SAVITRIBAI PHULE PUNE UNIVERSITY

A PROJECT REPORT ON

SMART MUSEUM DESIGN USING INDOOR LOCALIZATION

SUBMITTED TOWARDS THE
PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE

BACHELOR OF ENGINEERING (Computer Engineering)

BY

Sourabh Khasbag	B120454285
Shubhankar Ranade	B120454330
Abhijeet Wani	B120454355
Parth Hiralikar	B120454262

Under The Guidance of

Prof. Sankirti Shirvale

'येथे बहुतांचे हित'

DEPARTMENT OF COMPUTER ENGINEERING
Maratawada Mitra Mandal's College of Engineering
Karvenager, Pune-411 011

2015 - 2016

'येथे बहुतांचे हित'

Marathawada Mitra Mandal's College of Engineering
DEPARTMENT OF COMPUTER ENGINEERING

CERTIFICATE

This is to certify that the Project Entitled

Smart Museum Design using Indoor Localization

Submitted by

Sourabh Khasbag	B120454285
Shubhankar Ranade	B120454330
Abhijeet Wani	B120454355
Parth Hiralikar	B120454262

is a bonafide work carried out by Students under the supervision of Prof. Sankirti Shiravale and it is submitted towards the partial fulfillment of the requirement of Savitribai Phule Pune University,Pune for the award of the degree of Bachelor of Engineering (Computer Engineering) Project.

Prof. Sankirti Shiravale Internal Guide Dept. of Computer Engg.	Prof. Harmeet Khanuja HOD Dept. of Computer Engg.	External Examiner

Date:

Place:

Abstract

The current localization techniques heavily depend upon the Global Positioning System (GPS) technology. The GPS works on the basis of visibility of the user. The user's smart phone must be in the range of the GPS satellites. Then only can the broadcast signal reach the satellite and the location can be identified. In places such as buildings and indoor facilities, GPS may be unavailable. Moreover GPS does not provide any knowledge of the user's location pertaining to a particular floor in an indoor facility. Today the size of building environments such as airports and supermarkets has expanded to a great extent. Providing context based information to the user in such environments is highly beneficial. This project explores the possibility of using the IEEE 802.11 signal strength and the Bluetooth signal strength to determine indoor location of the user.

The proposed system is based upon the fingerprinting technique. Initially in the training or the mapping phase, the RSSI values of candidate locations are recorded in the database. In the second phase the RSSI values are taken as input and using a suitable algorithm the approximate position of the user is determined.

In a museum scenario, the indoor location will be used to judge the proximity of the user to an artifact. The information of the artifact will be streamed live to the user's mobile device.

Acknowledgments

It gives us great pleasure in presenting the project report on ***'Smart Museum Design Using Indoor Localization'****.*

I would like to take this opportunity to thank my internal guide ***Prof. Sankirti Shiravale*** *for giving me all the help and guidance I needed. I am really grateful to them for their kind support. Their valuable suggestions were very helpful.*

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Sourabh Khasbag
Shubhankar Ranade
Abhijeet Wani
Parth Hiralikar
(B.E. Computer Engg.)

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CHAPTER 1

SYNOPSIS

1.1 PROJECT TITLE

Smart Museum Design : Provide context based services depending upon the environment of the user.

1.2 PROJECT OPTION

This project will be taken as an in house project and the finances will be managed by the team members.

1.3 INTERNAL GUIDE

Prof. Sankirti Shiravale.

1.4 TECHNICAL KEYWORDS (AS PER ACM KEYWORDS)

1. C. Computer Systems Organization
    (a) C.2 COMPUTER-COMMUNICATION NETWORKS
        i. C.2.1 Network Architecture and Design
            A. Wireless Communication
            B. Network Communications
        ii. C.2.4 Distributed Systems
            A. Client/server
            B. Distributed applications
            C. Network operating systems
        iii. C.2.6 Internetworking
            A. Routers
    (b) C.5 COMPUTER SYSTEM IMPLEMENTATION
        i. C.5.3 Microcomputers
            A. Microprocessors
            B. Portable Devices

ii. C.5.5 Servers

2. K.4 Computers and Society

   (a) K.4.3 Organizational impacts

      i. Automation

1.5 PROBLEM STATEMENT

GPS is not effective in finding the indoor location of a device as its range is limited in indoor facilities. The GPS is accurate within 15 meters which is inadequate for extracting the precise location of the user. To obtain a better accuracy, technology such as BLE(Bluetooth Low Energy) and Wi-Fi can be used effectively. RSSI values of BLE and Wi-Fi have been used in this system for obtaining the users accurate location. By accessing the user's location, context based information will be provided to the user.

1.6 ABSTRACT

The current localization techniques heavily depend upon the Global Positioning System (GPS) technology. The GPS works on the basis of visibility of the user. The user's smart phone must be in the range of the GPS satellites. Then only can the broadcast signal reach the satellite and the location can be identified. In places such as buildings and indoor facilities, GPS may be unavailable. Moreover GPS does not provide any knowledge of the user's location pertaining to a particular floor in an indoor facility. Indoor localization requires higher accuracy and thus the use of GPS is not feasible in such scenarios. On an average, a person spends around 80 percent of time in indoor locations. Today the size of building environments such as airports and supermarkets has expanded to a great extent. Providing context based information to the user in such environments is highly beneficial. This project explores the possibility of using the IEEE 802.11 signal strength and the Bluetooth signal strength to determine indoor location of the user.

The proposed system is based upon the fingerprinting technique. Initially in the training or the mapping phase, the RSSI values of candidate locations are recorded

in the database. In the second phase the RSSI values are taken as input and using a suitable algorithm the approximate position of the user is determined.
In a museum scenario, the indoor location will be used to judge the proximity of the user to an artifact. The information of the artifact will be streamed live to the user's mobile device.

1.7 GOALS AND OBJECTIVES

Objectives:
The main objective is to provide an indoor positioning system which will be accurate enough to identify the location of the device and further provide services according to the location of the user. The system is implemented to make a "Smart Museum" in which the user will get information regarding the artifact according to his location. The user will get the information implicitly without the need of pressing any button. The above objective will be considered successful only if the following criteria are met:
1. Accurate position readings of the user are obtained.
2. Minimization of error and removal of vague readings.
3. Correctly finding out the location after comparing the values recorded with the database using euclidean distance algorithm.

1.8 RELEVANT MATHEMATICS ASSOCIATED WITH THE PROJECT

System Description:

- Input: Signal strength values of the Wi-Fi or Bluetooth modules.
- Output: Information with respect to the location of the user i.e. Data or Images related to the artifact in front of which the user is standing.
- Identify data structures, classes, divide and conquer strategies to exploit distributed/parallel/concurrent processing, constraints.

- Functions :

  F1: Create a database containing signal strength values of the artifact.

  F2: Extract signal strength values of the user's mobile device.

  F3: Communication between Client and Server.

  F4: Calculate precise location according to the signal strength values recieved from the user.

  F5: Displaying of relevant information according to the location of the user.

- Mathematical formulation used:

  Euclidean Distance

  Statistical Classification

- Success Conditions: Correct data regarding the artifact is displayed.

- Failure Conditions: No information is displayed on the smartphone.

1.9 NAMES OF CONFERENCES / JOURNALS WHERE PAPERS CAN BE PUBLISHED

- IJCSN International Journal of Computer Science and Network.

- Conferences/workshops in IITs

- Central Universities or SPPU Conferences

- IEEE/ACM Conference/Journal 1

1.10 PLAN OF PROJECT EXECUTION

Name	Begin date	End date
Documentation (Phase I)	8/10/15	8/28/15
Abstract & Topic choice	8/10/15	8/18/15
Literature Survey	8/19/15	8/21/15
Modeling problem statement	8/26/15	8/28/15
Design & Analysis	9/14/15	9/23/15
Finalizing interactivity of co...	9/14/15	9/16/15
Deciding structure of system	9/18/15	9/23/15
Risk identification & aversion	10/5/15	10/13/15
Identifying risks	10/5/15	10/9/15
Designing workarounds	10/12/15	10/13/15
Documentation (Phase II)	10/20/15	12/2/15
Synopsis	10/20/15	10/23/15
UML Diagrams	10/27/15	11/9/15
Finalizing documentation	11/30/15	12/2/15
Pre-implementation research	12/7/15	1/12/16
Researching APIs	12/7/15	12/18/15
Designing prototype modules	12/21/15	1/7/16
Comparing expected results ...	1/11/16	1/12/16
Implementation	2/5/16	3/30/16
Designing modules	2/5/16	2/26/16
Integrating modules	2/29/16	3/3/16
Synchronizing interconnecti...	3/4/16	3/8/16
Real time application testing	3/15/16	3/18/16
Collecting test data	3/25/16	3/30/16
Testing	4/4/16	5/6/16
Unit testing	4/4/16	4/8/16
Integration testing	4/11/16	4/15/16
System testing	4/19/16	4/22/16
Acceptance testing	5/3/16	5/6/16

Figure 1.1: Plan of Project Execution)

CHAPTER 2

TECHNICAL KEYWORDS

2.1 AREA OF PROJECT

- Embedded Systems
- Android Application
- Networking

2.2 TECHNICAL KEYWORDS

1. C. Computer Systems Organization
   (a) C.2 COMPUTER-COMMUNICATION NETWORKS
      i. C.2.1 Network Architecture and Design
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2. K.4 Computers and Society
   (a) K.4.3 Organizational impacts
      i. Automation

CHAPTER 3

INTRODUCTION

3.1 PROJECT IDEA

The basic idea of the project is to make a system for identification of the users location in an indoor facility. This will be in turn used to provide service or information based on the users location in real time. The project will be implemented for a museum. The application will give the information about the artifact in front of which the user is standing.

3.2 MOTIVATION OF THE PROJECT

This system will be able to identify the location of the user and give information according to it. Displaying the information prevalent to users location is important advancement in technological terms. This information may be about a specific entity in the environment. If it is connected to a server, this information can even be made dynamic in nature. For example, in museums the tourists or the visitors will be able to get information about the artifact they are currently looking at without pressing any button. The whole information about the exhibits which they are visiting will be given to the users i.e. audio files containing the history of the item. Images and important data will also be displayed on their personal smartphones.

Dynamic nature of this project:
Consider a hospital where each bed is equipped with a Bluetooth module. The module will be linked to the information about the patient. The doctor can automatically get all the reports of the patient as soon as he goes near the concerned bed.

3.3 LITERATURE SURVEY

3.3.1 Survey 1: Hybrid Indoor Positioning With Wi-Fi and Bluetooth: Architecture and Performance

Authors: Artur Baniukevic, Christian S. Jensen, Hua Lu
Published in: 2013 IEEE 14th International Conference on Mobile Data Management

This paper first explores the merits and demerits of WiFi and Bluetooth based indoor positioning system and then a Hybrid positioning system is proposed which includes usage of both WiFi routers and Bluetooth beacons simultaneously. Two approaches have been proposed to combine WiFi and Bluetooth into one positioning system.

1.This approach is used to employ scene analysis for both infrastructures. A combined radio map is created for both WiFi and Bluetooth signals at each reference position in the offline phase.

2.The combined radio map is utilized in the online phase to estimate user positions. Given an indoor space with WiFi deployed as the main wireless infrastructure, a limited number of Bluetooth hotspots are deployed as addons to divide the indoor space into disjoint partitions.

3.The original, large radio map is divided into small ones, each of which corresponds to an indoor partition induced by the deployment of Bluetooth hotspots. This approach reduces the computation cost of online position estimation. In particular, when a user enters the detection range of a Blueooth hotspot, as indicated by Bluetooth based on proximity analysis, the users position is simply estimated as the hotspots position without involving signal strengths.

4. After the user leaves a Bluetooth hotspot, a process called partition switching is invoked to decide the current possible partition(s) for the user. Afterwards, the online Wi-Fi based position estimation only involves the corresponding part(s) of the radio map. Searching the entire radio map only happens until the first Bluetooth hotspot is seen by the user device.

