RSSI Fingerprinting Approach for Location-Based Services

By

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Desertion submitted in partial fulfillment of
the requirements for the
Bachelor of Technology (Hons)
(Business Information System)

OCTOBER 2006

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5105.78
.M697
2006
1) Wireless communication systems
2) Local area networks (computer networks)

CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Business Information System Programme
Universiti Teknologi PETRONAS
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Approved by,

Mr. Abdullah Sani Abdul Rahman

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
October 2006

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work in my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

MOHD JUZAILI BIN ABD RASHID

ABSTRACT

Location information is becoming increasingly important in many pervasive computing applications and it has been widely used in various industries as location aware that can provide functions such as navigation aids, geographic contextual information, movement tracking, emergency location, geographically selective communication and many other useful functions. The objective of this project is to implement Location Based Services (LBS) for medical facilities such as hospitals and asylums in order to improve their operations. For the first half of the project duration which is this semester, I mainly focus on the problem of localization. Therefore, based on my knowledge and developed tools in localization, I can further develop a location based service system. In order to perform this project, I will create a simulation whereby I will select one area probably my hostel house to study the problem of localization. My goal is to locate a person when she/he is walking around the house. To achieve the goal, we will encounter a lot of problems such as, how to collect the signals from the wireless access points, how to process the data, how to choose and apply the algorithm in order to use the collected signals and so on. Every problem mentioned will affect the accuracy in localization. Therefore in this report, we will introduce how we can solve this problems.

ACKNOWLEDGMENT

Special thanks to my supervisor, Mr. Abdullah Sani bin Abdul Rahman for his endless guidance and useful suggestions throughout the project.

I would also like to express my gratitude to the developer of WiFiCore library, which enables me to develop this location based service system.

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CHAPTER 1
INTRODUCTION

1.1 BACKGROUND STUDY

The evolution of enterprise wireless LANs (WLANs) continues as IT recognizes the productivity benefits of low-cost anywhere connectivity and acknowledges that WLANs can operate securely. As a result, facility-wide deployments are rapidly becoming commonplace, which in turn enables new service possibilities.

An emerging category of services intends to take advantage of Wi-Fi access points (APs) distributed throughout a building to aid in determining the physical location of Wi-Fi client devices and other 802.11-compatible devices like Wi-Fi tags. Localization is necessary for many higher level sensor network functions such as tracking, monitoring and geometric-based routing. Many positioning systems designed to determine or track a user's location have been proposed in recent years. Those systems fall into three categories: global location systems, wide-area location systems based on cellular networks, and indoor location systems.

A typical global location system is the Global Positioning System (GPS), which receives signals from multiple satellites and employs a triangulation process to determine physical locations with an accuracy of approximately 10 m [1]. However, GPS is inefficient for indoor use or in urban areas where high buildings shield the satellite signals. Several cellular-network-based wide-area location systems have been proposed in recent years. The technological methods of location determination involve measuring the signal strength, the angle of signal arrival, and/or the time difference of signal arrival. However, the accuracy of wide-area location systems is highly limited by the cell size. Moreover, the effectiveness of systems for an indoor environment is also limited by the multiple reflections suffered by the radio frequency (RF) signal.

For an indoor environment, several systems based on various technologies such as infrared (IR), ultrasound, video surveillance, and radio signal are emerging. Among these systems, radio-signal-based approaches, more specifically, the wireless local-area network (WLAN) (IEEE 802.11b, also named Wi-Fi) radio-signal-based positioning system has drawn great attention in recent years. For example, in the healthcare industry, WLAN location-based services will be used to track medical devices such as infusion pumps, patient monitoring devices, and even wheelchairs and stretchers, locating doctors and medical staff during the event of emergency, managing patient's information. The objective is to minimize the time it takes to locate equipment that is necessary for a medical procedure, and to increase the efficiency of staff.

For indoor positioning system, WLAN is an economical solution because the WLAN networks usually already exist as part of the networking infrastructure in the organization. With the usage of laptops, PDA and other mobile devices with WLAN features, the positioning system can be implemented

1.2 PROBLEM STATEMENT

1.2.1 OVERVIEW

This WILS is a software only solution for determining the physical location of a mobile device on a Wireless Local Area Network (WLAN) by using only the existing WLAN infrastructure and no additional hardware. In other words if one have a Notebook PC or a Personal Digital Assistant (PDA) that person's physical location can be determined without the need to install any additional equipment. This approach is different from other proposed solutions which require attaching a tag to the mobile devices. The main objectives of the project are to demonstrate the technology behind location determination and to develop modular software that will encompass two general modules: a User Location Sensing (ULS) and a User Location Display (ULD). By completing this project and developing the software I hope to encourage further research and commercial development in this area. In the next section, we discuss some of the possible problem that can be solved with the use of WILS.

1.2.2 PROBLEM IDENTIFICATION

In the event of catastrophes that results in mass casualties, hospitals are confronted with simultaneously treating hundreds of patients with varying degrees of injuries. To meet the challenge of managing patients, checking the availability of doctors and locating open beds and medical equipment in wide-scale emergency, they required a quick responsive system that able to quickly locate doctors, nurses or any other personnel during an emergency event. The current and popular method in calling doctors and nurses for assistance through announcement using PA system is not so efficient as personnel may be in one part of the building where the announcement is not heard clearly hence resulting in poor respond time and this may cause serious impact to patient or any other parties involved. Inefficient and time consuming method used currently to alert doctors, nurses is not very efficient. If doctors do not aware of the announcement or do not hear in clearly, he or she might ignore the message, and somebody will have to get the doctor to alert him or her about the emergency. This process required a lot of unnecessary time which may lead to unnecessary results.

In medium-large medical facilities, doctors need to give medical assistance to a number of patients. So if they are required to assist a certain patient through the PA system, the doctor might have to go to the patient information centre in order to confirm the exact location of the patient and get the patient's medical files before proceeding to the patients ward. This time consuming method can be eliminated by implementing LBS system so doctors could find the correct patient and maintain real-time treatment information in hospital databases that had been integrated with the LBS system. During the emergency event, a patient might need immediate attention; the first thing to do is to place them in the emergency room for immediate treatment. But the process of doing so is to check which room is available for this particular patient from the person in charge of letting know which room should the patient placed, and again it requires unnecessary amount of time to do so.

1.3 OBEJECTIVE & SCOPE OF STUDY

The objective of this project is to develop a location determination system that will be used to locate the location of the user and use this information to provide service based on the user's location. In this project, I will developed the location determination system using an approach called location fingerprinting. Location fingerprinting is more on software approach rather than technique or hardware approach. If we use triangulation method for location detection, we have to consider the access points' location and positioning.

For this project, I will develop a Wi-Fi signal strength fingerprints collector. This application will be used by the user to specify the location information, the maps and user will use the signal scanner tool to record series of Received Signal Strength Indicator (RSSI) from a specified reference points that they have set earlier. After that, the RSSI sets will be saved to the database. Later this sets of fingerprints in the database will be used to infer user's location by comparing the pre-recorded RSSI with the live RSSI .

