THE APPLICATION OF GIS TO IDENTIFY THE SUITABLE LOCATION FOR WIRELESS ACCESS POINT INSTALLATION

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A THEMATIC PAPER SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF SCIENCE
(TECHNOLOGY OF INFORMATION SYSTEM MANAGEMENT)
FACULTY OF GRADUATE STUDIES
MAHIDOL UNIVERSITY
2012

Thematic Paper
entitled

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was submitted to the Faculty of Graduate Studies, Mahidol University
for the degree of Master of Science
(Technology of Information System Management)
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ACKNOWLEDGMENTS

Firstly I would like to express my appreciation and sincere gratitude to my supervisors Lect. Dr.Wutjanun Muttitanon, my major advisor and Asst. Prof. Dr.Kritsanat Surakit, my co- advisor for their encouragement gridline, enthusiasm and support for the duration of this thematic paper.

I would like to be grateful the division of student affairs, Mahidol University for support data for analysis.

Finally, I would like to thank faculty of graduate studies and program in Technology of Information System Management for harmonize knowledge to complete these works.

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ABSTRACT

Nowadays, wireless communication technology has recently attracted a significant amount of attention. There have also been many schools of thought regarding the best technology.

The present study aimed at being the guideline to the characteristics and factors that affect the wireless signal, identify the weak area of wireless signal strength, and identify the suitable location to increase wireless access point installation at the faculty of engineering building1, 1^{st} floor, Mahidol University. The factors used in the analysis comprised signal strength, distance, and number of user. The result of spatial analysis used by the Inverse Distance Weighted (IDW) classified area into 4 levels: most suitable, moderately suitable, marginally suitable, and not suitable. The study found suitable areas to increase the wireless access point installation area in R114.

KEY WORDS: WIRELESS / RSSI / SIGNAL STRENGTH / GIS

76 pages

ระบบสารสยเทศภูมิศาสตร์แสดงพื้นที่ที่เหมาะสมในการเพิ่มจุดกระจายสัญญาณไร้สาย

THE APPLICATION OF GIS TO IDENTIFY THE SUITABLE LOCATION FOR WIRELESS ACCESS POINT INSTALLATION

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บทคัดย่อ

ปัจจุบันเทคโนโลยีการสื่อสารไร้สารได้รับความน่าสนใจมากขึ้น เป็นจำนวนไม่น้อย โดยเฉพาะในสถานศึกษาได้มีการนำเทคโนโลยีนี้มาใช้เพื่อก้าวไปสู่ความเป็นผู้นำด้านเทคโนโลยี

การศึกษาครั้งนี้มีวัตถุประสงค์เพื่อศึกษาถึงคุณลักษณะและปัจจัยที่มีผลต่อสัญญาณไร้สาย การหาพื้นที่ที่มีความแรงของสัญญาณอ่อน และการหาพื้นที่ที่เหมาะสมในการเพิ่มจุดกระจายสัญญาณไร้สารภายในบริเวณอาคารคณะวิศวกรรมศาสตร์ อาคารเรียน 1 ชั้น1 มหาวิทยาลัยมหิดล โดยปัจจัยที่ผู้ศึกษาได้กำหนดขึ้น ได้แก่ ความแรงของสัญญาณ ระยะทาง และจำนวนผู้ใช้ ซึ่งในการวิเคราะห์จะใช้วิธิ Inverse Distance Weighted และมีการแบ่งเกณฑ์ออกเป็น 4 ระดับ คือ เหมาะสมมาก เหมาะสมปานกลาง ค่อนข้างเหมาะสม และไม่เหมาะสม โดยผลการศึกษาพบว่า พื้นที่ที่เหมาะสมการเพิ่มจุดกระจายสัญญาณไร้สายจะอยู่ในบริเวณห้อง R114

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CHAPTER I
INTRODUCTION

1.1 Background and Problem Statement

The local area networks that bring computers alive in buildings by providing connectivity between users and the internet are sprouting wireless segments at an increasing rate, and for good reasons. Foremost among these are the freedom and simplicity of working without wires. (McKenzie, 2001)

In a world of communication, there is a growing need for people to communicate with each other and have timely access to information regardless of the location of the individuals or the information. The demand for wireless communication systems of increasing sophistication and ubiquity has led to the need for a better understanding of highly-capable wireless systems.

Wireless communication technology has recently attracted a significant amount of attention. There have also been many schools of thought regarding is the best technology. (Paul, 2003)

Now internet is the thing that usually use in daily life. Whether for education, communication, and entertainment. In the past, there were use wire network to connect to the internet, but now wireless network can make people connect to the internet even if they are moving. For broadcast the wireless system have to analyze an information correctly. Whether the building information, data of using wireless signal, and wireless signal information. So GIS was developed. GIS is that used to identify the suitable area for wireless access point installation" that show the best area to increase more wireless transmitter at the faculty of Engineering building1. This can make to support the number of student who use wireless network that increasing in each years are shown in Figure 1.1.

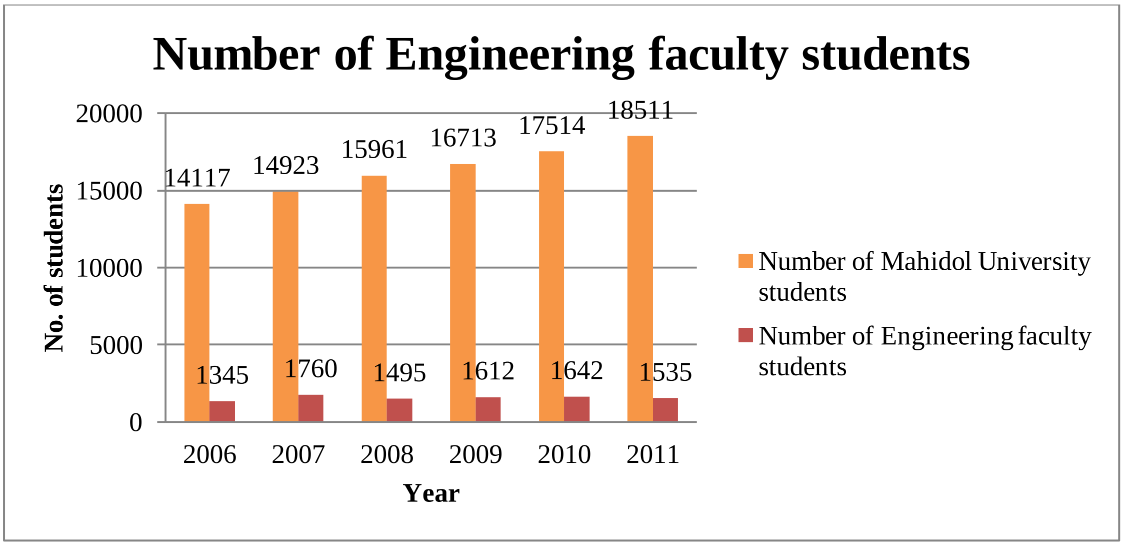

Figure 1.1 The number of engineering faculty students, Mahidol University

Source: Division of student Affairs, 2012

1.2 Objective of the study

1. To study the characteristics and factors that affect wireless signal can be used for expand the application of GIS.

2. To locate weak areas of wireless signal strength at the faculty of Engineering building1, 1st floor, Mahidol University.

3. To locate suitable areas for add the Wireless Transmitter at the faculty of Engineering building1, 1st floor, Mahidol University.

1.3 Scope of the study

1. The study area is faculty of Engineering building1, 1st floor, Mahidol University.

2. To collect the signal strength data by using the inSSIDer program and receiver at frequency of 2.4 GHz.

1.4 Expected Results

1. Being the guideline to the characteristics and factors that affect the wireless signal.

2. Locate sites to identify the weak area of wireless signal strength at the faculty of Engineering building1, 1st floor, Mahidol University.

3. Locate sites to identify the increase area of wireless signal for access point installation at the faculty of Engineering building1, 1st floor, Mahidol University.

CHAPTER II
LITERATURE REVIEW

This research was study the application of the Geographic Information System (GIS) on the weak area of wireless signal for access point installation in faculty of engineering building1, Mahidol University. Hence, the literature review in this chapter are following topics:

1. Wireless Signal
2. Study Area
3. Geographic Information System (GIS)
4. Weighting rating model
5. Related Researches

2.1 Wireless Signal

2.1.1 Overview of wireless communication

Wireless communications is, by any measure, the fastest growing segment of the communications industry. As such, it has captured the attention of the media and the imagination of the public. Cellular systems have experienced exponential growth over the last decade and there are currently around two billion users worldwide. Indeed, cellular phones have become a critical business tool and part of everyday life in most developed countries, and are rapidly supplanting antiquated wireline systems in many developing countries. In addition, wireless local area networks currently supplement or replace wired networks in many homes, businesses, and campuses. Many new applications, including wireless sensor networks, automated highways and factories, smart homes and appliances, and remote telemedicine, are emerging from research ideas to concrete systems. The explosive growth of wireless systems coupled with the proliferation of laptop and palmtop computers indicate a bright future for wireless networks, both as stand-alone systems and as part of the larger networking infrastructure. (Andrea, 2005)

2.1.2 Receive Signal Strength Indicator (RSSI)

The IEEE 802.11 standard defines a mechanism by which radio frequency(RF) energy is to be measured by the circuitry on a wireless NIC. This numeric value is an integer with an allowable range of 0-255 (a 1-byte value) called the Receive Signal Strength Indicator (RSSI). No vendors have chosen to actually measure 256 different signal levels, and so each vendor's 802.11 NIC will have a specific maximum RSSI value ("RSSI_Max"). For example, Cisco chooses to measure 101 separate values for RF energy, and their RSSI_Max is 100. Symbol uses an RSSI_Max value of 31. The Atheros chipset uses an RSSI_Max value of 60. Therefore, it can be seen that the RF energy level reported by a particular vendor's NIC will range between 0 and RSSI_Max. Notice that nothing has been said here about measurement of RF energy in dBm or mW. RSSI is an arbitrary integer value, defined in the 802.11 standard and intended for use, internally, by the microcode on the adapter and by the device driver. For example, when an adapter wants to transmit a packet, it must be able to detect whether or not the channel is clear (i.e., nobody else is transmitting). If the RSSI value is below some very low value, then the chipset knows that the channel is clear. This is the "Clear Channel Threshold" and some particular RSSI value is associated with it. When an 802.11 client is associated to an access point and is roaming, there comes a point when the signal level received from the access point drops to a somewhat low value (because the client is moving away from the access point). This level is called the "Roaming Threshold" and some intermediate (but low) RSSI value is associated with it. Different vendors use different signal levels for the Clear Channel Threshold and the Roaming Threshold and, moreover, the RSSI value that represents these thresholds differs from vendor-to-vendor because different RSSI_Max values are implemented. (WildPackets, Inc., 2002)

An alternative approach is to use empirical measurements of received radio signals, known as RSSI to estimate location. By recording a database of radio ‘‘signatures’’ along with their known locations, a device node can estimate its position by acquiring a signature and comparing it to the known signatures in the database. A weighting scheme can be used to estimate location when multiple signatures are close to the acquired signature. (Konrad and Matt, 2005)

InSSIDer is a simple but powerful software tool that detects available wireless networks. When used on a laptop, inSSIDer can help determine where weak spots in the WLAN could possibly be. It is a great program to use with Chanalyzer.

The new native Wi-Fi API allowed Metageek to easily integrate the AP MAC address, and channel, which limits inSSIDer's software compatibility to Windows Vista and partial functionality in XP. The interface program is shown in Figure 2.1.

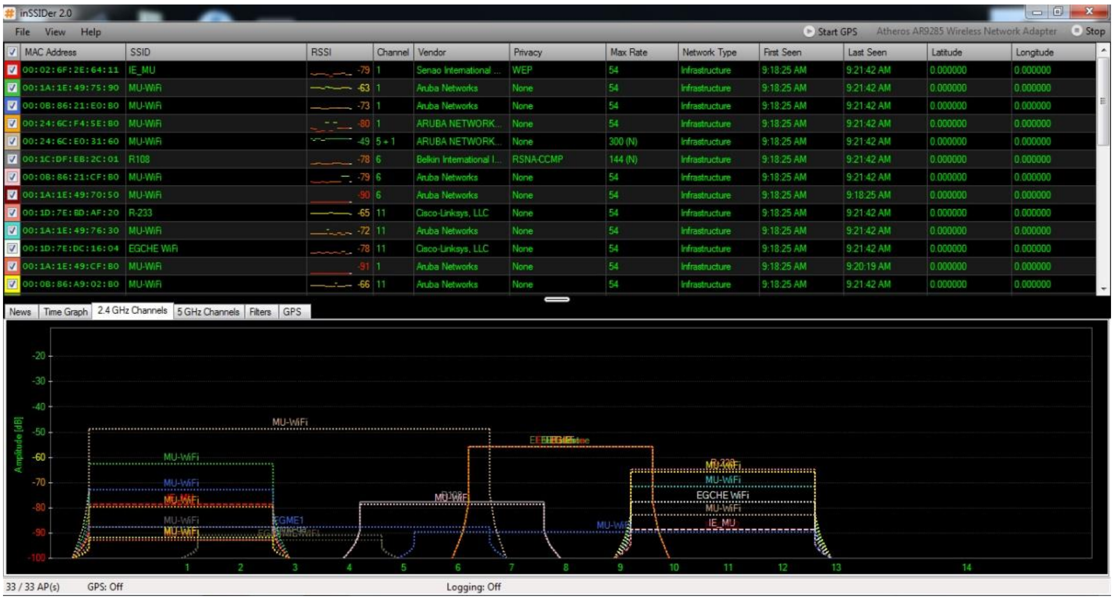

Figure 2.1 The interface program of inSSIDer

InSSIDer track and record wireless network activity graphically for performance interpretation. While inSSIDer may aid in identifying interference, we recommend the user also run Chanalyzer using Wi-Spy 2.4x. Interference may be caused by other devices, that inSSIDer not display. Chanalyzer help any user determine specifically where it is occuring, and most likely what is causing it.

2.2 Study Area

The faculty of Engineering, Mahidol University, established on August 29, 1990, currently offer Bachelor's Degree program in seven disciplines: Chemical Engineering, Civil Engineering, Environment Engineering, Computer Engineering, Electrical Engineering, Industrial Engineering and Mechanical Engineering. The plan of the Faculty of Engineering building1 first floor, Mahidol University are shown in Figure 2.2.

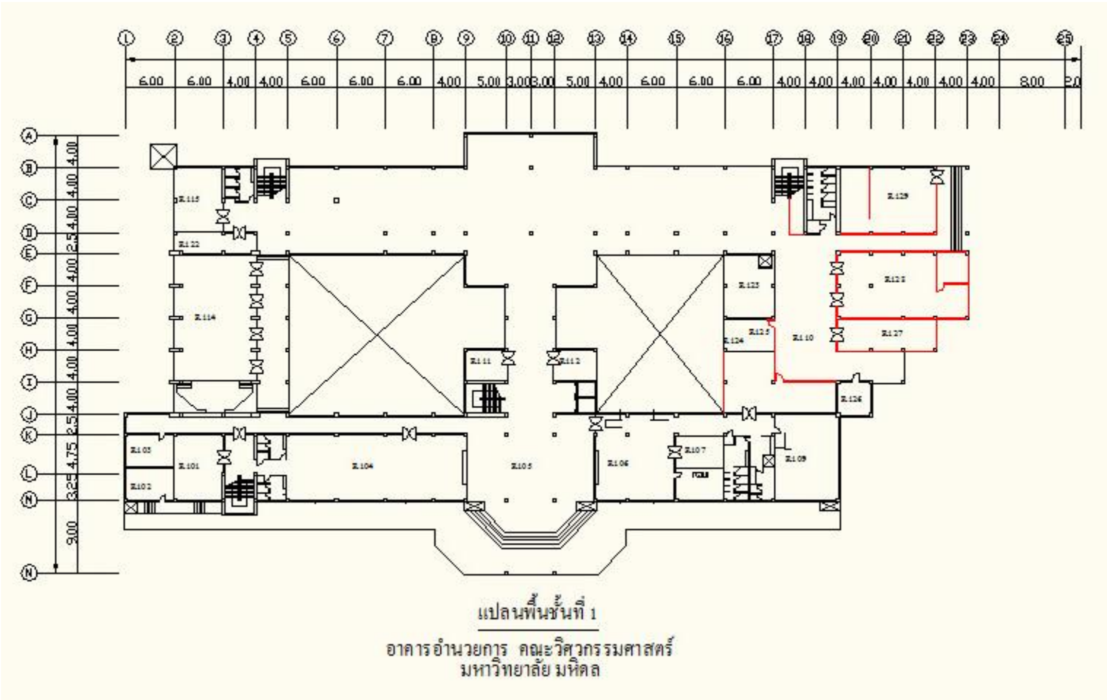

Figure 2.2 Plan of the faculty of Engineering building1, 1st floor, Mahidol University

Source: The faculty of Engineering, Mahidol University, 2012

The study area is located at the faculty of engineering building1, 1st floor, except R111 because this room is an electrical control room, R112 because this room is a water pump control room, R115 because this room is a maintenance room, and R122 because this room is a storage room. There are six access points in this study.

2.3 Geographic Information Systems (GIS)

2.3.1 Definitions

Geographic Information System: GIS is the process of working with spatial data in a computer system. The use of the data and information. That is correlated with spatial position, as residing at the position in relation to map latitude and longitude data in the GIS map system information in the form of tables. The databases that contain information related to spatial (Spatial Data), which form and spatial relationships of all. Can be analyzed with GIS, and make meaningful changes in relation to time, such as the spread of disease. The settlers moved to destroy the attacker. This information appears on the map to be translated and meaningful user-friendly. (Elizabeth, 2005)

A Geographic information system (GIS) is any system (Emphasize Digital Data) that capture, store, analyzes, manages, and presents data that are liked to location. (Geospatial Media and Communications Pvt Ltd, 2010)

Technically, a GIS is a system that includes mapping software and its application to cartography, remote sensing, land surveying, mathematics, photogrammetric, geography, and tools that can be implemented with GIS software. Still, many refer to “Geographic Information System” as “GIS” even though it doesn’t cover all tools connected to topology. (University of York, 2010)

GIS is a system information stored on computer, but can interpret the geography associated with other State local conditions, system performance relative to proportion the distance and actual space on a map of the differences between the GIS and MIS that can determine the nature of the data is the data stored in the GIS looks as spatial data that shown in the picture map associated with descriptive information (Attribute Data) or a database linking the two data types together to allow users to display both types simultaneously. Well as to find the location of the measuring black smoke. White smoke was identified by a checkpoint, or in contrast to the inquiry of the checkpoints from where the pick-up which is different from the MIS to show only by the lack of a link to a database that is linked to that image, such as in CAD (Computer Aid Design) is a picture alone, but the map in GIS are related to the position in terms of geographical area is the range of course information in GIS and spatial data and descriptive to refer to the position that exists on earth. Is through a system of geographic coordinates (Geocode), which can refer to both direct and indirect reference to the GIS data in the Earth's surface directly Means valuable data or coordinate with the actual location on earth or in the map Such as building roads, etc. for positions that are based on GIS data on the earth by indirect information such as your home (including cottage road, soi region, province and postal code) by the address information. We can know that this house is located. As anywhere on earth. Because every house has a unique address. (Elizabeth, 2005)

2.3.2 The components of GIS

The Institute for the Promotion of Teaching Science and Technology (IPST, 2004) identified five significant elements of GIS as data/information, hardware, software, procedure and user/people, as shown in Figure 2.3.

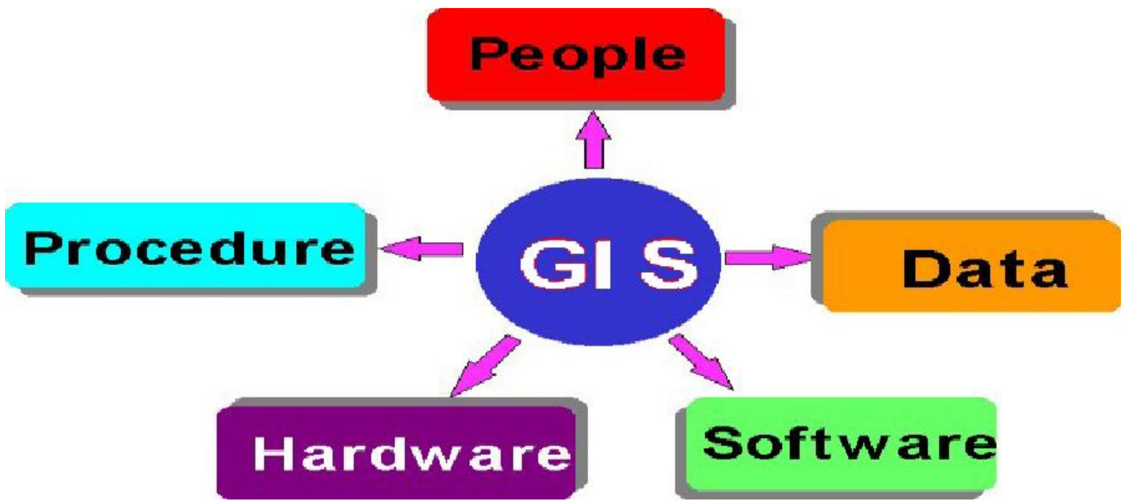

Figure 2.3 GIS component

Source: The Institute for the Promotion of Teaching Science and Technology, 2004

2.3.2.1 Data/Information input GIS should be specific theme, updated data that is accurate and reliable and able to give appropriate answers.

Important technical and logistic innovations in data and data access for GIS are under way and will come to fruition before the end of the century. First, and by far the most important, have been increased access to the Defense

Department's global positioning systems (GPS), the availability of in expensive and held devices for using the system, and the addition of direct-to-GIS data links to these systems. For a relatively modest investment, field users can add geographic coordinates to their data collection from anywhere in the world, at any time, and in any weather. (Monmonier, 1996)

2.3.2.2 Hardware is consisted of computerized input equipment such as digitizer, scanner, Global Positioning System (GPS), data reading, maintaining and displaying equipments such as printer plotter. Each equipment function differently.

This trend continue to the extent that few technical constraints like memory and central processing unit (CPU) power exist for GIS. Some tasks, such as skilled visual image identification and interpretation, have been partly or wholly automated. (Johnson, 1992)

On the low end, microcomputers have become immensely powerful and fast, easily capable of performing basic GIS operations even on portable computers. The theme of GIS mobility, added to satellite and cellular telephone communications, has permanently transformed the ability to operate with GIS in the field, and will lead to a new "data rich" era for epidemiologic study. (Melnick, and Fleming, 1999)

2.3.2.3 Software is defined as the managing and commanding program for hardware to perform or recall data in the database. Generally, GIS program is consisted of unit for inputting and managing data, including data analysis, transformation, display and user interface.

Most of software systems now support context-sensitive help, electronic manuals, and automatic installation and update procedures. Each of these could benefit from intelligent software that uses an expert system base and continues to tailor the system around the GIS operator's revealed use. Such software, used over a network, has been termed an intelligent agent. (University of York, 2010)

2.3.2.4 Procedure in the GIS, data accuracy is matter the most because incorrect analysis and wrong decision could cause error, leading to the lost in labor, effort and investment unit becoming big waste. In order to build good database, operation procedures must be clearly defined for efficiency. Database should be designed to share in various activities.

2.3.2.5 User/People are comprised of system analyst and user with expertise in GIS and already received training. Generally, system users would choose own hardware and software to serve their own needs and respond to agency's demand. As for users, they are planner or decision-maker who applied data to solve problems

2.3.3 Data type of GIS

Application of GIS is efficiently depending on data and information. The geographic data divide to two types as the following.

2.3.3.1 Non-spatial data, addition non-spatial data can also be stored along with the spatial data represented by the coordinates of vector geometry or the position of a raster cell. In vector data, the additional data contains attributes of the feature. For example, a forest inventory polygon may also have an identifier value and information about tree species. In raster data the cell value can store attribute information, but it can also be used as an identifier that can relate to records in another table.

Software is currently being developed to support spatial and non-spatial decision-making, with the solution to spatial problems being integrated with solutions to non-spatial problems. The end result with these Flexible Spatial Decision-Making Support System (FSDSS) is expected to be that non-experts will be able to use GIS, along with spatial criteria, and simply integrate their non-spatial criteria to view solutions to multi-criteria problems. This system is intended to assist decision-making.

2.3.3.2 Spatial data, this kind of data geographical location or so-celled Geo-referenced data of Graphic feature, such as administrative district, water resource, altitude, location of village/ sub-district/ district/ province, which mostly display in the form of maps. Such data can be satellite imagery, aerial map, or data from GPS. (Elizabeth, 2005)

2.3.4 Data Interpolation

Interpolation is a method of constructing new data points from a discrete set of known data points and estimates the values in unsampled locations. Surface interpolation functions create a continuous (or prediction) surface from sampled point values. The continuous surface representation of a raster dataset represents height, concentration, or magnitude - for example, elevation, pollution, or noise. Surface interpolation functions make predictions from sample measurements for all locations in a raster dataset whether or not a measurement has been taken at the location. There is a variety of ways to derive a prediction for each location; each method is referred to as a model. With each model, there are different assumptions made of the data and certain models are more applicable for specific data - for example, one model may account for local variation better than another. Each model produces predictions using different calculations. (Muttitanon, 2007)

The characteristics of an interpolated surface can be controlled by limiting the input point that used in the calculation of output cell values. This can be done by limiting the number of sampled point or the area from which sampled points are taken. Specifying the maximum number of points to be sampled will return the points closest to the output cell location unit the maximum number is reached. Alternatively, specifying a fixed radius in map units will select only input point within the radius distance from the center of the output cell unless there are not enough point within that radius. (Colin, 2004)

The mapping and spatial analysis often requires converting the field measurements into continuous space. Therefore the point data sets must be converted to a continuous form using an interpolation method. The errors, however, enter the spatial database long before any interpolation method is applied to the data set. The first type of error is associated with sampling design. The magnitude of a sample, as well as the procedure of obtaining it, depends on the objectives of the sampling process. Increasing the sample size also improves the accuracy of measurements up to a certain point. In spatial analysis the sampling is often performed on a regular grid or on an irregular set of points however, this might not depict the true variation of studied phenomena in the space. There are three interpolation methods used to be compare: Kriging, Spline and The Inverse Distance Weighted.

