Palestine Polytechnic University

Department of Electrical Engineering

Graduation Project

Characterization of the cellular coverage and congestion at Abu Rumman Campus

Project team

Renan Sweaty
Ali Brewish

Project supervisor
Dr. Murad Abusubaih

hebron-palestine
December 2014

اهداء

قال تعالى آيَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ وَاللَّهُ بِمَا تَعْمَلُونَ خَبِيرٌ آ

ولكن أليس لصاحب القلم المتعب دقيقة يتأمل فيها ما كتب ، دقيقةلن أجد اغلى من أمي وأبي لأهدي لهما مشروع تخرجي الى من أحيوا بداخلي حب العلم الى من كانوا بجانبي طوال مسيرتي التعليمية الى من كانوا المثابرة والاصرار على دعمي أمي و أبي انتما روحي لن أساويكما بأثمن حجر كنتما دوما فخرا واعتزاز و أنا هنا اليوم على أول درجات العلم وأتمنى أن أكون لكم اليوم فخرا واعتزازا ولن أكمل طريقي إلا وأنتما بجانبي يا أغلى من روحي . '\

كما وأهدي هذا المشروع الى زوجي رفيق دربي على دعمه و مساندته لي طوال دراستي الجامعية وأيضا الى ابني حبيبي مالك رفيقي الصغير.

وأهدي مشروعي أيضا الى اخوتي واخواتي أحبابي كنتم دوما سندي وعوني بعد الله وقدوة حسنة والطاقة الايجابية التي استمدها منكم.

ولن أنسى بتقديم كامل الشكر والعرفان لمن كانوا أهلا للمساعدة والدعم شركة جوال وموظفيها : المهندسة عبير امطير المهندس كريم الحساني المهندس عرفات اطميزة تستحقون جزيل الشكر والاحترام لم ترددوا للحظة بتقديم العون لنا .

كما وأشكر من كان بجانبي طوال فترة المشروع الدكتور مراد أبو صبيح...شكرا معلمي قد كنت دوما قدوة حسنة وستبقى كذلك في ذاكرتي.

رنان السويطي

اهداء

الى ينبوع العطاء الذي زرع في نفسي الطموح والمثابرة.... والدي العزيز
الى نبع الحنان الذي لا ينضب... أمي الغالية
الى من يحملون في عيونهم ذكريات طفولتي وشبابي........ اخوتي واخواتي
الى من ضاقت السطور من ذكرهم فوسعهم قلبي....... اصدقاؤنا
الى من ضحوا بحريتهم من اجل حرية غيرهم........ الاسرى والمعتقلين
الى من هم اكرم منا مكانة........ شهداء فلسطين
الى كل محبي العلم والمعرفة
الى من احتضنتني كل هذا الكم من السنين .... فلسطين الحبيبة
الى زملائي وزميلاتي في جامعة بولتكنيك فلسطين
الى كل من ساهم في انجاح هذا العمل

علي بريوش

Contents

List of Figures

ABSTRACT

Global system for mobile communications (GSM) is a digital cellular radio network that uses more advanced technology and handles more subscribers compared to the analog cellular network. This is due to the use of Time Division Multipleaccess. GSM offers high quality voice communication and low bandwidth (9.6kb/sec) data connections for fax and Short Message Service (SMS). Data connection services like browsing, multimedia and e-mail demands on mobile telephone services have increased tremendously.

Many people have subscribed to GSM services due to the outlined features and all these coupled with the increasing number of cellular users may lead to congestion on the GSM network

Coverage's a key problem for cellular providers, especially inside large buildings and underground floors. Congestion is another problem that is obvious in campuses, hotspots, and large scale enterprises.

In this project, we address the coverage and capacity problems in one large campus of Palestine Polytechnic University (PPU). This campus is located in Abu Romman. We firstly conduct drive testmeasurements and analyze the traces. Then, solutions for the observed problems will be developed and assessed.

Chapter 1

INTRODUCTION

1.1 Introduction

Global system for mobile communications (GSM) was introduced to solve the problem of capacity, high-level of interference, high power consumption, signaling, and the inefficient use of radio spectrum that were faced in the analog mobile system. It was embraced by everybody considering the advantages associated with GSM like increase in the number of simultaneous users, and clarity of voice communication. The performance of GSM has been affected due to the demand for the advanced data services like e-mail, internet browsing, multimedia that are accommodated within the technology.

The best way to acquire more subscribers and keep them satisfied is to make the service as easy to use and as reliable as possible. The need to satisfy the subscribers of wireless services and keeping them is paramount to the GSM companies. Thus, the need to tackle the problem of congestion on the GSM network as this will both be the desire of both operators and users. [1]

This research project studies ways to maintain a good, secured, uninterruptible service for users at Abu Romman PPU campus. A focus is given to the congestion and coverage problems.

1.1.1 CONGESTION

Congestion simply means 'full of traffic'. It occurs when too many things or people are seeking for use of a resource that is limited. When the congestion happened in network Leads to the occurrence the blocking in call where the blocking means unavailability of network to the subscriber at the time of making a call. It is the situation when the blocking occurs and no free path can be provided for an offered call.

1.1.2 CONGESTION ON GSM

Traffic channels congestion (TCHC): Traffic channels(TCH) represent a voice channel and each call uses TCH. There are eight channels defined for each radio frequency carrier and most are used for traffic channels and some for control channels. When there is no free voice channel (TCH), there will be traffic channels congestion (TCHC).

Dedicated control channel congestion (DCHC): Stand-alone dedicated control channel (SDCCH) is used to provide authentication to mobile station, location updating and assignments to voice channel (TCHs) during idle periods. When making a call or responding to paging message for the allocation of an SDCCH for authentication, if there is no vacant SDCCH to use at that time, the call will be terminated. This failure is called the dedicated control channel congestion.

Common control channels congestion (CCCHC): Common control channel is a group of control channels that support the establishment and maintenance of communication links between mobile stations and base stations. It consists of random access channel (RACH), paging channels (PCH) and access grant channel (AGCH).

RACH is used to make request for network assignment, PCH is used to alert the mobile station of incoming call and AGCH is used to assign mobile station to a specific DCCH or SDCCH for on ward communication. When any of these three control channels is congested, there cannot be any call establishment between the sender and receiver, then, we have CCCH congestion.

Pulse code modulation congestion (PCMC): Pulse code modulation (PCM) or E1 is the link required to connect the base station (BS) and mobile-switching center (MSC) together. Each PCM can carry between 1 and 32 calls. When there is no free PCM to carry the call signals between the BS and MSC, then we have pulse code modulation congestion. [2]

1.1.3 Capacity in a Cellular System

Capacity is a key concern in any wireless communications system. High demand for cellular services, especially in large urban markets, has created a need to serve a greater number of users in a limited amount of frequency space.

Cellular system operators are looking for new ways to fit more users into their increasingly crowded network, and many are choosing to move from the existing analog transmission technology to one of the competing digital standards. These standards are also being selected by the new PCS providers as they begin to build out their own networks. Although digital systems provide a variety of benefits.

Almost all current and proposed digital standards are based on either Time Division Multiple Access (TDMA) or Code Division Multiple Access (CDMA). These two methods are fundamentally different and incompatible with each other, but each claim to able to support anywhere from three to more than twenty times the number of simultaneous callers than the current AMPS cellular standard, which uses Frequency Division Multiple Access (FDMA). [3]

1.2 Motivation

In this project, the aim is to improve the quality of communication service provided by JAWWAL company at Abu Romman PPU campus. JAWWAL has a large number of students using their services in that area. The presence of such a large number of students at the same time and place leads to weaken the quality of communication service. Problems have been reported to Jawwal.

1.3 Objectives

- Conduct some measurements, and collect traces at Abu Romman PPU campus.
- Analyze traces and identify the coverage, quality of service, and congestion levels within the campus.
- Propose and evaluate a solution if some problems are noticed from measurements.

1.4 Related work

Several studies were produced the cellular characteristic and indoor radio propagation. For example a study was done in Palestine polytechnic university in 2010. The study focuses on indoor coverage in building B of PPU. The measurements were used to develop a loss model.

However, our research focuses on different parameters that impacts the quality of service.

1.5 Project plan

Weeks																
Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
literate review	■	■	■													
Proposal witting		■	■													
Learning software (mentor planet) And using measurement tools.				■	■	■	■									
Data analysis						■	■	■	■	■	■	■				
Drafting chapters				■	■	■	■	■	■	■	■	■				
documentation	■	■	■	■	■	■	■	■	■	■	■	■	■			

1.6 Equipment

We will use special software provided by JAWWAL company called Mentom Planet special device NEMO handy and other devices.

1.7 Methodology

We will tackle the research problem as follows: Through the measurement of a set of various parameters of the cell such as (capacity, total traffic, signal to noise ratio, received signal level, path loss, penetration loss), congestion and coverage levels will be identified. If problems are found, solutions will be developed and tested.

Chapter 2

CELLULAR NETWORK (GSM)

2.1 Introduction to cellular networks

A cellular network or mobile network is a wireless network distributed over land areas called cells, each served by at least one fixed-location transceiver, known as a cell site or base station. In a cellular network, each cell uses a different set of frequencies from neighboring cells, to avoid interference and provide guaranteed bandwidth within each cell.

Cellular networks offer a number of desirable features:

1. More capacity than a single large transmitter, since the same frequency can be used for multiple links as long as they are in different cells.

2. Mobile devices use less power than with a single transmitter or satellite since the cell towers are closer.

3. Larger coverage area than a single terrestrial transmitter, since additional cell towers can be added indefinitely and are not limited by the horizon.

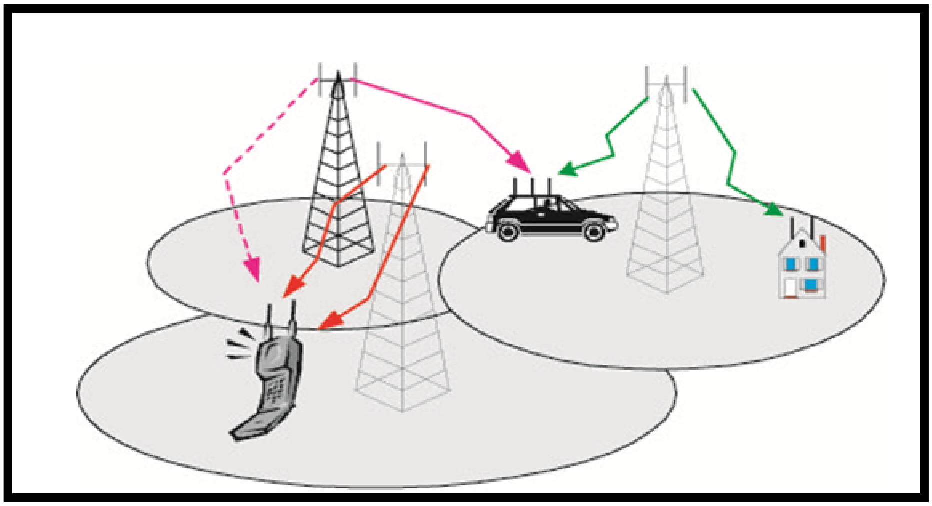


Figure 2.1: communications in cellular system.

2.2 Global system for mobile communications (GSM)

Standard for Global system for mobile communications:is a digital cellular radio network that uses more advanced technology and handles more subscribers than the analog cellular network due to the use of Time DivisionMultiple Access to divide the channel in time, (GSM) type of cellular network and it's Upgraded from the analog first generation and jawwal using (GSM) with frequency 900GHZ-1800GHZ. [4]

2.2.1 GSM FREQUENCY BANDS

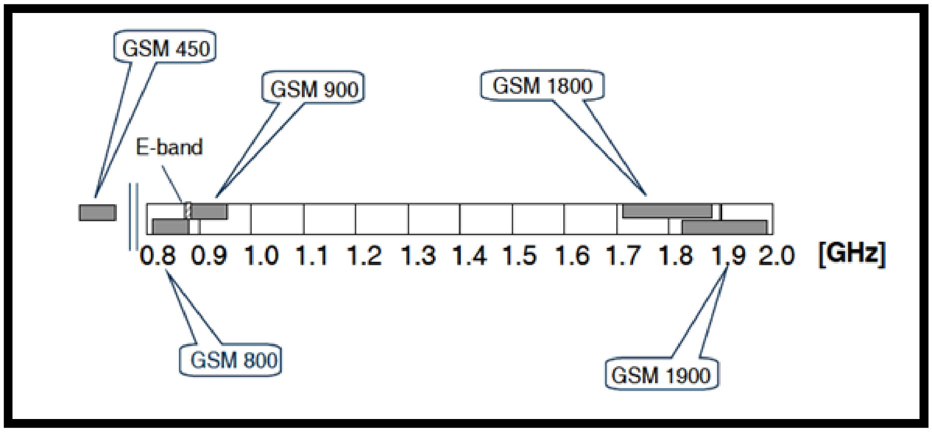


Figure 2.2: frequency band in GSM .

GSM 900: The original frequency band specified for GSM was 900 MHz. Most GSM networks worldwide use this band. In some countries and extended version of GSM 900 can be used, which provides extra network capacity.

GSM 1800: In 1990, in order to increase competition between operators, the United Kingdom requested the start of a new version of GSM adapted to the 1800 MHz frequency band. Licenses have been issued in several countries and networks are in full operation. By granting licenses for GSM 1800 in addition to GSM 900, a country can increase the number of operators. In this way, due to increased competition, the service to subscribers is improved. [5]

2.2.2 GSM Architecture and Subsystems

GSM network is divided into four subsystems:

1. The Base-Station Subsystem.

2. The Network Subsystem.

3. The Operation and Support Subsystem

4. The Mobile Station Subsystem

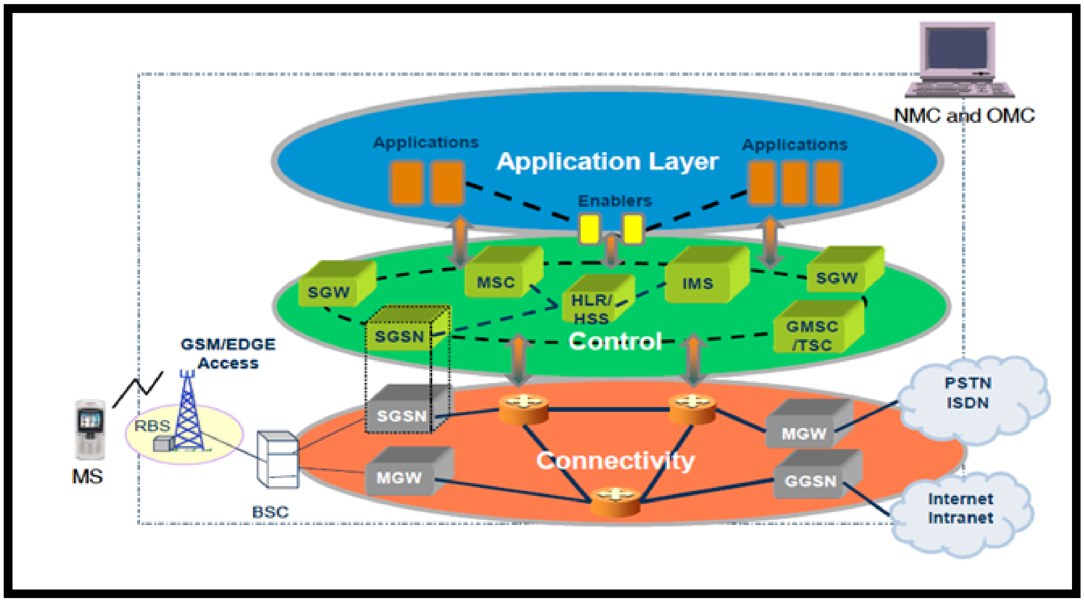


Figure 2.3: GSM architecture.

2.2.3 Problems in (GSM)

1. The increasing number of cellular users may lead to congestion on the GSM network.

2. We have coverage problems specially inside the buildings in specific in floors under the ground level, also dominant Service problems specially in the higher floor.

3. The improvement for quality of service .

2.3 Capacity and Coverage in cellular systems

The developments in wireless communication network over the past couple of decades have been enormous and have become ubiquitous in modern days. It is commonly assumed that the next generation of wireless communication networks will be heterogeneous, with different types of wireless network and technologies co-existing . There are currently many different types of wireless networks. Wireless local area networks and cellular networks are by far the most dominant wireless networks of our generation and have still sparked numerous research studies.

The design objective of early mobile radio systems was to achieve a large coverage area by using a single, high powered transmitter with an antenna mounted on a tall tower. While this approach achieved very good coverage, it also meant that it was impossible to reuse those same frequencies throughout the system, since any attempt to achieve frequency reuse would result in interference. Faced with the fact that government regulatory agencies could not make spectrum allocations in proportion to the increasing demand for mobile services, it became imperative to re-structure the radio telephone system to achieve high capacity with limited radio spectrum while at the same time covering very large areas.

The idea of cellular network it was thought that instead of using just one high-powered antenna to cover an entire metropolitan area, we should employ several lower powered antenna base stations scattered throughout the city, thereby breaking a macro-cell into several smaller micro-cells.

The spectrum is then divided such that the base stations of each of these micro-cells would be able to use a certain frequency band or channel without being affected too much by neighboring cells Cellular radio systems rely on an intelligent allocation and reuse of channels throughout a coverage region.

Each cellular base station is allocated a group of radio channels to be used within a small geographic area called a cell. Base stations in adjacent cells are assigned channel groups which contain completely different channels than neighboring cells. The base station antennas are designed to achieve the desired coverage within the particular cell. By limiting the coverage area to within the boundaries of a cell, the same group of channels may be used to cover different cells that are separated from one another by distances large enough to keep interference levels within tolerable limits.

2.3.1 Frequency Reuse concept in cellular Networks

The design process of selecting and allocating channel groups for all of the cellular base stations within a system is called frequency reuse or frequency planning .

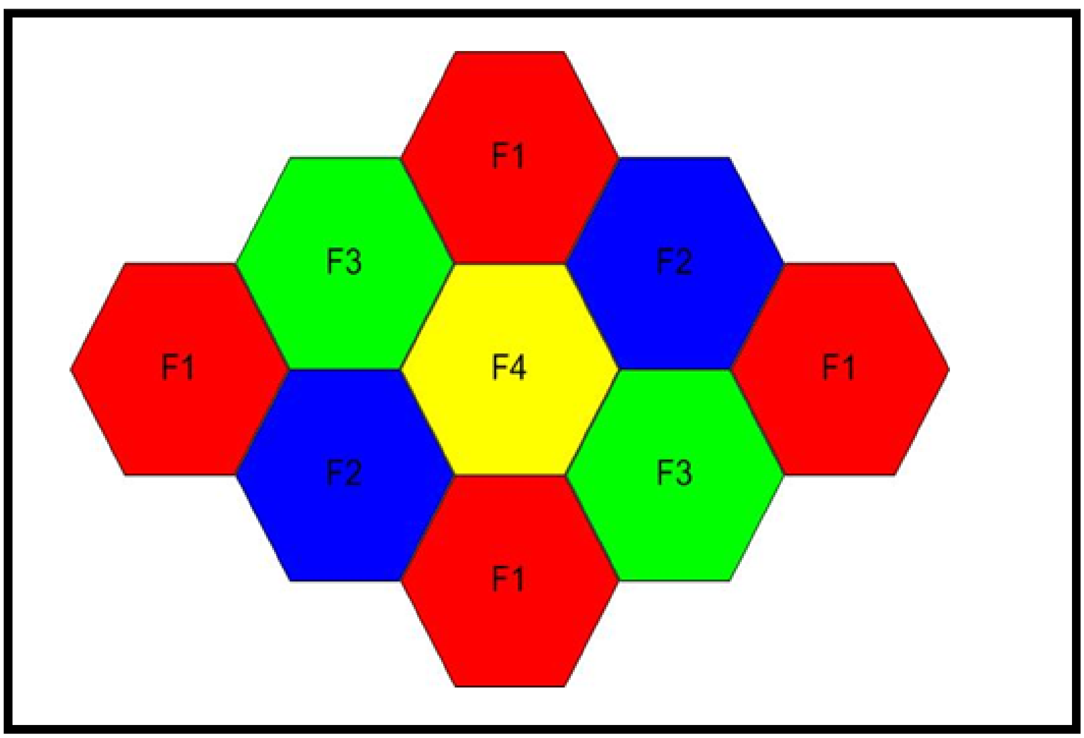


Figure 2.4: distribution of frequency reuse.

The hexagonal cell shape shown in Figure is conceptual and is a simplistic model of the radio coverage for each base station, but it has been universally adopted since the hexagon permits easy and manageable analysis of a cellular system. The actual radio coverage of a cell is known as the footprint and is determined from field measurements or propagation prediction models

The concept of frequency reuse is based on assigning to each cell a group of radio channels used within a small geographic area called cell. Cells are assigned a group of radio channels that is completely different from neighboring cells. The coverage area of cell is called the footprint. This footprint is limited by a boundary so that the same group of channels can be used in different cells that are far enough away from each other so that their frequencies do not interfere Cell with the same letter uses same set of frequencies. Here, the cluster size, N, is equal to 7, and the frequency reuse factor is 1/7 since each cell contains the one-seventh of the total number of available channels.

To understand the frequency reuse concept, we consider a cellular system which has a total of S duplex channels available for use. If each channel is allocated a group of m channels (m ¡ S), and if S channels are divided among N cells into unique and disjoint channel groups which each have the same number of channels, the total number of available radio channels can be expressed as in eq 2.1

$$S = mN \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2.1$$

The cells N which collectively use the complete set of available frequencies is called a cluster. If a cluster is replicated M times within the system, the total number of duplex channels, C, can e used as measure of capacity and is given as

$$C = MkN = MS \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.2)$$

As seen from above equation, the capacity of a cellular system is directly proportional to the number of times a cluster is replicated in a fixed service area. The factor N is called the cluster size and typically equal to 4, 7, or 12. From a design viewpoint, the smallest possible value of N is desirable in order to maximize capacity over a given coverage area. The frequency reuse factor of a cellular system is given by 1/N, since each cell within a cluster is only assigned 1/N of the total available channels in the system. To connect each cell in the manner that no gaps are present in adjacent cells, the geometry of hexagons is such that the number of cells per cluster (N) can only have values which satisfy the following equation

$$N = i^(2) + i * j + j^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.3)$$

Where i and j are non negative integers. To find the nearest co-channel neighbors of a particular cell, one must do the following

- Move i cells along any chain of hexagons and then
- Turn 60 counter clockwise and move j cells.

2.3.2 Improving Capacity in Cellular Networks

2.3.2

As the demand for wireless service increases, the number of channels assigned to a cell eventually becomes insufficient to support the required number of users. At this point, cellular design techniques are needed to provide more channels per unit coverage area. Techniques such as cell splitting, sectoring, and coverage zone approaches are used in practice to expand the capacity of cellular systems.

Cell splitting allows an orderly growth of the cellular system. Sectoring uses directional antennas to further control the interference and frequency reuse of channels. The zone microcell concept distributes the coverage of a cell and extends the cell boundary to hard-to-reach places.

While cell splitting increases the number of base stations in order to increase capacity, sectoring and zone microcells rely on base station antenna placements to improve capacity by reducing co-channel interference. Cell splitting and zone microcell techniques do not suffer the trunking inefficiencies experienced by sectored cells, and enable the base station to oversee all handoff chores related to the microcells, thus reducing the computational load at the mobile switching centre (MSC).

2.3.3 Cell Splitting

2.3.3

Cell splitting is the process of subdividing a congested cell into smaller cells, each with its own base station and a corresponding reduction in antenna height and transmitter power. Cell splitting increases the capacity of a cellular system since it increases the number of times that channels are reused. By defining new cells which have a smaller radius than the original cells and by installing these smaller cells (called microcells) between the existing cells, capacity increases due to the additional number of channels per unit area .

consequence of the cell splitting is that the frequency assignment has to be done again, which affects the neighboring cells. It also increases the handoff rate because the cells are now smaller and a mobile is likely to cross cell boundaries more often compared with the case when the cells are big. Because of altered signaling conditions, this also affects the traffic in control channels . it is assumed that the cell cluster is congested and as a result, the call blocking probability has risen above an acceptable level.

In order to cover the entire service area with smaller cells, approximately four times as many cells would be required. The increased number of cells would increase the number of clusters over the coverage region, which in turn would increase the number of channels, and thus capacity, in the coverage area the smaller cells were added in such a way as to preserve the frequency reuse plan of the system. In this case, the radius of each new microcell is half that of the original cell.

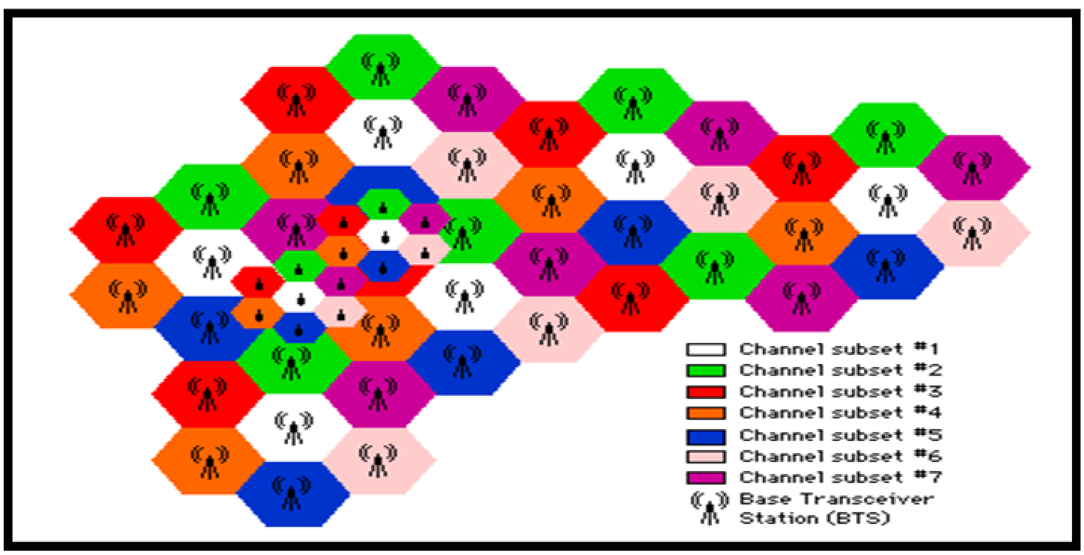


Figure 2.5: cell splitting structure.

2.4 Congestion in cellular systems

2.4.1 What is congestion?

Congestion is the unavailability of network to thesubscriber at the time of making a call. It is the situationwhen the blocking occurs and no free path can be provided for an offered call.That is, when asubscriber cannot obtain a connection to the wanted subscriber immediately.

2.4.2 Congestion on GSM

the network side four elements are related to congestion or indicate that a call could not be completed :

1. 1- Traffic channels congestion (TCHC): Traffic channels(TCH) represent a voice channel and each call uses TCH. There are eight channels defined for each radio frequency carrier and most are used for traffic channels and some for control channels. When there is no free voice channel (TCH), there will be traffic channels congestion (TCHC).

2. Dedicated control channel congestion (DCHC): Stand-alone dedicated control channel (SDCCH) is used to provide authentication to mobile station, location updating and assignments to voice channel (TCHs) during idle periods. When making a call or responding to paging message for the allocation of an SDCCH for authentication, if there is no vacant SDCCH to use at that time, the call will be terminated. This failure is called the dedicated control channel congestion.

3. Common control channels congestion (CCCHC): Common control channel is a group of control channels that support the establishment and maintenance of communication links

between mobile stations and base stations. It consists of random access channel (RACH), paging channels (PCH) and access grant channel (AGCH). RACH is used to make request for network assignment, PCH is used to alert the mobile station of incoming call and AGCH is used to assign mobile station to a specific DCCH or SDCCH for on ward communication. When any of these three control channels is congested, there cannot be any call establishment between the sender and receiver, then, we have CCCH congestion.

4. 4- Pulse code modulation congestion (PCMC): Pulse code modulation (PCM) or E1 is the link required to connect the base station (BS) and mobile-switching center (MSC) together. Each PCM can carry between 1 and 32 calls. When there is no free PCM to carry the call signals between the BS and MSC, then we have pulse code modulation congestion .

Other factors that could lead to congestion are:

1. Inadequate radio channels and infrastructure tosupport the vast number of subscribers on the network.
2. Redialing of subscribers when they experienceblocking.
3. Too many users on the network.
4. Marketing strategies and pricing schemes also affect traffic behavior since this would have increased the number of subscribers on the network.
5. Use of the old equipment facilities instead of new ones.
6. The TRU in side BTS if it's using one of the full or half rate techniques which providing voice call service and data SMS and increasing numbers of users using the same BTS for calls and messages at the same times the TCH will be busy and the congestion will occur.

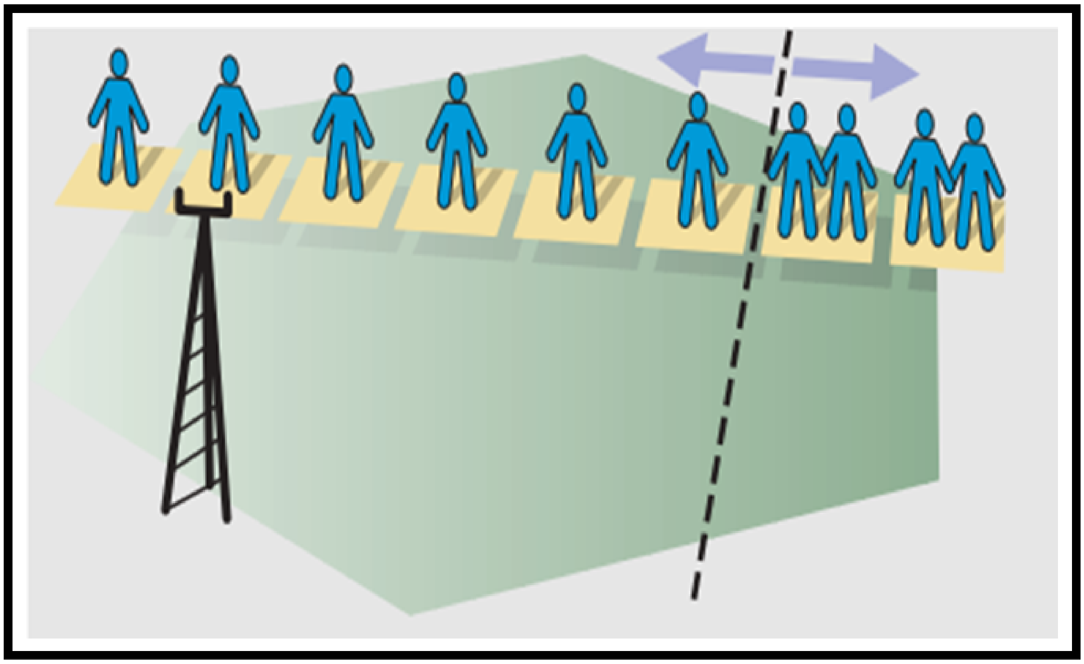


Figure 2.6: the full and half rate techniques in TRU

2.5 Quality of service

2.5.1 What is QoS?

Imagine a situation where you are hardly able to hear what your friend is talking over the phone or the phone gets cut when you are talking something important. These things are highly undesirable and you do not want to get low quality service for paying high monthly bills. Communication plays a major role in today's world and to support it QoS has to be given maximum priority. It is important to differentiate the traffic based on priority level. Some traffic classes should be given higher priority over other classes, Example: voice should be given a higher priority compared to data traffic as voice is still considered as the most important service. It should be noted that more preference has to be given to customers who pay more to get better service, without affecting the remaining customers who pay normal amount. To realize all these things effective QoS schemes are needed. Issues and schemes related to providing better QoS is the main subject of this report.