After comparing the RSSI, server will determine the area of where the user is at the moment. Then the server will check for area information regarding the area of which the user at and return the information to user mobile device. At the moment the project is limited to sending information regarding the area only. The system will be improved if time is sufficient to do so. For more details on the system design and approach, read through the chapters ahead.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION TO WIRELESS NETWORK

ACCESS POINTS

It is a hardware device or a computer's software that acts as a communication link for user to access the wired Local Area Network (LAN). Each Access Point has a unique Network Interface Card (NIC). User can communicate the Access Point through this interface.

WIRELESS TERM

- Media Access Control address (MAC Address)

  It is a unique hardware address that identifies each node in the network. Referencing to Open System Interconnection (OSI) 7 Layer Model, the Data Link Control (DLC) layer in the wireless network is divided into two sub layers: the Logical Link Control (LLC) layer and the Media Access Control (MAC) layer. And each different type of network medium requires a different MAC layer. Those networks that do not confirm to wireless standards, the nodes in the network are called Data Link Control (DLC) address.

- Service set identifier (SSID)

  It is a 32 character. It adds to the header of packets that acts as a password when mobile device sends the packet through Wireless Local Area Network (WLAN). The SSID in one WLAN is different from another. All access points and mobile devices connecting to a specific WLAN must use the same SSID. They can be permitted to join the WLAN provided that they can provide the unique SSID.

- Receive Signal Strength Indicator (RSSI)

  It is the signal strength received by the mobile device in the WLAN. Its unit is in dBm. The smaller values of RSSI, the greater strength received by the mobile device.

WIRELESS STANDARD

- IEEE 802.11

  It is a family of wireless Local Area Network (WLAN) specifications developed by Institute of Electrical and Electronics Engineers (IEEE). Currently, there are four specifications in IEEE 802.11 family:

  a. IEEE 802.11a
  b. IEEE 802.11b
  c. IEEE 802.11g
  d. IEEE 802.11e
  e. IEEE 802.11i
  f. IEEE 802.11n

OPEN SYSTEM INTERCONNECTION (OSI) LAYER

The model defines a networking framework in seven layers. The protocol is implemented according to each layer requirement in the model. Control in each layer is passed from one layer to next layer, starting at the application layer to the physical layer. The following is the OSI 7 Layer Model:

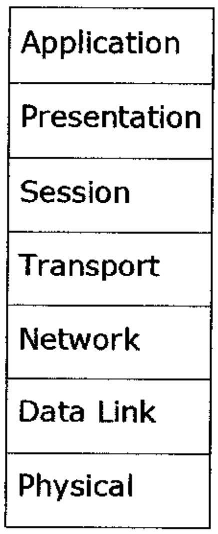


Figure 2.1 : OSI Layer

2.2 LOCATION SENSING METHODS

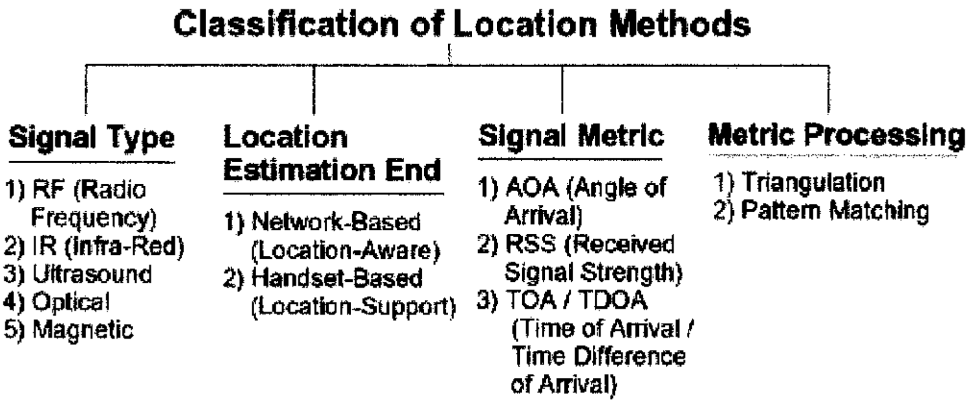


Figure 1.2 Classification of Location Detection Methods

<u>OUTDOOR POSITIONING</u>

GPS (Global Positioning System) is a satellite-based navigation system, which consists of 24 or more satellites and works worldwide. The first GPS satellite was launched in 1978. Each satellite is placed about 20,000 m above the ground and transmits RF signals to ground-based receivers [2]. GPS satellites have a synchronized clock to determine their own orbit. GPS receivers use the signals from these satellites to determine their own location by using location of the satellites and the distance to them. The positioning accuracy of GPS after SA (selective availability) was turned off in 2000 is typically about 10 m. However, GPS signals cannot be received close to high-elevation obstructions or in buildings.

Cellular phone carriers provide user location services using a number of systems, including A-GPS, TDOA, AOA/TDOA, and E-OTD. A-GPS (Assisted GPS) uses the GPS infrastructure to determine user location. A-GPS is assisted by base stations, which provide information to the GPS measurement processing of a cellular phone. The cellular phone can search GPS signals quickly and sensitively using the aiding information. The cellular phone sends the captured GPS signal to the base station. Then, the base station calculates the location of the cellular phone.

INDOOR LOCALIZATION

For indoor environment, a number of different systems using infrared, ultrasonic, RFID tags, and RF devices have been designed to determine the user position. The Active Badges system is an infrared-based location system, which typically provides room-size-location information. A base station is placed in each room and users carry a badge that emits its ID over infrared. The base station senses the ID, and a central server collects the data from the base stations. The Active Bat system [3] is an ultrasonic-based location system, which determines Bat tag position by ultrasound time-of-flight measurement. In this system, users carry a Bat that acts as an ultrasonic generator. Receivers are mounted in the ceiling and measure the distance to the Bat, and a central controller determines the Bat location. This system provides accuracy of 95% within 9 cm of true position. Although they have many applications, RFID tags are typically used as a substitute for bar-codes. RFID tags can also be used for location determination. In such systems, RFID tags are placed at key points and the relation between tag ID and location is entered into a database. When a user moves the tag reader closer to a tag, the reader reports the location of the tag to the user.

RADAR [4] is probably the first example of a positioning system using an IEEE 802.11 network. They overcome the noisy environment by creating a Radio Map in the off-line phase by collecting signal strength samples for each user location and orientation. In the real-time phase, each access point measures signal strength of the mobile terminal and searches through the Radio Map database to determine the location of the mobile terminal. The Radio Map-based method is an empirical method. A mathematical method using a mathematical model of indoor RF propagation and floor layout information instead of a Radio Map has also been proposed for RADAR.

All of these approach either using additional hardware or complex algorithm to make work. Using fingerprinting approach it is cost efficient as you just need software to use with your existing Wi-Fi architecture and you can get a location determination system.

CHAPTER 3

METHODOLOGIES

3.1 PROCEDURES DESCRIPTIONS

- Identify the fundamental requirement for system implementation - As basic requirements to execute this study, it is essential to understand the foundation of the location based service and location detection, Wi-Fi technologies and wireless and networking hardware and techniques in determining locations. This will be done by doing literature reviews in order to get the information needed and sample of previous system implementation.

- Data gathering on identifying the requirement for set up the LBS system – Listing out the components and services that will be used in a LBS system for hospital. Selecting a case study in order to simulate the working LBS.

- Create software design, hardware design and access point layout. Create driver to make the hardware communicate with the central service.

- Finding the right hardware and make necessary modification to build up a LBS system tailored for hospital needs.