2.3.4.1 Kriging is a geostatistical interpolation technique that considers both the distance and the degree of variation between known data points when estimating values in unknown areas. A weighted linear combination of the known sample values around the point is to be estimated. It attempts to minimize the error variance and set the mean of the prediction errors to zero so that there are no over or under-estimates. Kriging should be applied where best estimates are required, data quality is good and error estimates are essential. (Muttitanon, 2007)

The predicted values are derived from the measure of relationship in sample using sophisticated weighted average technique. It uses a search radius that can be fixed or variable. The generated cell values can exceed value range of samples, and the surface does not pass through samples. (Colin, 2004)

2.3.4.2 Spline interpolation is a form of interpolation where the interpolant is a special type of piecewise polynomial called a spline. Spline interpolation is preferred over polynomial interpolation because the interpolation error can be made small even when using low degree polynomials for the spline. Spline estimates values using mathematical function that minimizes overall surface curvature. This results in a smooth surface that passes exactly through that input points. Conceptually, it is like bending a sheet of rubber so that it passes through the point while minimizing the total curvature of the surface. It can predict ridges and valleys in the data and is the best method for representing the smoothly varying surfaces of phenomena such as temperature. (Colin, 2004, and Muttitanon, 2007)

2.3.4.3 The Inverse Distance Weighted (IDW) interpolation is a bar centric interpolation and one of the most commonly used techniques for interpolation of scatter points when the set of points is dense enough to capture the extent of local surface variation needed for analysis. The interpolating surface is a weighted average of the scatter points and the weight assigned to each scatter point diminishes as the distance from the interpolation point to the scatter point increases. Inverse Distance Weighted (IDW) interpolation determines cell values using a linearly weighted combination of a set of sample points. The surface being interpolated should be that of a locationally dependent variable. The input can be limited by the number of sample points to be used or by radiuses within which there are points to be used in the calculation of the interpolated points. (Muttitanon, 2007)

The IDW function should be used when the set of point is dense enough to capture the extent of local surface variation needed for analysis. IDW determines cell values using a linear-weighted combination set of sample points. The weight assigned is a function of the distance of an input point from the output cell location. The greater the distance, the less influence the cell has on the output value. (Colin, 2004)

2.4 Weighting rating model

The basic pre-requisite for studies the determination of weight and rating values representing the relative importance of factors and their categories respectively for landslide occurrence. These weights and ratings can be determined based on the subjective expert opinions as well as based on an objective analysis. (Kanungo, 2006)

The operation of these educations to data overlay procedures by GIS software and sum of weight linear model Notation following:

$$S = W_1R_1 + W_2R_2 + W_3R_3 + \ldots W_nR_n$$

Where S = Sum of point of risk area factor

W_n = Weighting at n series

R_n = Rating at n series

In this method to merge quantitative and qualitative factors, factors are assigned weights based on relative importance and weighting score for each site using a preference matrix is calculated. The site with the highest weighted score is selected as the best choice.

2.5 Related Researches

David (2005) studied about a new approach to location estimation where, instead of locating a single client, *simultaneously* locate a set of wireless clients. We present a Bayesian hierarchical model for indoor location estimation in wireless networks. We demonstrate that our model achieves accuracy that is similar to other published models and algorithms. By harnessing prior knowledge, our model eliminates the requirement for training data as compared with existing approaches, thereby introducing the notion of a fully adaptive *zero profiling* approach to location estimation.

Wang (2003) studied about the configuration of WPS. Experiments and a discussion of the accuracy are presented. The results of the experiments shoe that a wireless access point-based indoor positioning system is feasible and a positioning accuracy of 1-3m. can be achieved while an accuracy of 0.1m. can be obtained under an idealized situation.

Muttitanon (2007) studied about a system to determine the location of a mobile terminal or a handheld PDA in high speed, low-cost wireless networks by using the wireless communications infrastructure. The experimental set up used an indoor wireless facility of an auditorium, where signals from three Access Points (APs) were recorded to train a position determination model to calculate and map a position. Grid model was applied and compare the resulted position of a client. A handheld PDA equipped with application software was the client device. The accuracy assessment has been performed to identify the distance error and the average distance error was found lowest for the grid model. The results of the experiments reveal that the accuracy of 0.05 m. can be achieved.

Sawada (2006) studied about dramatic changes in how spatial considerations affect the provision of broadband internet services (BIS) to areas beyond the urban zone. In particular, the spatial question is now focused on assessing the capacity for different technological solutions to reach profitable population bases, and brings to the forefront organizations that are developing non-line-of-sight (NLOS) technologies that would permit wireless Internet access over much greater distances than current solutions.

EL-Gamily (2010) studied about establish a mobile field-based GIS facility, a concise system architecture should be designed. This architecture includes client-side components, wireless communication facility, and server components. The integration and automation of these components can provide the capability to collect, update, validate, and query the enterprise geo-database remotely in a near real-time mode. One of the potential fields of applications for the mobile field-based GIS is the crisis management process. A prescribed system has been previously defined as emergency response cycle for managing both the natural and the man-made crises. Three phases of the emergency response cycle are outlined which are the response and rescue phase, the recovery and reconstruction phase, and preparedness phase. In each phase, various takes are undertaken based on the type of the event. Selective tasks of the response and the rescue phase of the fire event occurred in the Sheraton Exchange Center have been chosen to check the validity of using the mobile field-based GIS for enhancing the performance of these tasks. These tasks are path selection and quick damage estimates.

Wiriyaporn (2008) studied about Receive Signal Strength Indicator (RSSI). The research is Ranging in Wireless Sensor Network System. This paper presents ranging in Wireless Sensor Network System by using Receive Signal Strength Indicator (RSSI) and trend equation of RSSI and distance. By collect the RSSI data in order to study behavior of RSS (Receive Signal Strength) that relates with Power Level and distance.

Hui (2007) studied about the existing wireless indoor positioning solutions and attempts to classify different techniques and systems. Three typical location estimation schemes of triangulation, scene analysis, and proximity are analyzed. This paper also discusses location fingerprinting in detail since it is used in most current system or solutions. This paper then examine a set of properties by which location systems are evaluated, and apply this evaluation method to survey a number of existing systems. Comprehensive performance comparisons including accuracy, precision, complexity, scalability, robustness, and cost are presented.

Kee (2003) studied about produced the Integrity Beacon Landing System (IBLS) for flight inspection in 1994. They used the IBLS to resolve carrier-phase cycle ambiguity. In the land-based applications, Elkaim and O'Connor controlled a robotic tractor using carrier-phase differential GPS (CDGPS) with the assistance of pseudolites in 1995. Stone developed a precise positioning system using GPS satellites and pseudolites for open pit mining in 1999. In this research, he used carrier-phase measurements from both pseudolites and GPS satellites to calculate the user's position.

CHAPTER III
MATERIALS AND METHODOLOGY

The study of the application of GIS to identify the weak area of wireless access point installation in faculty of engineering building1, Mahidol University. Research information of building, data of wireless signal, and researcher collect information of signal strength in this location of engineering building1. This information use for improve the map accuracy and correctly.

3.1 Materials

3.1.1 Hardware

CPU	:	Intel Core i5-460, 2.53GHz
Hard Disk	:	320 GB
RAM	:	2 GB
Peripheral Devices	:	Mouse, Printer

3.1.2 Software

Operating System	:	Microsoft Windows 7
Statistical Program	:	inSSIDer 2.0
Analysis Program	:	ArcGIS 9
PDF View Tool	:	Adobe Acrobat 10.0 Professional
Document Generator	:	Microsoft Word 2007

3.1.3 Data

This research has collected building information and wireless signal strength in this location of engineer building1 first floor. Data collection, the position of wireless access point installation and the position of data to collected are shown in Figure 3.1-3.3

Data Collections		
Usability	Number of users	
Signal Strength	MAC Address	00 : 1A : 1E : 49 : 76 : 30 (AC1)
		00 : 1A : 1E : 49 : 70 : 90 (AC2)
		00 : 0B : 86 : 21 : E0 : B0 (AC3)
		00 : 24 : 6C : E0 : 31 : 60 (AC4)
		00 : 1A : 1E : 49 : 75 : 90 (AC5)
		00 : 0B : 86 : A9 : 02 : B0 (AC6)

Figure 3.1 Data collection and manipulation

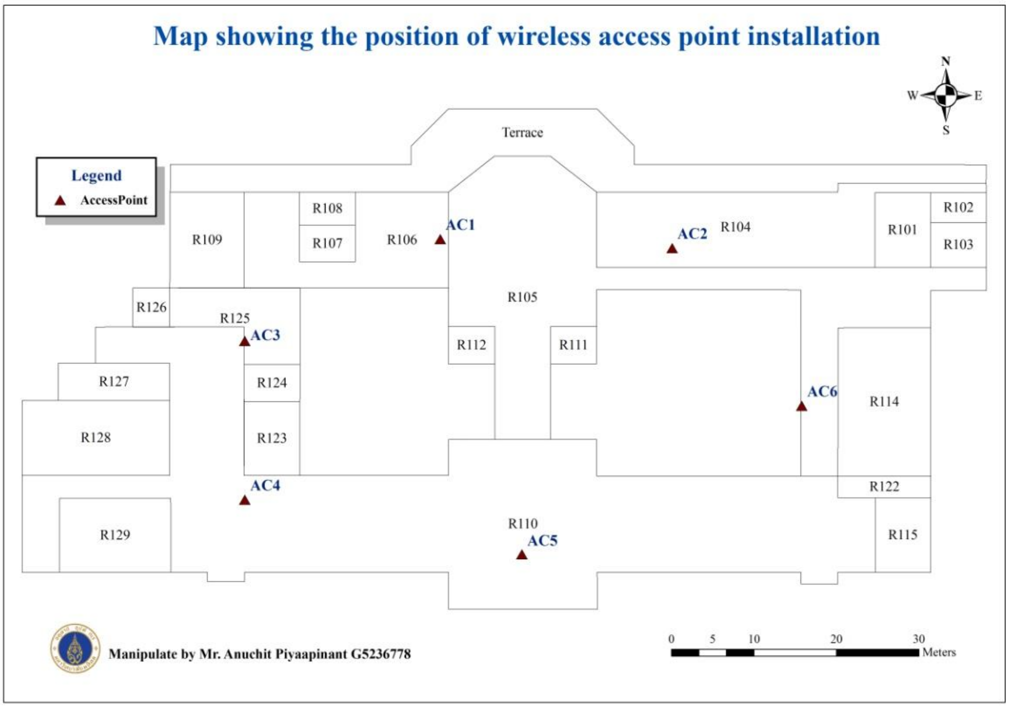

Figure 3.2 The position of wireless access point installation

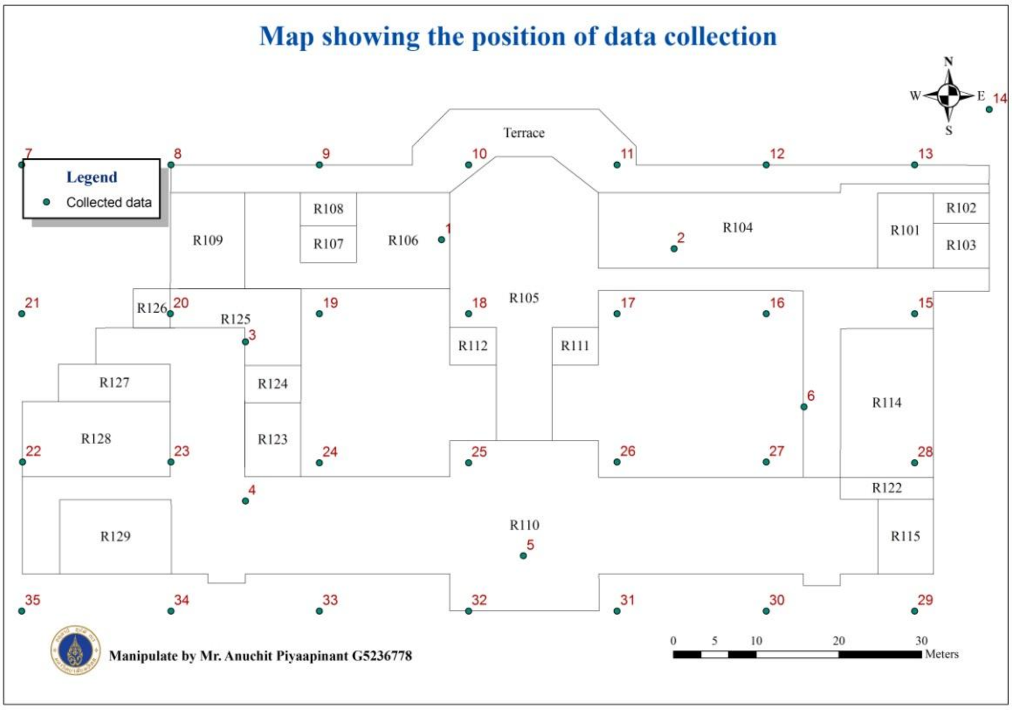

Figure 3.3 The position of Data collection

To collect the signal strength data by using the inSSIDer program and receiver at frequency of 2.4 GHz. Data were classified to six wireless access points installation followed by activity time:

Early Morning	=	at 7.30 am.
Morning	=	at 10.00 am.
Noon	=	at 12.30 pm.
Afternoon	=	at 15.00 pm.
Evening	=	at 19.00 pm.

3.2 Methodology

To the availability of both hardware and software technologies that have been made. To be used for presentation of maps where appropriate to increase the installed wireless signal at the faculty of engineering building1 1st floor. Mahidol University. The descriptions of methodology are step of work are shown in Figure 3.4.

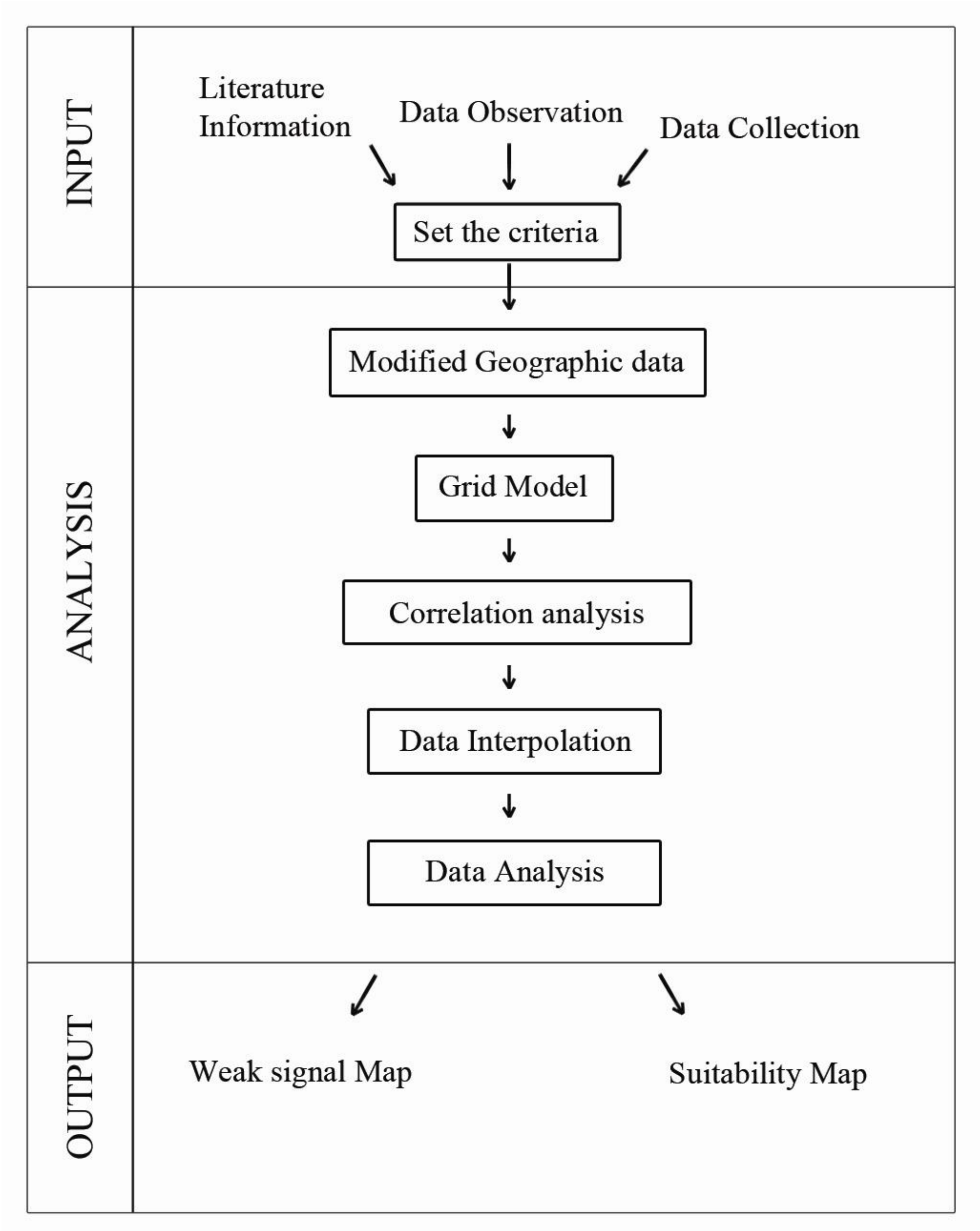

Figure 3.4 Conceptual framework diagrams

3.2.1 Input

These steps are related about data used for analyze: literature information, data observation, and data collection.

3.2.1.1 Data observation to known about study area, they are six access points and a user device in WLAN environment, which is based on Wi-Fi.

Access point and user device connect with Wi-Fi (IEEE 802.11b standard). The user device receives radio frequency signals from these six access points.

3.2.1.2 Data collection is used to determine the location. The collected signal strength is recorded in units of negative decibel-meters (-dBm). The cycle frequency was set to one second. Data collection was conducted for about 100 second at a particular spatial point and 35 such different sample points were collected.

3.2.2 Analysis

All data collection completed by inSSIDer program then the researcher normalized by Information Technology method and stored to database. And then, analyze by ArcGIS 9.3 to known the weak signal strength area and result of analyzed to known the suitable area for wireless access point installation.

3.2.2.1 Modified Geographic data were administrative boundary layer map of the faculty of engineering building1, first floor scale 1: 300. All formats were manipulated in ArcGIS and saved in to files data type ".shp".

3.2.2.2 Grid model is the probabilistic model, using an experimental approach only based on the calibration of a grid and is opposite of a method searching a functional relationship between signal strength and distance to the access point. A grid is a spatial data structure that defines space as an array of cells of equal size arranged in rows and columns. In fact, experiment measures of signal strength and distance to the access point and grid model seems to be the only way to ensure good results.

The grid pixel width depends on expected precision for localization. This expected precision determined, pixel values must be estimated. In general, the number of pixels is very high and it is impossible to measure directly the value of each pixel: process by interpolation from measures in some point. For each access point, the signal strength is measured in some points of the domain, uniformly distributed to cover the domain and to allow a good spatial interpolation process. At each point, the number of measures must be enough to be considered as a statistical representative sample of the point value. Six access points were installed in the auditorium, the locations are shown in Figure 3.5. The cell size or pixel cell is 2 m. The origin of the coordinate system (0, 0, 0) was placed at the left bottom corner of the map. The (x, y, z) coordinate of the access points are as follow: AC1 = (45, 40, 2.5), AC2 = (70, 39, 2.5), AC3 = (24, 29, 2), AC4 = (24, 12, 2.5), AC5 = (54, 6, 2.5), and AC6 = (84, 22, 2.5).

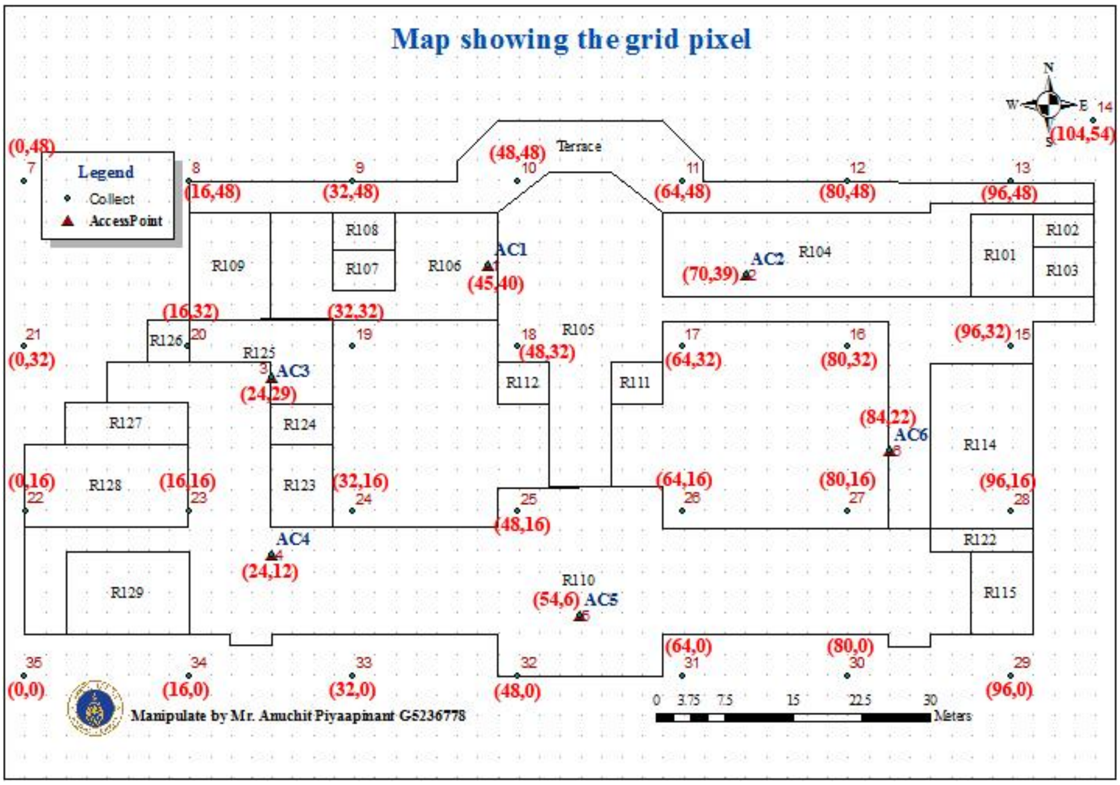

Figure 3.5 Map of grid pixel

The data to collect start at the same position of wireless access point, the collect start at the origin of coordinate measurement out all 16 meters and finish at coordinate (104,54) to cover in this building.

3.2.2.3 Correlation analysis is statistics technique which have a simple and quickly way, and measurement quantitative data, the statistics are based on comparing of mean value among adjacent polygons having the same or different values. Usually types of data are display between -1 to 1 index. To description, the possible attribute values associated with polygon would be. (Chang, 2006, Pramod, 2006)

3.2.2.4 Data interpolation to obtain the required spatial data that is necessary before the next step of this paper. The Inverse Distance Weighted (IDW) technique was considerate to interpolate the value of climate information factor in each access point installation map. Three factors were interpolate consist signal strange, distance, and time by ArcGIS.

3.2.2.5 Data analysis by mean of weighted and rated spatial data consider by experts and social data are divided in three groups; weighted and rated spatial data consider by experts and rated value from sampling, analyze to get rating value and go to next steps.

The operation of these educations to data overlay procedures by GIS software and sum of weight linear model Notation following:

$$S = W_1R_1 + W_2R_2 + W_3R_3 + \ldots W_nR_n$$

Where S = Sum of point of risk area factor

W_n = Weighting at n series

R_n = Rating at n series

In this method to merge quantitative and qualitative factors, factors are assigned weights based on relative importance and weightage score for each site using a preference matrix is calculated. The site with the highest weighted score is selected as the best choice.

Define all result was put into the table for determine weighting and rating point scale are shown in Table 3.1.

Table 3.1 Determine weighting and rating point scale of weak area signal

Type of Factor	Weighting and Rating point scale	
	Weighting value	Rating point
1. Signal strength (-dBm)	(1)X	
Very low (-93 to -78.55) Low (-78.54 to -64.1) Medium (-64.09 to -49.65) High (-49.64 to -35.2)		4 3 2 1

Table 3.1 Determine weighting and rating point scale of weak area signal(cont.)

Type of Factor	Weighting and Rating point scale	
	Weighting value	Rating point
2. Distance (meters)	(1)X	
2 to 24.1		1
24.11 to 46.2		2
46.21 to 68.29		3
68.3 to 90.39		4
3. Number of user (persons)	(2)X	
0 to 8		1
9 to 16		2
17 to 24		3
25 to 32		4
33 to 40		5

3.2.3 Output

This procedure results in map out to answer the objectives: weak signal strength area map, and suitable area map.

3.2.3.1 Weak area map obtained from the signal strength of each wireless access point installation to analyze method. The climate interpolations were based on geospatial information technique and computer program.

3.2.3.2 Suitable map obtained from analyzed method the appropriate area by using the spatial analyst by geospatial software. The output was analyzed from zonal statistics method, and the map shows the appropriate area of wireless access point installation.

CHAPTER IV
RESULTS AND DISCUSSION

The present study on geographic information system reveals an appropriate location to increase the installed Wireless Signal at the Faculty of Engineering building1 first floor, Mahidol University. Data used in this research can be divided as follows.

The signal strength data as received by inSSIDer program receiver at the sample point is not constant but varies for few dB. The variation is caused by several factors such as movement of people and other effects. The data distribution of 35 sample points show a little difference, quite little overlap of each access point is observed.

4.1 Signal Strength Interpolation Maps

The signal strength of each wireless access point installation is important to the analysis in this research. The interpolation maps were based on geospatial information technique and computer program. In order to get data, as shown in table 4.1- 4.6 followed by activity times.

All data collection completed in one week then the average value obtained. The signal strength measurement has a maximum value was -35.2 and a minimum value was -93.