3.3.2 Survey 2: Precise Indoor Localization Using Smart Phones

Precise Indoor Localization Using Smart Phones

Authors: Eladio Martin, Oriol Vinyals, Gerald Friedland, Ruzena Bajcsy

This paper explores the possiblities of 3 available resources found in smart phones:WiFi radio, cellular communications radio and accelerometer for indoor localization. The two main approaches for the estimation of location making use of RSSI values are:

I. fingerprinting, where a prerecorded radio map of the area of interest is leveraged to infer locations through best matching, and

II. propagation based, in which RSSI values are used to calculate distances through the computation of the path loss.

As propogation based system face errors upto 50 percent and fingerprinting techniques have already proven to be accurate. Therefore, fingerprinting technique has been used in the scenario. The process contains two stages,

1) Training phase, also called offline phase, in which a radio map of the area in study is built. RSSI values from different beacons are recorded at different locations; the separation between these chosen locations will depend on the area in study, and for instance, for indoor environments this separation can be of around a meter. Each measurement consists of several readings, one for each radio source in range.

2) Online phase in which the mobile terminal infers its location through best matching between the radio signals being received and those previously recorded in the radio map. Localization algorithms employed in this case generally make use of deterministic or probabilistic techniques.

3.3.3 Survey 3: Survey of Wireless Based Indoor Localization Technologies

Authors:Junjie Liu

This paper explores different wireless technologies that can be used for indoor loclization and different algorithms which can be used to determine accurate location. Wireless technologies that can be used:

1. FM(Frequency Modulation)
2. GSM/CDMA

3. Wi-Fi

4. Zigbee

5. Bluetooth

6. RFID(Radio Frequency Identification)

7. UWB(Ultra Wide Band)

Different algorithms for indoor localization:

1. Proximity: It is the simplest method for localization. The assumption in this method based on is, if the user point is in the range of a known station, then we can approximate the location of the user point to the known station.

2. Triangulation: It uses geometric knowledge to obtain the location of user. The location of user can be determined by either the distance to the fixed known measurement points, or the received signal angle.

3. Fingerprinting: It means the characteristic or feature of signals. In most literatures, RSS is used a fingerprint. The assumption underneath this fingerprint based indoor localization is that for each position in area the features of signals are different.

3.3.4 Survey 4: An Alternative Indoor Localization Technique Based on Fingerprint in Wireless Sensor Networks

Authors: Yetkin TATAR, Gngr YILDIRIM

Published in: International Journal of Advanced Research in Computer and Communication Engineering Vol. 2, Issue 2, February 2013

This paper explores the use of Fingerprinting technique in Wireless Sensor Nodes(WSN).

1. Fingerprint technique: In this technique, the indoor area is divided into cells in which the coordinates are known. Next, for each cell, the RSSI values of all anchors are recorded into a database. The radio map is created in this phase.The second phase is the position estimation according to radio map. In the phase, the methods used for localization are generally based on deterministic, probabilistic or soft computing methods.

The proposed method is divided into two phases

A. RSSI Measurements and Radio Map: In this study, the test area has been divided

into 66 cells having the size of 1x1 m as shown in Figure 1 and it was assumed that there are no any transient RSSI distorting signals in the test area.
B. Localization: In localization, firstly, all the cells matching up with the online RSSI values are achieved from the radio map. A large number of the cells can be available. The next process is that the cells are eliminated in order to obtain minimum cells for the position detection.

3.3.5 Survey 5: Indoor location estimation using multiple wireless technologies

Authors: Dhruv Pandya, Ravi Jain, Emil Lupu
Published in: The 14th IEEE 2003 International Symposium on Personal, Indoor and Mobile Radio Communication Proceedings
This paper focuses on obtaining and fusing data i.e RSSI values from various multiple wireless technologies that can be used for indoor localization like WiFi and bluetooth.
1.Bluetooth data collection: The strength of a Bluetooth connection is measured in terms of link quality that varies from 0 to 255. Although dBm would have given better results due to hardware constraints only link quality was judged. In this experiment 50 link quality were measured.
2. 802.11 data collection:The method for 802.11 data collection is similar to that for Bluetooth with the strength of the 802.11 wireless connection is measured in term of signal strength and in dBm.
Algorithms: The Paper explains the use of a combination of approaches. The candidate locations are identified using K-nearest neighboring algorithm. In the K nearest neighboring algorithm, the Root mean square value is calculated. K neighbors having the least root mean square value are selected as candidate locations.After generating the candidate locations Smallest polygon algorithm is used.This algorithm gives the polygon having the smallest perimeter as the output. The centroid of the polygon will give the users location.

3.3.6 Survey 6: Low latency Indoor localization using Bluetooth Beacons:

In this paper the possibility of using bluetooth beacons to find the position of the user is explored.

1. Bluetooth beacons: The bluetooth beacons have a range of 100 meters. The bluetooth nodes are fixed and may be present anywhere in the room. The RSSI value of the bluetooth beacons is used to estimate the users location from the Beacons.

2. Algorithm : The Triangulation approach is used to specify the users location . In this algorithm the Input RSSI values are taken . The RSSI values for each individual bluetooth beacon are considered. A radius pertaining to the RSSI values are drawn for each beacon. The intersection of the circles are obtained.

3. After obtaining the intersection points of all the radii, the points forming a triangle with the smallest area are selected. The centroid of this triangle will give the users location.The user is required to handle a smartphone. The smart phone contains various other sensors such as pedometer and accelerometer. However this is not implemented as the input values are variable.

CHAPTER 4

PROBLEM DEFINITION AND SCOPE

4.1 PROBLEM STATEMENT

GPS is not effective in finding the indoor location. The GPS is accurate within 15 meters which is inadequate. Moreover in indoor facilities GPS range is limited. To obtain a better accuracy, technology such as BLE and Wi-Fi can be used effectively. RSSI values of BLE and Wi-Fi have been used in this system for obtaining the accurate users location. By accessing the users location, context based information will be provided to the user.

4.1.1 Goals and objectives

Goals:

- To study and implement a method which could be used for indoor location identification where GPS location is not available.
- Optimize the working so that it can keep accurate track of the users movements through an indoor facility.
- Study the effectiveness of the system in terms of power consumption and the obtained users location.
- To implicitly provide smart information to the user according to his indoor location.

Objectives:

- To implement the above system for a museum environment.
- To find out and approximate the visitors location in a museum.
- The main objective is that the information of the artefact must be provided to a visitor as soon as he is standing in front of it.

4.1.2 Statement of scope

- One cannot use GPS services when one is in indoor facilities. Thus it cannot be used in bigger structures such as malls, airports etc. The scope of this project is to successfully identify the location of the user inside the building. Moreover it will also be used to identify the context of the users location.The above functionalities are implemented in a museum based environment. The application should be able to approximately identify the artifact nearest to the user. After identifying the nearest artifact, the user will be provided with the relative information. This information transmission will be in real time.

The system will include a Bluetooth module , an android application and a system of Wireless routers. The Bluetooth module will be used to judge the users in its range. In case of overlapping signals, the RSSI value of the Bluetooth beacons and the wireless routers will be use to efficiently judge the nearest artifact.

In this project we plan to:

1. Study various techniques used for indoor location estimation

2. To develop a technique which will use both the IEEE 802.11 standard and Bluetooth beacon.

The information will be transferred from the server over the Wi-Fi to the client devices. The information will be in audio or in text format and will be displayed or played automatically as per the context of the user.

4.2 SOFTWARE CONTEXT

This software can be used globally where identifying the location of the user can be useful. This system has a lot of applications worldwide. This system is used to implicitly give information to user which can save a lot of time and increase reliability and efficiency at various places.

Such a system can be used in museums as demonstrated. Other than that, it can be used in hospitals, malls, airports, supermarkets where information given is relative to the location of the user. In all of these scenarios, important information can be conveyed implicitly to the user which will be very convenient for the society.

4.3 MAJOR CONSTRAINTS

- Time being a constraint, it wont be possible to project a high end GUI.

- Area of System installation will be a constraint in designing the system.

4.4 METHODOLOGIES OF PROBLEM SOLVING AND EFFICIENCY ISSUES

- The single problem can be solved by different solutions. This considers the performance parameters for each approach. The most optimal of these methodologies is by using euclidean distance algorithm which we have implemented. Some other methods of solving this specific problem are the Centroid algorithm, Kalman filter, etc.
- Efficiency issues here will be time-lag in refreshment of obtaining the latest signal strength values. The signal strength of Wi-Fi routers and Bluetooth modules may change abruptly due to changes in the environment. These values can change if there is change in any physical entity in the vicinity.

4.5 SCENARIO IN WHICH MULTI-CORE, EMBEDDED AND DISTRIBUTED COMPUTING USED

All the artifacts where the range between them is 7-9 metres, Arduino board along with bluetooth modules are used placed which are used to give clarity and make the result more efficient.
The whole system is based on a distributed system which is present between a number of client devices and a server which provides the connectivity and transferring of information to user devices.

4.6 OUTCOME

1. An accurate estimation of the users location in an indoor facility.
2. Identification of relevant information according to the users environment.
3. Correct information regarding the artifact is displayed.
4. Once the user goes out of the range, then the information will stop transmitting.

4.7 APPLICATIONS

- **Museum**: The main application of this system is in smart museums which we are going to implement. In a smart museum the visitors will get information about artifacts or exhibits as soon as they enter the proximity of the artifact.
- **Hospital**: In hospitals, Bluetooth beacons can be installed on hospital beds. When a doctor visits the patient he will receive all the information about the patient on his device.
- **Car Unlock**: A Bluetooth module can be installed on cars which will help users to unlock their cars in a smart way. When the user will go near their car, the smart-phone will be sensed by the beacon which will unlock the car.
- **Supermarkets**: By identifying the location of the user, various offers and information regarding the items present in the aisle where the user is present can be displayed. Also, it will be easier to navigate around the supermarket by integrating a querying system.
- **Airports**: The user can be shown to any important booth like the boarding gate or the baggage collection room for instance. Navigation around the airport will become handy and easier.

4.8 HARDWARE RESOURCES REQUIRED

Sr. No.	Parameter	Minimum Requirement	Justification
1	CPU Speed	2 GHz	Multi-threading
2	RAM	3 GB	Multiple client threads
3	Wi-Fi Router	Range covering the indoor space	Transmission of data
4	Smartphone	Bluetooth, Wi-Fi available	RSSI values

Table 4.1: Hardware Requirements

Arduino with HC-05 Module which will act as a Bluetooth Beacon.

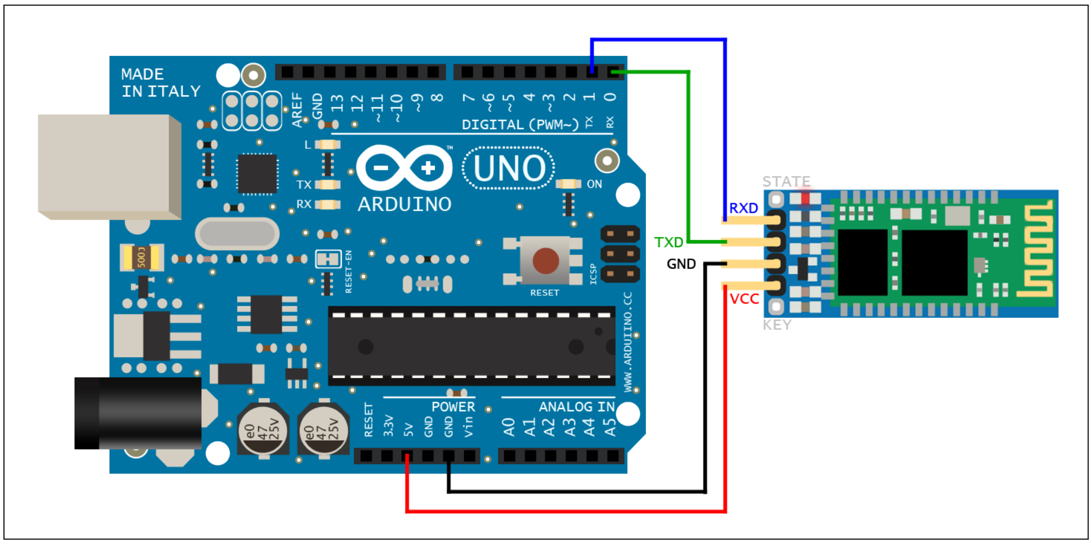

Figure 4.1: Bluetooth Module(Arduino with HC-05)

In this project, Bluetooth modules(Arduino microprocessor paired with HC-05) are placed at artifacts which are closer to each other by less than 10 meters. This is done to obtain better clarity in results.