- Perform system testing to check system reliability.

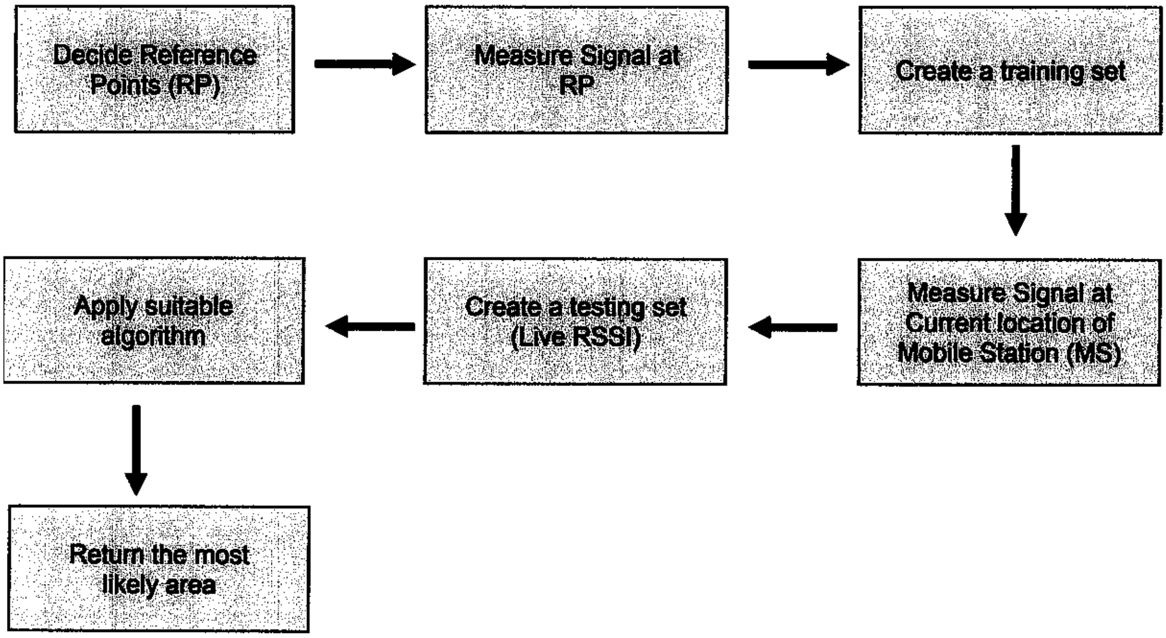


Figure 2.1 : Main Steps In Fingerprinting Localization

The basis of location fingerprinting is first to establish a database – Contains the measurements of the wireless signals at some Reference Points. Then, the location of Mobile Station (MS) can be identified by comparing the signal strength with the reference data. Location fingerprinting consists of two phases:-

- Training Phase (offline phase)
- Positioning Phase (online phase)

In the Training Phases, the objective is to generate fingerprint database. Fingerprint is the vector of received signal strength at a particular RP. In order to generate fingerprint database, we will carefully select a suitable reference points. RPs are selected based on special criteria like the building design, the potential of wireless signal covering the area.

During the training phase, we detect signal strength (SS) at the MS location from series of available access points (AP_i, where i = 0…N) for a period of time and get the average SS. This is because; wireless signal is unstable and variable over time. We will also need to record the training set in two situations. The first situation is when people are around and the other situation when no people are around. Human can affect signal strength as water in human body have high resonance to signal thus can affect the strength. So in locating MS in a crowded situation, comparing MS's Receive Signal Strength (RSS) with fingerprints recorded when people are around will be resulting in more accurate result.

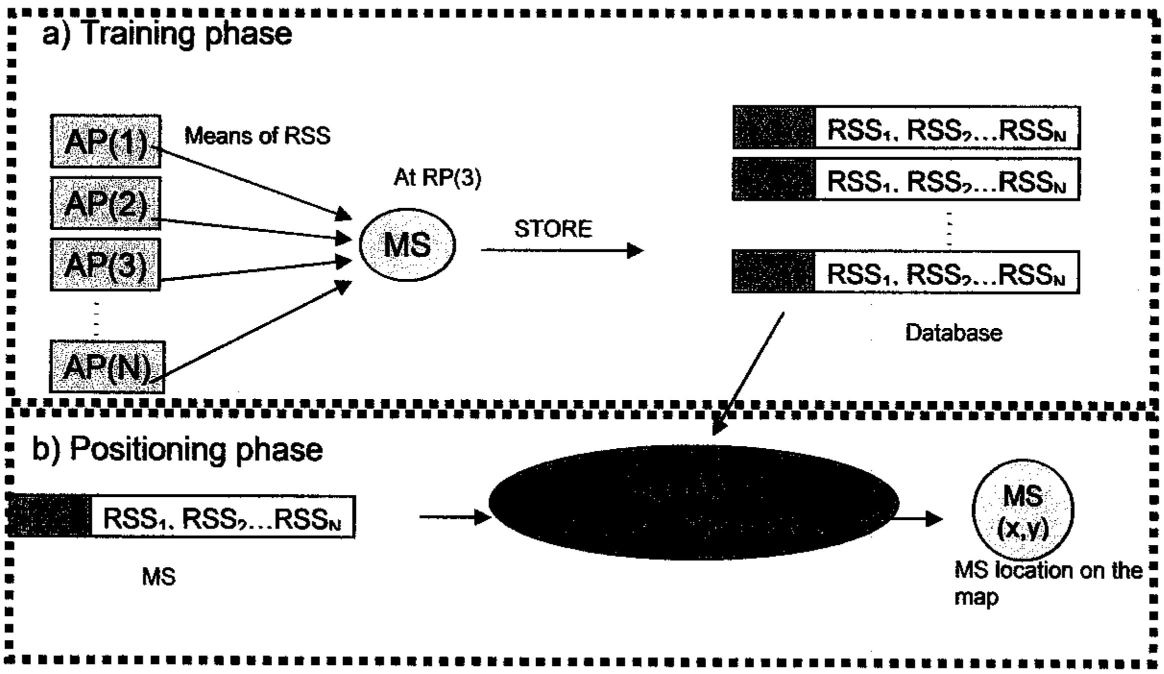


Figure 3.2: Overall Phases in localization

3.2 APPROACH & DESIGN

Algorithm that will be used in this system for the moment is nearest-reference based technique. Before the system can determine user location, we have to maintain the location information of the place that we want to apply the system. For example, if we want to set up a training set (pre-recorded RSSI) at Building A, we must let the system know the information about the building such as, the name of the building, specify the floors, and the floor plan for each floors of the Building A. We also have to specify know access points (AP) for that building, this is to ensure the integrity of the RSSI collected during the training phase later on. There will be cases whereby during training phases, the Signal Scanner might have picked up RSSI from and unknown AP. So by referring to the Known AP list, we can filter out the RSSI from an unknown AP. This is very crucial as it can affect the pre-recorded RSSI. Let say we know that we installed 3 APs at Building A, but when we scan for signal, there are more than 3, so quickly we can identify that the remaining is from other buildings or someone might have installed it temporarily. RSSI picked up from unknown AP might provide with unstable RSSI set. So later when we want to compare Live RSSI with pre-recorded RSSI, the result may not be as we expected.