Table 4.1 Signal strength of the first wireless access point installation (AC1)

PositionID	Early Morning	Morning	Noon	Afternoon	Evening
1	-42.2	-47.6	-40.2	-48	-38.6
2	-75.2	-74	-71.6	-80	-70.4
3	-90.2	-82.8	-72.8	-81.2	-75.8
4	-89.6	-88.6	-83.6	-91.4	-89.4
5	-87.8	-87.6	-86.8	-87.8	-87.4
6	-89.8	-88.8	-90.2	-89.2	-88.8
7	-86.8	-90.4	-88	-86.2	-90.4
8	-85	-79.4	-84	-82.2	-86.8
9	-69	-70.6	-61.4	-71.2	-72.4
10	-59.2	-62.8	-59	-61.6	-63.8
11	-80.2	-80.6	-83.4	-73.2	-76.8
12	-90.4	-90.8	-88	-91.8	-88.8
13	-90.4	-89.8	-88	-89.4	-89.8
14	-88	-89.8	-87	-89	-92.4
15	-85.6	-88	-92	-90.4	-87.8
16	-89.6	-81.4	-79.2	-84.2	-85.8
17	-79	-79.6	-84.6	-78.8	-81.8
18	-68.6	-63.6	-66.2	-72.2	-66.4
19	-67.6	-68.6	-66.2	-66.6	-66.4
20	-89.8	-89.8	-91.2	-90.4	-93
21	-88	-90.8	-86.2	-91.4	-92
22	-88	-91.2	-85.8	-90.4	-92
23	-88	-89	-86.8	-89.4	-89
24	-65.2	-69.8	-66.8	-78.4	-68.4
25	-75.6	-77.4	-73.2	-84.2	-78.4
26	-89.8	-89	-86	-87.4	-87.8
27	-88	-86	-87	-87.4	-88.8
28	-92.8	-86.8	-88.4	-91.4	-90.4
29	-92.8	-86.8	-88.4	-91.4	-90.4
30	-92.8	-86.8	-88.4	-91.4	-90.4
31	-88.4	-87.8	-87.4	-86.4	-90.4
32	-79	-83.2	-88.4	-85.4	-82.4
33	-69.8	-78	-71.4	-77.2	-77.8
34	-74.8	-77.4	-75	-78.2	-79.8
35	-74.8	-77.4	-75	-78.2	-79.8

Table 4.2 Signal strength of the second wireless access point installation (AC2)

PositionID	Early Morning	Morning	Noon	Afternoon	Evening
1	-68.8	-66.6	-70.6	-69.6	-74.8
2	-42.8	-44.2	-37.8	-44.8	-38.8
3	-82.2	-87	-82	-88.8	-90.4
4	-82.2	-87	-82	-73.2	-90.4
5	-84.8	-86.8	-85.4	-82.8	-81.8
6	-73.8	-72.8	-72.8	-74	-71.8
7	-81.8	-87	-82	-88.6	-91
8	-81.8	-88.8	-88.2	-90.6	-91
9	-88	-87.4	-84.4	-83.4	-88.8
10	-66.2	-69.2	-66.8	-68.8	-72.4
11	-58.2	-65.4	-60.4	-60.8	-65.8
12	-66.8	-75.4	-71.4	-72.8	-69.8
13	-90	-83.2	-82.4	-88.4	-86.8
14	-89	-89.6	-86.4	-90.4	-83.8
15	-74.2	-75.6	-73.6	-73.8	-73.8
16	-64.2	-60.8	-65.4	-63.8	-66.8
17	-60.8	-53.6	-57.8	-56.4	-56.4
18	-75.2	-71.2	-69.2	-77	-65.8
19	-90.6	-91	-89.2	-81.4	-90.4
20	-88.6	-91	-89	-81.4	-89.4
21	-88.6	-91	-89	-81.4	-89.4
22	-88.6	-91	-89	-87.8	-89.4
23	-88.6	-91	-89	-81.4	-89.4
24	-88.6	-90.6	-89.8	-81.4	-89.4
25	-82	-81.2	-80.2	-83.4	-79.4
26	-79	-77.8	-70.2	-72.6	-74.8
27	-60.2	-71.6	-70.2	-69	-66.4
28	-72.8	-76.2	-79.8	-77.8	-76.4
29	-80	-85.8	-77.8	-79.4	-87.4
30	-75.8	-78.2	-76	-73.4	-77.8
31	-83	-82.4	-79	-84.4	-81.8
32	-86.8	-87.8	-89.6	-89.6	-90.4
33	-88	-88.2	-82.4	-83.6	-89.4
34	-88	-90.4	-82.4	-84	-89.4
35	-88	-90.4	-82.4	-84	-89.4

Table 4.3 Signal strength of the third wireless access point installation (AC3)

PositionID	Early Morning	Morning	Noon	Afternoon	Evening
1	-66.6	-68.8	-68	-71.6	-74.8
2	-91.4	-90.6	-86	-87.2	-90.4
3	-37.8	-41.2	-35.2	-43.2	-38.8
4	-60	-61.4	-64.2	-61.4	-60.4
5	-71.4	-70.2	-70.4	-73.2	-68.8
6	-89.4	-90.2	-91.2	-92.6	-92.4
7	-73.6	-71	-73	-71.2	-72.4
8	-77.6	-81	-83.6	-77.2	-74.8
9	-81.6	-83.6	-84.2	-84.4	-81.8
10	-79	-82	-87.2	-80.4	-77.8
11	-86.6	-85.4	-87.2	-90	-80.8
12	-91.2	-86.8	-87.2	-89	-80.8
13	-91.2	-86.8	-87.2	-89	-80.8
14	-91.2	-86.8	-87.2	-89	-80.8
15	-88.6	-89	-92.4	-86.4	-87.8
16	-90.2	-89	-87.6	-84.8	-91.4
17	-86	-90.6	-87.6	-92.8	-91.4
18	-88.6	-85.6	-80.4	-84.8	-79.8
19	-57	-62.4	-72.6	-58.8	-53.4
20	-50	-50.2	-53.8	-47.8	-50.4
21	-55	-61.4	-66.6	-61.8	-66.8
22	-76	-77.6	-75.4	-74.2	-76.8
23	-54.6	-57.6	-58.6	-58.4	-58.8
24	-68.6	-69.4	-68.4	-70.6	-69.8
25	-76.6	-70.2	-70.4	-68.6	-77.8
26	-82.6	-80.2	-83.6	-77.4	-81.8
27	-92.2	-88.2	-88.2	-92	-85.8
28	-90.2	-85.8	-90	-90	-87.8
29	-92.2	-88.2	-85.8	-86.4	-79.8
30	-80.6	-80.4	-81.8	-81.2	-87.8
31	-83.6	-83.8	-79.4	-79.2	-77.8
32	-76.6	-77.2	-77.4	-72.2	-88.8
33	-71	-79.2	-71.6	-75.2	-69.8
34	-88.4	-88.8	-89.6	-83.4	-86.8
35	-75.6	-84.4	-77	-79.2	-77.8

Table 4.4 Signal strength of the forth wireless access point installation (AC4)

PositionID	Early Morning	Morning	Noon	Afternoon	Evening
1	-86.6	-89.6	-88.2	-88	-91.2
2	-92.4	-88.6	-88.2	-88	-90.2
3	-53	-59.8	-56.6	-58	-57
4	-38.2	-46	-38.2	-41.8	-38.4
5	-61.2	-67	-61.6	-69.6	-66.8
6	-85.4	-89.2	-89	-88.2	-88.4
7	-87.4	-87	-86.2	-82.4	-89.4
8	-85.4	-86.8	-87.8	-88.6	-90.4
9	-85.4	-88.6	-87.8	-88.8	-90.4
10	-85.4	-88.6	-87.8	-88.8	-90.4
11	-85.4	-88.6	-87.8	-88.8	-90.4
12	-85.4	-88.6	-87.8	-88.8	-90.4
13	-85.8	-88.6	-87.8	-88.8	-90.4
14	-85.8	-88.6	-88.2	-88.8	-90.4
15	-85.8	-88.6	-88.2	-88.8	-90.4
16	-86	-88.6	-91.8	-88.8	-90.4
17	-86	-90.4	-91	-88.8	-88.4
18	-90.4	-88.4	-89.6	-87.2	-89
19	-79	-81.8	-74.6	-81.2	-73.8
20	-66.4	-65	-63.4	-68.2	-66.8
21	-76	-80.2	-83	-79.2	-80.8
22	-84	-86.2	-86.4	-85.2	-88.4
23	-48.4	-44.6	-40.4	-45.6	-40.8
24	-61.4	-62.2	-63.2	-83.2	-68.4
25	-85.4	-84.8	-84.8	-87.2	-80.8
26	-73.4	-80	-79	-84.2	-74.8
27	-79	-84.2	-81	-83.2	-77.8
28	-87	-85.2	-86.8	-84.2	-91.8
29	-88.4	-84.4	-89.8	-86.2	-85.8
30	-83	-81.6	-78	-83.2	-79.8
31	-86	-85.6	-81	-84.2	-87.8
32	-82	-76.2	-83.8	-76.6	-77.8
33	-60	-74.2	-57.8	-64.6	-53.8
34	-82	-85.8	-82.2	-83.2	-83.8
35	-87	-87.8	-91	-87.2	-85.8

Table 4.5 Signal strength of the fifth wireless access point installation (AC5)

PositionID	Early Morning	Morning	Noon	Afternoon	Evening
1	-90.6	-86.2	-87.8	-87.6	-90.4
2	-80.6	-83.2	-81.8	-79	-79.4
3	-89.6	-87.4	-85.6	-87	-90.4
4	-73.2	-70.8	-68.6	-80	-73.8
5	-35.4	-37.8	-40.8	-42.2	-35.2
6	-85.8	-83.4	-86.8	-82.8	-88.8
7	-85.8	-86.2	-88.2	-86.8	-87.8
8	-85.8	-86.2	-88.2	-86.8	-87.8
9	-85.8	-88.2	-88.2	-86.8	-87.8
10	-72.2	-77.2	-76.6	-73.2	-71.8
11	-81.8	-84.2	-82.6	-88.4	-84.8
12	-81.8	-84.2	-82.6	-88.4	-84.8
13	-81.8	-84.2	-82.6	-88.4	-84.8
14	-81.8	-84.2	-82.6	-88.4	-84.8
15	-81.2	-85.8	-80	-83.4	-87.8
16	-87.2	-81	-77.8	-80.6	-80.8
17	-82.8	-87.4	-86.4	-88.4	-82.4
18	-81.8	-83	-70.8	-80	-76.8
19	-80.8	-82.8	-77.6	-76.4	-80.8
20	-91.8	-91.8	-84.8	-87.8	-85.8
21	-89.8	-89.8	-86.8	-91.8	-91.4
22	-89.8	-89.8	-86.8	-91.8	-91.4
23	-75.8	-84.6	-80	-80.6	-82.8
24	-64.2	-70	-60.2	-64	-73.8
25	-64.6	-66	-67.8	-65	-61.8
26	-59.2	-59.2	-59.2	-59.6	-57.8
27	-70.2	-71	-72.2	-67.4	-72.8
28	-86.2	-81.6	-81.8	-83.4	-78.8
29	-82.2	-76.2	-81.8	-83.4	-76.8
30	-84.2	-72	-72.2	-80.4	-74.8
31	-60.8	-68.2	-61.6	-64.4	-57.8
32	-53.2	-52.2	-55	-53.4	-53.8
33	-75.8	-74	-70.6	-74.6	-70.8
34	-88	-88.8	-87.8	-89.4	-91.4
35	-91.4	-87.6	-91.2	-87.4	-90.4

Table 4.6 Signal strength of the sixth wireless access point installation (AC6)

PositionID	Early Morning	Morning	Noon	Afternoon	Evening
1	-76.8	-82.8	-76.8	-75.6	-77.2
2	-66.8	-65.2	-67.6	-68.2	-63.2
3	-90.6	-87.8	-91.2	-90.4	-93
4	-88	-89.8	-89.6	-89.4	-89.6
5	-86	-70.6	-76.8	-76.4	-72.2
6	-39.8	-40.6	-41.6	-37.6	-39.2
7	-90.4	-87.8	-91.2	-90.4	-93
8	-90.4	-87.8	-91.2	-90.4	-93
9	-90.4	-88.6	-91.2	-90.4	-93
10	-79.6	-85.2	-83.2	-82.2	-86.6
11	-89.8	-86.6	-90.2	-85.2	-88.8
12	-84.8	-84.8	-83	-88.4	-83.2
13	-86.8	-85	-83	-86.4	-87.8
14	-86.8	-85	-83	-86.4	-87.8
15	-49.8	-51.2	-60.4	-57.2	-57.2
16	-56.2	-63.4	-63.6	-59.2	-59.2
17	-67	-65.8	-66	-68.2	-66.2
18	-86	-79.2	-79	-83.4	-86.2
19	-90.6	-91.2	-85	-91.4	-89.2
20	-86.6	-88.4	-90.2	-89.4	-92
21	-86.6	-88.4	-90.2	-89.4	-92
22	-86.6	-88.4	-90.2	-89.4	-92
23	-90.6	-91	-90.2	-86.4	-89
24	-79.6	-84.2	-83.4	-81.2	-90.4
25	-73.6	-69.6	-69.2	-70.2	-72
26	-68.8	-70.8	-63.6	-72.2	-67.2
27	-58.6	-63	-53.8	-64.2	-36.2
28	-48.8	-56.4	-57.6	-57.8	-51.2
29	-77.8	-79.8	-82	-75.2	-78.2
30	-81	-85.6	-65.4	-86.2	-87.2
31	-89.4	-81.8	-90	-76.2	-90
32	-81.6	-74.6	-90	-80.2	-85.2
33	-88.6	-85.8	-86.6	-88.4	-84.2
34	-87.6	-90.6	-89.4	-88.4	-88.2
35	-87.6	-88.2	-90.4	-88.4	-90

4.1.1 Signal strength interpolation of access point1

Figure 4.1-4.5, are showed signal strength interpolate information of access point1 in each of period activities. It had seen that the average signal strength of access point1 when compare in each by activity times.

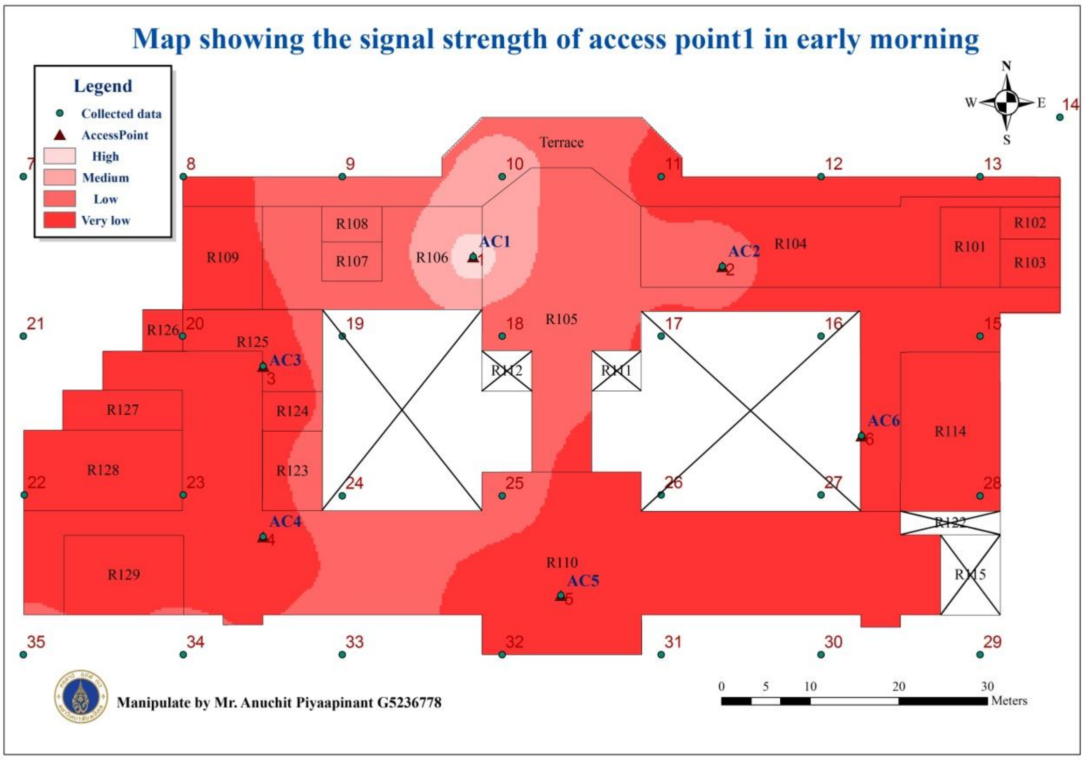

Figure 4.1 Signal strength of access point1 in early morning.

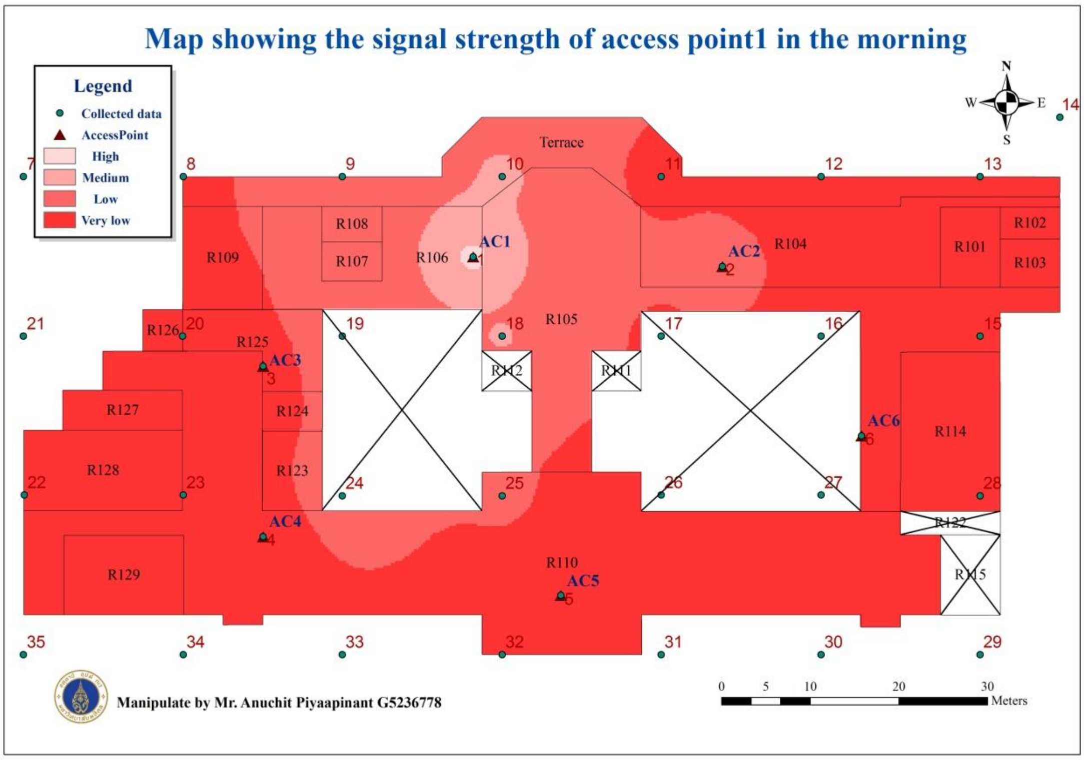

Figure 4.2 Signal strength of access point1 in the morning.

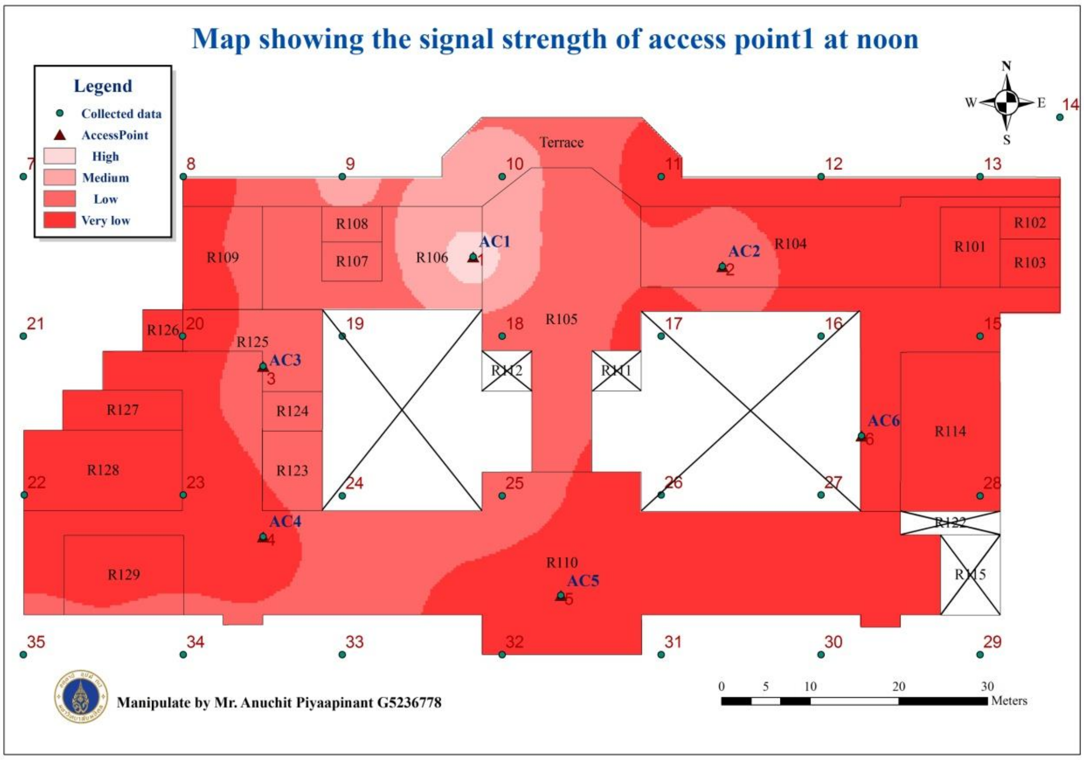

Figure 4.3 Signal strength of access point1 at noon.

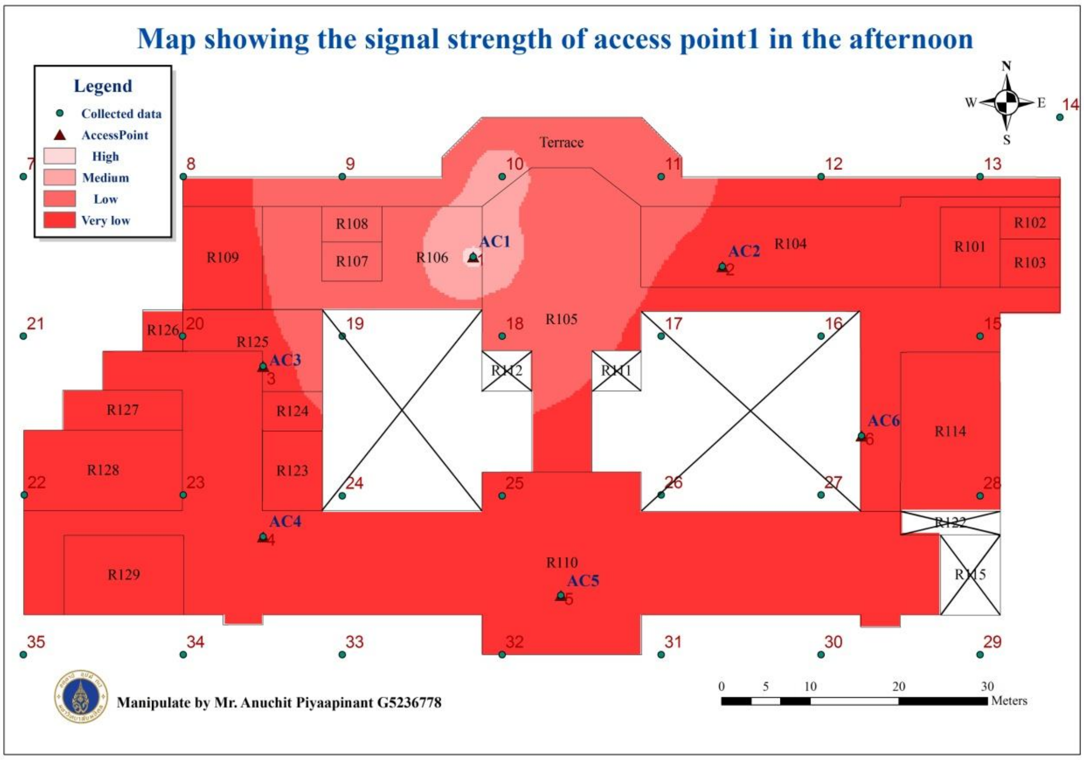

Figure 4.4 Signal strength of access point1 in the afternoon.

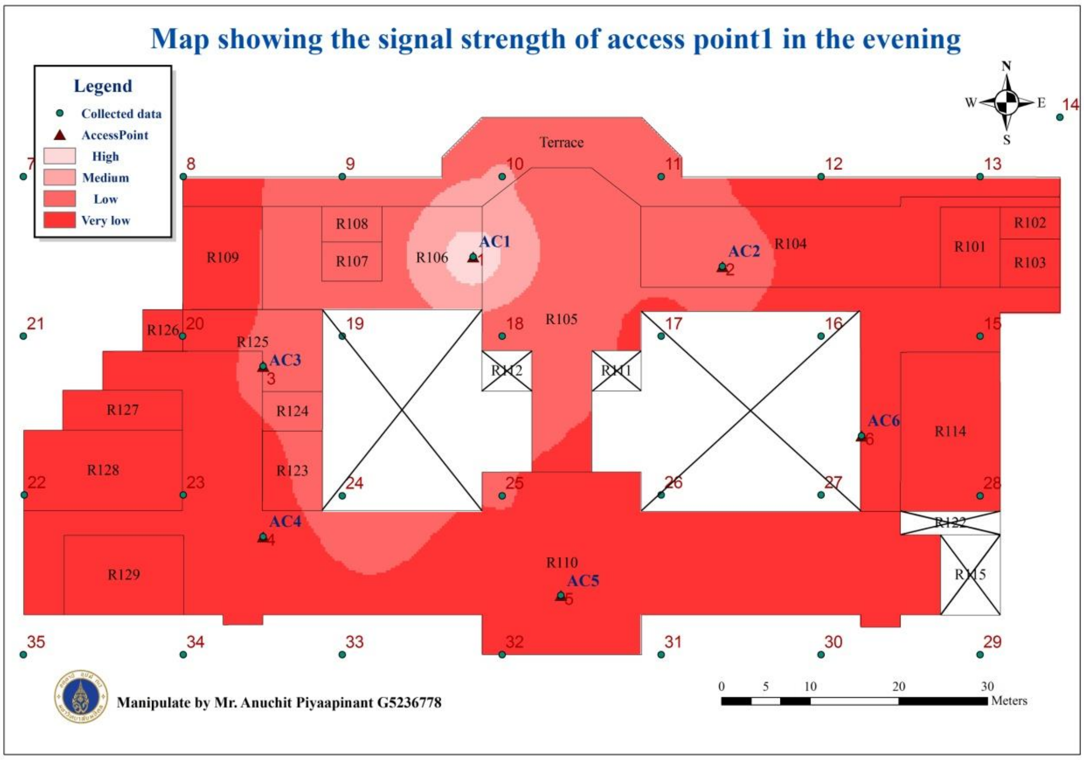

Figure 4.5 Signal strength of access point1 in the evening.