Arduino Hardware Specifications:

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage(recommended)	7-12V
Input Voltage(limit)	6-20V
Digital I/O Pins	14(of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20mA
DC Current for 3.3V Pin	50mA
Flash Memory	32KB
SRAM	2 KB
EEPROM	1KB
Clock Speed	16MHz
Length	68.6mm
Width	53.4mm
Weight	25 g

4.9 SOFTWARE RESOURCES REQUIRED

Platform :

1. Operating System: Windows, Android 4.0+
2. IDE: Android Studio, Eclipse, Arduino IDE
3. Programming Languages: Java, C++, MySQL

CHAPTER 5

PROJECT PLAN

5.1 COCOMO MODEL

The Constructive Cost Model(COCOMO) is an algorithmic software cost estimation model developed by Barry Boehm. The model uses a basic regression formula, with parameters that are derived from historical project data and current project characteristics.

COCOMO applies to three classes of software projects:

- Organic projects - ”small” teams with ”good” experience working with ”less than rigid” requirements.

- Semi-detached projects - ”medium” teams with mixed experience working with a mix of rigid and less than rigid requirements.

- Embedded projects - developed within a set of ”tight” constraints.

The basic COCOMO equations take the form:

Effort Applied = ab(KLOC)bb [man-months]

Development Time = cb(Effort Applied)db [months]

Basic COCOMO is good for quick estimate of software costs. However it does not account for differences in hardware constraints, personnel quality and experience, use of modern tools and techniques.

1. Compute the count-total which will be used to define the complexity of a project.

   The Count-total value of our system is 97.00

2. Find the complexity adjustment values based on responses asked to the developer.

   The weighting factor of our system is: 44.00

   The function point is: 105.73

3. Find LOC (Lines of Code) of the software.

   Object-oriented language is selected where LOC/FP = 30.

   LOC in our system is: 3171.90

4. Select complexity of the software project.

   Our system is embedded project system.

Calculation of Effort:

Effort (E) = ab(KLOC)bb = 14.38 [man-months]

Calculation of Duration:

Duration (D) = cb(E)db = 5.87 [months]

5.2 PROJECT ESTIMATES

1. **Requirement Phase:**

   (a) **Hardware:** Bluetooth modules with 32 bit micro-controller are used where it is necessary to increase the accuracy and the difference between 2 artifacts is less than 8 meters. Wi-Fi routers are placed at necessary points in the area where the system is to be planted. Minimum 2 Wi-Fi routers are necessary for the system to work precisely. Furthermore, a Server (Windows/Ubuntu, 2GB RAM) is used to give services to all the clients over Wi-Fi network. This server connects the whole system with each other and acts as the bridge

   (b) **Software:** Software needs to be open so that information will be displayed at user side. There are no buttons at client side as it is a context based application and works without the user having to press anything.

2. **Design:** Software design is the process of implementing software solutions to one or more set of problems. One of the important parts of software design is the software requirements analysis (SRA). Hence the data is collected in MySQL on which the processing is done. Client-Server Architecture is required for the communication of the processor node to the user's device.

3. **Implementation:** Coding is done in Java, C/C++ for the communication of all the nodes and user's device as well for reading and writing the values. For mobile devices Android programming is done.

4. **Verification:** The systematic discovery and debugging of defects in individual nodes .

5. **Maintenance:** After the delivery of the product, maintenance is to be done from the point of view of hardware parts of the Bluetooth Module when the modules run out of battery and from software point of view to ensure whether the server is reachable or not.

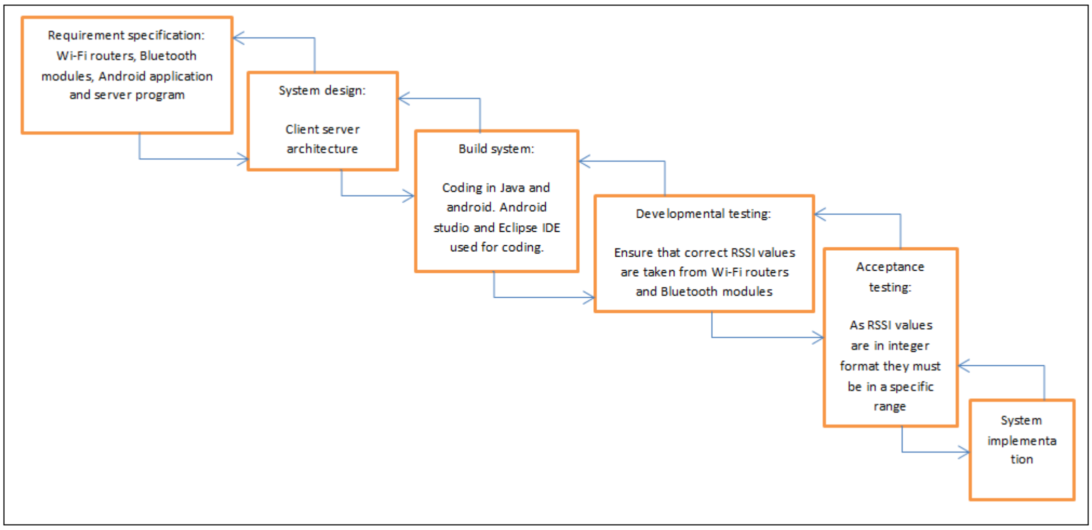

Figure 5.1: Agile Waterfall Model

5.2.1 Reconciled Estimates

5.2.1.1 Cost Estimate

At prototype level the cost of implementation will be low ranging from Rs.500-1000. The cost of deploying the system will be dependant on the area where the system is to be used as the number of routers and bluetooth modules will vary according to the size of the area.

5.2.1.2 Time Estimates

The system is divided into a number of modules and applications namely Wi-Fi, Bluetooth , Admin Application, User Application and the Database module. Each module was developed independently and was integrated whenever it was satisfactorily completed. The development time required varied according to the difficulty

level of the module. The development phase was followed by the integration of all the modules in one system. The total time required for the development and integration of the system was approximately 4 months.
Testing was conducted on each module and also on the completed system. The time required for testing was approximately 1 month.

5.2.2 Project Resources

Project resources [People, Hardware, Software, Tools and other resources] based on Memory Sharing, IPC, and Concurrency.
1. People : Developers and Testers.
2. Hardware: Bluetooth module, Wi-Fi Routers, Server.
3. Software: Linux OS/ Windows OS, Android application, Client-Server based on C/C++ program.
4. Tools: Android Studio, Eclipse, Text Editor , GUI tools.

5.3 RISK MANAGEMENT W.R.T. NP HARD ANALYSIS

This section discusses Project risks and the approach to managing them.

- The risk associated with this project is that the user devices may get abrupt RSSI values of the respective Wi-Fi routers. The outcome of this problem can be that wrong data will be obtained as result.
- The scalability can be counted as issue since there will be problem in handling multiple read, write, get request from multiple clients. This is because a new service is created for every user which enters in the area of execution.
- In some cases the server can be unreachable.

5.3.1 Risk Identification

The following risk identification questionnaire was used to identify possible risks and expose them:

1. Have top software and customer managers formally committed to support the project?

2. Are end-users enthusiastically committed to the project and the system/product to be built?

3. Are requirements fully understood by the software engineering team and its customers?

4. Have customers been involved fully in the definition of requirements?

5. Do end-users have realistic expectations?

6. Does the software engineering team have the right mix of skills?

7. Is the number of people on the project team adequate to do the job?

8. Do all customer/user constituencies agree on the importance of the project and on the requirements for the system/product to be built?

5.3.2 Risk Analysis

- Product size risks associated with the overall size of the software to be built or modified: Java programs have limitations to handle large set of data

- Business impact risks associated with constraints imposed by management or the marketplace: No risks

- Customer characteristics risks associated with the sophistication of the customer and the developer's ability to communicate with the customer in a timely manner: Absence of GUI.

- Process definition risks associated with the degree to which the software process has been defined and is followed by the development organization: The degree of risk is considerably low.

- Technology to be built risks associated with the complexity of the system to be built and the "newness" of the technology that is packaged by the system: The technology being trending, significant help can be obtained from different blogs and forums.

- Staff size and experience risks associated with the overall technical and project experience of the software engineers who will do the work.

Probability	Value	Description
High	Probability of Occurrence	0-10%
Medium	Probability of Occurrence	10-30%
Low	Probability of Occurrence	30-50%

Table 5.1: Risk Probability Analysis

Impact	Value	Description
Very High	>10 %	Schedule impact or Unacceptable quality
High	5-10 %	Some parts of the project have low quality
Medium	<5%	Barely noticeable degradation

Table 5.2: Risk Impact Definitions

5.3.3 Overview of Risk Mitigation, Monitoring and Management

Following are the details of each risk:

Risk ID	1
Risk Description	Abrupt RSSI values received
Category	Runtime Environment
Source	Identified during Unit Testing
Probability	Medium
Impact	High
Response	Mitigate
Strategy	Record the values again
Risk Status	Identified

Table 5.3: Risk Details

Risk ID	2
Risk Description	Miscellaneous Runtime errors occurred
Category	System
Source	Software Requirement Specification
Probability	Low
Impact	High
Response	Restart application
Strategy	Retry or restart phone
Risk Status	Identified

Table 5.4: Risk Details 2

Risk ID	3
Risk Description	Application Server or Clients randomly shut down
Category	Runtime Environment
Source	Software Requirement Specification
Probability	Low
Impact	High
Response	Restart application
Strategy	Retry or restart phone
Risk Status	Identified

Table 5.5: Risk Details 3

5.4 PROJECT SCHEDULE

5.4.1 Project task set

Major Tasks in the Project stages are:

- Task 1: Create a working Bluetooth Module.
- Task 2: Extract Wi-Fi RSSI values in android application.
- Task 3: Establish communication between client and server.
- Task 4: Write a working algorithm for calculation of location from RSSI values.
- Task 5: Testing the system to minimize the error.

5.5 TEAM ORGANIZATION

5.5.1 Team Structure

5.5.2 Management Reporting and Communication

Name	Responsiblities
Sourabh Khasbag	Development and Testing
Shubhankar Ranade	Development and Testing
Abhijeet Wani	Documentation and System Design
Parth Hiralikar	Software Engineering and Module Development

Table 5.6: Team Structure

Reporting	Date	Status
Idea	10th August	Accepted
Final Problem Statement	20th August	Accepted
Literature Survey	30th August	Accepted
System Architecture	14th September	Accepted
Risk Workarounds	28th September	Accepted
UML Diagrams	7th November	Accepted
Finalized Documentation	2nd December	Accepted

Table 5.7: Management Reporting

Intra-team Communication:

Meeting Purpose	Date	Accomplishments
Initial Idea Delivery	8/9	Successfully explained logic to all members
System Design	13/9	Successfully decided system architecture
Constraints Discussion	21/9	Successfully identified risks in project
Workarounds	25/9	Unanimously decided workaround
Allotment of UML Diagrams	4/10	Successfully allotted UML diagrams to every member
Final Documentation	30/10	Successfully edited and finalized documentation

Table 5.8: Intra-Team Communication

CHAPTER 6

SOFTWARE REQUIREMENT SPECIFICATION

6.1 INTRODUCTION

6.1.1 Purpose and Scope of Document

The purpose of Software Requirements Specification is to outline the requirements for the deployment of our Indoor Location Identification System. We will develop an Android application which will be responsible for the display of information regarding the artifact and also transfer data to the server. The SRS will lay out functional and non-functional requirements along with a set of use cases to describe the interaction users will have with our system.

