Journal of Multidisciplinary Engineering Science Studies (JMESS)
ISSN: 2458-925X
Vol. 5 Issue 9, September - 2019

Application Of Ekahau Real Time Location Software For The Calibration Of Test Beds For Wireless Network-Base Asset Location Management System

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Abstract **In this paper, empirical research is conducted for the application of wireless network in real-time indoor asset location management system. Particularly, the aspect of the work presented in this paper entails setting up of Ekahau real-time location system (ERTLS), conducting site survey on selected test beds in the Faculty of Engineering located at the main campus of University of Uyo and calibrating the selected test beds with the Ekahau ERTLS for application in a wireless network-based real-time indoor asset location management system. The selected test beds in the Faculty of Engineering includes the FL3 classroom, the Computer Engineering laboratory, and the Engineering workshop. The site survey and calibration results show that the FL3 classroom and the Computer Engineering laboratory have very good calibration quality, signal strength, location coverage and data rate in almost all the surveyed areas whereas the Engineering workshop has poor results in some areas due to high electro-magnetic interference (EMI) present at various sections of the workshop. Specifically, the signal strength value for the FL3 classroom and the Computer Engineering laboratory is about -20dBm which is very good but that of the workshop test bed fall within -40dBm and -55dBm which is a fair value. Also, the data rate in the FL3 classroom and the Computer Engineering laboratory tends towards 150Mb/s which is a high data rate but that of the workshop test bed fall significantly below the value of 150Mb/s. In all, the site survey and calibration results show that the different test beds presented different characteristics that affected their survey metrics.**

Keywords— Keyword Ekahau; real-time location system; calibration quality; signal strength; test bed; site survey

I. Introduction

The advent of different technologies such as wireless networks, internet, geographical information systems (GIS) and global positioning systems (GPS), have introduced a new type of information technology called location based service (LBS) [1,2,3,4,5]. Location based service (LBS) is defined as the ability to locate a mobile user geographically and deliver services to the user based on his location [6,7,8,9,10]. Also, location based services can be defined as services that integrate a mobile device's location or position with other information so as to provide added value to a user [11,12,13,14].

An Indoor Location System (ILS) is a term that describes a technology that locates, monitors and tracks assets and people using various positioning algorithms [15,16,17]. Ideally, such technologies do these in real time[18]. A location system determines the location of an object (client) in a particular space, such as an enterprise facility or warehouse. Positioning technologies realize a number of location-aware solutions through the coordinates of an object. They are able to determine positions in real time. Hence, location technologies are also referred to as time location system (RTLS).In terms of implementation, there are generally two approaches for the indoor location system implementation [19].The first approach is to develop a signaling system and a network infrastructure of location sensors focused primarily on location application [19]. The second is to use an existing wireless network infrastructure such as a WLAN to locate devices [19]. The first approach has the positioning system designed from scratch. The focus is on detecting the first path, and all the system architecture building blocks are designed accordingly. For the second approach, the use of the network infrastructure in indoor positioning is also feasible, but more complex algorithms are needed in order to compensate for overall design.

For any RTLS to be applied in asset location management system, the region where the asset is to be located and monitored must be surveyed and calibrated using appropriate software system and allied devices. One of such software system is the Ekahau time location system (RTLS) [20,21,22]. In this paper, the Ekahau RTLS software is used to survey and calibrate selected test beds for deployment of wireless network-base asset location management system. The survey and calibration results are expressed in the following metrics: asset calibration quality, signal strength indicator (RSSI), location coverage and data rate. The case study sites are located in the Faculty of Engineering of university of Uyo and they include the FL3 classroom, the Computer Engineering laboratory, and the Engineering workshop. The details of the Ekahau RTLS software, the survey and calibration procedure as well as the survey and calibration results for the selected test beds are presented in this paper.

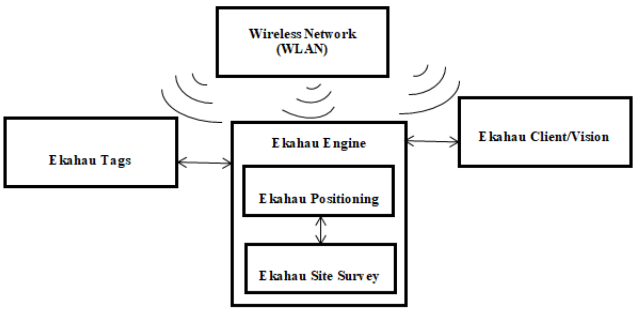

Figure1: Block diagram of the Ekahau RTLS

The WLAN infrastructure that is required for the Ekahau system to operate consists of the following items:

i. **Server** (a computer system).
ii. **Cables** such as the Ethernet CAT-5 cables, power cables, etc.
iii. **Wireless Adapter** such as the Dlink's wireless N-150 USB adapter).
iv. **Access points (Aps)** such as the Linksys WAP610N.

II. Overview of Ekahau Real-Time Location System (ERTLS)

Ekahau real time location system (RTLS) software system is a technology that enables automated monitoring of asset or personnel location in real time. Ekahau RTLS system relies on standard 802.11 a/b/g wireless networks and it employs Wi-Fi access points' signal strength measurements for the tracking the asset or personnel location[23]. Since it can utilize existing wireless network infrastructure which makes it more cost effective to deploy where wireless network is already in use. Besides, the deployment of Ekahau RTLS does not interrupt network activities. The basic structure of the Ekahau RTLS is made up of the various components, as shown in Figure 1.The Ekahau RTLS configuration is based on the wireless local area network (WLAN) components along with the Ekahau kits, as shown in Figure 2.

The Ekahau kit comprise of software and hardware components. The software components comprises of the following items:

i. **Ekahau Positioning Engine (EPE)**:
ii. **Tag Activator**
iii. **License File**
iv. **Ekahau Site Survey (ESS)**:
v. **Ekahau Vision**: Ekahau proprietary web application for assets location monitoring

The Ekahau kit hardware components are as follows:

i. Network Interface Card**(NIC)-300**
ii. **Tags**: The two tags used in this project work are Ekahau T301-A and T301-B as shown in Figure 3.