The statistics was summarized to interpolation of signal strength and correlation analysis, access point1 were shown in Table 4.7. Signal strength were most common at noon and followed by in early morning, mean signal strength -79.93, and -81.48 dB, maximum signal strength -40.2, and -42.2 dB, and minimum signal strength -92, and -92.8 dB, respectively. In the evening, found that the average signal strength -82.02 dB, maximum signal strength -38.6 dB, and minimum signal strength -93 dB.

Table 4.7 Statistics of signal strength, access point1

Activity Time	Correlation with distance	Min	Max	Mean	SD
Early Morning	-0.66	-92.8	-42.2	-81.48	9.17
Morning	-0.72	-91.2	-47.6	-81.49	7.66
Noon	-0.70	-92	-40.2	-79.93	9.21
Afternoon	-0.74	-91.8	-48	-82.66	7.44
Evening	-0.75	-93	-38.6	-82.02	8.67
Average	-0.71	-92.16	-43.32	-81.51	8.43

Table 4.8 Correlation analysis, Access point1

		Distance	EM	M	N	A	E	No. user
Distance	Correlate	1	-0.663**	-0.724**	-0.699**	-0.738**	-0.752**	-0.320
	Sig.		0.000	0.000	0.000	0.000	0.000	0.061
EM	Correlate		1	0.944**	0.918**	0.929**	0.937**	0.269
	Sig.			0.000	0.000	0.000	0.000	0.118
M	Correlate			1	0.946**	0.944**	0.966**	0.313
	Sig.				0.000	0.000	0.000	0.067
N	Correlate				1	0.916**	0.948**	0.345*
	Sig.					0.000	0.000	0.042
A	Correlate					1	0.945**	0.253
	Sig.						0.000	0.142
E	Correlate						1	0.408*
	Sig.							0.015
No.user	Correlate							1
	Sig.							

** Correlation is significant at 0.01 level (2-tailed).

* Correlation is significant at 0.05 level (2-tailed).

The result of correlation analysis of access point1 had shown in table 4.8. That found the signal strength and distance was negative indicates between -0.752 to -0.663. Maximum negative correlation was -0.752 in the evening and the level of confident 0.99.

4.1.2 Signal strength interpolation of access point2

Figure 4.6-4.10, are showed signal strength interpolate information of access point2 in each of period activities. It had seen the average signal strength of access point2 when compare in each by activity times.

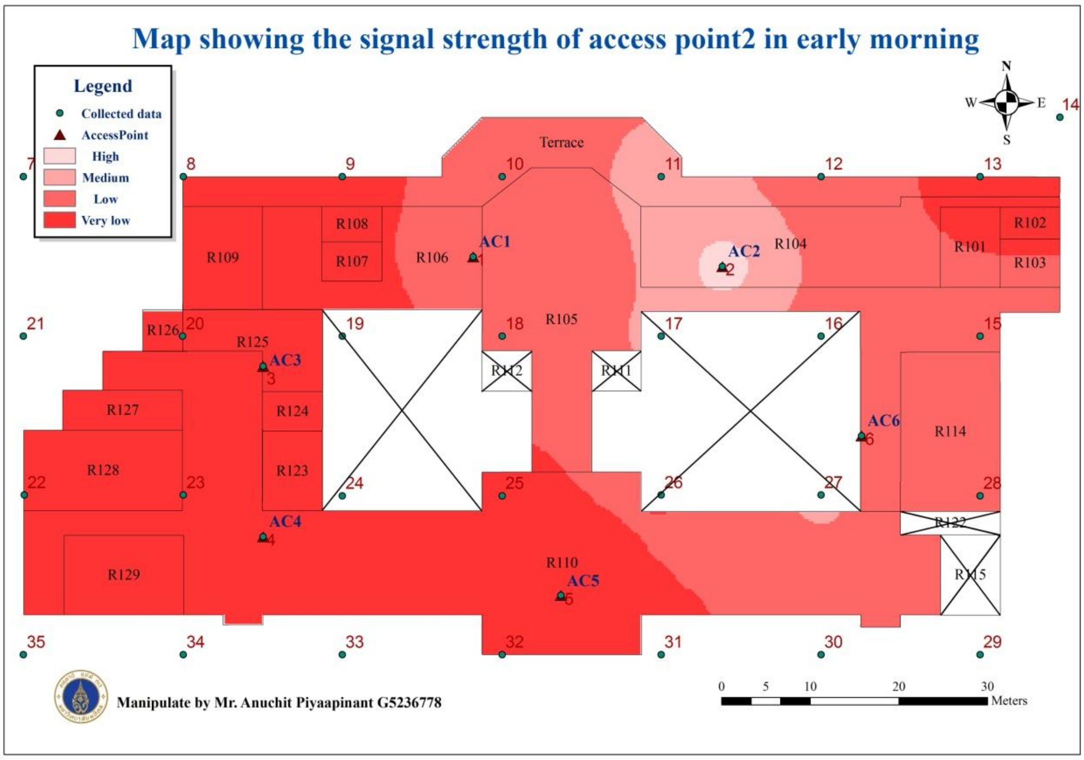

Figure 4.6 Signal strength of access point2 in early morning.

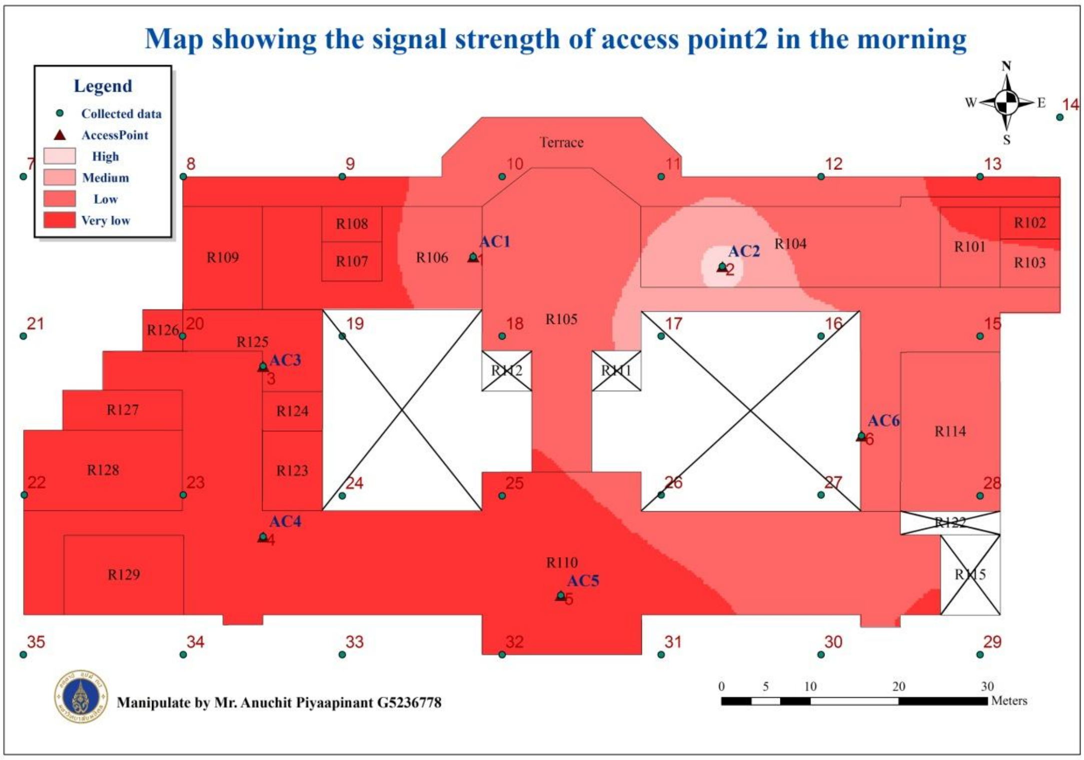

Figure 4.7 Signal strength of access point2 in the morning.

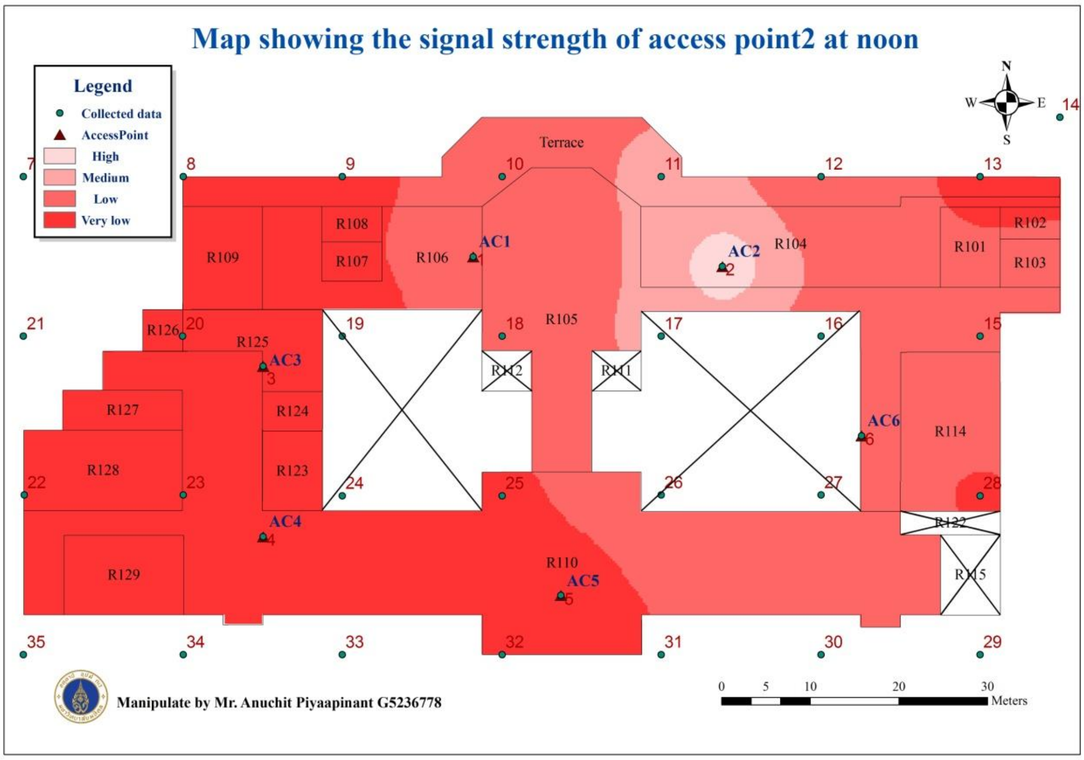

Figure 4.8 Signal strength of access point2 at noon.

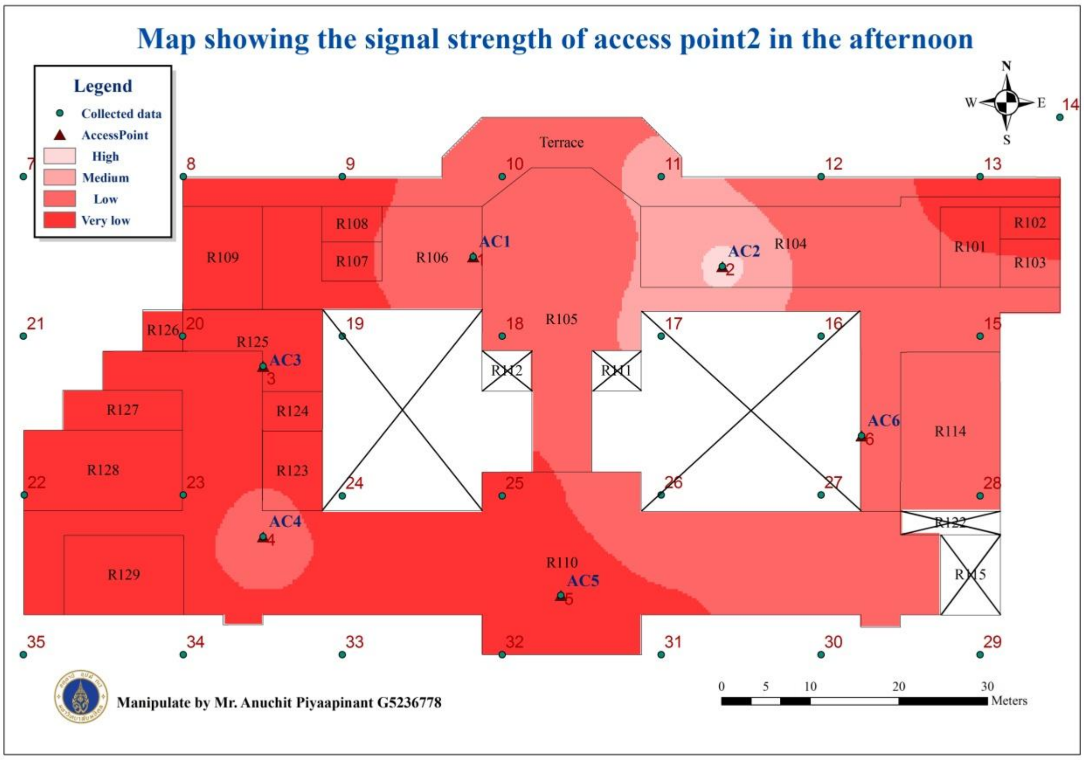

Figure 4.9 Signal strength of access point2 in the afternoon.

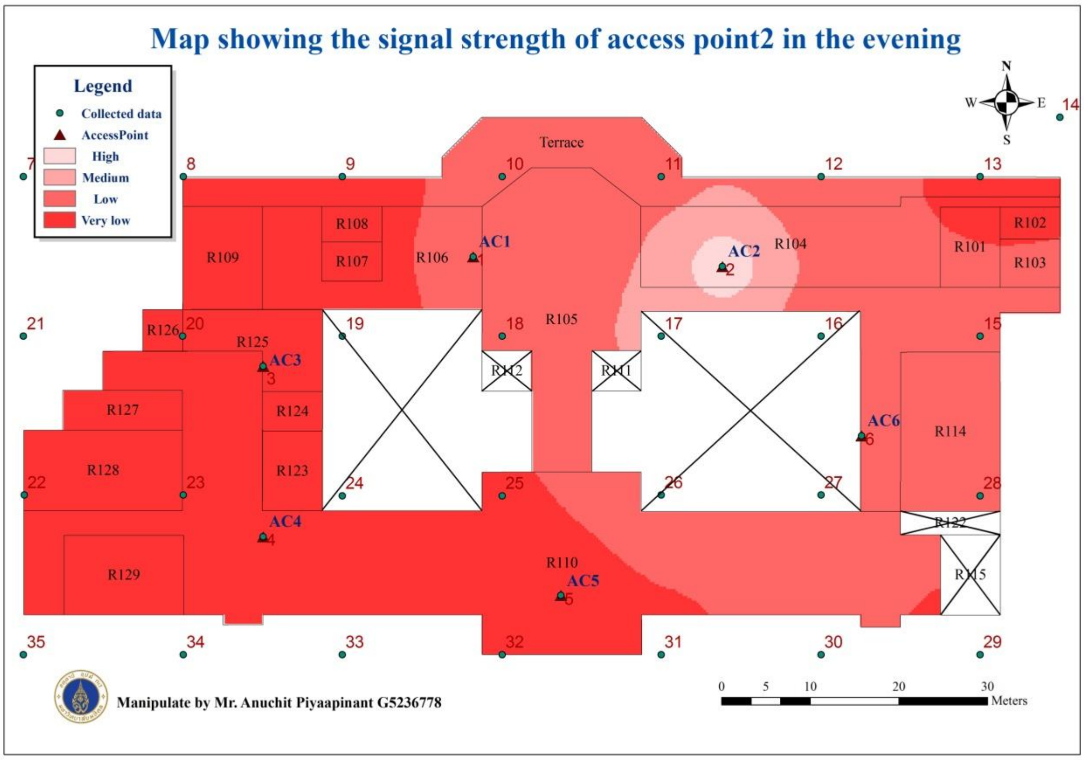

Figure 4.10 Signal strength of access point2 in the evening.

The statistics was summarized to interpolation of signal strength and correlation analysis, access point2 were shown in Table 4.9- 4.10. Signal strength were most common at noon and followed by in the afternoon, mean signal strength -77.82, and -77.83 dB, maximum signal strength -37.8, and -44.8 dB, and minimum signal strength -89.8, and -90.6 dB, respectively. In the evening, found that the average signal strength -80.01 dB, maximum signal strength -38.8 dB, and minimum signal strength -91 dB.

Table 4.9 Statistics of signal strength, Access point2

Activity Time	Correlation with distance	Min	Max	Mean	SD
Early Morning	-0.76	-90.6	-42.8	78.51	9.19
Morning	-0.83	-91	-44.2	-80.21	9.39
Noon	-0.76	-89.8	-37.8	-77.82	8.54
Afternoon	-0.72	-90.6	-44.8	-77.83	7.98
Evening	-0.83	-91	-38.8	-80.01	9.66
Average	-0.78	-90.6	-41.68	-78.87	8.95

Table 4.10 Correlation analysis, Access point2

		Distance	EM	M	N	A	E	No. user
Distance	Correlate	1	-0.759**	-0.828**	-0.763**	-0.392*	-0.829**	-0.280
	Sig.		0.000	0.000	0.000	0.000	0.000	0.103
EM	Correlate		1	0.943**	0.936**	0.508**	0.926**	0.476**
	Sig.			0.000	0.000	0.002	0.000	0.004
M	Correlate			1	0.957**	0.490**	0.959**	0.482*
	Sig.				0.000	0.003	0.000	0.003
N	Correlate				1	0.498**	0.946**	0.524**
	Sig.					0.002	0.000	0.001
A	Correlate					1	0.437**	0.137
	Sig.						0.009	0.431
E	Correlate						1	0.480**
	Sig.							0.004
No.user	Correlate							1
	Sig.							

** Correlation is significant at 0.01 level (2-tailed).

* Correlation is significant at 0.05 level (2-tailed).

The result of correlation analysis of access point2 had shown in table 4.10. That found the signal strength and distance was negative indicates between -0.829 to -0.392. Maximum negative correlation was -0.829 in the evening and the level of confident 0.99.

4.1.3 Signal strength interpolation of access point3

Figure 4.11-4.15, are showed signal strength interpolate information of access point3 in each of period activities. It had seen the average signal strength of access point3 when compare in each by activity times.

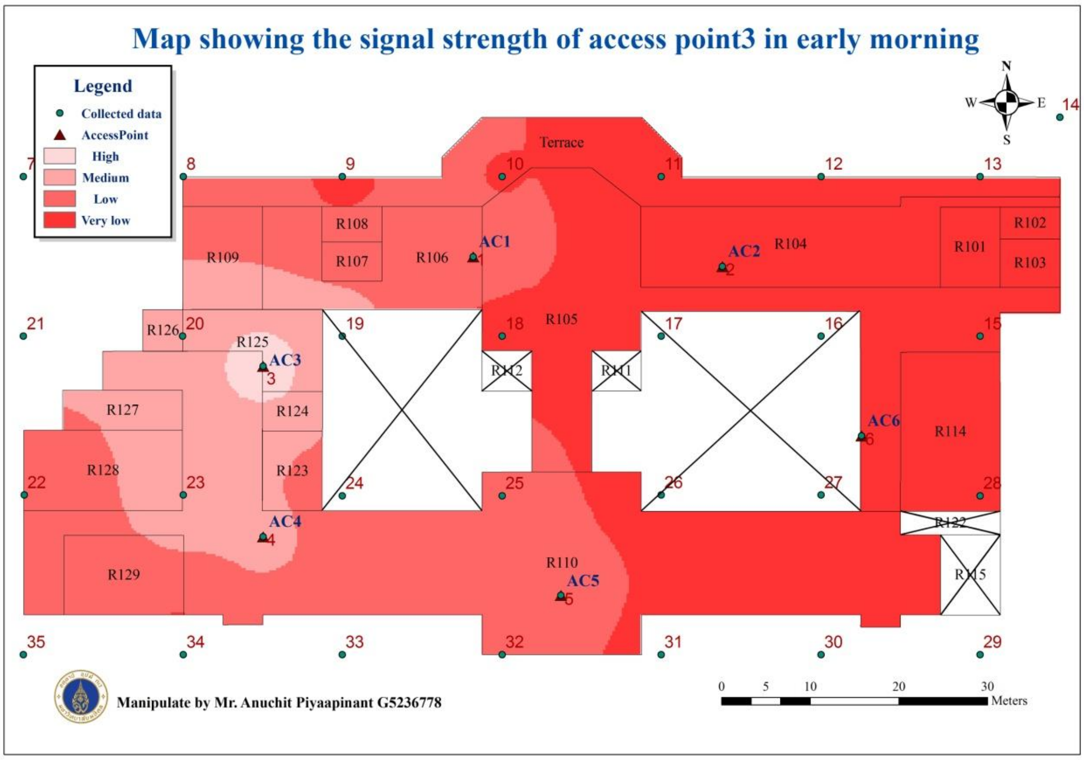

Figure 4.11 Signal strength of access point3 in early morning.

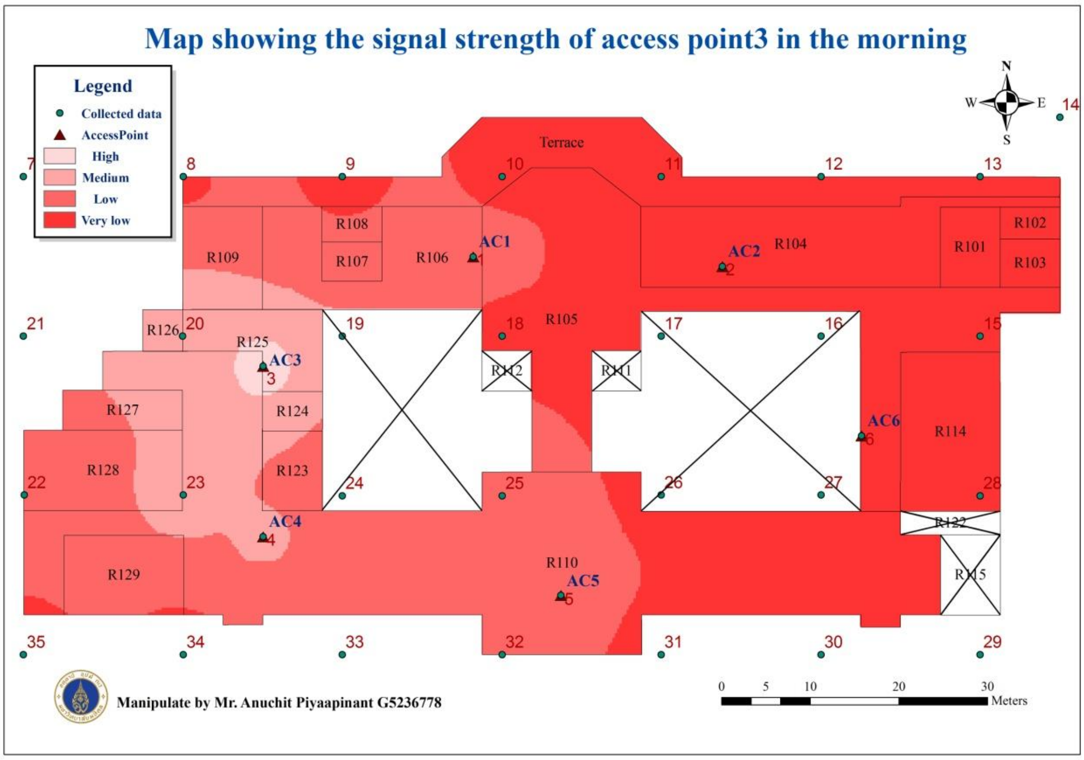

Figure 4.12 Signal strength of access point3 in the morning.

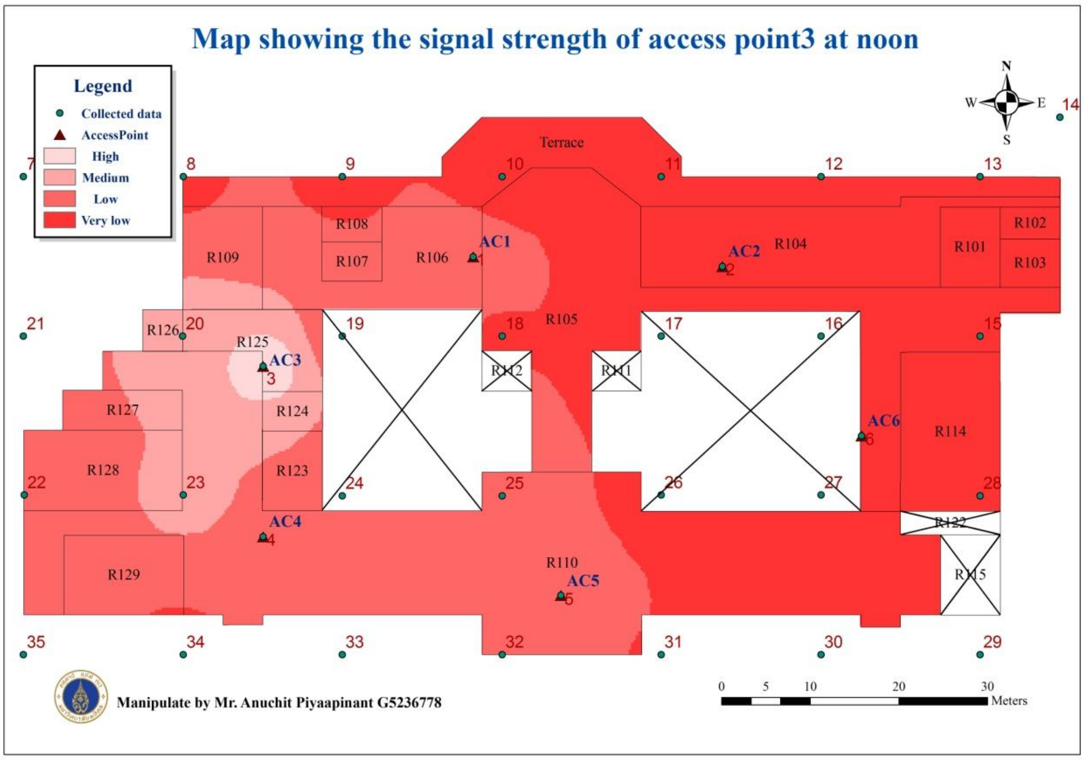

Figure 4.13 Signal strength of access point3 at noon.