Quality of Service (QoS) in cellular networks is defined as the capability of the cellular service providers to provide a satisfactory service which includes voice quality, signal strength, low call blocking and dropping probability, high data rates for multimedia and data applications , and controls the performance, reliability and usability of a telecommunications service. The goal of (QoS) to eliminate any problems that will affected to the quality of service. For network based services QoS depends on the following factors

2.5.2 Factors affecting QoS

Many factors affect the quality of service of a mobile network. It is correct to look at QoS mainly from the customer's point of view, that is, QoS as judged by the user. There are standard metrics of QoS to the user that can be measured to rate the QoS. These metrics are: the coverage, accessibility (includes GoS), and the audioquality. In coverage the strength of the signal is measured using test equipment and this can be used to estimate the size of the cell. Accessibility is about determining the ability of the network to handle successful calls from mobile-to-fixed networks and from mobile-to-mobile networks. The audio quality considers monitoring a successful call for a period of time for the clarity of the communication channel. All these indicators are used by the telecommunications industry to rate the quality of service of a network.

1. Throughput :The rate at which the packets go through the network. Maximum rate is always preferred.

2. Delay This is the time which a packet takes to travel from one end to the other. Minimum

delay is always preferred.

3. Packet Loss Rate The rate at which a packet is lost. This should also be as minimum as possible.

4. Packet Error Rate This is the errors which are present in a packet due to corrupted bits. This should be as minimum as possible

5. Reliability The availability of a connection. (Links going up/down).

2.6 Measurements tools

We will use a special software provided by JAWWAL Company called Mentom Planet special device NEMO handy and other devices.

Mentom planet: a special softwareusing for cell planning design, analysis and optimization for cellular network. In this program the designer could any area city or country to make design for it.

NEMO handy (drive test): its portable devise that measuring and assessing the coverage, capacity and Quality of Service (QoS) of a mobile radio network.

Figure 2.7: NEMO handy devise.

Chapter 3

Experimental Design

3.1 introduction

This chapter presents the measurement tool used in this project. The design of the experiments is presented. Then, the measurement results will be analyzed to find out if there exits capacity or coverage problems.

3.2 Tool of measurement

3.2.1 Mentom Planet

Mentum Planet is a reliable and proven solution used by the majority of mobile operators, integrators and equipment vendors for RF planning, mobile network optimization and network performance management. Mentum Planet supports all major wireless access standards, including GSM, GPRS, EDGE, WCDMA, , LTE (TDD and FDD), Wi-Fi, WiMAX, cdma2000, TDMA, FDMA, and generic TDMA/FDMA, and addresses every stage of the network lifecycle, from strategic planning to planning, management and re-planning / optimization .

By leveraging Mentum Planet's state-of-the-art modeling capabilities and built-in Automated Network Planning (ANP) capabilities, engineers and optimization departments can select the best deployment scenarios, automate RF network planning and design, and manage large-scale networks. Mentum Planet's capabilities allow mobile operators to improve radio network design quality, roll out next-generation networks faster.

Mentum Planet offers an intuitive user interface that is contextually driven and is backed by best-in-class user documentation and a comprehensive help system to ensure you get the answers to your questions quickly. As the only RF network planning and optimization tool that embeds MapInfo professional GIS, Mentum Planet users have easy access to worldwide data and an advanced GIS toolset that provides a foundation for managing all geographic data in the network planning environment. Engineers can harness the power of Mentum Planet quickly, with any level of expertise, and increase efficiency. Figure 3.1 show the simulation by use Mentum Planet .

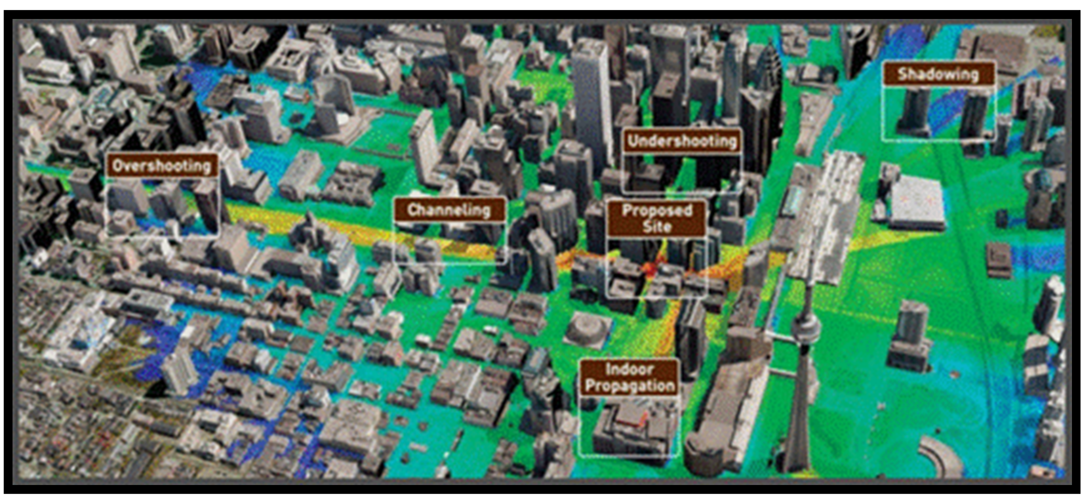


Figure 3.1: Simulation by Mentom Planet

3.2.2 Nemo Handy

The handheld Nemo Handy products are highly suitable for performing measurements both outdoors and in busy and crowded indoor spaces while being simultaneously used as a regular mobile phone. Nemo Handy products provide you with the best real-time measurement visualization on the handheld market .

In addition to a rich variety of real-time displays, all RF and signaling data is logged to phone's internal storage or memory card. Log files are made available in Nemo file format that allows easy post-processing with Nemo. Outdoor playback, Nemo Analyze, or third-party post-processing tools. As shown in the figure 3.2 .

Nemo handy supports several built in application testing option if it possible to test voice quality voice and video calls ,SMS massaging ,emile sending and receiving and ping the quality of service logged by Nemo handy include connection setup delay, download time , time to content delay, throughput.

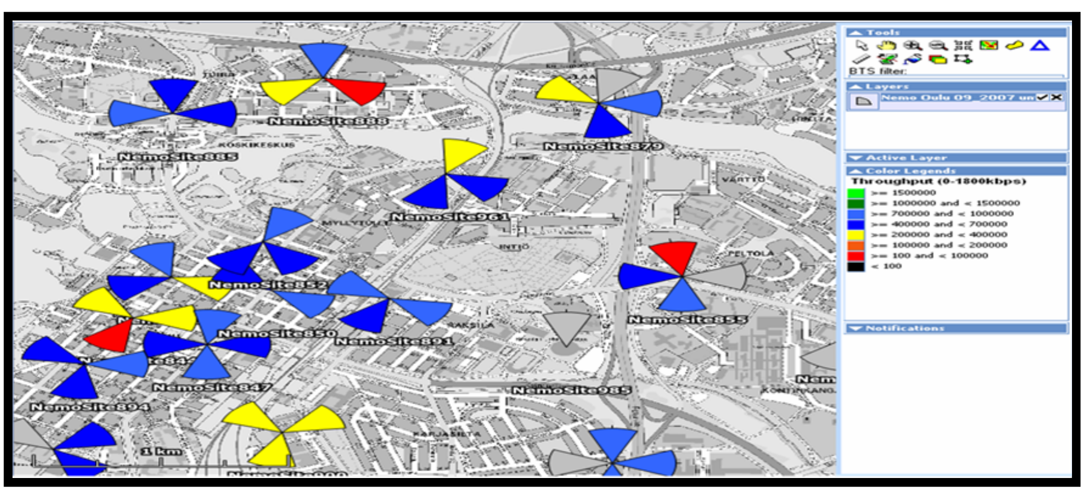


Figure 3.2: Nemo handy used in drive test

3.2.3 Drive test

Every good RF design, after its implantation should be evaluated. There are few ways to do this, for example through analysis of KPI (Key Performance Indicator) or through prediction tools and signal interference. Other very common and efficient way to evaluate the network is conducting a Drive Test.

The Drive Test is a test performed in cellular networks regardless of technology (GSM, CDMA, UMTS, LTE, etc. ...). Means collecting data on vehicle movement. Its variation has also intuitive: Walk Test, collect data by walking areas of interest.

The main goal is to collect test data, but they can be viewed / analyzed in real time (Live) during the test, allowing a view of network performance on the field. Data from all units are grouped by collection software and stored in one or more output files.

The minimum required to conduct a drive test, simplifying, is a mobile device with a software to collect data and a GPS. Currently, there are already cell phones that do everything. They have a GPS, as well as a collection of specific software. They are very practical, but are still quite expensive.

3.2.4 Actix Software

Actix creates software platforms that enable mobile operators to run more effective networks; delivering better customer experience, maximizing network ROI and generating new revenues by locating,optimizing and monetizing their subscriber experience. Actix provides operators with real-time, geolocated,visibility and control over the Radio Access Network (RAN); the most critical part of a mobile operator's infrastructure.

Analyzer from Actix, the most widely used tool for mobile network advanced drive test survey analytics, now supports network optimization, network acceptance and validation for LTE Advanced rollouts as well as for 2G, 3G and LTE.

enables drill down to a detailed session analysis providing all the information required by engineers to understand the root cause of the problems affecting service performance .The analysis covers the entire session, correlating service performance with the underlying network measurements .This enables engineers to establish whether the underlying cause of poor service performance is due to poor radio quality or congestion on the core or radio networks and to understand when and where network features were available and used.

Indoor analysis Analyzer geo-references all collected RF measurements and events and overlays them with an image for visualizing the layout of the venue. Measurements are distributed linearly across the image using waypoint interpolation.

Sophisticated KPI reports can be generated to automatically evaluate the readiness of the in-building network ahead of launch. as show in figure 3.3

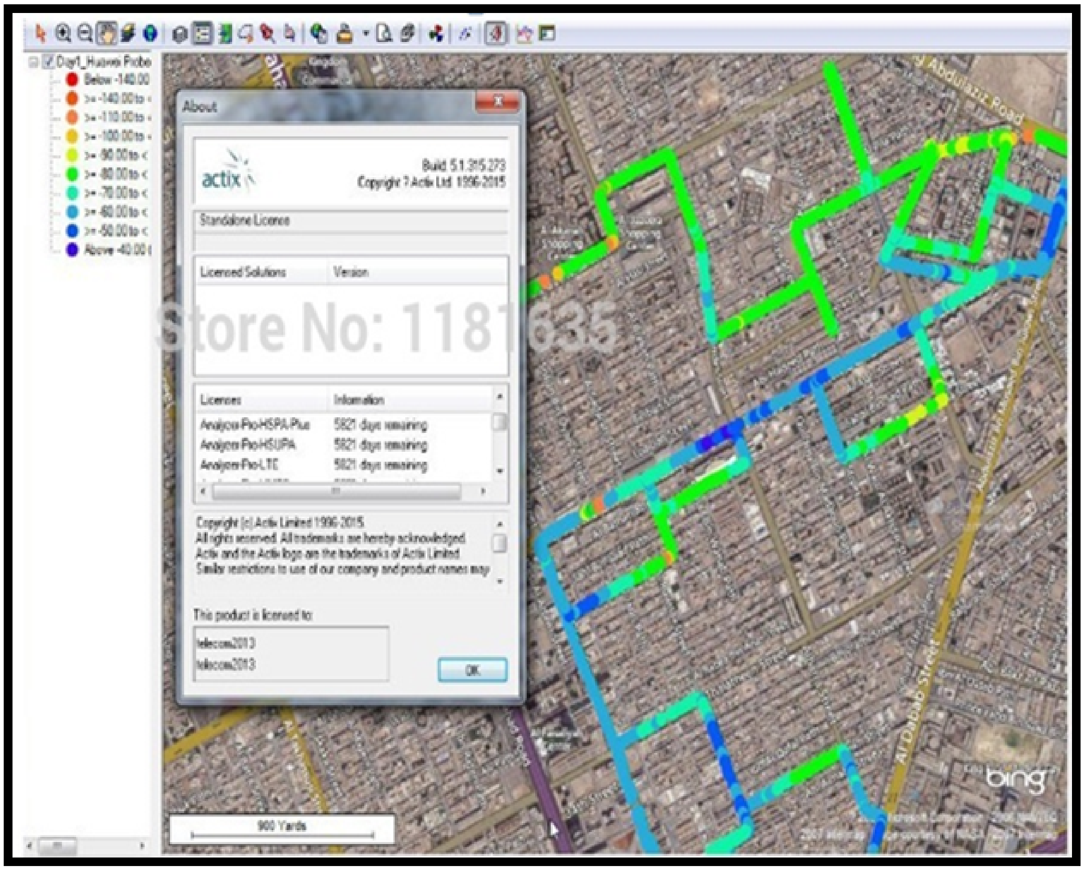


Figure 3.3: Simulation Actix Software

3.3 Data Collection

In this study, various call quality parameters are being evaluated for JAWWAL network. These parameters are:

- Congestion
- Coverage
- Signal quality

Various methods have been used by researchers to collect the data. It can also be obtained from analysis of drive test data. In this study, data collection was obtained from the Network Operation Centre in the last year (2013).

3.3.1 Congestion measurement

To measure the congestion within the boundaries of the university we will follow a plan of action based on, Know the number of students at the university and considered among JAWWAL subscribers, Where each one will be modeled to inject 0.25 Erlang.
After finding out the number of subscribers and the percentage represented by each participant, the total traffic can be computed as: Total Traffic =Number of users * 0.25E

After finding the total traffic from the university, we will approximate the total traffic from the site, to find the rate of traffic from university to traffic from all site .

The next step after approximating the total traffic from all site we will define Acceptable probability of blocking. Knowing the number of users and probability of blocking and using

Erlang B table, it is possible to know the number of servers we need to achieve the probability of blocking required. If the number of servers used in site less the required, then it is concluded that congestion can occur. To get more idea on congestion probability, we can go back to site statics in last year and look at the days when events happened in the last year, if the congestion happened in this day's this mean the cell faces congestion problem.

3.3.2 Coverage and Signal Quality Measurement

To measure the coverage, it is intended to follow these steps:

- Conduct drive tests using Nemo handy in all university area and buildings to measure the signal level inside all university area.
- Use the actix software to simulate the measurements.
- Analyze data collection.
- Plot results of signal level and carrier to interference ratio, in all sub areas inside the university and in each building and floor.
- Compare with reference values to determine the coverage problems.

Chapter 4

Measurement Analysis

This chapter presents the analysis of data traces. We try to identify the problem and propose possible solutions.

4.1 Analysis of Coverage

Here we need to study the power level of the signal at each floor inside university buildings and in each sub area. For good coverage, the signal level must be higher than -80dBm. If the signal level falls below this threshold value, coverage problem is assumed.

4.1.1 First building (IT center of excellence)

First floor

The signal level and coverage in this floor is shown in figure 4.1. The figure shows the signal level represented by points with different colors. Colors represent different signal levels. It is clear that the power level in some areas falls below -80dBm(see circles). In these areas the coverage is bad.

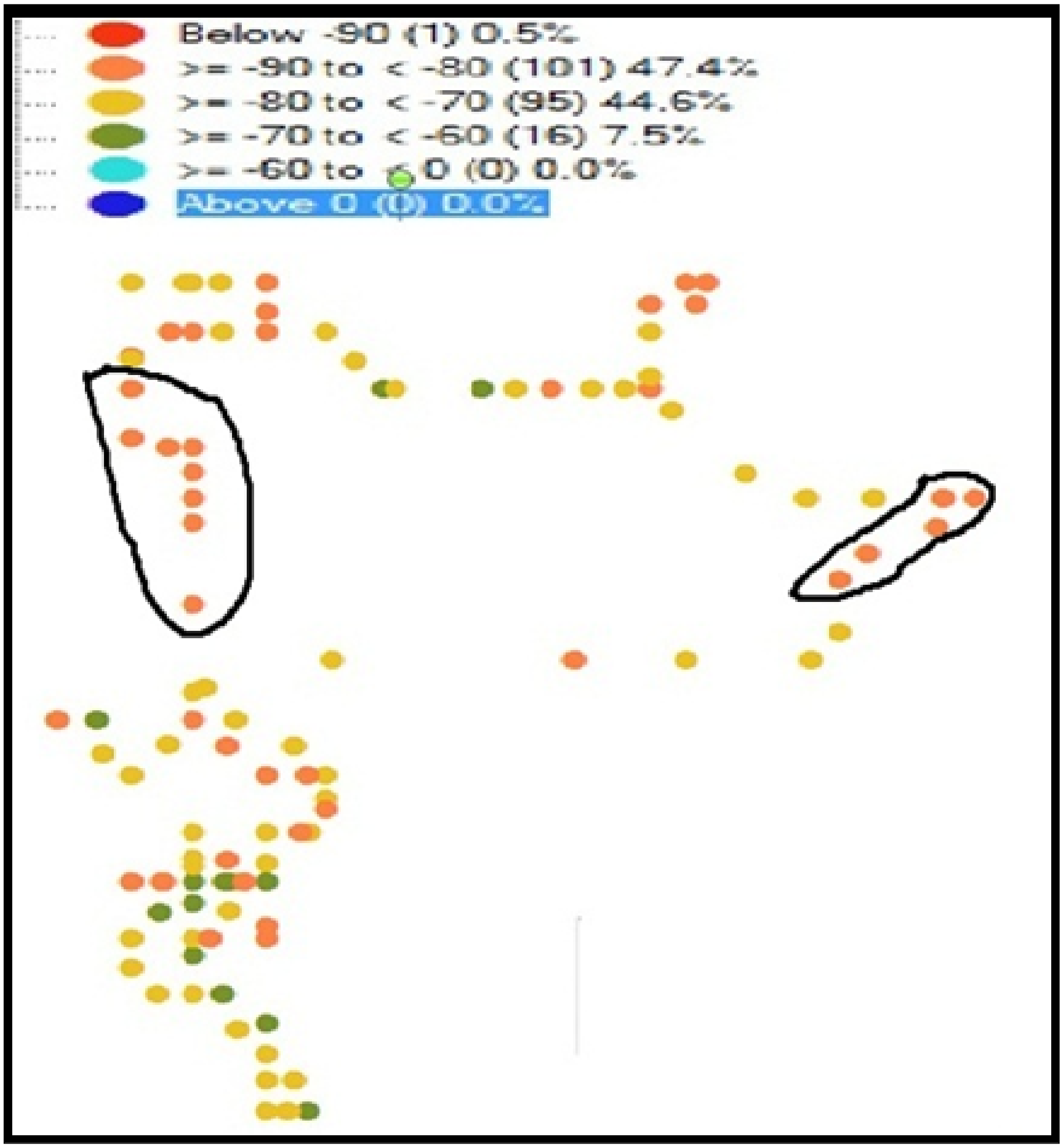


Figure 4.1: Coverage in the first floor (first building)

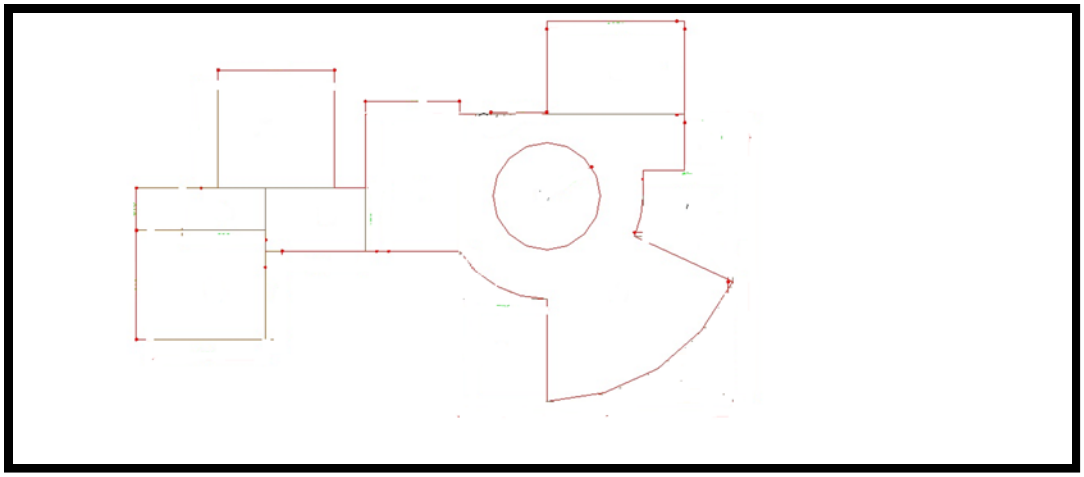


Figure 4.2 shows the percentage of each signal level from total point

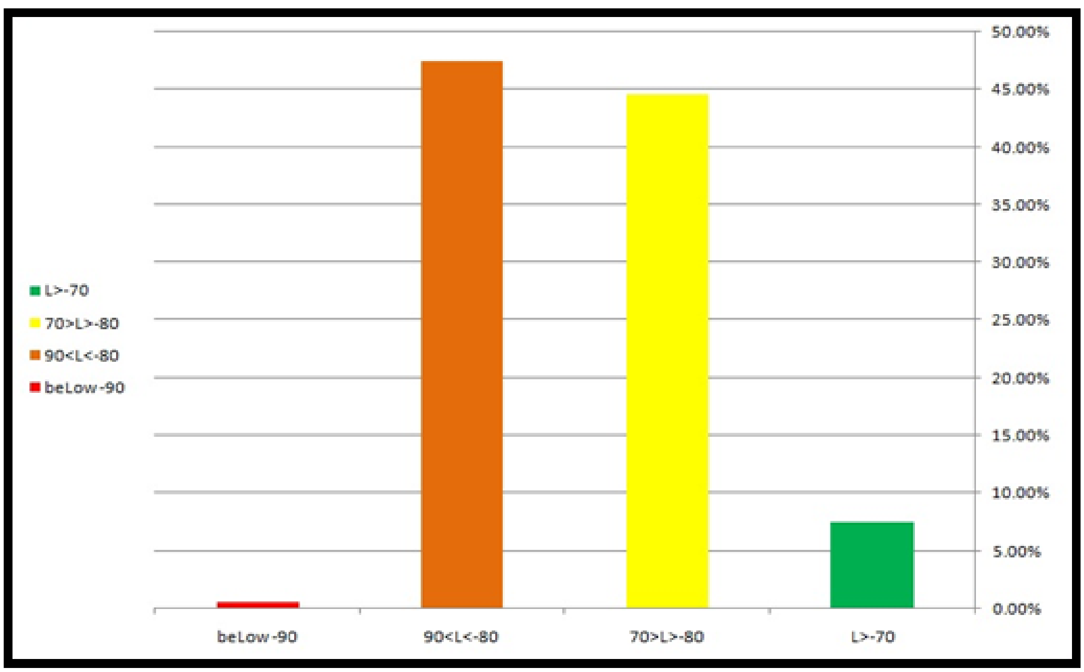


Figure 4.2: Percentage of signal level from total point in the first floor of the first building

Second floor

Figure 4.3 shows the signal level in the second floor. It can be seen that the signal level in this floor is wobbling where most points are located between -90dBm and -80 dBm. This results in bad coverage.

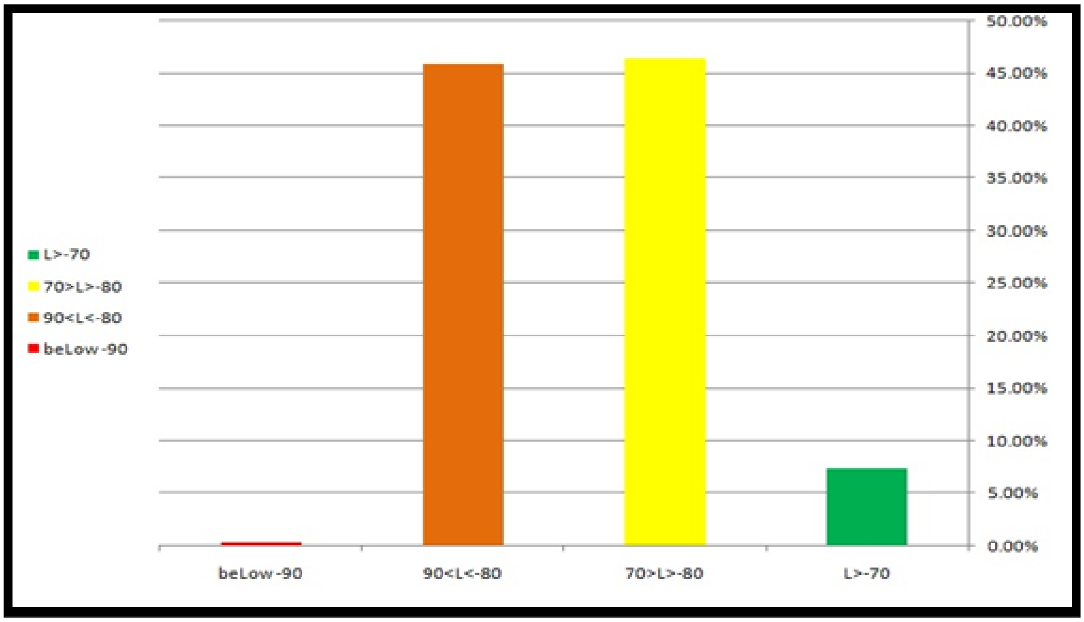
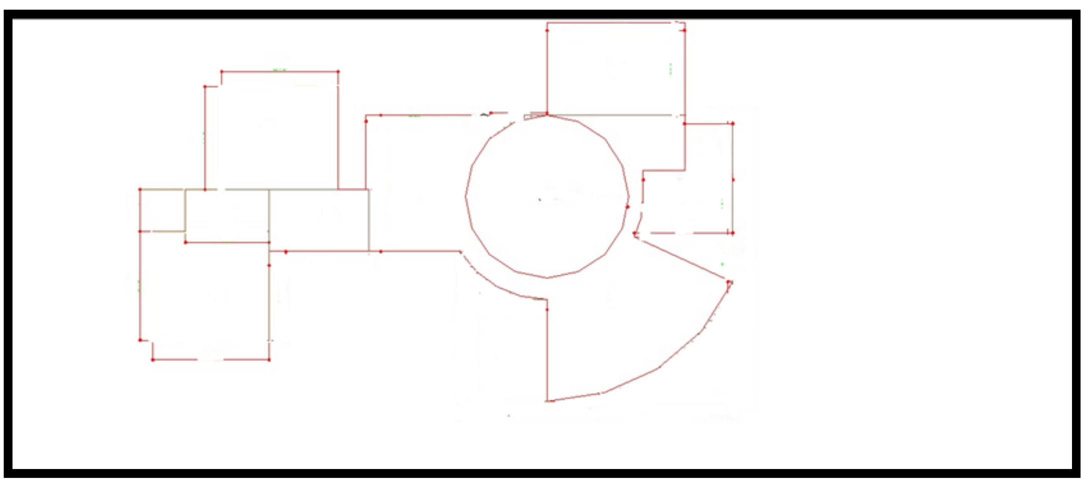


Figure 4.3: Percentage of signal level from total point in second floor first building



4.1.2 Second Building

First floor

The signal level in this floor is shownin figure 4.4. The results show that most points are located between -80dBm and -90dBm.This concludes that the coverage is bad in this floor

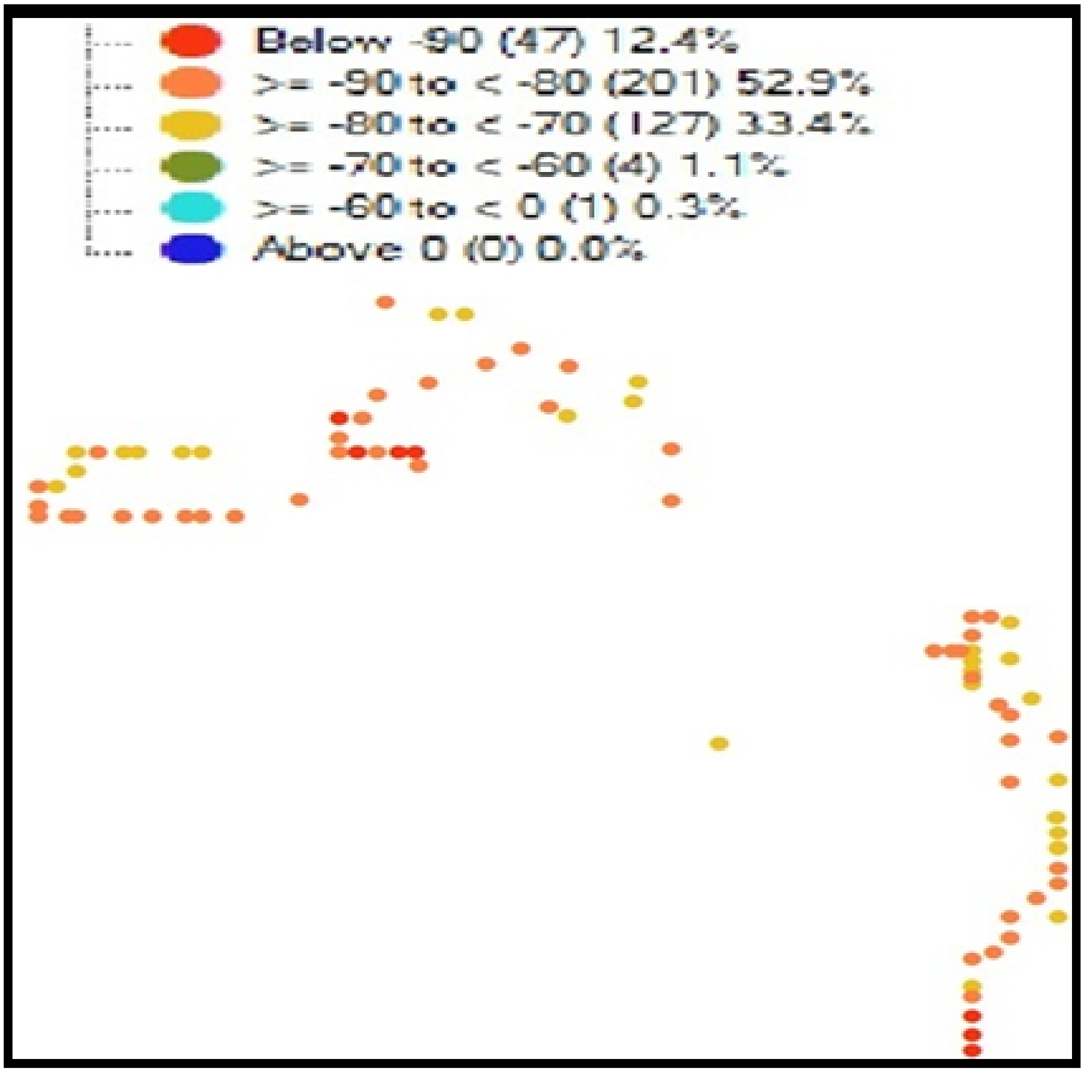


Figure 4.4: coverage in first floor in second building

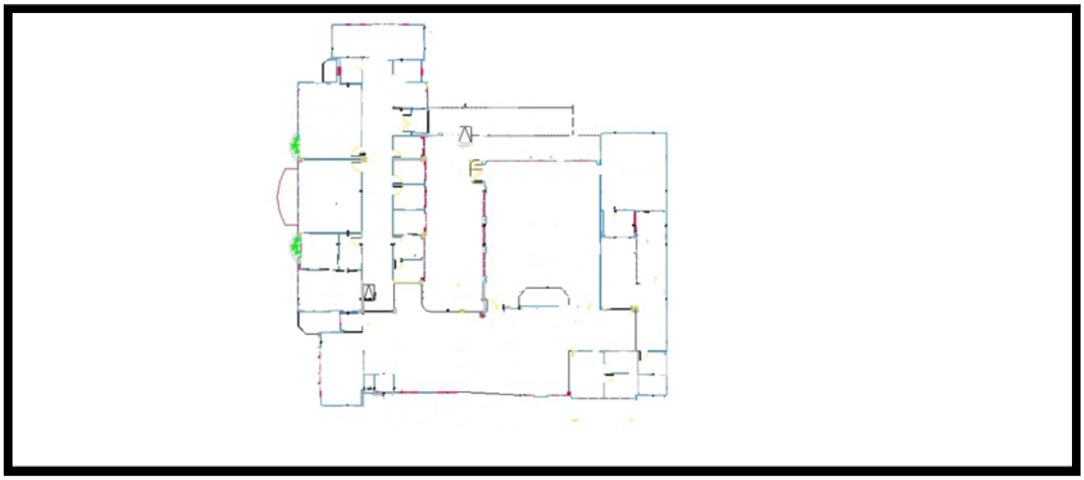


Figure 4.5 shows the percentage of each signal level from total points.