6.1.2 Overview of responsibilities of Developer

The developer is responsible for the functional specification of each and every module that needs to be developed. The most important responsibility of the developer is to identify and utilize the right technology for this project. We have used Android smartphones along with Arduino boards and routers to determine the users location. In this project it is the developers responsibility to design the algorithm for extracting the RSSI values from the Wi-Fi and the Bluetooth data structures. The database creation and database cleaning are also important aspects of this project.

It is the duty of the developer to Plan, coordinate and execute project activities to ensure timely completion. After the completion of the system, it is the developers job to design the test cases and strategies to ensure the complete and through testing of the entire system.

6.2 USAGE SCENARIO

As a developer, for Bluetooth modules we chose the Arduino Microcontroller as it is a low power, low cost ARM architecture based embedded board which has sufficient amount of resources for our project implementation. Along with that we use the Wi-Fi protocol 802.11 a/b/g/n to establish connectivity among users with server via a wireless router.

6.2.1 User profiles

There are 3 actors present in the system.
User: The user is the client side of the system. Android application is present with every user.
Server: The server is responsible for calculation of information to be given to user according the the inputs received. The server is also responsible for communication with multiple clients.
Administrator: The administrator is responsible for creating the database containing the signal strength values with respect to the artifacts.

6.2.2 Use-cases

The description of all the main use-cases in the system is given below:

1. Scan for Bluetooth modules and get SSID: Responsible for the identification of the bluetooth module.

2. Scan for Wi-Fi Routers and get SSID: Responsible to extract information about the Wi-Fi routers present in the area.

3. Extract RSSI values: This is useful to extract the signal strength of the Bluetooth modules or Wi-Fi routers.

4. Send RSSI values: This is used to send the RSSI values to the server.

5. Find position of user: Used to calculate the position of the user by using the recieved RSSI values and comparing them to the database with specific algorithms.

6. Send information: The server sends the information to the user device.

7. Record RSSI values of Wi-Fi and Bluetooth: Create the database at server side. The system administrator has to record the RSSI values.

6.2.3 Use Case View

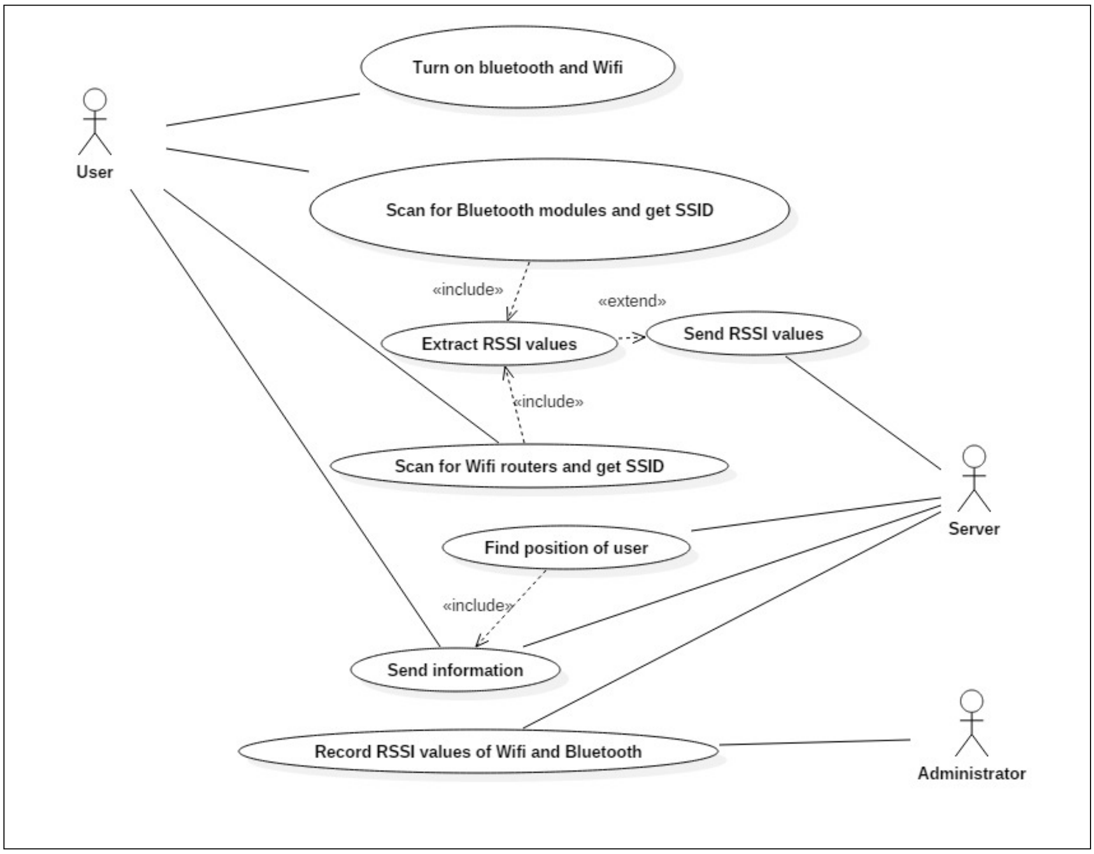

Figure 6.1: Use case diagram

6.3 DATA MODEL AND DESCRIPTION

6.3.1 Data Description

The Data Types are Mentioned below:

1. Artifact: This object is used to specify the properties of the Artifact. It is used to contain the RSSI values of the router which are recorded by the Admin Application. It contains the Artifact ID which is used to distinguish between the two Artifacts.

2. ScanResult: This is used in the android applications to store the result of the Wi-Fi scan and extract the RSSI values.

3. TimerTask: This is used to run Bluetooth and Wi-Fi scan at specific intervals of time. It contains a overridden run method which specifies the code which is executed at each iteration.

4. DatabaseCreator: The object of this class takes the input of the RSSI values from the admin application. It then cleans and stores the RSSI values into the MySQL database. The database details are explained below.

5. User: The object of this class takes the input from the User Android Application. It is responsible for fetching of the Artifact RSSI values from the database. The fetched values are combined with the user values and the position is guessed.

6.3.2 Data objects and Relationships

In this project we have used the relational MySQL database to store the values of the Artifact.

- ArtifactR1: This table in the database stores all the values received for the First Router for the particular artifact.

- ArtifactR2: This table is used to store all the values received for the Second Router for that particular artifact.

SCHEMA = RSSI (INT), ID (INT)

- Artifact database table: This stores the cleaned RSSI values of both the routers for the Particular Artifact.

  SCHEMA = R1 (INT), R2 (INT)

6.3.3 Data Flow Diagram

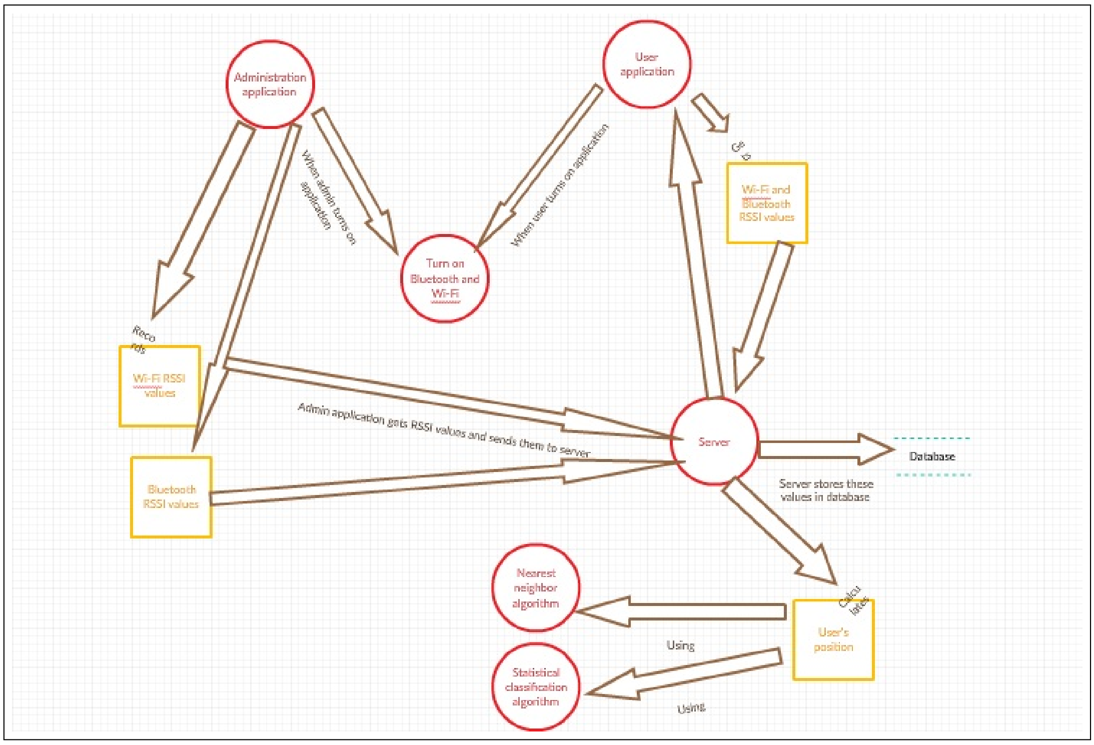

Figure 6.2: Data Flow Diagram

6.4 FUNCTIONAL MODEL AND DESCRIPTION

6.4.1 Description of functions

1. Check Bluetooth and Wi-FI: To check if Wi-Fi and Bluetooth is working on the user's device.

2. Get Wi-Fi inputs: If no bluetooth is in range, get Wi-Fi RSSI values.

3. Get bluetooth information: If bluetooth is in range, get bluetooth module information.
4. Send values to server: Send RSSI values to the server.
5. Calculate result: The server calculates result according to the RSSI values which are taken as input.
6. Send result to client: The information is sent to the client.
7. Display result: The result is displayed at client side.

6.4.2 Activity Diagram:

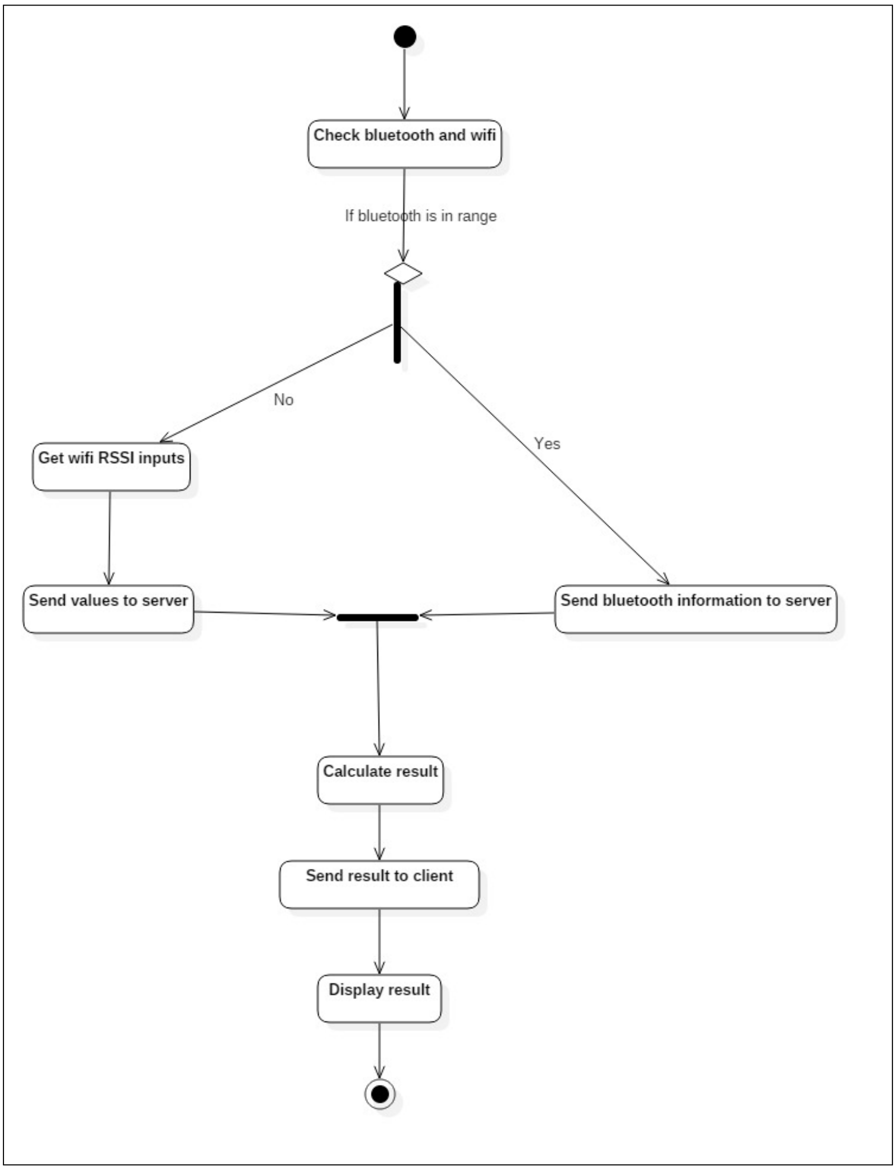

Figure 6.3: Activity diagram

6.4.3 Non Functional Requirements:

- Interface Requirements:There is no interface as the application is a context based application.
- Performance Requirements:The performance of this system depends upon various factors such as stable power supply, proper handling of modules. The system should be working at all times so that proper service can be given to