After we have specify the building information mentioned above, we save it to the database. Next we select a building and open up a floor map that we want to work on, we set a grid size and the system will overlay a grid on the floor plan. We then study the grid properly and take into consideration of access points, we choose the best reference points from the grid. After doing so, we save the reference points information to the database. After setting up all the reference points, we are ready to go to the training phase. In training phase, we will collect the RSSI set for all the reference points that we have specified. Load the map and the system will show the reference points that we have specified before. By physically go to the respected points we begin to record the RSSI. RSSI are recorded for a period of time and the average RSSI for that particular reference point will be saved. After finish recording, refer to the graph of RSSI we have collected in order to make sure it is consistent.

After we have finished recording the RSSI sets for all reference points, we already have a database containing RSSI training set. When a mobile user requesting for his/her location, the application that the mobile user use to sent out request to server will also scan the RSSI from all available AP nearby at his/her location. This is called Live RSSI. This Live RSSI later will be used by the server application to determined the possible area of where the user is. First it will compare the Live RSSI with the pre-recorded RSSI can short-list to several possible pre-recorded RSSI. Next, the Live RSSI will be subtracted with the pre-recorded RSSI. The pre-recorded RSSI represent a point on the map as it is considered as the reference point at first. The least difference we get from the subtraction is the possible points that is closest to the actual point where the user is. So the reference point that having the least difference with the Live RSSI is returned. And based on the found reference point the system know that the point is in which area as before we already specified that the reference points that we selected belongs to which area. So on the user screen, the system will display the possible user location and the services/information regarding that area.

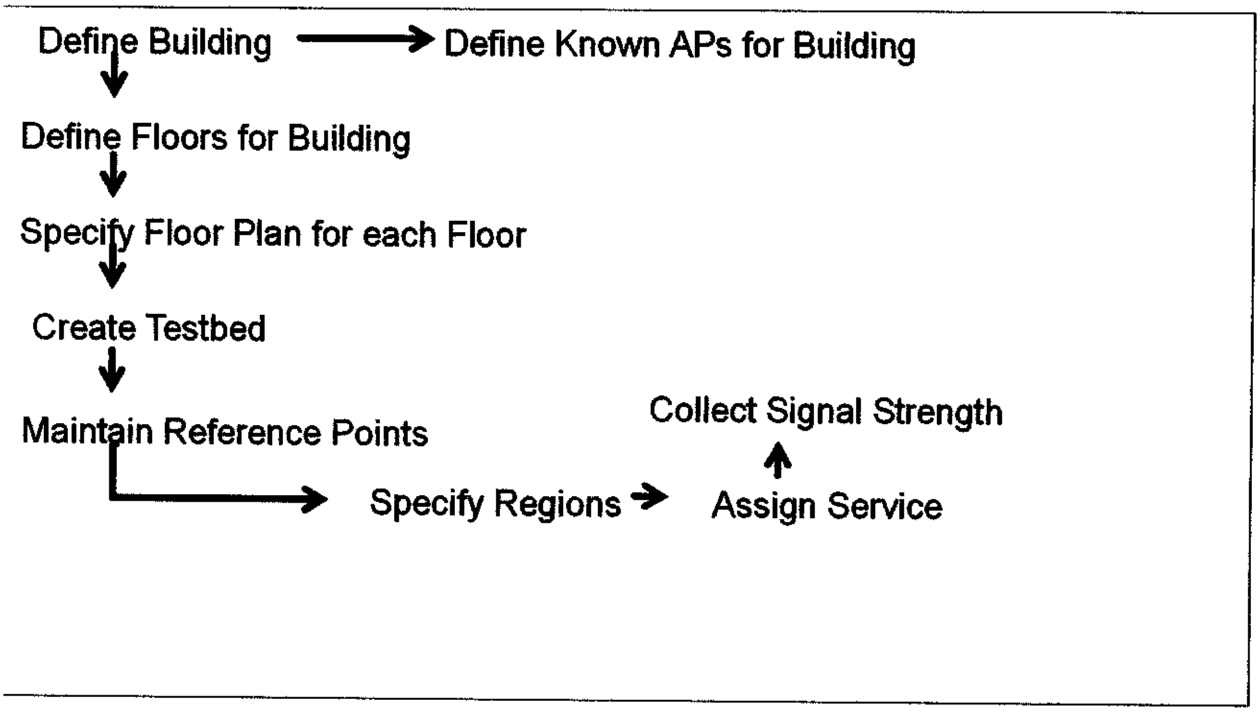
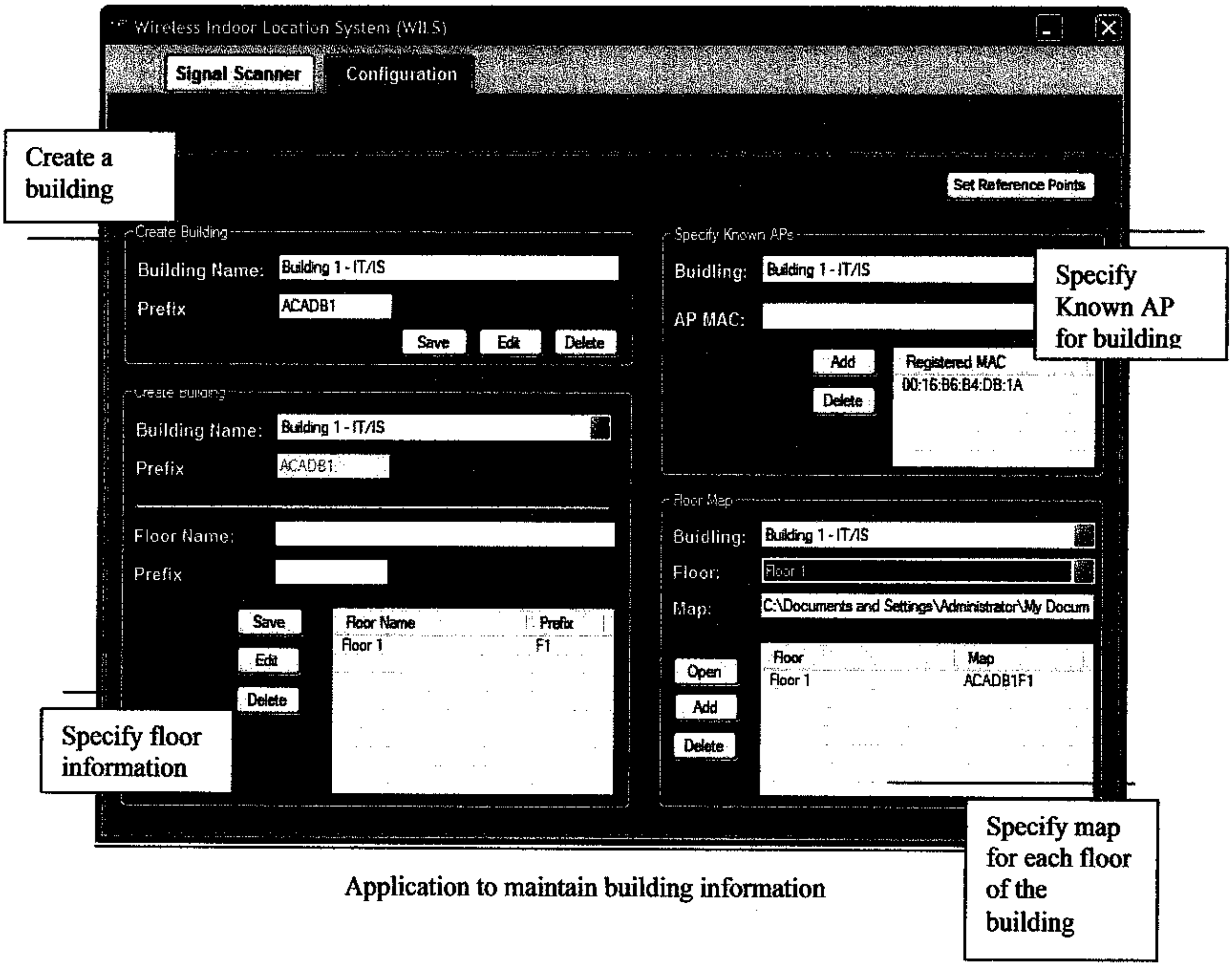
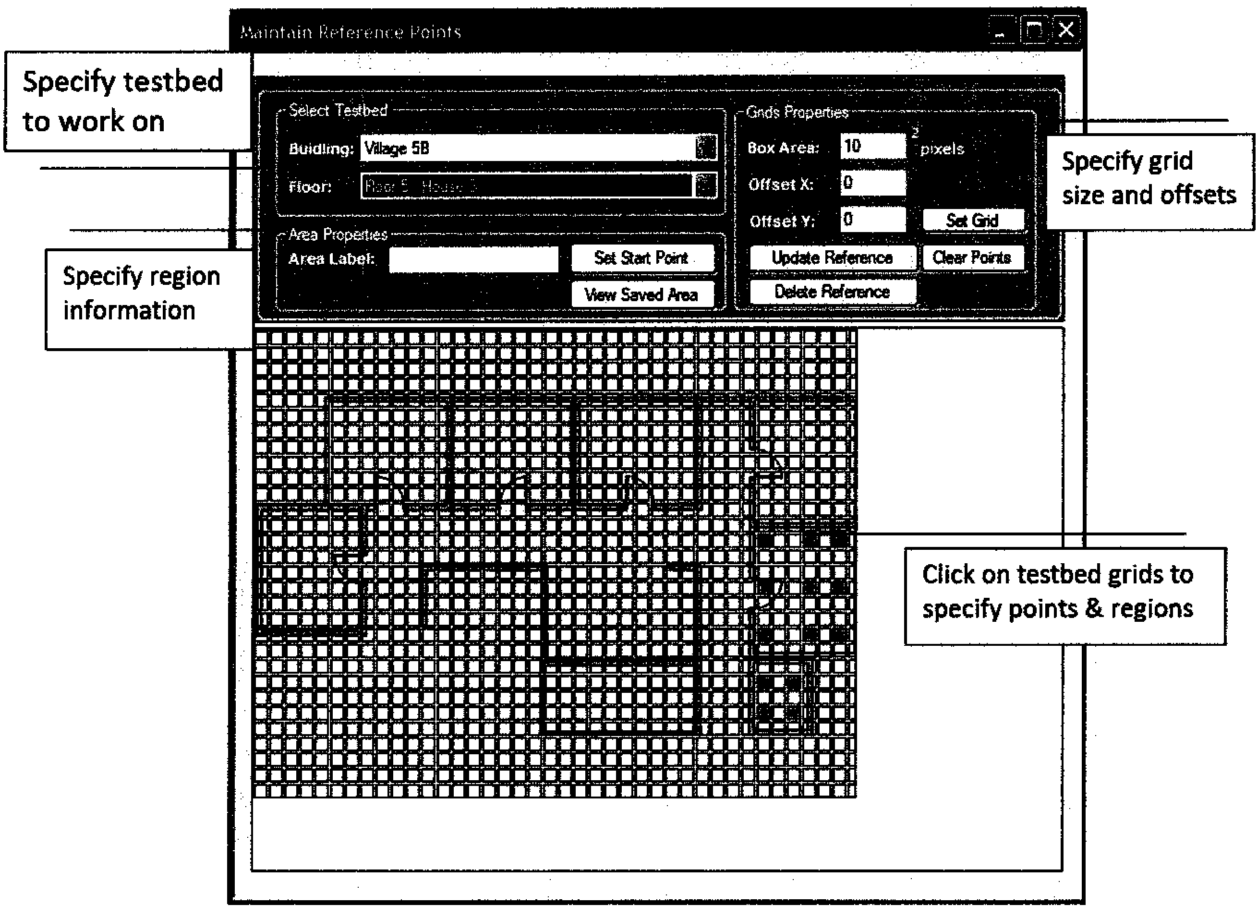