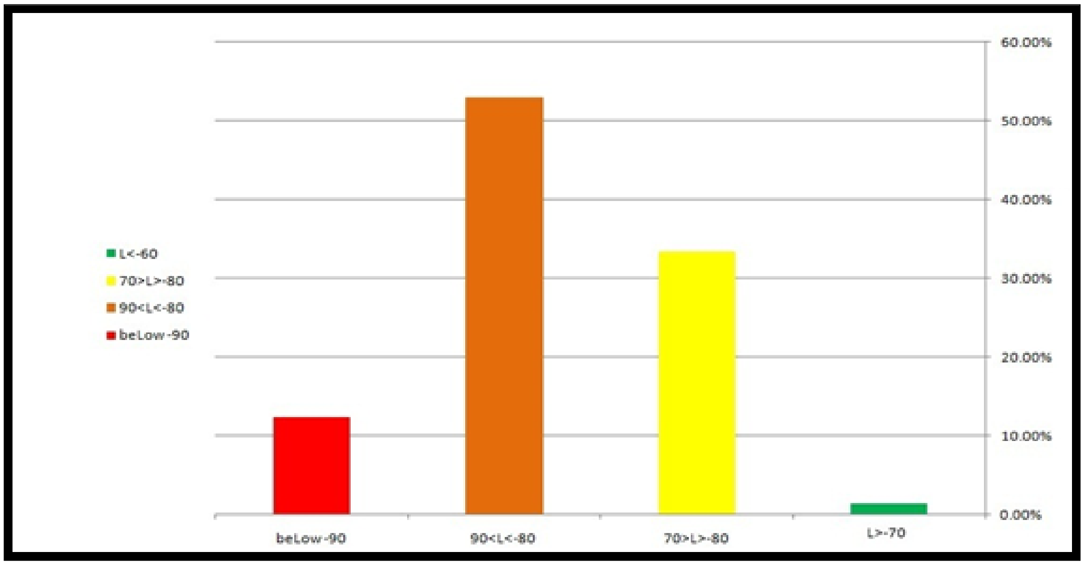


Figure 4.5: Percentage of signal level from total point

Second floor

Figure 4.6 shows the signal level inside the second floor. It is clear that the signal level is acceptable. In some areas the signal level is wobbling between -70dBm to -90dBm(See the circled area) .

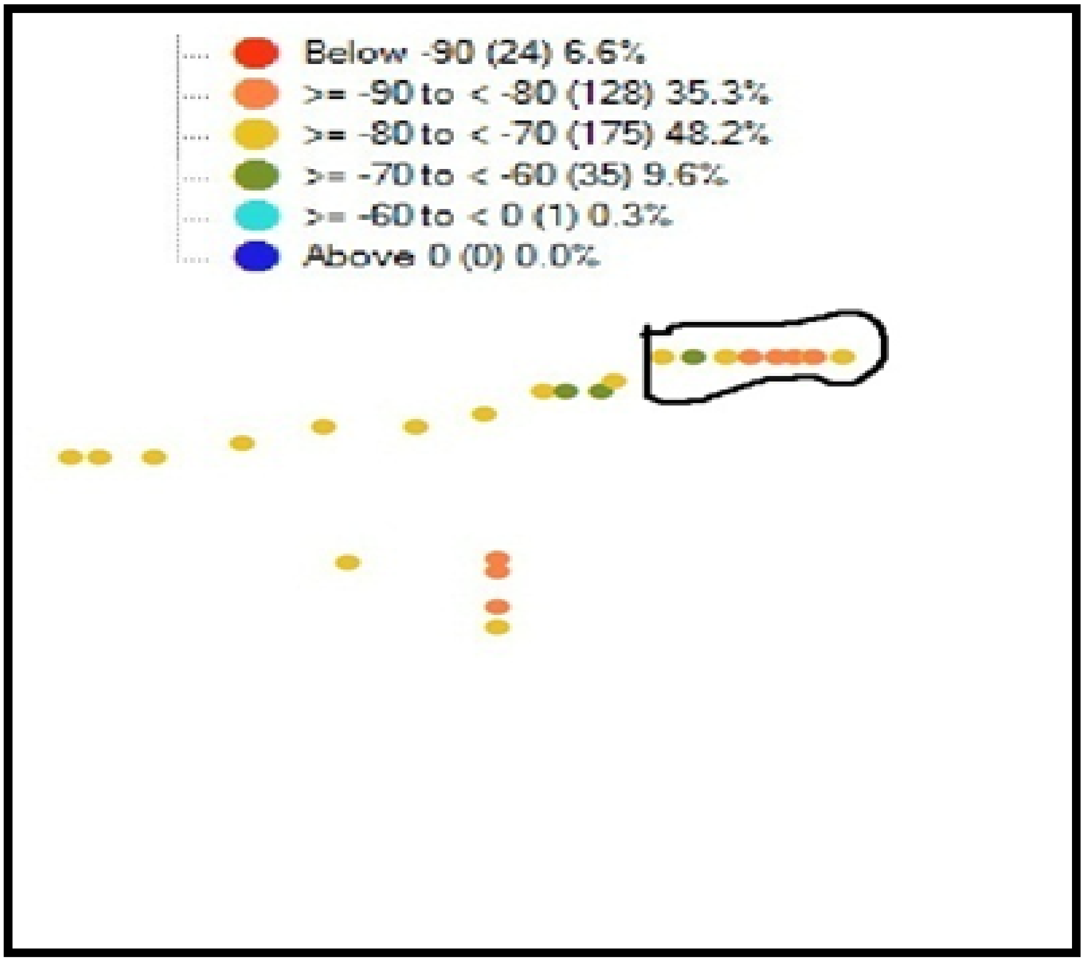


Figure 4.6: Coverage in the second floor of the second building

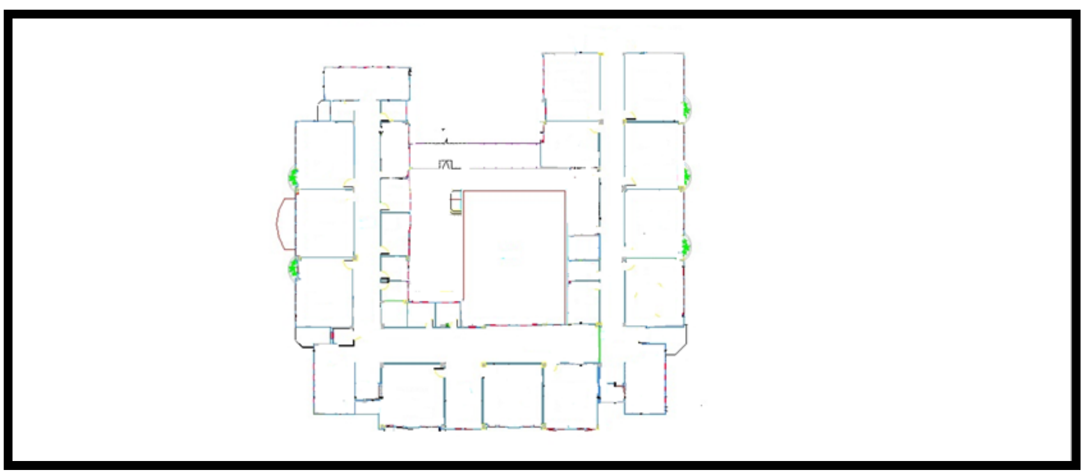


Figure 4.7 shows the percentage of each signal level from total point.

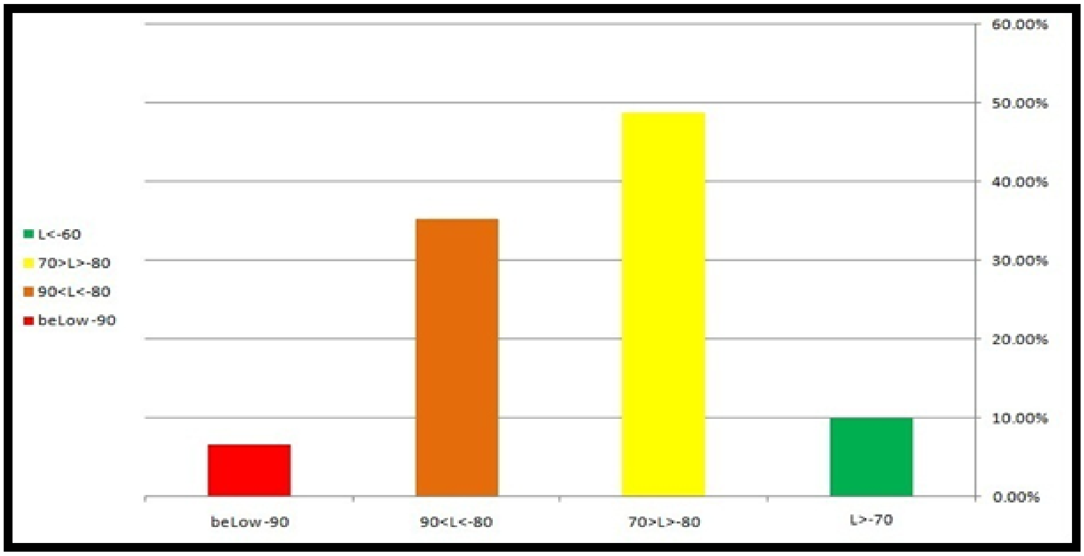


Figure 4.7: Percentage of each signal level from total point in second floor

Third and fourth floors

The measurement results for the third and fourth floors are approximately the same. Figure 4.8 shows the signal level in these two floors. From the figure, it is clear that all points are approximately within the range from -70dBm to -80dBm except a few points. This means that the coverage is acceptable.

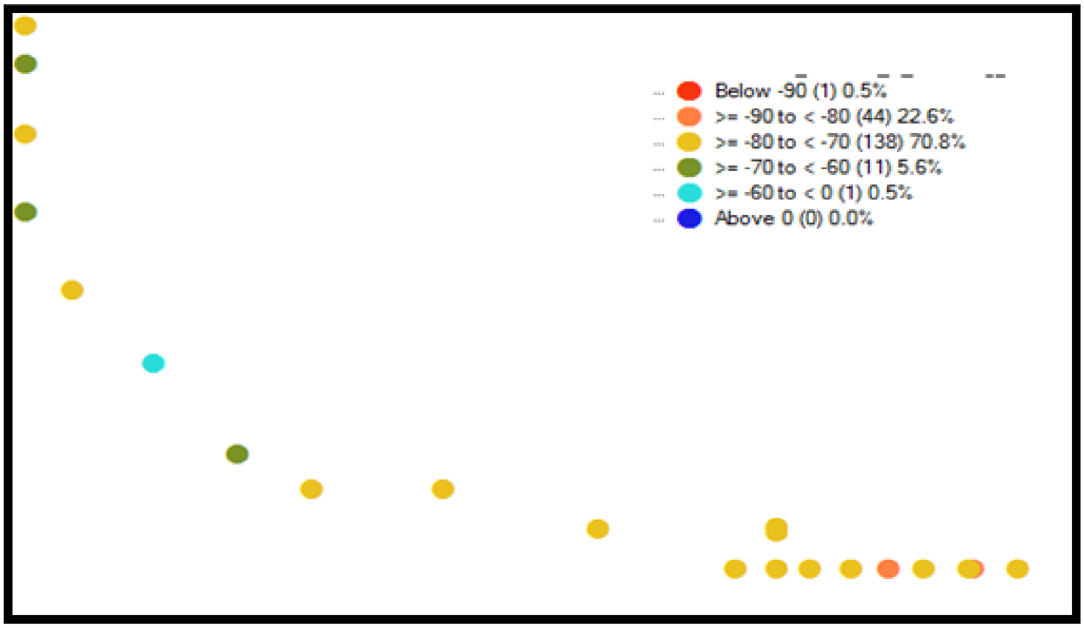


Figure 4.8: Signal level in the third and fourth floors

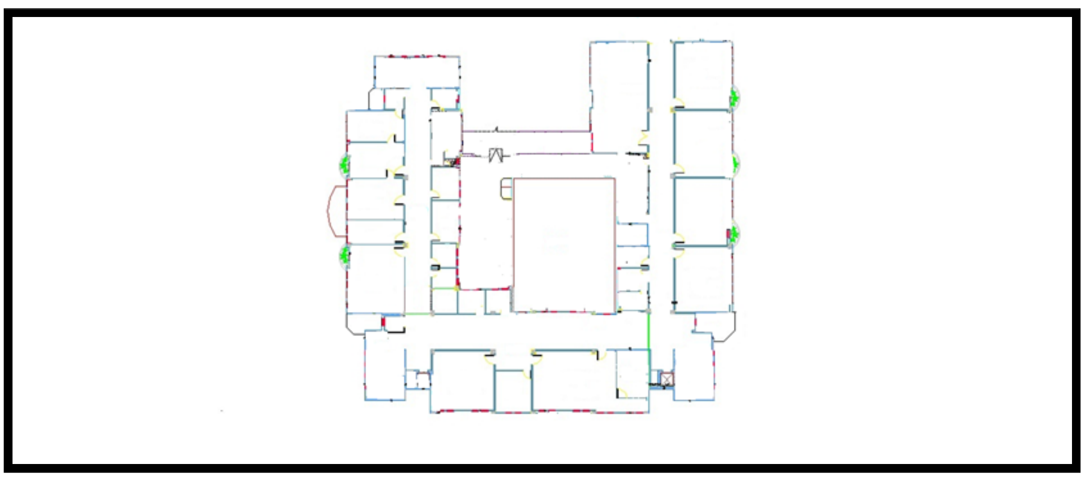


Figure 4.9 shows the percentage of each signal level from total point.

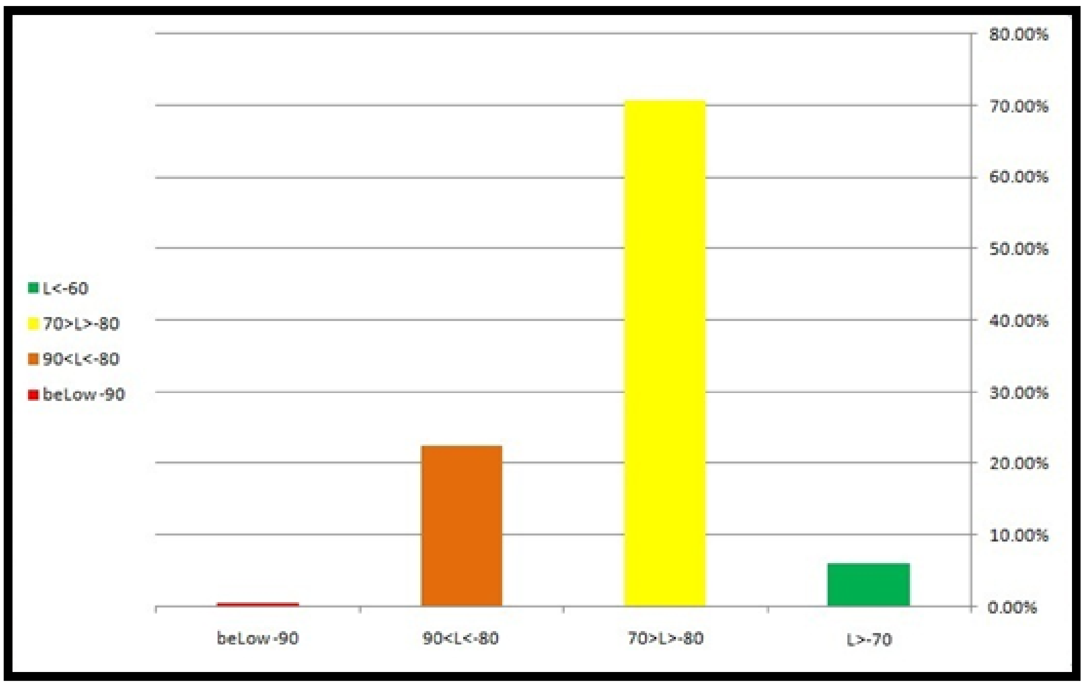


Figure 4.9: Percentage of each signal level from total point in third and fourth floors

Fifth floor

The signal level and coverage in this floor is shown in figure4.10. From the figure, we can deduce that the coverage and signal level in this floor are good. All points are approximately located in the range between -70dBm to -80dBm expect some points were found to be located out of this range(See circled area).

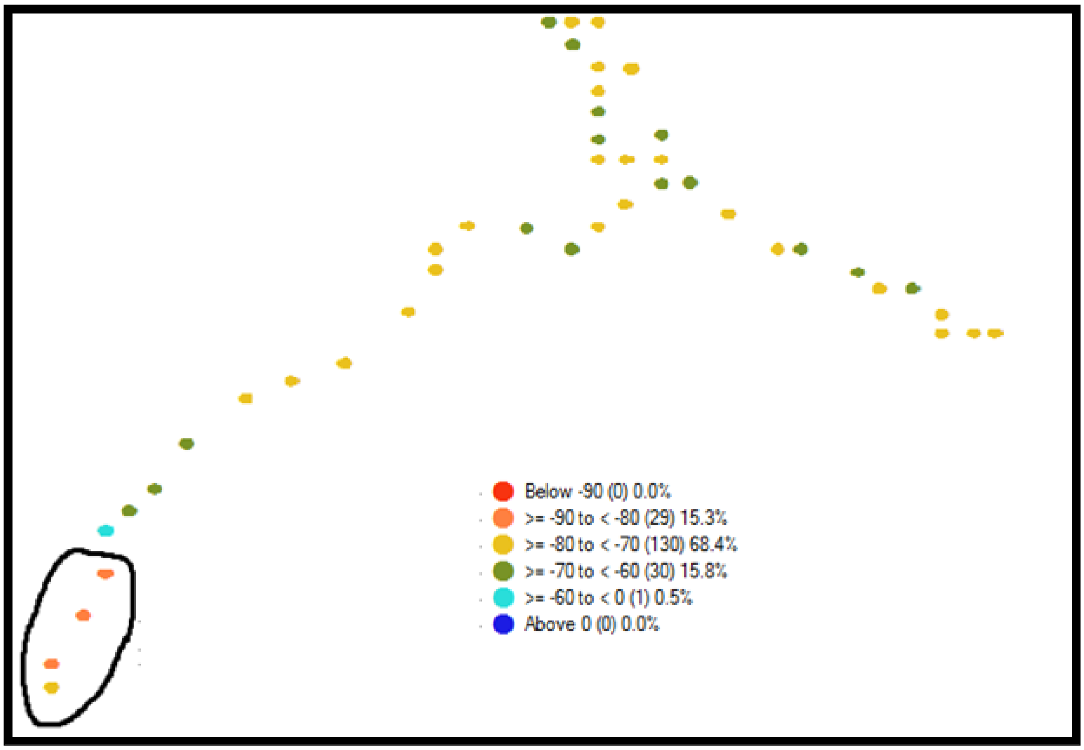


Figure 4.10: Signal level in the fifth floor

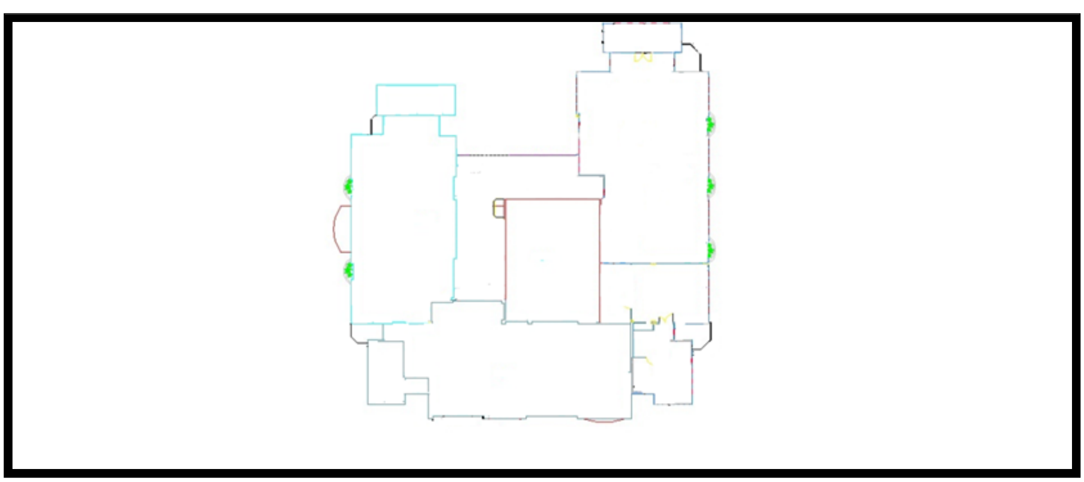


Figure 4.11 shows the percentage of each signal level from total point.

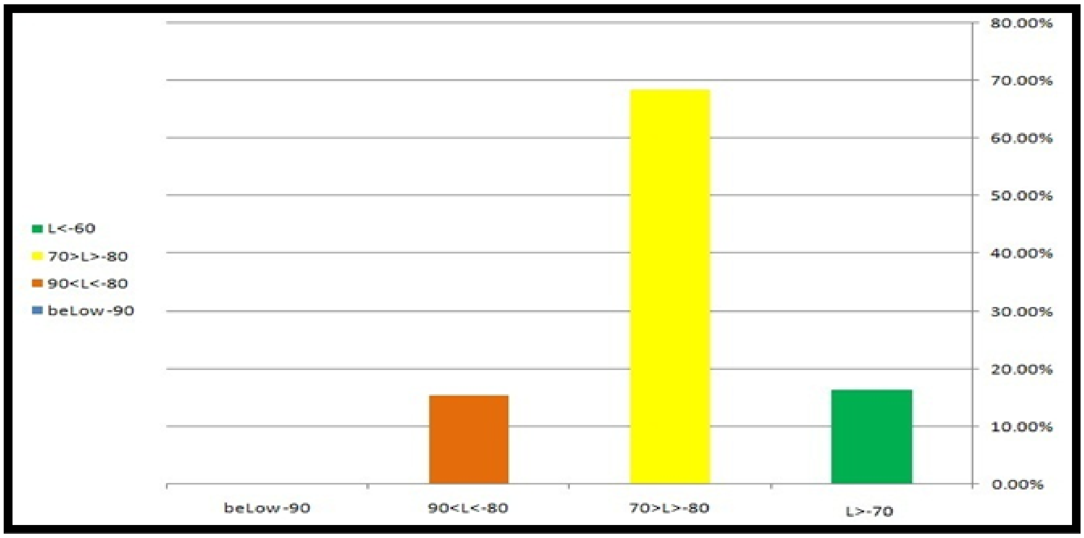


Figure 4.11: Percentage of each signal level from total point in the fifth floor

Cafeteria

The cafeteria is an important place because most of the time large number of studentsexist in this place. Figure 4.12 shows the signal level in the cafeteria. The figure shows that most points in the cafeteria are well covered expect some areas (see circled area).

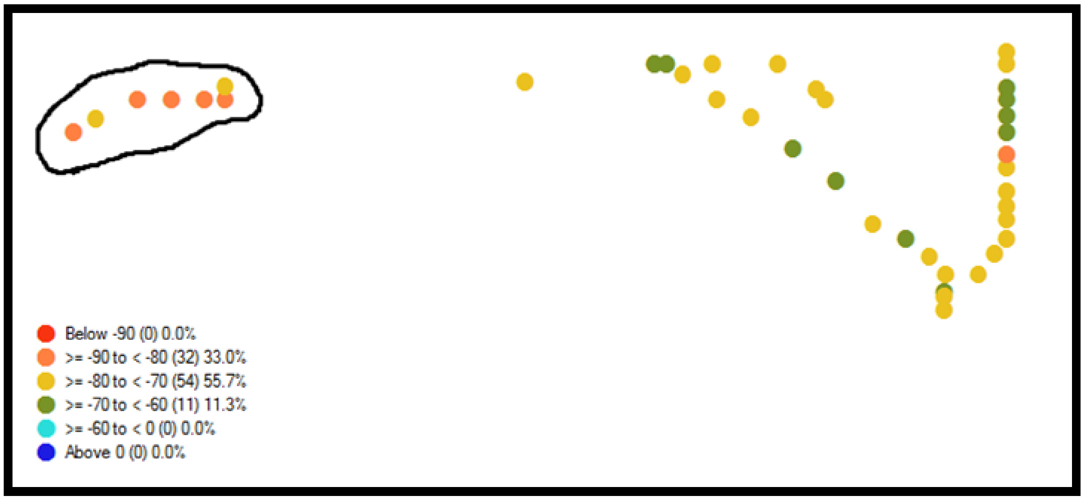


Figure 4.12: Signal level in the cafeteria

Figure 4.13 shows the percentage of each signal level from total point.

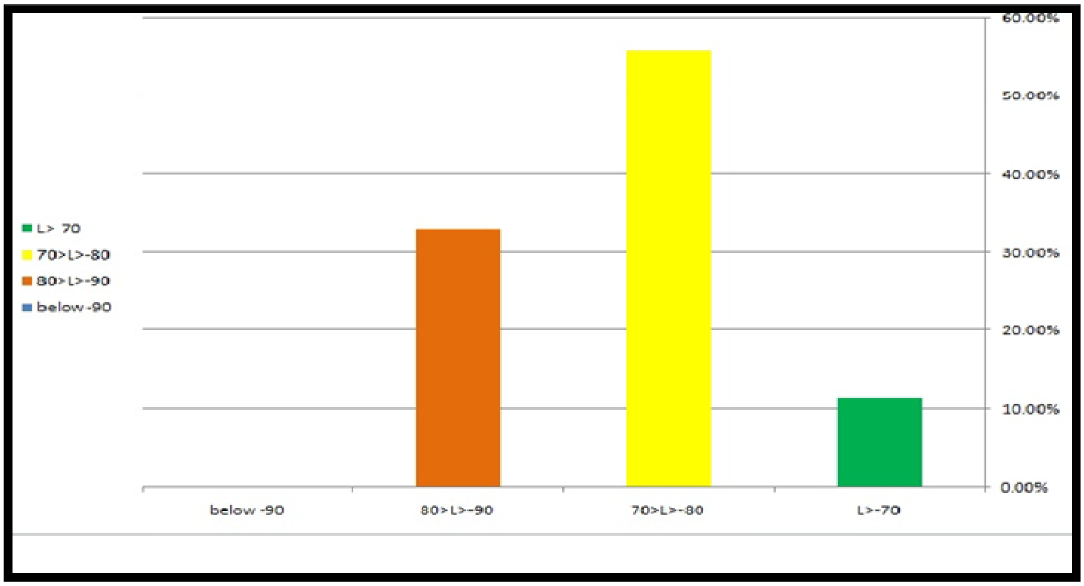


Figure 4.13: Percentage of each signal level from total point in the cafeteria

Piazza

Figure 4.14 shows the signal level in the piazza. The figure reveals that the signal level is between -60dBm to -80dBm which indicates good coverage expect in some areas where the signal level falls below -80dBm.