the users at all times.

- Availability: All time

  Reliability: High

  Modifiability: Very convenient

  Portability: Yes

  Re-usability: Yes

  Scalability: At low level

  Performance: High

  Security: Adjustable (Depends on the security protocols)

  Testability and Usability: Easy

6.4.4 State Diagram:

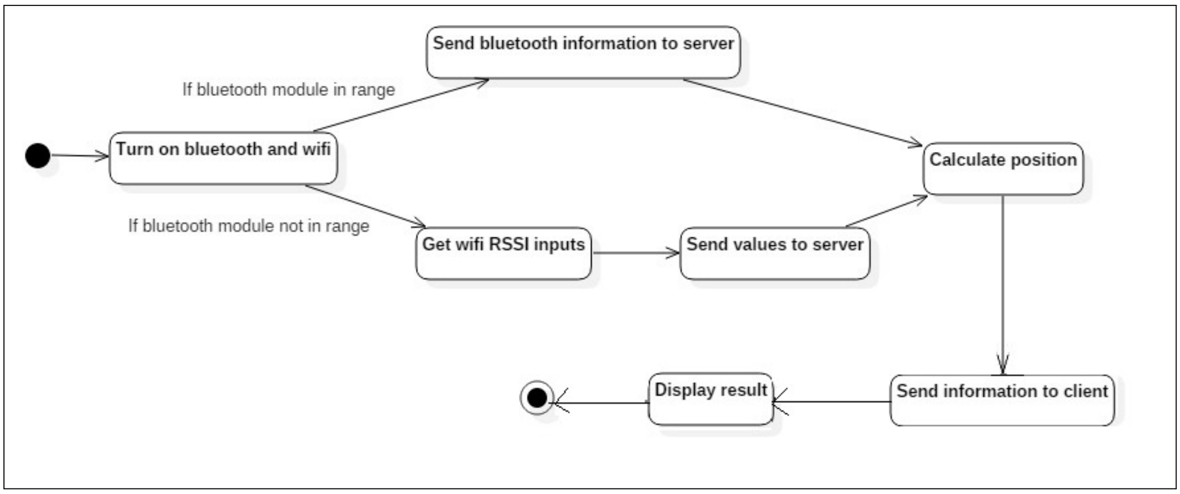

Figure 6.4: State transition diagram

6.4.5 Design Constraints

1. Wi-Fi Routers should contain a stable power supply at all times.

2. Bluetooth modules should be working at all times and be recharged when necessary.

3. Wi-Fi routers installed should have adequate range so as to cover the area of deployment

6.4.6 Software Interface Description

The server side of the system will give information regarding the location of every user and the information provided to him.

The user application has no interface as it is a context based application. The information regarding the artifact will automatically be displayed on the user's mobile device.

CHAPTER 7

PROJECT DESIGN DOCUMENT

7.1 INTRODUCTION

This document specifies the design that is used to solve the problem of Product.

7.2 ARCHITECTURAL DESIGN

A description of the program architecture is presented. Subsystem design or Block diagram,Package Diagram,Deployment diagram with description is to be presented.

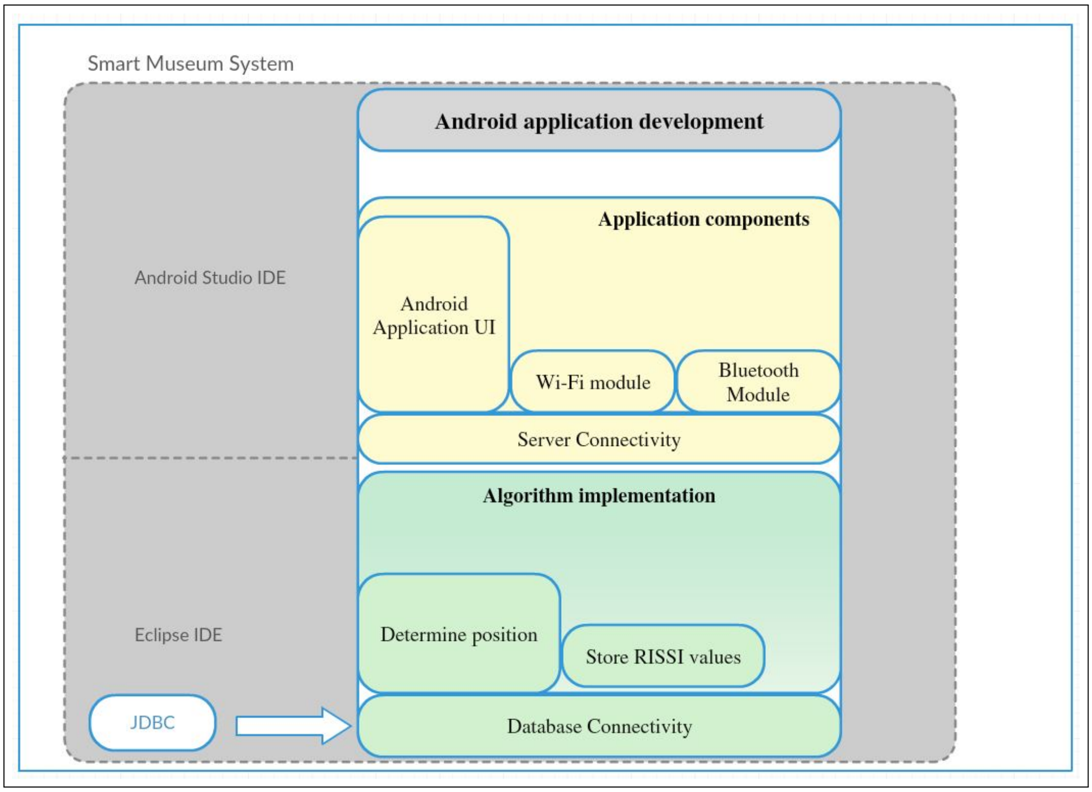

Figure 7.1: Architecture diagram

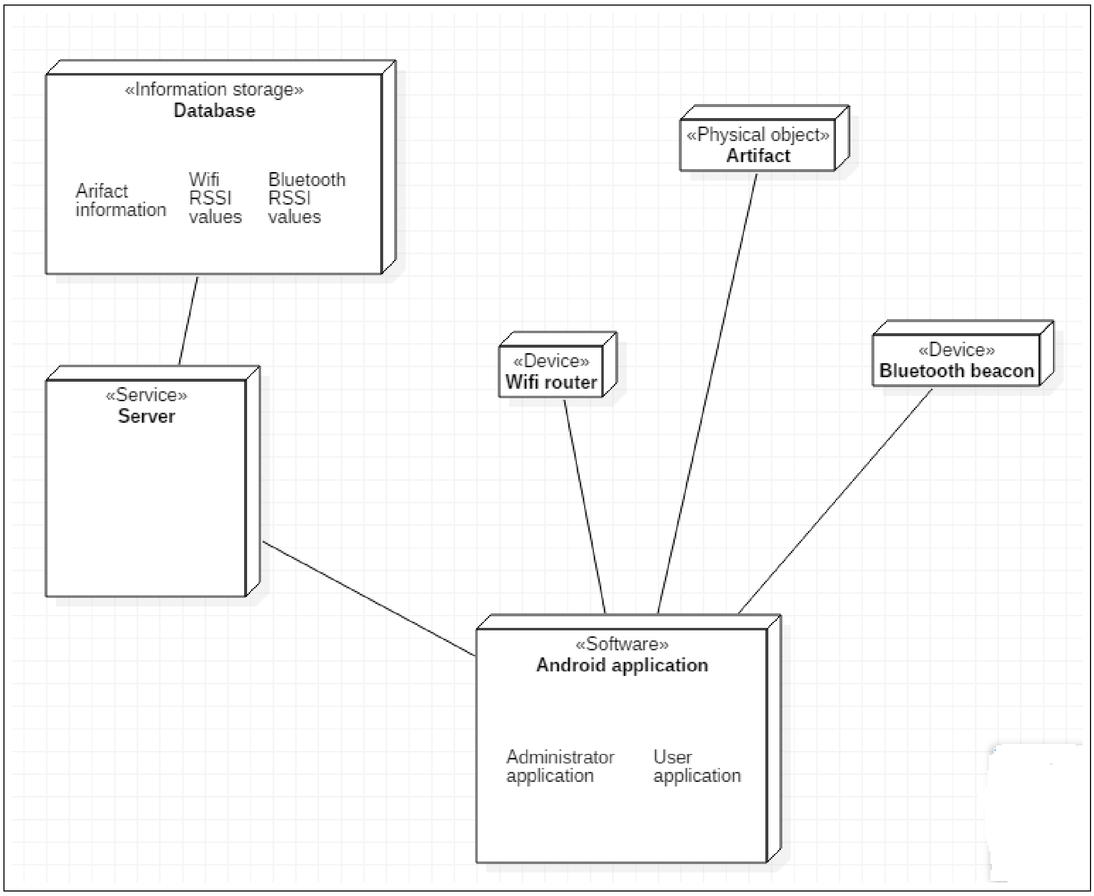

Figure 7.2: Deployment diagram

7.3 DATA DESIGN

7.3.1 Internal software data structure

RSSI values are passed from the user application to the server node when the application is used. The result is then computed and then transmitted to the user back again from the server to the user device.
When the administrator application is used, the values will be transmitted only from the admin device to the server and the values will be stored with respect to the location from where they were recorded.

7.3.2 Global data structure

The global database will consist of values which are retrieved at various locations throughout the area. The results obtained from the user will be compared to this global data structure. The administrator is responsible for creating the main database of the system. The global database will be present at the server node.

7.3.3 Temporary data structure

The RSSI values of the user are temporarily stored at the Server. Once the appropriate result is given to the user, the values are replaced with the net set of values transmitted.