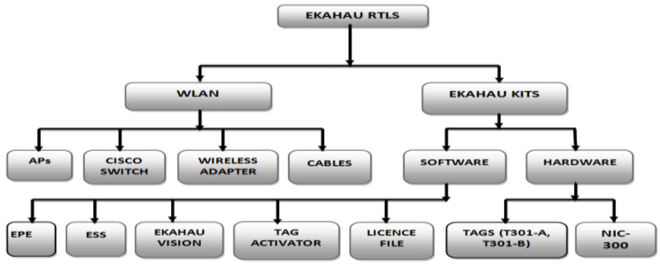

Figure2: Components of the Ekahau kit and the WLAN[23]

Figure 3: Tags

III. METHODOLOGY

A. THE STEPS FOR SETTING UP THE EKAHAU RTLS FOR THE CALIBRATION OF THE TEST BEDS TO BE USED IN AN ASSET LOCATION MANAGEMENT SYSTEM

The following steps were followed in setting up the Ekahau RTLS:

i. Draw the test bed map to scale.
ii. Setting up a WLAN with static IP addresses assigned to the APs.
iii. Upload the test bed map to Ekahau site survey kit.
iv. Scale the uploaded map to become radio map.
v. Conduct site survey and calibration.
vi. Obtain and interpret the survey metrics for the best site calibration.

B. THE CASE STUDY TEST BEDSMEASUREMENTS AND CHARACTERISTICS

The cases study test environments (referred to as test beds) are the sites where the Ekahau RTLS was implemented. The test beds selected for the study is located in the Faculty of Engineering at the main campus of University of Uyo and they include; the FL3 classroom, Computer Engineering laboratory, and the Engineering workshop. The site measurements and floor plan for each of the test beds are presented in Figures 4, Figures 5 and Figures 6.

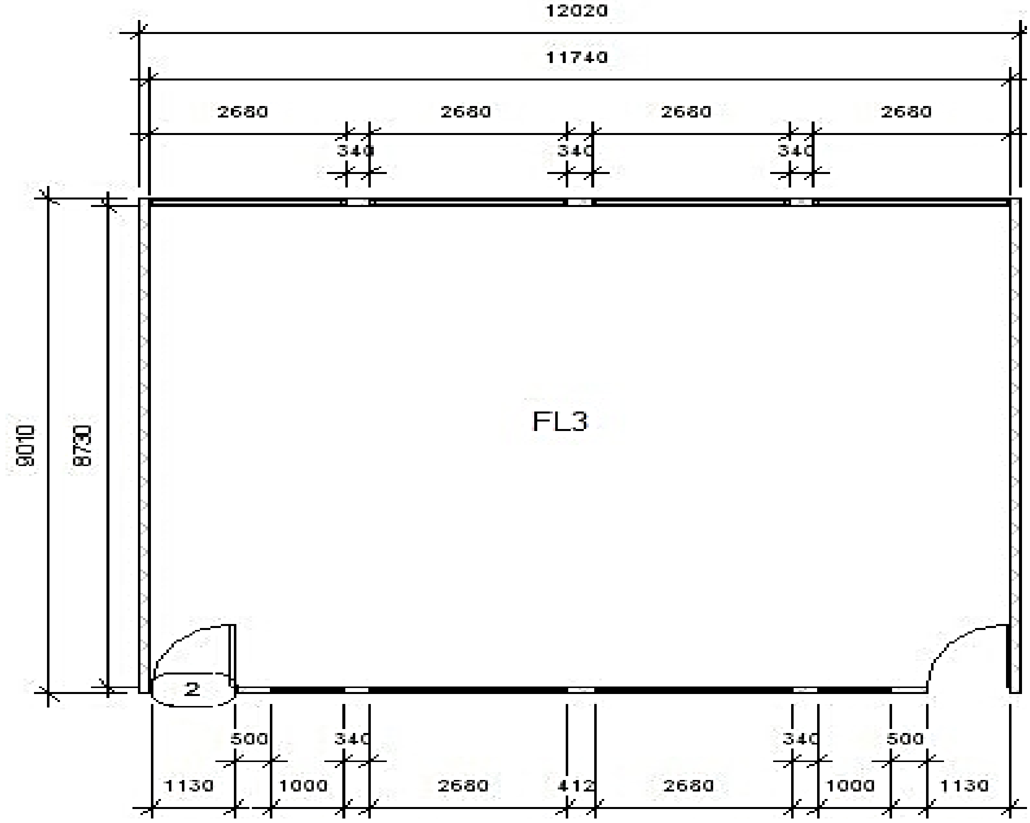

Figure 4: Site measurements for FL3 classroom with dimension of 11.04 x 9.01 m^2 drawn at a scale of 1:100

The FL3 classroom characteristics are as follows:

i. Sources of electro-magnetic interference (EMI): 8 ceiling fans, fluorescent bulbs.
ii. It is not too close to the densely populated machine area (workshop).
iii. Top floor of the popular Campus GD/FL block, therefore it has less movement of people when compared to the ground floor.