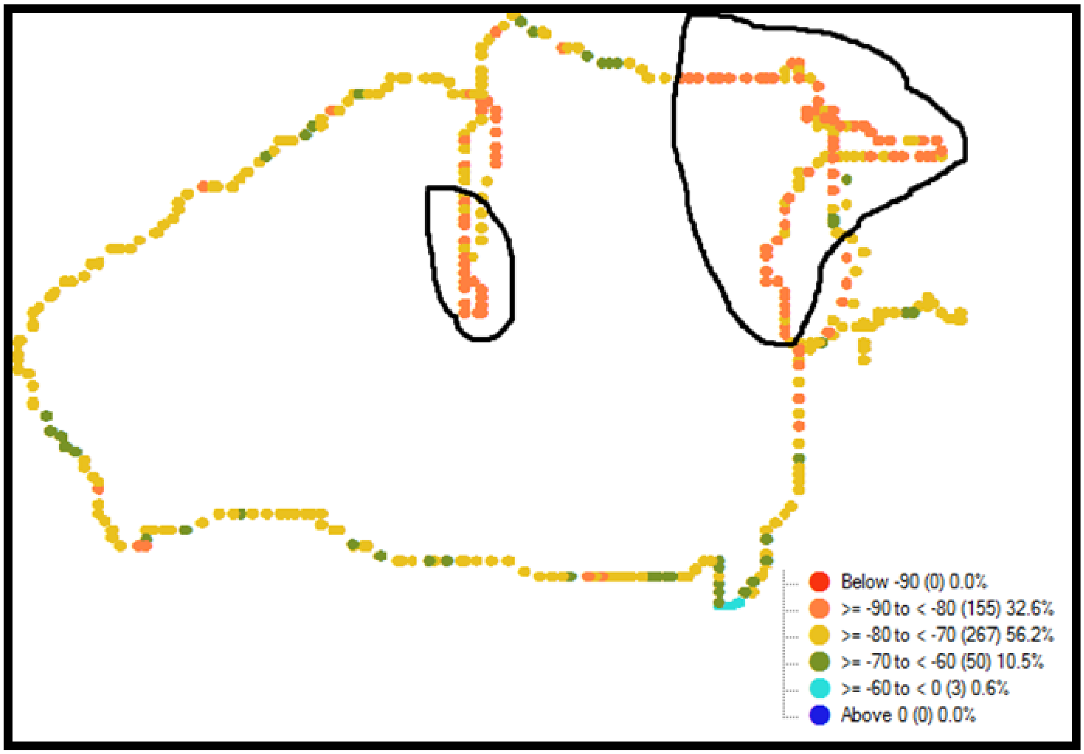


Figure 4.14: Signal level in the piazza

Figure 4.15 shows the percentage of each signal level from total point.

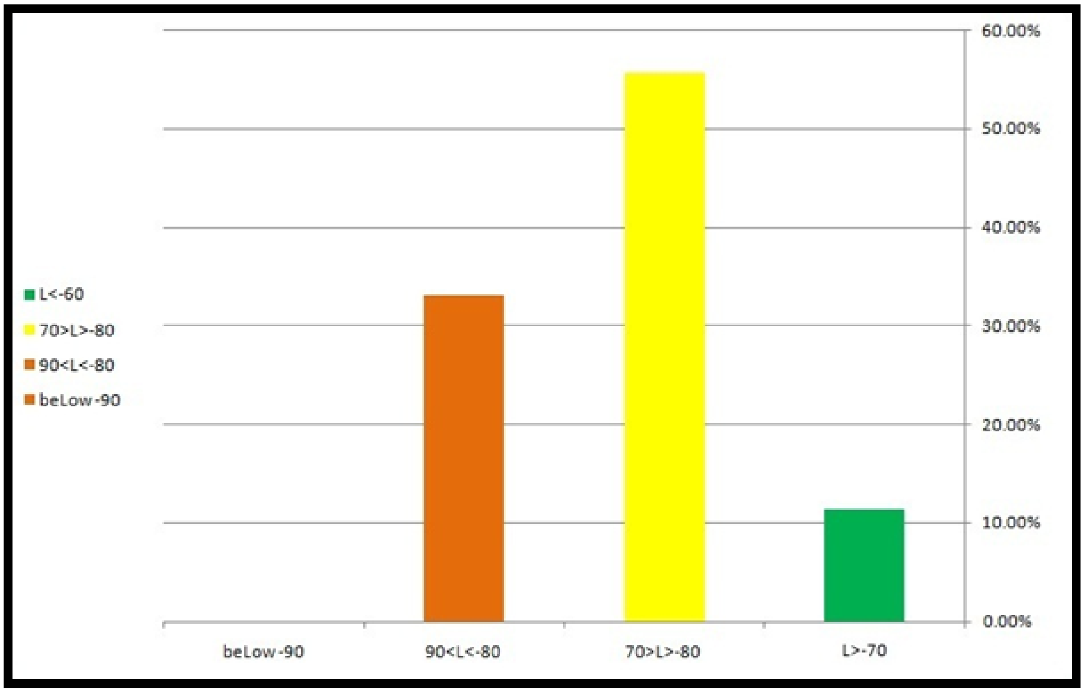


Figure 4.15: Percentage of each signal level from total point in piazza

4.2 Analysis of Carrier to Interference (C/I) parameter.

In this section we analyze the signal quality of data communications by observing the carrier to interference ratio of the signal inside university buildings. The carrier to interference ratio of a good signal should be above 13dB. C/I below 13dBindicates low quality.

4.2.1 First building (IT center of excellence)

First floor

The C/I in this floor is shown figure 4.16. The results show the signal quality in some areas in this floor is bellow 13dB.

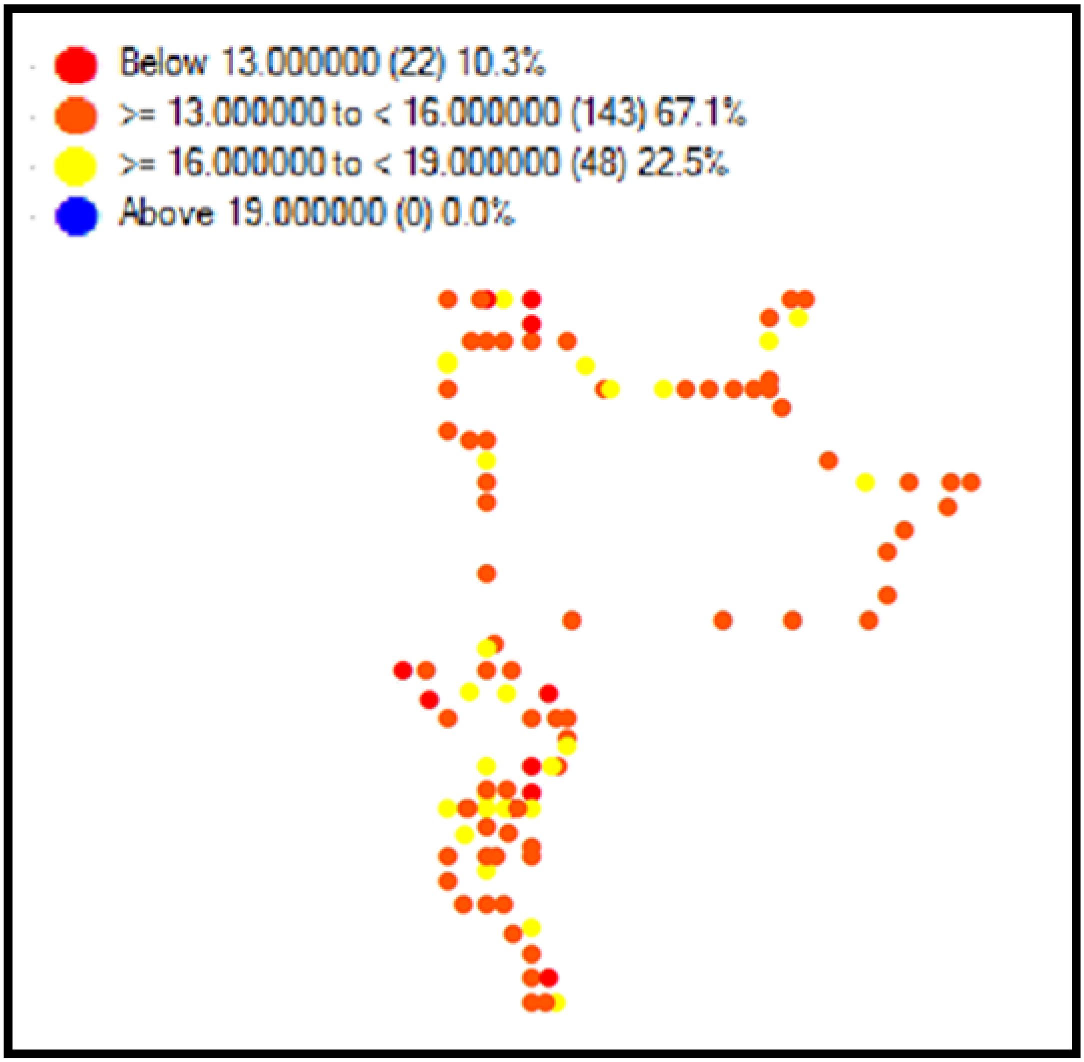


Figure 4.16: C/I in the first floor of the first building

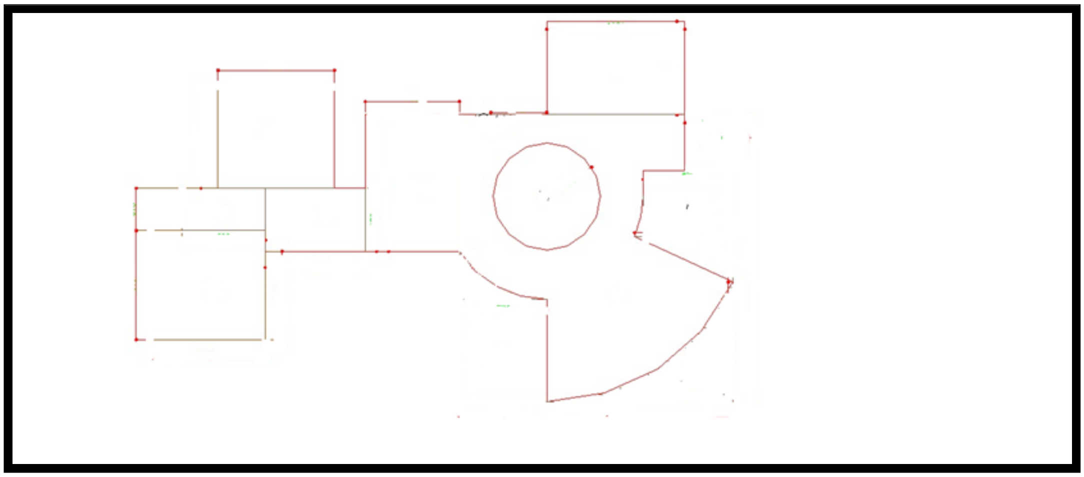


Figure 4.17 shows the percentage of each level to carrier to interference ratio where the red color represents bad signal.

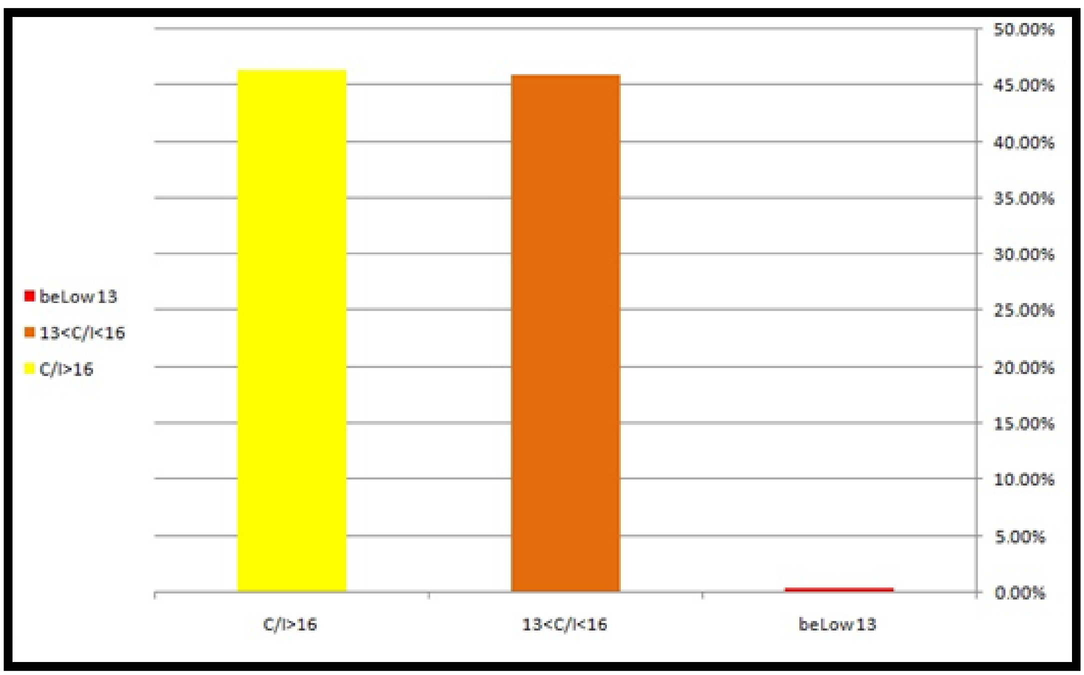


Figure 4.17: percentage of each level

Second floor

The C/I in this floor is shown in figure 4.18. It can be seenthatthe signal quality in some areas in this floor is bellow 13dB, while most of area is located at normal range.

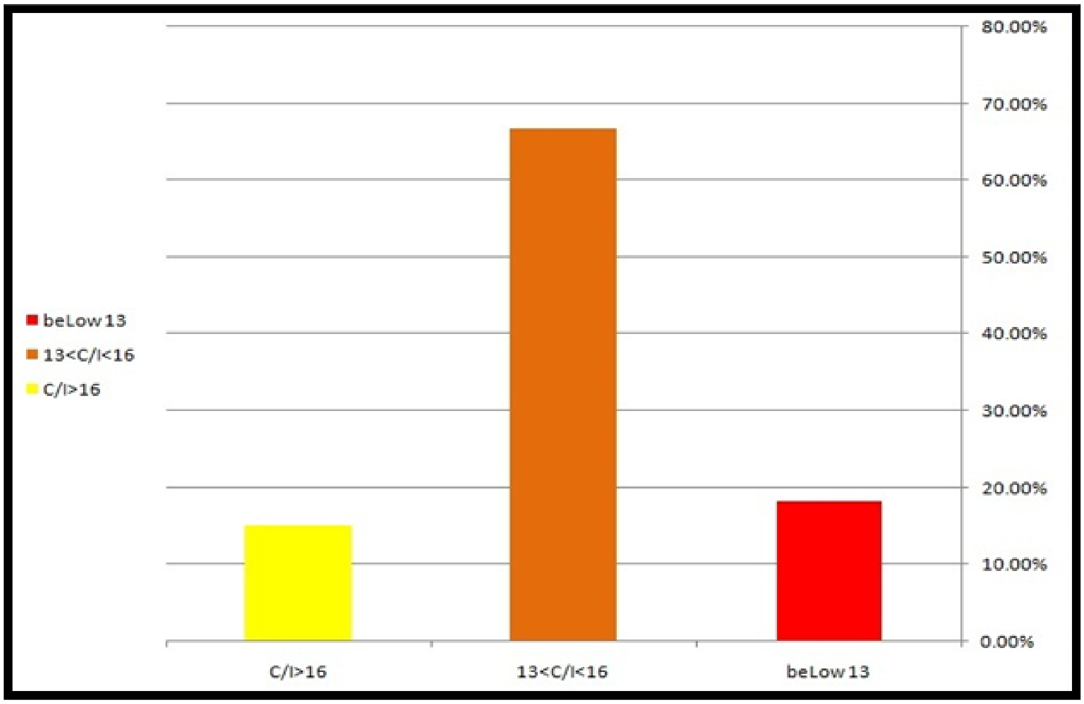


Figure 4.18: Percentage of carrier to interference ratio in the second floor

4.2.2 Second Building

First floor

Figure 4.19 shows the C/I in this floor. It can be seen that the whole area is approximately located in the normal range expect some places (see circled area).

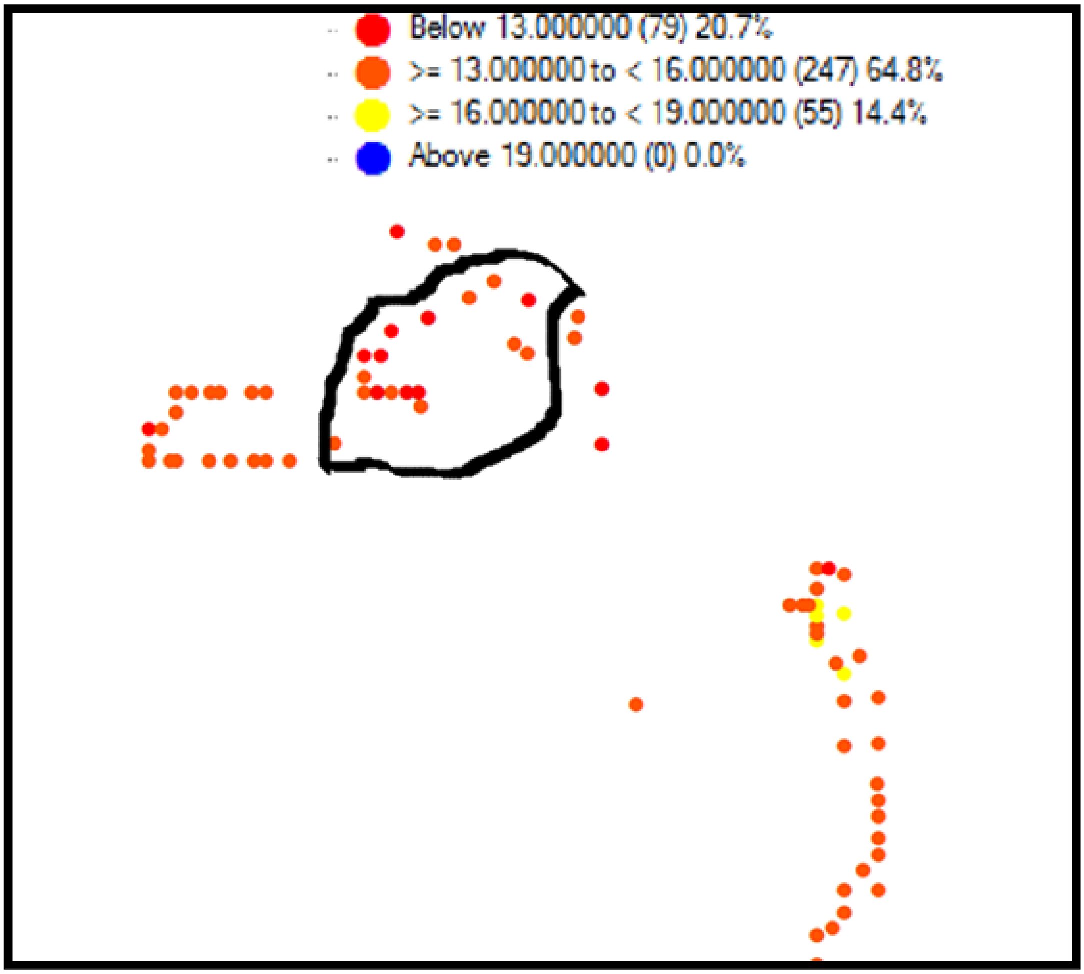
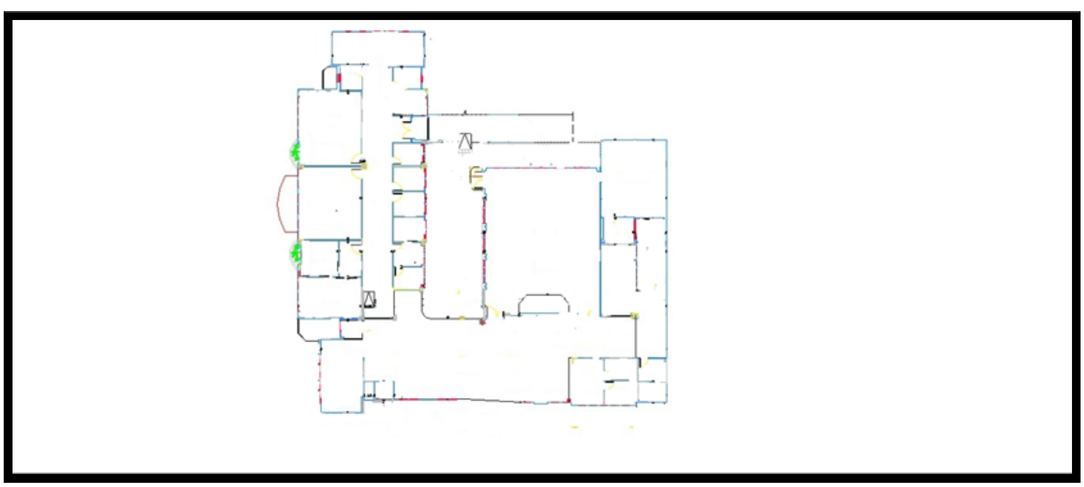


Figure 4.19: carrier to interface ratio in first floor in second building



The percentage of each level of C/I is shown in figure 4.20.

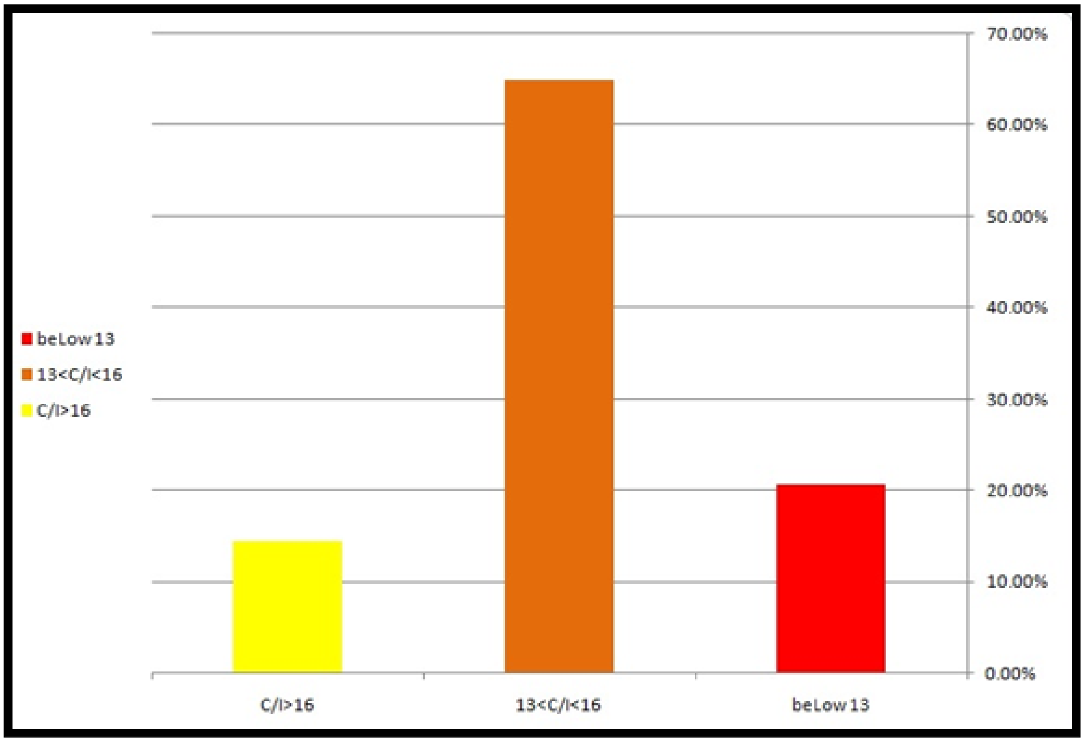


Figure 4.20: Carrier to interference ratio in the first floor of the second building

Second floor

In this floor there exist a problem. The C/I in large sub areas inside this floor was found to be less than 13dB. Figure 4.21 plots C/I for this floor.In some other places C/I was found to be acceptable.

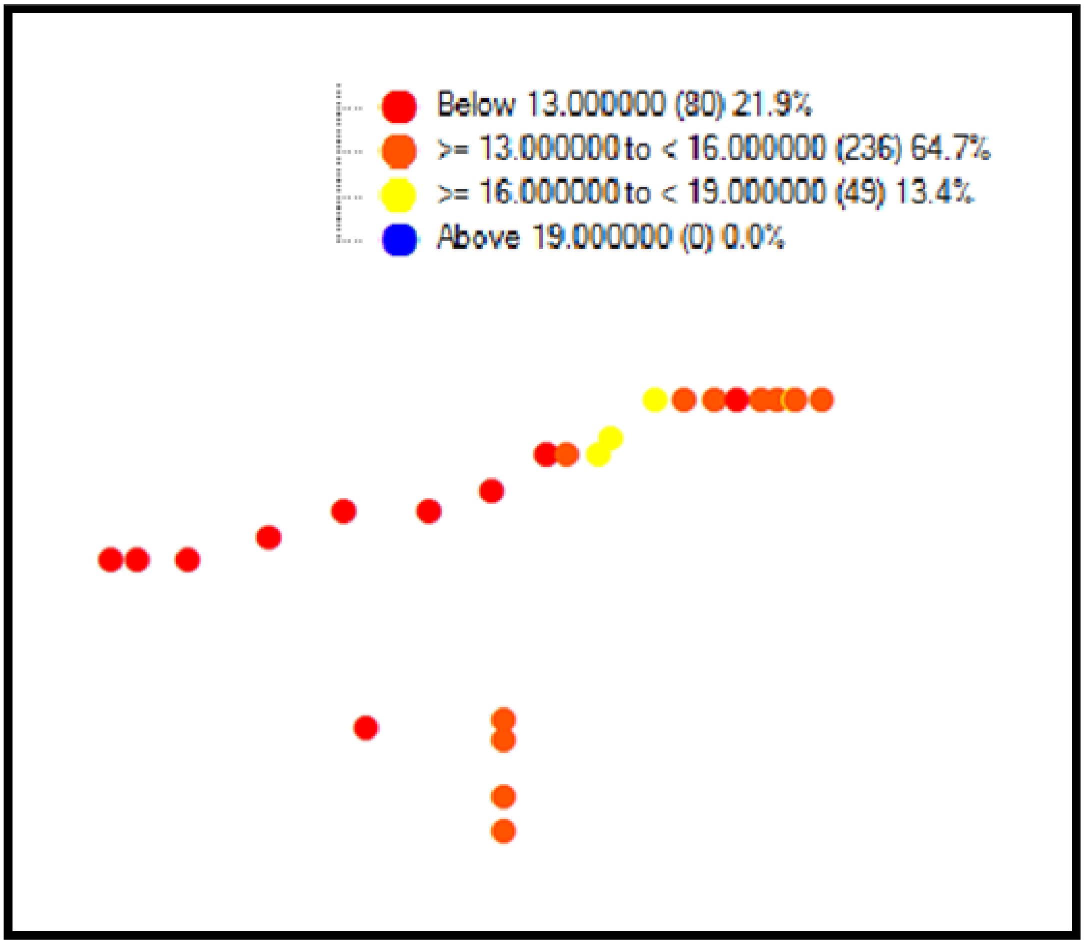


Figure 4.21: C/I in the second floor of the second building

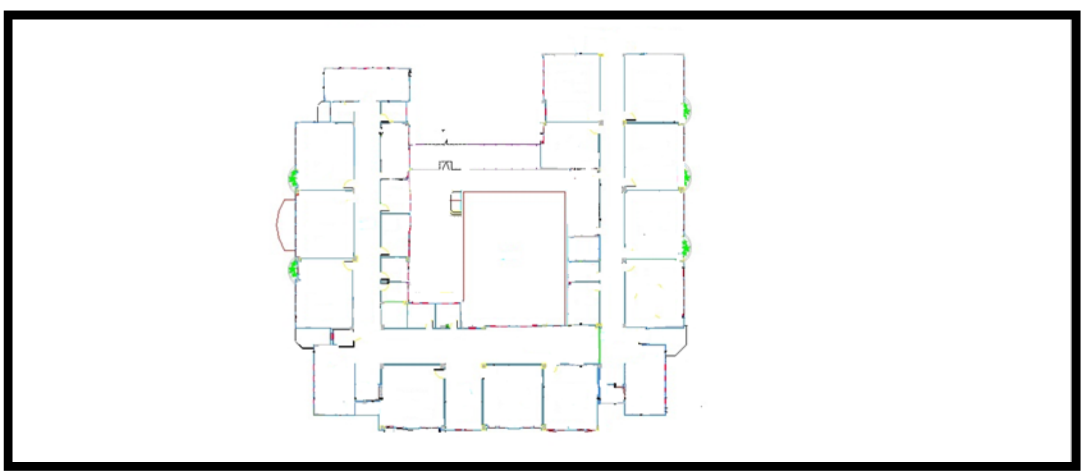


Figure 4.22 shows the percentage of C/I values in the different areas.

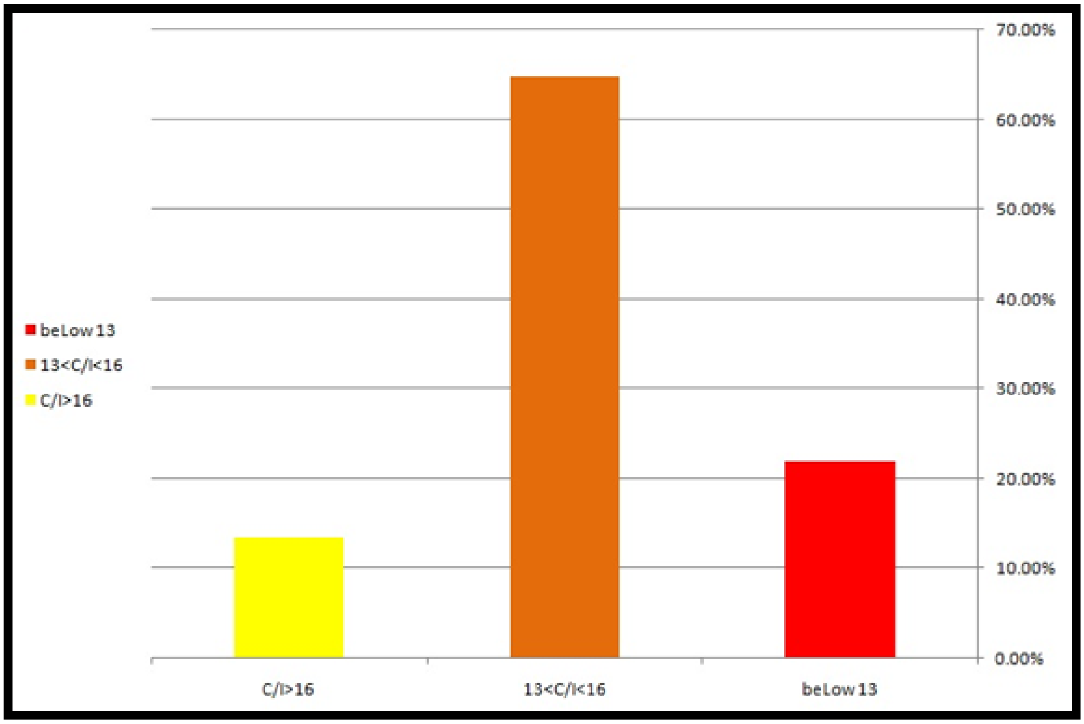


Figure 4.22: C/I in the second floor of the second building

Third and fourth floors

Figure 4.23 shows the C/I ratio in these floors. The figure shows that all values of C/I are within the acceptable range (¿13dB).