7.3.4 Database design diagram

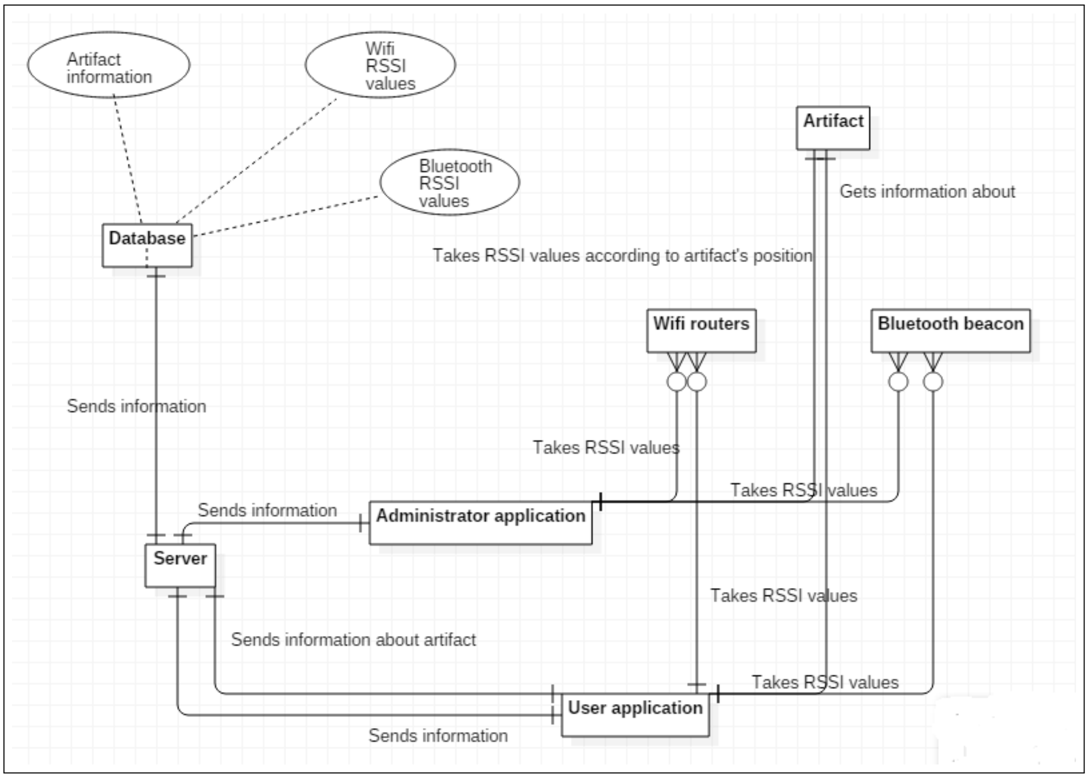

Figure 7.3: Class Diagram - Server

7.4 COMPONENT DESIGN

7.4.1 Server Component

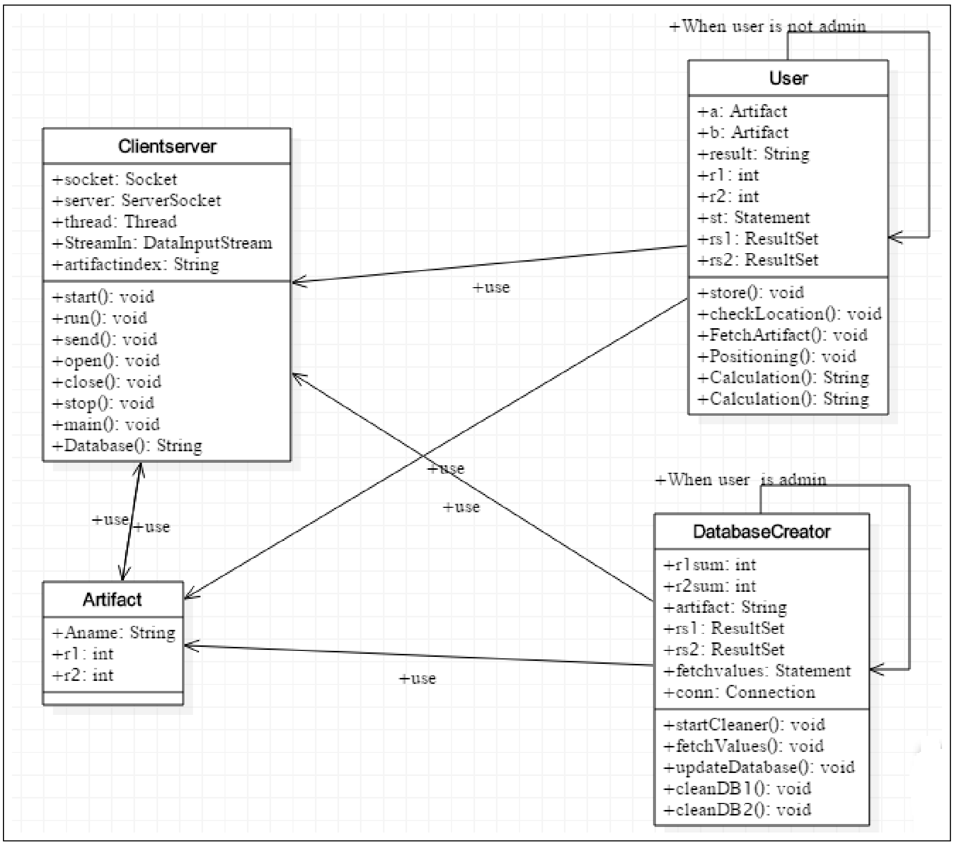

Figure 7.4: Database Design Diagram

Description of Server Component

The Server software is responsible for communication between the database and the user. The server is going to provide data to the user. The server is also responsible for extracting the necessary data from the database which is retrieved using RSSI values. The server is also responsible for creating the database with the help of the System Admin.

7.4.2 Administrator Component

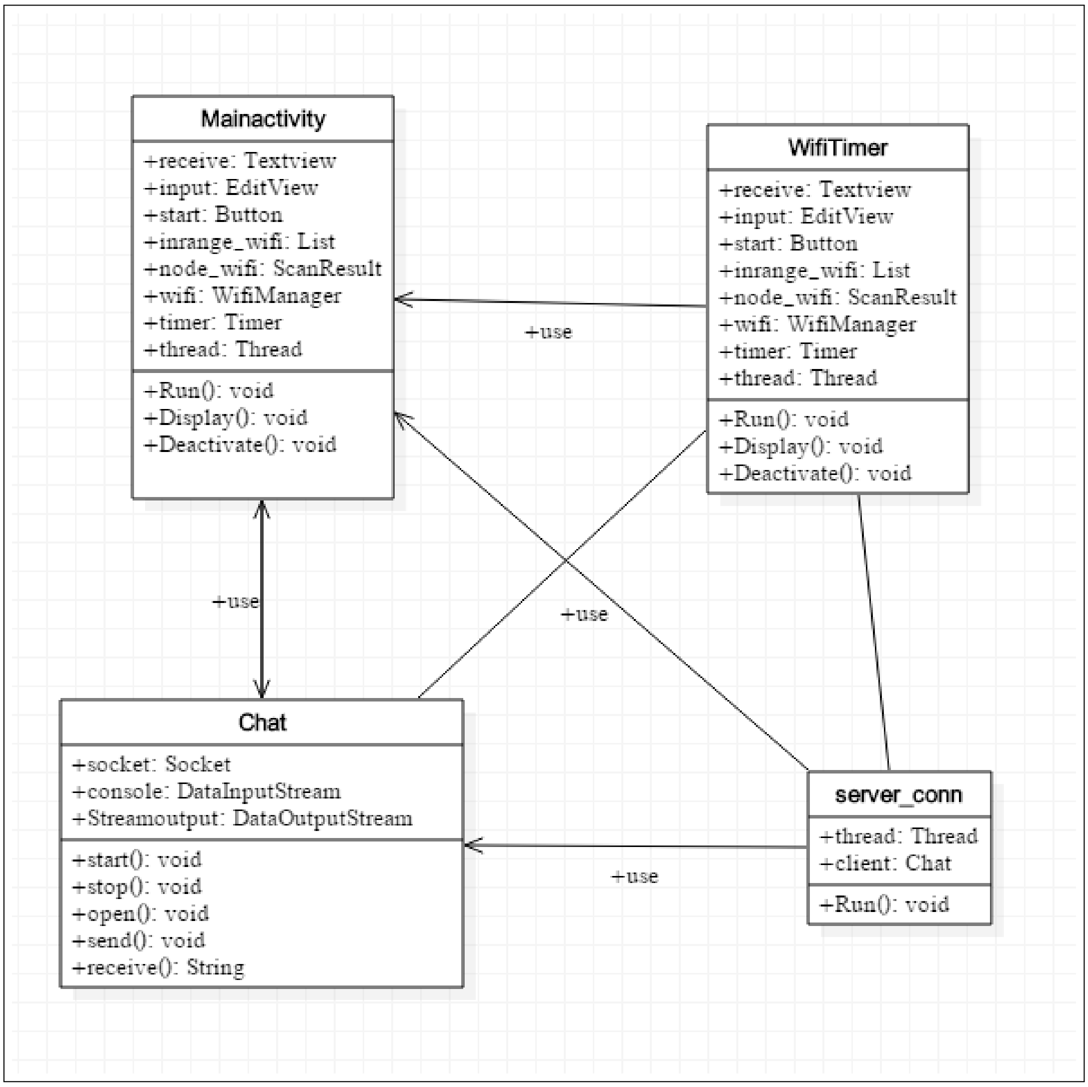

Figure 7.5: Class Diagram - Administrator

Description of Administrator Component

The system administrator is responsible for creating the database. The admin will record RSSI values at different places throughout the area and will connect with the server to store them in the database.

7.4.3 User Component

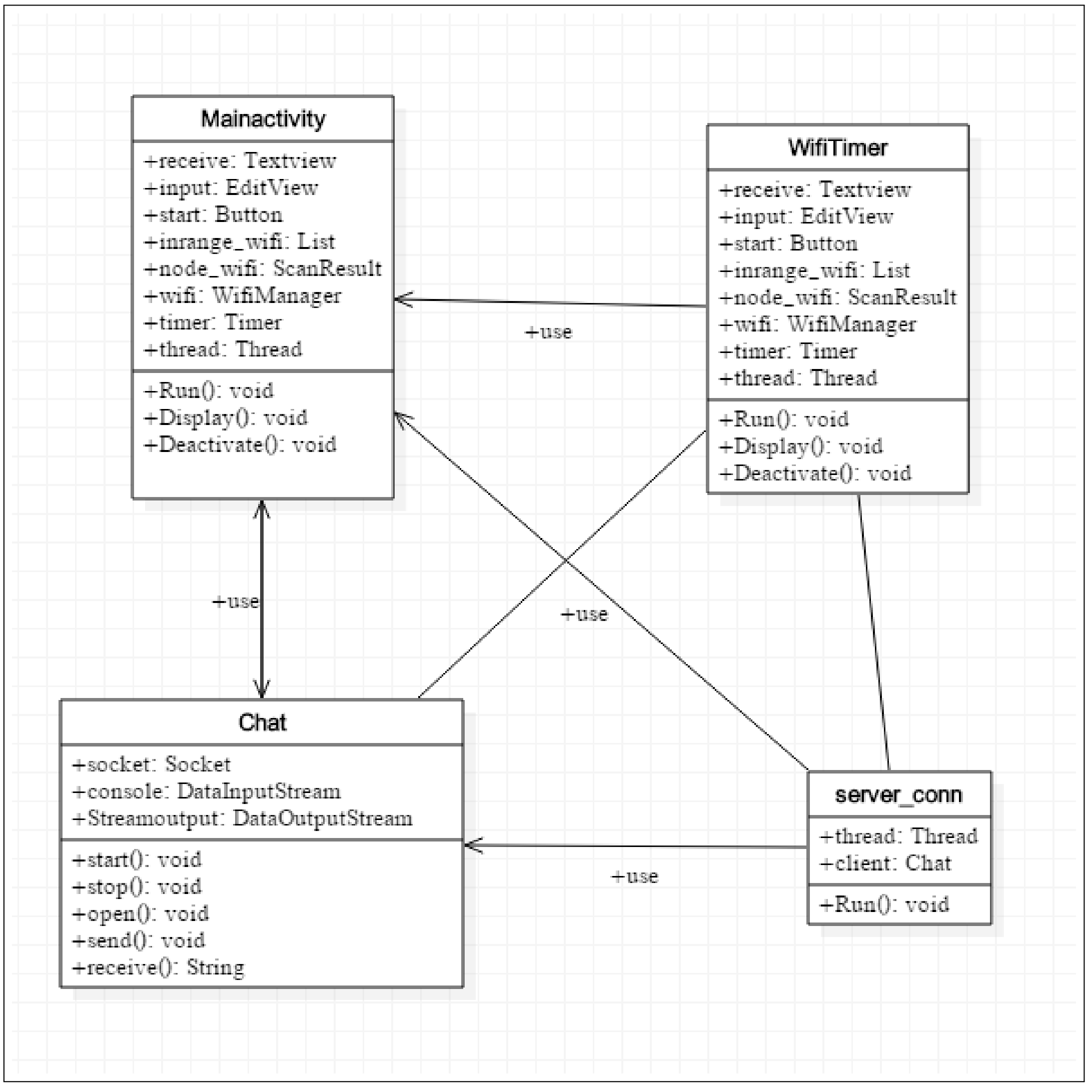

Figure 7.6: Class Diagram - User

Description of User Component

The user is the final customer in the system. The user will install the application and he will get context based information according to his location.

