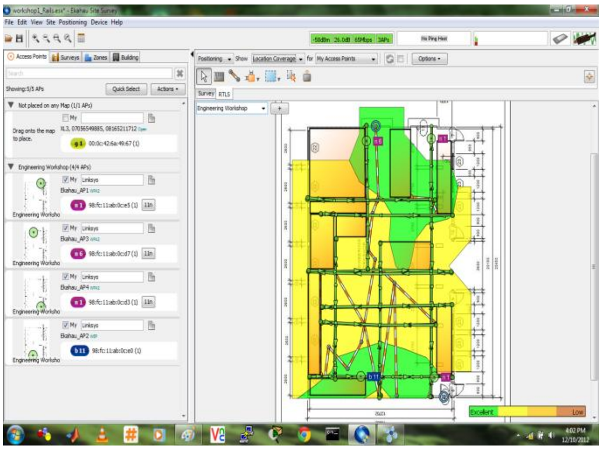

Figure 4.6: Location Coverage – Workshop

V. CONCLUSION

Indoor positioning system based on Ekahau Real Time Location System (RTLS) was developed to track the location of assets and people in selected test environments (test beds) within the permanent site of University of Uyo. The different test beds presented different characteristics that affected their survey metrics such as data rate and location coverage. It is evidenced,from the measurements that heavy machineries, walls and EMI sources posed signal degradation effects to the IPS system. It is therefore recommended that deployments of IPS systems should follow a detail site plan to ascertain best placement of the APs to enhance coverage. The reliability of the service in heavily machined areas will depend considerably on the positioning of the devices to ensure strong signals receptions when the machines are operational.

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