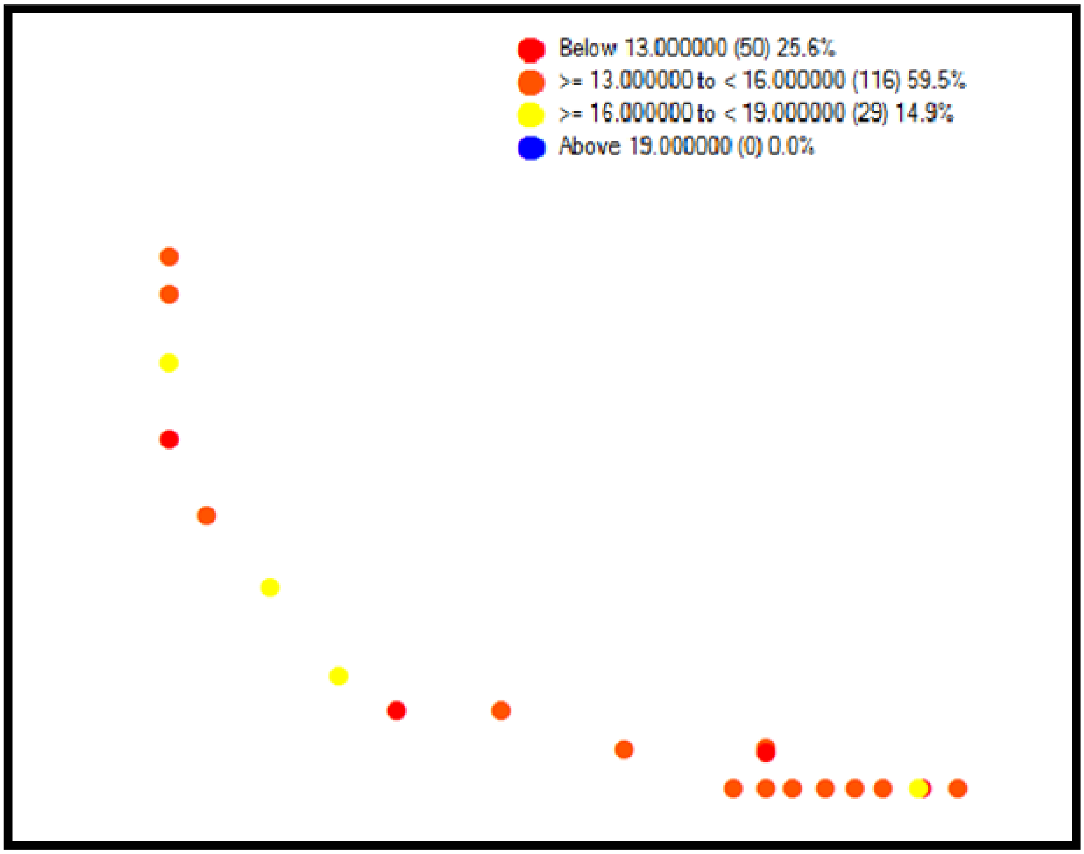


Figure 4.23: C/I in the third and fourth floors

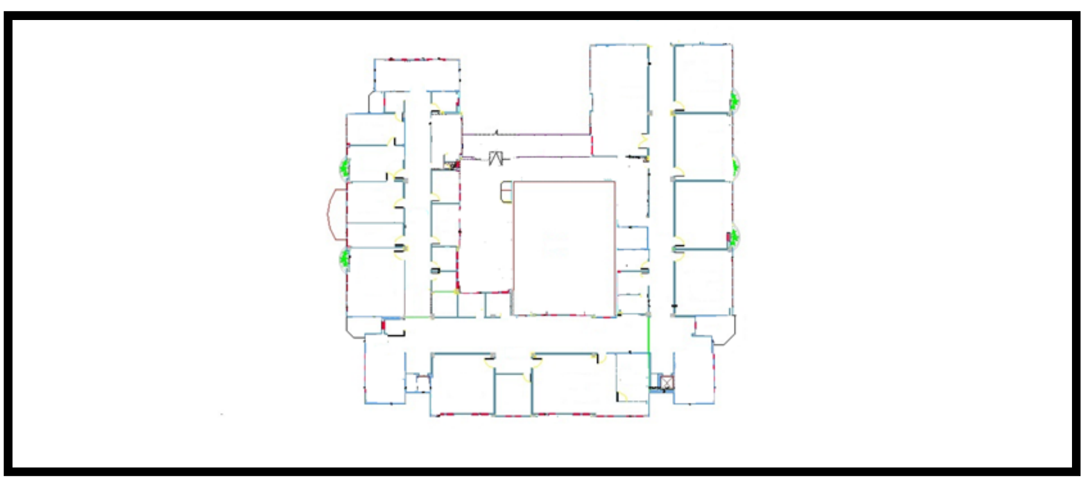


Figure 4.24 shows the percentage of each level to C/I ratio, where the red color indicates bad signal.

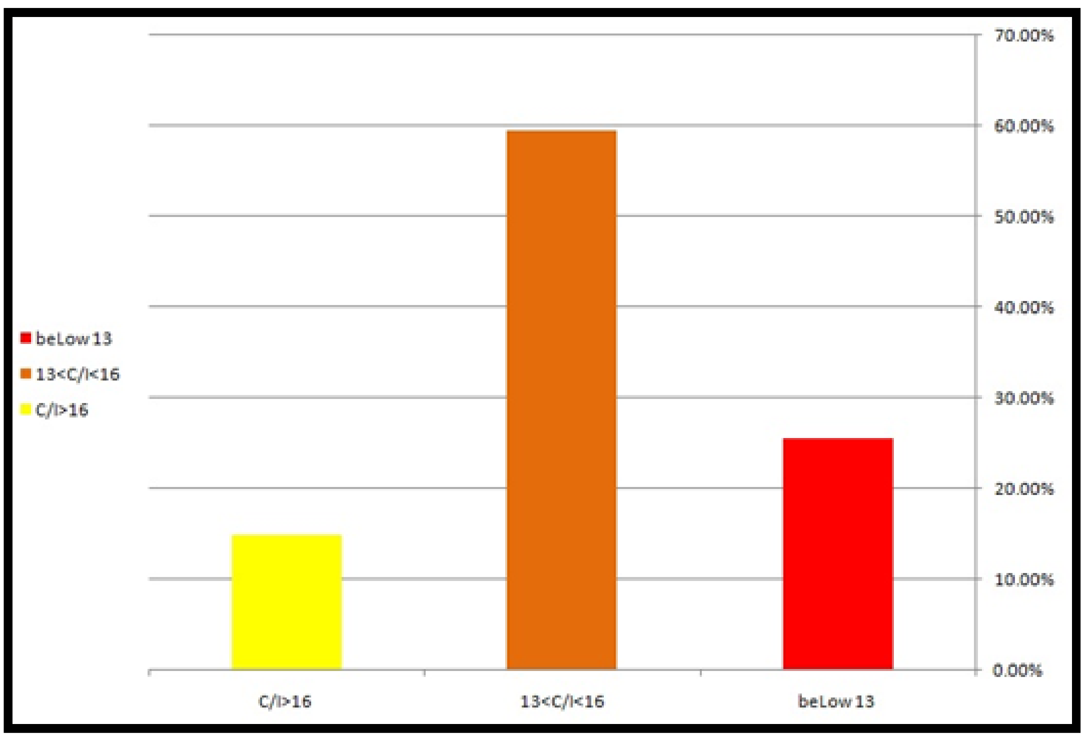


Figure 4.24: C/I in the third and fourth floors of the second building

Fifth floor

Figure 4.25 plots the C/I in this floor. The results show that C/I inside this floor is bad where the percentage of pointsbelow 13dB is high.

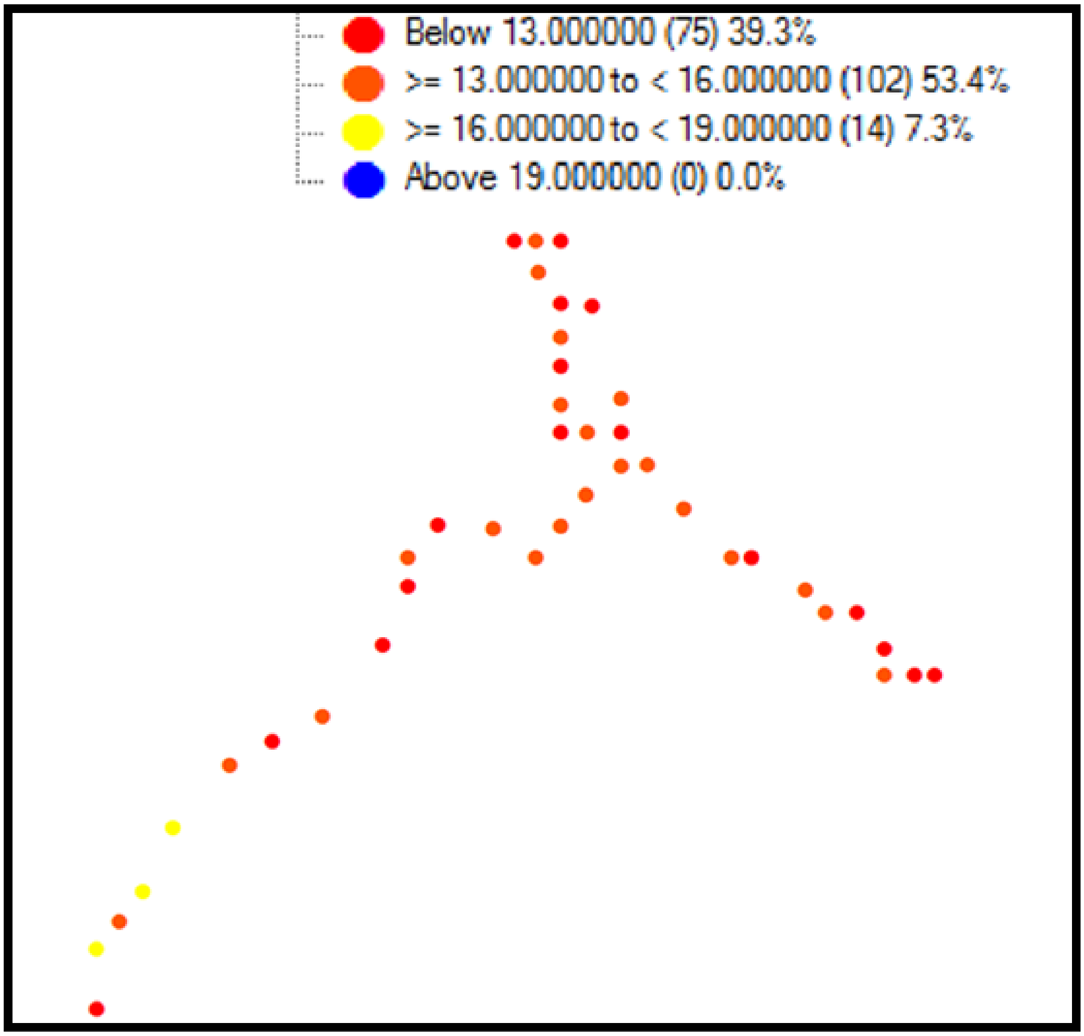


Figure 4.25: C/I in the fifth floor

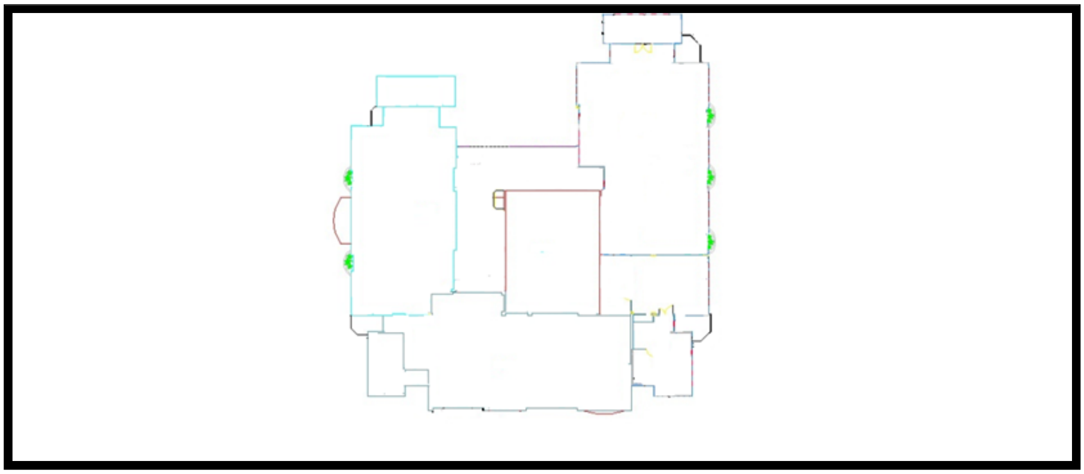


Figure 4.26 plots the percentage of each level to C/I ratio where the red color represents bad signal.

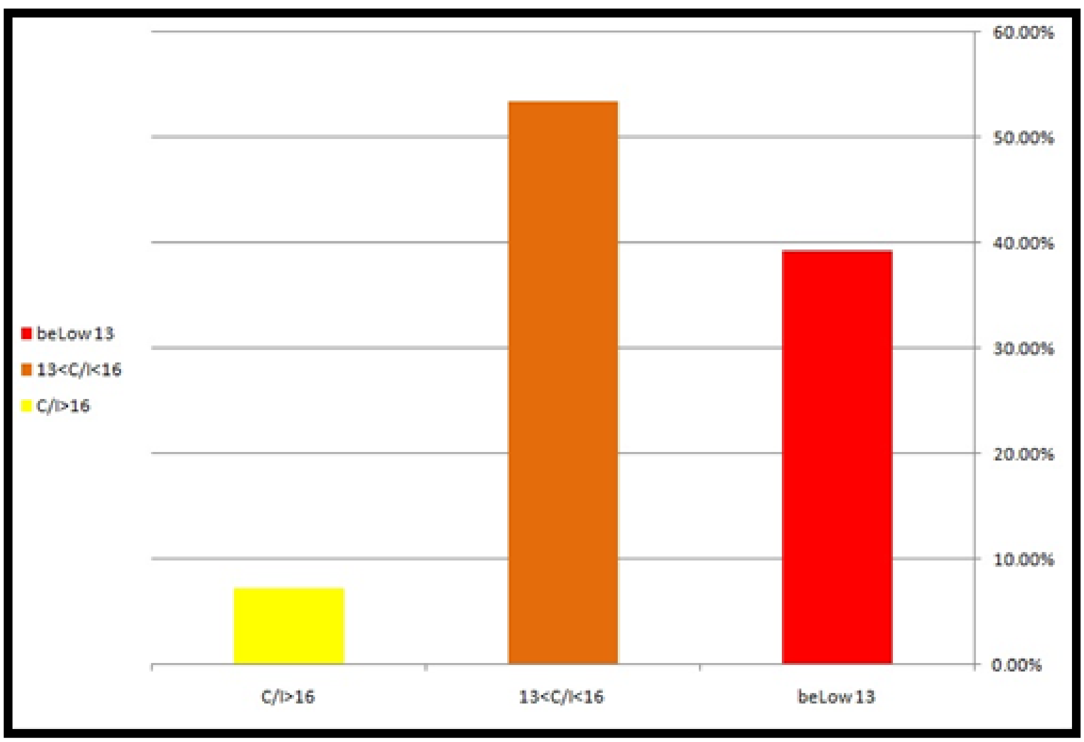


Figure 4.26: C/I in the fifth floor of the second building

Cafeteria

TheC/I ratio in this floor is shown in figure 4.27. It can be see that the signal quality in some areas in this floor is bellow 13dB, where most area is located within the normal

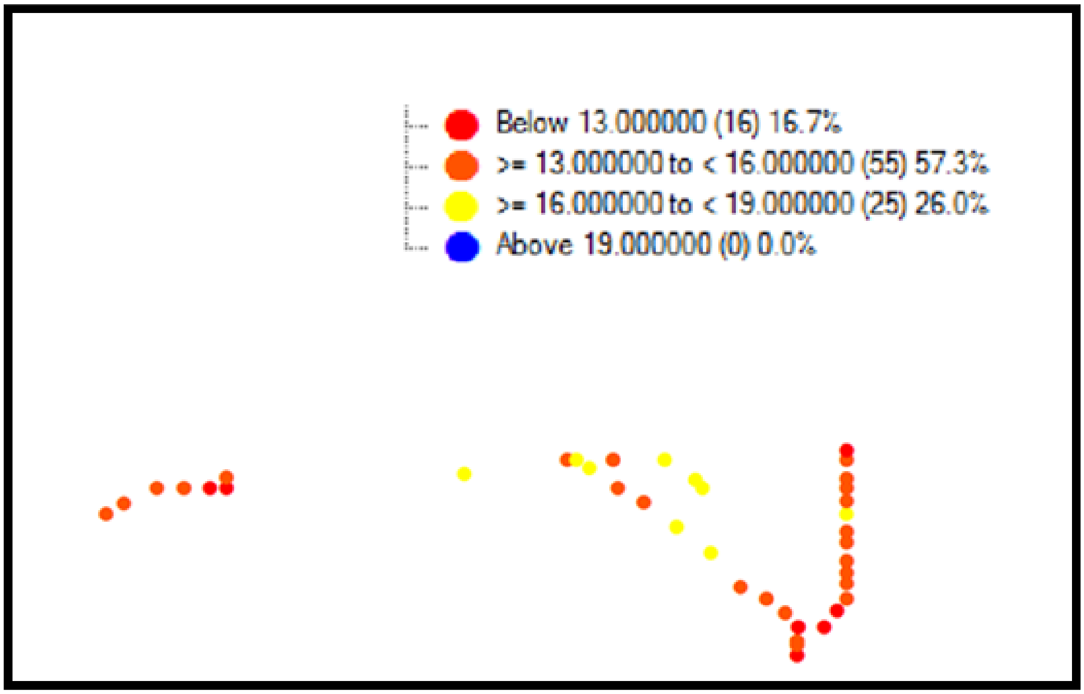


Figure 4.27: C/I in the cafeteria

Figure 4.28 shows the percentage of each level to C/I ratio, where the red color indicates

bad signal.

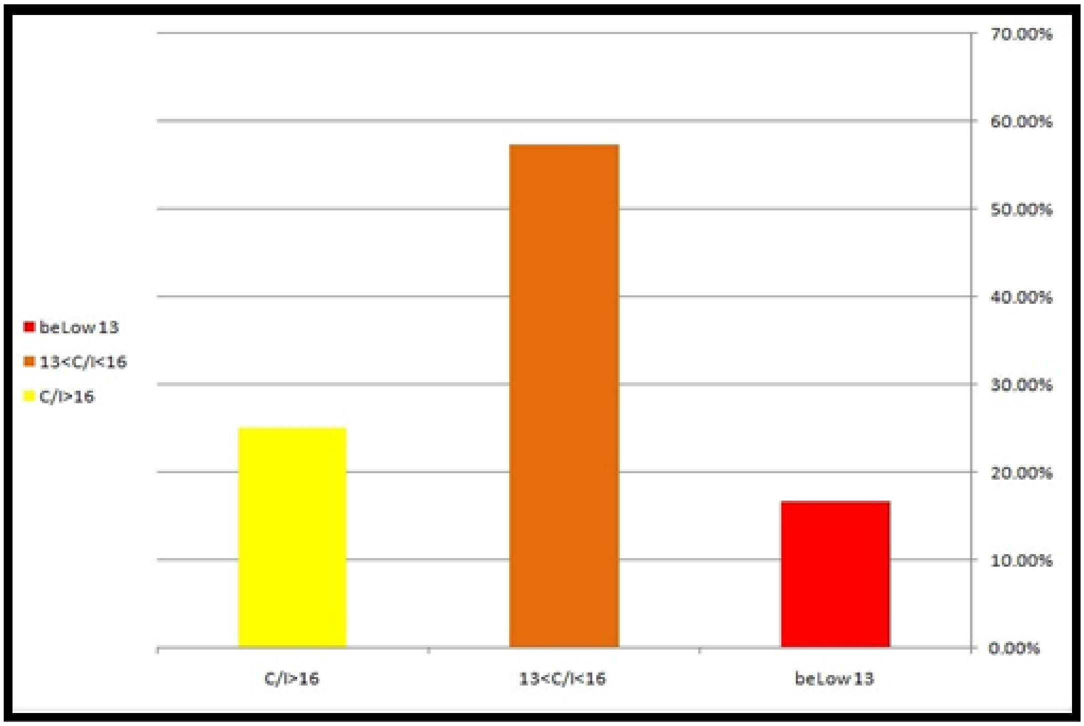


Figure 4.28: C/I ratio in cafeteria

Piazza

Figure 4.29 shows The C/I ratio in the piazza around buildings ,It can be sees that the signal quality in some areas in this floor is bellow 13dB, where most area is located within the normal range.

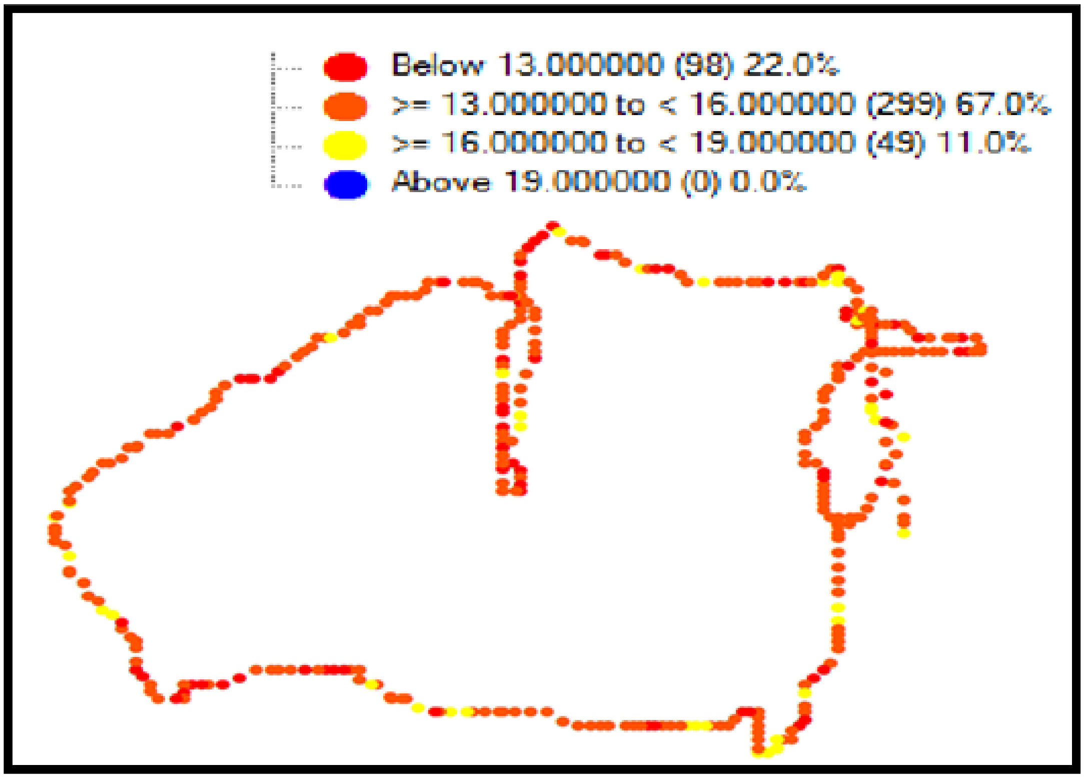


Figure 4.29: C/I ratio in piazza

Figure 4.30 shows the percentage of each level to C/I ratio, where the red color indicates bad signal.

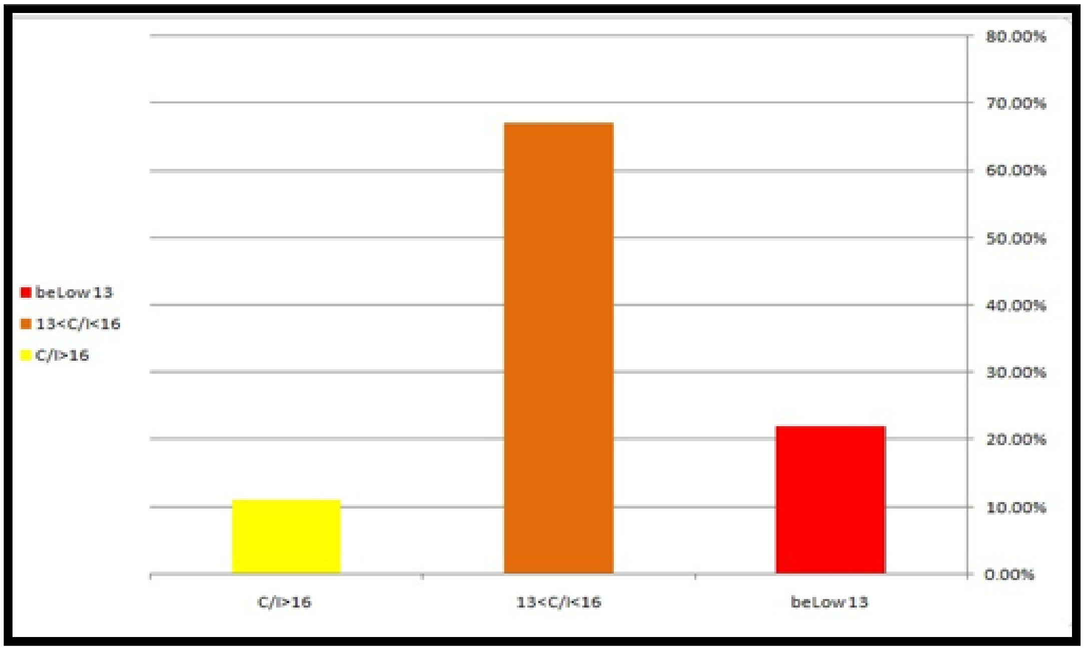


Figure 4.30: C/I ratio in piazza

4.3 Analysis of Signal Quality

In this part we take measurements by using Nemo handy (drive test) and analyze these results using the special analyzer software called ACTIX. To assess signal quality, we need to study the signal level for each floor inside university buildings and in each sub area inside and outside the university. The signal quality is assumed to be good if it is below 6. Values above of this threshold indicates bad quality. Signal quality measurement determine the quality of voice calls communications.

4.3.1 First building (IT center of excellence)

First floor

The signal level and quality in this floor is shown in the following figure 4.31.The figure shows the signal level represented by points with blue color. Blue Color represents signal quality range below 6.It can be concluded that the signal quality range in the first floor is good. In some small areas, the quality is not acceptable.

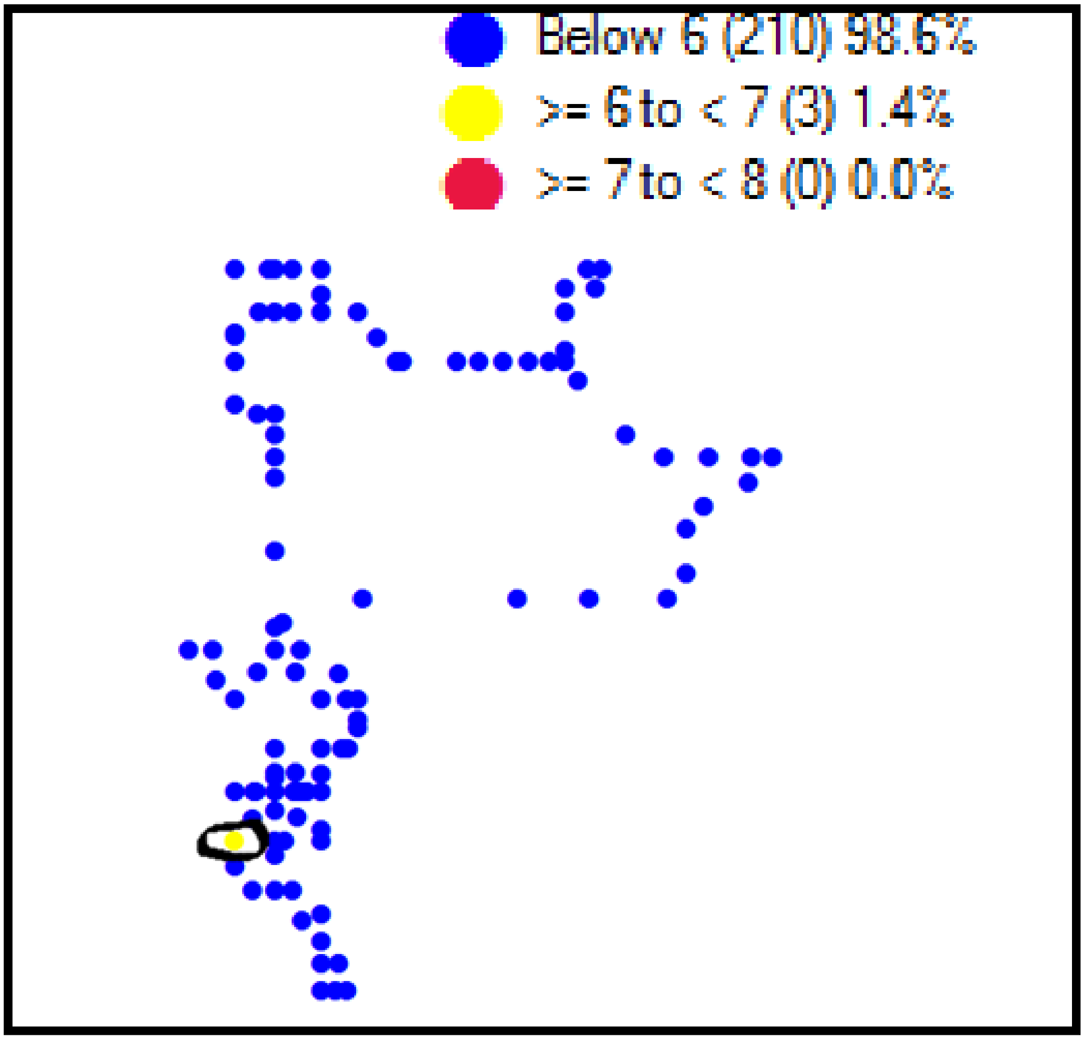
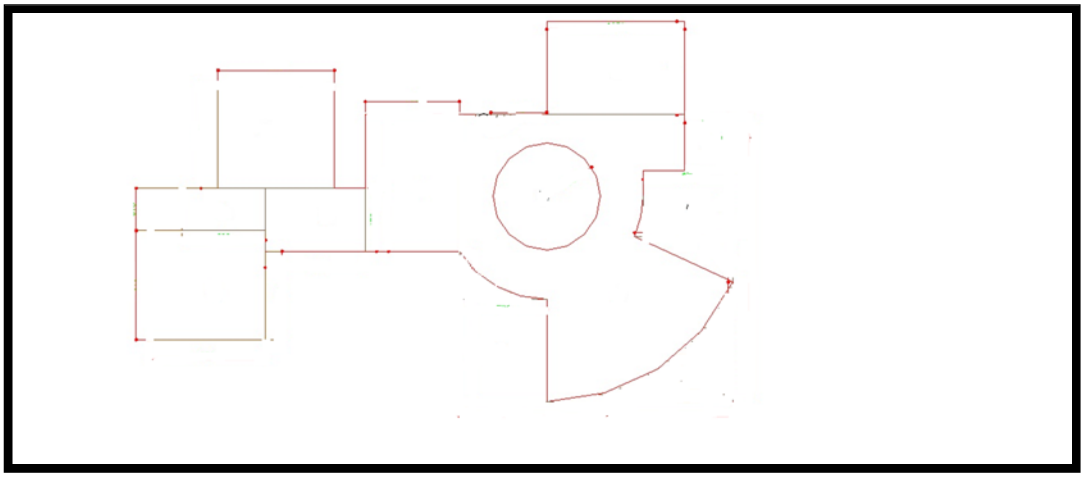


Figure 4.31: signal Quality in fawzi building first floor.