7.5 USER INTERFACE DESIGN

The UI will contain a basic screen which will contain text box where information regarding the artifact will be displayed.

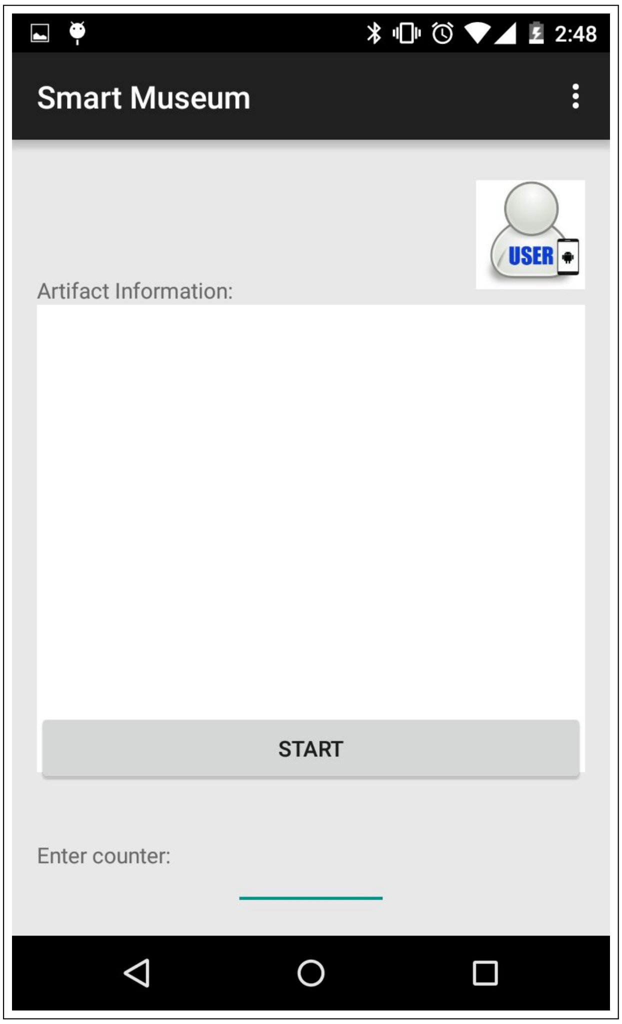

Figure 7.7: User Application User Interface

The User application UI will contain:

Text Box - Which will contain the information about the nearest artifact from the location of the user.

Button - To begin execution of the application i.e. start recording and sending RSSI values.

Counter - This will contain the counter to be given to the application. The counter will be hard coded in further stages of the system.

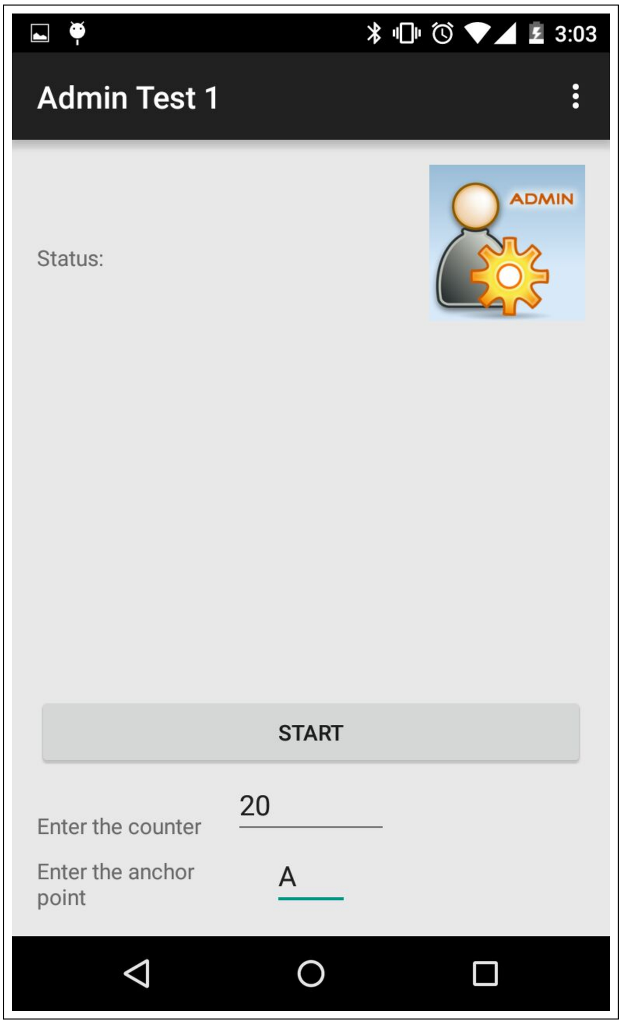

Figure 7.8: Admin Application User Interface

The Administrator application UI will contain:

Text Box - Which will give information about the current status of the system i.e. whether the values are being recorded and stored in database or not.

Button - To begin execution of the application i.e. start recording and sending RSSI values.

Counter - This will contain the counter to be given to the application. The counter will be hard coded in further stages of the system.

Anchor Point - This is the point which is to be stored in the database under the RSSI values received at that location.

CHAPTER 8

PROJECT IMPLEMENTATION

8.1 INTRODUCTION

In this project, Bluetooth modules(Arduino microprocessor paired with HC-05) are placed at artifacts which are closer to each other by less than 10 meters. This is done to obtain better clarity in results.

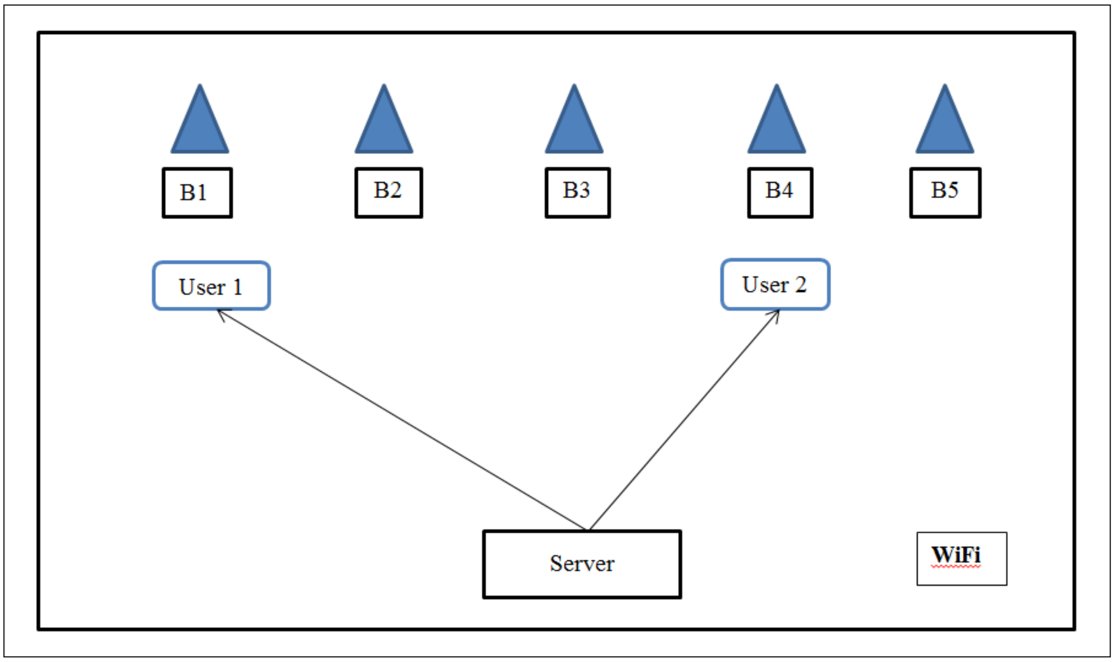

Figure 8.1: Bluetooth System

In our project, the complete area of project is present under a Wi-Fi router area. The user device identifies the bluetooth module which is near it and sends information about the module to the server. The server then responds with information based upon the bluetooth module which is identified by the mobile device.

The area where the system is deployed will contain Wi-Fi routers placed at specific points. Minimum 2 routers are needed for the system to work. The user device will record the RSSI values it receives from the Wi-Fi and creates a tuple of these values.

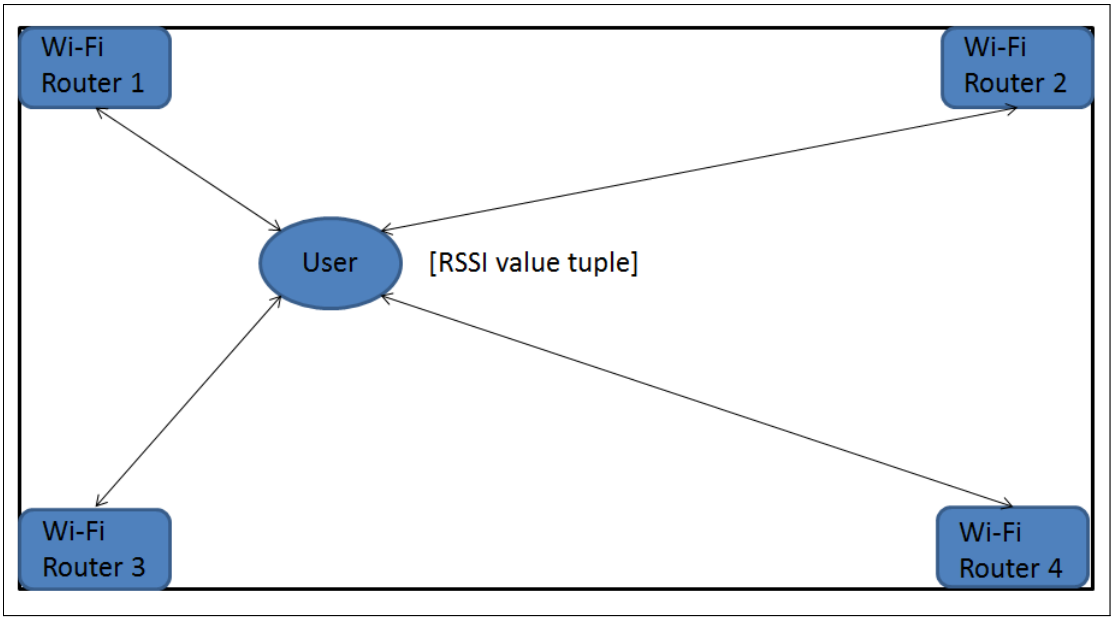

Figure 8.2: Wi-Fi Router System

These 2 systems are combined together to form our Smart Museum Design. The Bluetooth Beacon identification model is given a higher priority than Wi-Fi RSSI identification.