Figure 3.3: System configuration for training phase

Screenshots of the Application

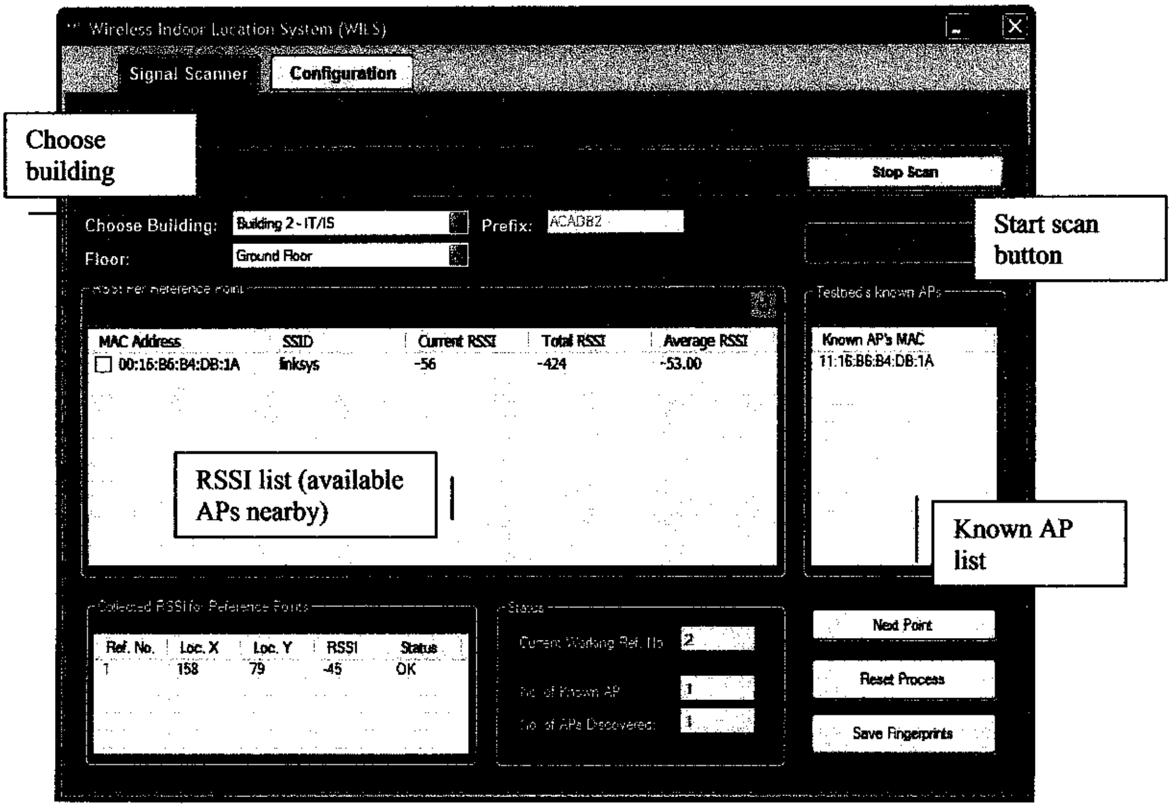


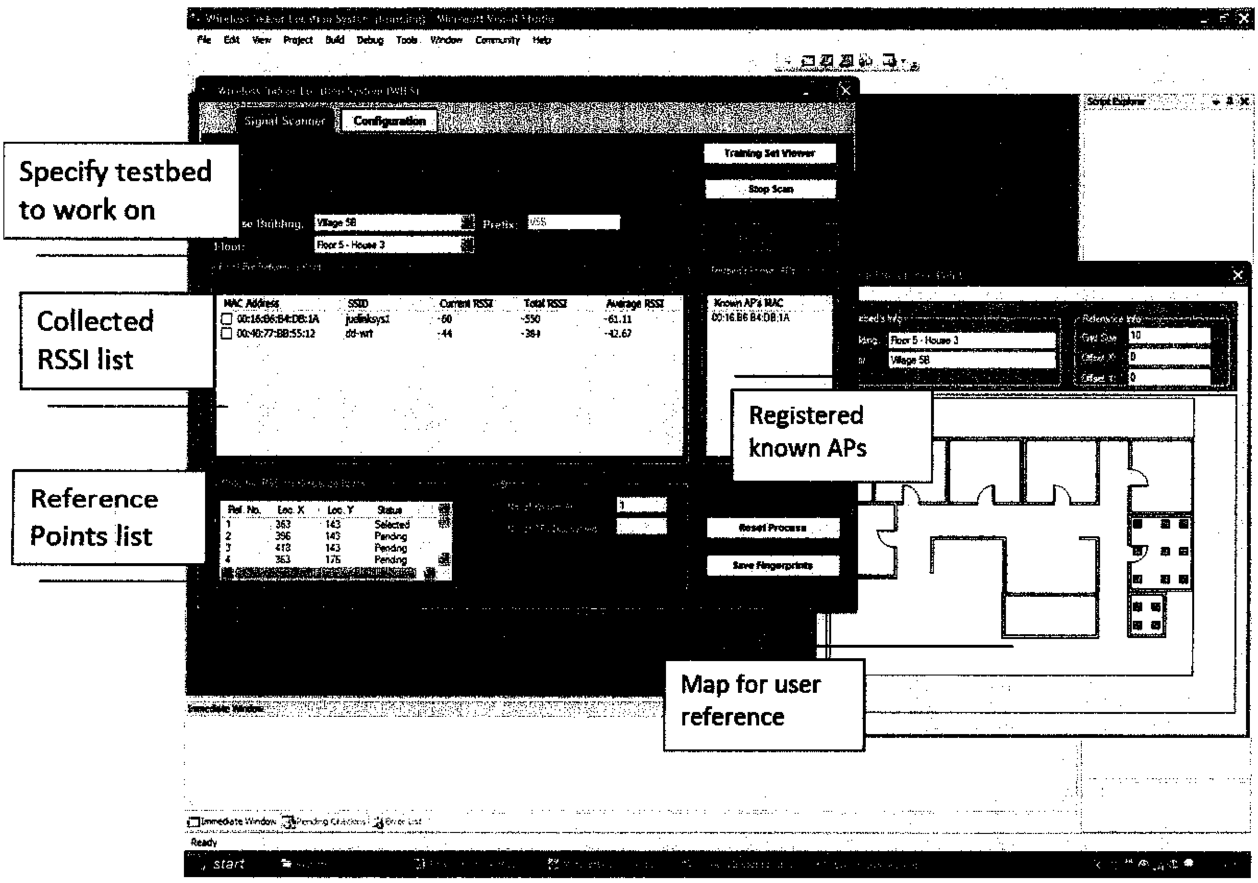
Application to maintain building information

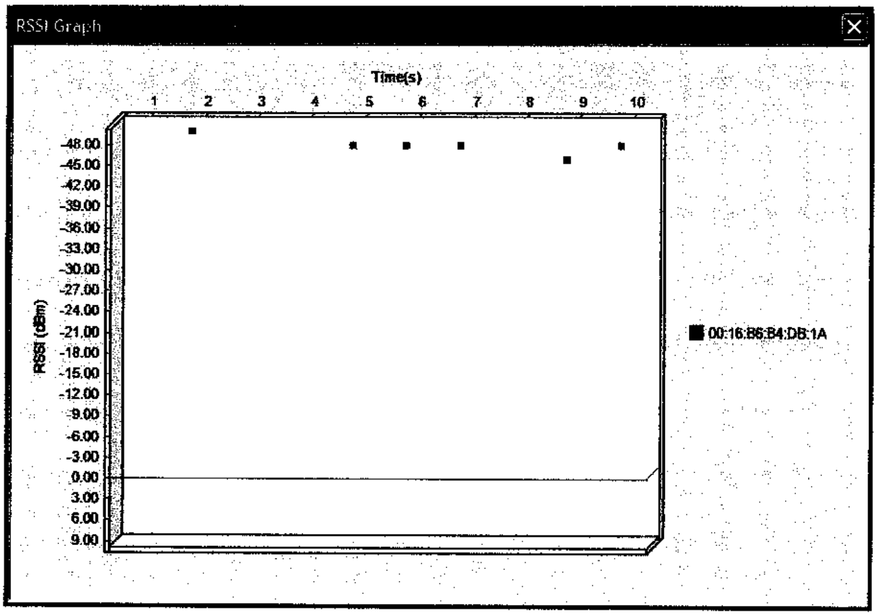


After finished setting up the building information, click on the "set reference points" button at the configuration screen and the system will navigate you to this screen. Here you will pick the building that you have created and set the grid size, once you have satisfied you can start setting up the reference points by clicking on the grid boxes that you have selected.

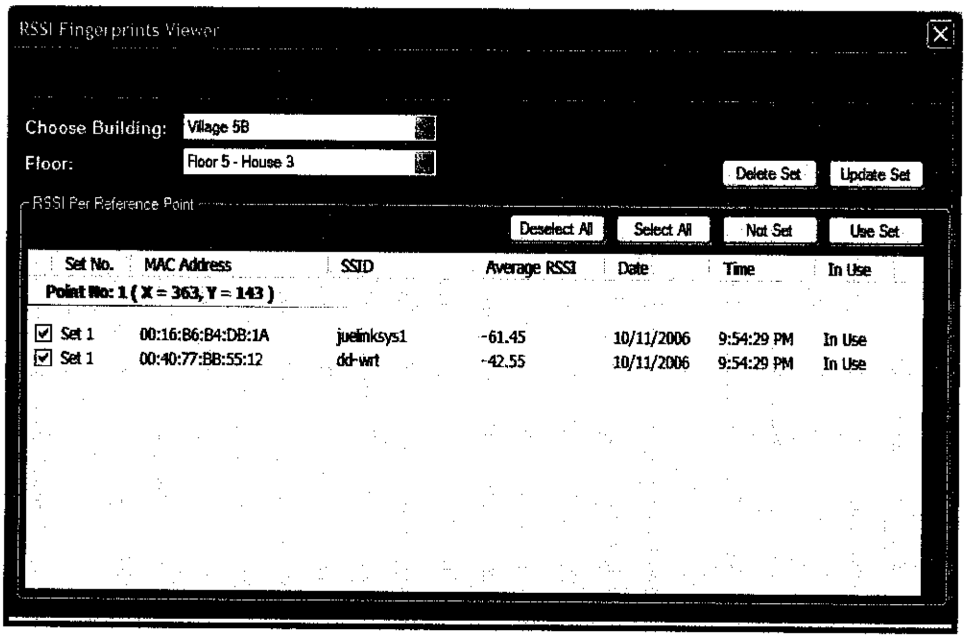
After setting up the points, you will have to tell the system the area labels. Simply select the area or region that you wish to label and specify the description and press the "mark region" button. The area labels will be saved to the database. This is important for the system to know that the reference points in which area. For the screenshot above, the region highlighted in gray color is labeled as "Room 6".