4.3.2 Second building

First floor

Figure 4.32 plots the signal quality in first floor. Most points are blue, i.e. normal signal quality range (6-7). There are some points with red color, which means that the quality of signal is bad.

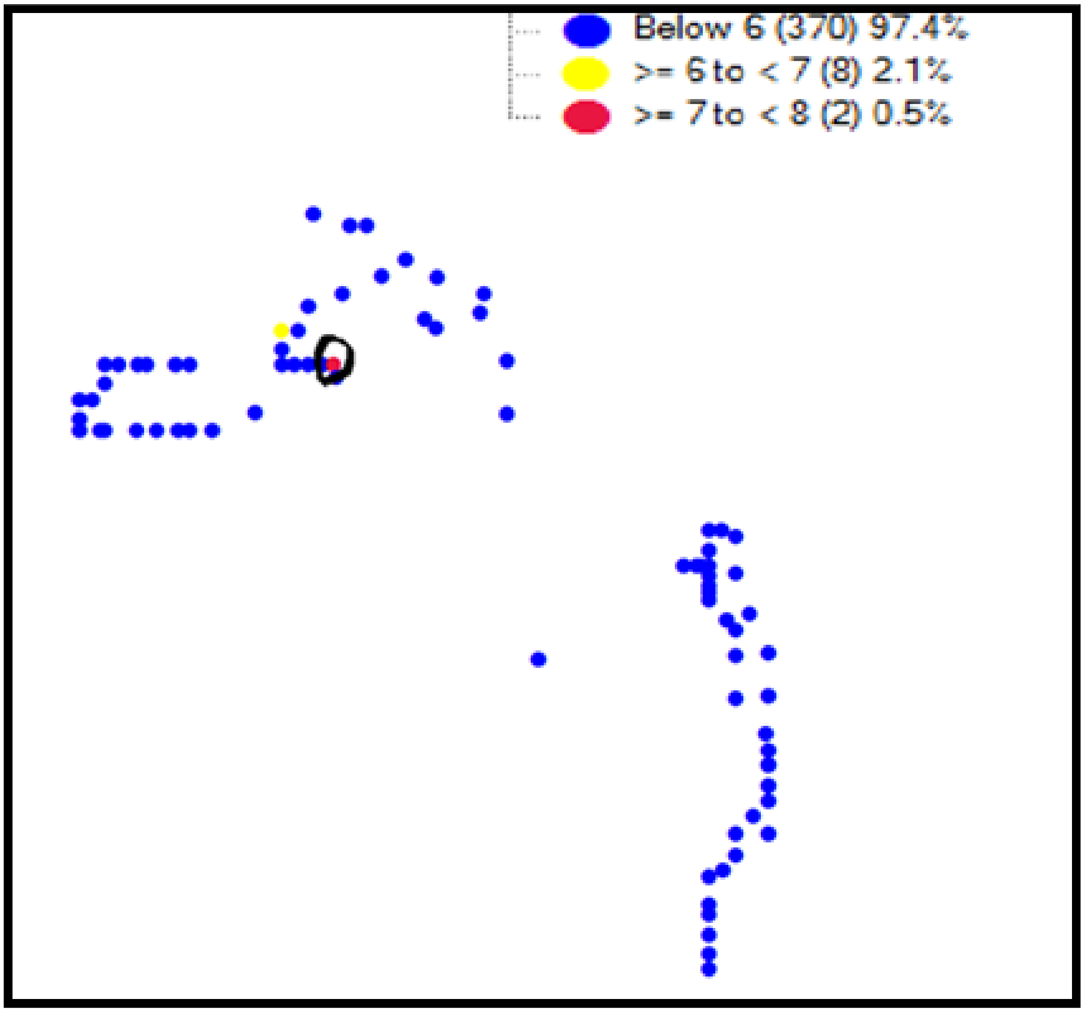
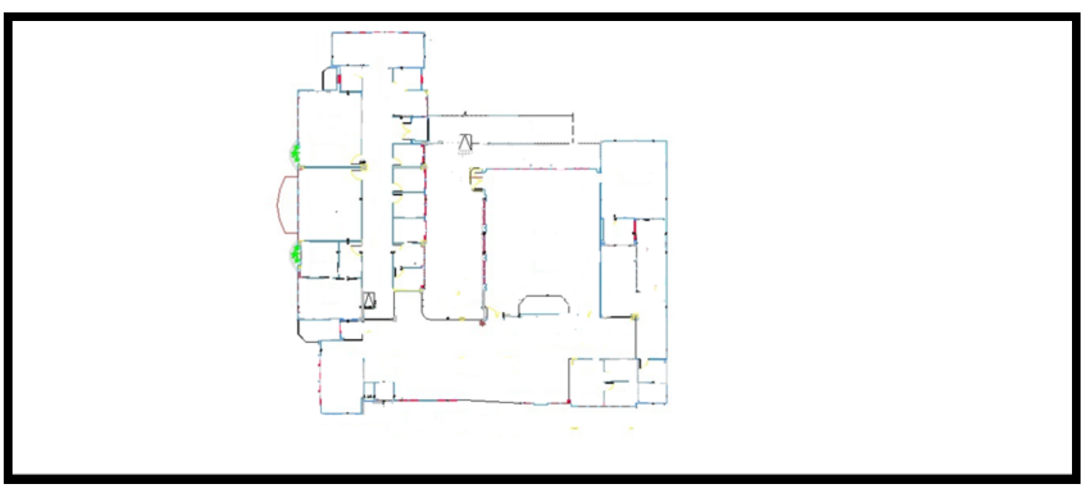


Figure 4.32: signal quality in first floor.



Second floor

Figure 4.33 shows the signal quality in second floor. Most points fall within

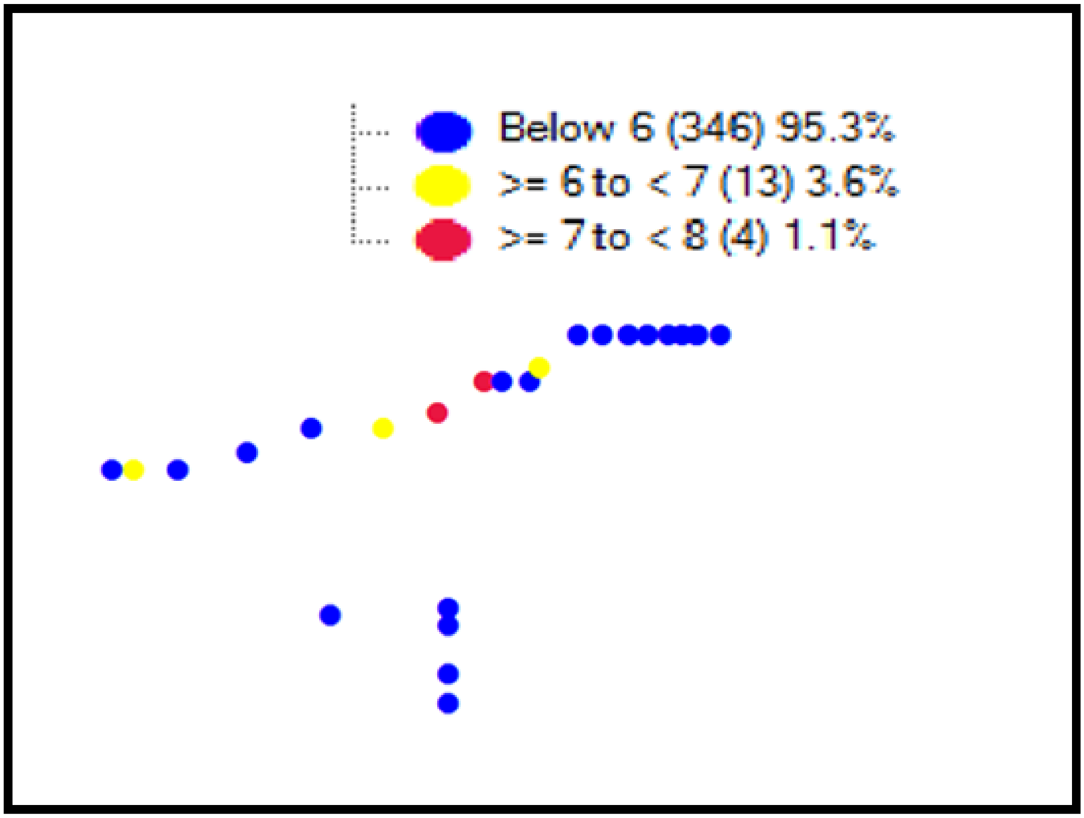
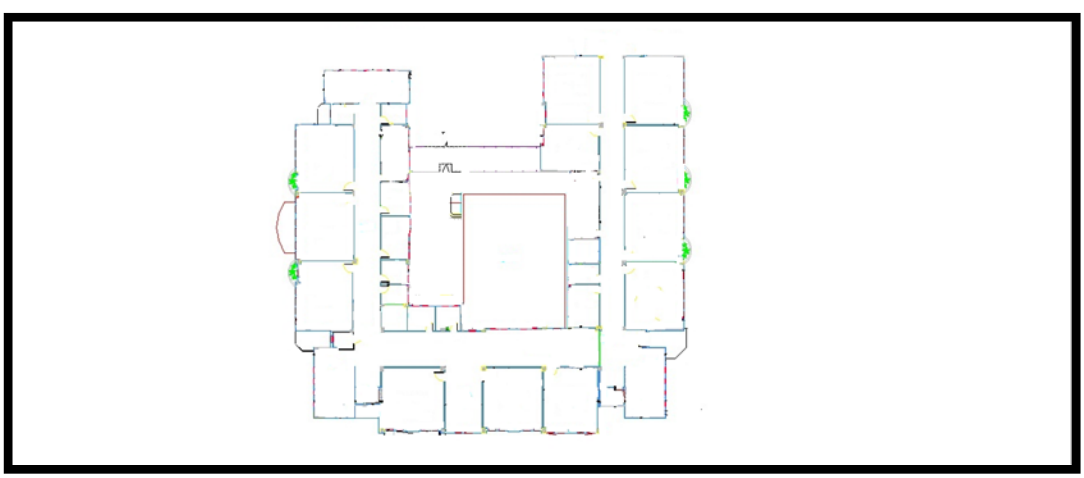


Figure 4.33: Signal quality in the second floor.



Third floor

The signal in this floor is shown in figure 4.34. The results indicate good quality in this floor.

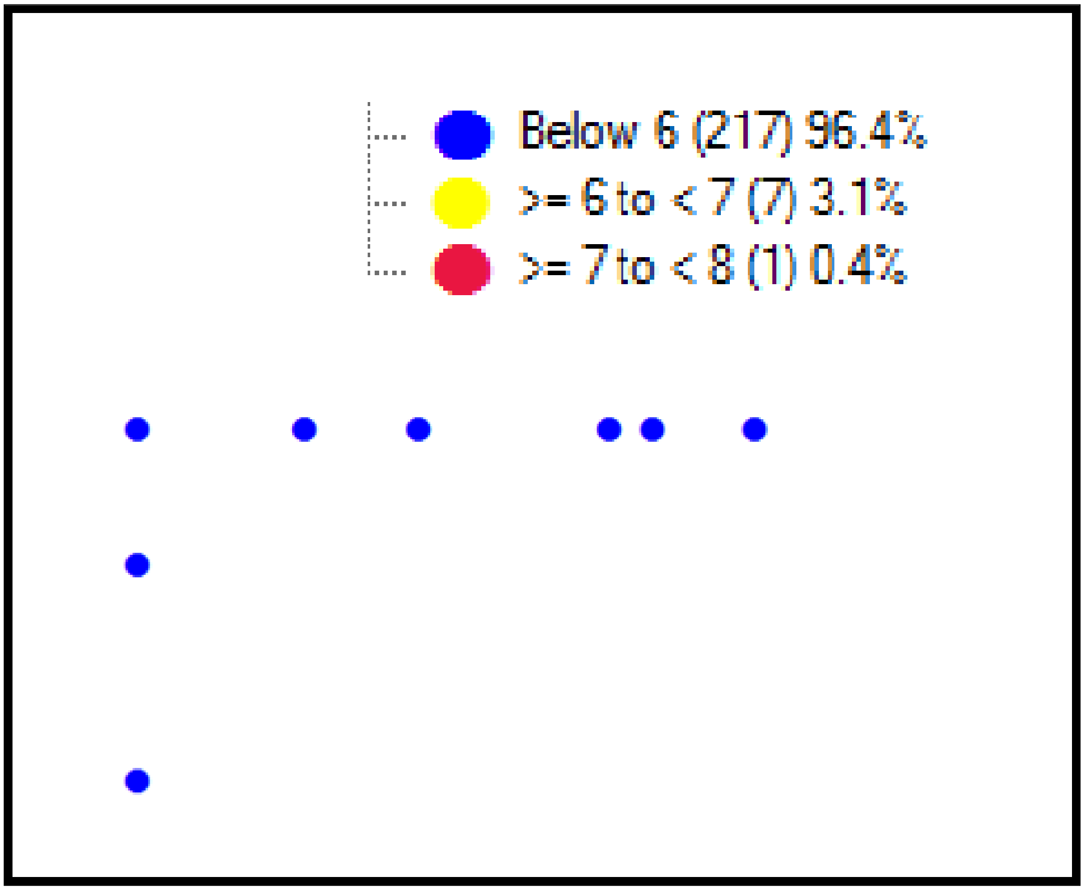
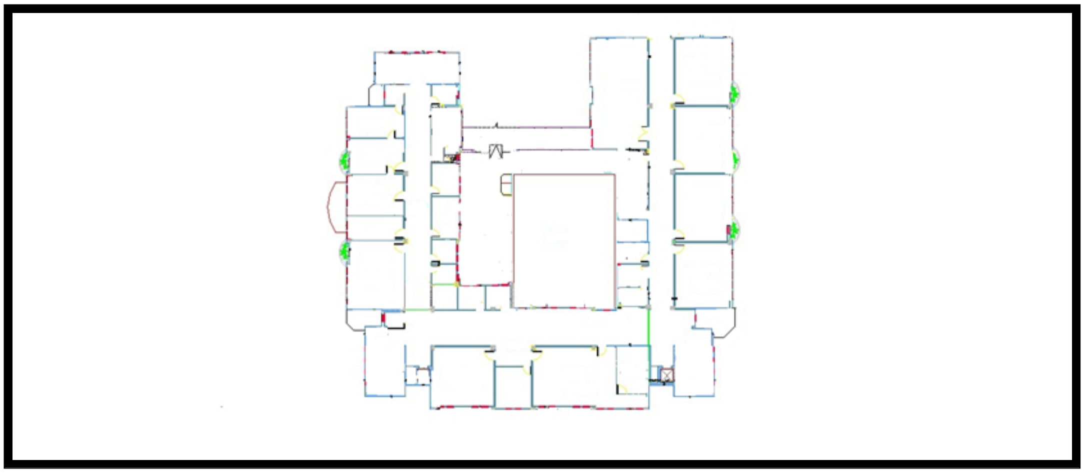


Figure 4.34: signal quality in third floor.



Fourth and fifth floors

Figures 4.35 and 4.36 show that the fourth and fifth floors have good quality of signal level. But, there is a small area in which the quality is worse than the other areas, i.e. from 6 to 7.

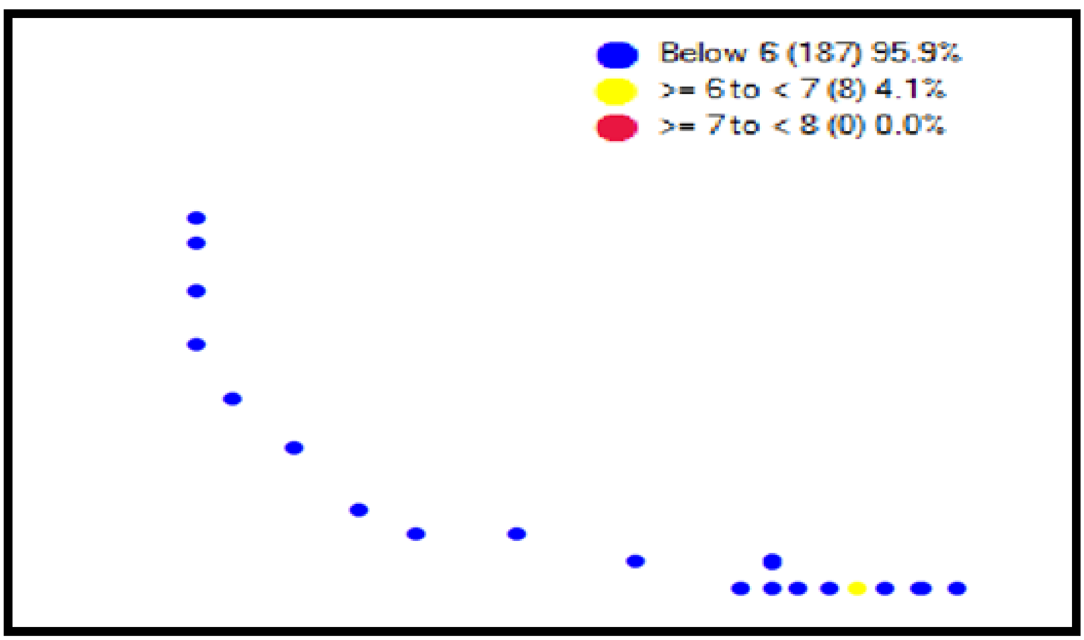


Figure 4.35: Signal quality in fourth floor.

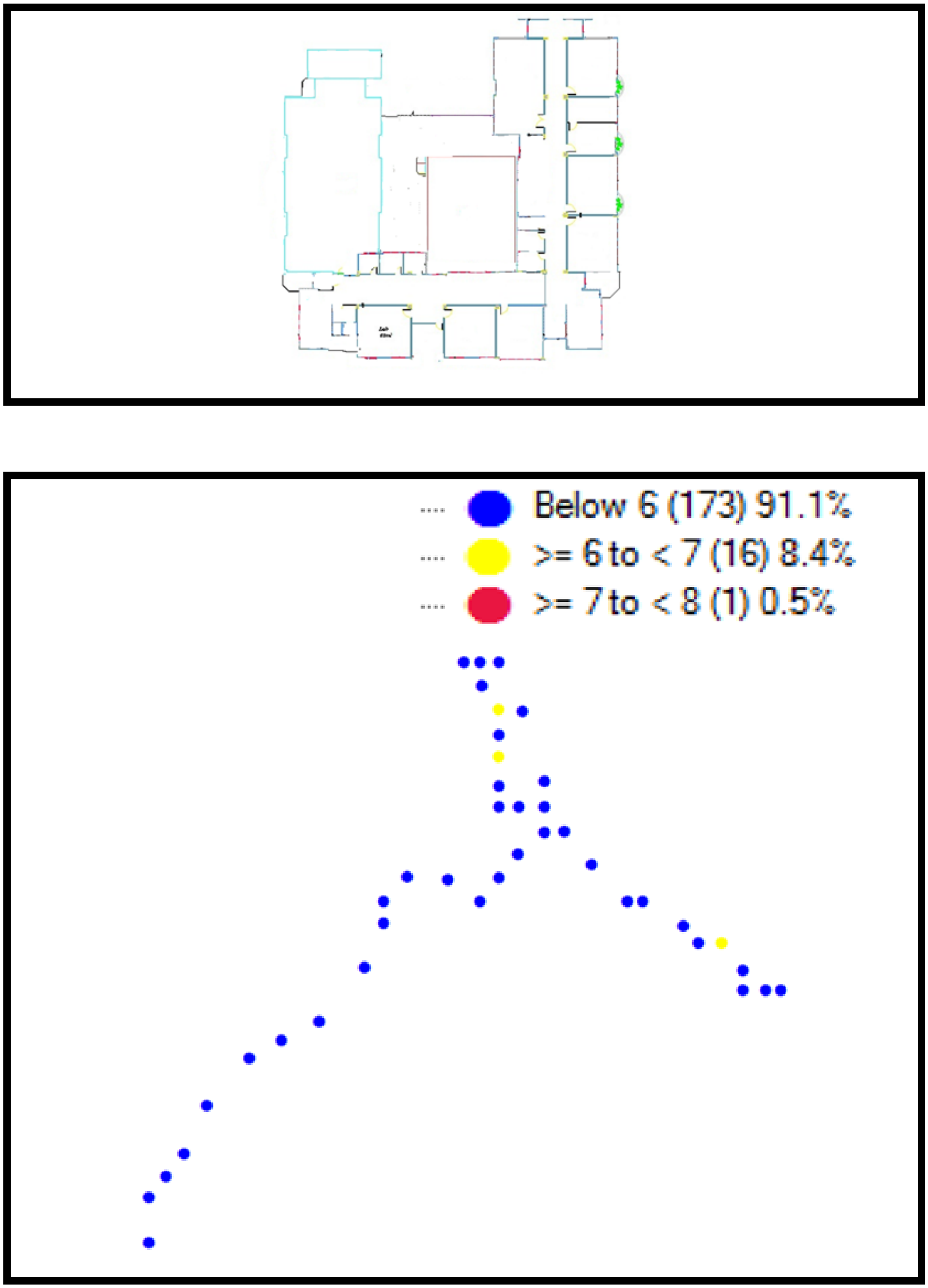
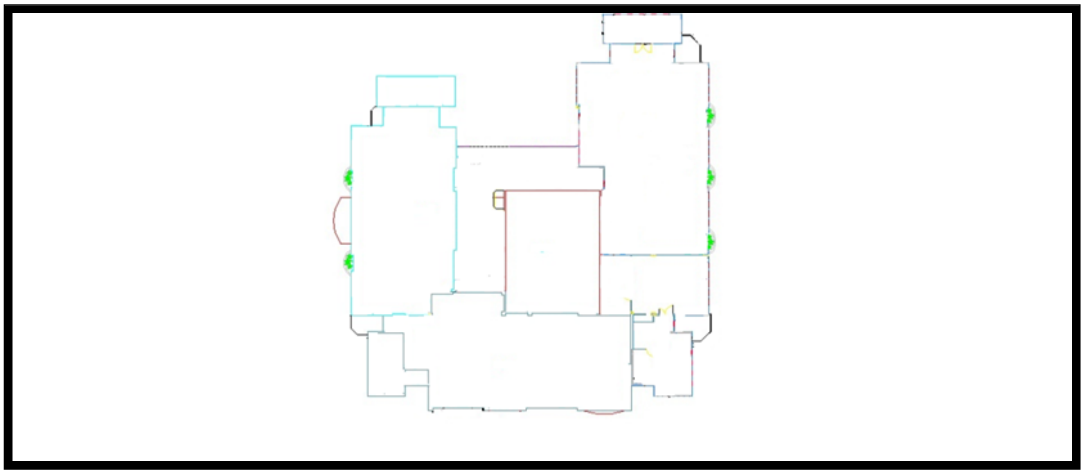


Figure 4.36: Signal quality in fifth floor.



Cafeteria

The cafeteria is an important place because most of the time large number of student sexist in this place. Figure 4.37 shows the signal level in the cafeteria. Figure 4.37 shows that most points in the cafeteria are well covered expect some areas it's range above 6 and these points are marked as yellow color points.

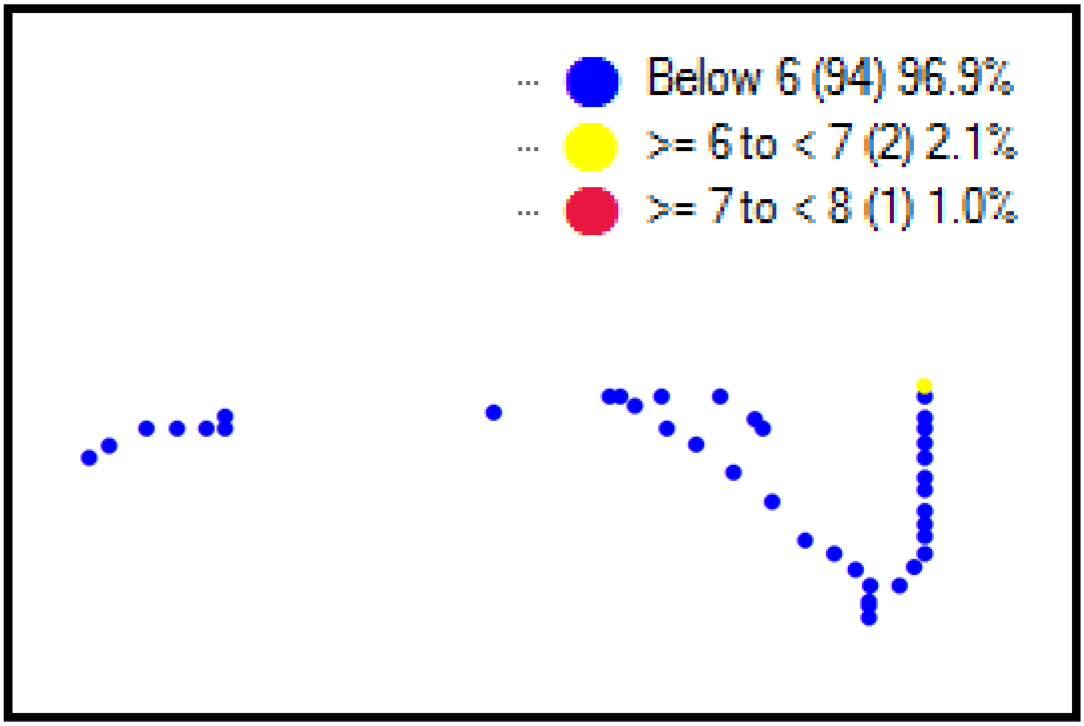
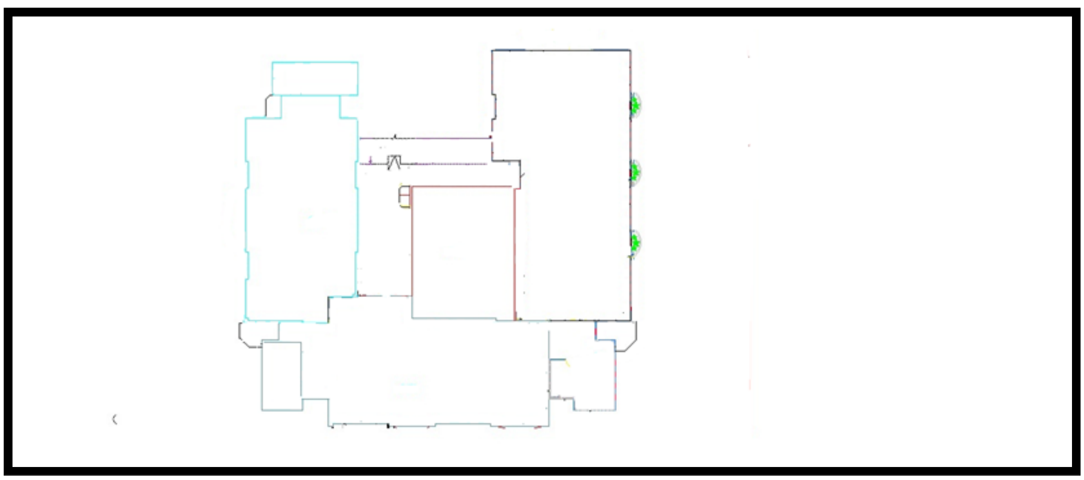


Figure 4.37: Signal quality in cafeteria.



Piazza

Figure 4.38 shows the signal quality in the piazza around buildings. It can be seen that the signal quality in some areas in the range above 6, where most area is located within the normal range.

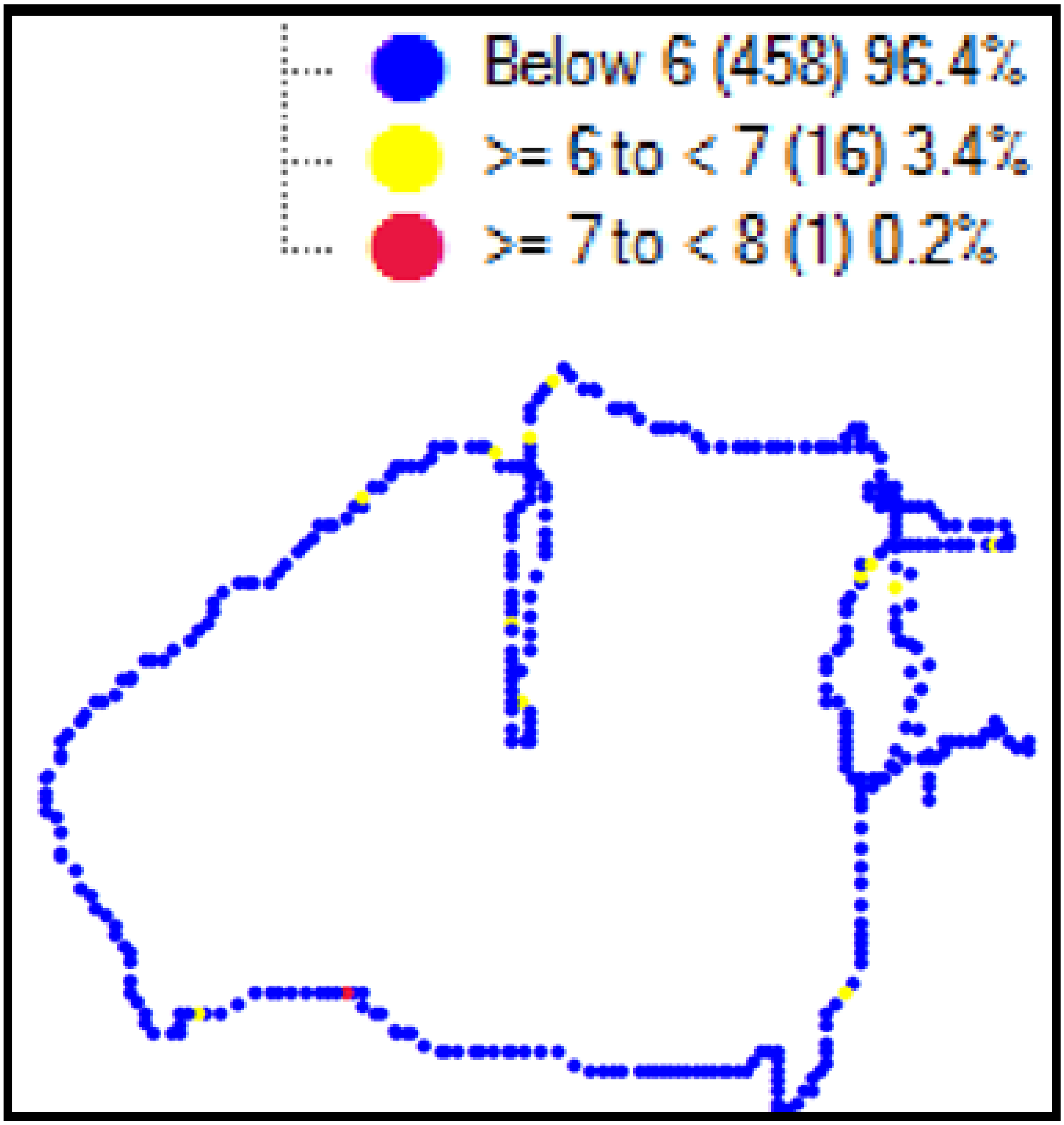


Figure 4.38: Signal quality in piazza.