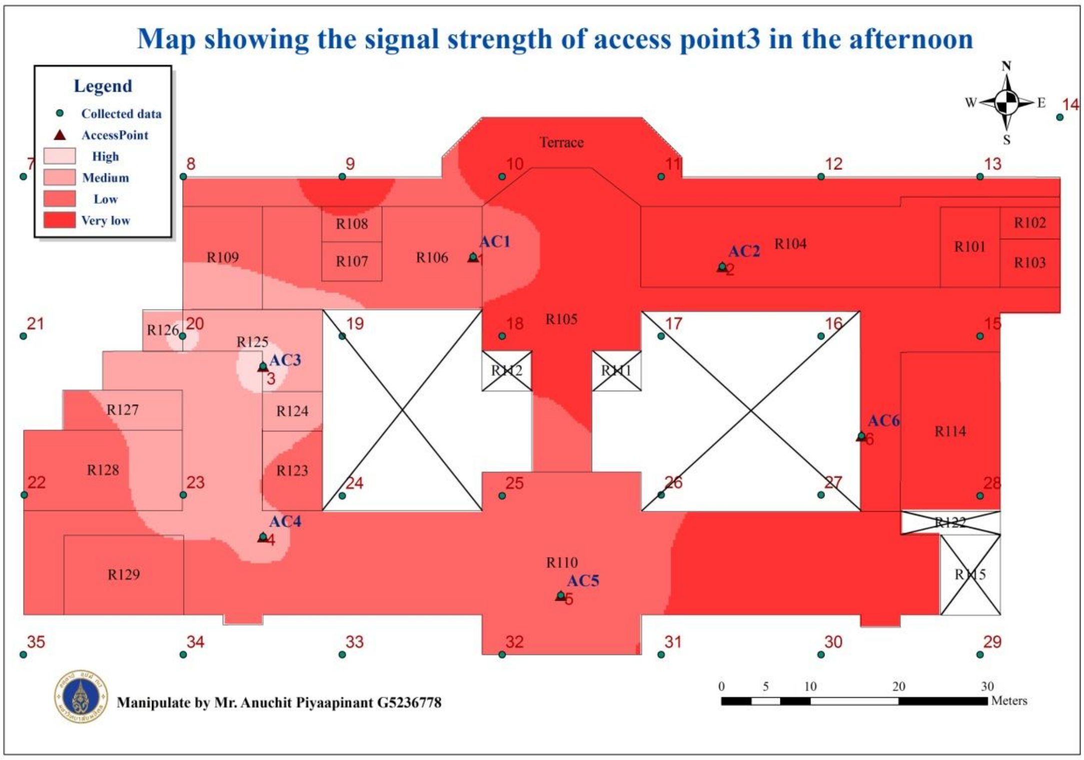

Figure 4.14 Signal strength of access point3 in the afternoon.

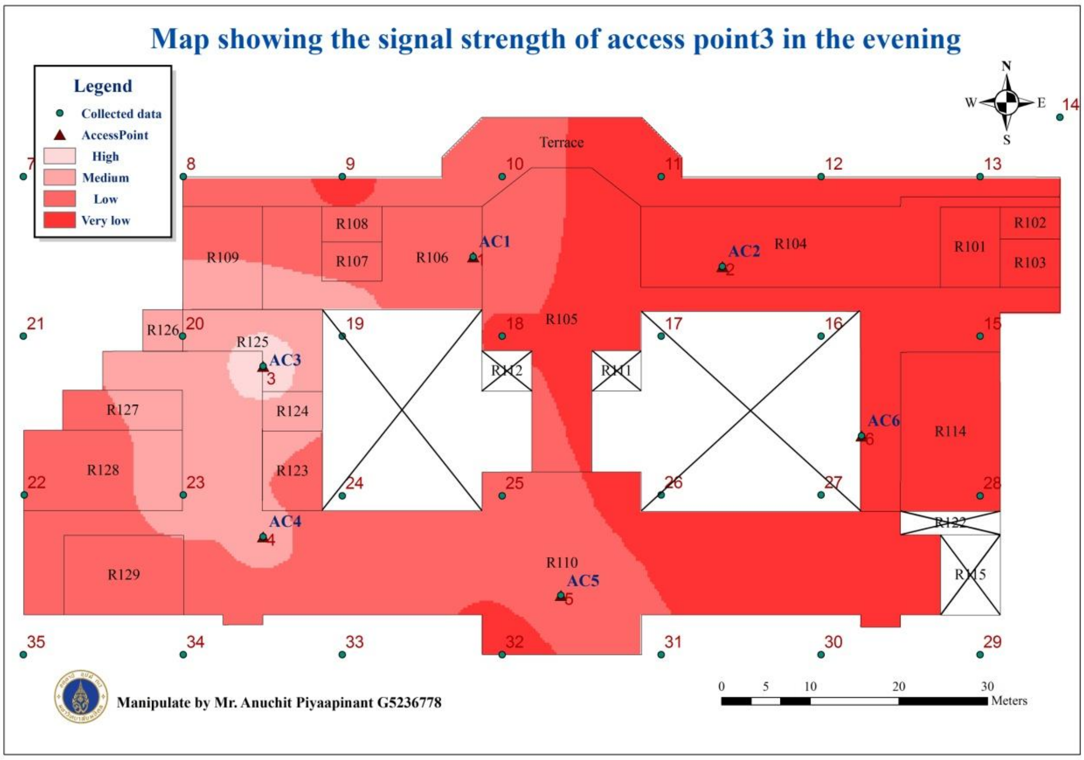

Figure 4.15 Signal strength of access point3 in the evening.

The statistics was summarized to interpolation of signal strength and correlation analysis, access point3 were shown in Table 4.11-4.12. Signal strength were most common in the evening and followed by in the afternoon, mean signal strength -76.68, and -77.27 dB, maximum signal strength -38.8, and -43.2 dB, and minimum signal strength -92.4, and -92.8 dB, respectively. At noon, found that the average signal strength -78 dB, maximum signal strength -35.2 dB, and minimum signal strength -92.4 dB.

Table 4.11 Statistics of signal strength, Access point3

Activity Time	Correlation with distance	Min	Max	Mean	SD
Early Morning	-0.79	-92.2	-37.8	-77.51	10.98
Morning	-0.73	-90.6	-41.2	-77.86	9.92
Noon	-0.72	-92.4	-35.2	-78	9.57
Afternoon	-0.77	-92.8	-43.2	-77.27	9.93
Evening	-0.69	-92.4	-38.8	-76.68	9.21
Average	-0.74	-92.08	-39.24	-77.46	9.92

Table 4.12 Correlation analysis, Access point3

		Distance	EM	M	N	A	E	No. user
Distance	Correlate	1	-0.789**	-0.720**	-0.725**	-0.769**	-0.695**	-0.146
	Sig.		0.000	0.000	0.000	0.000	0.000	0.403
EM	Correlate		1	0.957**	0.937**	0.962**	0.909**	0.125
	Sig.			0.000	0.000	0.000	0.000	0.474
M	Correlate			1	0.948**	0.959**	0.914**	0.135
	Sig.				0.000	0.000	0.000	0.441
N	Correlate				1	0.936**	0.895**	0.211
	Sig.					0.000	0.000	0.223
A	Correlate					1	0.901**	0.146
	Sig.						0.000	0.403
E	Correlate						1	0.073
	Sig.							0.677
No.user	Correlate							1
	Sig.							

** Correlation is significant at 0.01 level (2-tailed).

* Correlation is significant at 0.05 level (2-tailed).

The result of correlation analysis of access point3 had shown in table 4.12. That found the signal strength and distance was negative indicates between -0.789 to -0.695. Maximum negative correlation was -0.789 in early morning and the level of confident 0.99.

4.1.4 Signal strength interpolation of access point4

Figure 4.16-4.20, are showed signal strength interpolate information of access point4 in each of period activities. It had seen the average signal strength of access point4 when compare in each by activity times.

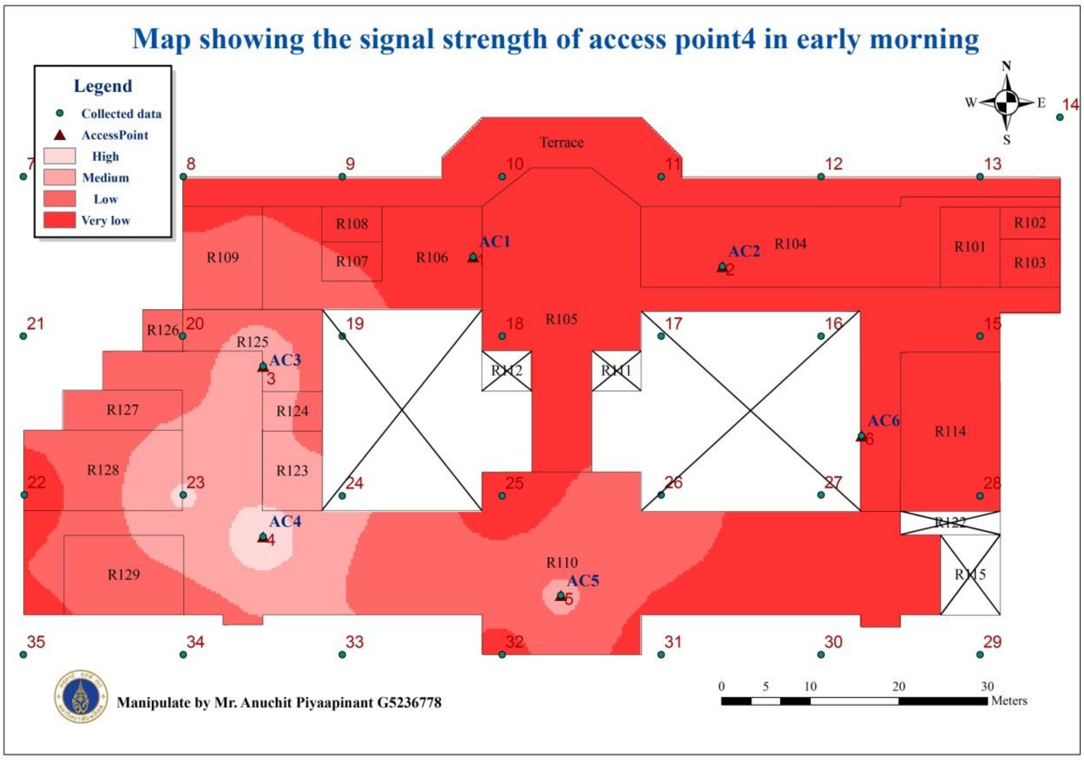

Figure 4.16 Signal strength of access point4 in early morning.

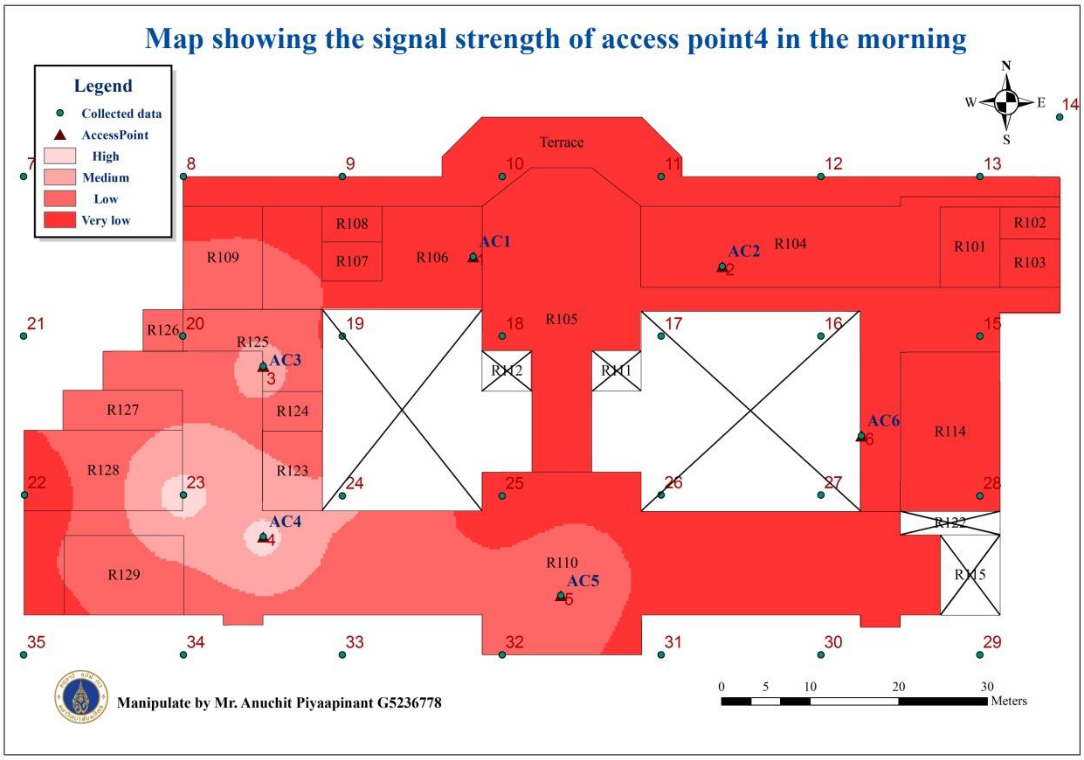

Figure 4.17 Signal strength of access point4 in the morning.

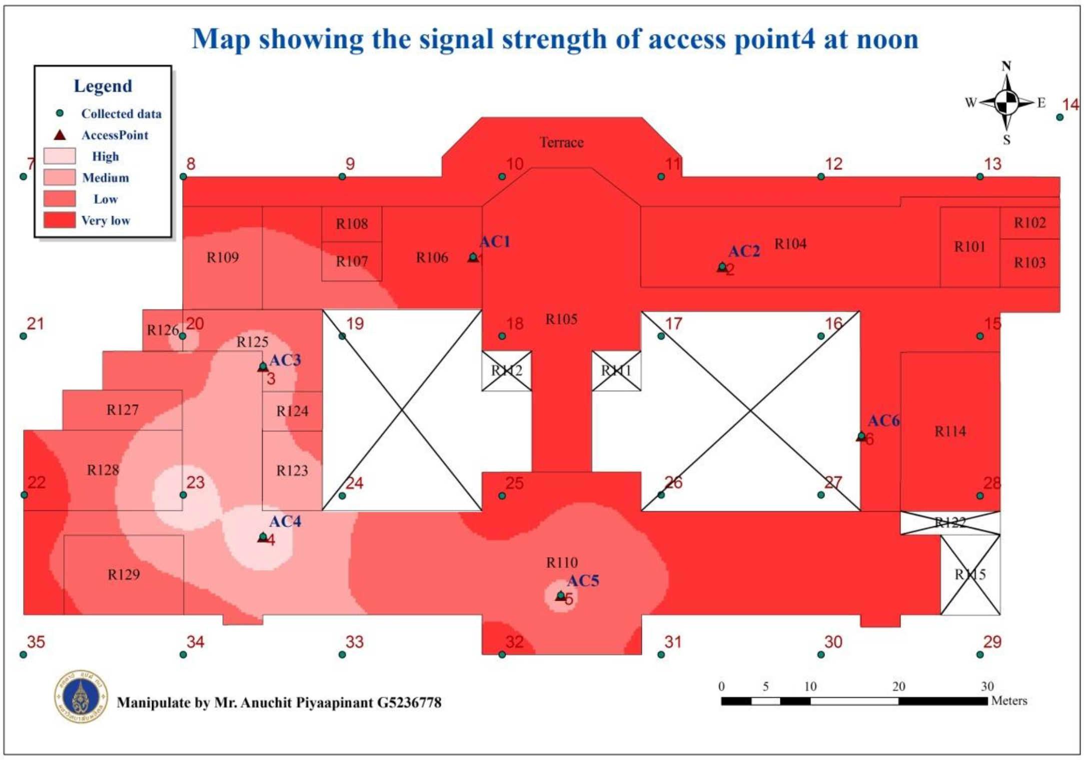

Figure 4.18 Signal strength of access point4 at noon.

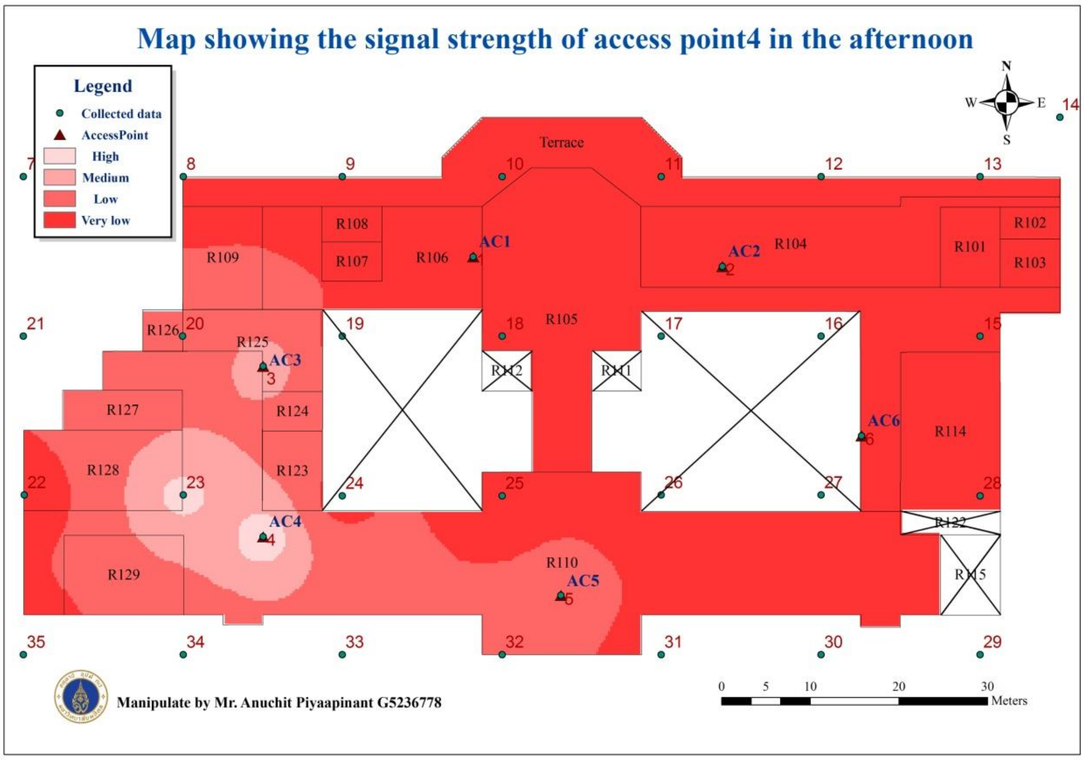

Figure 4.19 Signal strength of access point4 in the afternoon.

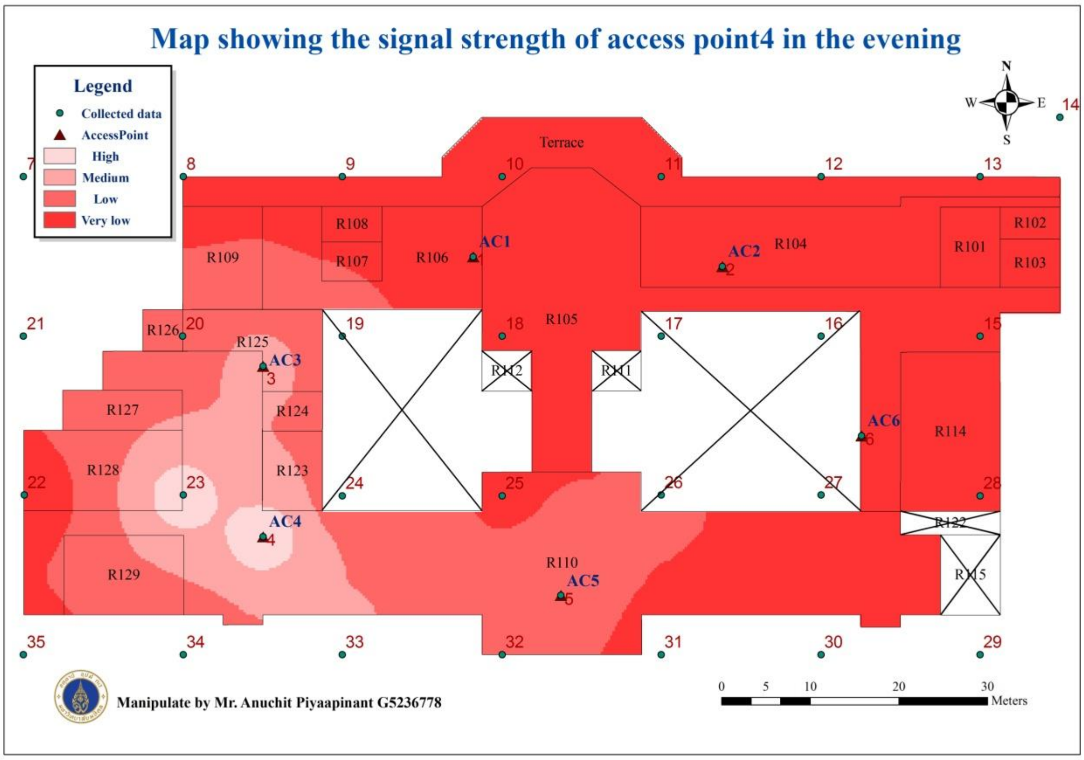

Figure 4.20 Signal strength of access point4 in the evening.

The statistics was summarized to interpolation of signal strength and correlation analysis, access point4 were shown in Table 4.13- 4.14. Signal strength were most common in early morning and followed by at noon, mean signal strength -78.84, and -79.71 dB, maximum signal strength -38.2, and -38.2 dB, and minimum signal strength -92.4, and -91.8 dB.

Table 4.13 Statistics of signal strength, Access point4

Activity Time	Correlation with distance	Min	Max	Mean	SD
Early Morning	-0.63	-92.4	-38.2	-78.84	9.8
Morning	-0.63	-90.4	-44.6	-80.9	8.79
Noon	-0.64	-91.8	-38.2	-79.71	10.53
Afternoon	-0.61	-88.8	-41.8	-81.07	8.29
Evening	-0.67	-91.8	-38.4	-80.32	10.73
Average	-0.64	-91.04	-40.24	-80.17	9.63

Table 4.14 Correlation analysis, Access point4

		Distance	EM	M	N	A	E	No. user
Distance	Correlate	1	-0.633**	-0.630**	-0.641**	-0.609**	-0.665**	-0.057
	Sig.		0.000	0.000	0.000	0.000	0.000	0.403
EM	Correlate		1	0.954**	0.972**	0.927**	0.962**	-0.018
	Sig.			0.000	0.000	0.000	0.000	0.917
M	Correlate			1	0.962**	0.934**	0.946**	0.045
	Sig.				0.000	0.000	0.000	0.797
N	Correlate				1	0.946**	0.974**	0.048
	Sig.					0.000	0.000	0.782
A	Correlate					1	0.949**	0.062
	Sig.						0.000	0.723
E	Correlate						1	0.014
	Sig.							0.936
No.user	Correlate							1
	Sig.							

** Correlation is significant at 0.01 level (2-tailed).

* Correlation is significant at 0.05 level (2-tailed).

The result of correlation analysis of access point4 had shown in table 4.14. That found the signal strength and distance was negative indicates between -0.665 to -0.609. Maximum negative correlation was -0.665 in the evening and the level of confident 0.99.

4.1.5 Signal strength interpolation of access point5

Figure 4.21-4.25, are showed signal strength interpolate information of access point5 in each of period activities. It had seen the average signal strength of access point5 when compare in each by activity times.

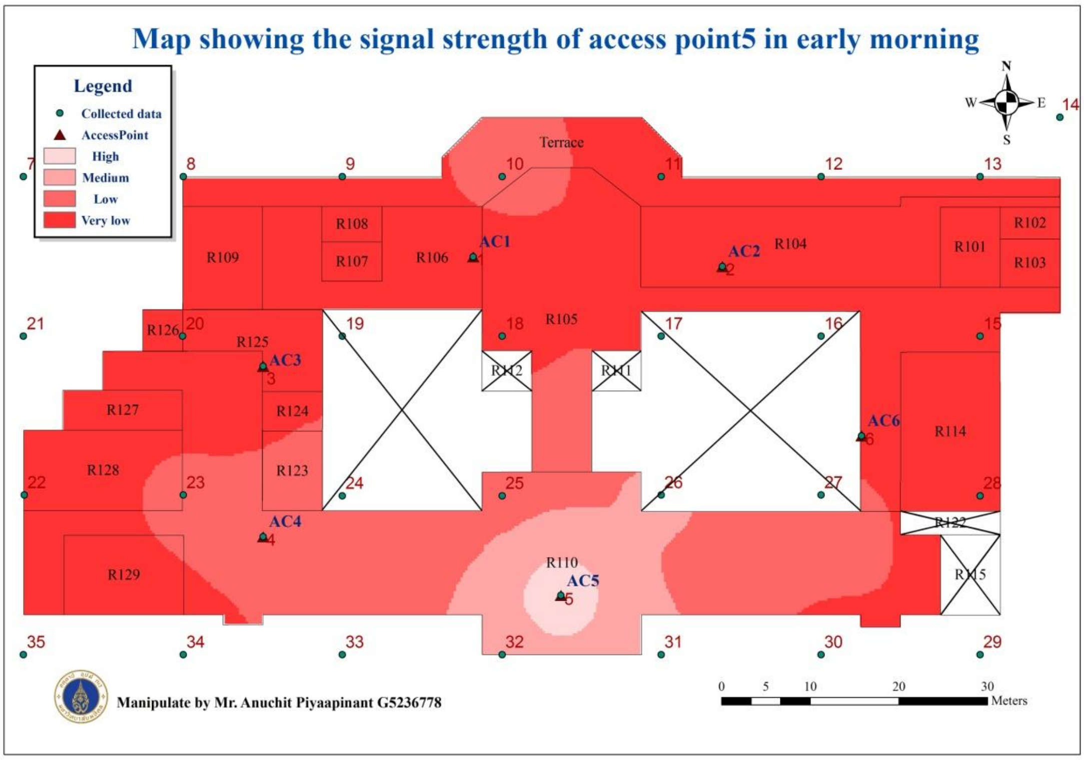

Figure 4.21 Signal strength of access point5 in early morning.