Wireless Indoor Location System (WILS)
Signal Scanner
Configuration
Choose building
Stop Scan
Choose Building:
Building 2 - IT/IS
Prefix:
ACADB2
Floor:
Ground Floor
Start scan button
Testbed's known APs
MAC Address
SSID
Current RSSI
Total RSSI
Average RSSI
00:16:B6:B4:DB:1A
linksys
-56
-424
-53.00
Known AP's MAC
11:16:B6:B4:DB:1A
RSSI list (available APs nearby)
Known AP list
Ref. No.
Loc. X
Loc. Y
RSSI
Status
1
158
79
-45
OK
Current Working Ref. No
2
1
1
Next Point
Reset Process
Save Fingerprints


Signal Scanner
Configuration
Training Set Viewer
Stop Scan
Specify testbed to work on
Village 5B
Floor 5 - House 3
Collected RSSI list
MAC Address
SSID
Current RSSI
Total RSSI
Average RSSI
00:16:B6:B4:DB:1A
judlinksys1
-60
-550
-61.11
00:40:77:BB:55:12
dd-wrt
-44
-384
-42.67
Known AP's MAC
00:16:B6:B4:DB:1A
Registered known APs
Reference Points list
Ref. No.
Loc. X
Loc. Y
Status
1
363
143
Selected
2
396
143
Pending
3
418
143
Pending
4
363
176
Pending
Reset Process
Save Fingerprints
Grid Size
10
0
0
Map for user reference
start



After the RSSI scanning finished, the RSSI collected for a period of time is displayed on a graph. Here we can observe the RSSI pattern to ensure that the RSSI collected is consistent before saving as a fingerprint to the database.



User may collect as many sets of RSSI fingerprints they wants, and through this screen they will let the system know which sets that the system should infer when applying the algorithm to locate mobile user. Only one set per reference point is allowed to be enabled. The rest will be disabled. This is useful as they will be times that less people will be around at that particular area, so the user will enable the set of RSSI fingerprints that they have collected where less people around (during training phase) this may increase the accuracy when such scenario applied, and vice versa.

3.3 SOFTWARE & HARDWARE REQUIREMENTS

Software Requirement

- Integrated Development Environment (Microsoft Visual C#)
- Microsoft Office for documenting works and designing layout
- WIFICORE Library
- CHARTFX Library

Hardware Requirement

- Wi-Fi access points,
- Wi-Fi adapter and
- Wi-Fi enabled mobile device

CHAPTER 4

RESULTS & DISCUSSIONS

1 DATA GATHERING & ANALYSIS

live_rssi1---|

live_rssi2---| → **RSSI collected from unknown location by Mobile User**

live_rssi3---|

....

offline_rssi1---|

offline _rssi2---| → **Refers to RSSI values for each of the candidates locations**

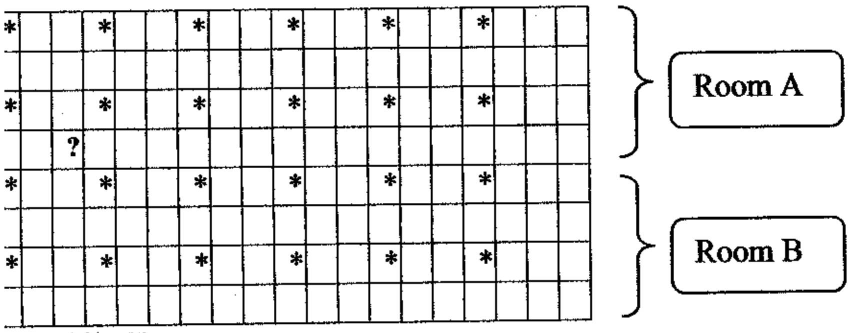
offline _rssi3---|

....

y using the Euclidean equation, the distortion (difference) between live RSSI values with the ffline RSSI values of each candidate location can be calculated as the following:

$$d = \sqrt{\begin{array}{l}(live\_rssi1 - off\_rssi1)^2 + (live\_rssi2 - off\_rssi2)^2 + \\ (live\_rssi3 - off\_rssi3)^2 + \ldots + (live\_rssi\_n - off\_rssi\_n)^2\end{array}}$$

is process is repeated for all the candidate locations to get distortion values d1,d2,d3...Further, the distortions are compared and the candidate location which has the minimum distortion is termined as the best match for this user's unknown location, as shown below:



= Mobile User
= Reference Point

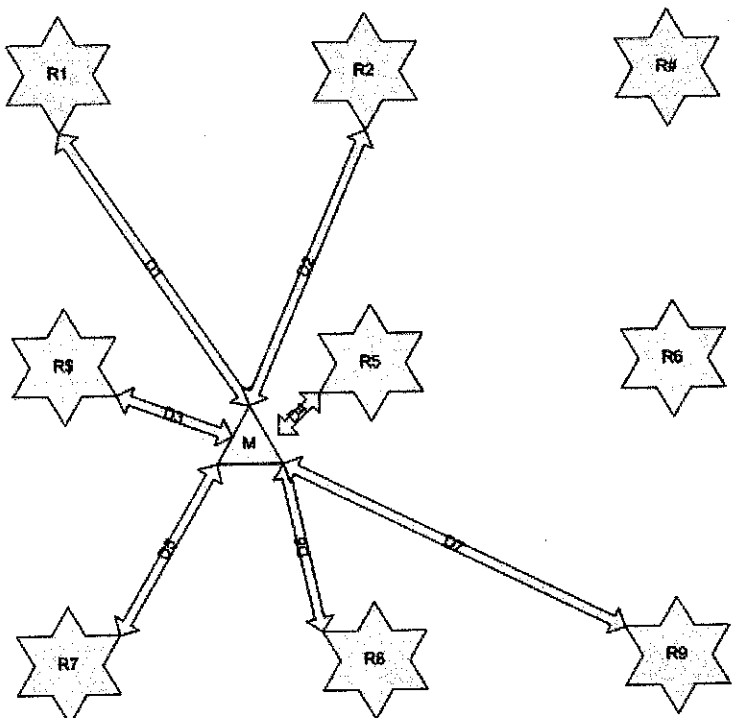


Figure 4.1 : Nearest-Reference Location Determination

'he triangle is the live (not yet known) location where this mobile user is at currently, while the tar shape indicated by R1 through R9 are the candidate locations. The RSSI values of the andidate locations (measured in the offline phase) are compared with that of the live RSSI 'alues. Distortions of all nine locations are calculated as D1,D2,D3...D9. In the example shown bove, since D4 < D1,D2,D3..D9, the best match is D4, and the location of point = R5 and area = Room A is returned by the system as the most probable live user's location.