4.4 Analysis of congestion problem

The area under consideration is served by 4 Cells from outside the university. This outer spillage will increases and stimulate the handover rate negatively inside the University campus "as ping pong situation" since no dominant server is available inside the campus. Accordingly, the TCH drop rate will increase negatively due to spectrum scarcity and week spillage. Those cells showed a range of TCH Drop up to 1.15 percentage , and those cells gets congested as per our statistics for more than 20 days in the academic year 2013 for over 100percentage . Taking into consideration bad KPI's will lead to bad perception and then to customers dissatisfaction. Also need to reemphasize that having the hot spots like universities separated by coverage would minimize affecting the capacity by new buildings and population outside the university campus which would create special kind of service and high customer service inside the university. Jawwal company have received many complaints from inside the offices in the collage itself which would show clearly in the walk test.

4.5 Conclusion

After analyzing drive test measurements using ACTIX software, it has been found that some coverage and signal quality problems exist at Abu roman campus. Congestion was observed during some time intervals. Using the challenger software package, it has been found that congestion intervals match with activities and events that took place in the campus.

Chapter 5

Proposal solution for problem

In this chapter we conclude the report. Proposals for the identified problems are provided.

5.1 Conclusion

After analyzing drive test measurements using ACTIX software, it has been found that some coverage and signal quality problems exist at Abu roman campus. Congestion was observed during some time intervals. Using the challenger software package, it has been found that congestion intervals match with activities and events that took place in the campus.

5.2 Proposals solutions for congestion and capacity problems

5.2.1 Cell splitting and sectoring

5.2.1 Cell splitting and sectoring Cell splitting and sectoring is a possible approach for enhancing channel capacity. Each of those has some pros and cons, which decides different area for applying them. It is known that the capacity of a cellular communication system can be increased using cell splitting and sectoring. The extent to which the capacity increment can be achieved is dependent on signal-to-interference ratio. The results show that when properly and orderly carried out, the cell splitting technique has the capability of increasing the capacity of a congested cellular system. Cell splitting achieves capacity improvement by essentially rescaling the system. By decreasing the cell radius R and keeping the co-channel reuse ratio D/R unchanged, cell splitting increases the number of channels per unit area. But cost factor will increase. In cell sectoring the main demerit is increase handoff condition. Sectoring decreases the trunking efficiency while improving the S/I for each user in the system. So the Mircocell zone concept can avoid the handoff, less interference and better reception and transmission.

5.2.2 Coverage

The coverage of GSM wireless networks can be improved by several methods such as the antenna height, antenna power and antenna tilt. For better performance, it is required that antenna height and power should be large.

The efficiency of a cellular network depends on correct configuration and adjustment of radiant systems: their transmit and receive antennas. One of the most important system optimizations task is based on correct adjusting tilts, or the inclination of the antenna in relation to an axis. With the tilt, we direct irradiation further down (or higher), concentrating the energy in the new desired direction.

When the antenna is tilted down, we call it 'downtilt', which is the most common use. If the inclination is up we call 'uptilt'.

Chapter 6

solutions for the problems on GSM

this chapter, we will propose and discuss possible solutions for the problems of coverage and capacity. The aim is to improve service on campus through a series of changes. Firstly, we try to resolve the problems by configuring the base stations that cover the university. Then, we develop and study an indoor solution. Finally, we study the idea of deploying a new outdoor site for Abu Romman campus.

6.1 Reconfiguration of Existing Sites

Abu Romman campus is currently covered by three sites (site 33, site 41 , site 68). Data related to those sites is used on MENTOM Planet software. We analyzed the signal strength prediction for each site. We try to control some variables and see the effect on coverage. The following figures show the signal strength radiations from each site before any configuration.

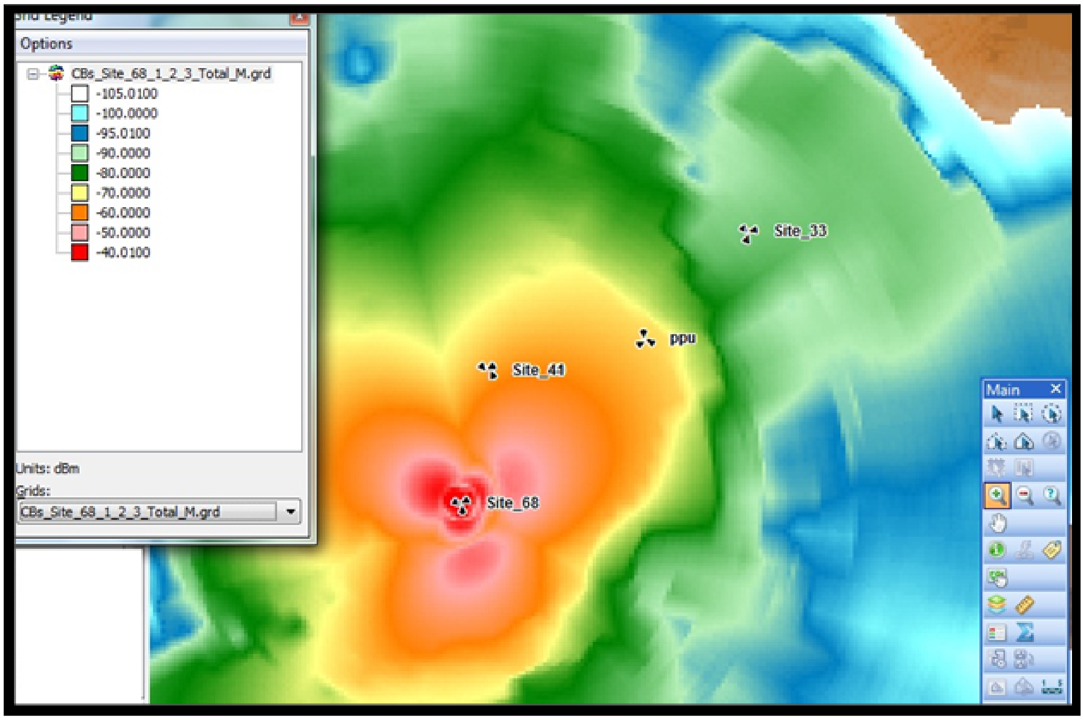


Figure 6.1: Site 68 Before Configuration

From figure 6.1, it is clear that the signal strength in PPU campus is about -70 dBm or even lower. This is due to the long distance between the site and the campus. Further, the site exists in the low-lying area.

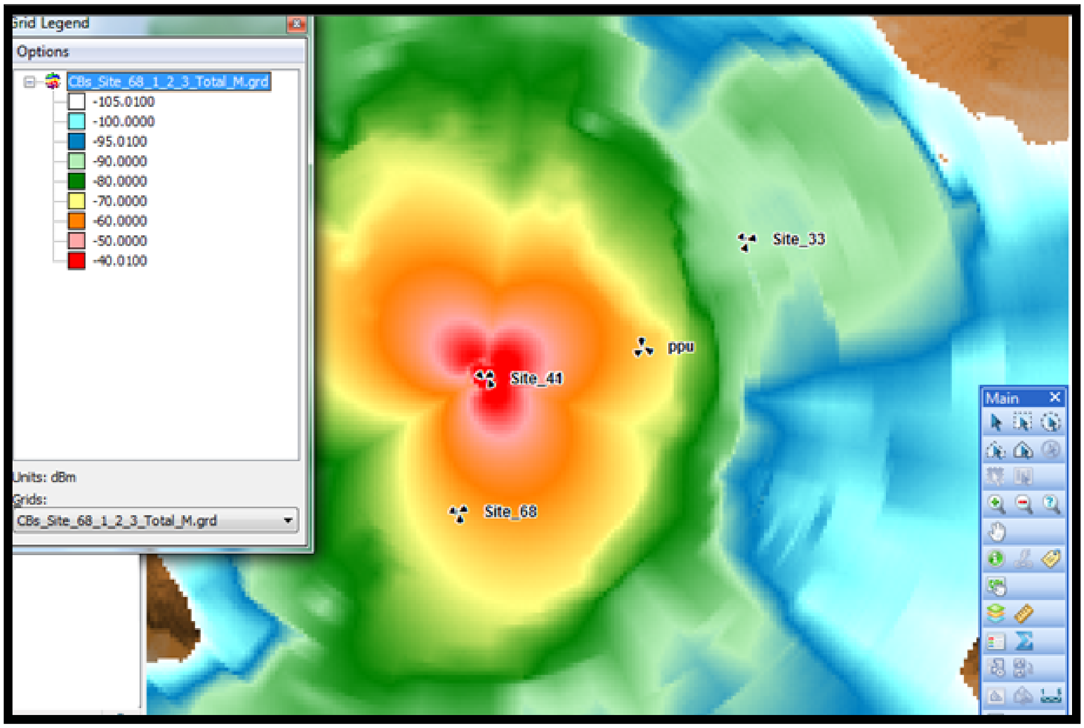


Figure 6.2: Signal strength from site 41 before configuration

Figures 6.2 and 6.3 show that weak signals from sites 41 and 33 reache the campus, due to the obstacles between the site and university campus. Also, the two sites exist in the low-lying area.

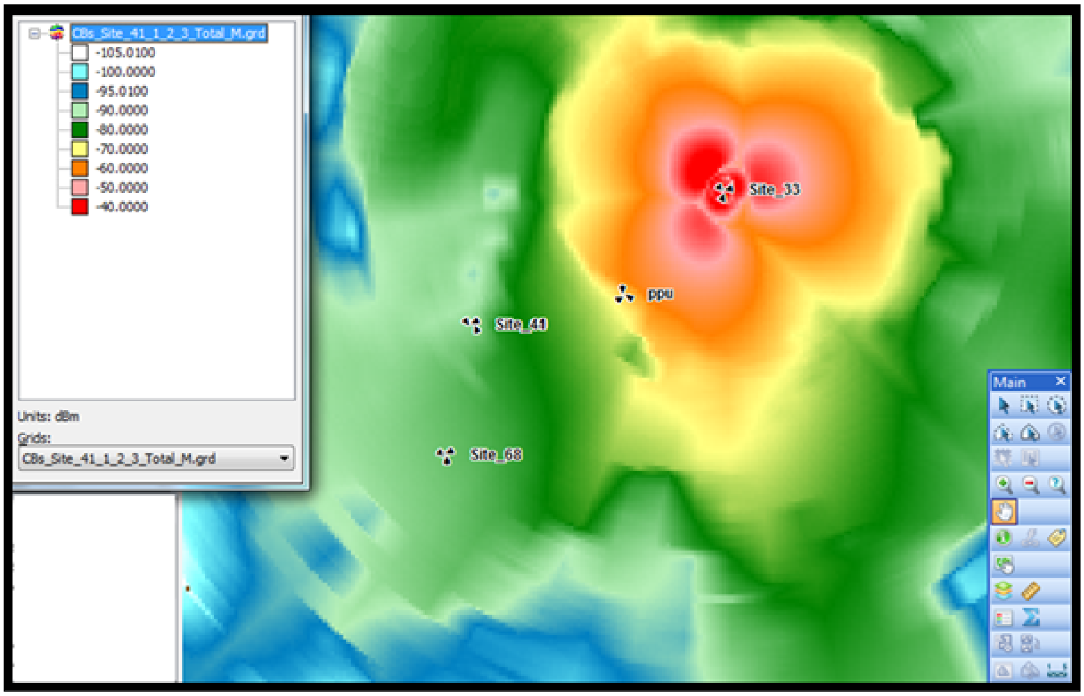


Figure 6.3: Signal strength from Site 33 before configuration

The reasons for getting weak signals from the three sites are:

- The long distance between the university and sites.
- The obstacles between the sites and the campus.
- The University is located in a high place, and this leads to the presence of many barriers preventing stronger signals at the campus.

Next we try improve the coverage by reconfiguring the three sites. Configuration includes the tilt, antenna height and antenna gain. The next section discusses the effect of such reconfigurations.

6.1.1 Reconfigurations of site 33

Using MENTOM Planet software we performed some changes on this site setting to reach try getting optimum coverage. We changed the antenna type, the tilt of antenna. Figure 6.4 shows the effect of using higher gain antenna on site 33. We found that the coverage is improved just around the site. No changes were observed at the campus.

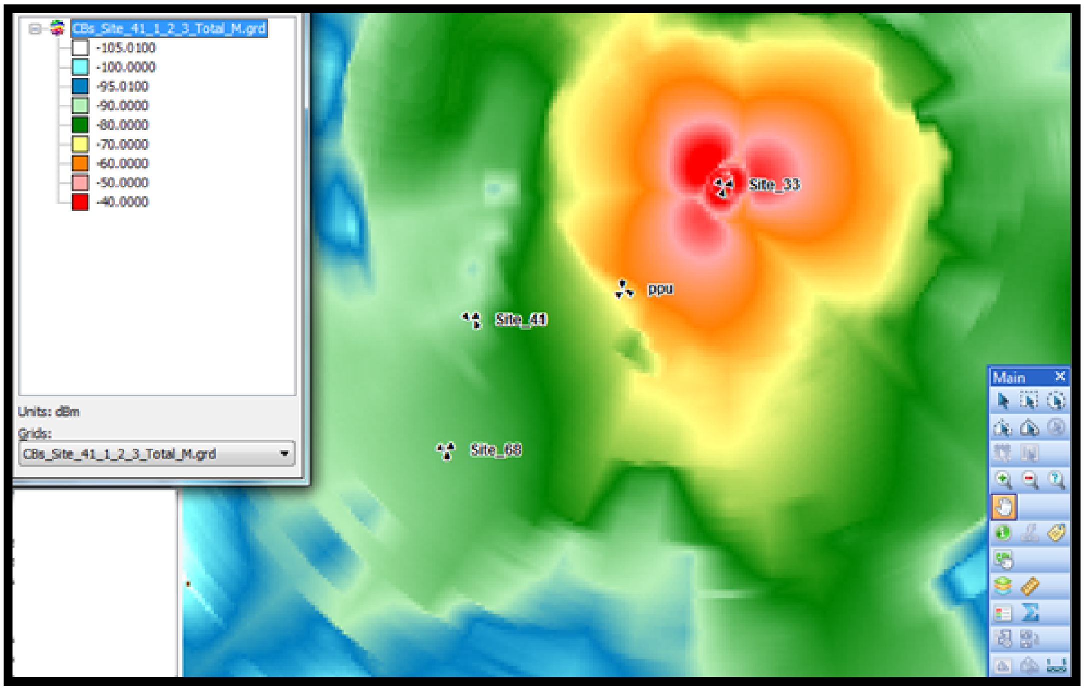


Figure 6.4: Signal strength for site 33 with higher gain

Figure 6.5 shows the effect of controlling the antenna tilt for site 33. Since the site is located below the below the university location, we used up tilt with -5 degree to directing the antenna to Abu-Romman buildings. We observed that this setting does not also improve coverage at the campus while the signal strength is decreased near site 33.

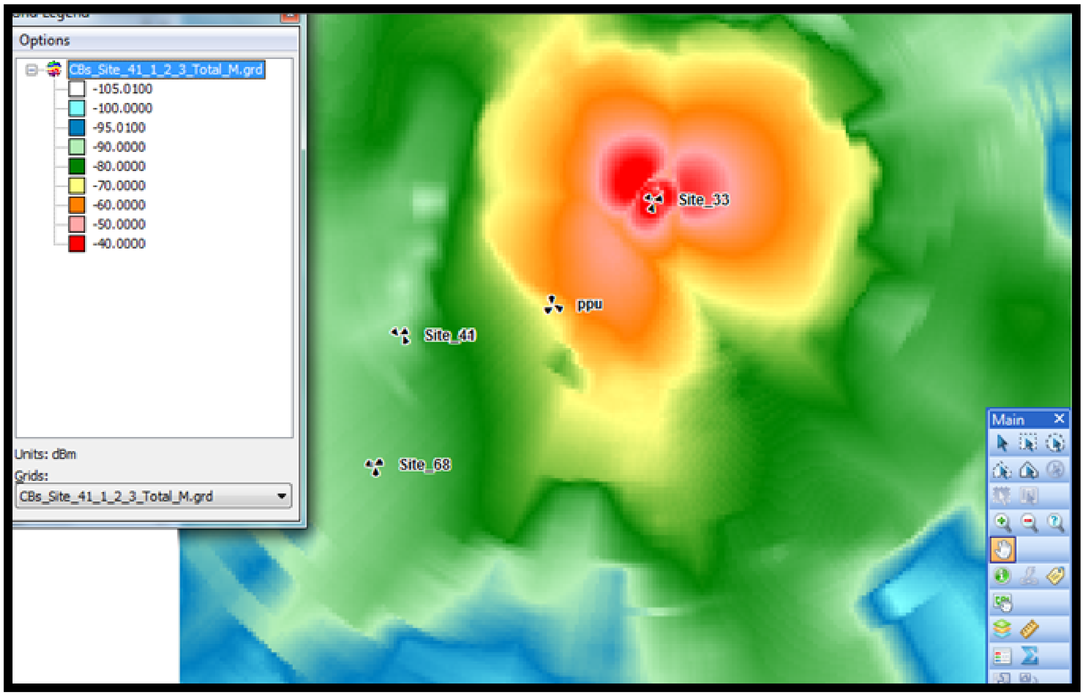


Figure 6.5: Signal strength for site 33 with tilt -5

Figure 6.6 shows the effect of applying down tilt with +5 degree and the prediction of signal strength reveals that the coverage increases in the area around site 33 and no change was observed at the campus.

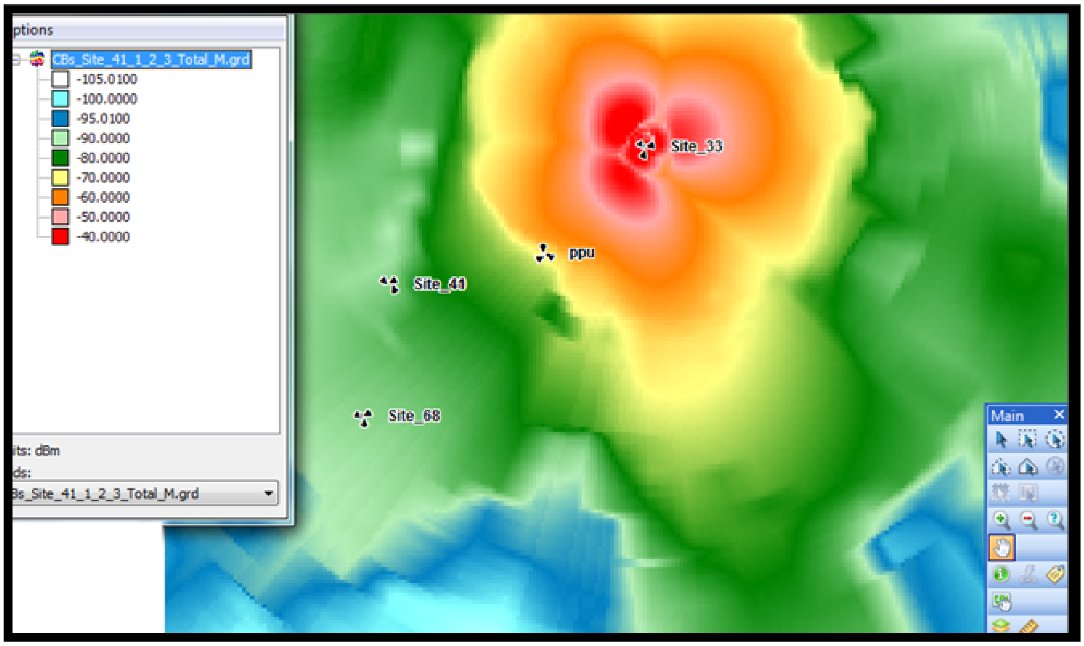


Figure 6.6: Signal strength for site 33 with tilt +5.

6.1.2 Reconfigurations of site 68

In site 68 first we change the antenna type and use the antenna with higher gain we found that the coverage is increased only for area near site and no changes on the campus ,the following figure 6.7 show The effect of this change.

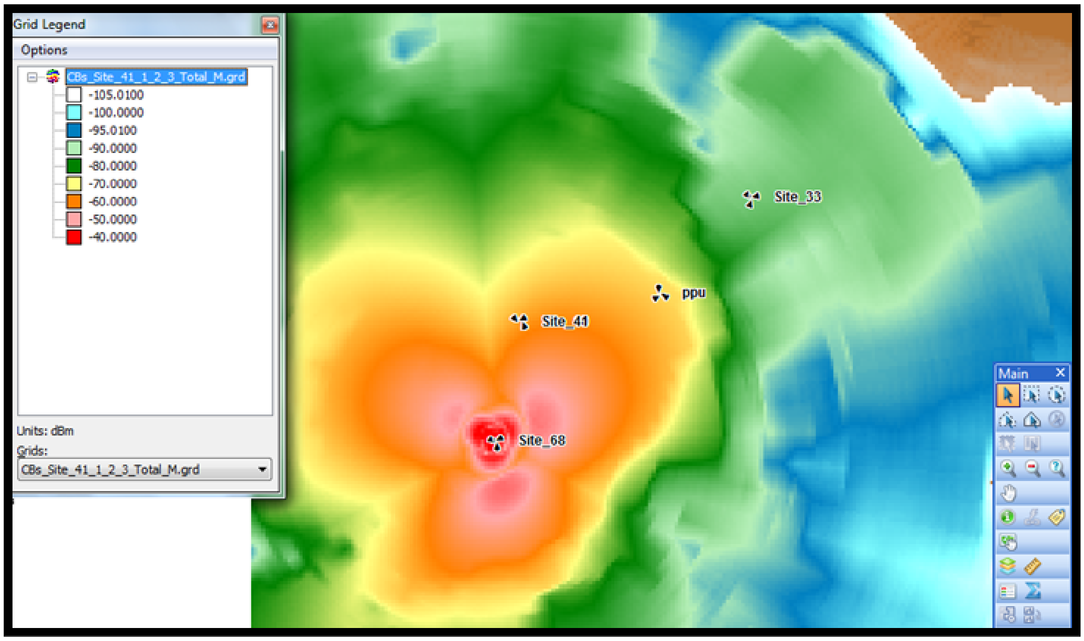


Figure 6.7: signal strength from site 68 with high gain antenna.

In the following figure 6.8 it's show the result of changing the tilt for sector C from -1 to -5 the coverage increase for the area around the site 68 and no change happen for the signal strength that reach Abu-Romman campus .

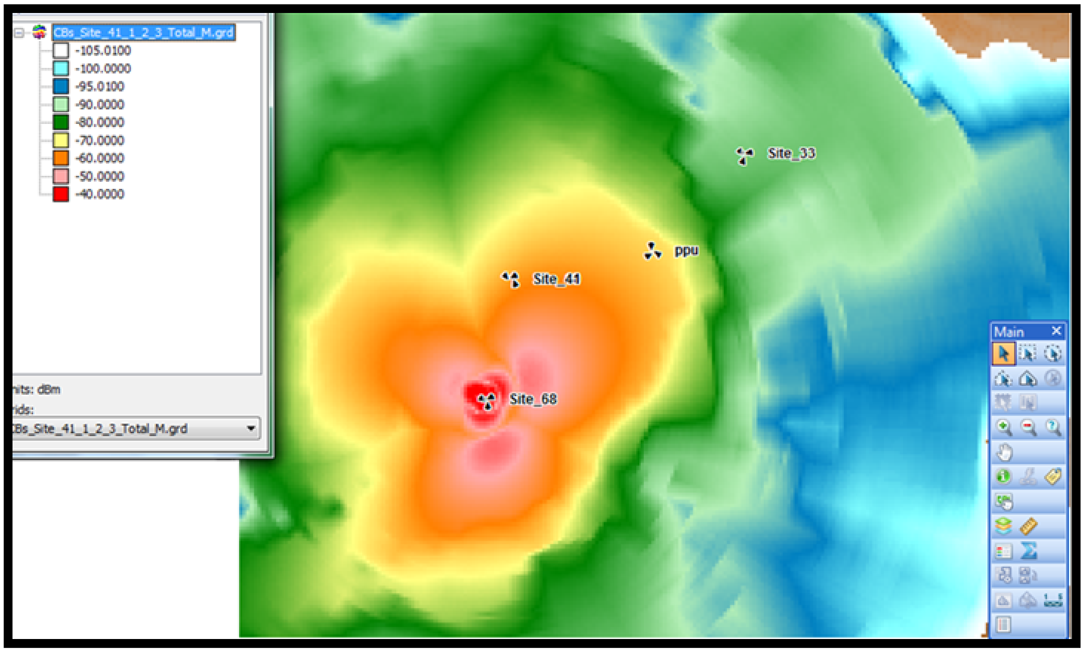


Figure 6.8: Signal strength for site 68 with -5 tilt.

Another configuration for site 68 is changing antenna with higher gain and changing the high of antenna but this change has no effect on the result of signal strength prediction at Abu-Romman campus, the following figure 6.9 explain the result.

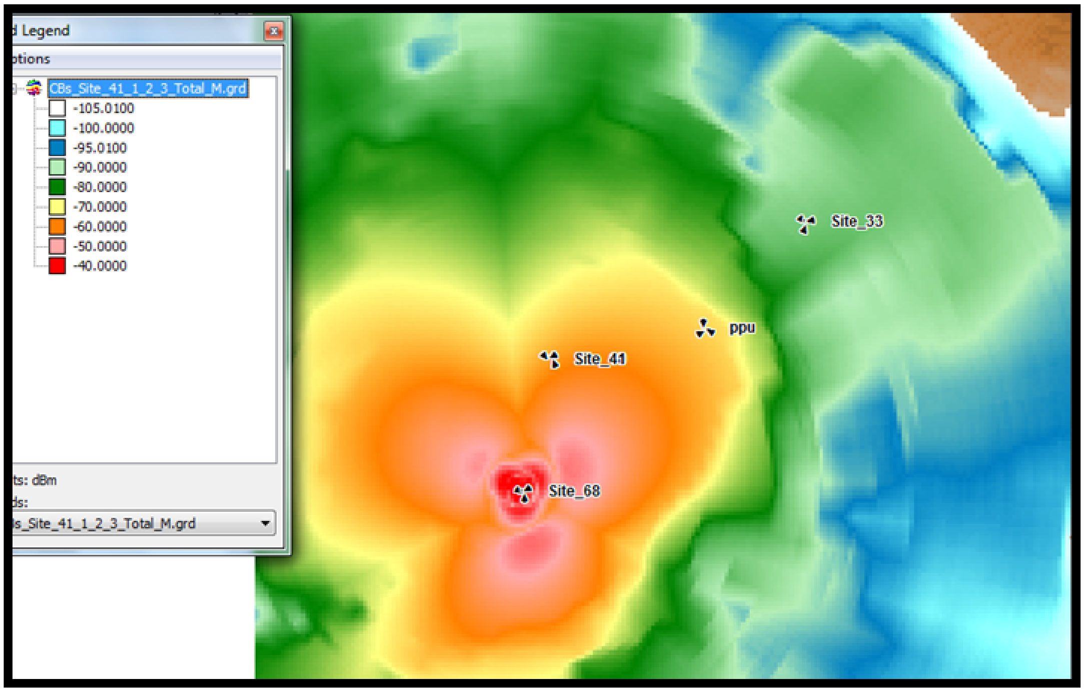


Figure 6.9: signal strength for site 68 with higher gain and antenna high equal 20m.

6.1.3 Reconfigurations of site 41

In site 41 first we change the antenna type and use the antenna with higher gain and the high of antenna we found that the coverage is increased only for area near site and no changes on the campus ,the following figure 6.10 show The effect of this change.

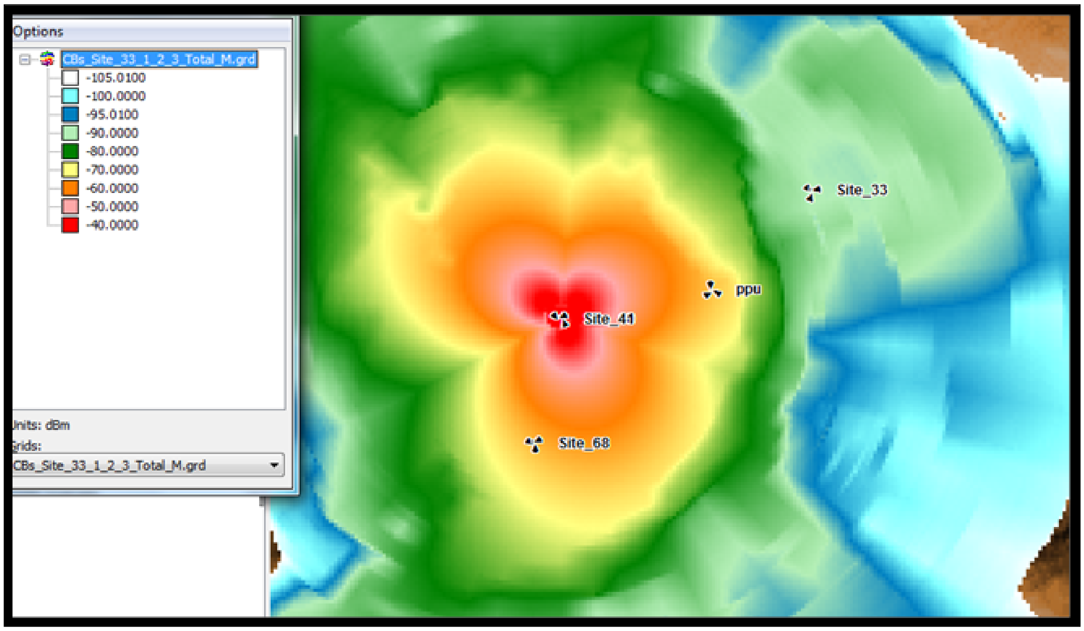


Figure 6.10: signal strength for site 41 after change antenna type and high.