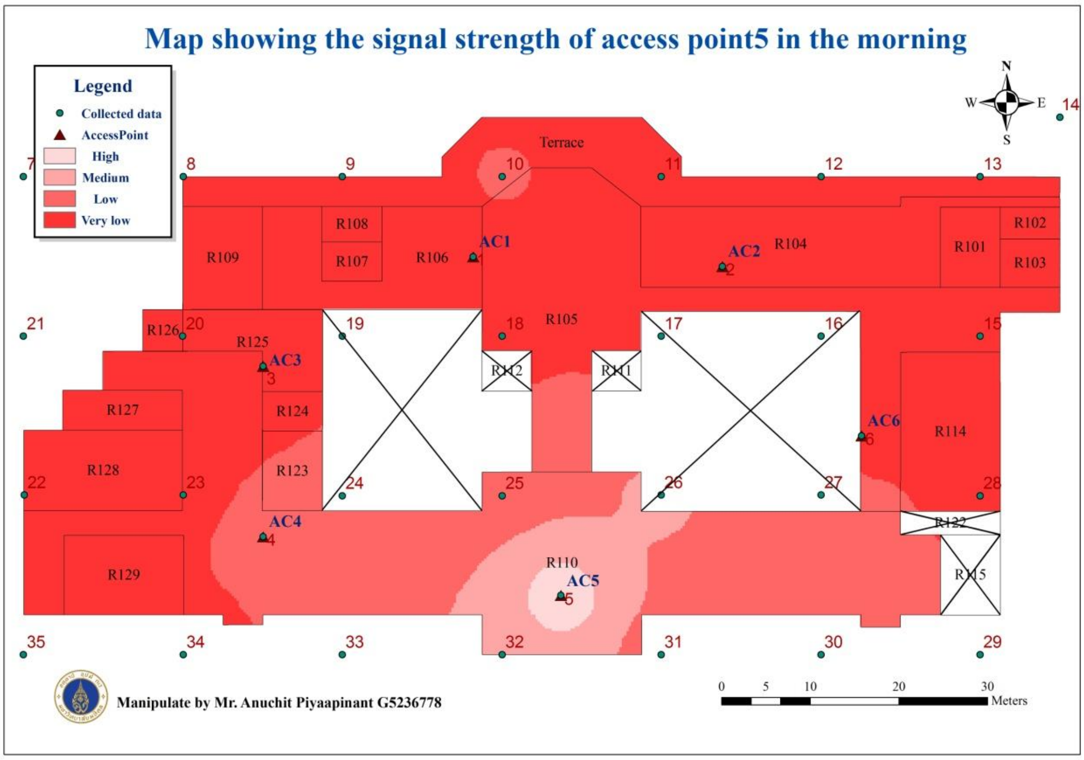

Figure 4.22 Signal strength of access point5 in the morning.

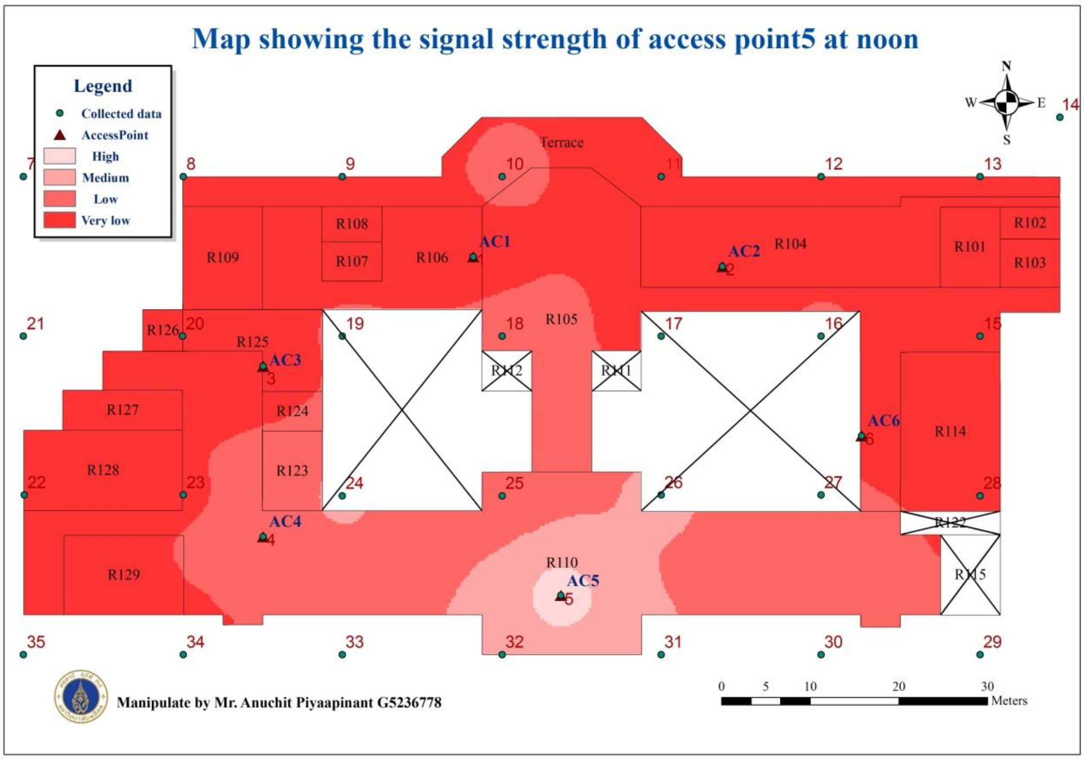

Figure 4.23 Signal strength of access point5 at noon.

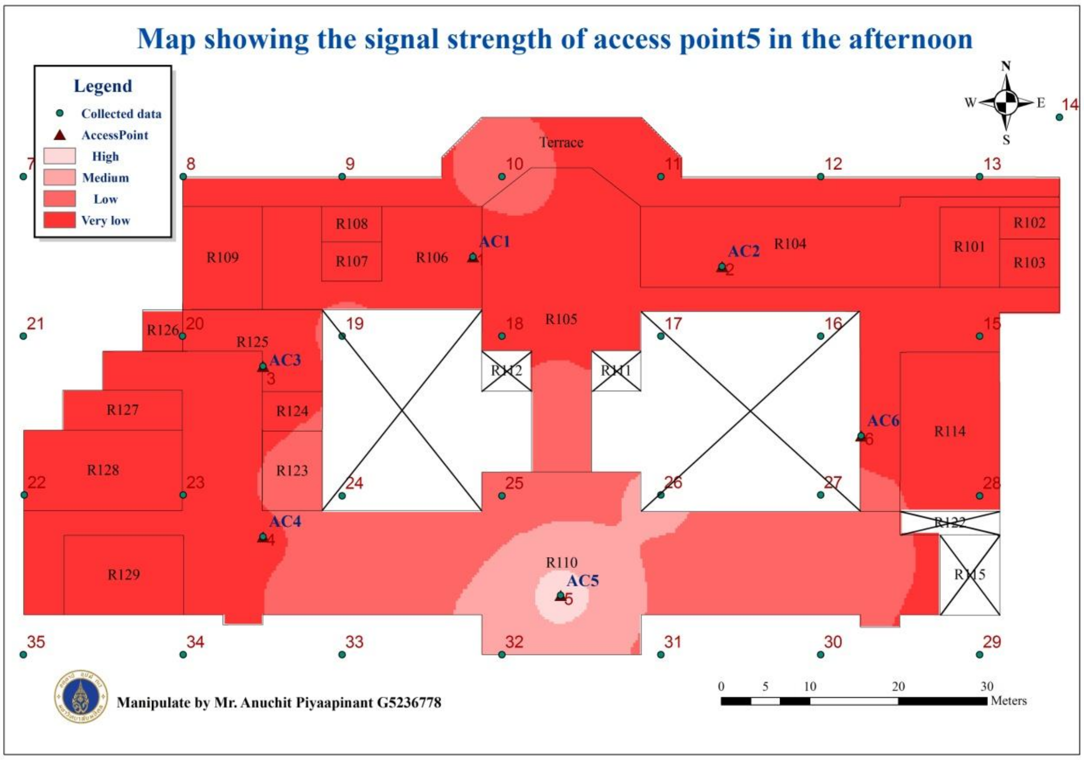

Figure 4.24 Signal strength of access point5 in the afternoon.

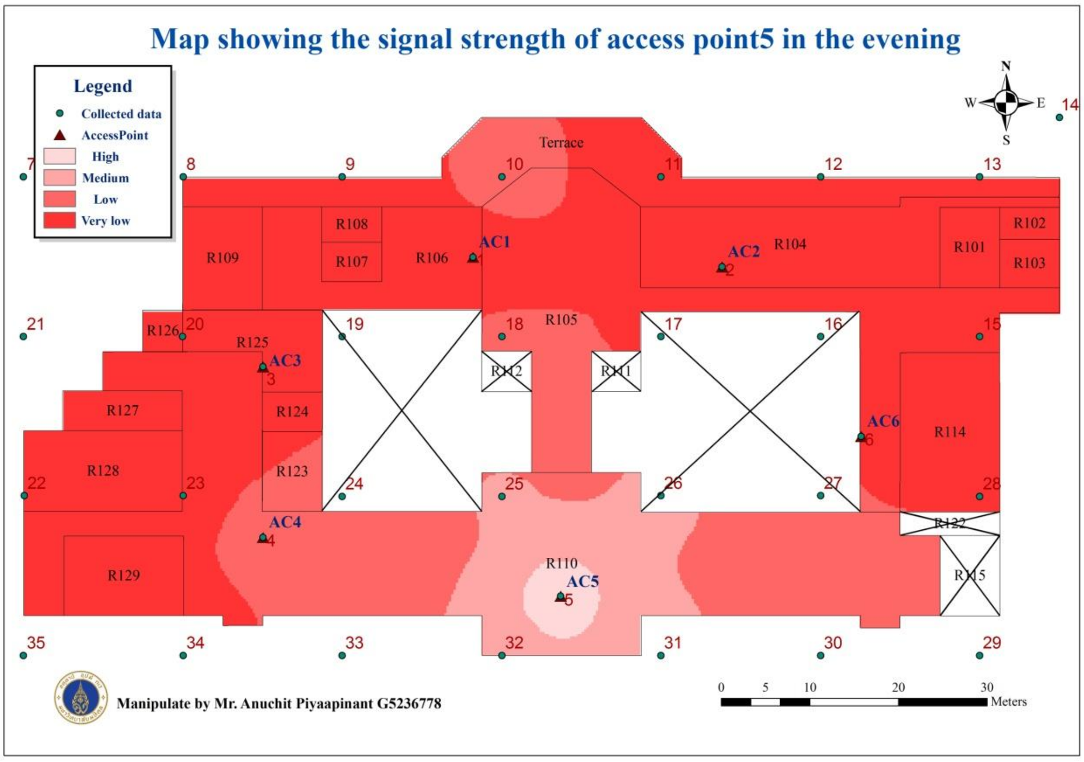

Figure 4.25 Signal strength of access point5 in the evening.

The statistics was summarized to interpolation of signal strength and correlation analysis, access point5 were shown in Table 4.15- 4.16. Signal strength were most common at noon and followed by in early morning and in the evening, mean signal strength -77.58, -78.66, and -78.66 dB, maximum signal strength -40.8, -35.4, and -35.2 dB, and minimum signal strength -91.2, -91.8, and -91.4 dB.

Table 4.15 Statistics of signal strength, Access point5

Activity Time	Correlation with distance	Min	Max	Mean	SD
Early Morning	-0.75	-91.8	-35.4	-78.66	9.18
Morning	-0.78	-91.8	-37.8	-79.03	8.79
Noon	-0.81	-91.2	-40.8	-77.58	8.88
Afternoon	-0.82	-91.8	-42.2	-79.4	8.81
Evening	-0.81	-91.4	-35.2	-78.66	9.42
Average	-0.79	-91.6	-38.28	-78.67	9.02

Table 4.16 Correlation analysis, Access point5

		Distance	EM	M	N	A	E	No. user
Distance	Correlate	1	-0.745**	-0.783**	-0.811**	-0.822**	-0.810**	-0.049
	Sig.		0.000	0.000	0.000	0.000	0.000	0.780
EM	Correlate		1	0.943**	0.938**	0.951**	0.945**	-0.103
	Sig.			0.000	0.000	0.000	0.000	0.555
M	Correlate			1	0.945**	0.946**	0.962**	-0.108
	Sig.				0.000	0.000	0.000	0.536
N	Correlate				1	0.942**	0.947**	-0.116
	Sig.					0.000	0.000	0.508
A	Correlate					1	0.946**	-0.045
	Sig.						0.000	0.797
E	Correlate						1	-0.074
	Sig.							0.674
No.user	Correlate							1
	Sig.							

** Correlation is significant at 0.01 level (2-tailed).

* Correlation is significant at 0.05 level (2-tailed).

The result of correlation analysis of access point5 had shown in table 4.16. That found the signal strength and distance was negative indicates between -0.822 to -0.745. Maximum negative correlation was -0.822 in the afternoon and the level of confident 0.99.

4.1.6 Signal strength interpolation of access point6

Figure 4.26-4.30, are showed signal strength interpolate information of access point6 in each of period activities. It had seen the average signal strength of access point6 when compare in each by activity times.

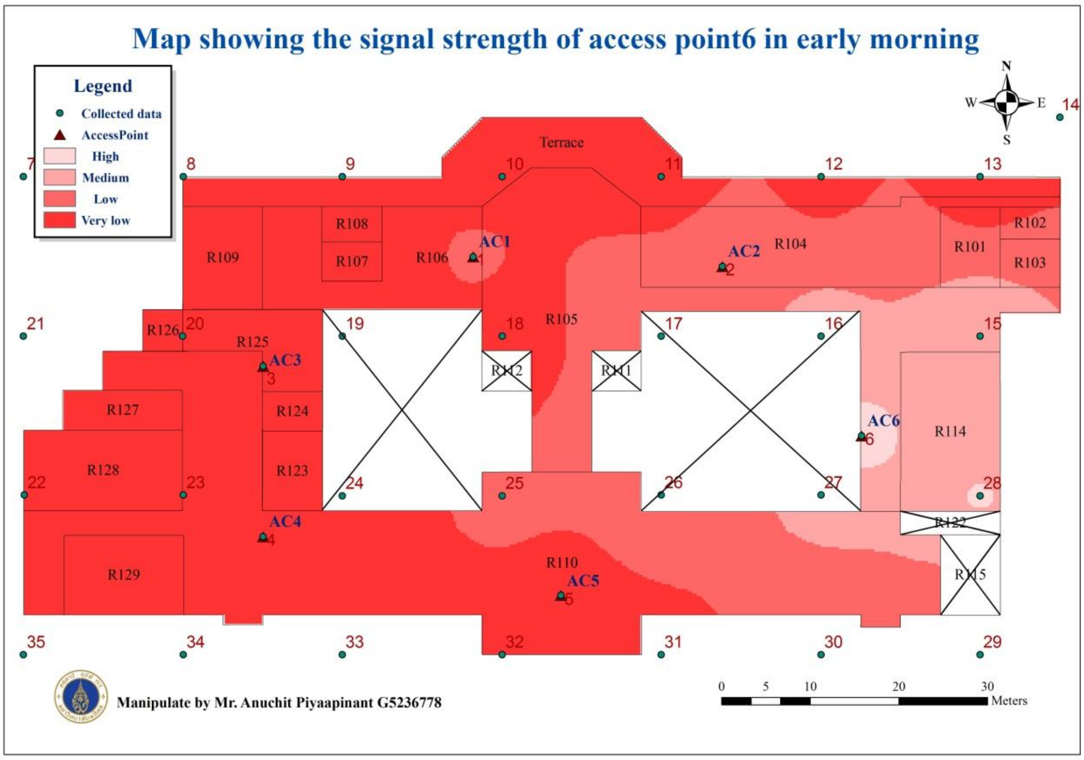

Figure 4.26 Signal strength of access point6 in early morning.

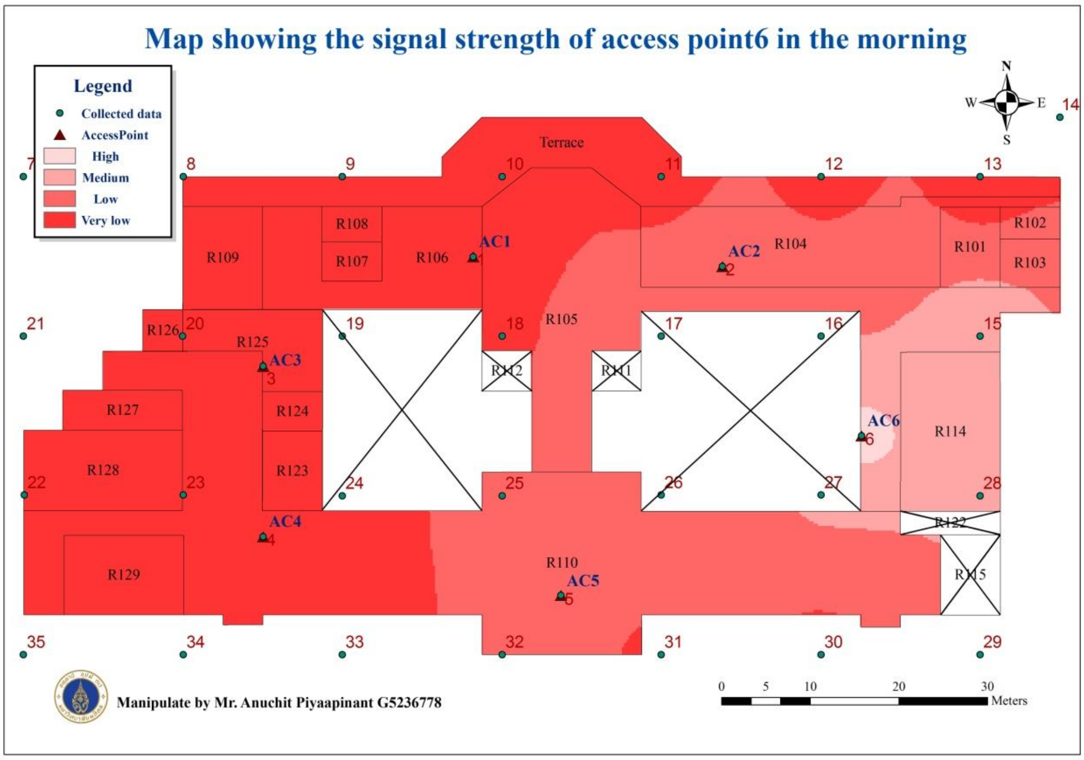

Figure 4.27 Signal strength of access point6 in the morning.

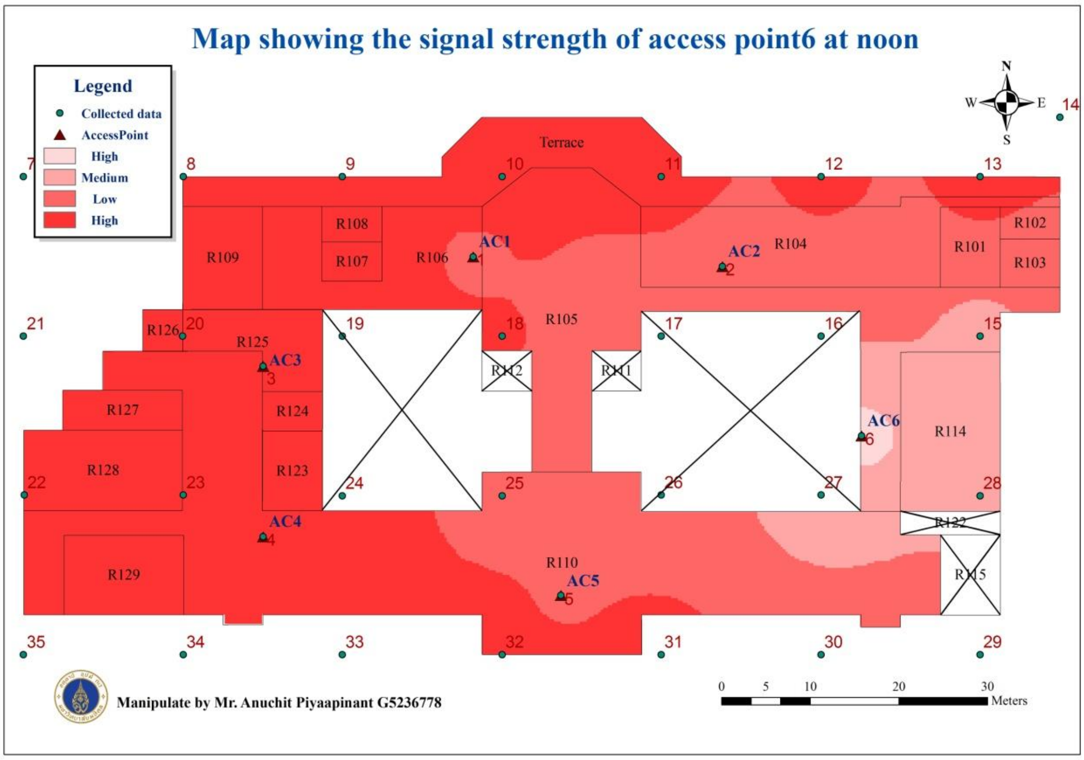

Figure 4.28 Signal strength of access point6 at noon.

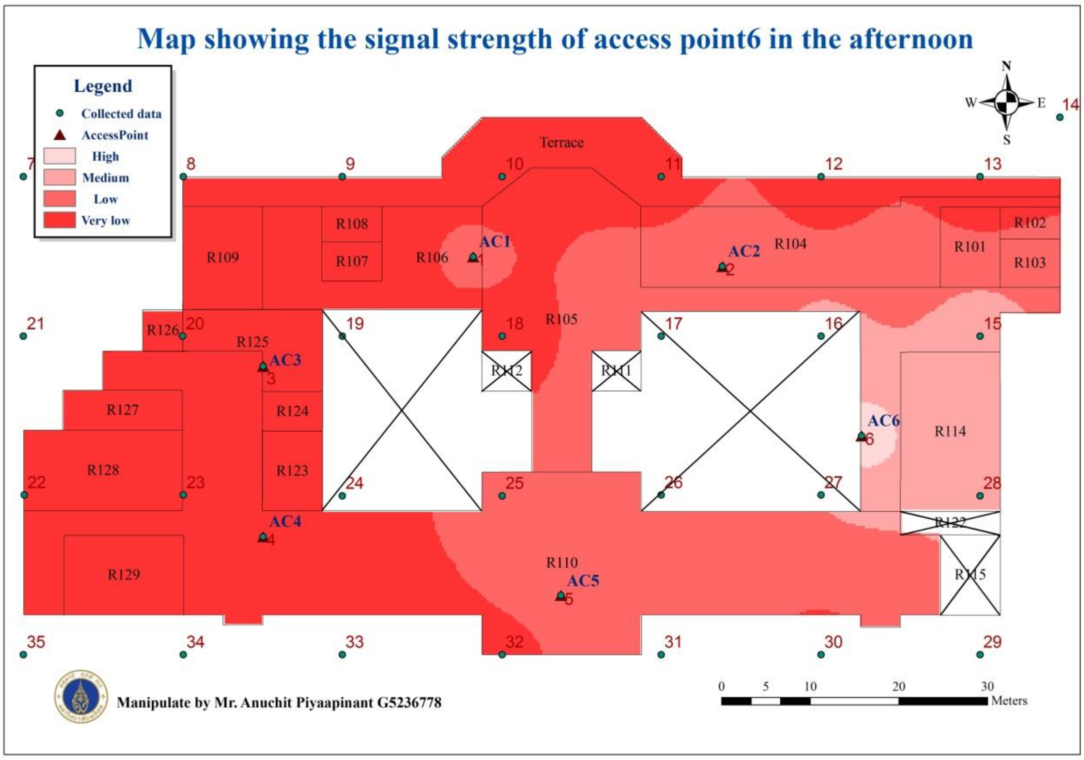

Figure 4.29 Signal strength of access point6 in the afternoon.

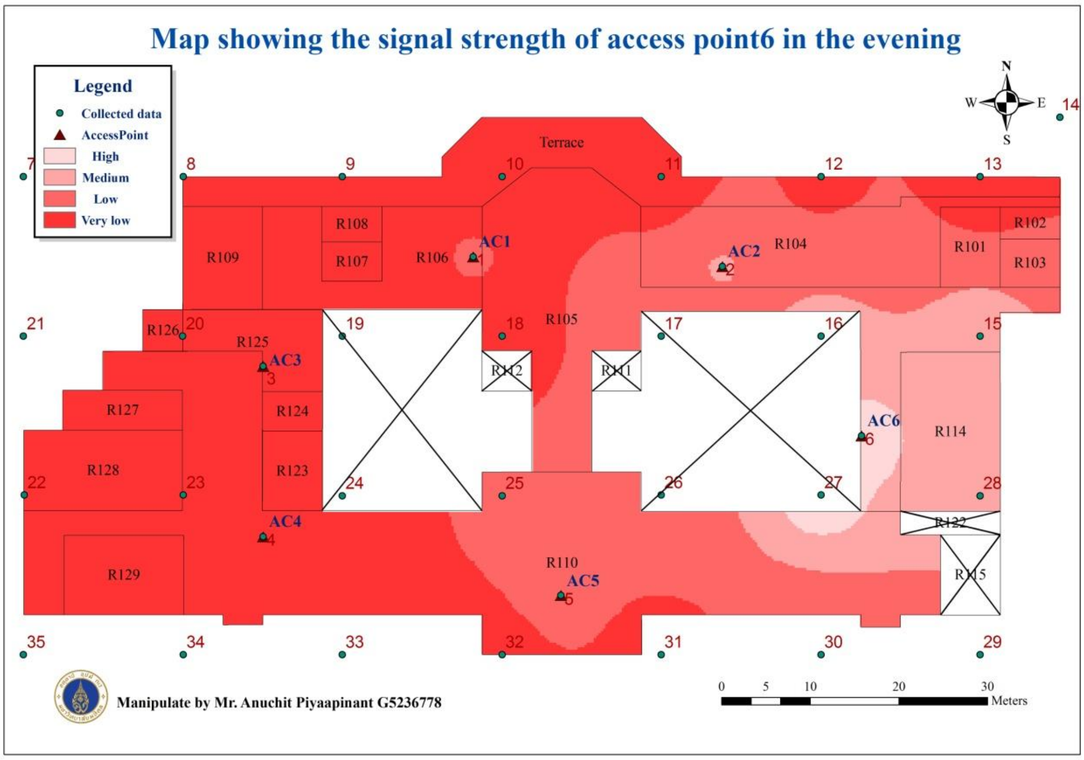

Figure 4.30 Signal strength of access point6 in the evening.

The statistics was summarized to interpolation of signal strength and correlation analysis, access point6 were shown in Table 4.17- 4.18. Signal strength were most common in the morning and followed by in early morning, mean signal strength -79, and -79.14 dB, maximum signal strength -40.6, and -39.8 dB, and minimum signal strength -91.2, and -90.6 dB, respectively. In the evening, found that the average signal strength -79.73 dB, maximum signal strength -36.2 dB, and minimum signal strength -93 dB.