! RESULTS

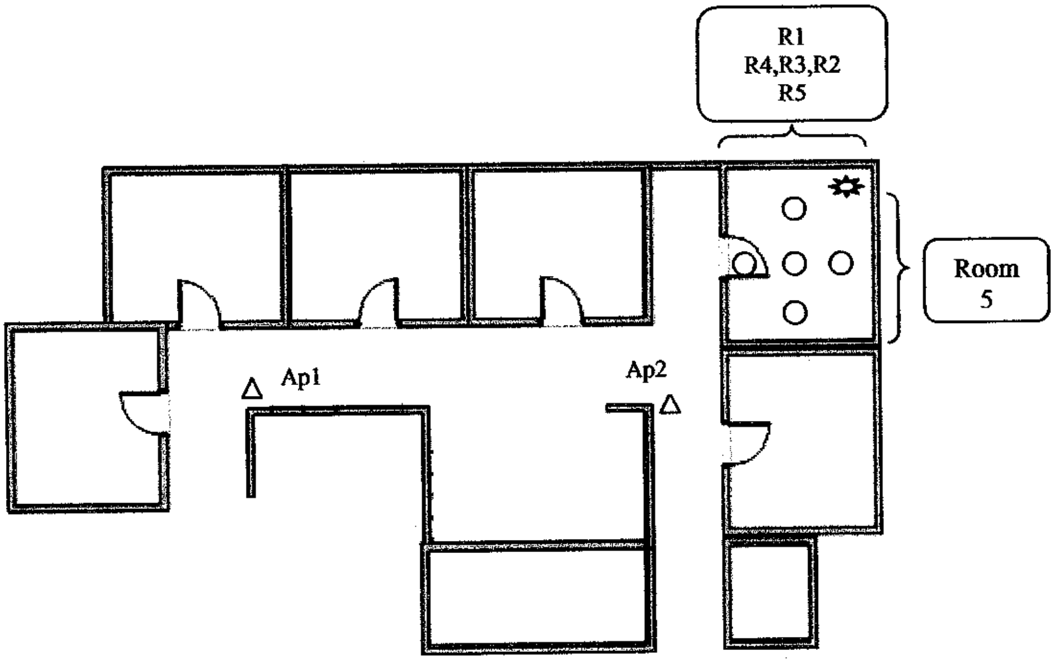


Figure 4.2 : Testbed for analysis

○ = Reference Points

△ = Access Points

✲ = Actual Location

Two APs are position at the locations shown in the figure above Two training sets were collected for Room 5. By inferring from 2 training set, I would like to analysis whether the training set are reliable or not. The two training sets are collected at a different time. First where people are around, the second one where no people are around. Tables below are the training sets collected:

Training Set 1 (when people not around)

ference Points	AP1	AP2
	RSSI (dBm)	
ference 1	-73.41	-50.34
ference 2	-73.23	-50.12
ference 3	-72.19	-50.30
ference 4	-68.11	-49.60
ference 5	-85.52	-65.54

Table 4.1 : Training set collected from 2 APs Type 1

Training Set 2 (when people are around)

ference Points	AP1	AP2
	RSSI (dBm)	
ference 1	-80.55	-52.11
ference 2	-78.22	-52.05
ference 3	-75.29	-51.00
ference 4	-72.18	-50.55
ference 5	-73.68	-54.78

Table 4.2 : Training set collected from 2 APs Type 2

Live RSSI 1 (when people not around) :

Avg. RSSI from AP1	Avg. RSSI from AP2
-76.25 dBm	55.45 dBm

Table 4.3 : Live RSSI collected from 2 APs Type 1

Live RSSI 1 (when people are around) :

Avg. RSSI from AP1	Avg. RSSI from AP2
-81.17 dBm	56.25 dBm

Table 4.4 : Live RSSI collected from 2 APs Type2

Training Set 1 with Live RSSI 1

Reference Points	AP1	AP2	
	RSSI (dBm)		Diff. with Live RSSI
Reference 1	-73.41	-50.34	5.84617
Reference 2	-73.23	-50.12	6.12611
Reference 3	-72.19	-50.30	6.55790
Reference 4	-68.11	-49.60	10.02476
Reference 5	-85.52	-65.54	13.70186

Table 4.5 : Distortion between Live RSSI 1 and training set 1

Reference point 1 is the closest to actual point which is logically correct.

Training Set 2 with Live RSSI 1

Reference Points	AP1	AP2	
	RSSI (dBm)		Diff. with Live RSSI
Reference 1	-80.55	-52.11	5.44478
Reference 2	-78.22	-52.05	3.92949
Reference 3	-75.29	-51.00	4.55237
Reference 4	-72.18	-50.55	6.36984
Reference 5	-73.68	-54.78	5.15614

Table 4.6 : Distortion between Live RSSI 1 and training set 2

Reference point 2 is the closest to actual point which is logically correct but not very accurate.

Training Set 2 with Live RSSI 2

Reference Points	AP1	AP2	
	RSSI (dBm)		Diff. with Live RSSI
Reference 1	-80.55	-52.11	4.18617
Reference 2	-78.22	-52.05	5.13249
Reference 3	-75.29	-51.00	7.88270
Reference 4	-72.18	-50.55	10.64472
Reference 5	-73.68	-54.78	7.632890

Table 4.7 : Distortion between Live RSSI 2 and training set 2

Reference point 1 is the closest to actual point which is logically correct. So this means that, the system should infer both type of training set, set where people are around and not around. Maybe we can set in the algorithm that the system will check whether the current time is a peak hour, if not then use a normal training set and vice versa. However this is a first attempt of the location determination. I might want to improve the algorithm to provide a more reliable and accurate result.

CHAPTER 5

CONCLUSION & RECOMMENDATION

l CONCLUSION

arest reference-based + RSSI fingerprinting algorithms present users a more intuitive way to ıson about localization uncertainty and direct users in their search for the object by returning ordered set of likely rooms and illustrate confidence. It is also cost efficient as the system is a ftware approach, can be easily integrated to existing wireless local area network (WLAN).

; a conclusion, for the first half of the project duration, requirement for system requirement is ılly essential. The implementation of the system will be done for the next phase which requires requirements needed to be available. In the end of this project, it is expected to have a ɔrking Location Detection system that really proves that it could cater or being usedfor location ısed services.

: RECOMMENDATION

I wish that in future I can improve the algorithm or even hybrid location fingerprinting with mathematical approach or any other approach so that the system would produce a more faster and accurate result and also easier to be implemented. A location fingerprinting approach system do have several limitation, for example, if number of access points have change (especially reduced) the training set needs to be gathered again. Or even if the building structure have change, renovation has been made, the training phase needs to be done again. It is a hectic task to do again. I would research more in future on how to resolve this issues.

I am also hoping that in future my system would be able to detect mobile user in motion not just a static point. Probably I need to alter my algorithm and my approach in order to make that happen.

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