In the following figure 6.11 it's show the result of changing the tilt from -1 to -5 the coverage increase for the area around the site 41 and no change happen for the signal strength that reach Abu-Romman campus .

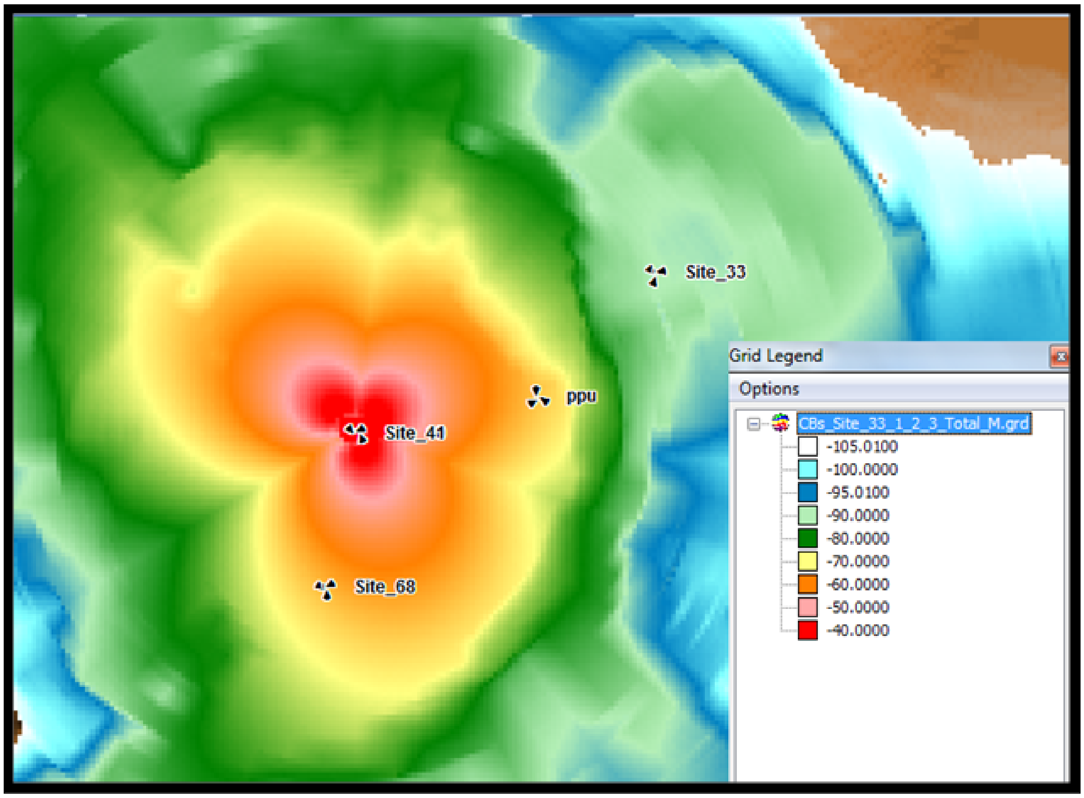


Figure 6.11: signal strength for site 41with tilt -5.

From the above result, we conclude that reconfiguration of sites covering the campus does not improve coverage. This is due to the fact that sites owned by JAWWAL company are located below the campus. This means that deploying a new site would be a viable solution.

6.2 Indoor Solutions

The indoor solution is another solution we proposed to improve service and solve problems. The aim of this solution is to increase the capacity and coverage. We use IBM WAVE simulation for designing and assessing and indoor solution. The idea is to deploy an RBS on the roof of Abu-romman building and connect it with a number of splitters and antennas. Antennas will be distributed inside the building on each floor. We used the building layout for each floor to apply the solution on each one. Through this way, we expect to provide better coverage inside the buildings. Figure 6.12 shows the design for the indoor solution.

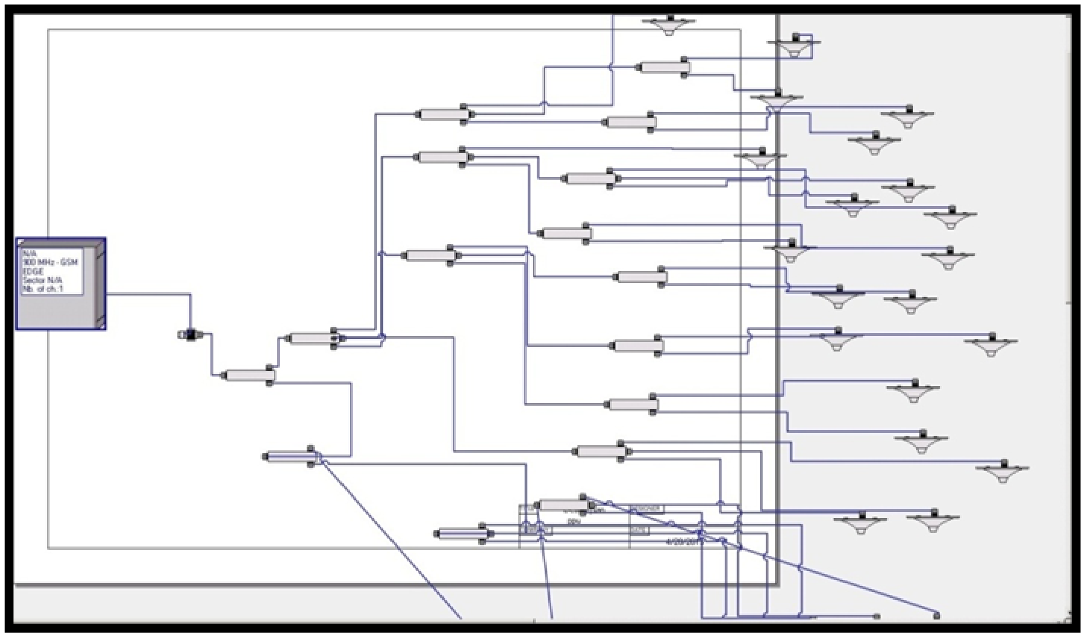


Figure 6.12: Design for indoor solution.

After applying the described solution on IBM WAVE software and distributing the suitable number of antennas on each floor, we analyzed the predicted signal strength. Results have shown that this solution provides better service and contribute to solving the coverage problem. Figure 6.13 show the signal strength on first floor.

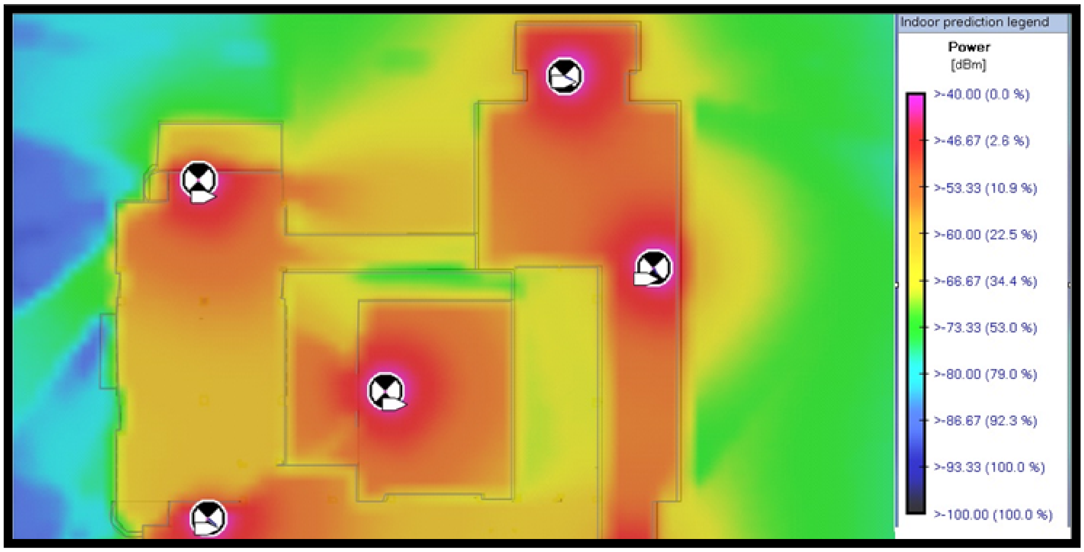


Figure 6.13: Distributed antennas inside the first floor and it's predicted results

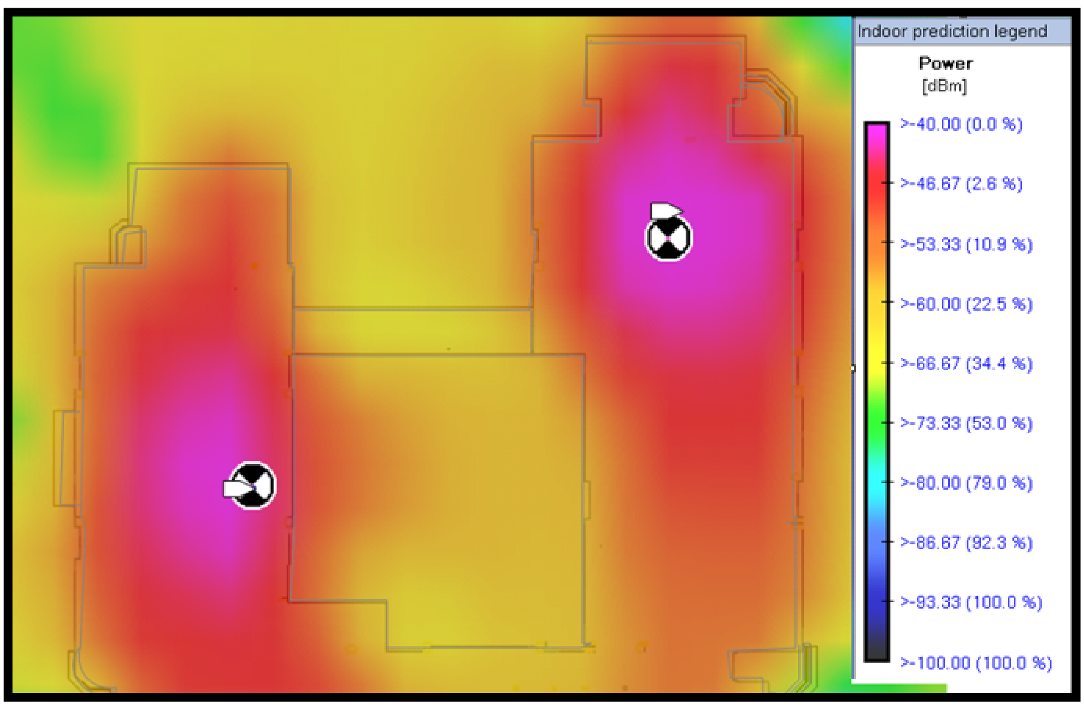


Figure 6.14: Distributed antennas inside the second floor and it's prediction results

From figure 6.14 shows that the power level in all location on the this floor is between -40 dBm to -70 dBm. This range ensures good service.

The following figures (figure 6.15), (figure 6.16), (figure 6.17), (figure 6.18) show the distributed antennas inside third, fourth, fifth floors and cafeteria.

We found that the antenna radiation power is in the range (-40 and -60) dBm, which means good improvement of QoS.

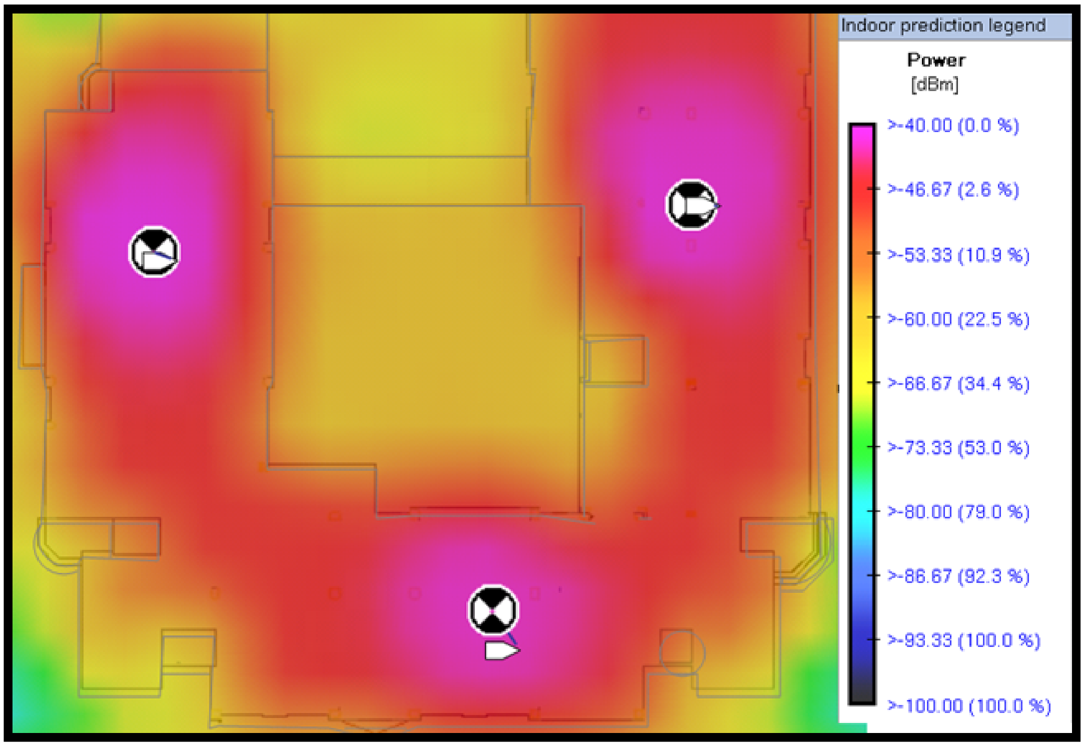


Figure 6.15: Distributed antennas inside the second floor and it's prediction results

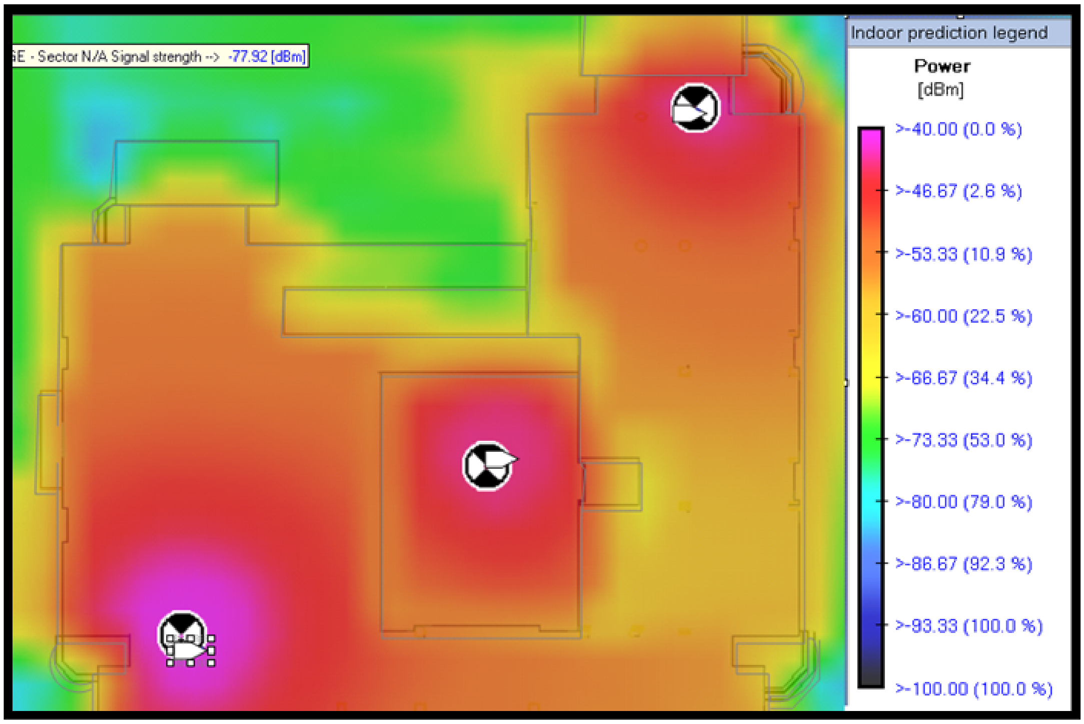


Figure 6.16: distributed antenna inside fourth floor and it's prediction result.

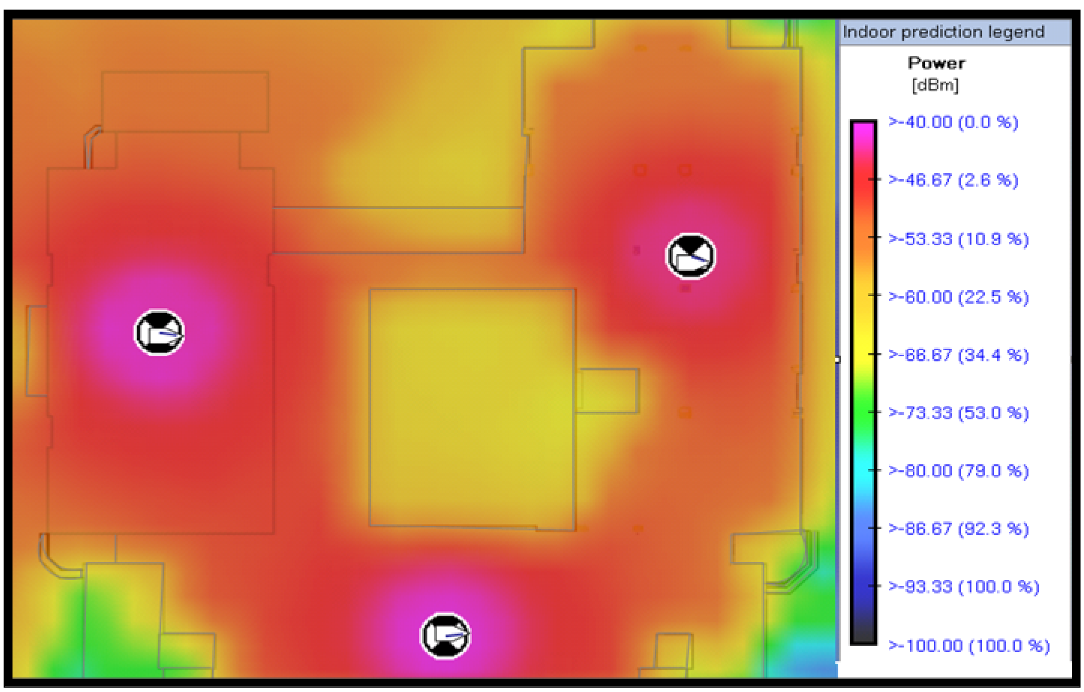


Figure 6.17: distributed antennas inside fifth floor and it's prediction result.

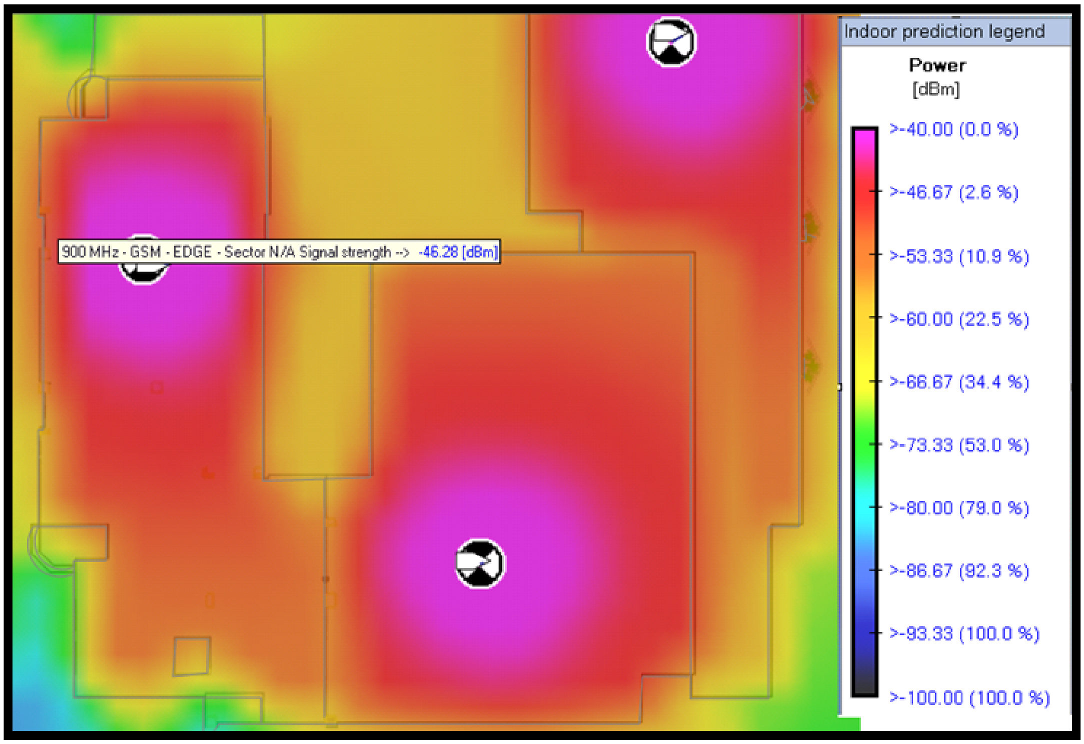


Figure 6.18: distributed antennas inside cafeteria and it's prediction result.

The following two figures show the distributed antennas in the second building (fuzzy kaush):

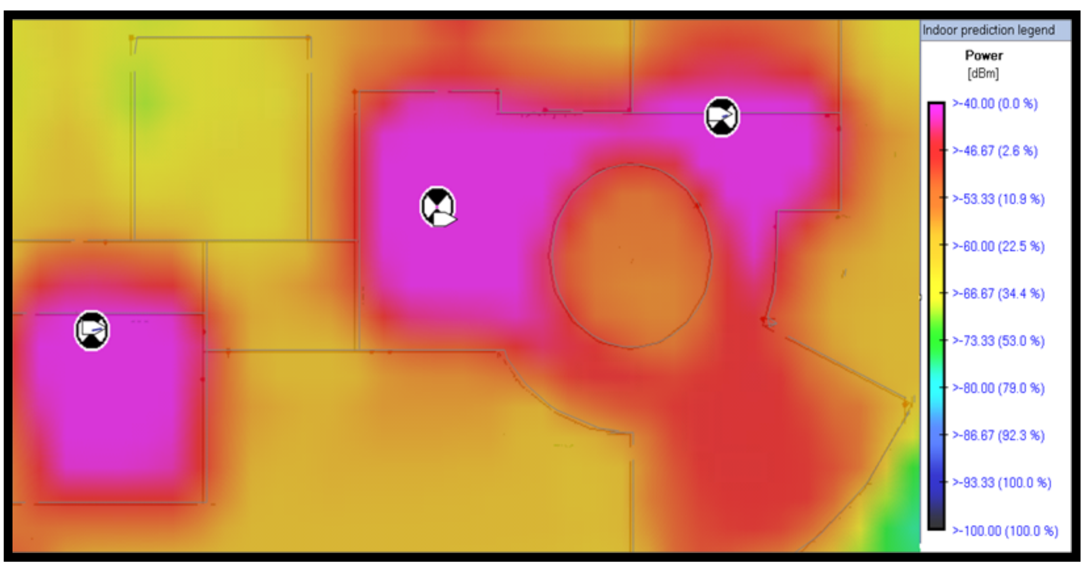


Figure 6.19: distributed antenna inside first floor in second building with prediction result.

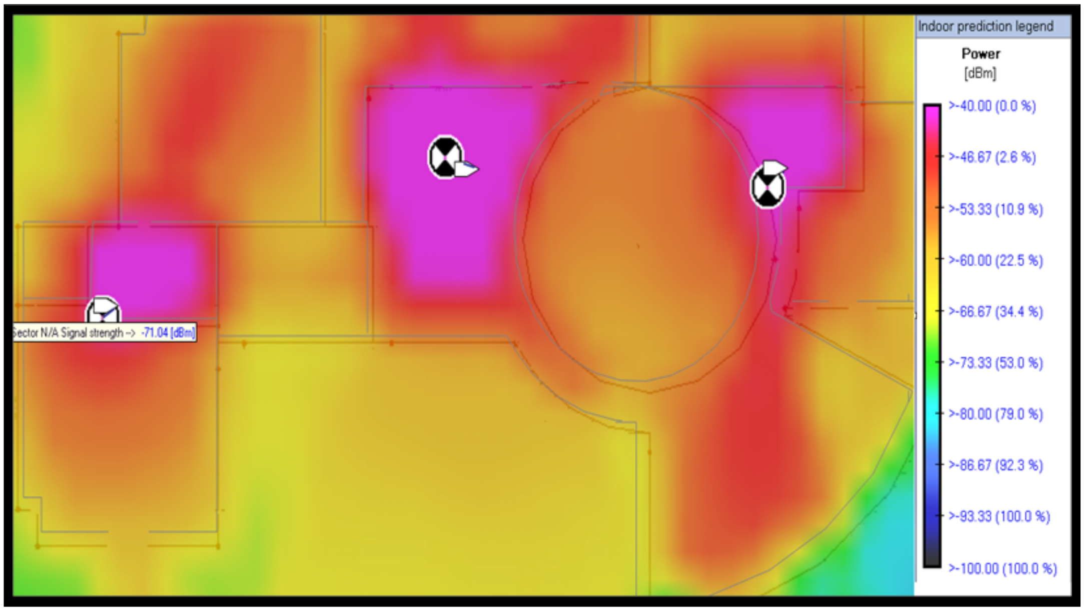


Figure 6.20: distributed antenna inside second floor in second building with prediction result.

From the above results, it is clear that better coverage can be achieved. However, this solution incurs high cost as it needs large number of antennas. Further, the complexity of installation is another issue. Moreover, this solution does not guarantee improved service outside the buildings.

6.3 Deploying new outdoor site on Abu-Romman campus

We studied the area outside the campus and chooses the best location and configuration for the new site, including antenna type, height, tilt , azimuth and power by using MENTOM planet simulation. We analyzed the predicted results. We used different frequencies than those used by neighboring sites. Results have shown good and acceptable performance in terms of service and coverage.

Trying different configurations, we determined this suitable parameters that give best signal strength coverage and high quality of services.

We use two cells: cell A with azimuth 270 degree, Antenna type 80010303 which has medium gain value and set at high 15m with mechanical and electrical tilt equal 14 and power 34dBm .

Cell B with azimuth 145 degree, Antenna type 80010303 has medium gain value and set at high 15m with electrical tilt equal 10 and power 34dBm.

Results are shown in figure 6.21.

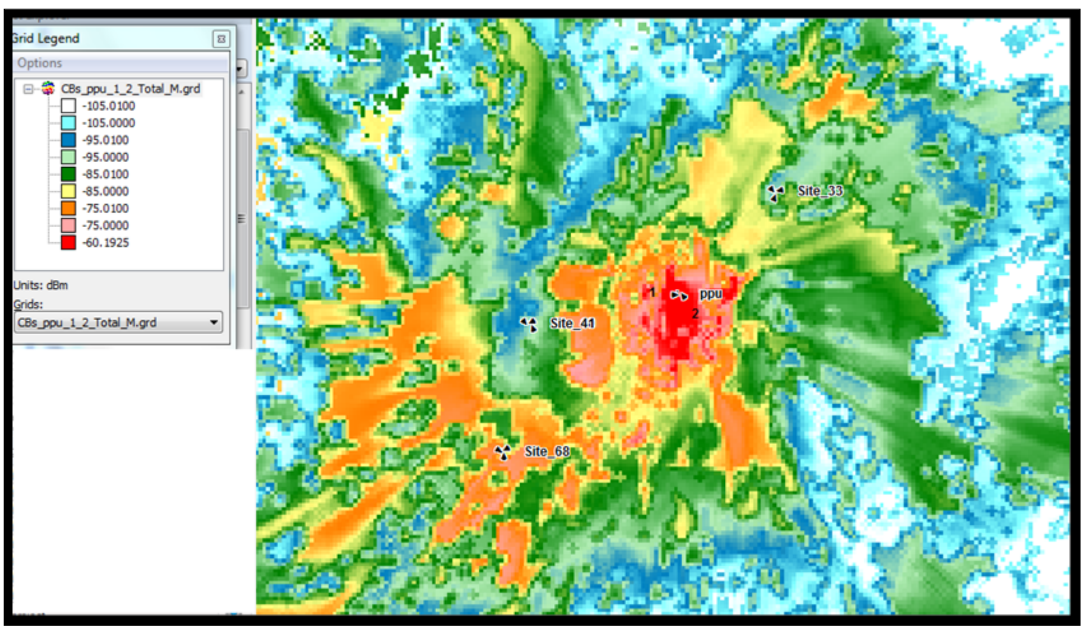


Figure 6.21: the best prediction result for new site.

We conclude that a new site is the best solution because it will cover the campus buildings and the outside area. Further, it will increase the capacity.

GSM :global system mobile

SMS : Short Message Service

TCHC : Traffic channels congestion

TCH : Traffic channels

DCHC :Dedicated control channel congestion

SDCCH:Stand-alone dedicated control channel

CCCHC: Common control channels congestion

RACH : random access channel

PCH : paging channels

AGCH :access grant channel

PCMC : Pulse code modulation congestion

PCM : Pulse code modulation

BS: base station

MSC : mobile-switching center

TDMA :Time Division Multiple Access

CDMA : Code Division Multiple Access

AMPS : advance mobile phone system

FDMA: Frequency Division Multiple Access

PCS: public and commercial service

QoS : Quality of Service

TRU: transceiver unit

BTS: base station transceiver

GPRS: general packet radio services

EDGE : Enhanced Data rates for Global Evolution

WCDMA: Wideband Code Division Multiple Access

LTE : long term evolution

TDD : time devsion dublexing

FDD : frequency devion dublexing

ANP : Automated Network Planning

RF: radio frequency

GIS : geographic information system

UMTS : Universal Mobile Telecommunications Service

GPS: global position system

RAN : Radio Access Network

KPI:key performance indicator

Bibliography

[1] Fosu C. and Ashiagbor G. Gis application for local government revenue mobilization. *Proceedings of Global Geospatial Conference*.

[2] Peter BE. Gis application for local government revenue mobilization. *Proceedings of Global Geospatial Conference*.

[3] Kuboye BM. Development of a framework for managing of congestion in gsm in nigeria. *Artech house, Inc*, pages 70–73, 2006.

[4] S. Cherry. The wireless last mile. *IEEE Spectrum*.

[5] C. Quinn. *M-Learning: Mobile, Wireless*. In-Your-Pocket, USA, 2010.