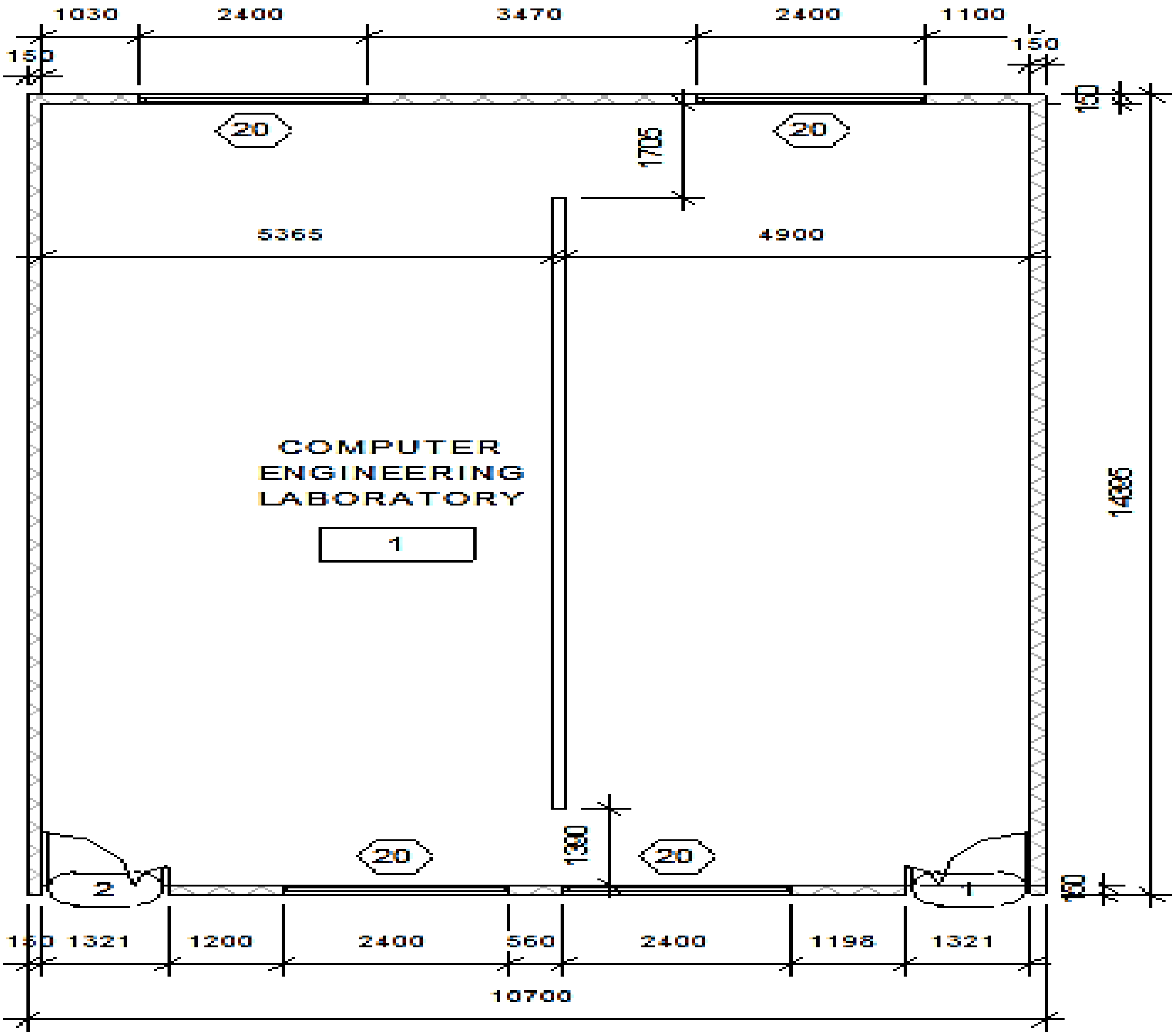

Figure 5: Site Measurements for Computer Laboratory with dimension of *14.39 x 10.70* m^2 drawn at a scale of 1:100

The computer laboratory characteristics are as follows:

i. Sources of EMI: 6 ceiling fans, fluorescent bulbs, inverters, computer monitors, voltage regulators.
ii. Relatively far from the densely populated machine area (workshop). It is separated from the main lecture halls. The laboratory is only used for practical purposes; this means there will be lesser movement of people when compared to the lecture hall area.