Table 4.17 Statistics of signal strength, Access point6

Activity Time	Correlation with distance	Min	Max	Mean	SD
Early Morning	-0.72	-90.6	-39.8	-79.14	10.66
Morning	-0.76	-91.2	-40.6	-79	10.16
Noon	-0.81	-91.2	-41.6	-79.31	10.83
Afternoon	-0.77	-91.4	-37.6	-79.43	9.96
Evening	-0.76	-93	-36.2	-79.73	12.43
Average	-0.76	-91.48	-39.16	-79.32	10.81

Table 4.18 Correlation analysis, Access point6

		Distance	EM	M	N	A	E	No. user
Distance	Correlate	1	-0.723**	-0.758**	-0.805**	-0.765**	-0.762**	-0.060
	Sig.		0.000	0.000	0.000	0.000	0.000	0.730
EM	Correlate		1	0.942**	0.925**	0.953**	0.930**	0.081
	Sig.			0.000	0.000	0.000	0.000	0.643
M	Correlate			1	0.900**	0.967**	0.925**	0.088
	Sig.				0.000	0.000	0.000	0.613
N	Correlate				1	0.897**	0.931**	0.080
	Sig.					0.000	0.000	0.650
A	Correlate					1	0.921**	0.094
	Sig.						0.000	0.590
E	Correlate						1	0.112
	Sig.							0.520
No.user	Correlate							1
	Sig.							

** Correlation is significant at 0.01 level (2-tailed).

* Correlation is significant at 0.05 level (2-tailed).

The result of correlation analysis of access point5 had shown in table 4.18. That found the signal strength and distance was negative indicates between -0.805 to -0.723. Maximum negative correlation was -0.805 at noon and the level of confident 0.99.

Figure 4.31-4.35, are showed the signal strength interpolate information of all access points in each of period activities. It had seen the average signal strength at this study area when compare in each by activity times.

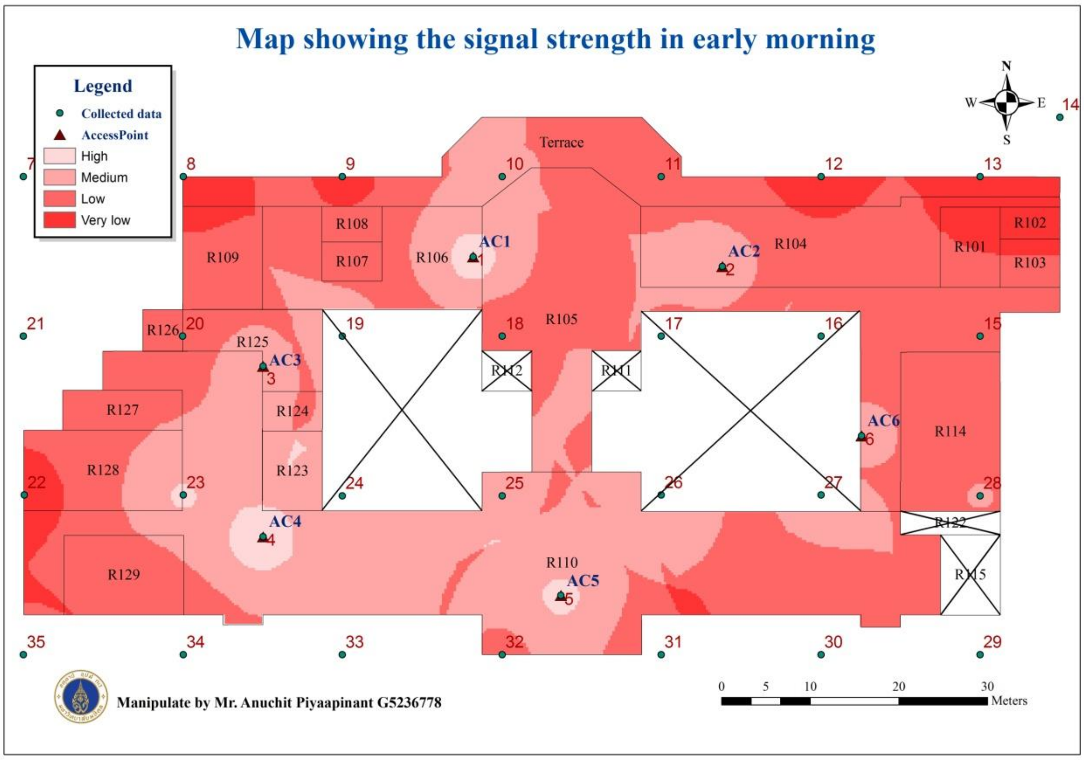

Figure 4.31 Signal strength in early morning.

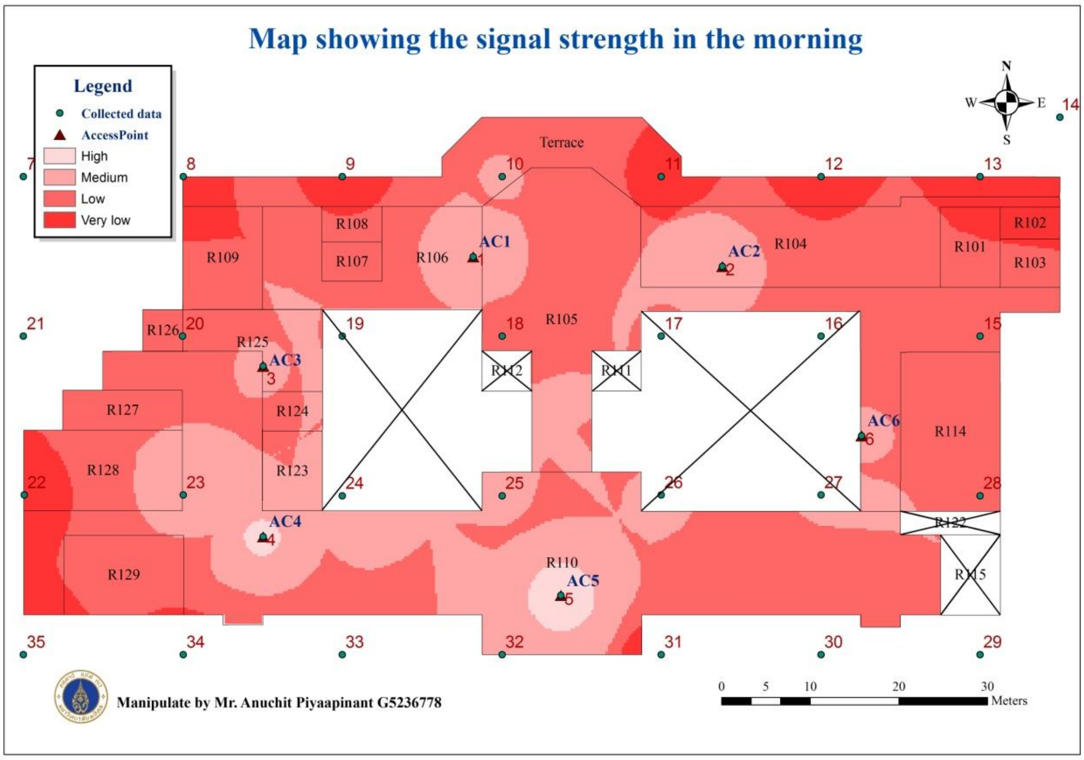

Figure 4.32 Signal strength in the morning.

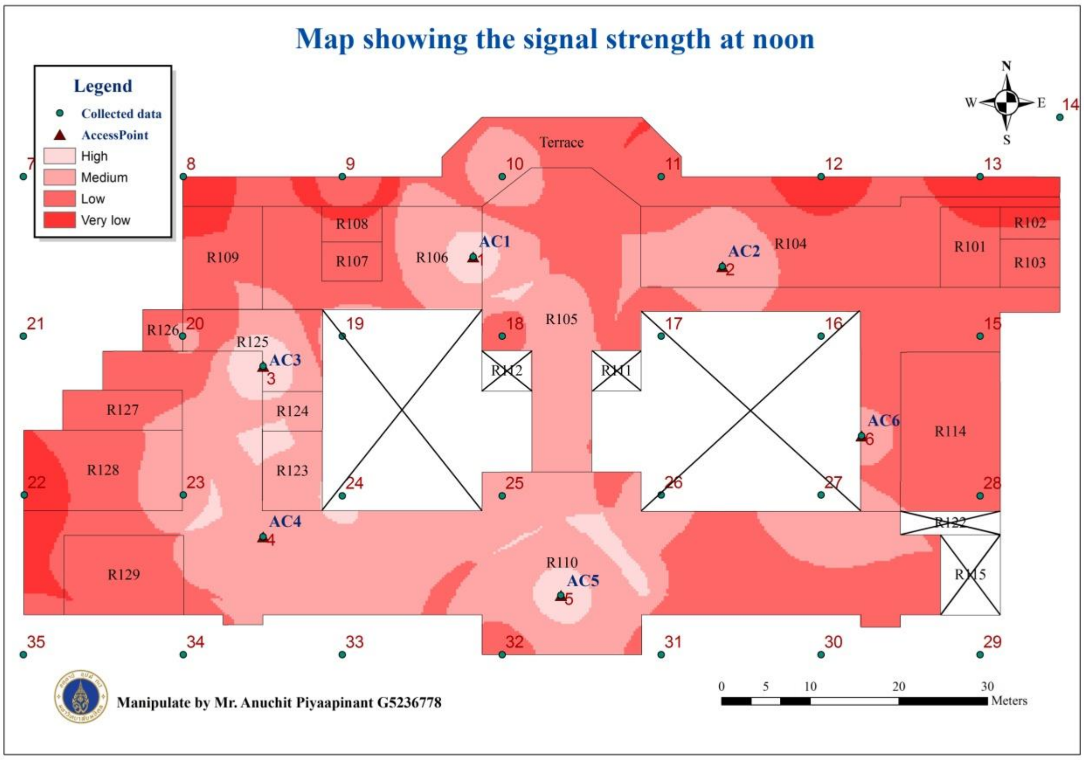

Figure 4.33 Signal strength at noon.

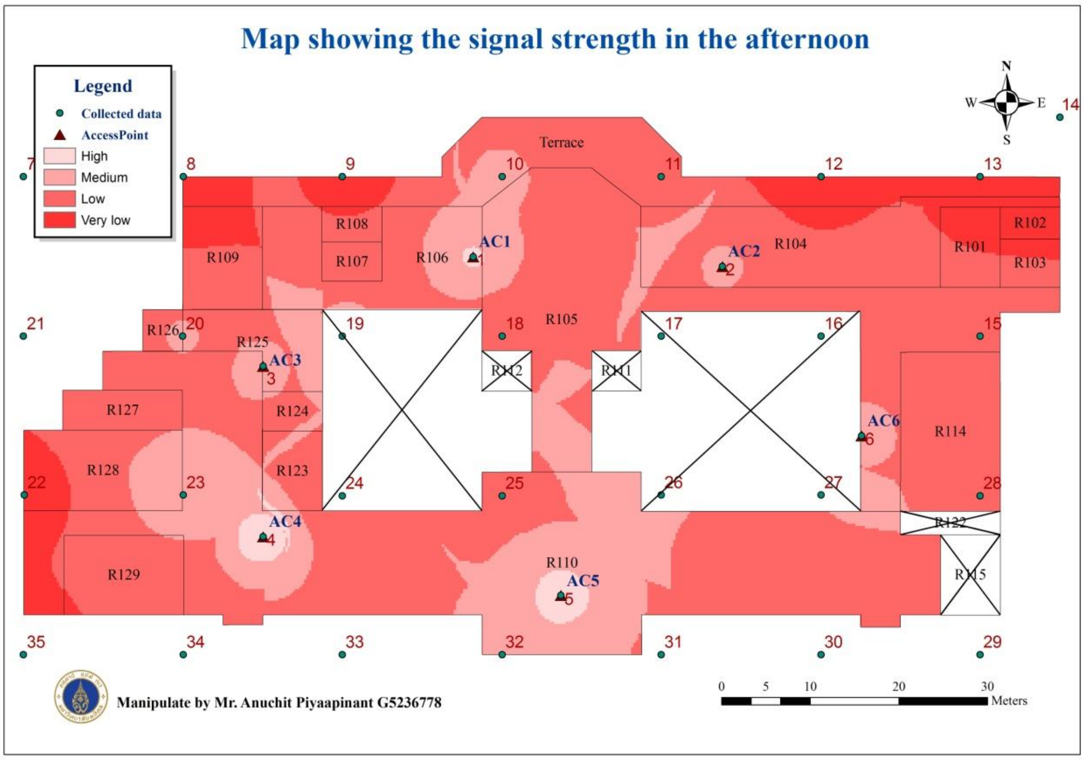

Figure 4.34 Signal strength in the afternoon.

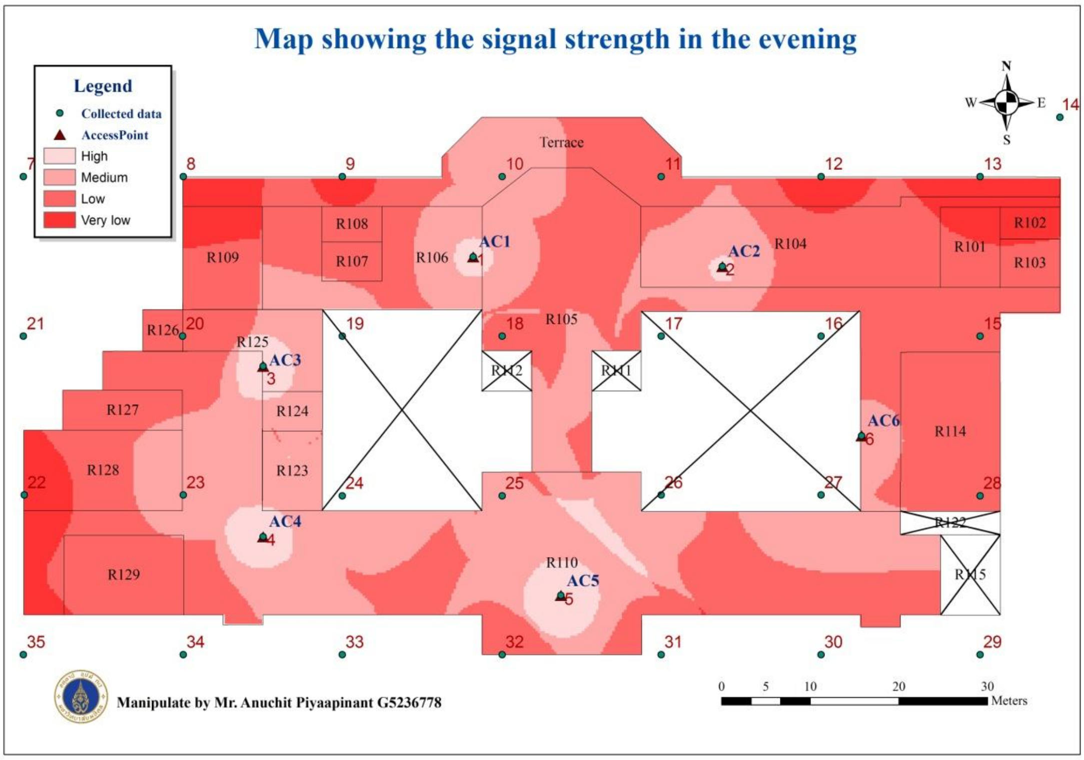

Figure 4.35 Signal strength in the evening.

4.2 The result of characteristics and factors that affect wireless signal strength

The difference activity times interpolation map had seen that the signal strength in early morning, at noon, and in the evening it have better of signal strength than the signal strength at the morning, and afternoon. Because in early morning, at noon, and in the evening it have the number of user less than the signal strength in the morning, and in the afternoon. The result of correlation analysis had seen that the signal strength of access point1 is the negatives correlate with distance in high probability level as shown in table 4.8, the signal strength of access point2 is the negatives correlate with distance in high probability level as shown in table 4.10, the signal strength of access point3 is the negatives correlate with distance in high probability level as shown in table 4.12, the signal strength of access point4 is the negatives correlate with distance in high probability level as shown in table 4.14, the signal strength of access point5 is the negatives correlate with distance in high probability level as shown in table 4.16, and the signal strength of access point6 is the negatives correlate with distance in high probability level as shown in table 4.18. So, the result of correlation analysis of the signal strength is negative correlation with distance in high probability.

4.3 The result of suitable location for increase wireless access point installation

4.3.1 The average of signal strength

The data of signal strength from statistics data of all 35 positions at the faculty engineering building1, 1st floor, to calculate the average of signal strength, as data is shown in table 4.19.

Table 4.19 Average of signal strength

PositionID	AC1	AC2	AC3	AC4	AC5	AC6
1	-43.32	-70.08	-69.96	-88.72	-88.52	-77.84
2	-74.24	-41.68	-89.12	-89.48	-80.8	-66.2
3	-80.56	-86.08	-39.24	-56.88	-88	-90.6
4	-88.52	-82.96	-61.48	-40.52	-73.28	-89.28
5	-87.48	-84.32	-70.8	-65.24	-38.28	-76.4
6	-89.36	-73.04	-91.16	-88.04	-85.52	-39.76
7	-88.36	-86.08	-72.24	-86.48	-86.96	-90.56
8	-83.48	-88.08	-78.84	-87.8	-86.96	-90.56
9	-68.28	-86.4	-83.12	-88.2	-87.36	-90.72
10	-61.28	-41.16	-81.28	-88.2	-74.2	-83.36
11	-78.84	-62.12	-86	-88.2	-84.36	-88.12
12	-89.96	-71.24	-87	-88.2	-84.36	-84.84
13	-89.48	-86.16	-87	-88.28	-84.36	-85.8
14	-89.24	-87.84	-87	-88.36	-84.36	-85.8
15	-88.76	-74.2	-88.84	-88.36	-83.64	-55.16
16	-84.04	-64.2	-88.6	-89.12	-81.48	-60.32
17	-80.76	-57	-89.68	-88.92	85.48	-66.64
18	-67.4	-71.68	-83.84	-88.92	-78.48	-82.76
19	-67.08	-88.52	-60.84	-78.08	-79.68	-89.48
20	-90.84	-87.88	-50.44	-65.96	-88.4	-89.32
21	-89.68	-87.88	-62.32	-79.84	-89.92	-89.32
22	-89.48	-89.16	-76	-86.04	-89.92	-89.32
23	-88.44	-87.88	-57.6	-43.96	-80.76	-89.44
24	-69.72	-87.96	-69.36	-67.68	-66.44	-83.76
25	-77.76	-81.24	-72.72	-84.6	-65.04	-70.92
26	-88	-74.88	-81.12	-78.28	-59	-68.52
27	-87.44	-67.48	-87.68	-81.04	-70.72	-55.16
28	-89.96	-76.6	-88.76	-87	-82.36	-54.36
29	-89.96	-82.08	-86.48	-86.92	-80.08	-78.6
30	-89.96	-76.24	-82.36	-81.12	-76.72	-81.08
31	-88.08	-82.12	-80.76	-84.92	-62.56	-85.48
32	-83.68	-88.84	-78.44	-79.28	-53.52	-82.32
33	-74.84	-86.32	-73.36	-62.08	-73.16	-86.72
34	-77.04	-86.84	-87.4	-83.4	-89.08	-88.84
35	-77.04	-86.84	-78.8	-87.76	-89.6	-88.92

4.3.2 The data of distance

The data of distance with wireless access point from Statistics data of all 35 positions at the faculty engineering building1, 1st floor, as shown in table 4.20.

Table 4.20 The data of distance

PositionID	D(AC1)	D(AC2)	D(AC3)	D(AC4)	D(AC5)	D(AC6)
1	2.5	25.14	23.79	35.09	35.26	43.03
2	25.14	2.5	47.12	53.4	36.76	22.16
3	23.84	47.14	2	17.18	37.88	60.46
4	35.09	53.4	17.12	2.5	30.7	60.88
5	35.26	36.76	37.85	30.7	2.5	34.09
6	43.03	22.16	60.44	60.88	34.09	2.5
7	45.77	70.62	30.68	43.34	68.46	87.97
8	30.19	54.8	20.71	36.96	56.69	72.84
9	15.47	39.13	20.71	36.96	47.48	58.19
10	8.9	23.9	30.68	43.34	42.5	44.48
11	20.77	11.1	44.33	53.87	43.25	32.9
12	35.99	13.68	59.17	66.62	49.46	26.42
13	51.68	27.63	74.49	80.54	59.45	28.74
14	60.69	37.25	83.84	90.39	69.36	37.82
15	51.68	27.04	72.09	74.77	49.46	15.82
16	35.99	12.46	56.12	59.52	36.85	11.06
17	20.77	9.55	40.16	44.79	27.97	22.5
18	8.9	23.22	24.27	31.34	26.8	37.45
19	15.47	38.72	8.77	21.69	34.15	53.01
20	30.19	54.51	8.77	21.69	46.11	68.78
21	45.77	70.39	24.27	31.34	59.99	84.63
22	51.06	73.72	27.37	24.46	54.97	84.25
23	37.73	58.75	15.39	9.29	39.37	68.31
24	27.41	44.49	15.39	9.29	24.3	52.4
25	24.32	31.93	27.37	24.46	11.93	36.58
26	30.71	23.9	42.11	40.28	14.36	21.03
27	42.51	25.2	57.52	56.2	27.97	7.63
28	56.42	34.8	73.19	72.15	43.25	13.65
29	64.86	46.94	77.65	73.04	42.5	25.18
30	53.21	40.34	63.1	57.33	26.8	22.5
31	44.35	39.54	49.45	41.84	11.93	29.84
32	40.19	44.85	37.7	26.95	8.85	42.26
33	42.13	54.51	30.15	14.64	22.94	56.52
34	49.47	66.66	30.15	14.64	38.55	71.51
35	60.26	80.17	37.7	26.95	54.39	86.87

4.3.3 The maximum numbers of user

The numbers of user in each room at the faculty engineering building1, 1^{st} floor, as shown in table 4.21, and presented in Figure 4.36.

Table 4.21 The maximum numbers of user

Room	Numbers of user
R101	0
R102	0
R103	0
R104	25
R105	0
R106	12
R107	0
R108	1
R109	10
R110	240
R114	36
R123	0
R124	0
R125	6
R126	3
R127	0
R128	0
R129	0
Terrace	0

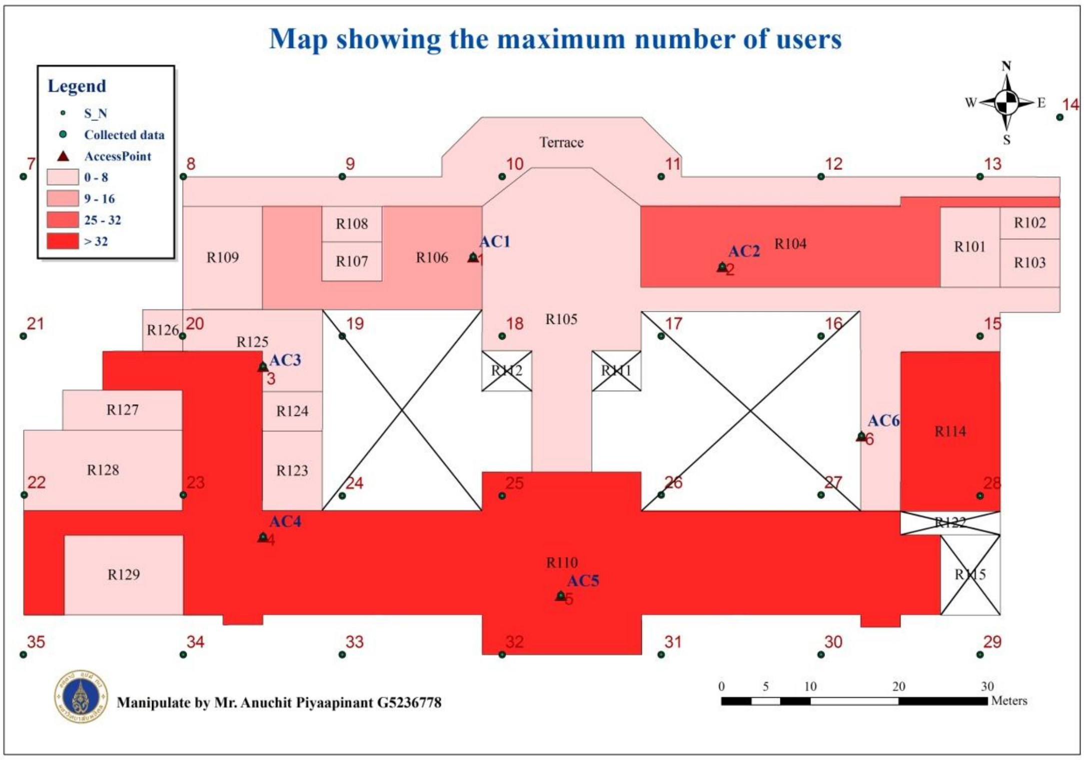

Figure 4.36 The maximum number of users

4.3.4 Weighting rating analysis

Weighted and rated spatial data consider by experts and social data are divided in three groups; weighted and rated spatial data consider by experts and rated value from sampling, analyze to get rating value and go to next steps.

The operation of these educations to data overlay procedures by GIS software and sum of weight linear model Notation following:

$$S = W_1R_1 + W_2R_2 + W_3R_3 + \ldots W_nR_n$$

Where	S	=	Sum of point of area factor
	W_n	=	Weighting at n series
	R_n	=	Rating at n series

The data calculate sum of weighting rating analysis used for interpolation to shown the appropriate areas are shown in table 4.22.

Table 4.22 The data sum of weighting rating analysis

PositionID	S of AC1	S of AC2	S of AC3	S of AC4	S of AC5	S of AC6
1	6	9	8	10	10	9
2	13	10	15	15	14	12
3	7	9	4	5	8	9
4	16	17	13	12	15	17
5	16	16	15	15	12	15
6	16	14	17	17	16	12
7	8	10	7	8	10	10
8	8	9	7	8	9	10
9	6	8	7	8	9	9
10	5	4	8	8	7	8
11	7	5	8	9	8	8
12	8	6	9	9	9	8
13	9	8	10	10	9	8
14	9	8	10	10	10	8
15	9	7	10	10	9	5
16	8	6	9	9	8	5
17	7	5	8	8	5	6
18	6	6	8	8	7	8
19	6	8	5	6	8	9
20	8	9	5	6	8	10
21	8	10	6	8	9	10
22	9	10	7	8	9	10
23	16	17	13	12	16	18
24	7	8	6	6	7	9
25	15	16	15	16	14	15
26	8	6	8	7	5	6
27	8	7	9	9	7	5
28	17	15	18	18	16	13
29	9	9	10	10	8	8
30	9	7	9	9	7	7
31	8	8	9	8	5	8
32	16	16	15	16	13	16
33	7	9	7	5	6	9
34	8	9	8	7	8	10
35	8	10	8	8	9	10

The data calculate sum of weighting rating model to interpolation are shown the appropriate areas for wireless access point installation, as shown in Figure 4.37- 4.42.