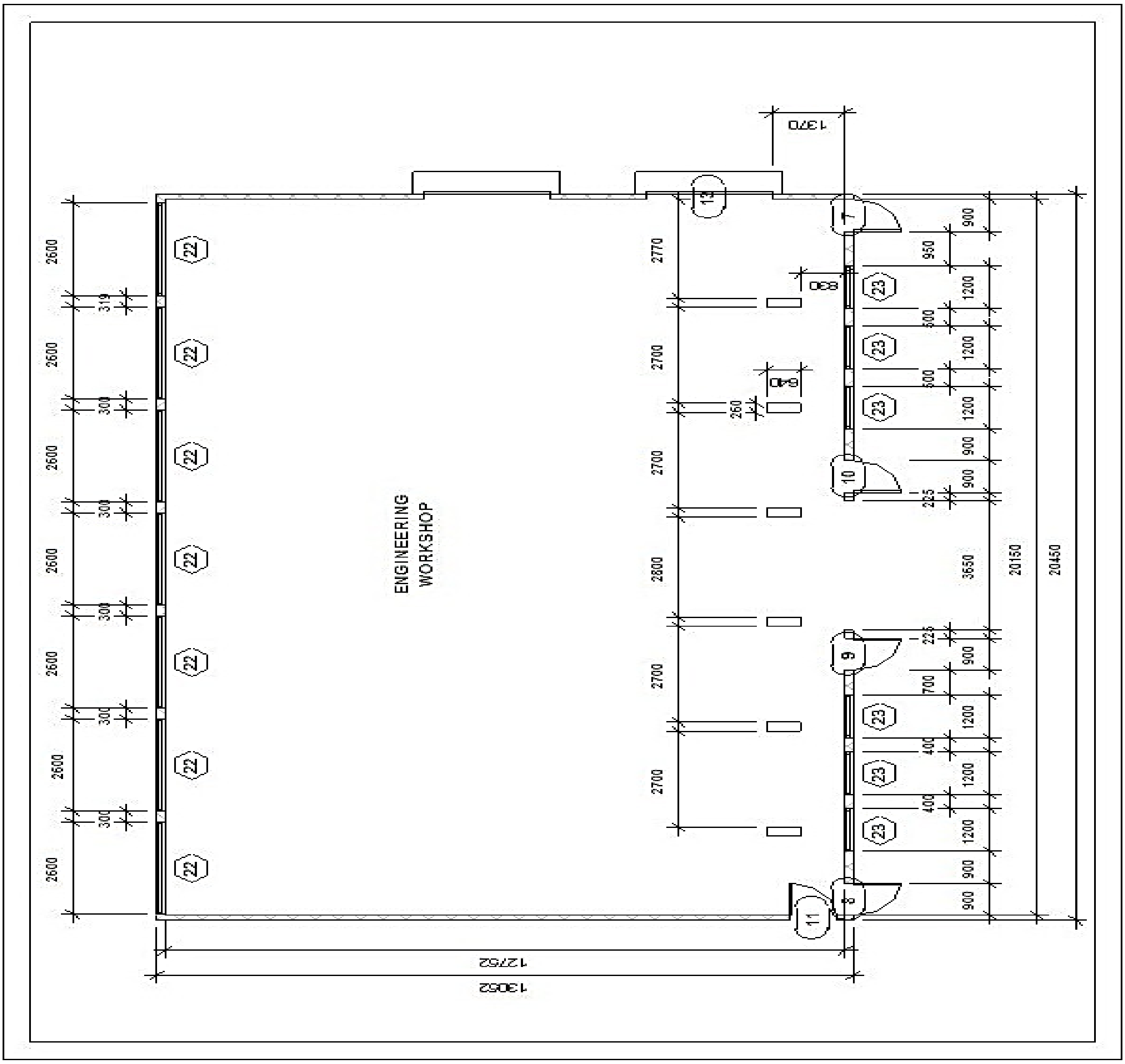

Figure6: Site measurements for Engineering Workshop with dimension of20.45 x 13.02 m^2 drawn at a scale of 1:100

The Engineering Workshop site characteristics are as follows:

i. Sources of EMI: lathe machines, heavy wattage bulbs, guillotine shear machine, drilling machine, welding machines, power inverters, metallic vices, iron benders.

ii. The most-populated machine area on campus.

C. SETTING UP OF THE WLAN WITH STATIC IP ADDRESSES ASSIGNED TO THE APS.

Linksys access point WAP610N was used in the WLAN; it has a dual band access point (AP) that is compatible with 802.11a/b/g/n radios. Configuration on the Linksys access point WAP610N was done using the graphical user interface (GUI) through the web application on local host, as shown in Figure 7.

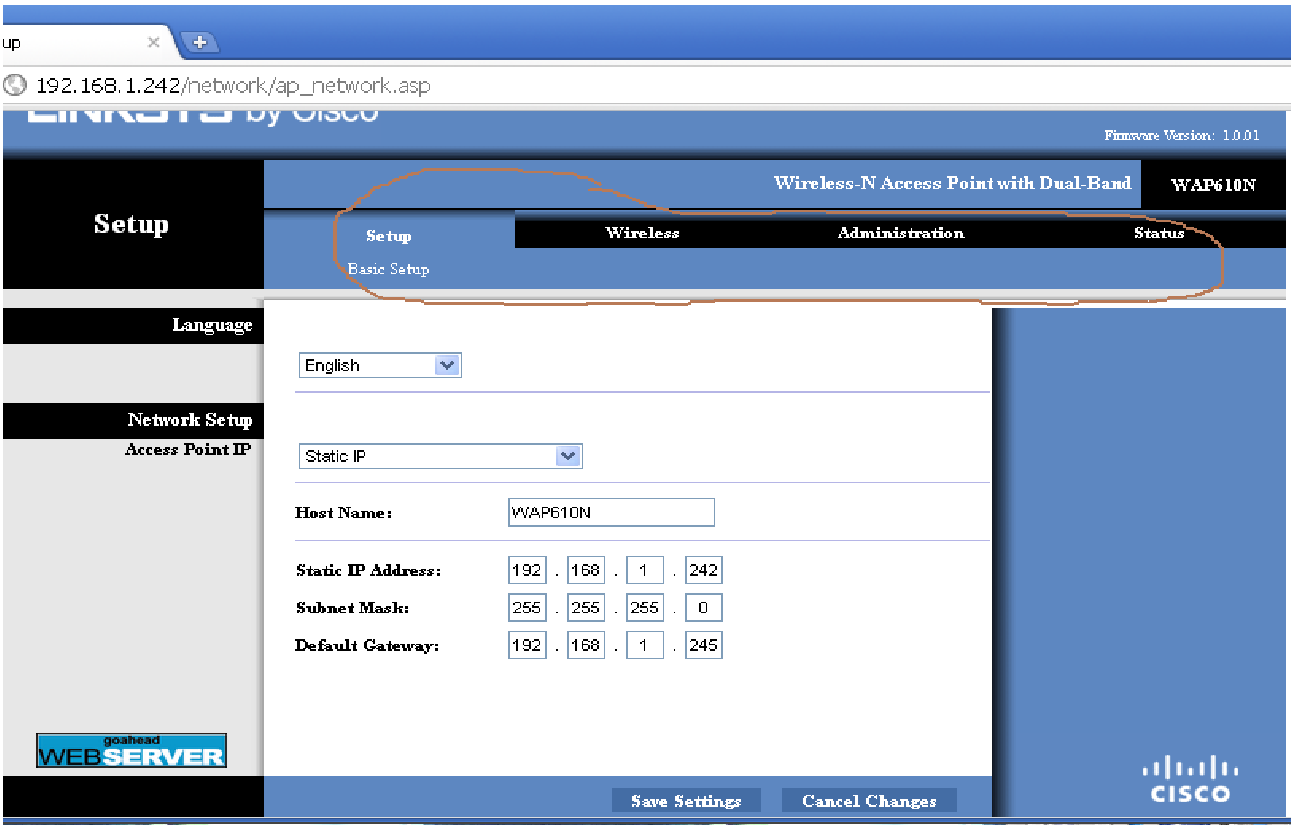

Figure 7: Access point configuration

Notably, IP address class C with subnet 255.255.255.0 were used for the tags, the access points and the computers used in the network. The IP address assigned to each device are as follows:

a) Network Segment Used

192.168.10.[host] Subnet: 255.255.255.0 (/24 in slash notation)

b) Tags: 192.168.10.100 - 192.168.10.105 Subnet: 255.255.255.0

<u>APs (Access Points)</u>: *IP Address and Subnet*

i. Ekahau_AP1
192.168.10.240 255.255.255.0

ii. Ekahau_AP2
192.168.10.241 255.255.255.0

iii. Ekahau_AP3
192.168.10.242 255.255.255.0

iv. Ekahau_AP4
192.168.10.243 255.255.255.0

v. Ekahau_AP5
192.168.10.244 255.255.255.0

c) Ekahau Positioning Engine:

192.168.10.24 Subnet: 255.255.255.0

d) Ekahau Site Survey (Laptop):

i. LAN : 192.168.10.13
Subnet: 255.255.255.0

ii. WAN : 192.168.10.15
Subnet: 255.255.255.0

[Dlink Wireless Network Card was used for Sniffing with Omnipeek Software]

D. ACTIVATION OF THE TAGS AND IMPLEMENTATION OF THE EKAHAU SITE SURVEY

The tags are miniature electronic devices that send the received RSSI information over the Wi-Fi network to the EPE. The tags are assigned IP addresses for identification on the network. The tags used for the work are Ekahau T301-A and T301-B tags. For the T301-A Tag, the media access control (MAC) address is located above the identification sticker as shown in Figure 8 whereas for the T301-B tag, the MAC address can be found behind the tag.

Figure 8: T301-A Tag overview

The tags were activated using the Ekahaus software tab activation module. The screenshot of tag activator dialogue box (shown in Figure 9) is from Ekahau's software application designed to manage tag activation process.

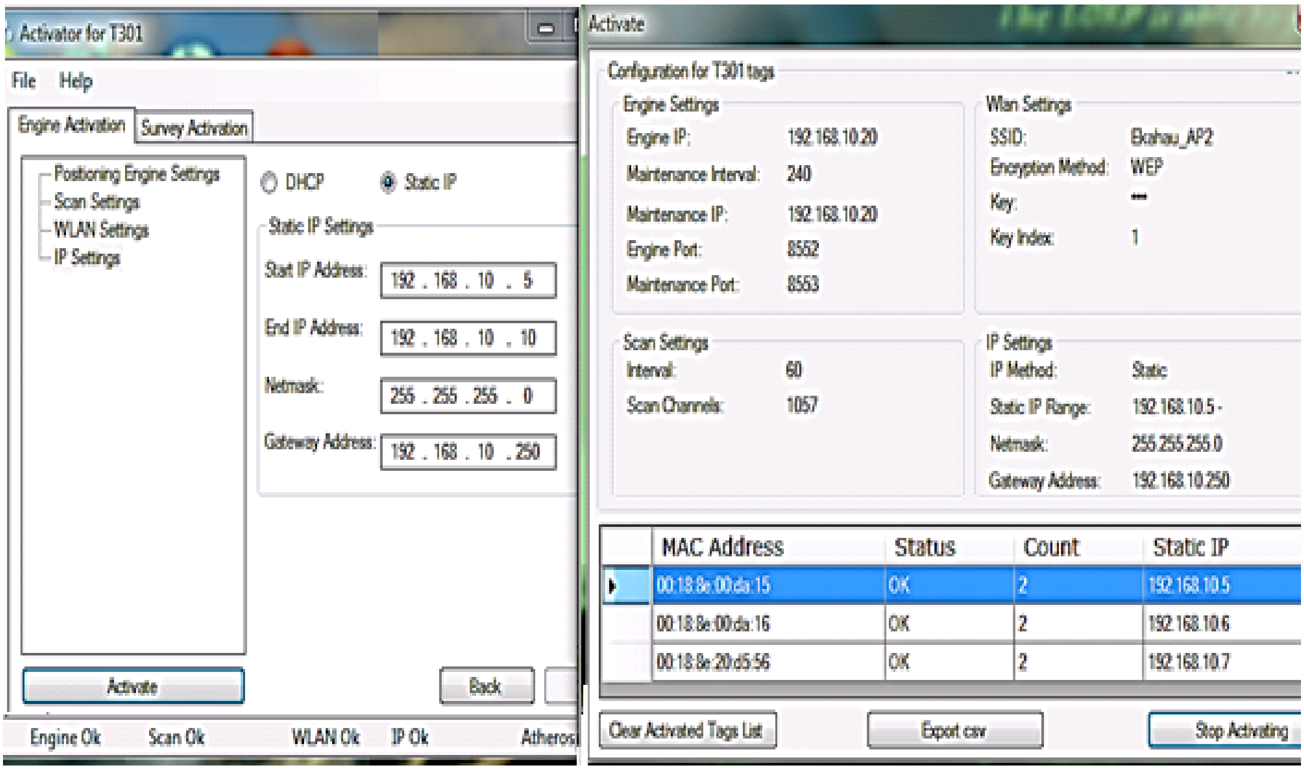

Figure9: The screenshot of Ekahau's tag activator dialogue box

After the WLAN was set up , the tags were activated in the Ekahau real-time location system (ERTLS), then , the site survey was conducted to calibrate the locations within each of the test beds. Site survey was conducted as follows:

i. The site maps were imported into the Ekahau site survey (EPE) application
ii. The site maps were then scaled on the application
iii. Calibration was carried out and site survey metrics were obtained and analysed.

The site survey metrics captured include calibration quality, signal strength, data rate and location coverage. The site survey results are presented in the next section.

IV. RESULTSAND DISCUSSION

A. SITE SURVEY AND CALIBRATION RESULTS: CALIBRATION QUALITY ANALYSIS

A good calibration will result into proper location of the tag to a high precision on the radio map, while a poor calibration will lead to error in tag placement.

Considering the legend shown on each site map below - from low to high; the red indicates a low calibration quality, yellow indicates fair calibration while the green indicates a high calibration quality. Tags that fall within the green portion will have more location accuracy while those within the red areas will have lower location accuracy.

B. FL3 CLASSROOM– CALIBRATION QUALITY

The calibration map of the FL3 classroomis shown in Figure 10;the entire is green. This test bed is separated from the workshop which is an EMI prone area, this givesit the advantage of good calibration quality.

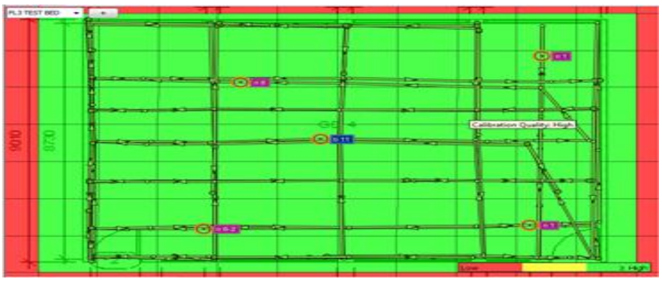

Figure10: Calibration Quality – FL3 Classroom

C. COMPUTER LABORATORY – CALIBRATION QUALITY

The calibration map of the Computer Laboratory is shown in Figure 11; Figure 11 has all area green except some few regions which means that there is very good calibration quality, particularly for the regions in green colour. On the other hand, the regions with red colour have poor calibration quality. Two zones were created because movement took place in those regions more frequently than others. The visible purple colouredlines is a result of the superimposed colours at the zones.

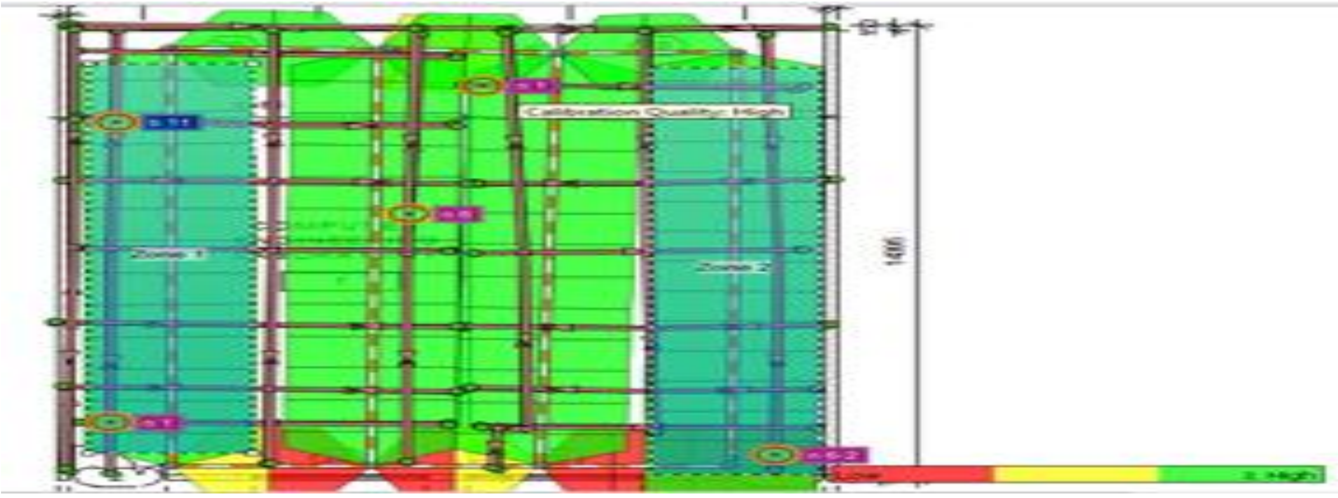

Figure11: Calibration Quality – Computer Laboratory

D. ENGINEERING WORKSHOP – CALIBRATION QUALITY

Unlike the other test beds, workshop is more prone to electro-magnetic interference (EMI) because there are so many machining processes running. Sources of EMI at the workshop include, the lathe machine, drilling machine, welding machine and cutting machine.

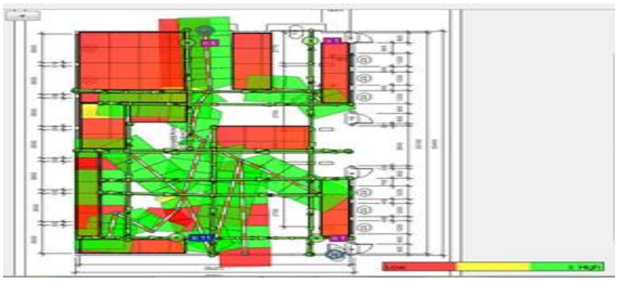

Figure 12: Calibration Quality – Engineering Workshop

The calibration map of the workshop shown in Figure 12 has many fields as red which interprets low or poor calibration quality in those areas. Most of the fields coloured red are restricted areas especially the rectangular portion (welding bay) at the top-left corner guided to prevent accidents to operators. Less movement of people takes place in those areas.

E. Site Survey and Calibration Results: Signal Strength Analysis

The signal strength metric, indicated as RSSI, is the measure of the power present in a received radio signal. Usually, the closer a device is to the network, the higher the RSSI value measured. Also the closer the value is to zero, the stronger the network strength.

F. FL3 CLASSROOM- SIGNAL STRENGTH

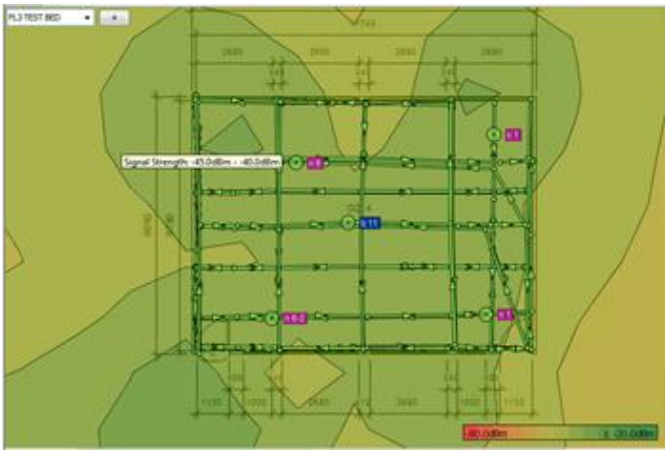

Figure 13: Signal Strength – FL3Classroom

The signal strength map of the FL3 classroom is shown in Figure 13. The map indicates considerably high signal strength as most of the regions on it appear green; the legend interprets the green colour to a value of about -20dBm.

G. COMPUTER LABORATORY - SIGNAL STRENGTH

The signal strength map of the computer laboratory is shown in Figure 14. The colours on Figure 14 appear mostly green. This indicates a strong RSSI value approaching -20dBm as interpreted on the legend.