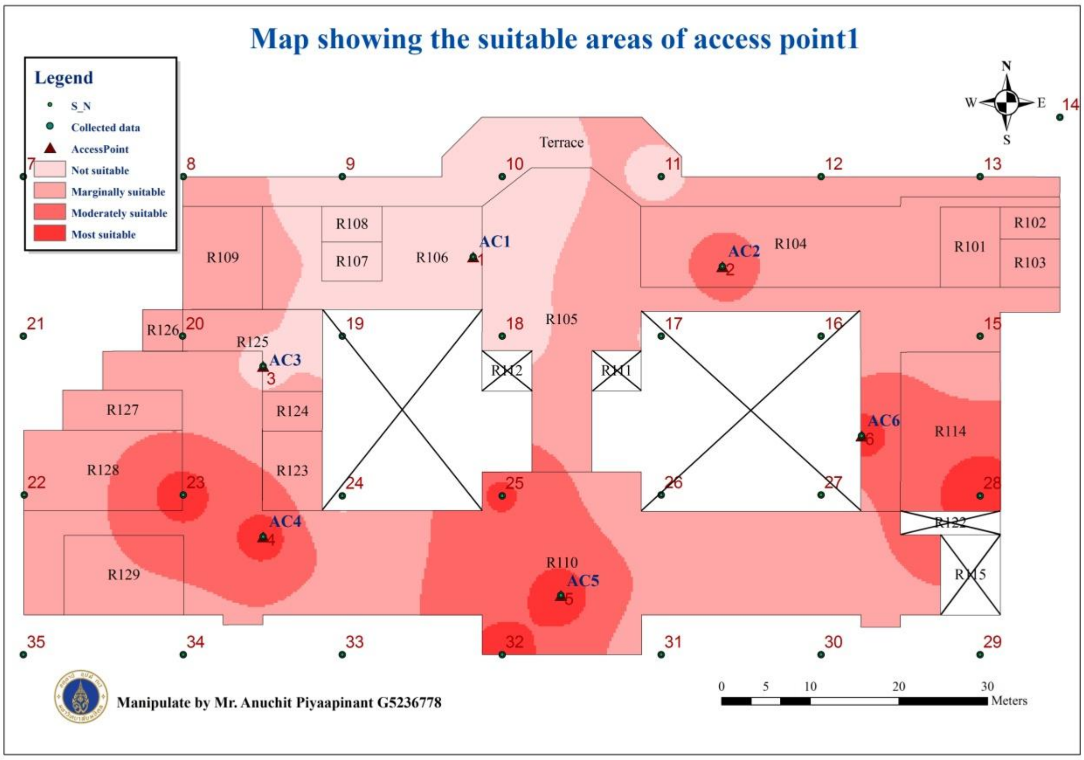

Figure 4.37 Suitable areas of access point1

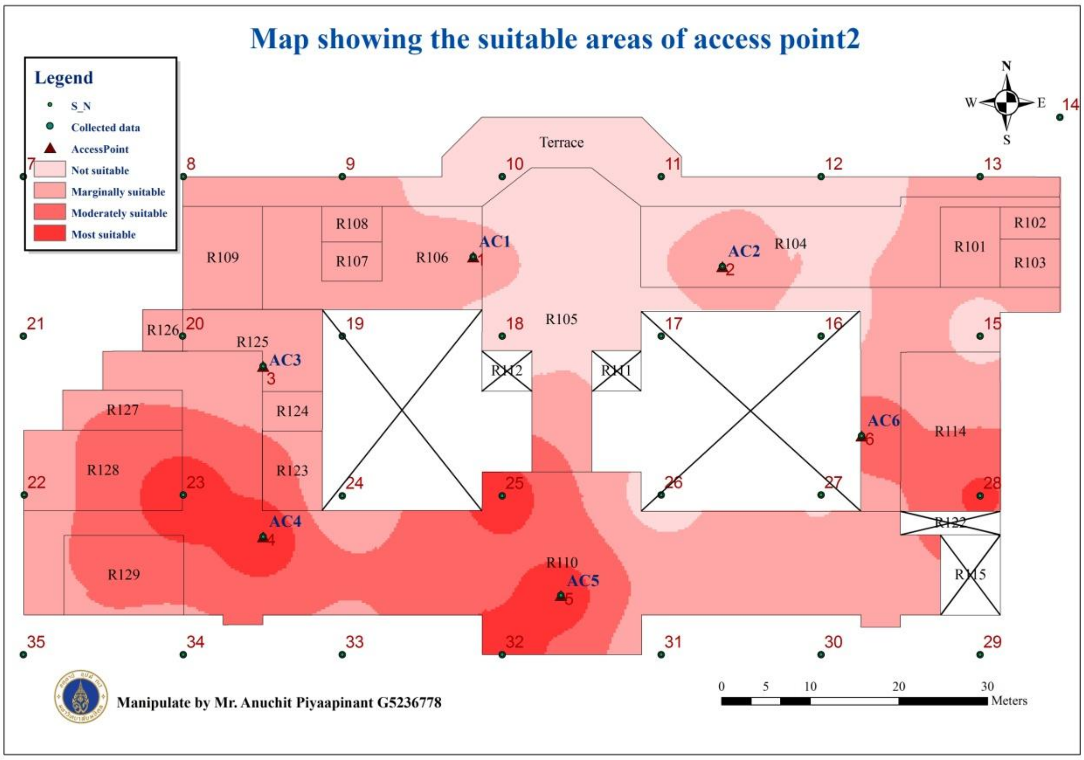

Figure 4.38 Suitable areas of access point2

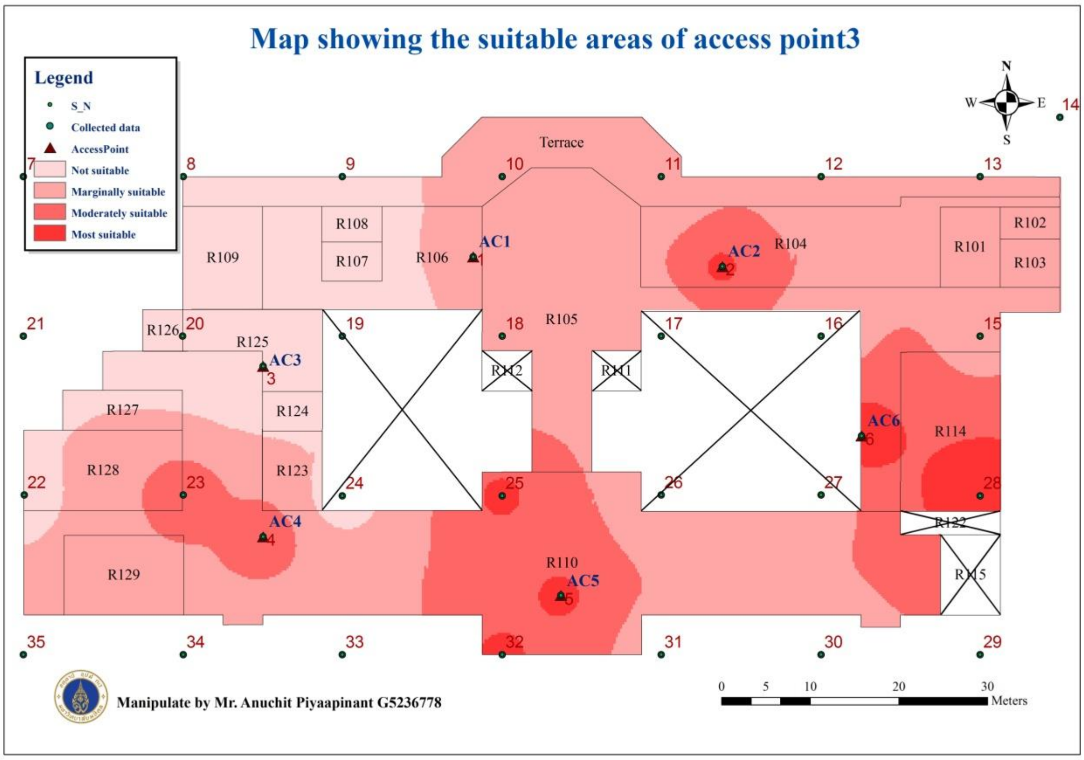

Figure 4.39 Suitable areas of access point3

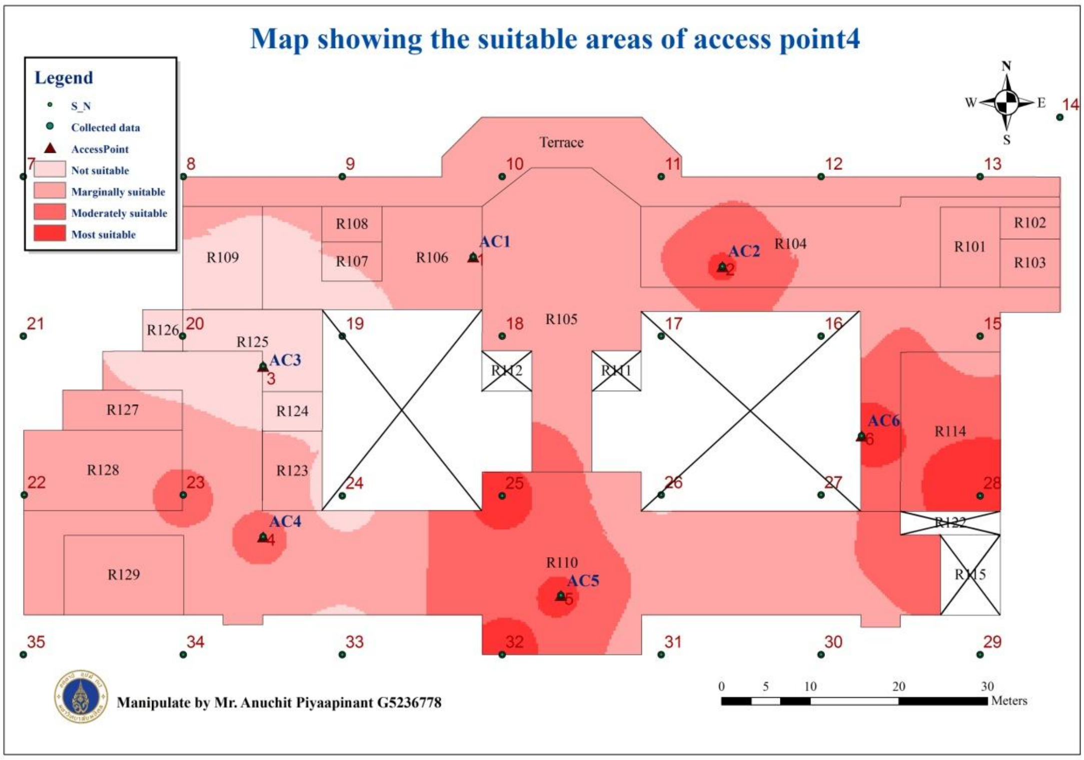

Figure 4.40 Suitable areas of access point4

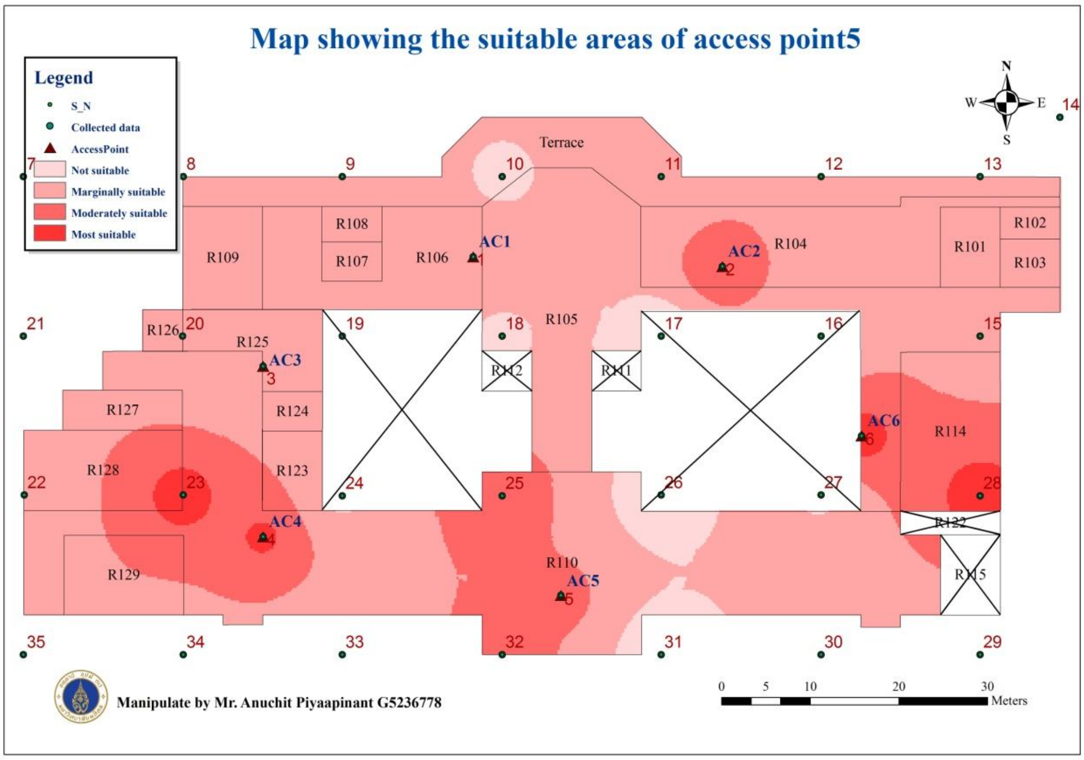

Figure 4.41 Suitable areas of access point5

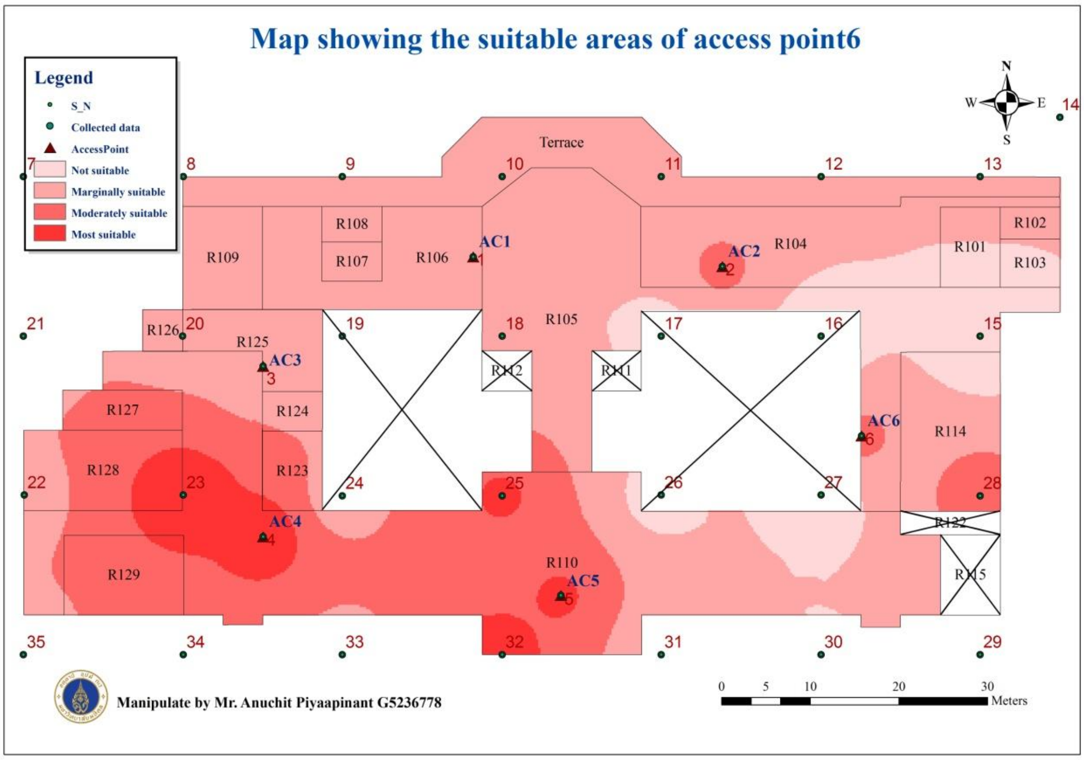

Figure 4.42 Suitable areas of access point6

An analysis area by program “ArcGIS9.3” can use spatial analyst for reclassified by using Equal interval was divide the data into four groups: most suitable, moderately suitable, marginally suitable, and not suitable, as shown in Figure 4.43.

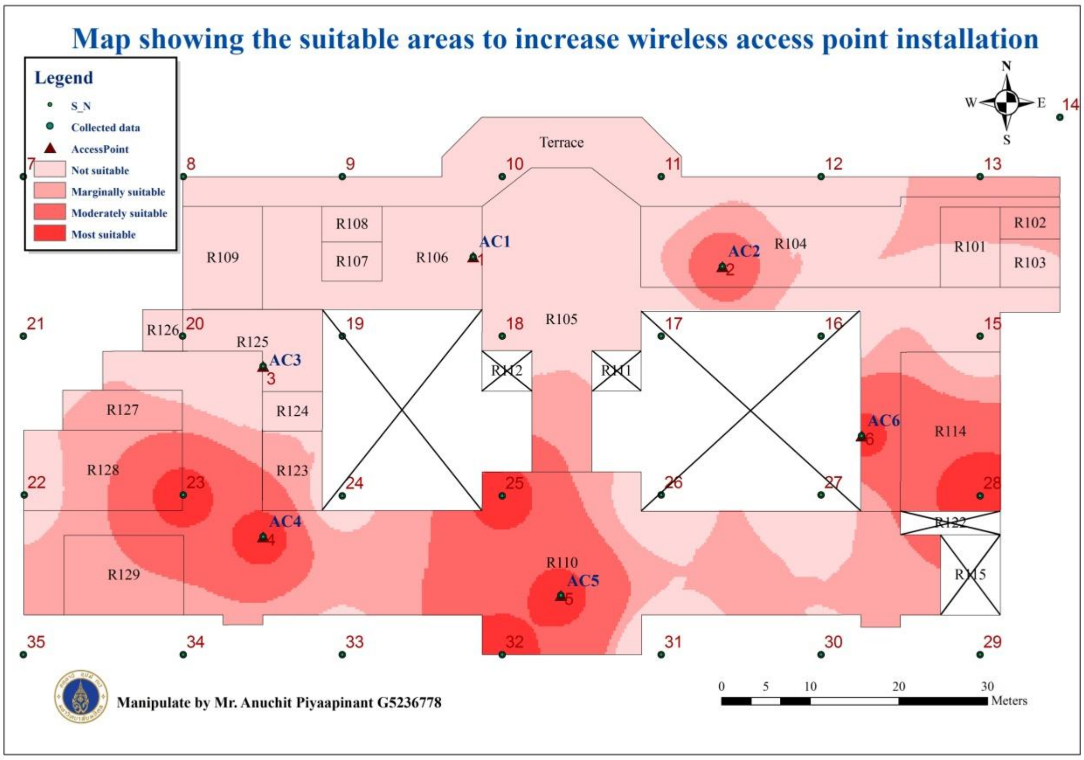

Figure 4.43 Suitable areas to increase wireless access point installation

In this session was analyzed the suitable area of wireless access point installation in faculty of engineering building1, Mahidol University, using the spatial analyst by geospatial software. The output was analyzed from zonal statistics method, and the map shows the suitable area of wireless access point installation that shown in Figure 4.44.

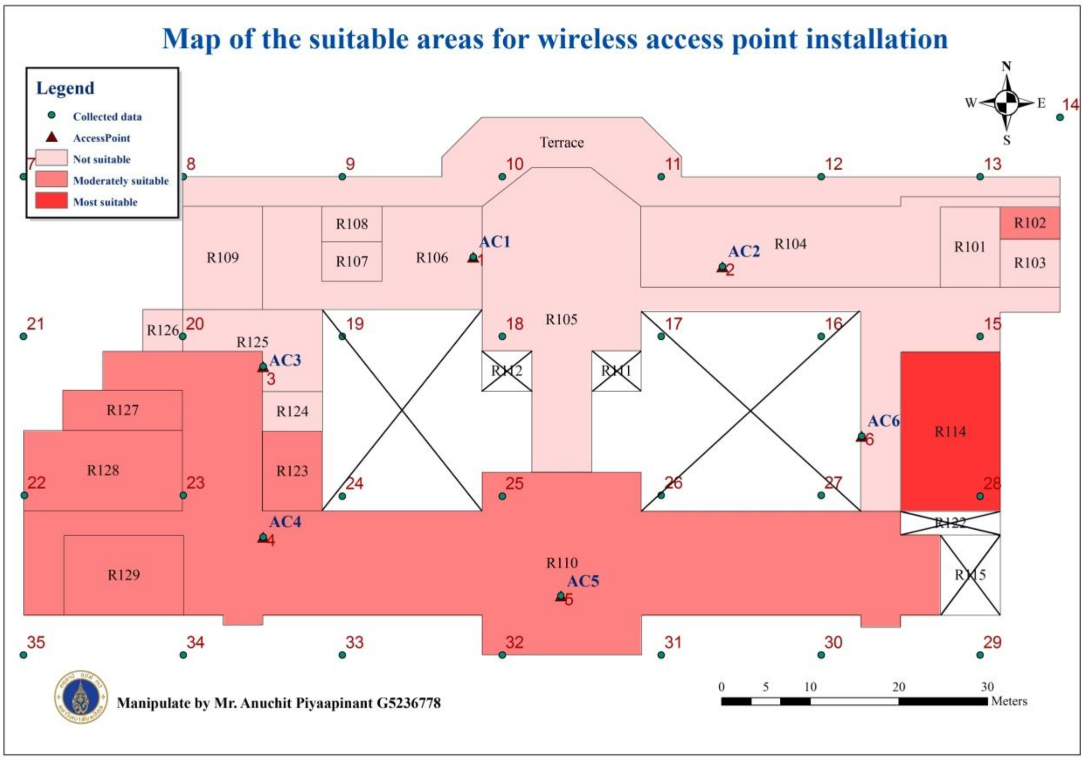

Figure 4.44 Suitable areas for wireless access point installation

As for the result of this analysis, it is found most suitable area for increase the wireless access point installation is in the faculty of engineering building1, 1st floor, Mahidol University in R114 because this room has many users in varies time. Then it should be in R102, R110, R123, R127, R128, and R129 because those rooms are shown the moderately suitable areas.

CHAPTER V
CONCLUSION AND RECOMMENDATION

This chapter had presents the summary of the factor that signal strength in Engineering building1, Mahidol University and recommendations for an analysis in the future or other building.

5.1 Conclusion

In conclusion, it is found that there are the most suitable areas for increase wireless access point installation in R114 because this room is show the most suitable area and the maximum number of users to use have 36 persons in that room. And followed by R102, R110, R123, R127, R128, and R129 because that room are show the moderately suitable area, as shown in Figure 5.1.

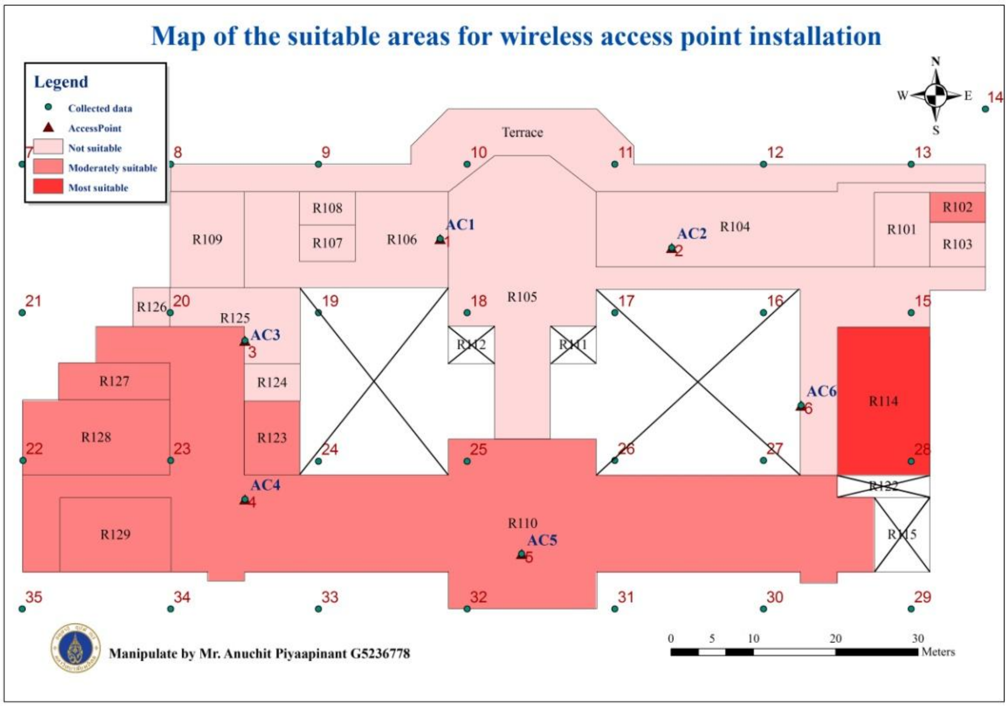

Figure 5.1 Suitable areas for wireless access point installation

The result of all factor found most suitable area covered 1 room (5.26%), moderately suitable area covered 6 rooms (31.58%), and not suitable area covered 12 rooms (63.16%) as shown in table 5.1.

Table 5.1 Percentage of the suitable area

Suitable area level	No. of room	Percentage of total room
Most suitable	1	5.26
Moderately suitable	6	31.58
Not suitable	12	63.16
Total	19	100

5.2 Recommendations for future study

According to the study findings, this research has many flaws in the conclusions or to predict the outcome in other areas, which is very different areas properly. Therefore, the researcher was to make recommendations for further research or for research in other areas following the issues.

5.2.1 Should be added more the factor that affect the wireless signal strength.

5.2.2 Should be use of statistical reliability and accuracy in analysis of results study.

5.2.3 This study area is too small. It should be studied in a large area or compared two areas there are geographical differences.

5.2.4 GIS should be used to find map of other area.

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