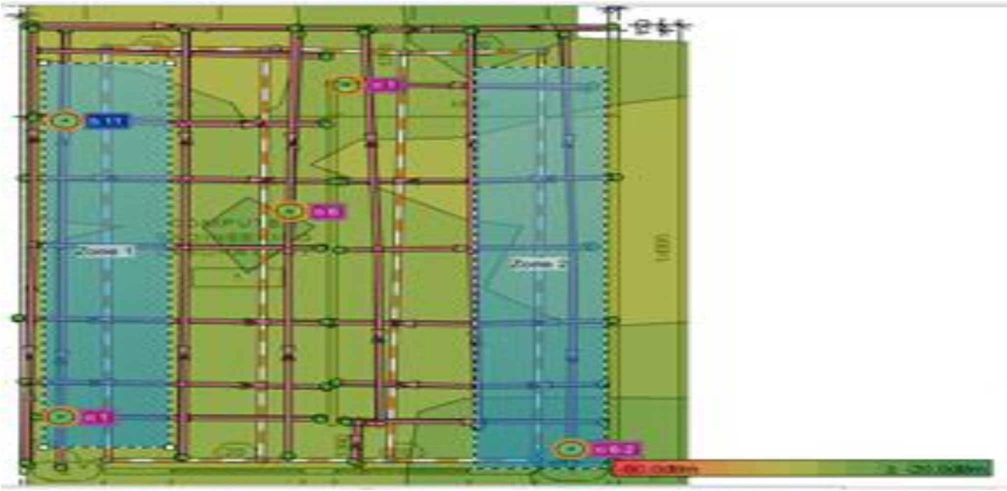

Figure 14: Signal Strength – computer Laboratory

H. ENGINEERING WORKSHOP – SIGNAL STRENGTH

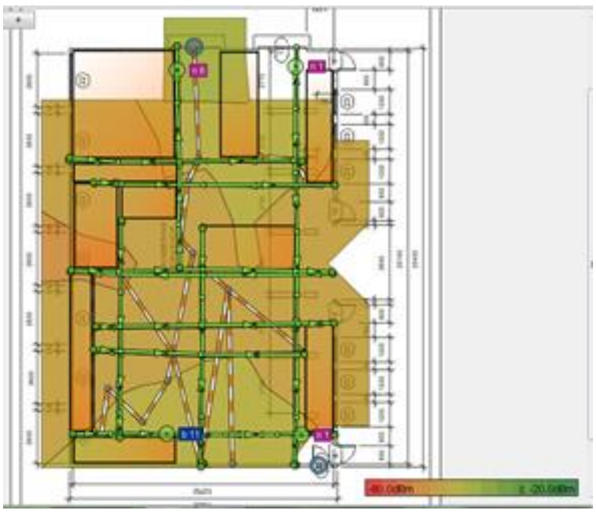

Figure 15: Signal Strength – Engineering Workshop

Unlike the signal strength map of the other test beds, Figure 15 has lesser green palettes. From the legend properties, the default setting is between -80dBm (weak) and -20dBm (strong). For the workshop, the RSSI value can be estimated on the legend to fall within -40dBm and -55dBm which is a fair value. The result is due to more EMI present within the workshop test bed.

J. SITE SURVEY AND CALIBRATION RESULTS: DATA RATE ANALYSIS

Data rate quickly gives an estimate of the achievable throughput per location.

K. FL3CLASSROOM– DATA RATE

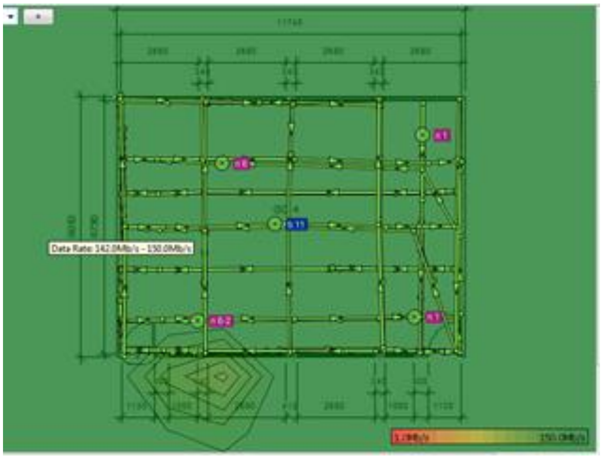

Figure 16: Data Rate –FL3Classroom

The data rate map for the FL3 classroom is shown in Figure 16. All portions on Figure 16 indicate green colour. From the Ekahau software legend properties, 150Mb/s is a high data rate. Checking the legend, the test bed's data rate strongly approaches 150Mb/s which shows that the FL3 classroom has a high data rate.

L. COMPUTER LABORATORY – DATA RATE

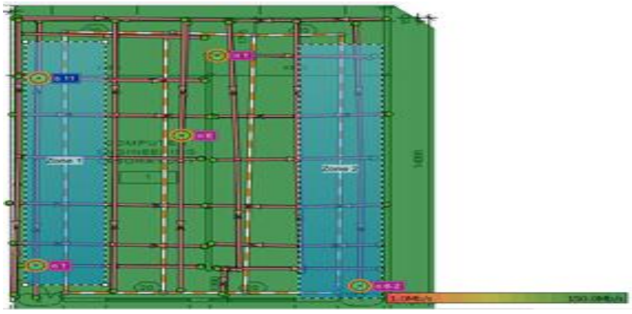

Figure 17: Data Rate – Computer Laboratory

The data rate map for the computer laboratory is shown in Figure 17. Figure 17 indicates a green. Considering the legend, the data rate strongly approaches 150Mb/s which is a good result.

M. ENGINEERING WORKSHOP – DATA RATE

Unlike the FL3 and computer engineering test beds, not all portions on the workshop map in Figure 18 indicate a green. Some parts are yellowish indicating a low data rate at such areas. The reason for this difference is due to the high EMI experienced in the workshop. It can be observed that the yellowish portions are machine areas, restricted portions and no walkthroughs areas.

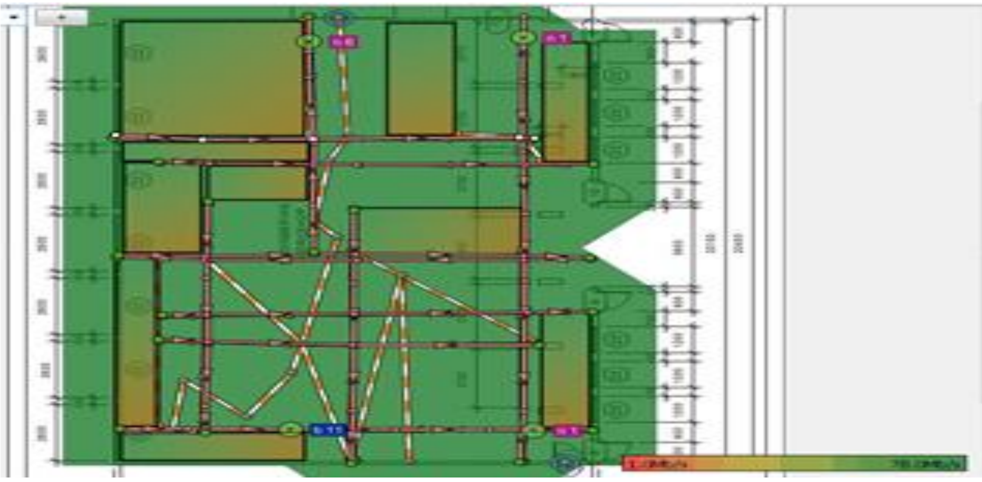

Figure18: Data Rate – Engineering workshop

N. SITE SURVEY AND CALIBRATION RESULTS: LOCATION COVERAGE ANALYSIS

The location coverage metric describes the amount of area reached by the network. It is needed in the survey to properly analyze the position of devices such as the APs for maximum coverage distance.

O. FL3 CLASSROOM– LOCATION COVERAGE

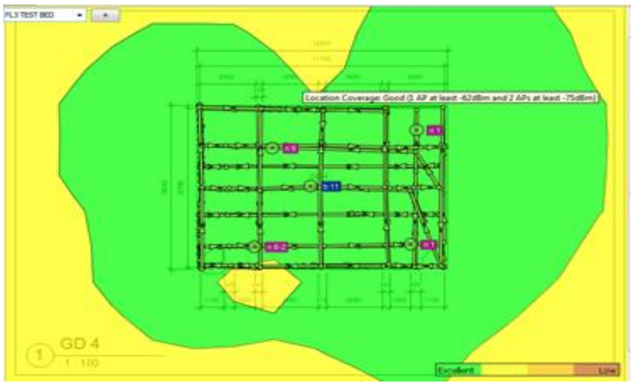

Figure19: Location coverage – FL3 classroom

The location coverage map for the FL3 classroom is shown in Figure 19. All portions on Figure 19indicate a green except outside the test bed region. Based on the Ekahau software legend, the map indicates excellent network coverage.

P. COMPUTER LABORATORY – LOCATION COVERAGE

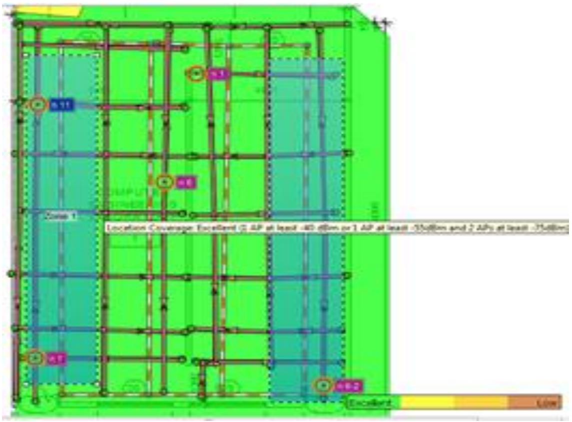

Figure20: Location coverage –Computer Laboratory

The location coverage map for the Computer Laboratory is shown in Figure 20. Figure 20 indicates a green in all the areas. According to the Ekahau software legend, the Computer Laboratory test bed's location network coverage is excellent.

Q. ENGINEERING WORKSHOP – LOCATION COVERAGE

Just as expected, due to the high EMI present in the workshop, not all portions on the map (Figure21) indicate a green. Some areas in the map are green while more portions are yellowish.

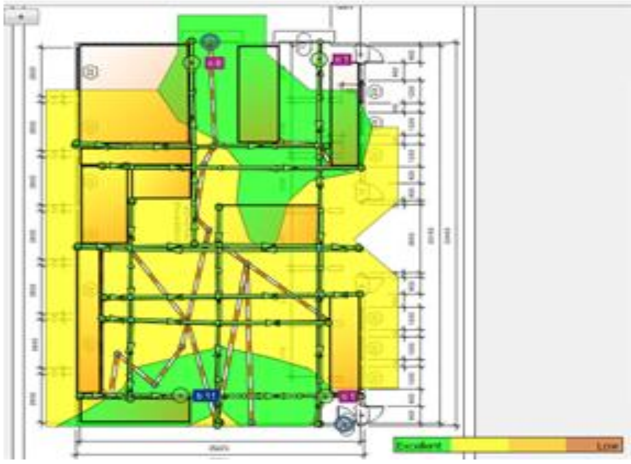

Figure 21: Location Coverage –Engineering Workshop

The green fields interpret excellent location coverage while the yellow fields interpret fair location coverage. It can also be observed that the yellow portions are machine areas, restricted portions and no walkthroughs, and these regions exhibit more EMI than others.

V. CONCLUSION

The application of Ekahau real time location system (RTLS) software and allied devices in real time asset location management system is presented. Specifically, the Ekahau real time location system RTLS software and allied devices were used to conduct site surveys on selected test beds in the Faculty of Engineering located at the main campus of University of Uyo. Furthermore, the Ekahau RTLS software was used to calibrate the test beds for use in a real time asset location management system. The different test beds presented different characteristics that affected their survey metrics; data rate, location coverage, signal strength and calibration quality.

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