8.2 METHODOLOGIES/ALGORITHM DETAILS

8.2.1 Algorithm 1: K-Nearest Neighbour Algorithm

The k-Nearest algorithm is a classification algorithm that uses the distance metric to classify the input object into a group of objects. In the k-nearest Neighbour algorithm there are two main phases or types: the training phase and the classification test. The training examples contain the pertaining data, each with a class label. The training phase of the algorithm consists only of storing the feature data and class labels of the training samples. In the classification phase, k is a user-defined constant, and an unlabelled data object (a query or test point) is classified by assigning the label which is most nearest to that query point. The two phases of the k-NN algorithm are explained below:

- Training data: To collect the Training dataset an Admin application is developed. The Admin application includes a simplistic interface along with the Wi-Fi RSSI, Bluetooth RSSI and the Client Server modules. The Wi-Fi module makes use of androids WifiManager data type to extract the RSSI values. Similarly the Bluetooth API framework provides RSSI values of the Bluetooth nodes. RSSI values are known to be highly volatile. Therefore to minimize the error the RSSI values are recorded continuously at a fixed interval of two second over stipulated amount of time. A TimerTask is employed to implement this in the algorithm. The TimerTask contains a overridden run method which contains the code which is to be run at a specific interval. The specifications of the intervals and the iterations are explained in detail in the testing phase. After the stipulated time, the RSSI recorded in every interval are averaged out. The averaged out values are then sent to the server.

- Positioning Computing: To compute the position of the person a Client side Android application is developed .The application has the following capabilities:
  a) Wi-Fi
  b) Bluetooth

c) Server connectivity

When the user application is started the Bluetooth functionality is first tested. If the Bluetooth is not switched on, the user is prompted to allow the Bluetooth functionality. The Wi-Fi adapter capabilities are also check to ensure that the Wi-fi Adapter is switched on. Android provides a Bluetooth adapter and a Wi-Fi Manager to get a handle on Bluetooth and Wi-Fi respectively.

The RSSI values are measured at a fixed interval using the TimerTask Class. The RSSI values are averaged out and then sent to the server. The specifications to extract the RSSI values are shown below:

a)Bluetooth:intent.getShortExtra(BluetoothDevice.EXTRARSSI, Short.MINVALUE)

The intent is the message which has been sent by the Bluetooth discovery activity. Intent is created for every device which has been discovered. The intent message contains the RSSI value of the discovered device in the EXTRA_RSSI field.

b)Wi-Fi: obj.level

The Wi-FI manager stores all the Results of the discovered Wi-Fi signals in a ScanResult Data Structure. Each identified signal has a SSID associated with it. The SSID can be obtained by using the SSID variable in the function. Similarly the Wi-Fi result is obtained by referring to the level variable in the identified object.

The data is then accumulated into a string in the following form:

Uk(R1value):a(R2value)—(Bluetoothvalue)

The letter U denotes that the data is received from a user application as opposed to the admin application. The letters k ,:, l act as delimiters for the server to differentiate between various values. Using such delimiters the values of all the routers can be sent at once to the server. This ensures that the communication between the client application and the server is restricted to a minimum.

- Server side computing: The server accepts the Strings from the client and the admin. Using the keys and the delimiters it initially determines whether the input is from an user application or an admin application. The delimiters are identified and the respective values of artifact, Routers and Bluetooth are extracted. In case this is a admin application, SQL connectivity is used to store the data in the database. In case of a user input the position is calculated using K-nearest algorithm.

- K-nearest neighbour algorithm : Initially using SQL connectivity the server extracts the stored values from the database. The values are extracted into arrays. To calculate the nearest neighbour Euclidean formulae is used:

For each artifact in the database the following calculations are executed:
1. The RSSI value of the first router (henceforth mentioned as R1) and the users RSSI value from the R1 router are subtracted and then squared(s1). Similarly the same calculation is carried out for the RSSI values from the second Router (R2)to obtain the square s2.The squared values s1 and s2 are then added. The square root of this value gives the Euclidean distance of the users input to the artifacts RSSI values.
2. The Euclidean distance of the user from all the artifacts is stored in an array.
3. The smallest Euclidean distance gives the most nearest artifact to the user.

Code Snippets:

```
//Extract values from database
public void Fetch_Artifact()
 {

       Class.forName("com.mysql.jdbc.Driver");
       Connection con= DriverManager.getConnection("jdbc:mysql://localhost:3306/");

        try{
        while(rs.next())
      {
              Artifacts_array[i]= new Artifact();
              Artifacts_array[i].AName=rs.getString(1);

         Artifacts_array[i].R1=(rs.getInt(2));

         Artifacts_array[i].R2=(rs.getInt(3));
         i++;
      }

 }
```

Figure 8.3: Extract values from database

```
//Calculate the Euclidean distance and return the result

public String calculation()
 {

        int u1=R1_value,u2=R2_value,a1,a2,temp1,temp2;
        double dist=999;
        String ans="Error";
        for (int i=0;i<count;i++)
        {

               a1=Artifacts_array[i].R1;
               a2=Artifacts_array[i].R2;
               temp1=u1-a1;
               temp2=u2-a2;
               temp1=temp1*temp1;
               temp2=temp2*temp2;
               if(dist>Math.sqrt(temp1+temp2))
               {
                      ans=Artifacts_array[i].AName;
                      dist=Math.sqrt(temp1+temp2);
               }


        }
```

Figure 8.4: Calculate Euclidean distance and return the result

8.2.2 Algorithm 2: Simple Statistical Classification

Statistical classification is the problem of identifying to which of a set of sub-populations a new observation belongs, on the basis of a training set of data containing observations (or instances) whose category membership is known. An example would be giving the classification if the new data based on the history of the training dataset. Statistical algorithm also works in two phases as mentioned below:

- Training data: To collect the Training dataset an Admin application is developed. The Admin application includes a simplistic interface along with the Wi-Fi RSSI, Bluetooth RSSI and the Client Server modules. The Wi-Fi module makes use of androids WifiManager data type to extract the RSSI values. Similarly the Bluetooth API framework provides RSSI values of the Bluetooth nodes. RSSI values are known to be highly volatile. Therefore to minimize the error the RSSI values are recorded continuously at a fixed interval of two second over stipulated amount of time.
  A TimerTask is employed to implement this in the algorithm. The TimerTask has a overridden run method which contains the code which is to be run at a specific interval. The specifications of the intervals and the iterations are explained in detail in the testing phase. The value at every interval is sent to the server. The RSSI values are first combined in a string which is then sent to the

server. This string is used by the server to differentiate between the values of different routers. The format of the string is as shown below:

Routerid/(artifactname):rssivalue—Bluevalues

The Routerid(R1 or R2) includes the id of the router whose RSSI values are being sent. The artifact includes the name of the current artifact. The rssi-values include the rssi values of the Router. The Bluetooth values are passed through the Bluevalues variable. As soon as the RSSI values are obtained they are sent to the server. As opposed to the initial algorithm the values are not averaged out.

The server accepts the data from the admin application, and stores all the recorded values in the database. The database is then Cleaned to remove any fluctuations in the input. The cleaned database is taken and stored into another table. This process is followed for every artifact and every router. Thus the database is cleaned of any input fluctuations and only the most optimum values are stored in the database.

- Positioning Computing: To compute the position of the person a Client side Android application is developed. The application has the following capabilities:

  a) Wi-Fi

  b) Bluetooth

  c) Server connectivity

  When the user application is started the Bluetooth functionality is first tested. If the Bluetooth is not switched on, the user is prompted to allow the Bluetooth functionality. The Wi-Fi adapter capabilities are also check to ensure that the Wi-fi Adapter is switched on. Android provides a Bluetooth adapter and a Wi-Fi Manager to get a handle on Bluetooth and Wi-Fi respectively.

  The RSSI values are measured at a fixed interval using the TimerTask Class. The RSSI values are averaged out and then sent to the server. The specifications to extract the RSSI values are shown below:

  c) Bluetooth: intent.getShortExtra(BluetoothDevice.EXTRARSSI, Short.MINVALUE)

The intent is the message which has been sent by the Bluetooth discovery activity. Intent is created for every device which has been discovered. The intent message contains the RSSI value of the discovered device in the EXTRARSSI field.

d) Wi-FI: obj.level

The Wi-FI manager stores all the Results of the discovered Wi-Fi signals in a ScanResult Data Structure. Each identified signal has a SSID associated with it. The SSID can be obtained by using the ssid variable in the function. Similarly the Wifi result is obtiaoned by referring to the level variable in the identified object.

The data is then accumulated into a string in the following form:

Uk(R1value):a(R2value)—(Bluetoothvalue)

The letter U denotes that the data is received from a user application as opposed to the admin application. The letters k ,:, l act as delimiters for the server to differentiate between various values. Using such delimiters the values of all the routers can be sent at once to the server. This ensures that the communication between the client application and the server is restricted to a minimum.

- Sever side computing: The Server accepts the user string and determines the rssi values of the routers. The RSSI router values are then extracted from the database. The following steps are executed for each router

  1. The R1s RSSI values of both the artifacts are extracted from the database. The RSSI value of the corresponding router is subtracted from the RSSI values of both the artifacts. Thus the function returns the artifact which has the minimum difference with the users RSSI value.

  2. Similarly R2s RSSI values for both the artifacts are extracted from the database. The RSSI value from the user and the one from the database are then subtracted for both the artifacts. The function returns the value which is the smallest.

3. The return values of both the above functions are considered. If both functions return same artifact then the location is returned to the user.

4. If different values are returned to the main function then the artifact having the smallest difference is returned as a location.

```
//Clean Database

public void cleanDb1(int[] rs1input, int [] rs2input)
	{
		for (int i=0;i<20;i++)
		{
			for(int j=i+1;j<20;j++)
			{
				if(rs1input[i]>rs1input[j])
				{
					int temp=rs1input[j];
					rs1input[j]=rs1input[i];
					rs1input[i]=temp;
				}
				if(rs2input[i]<rs2input[j])
				{
					int temp=rs2input[j];
					rs2input[j]=rs2input[i];
					rs2input[i]=temp;
				}
			}
		}
		for(int i=0;i<20;i++)
		{
			System.out.print(" "+rs2input[i]);
		}

		for(int i=0;i<sorted1;i++)
		{
			if(rs1input[i]!=0)
			{
			r1final[i]=rs1input[i];
			}
			else
				sorted1++;
		}
		for(int i=0;i<5;i++)
		{
			if(rs2input[i]!=0)
			{
				r2final[i]=rs2input[i];
			}
			else
				sorted2++;
		}
	}
```

Figure 8.5: Clean Database

```
//update database

public void updateDatabase()

{
	try {
		st=con.createStatement();
		for(int i=0;i<5;i++)
		{
			String query="Insert into "+artifact+"(R1,R2) values
("+r1final[i]+","+r2final[i]+")";
			System.out.println(query);
			st.executeUpdate(query);
		}
		st.close();
	}
	catch (SQLException e)
	{
		e.printStackTrace();
	}}
```

Figure 8.6: Update Database

```
//calculate position

public String calculation(String A1)
	{
		int sumA=0,sumB=0,a,b,diffa,diffb;
		for (int i=0;i<5;i++)
		{
			a=A.R1[i];
			b=B.R1[i];
			diffa=uavg1-a;
			diffb=uavg1-b;

			sumA=sumA+Math.abs(diffa);
			sumB=sumB+Math.abs(diffb);
			System.out.println(sumA);
			System.out.println(sumB);
		}
		if(sumA>sumB)
		{
			diffr1=sumA-sumB;
			return "B";
		}
		if(sumA<sumB)
		{
			diffr1=sumB-sumA;
			return "A";
		}
		else
		{
			if(Math.abs(ar1Sum)<Math.abs(br1Sum))
				return "A";
			else
				return "B";
		}}
```

Figure 8.7: Calculate position

CHAPTER 9

TEST SPECIFICATION

Our application, at an abstract view, is made up of two major components - The application server, and the Android application.
Due to the nature of the application (minimal user intervention), automated test cases CANNOT be developed. Instead, we performed manual testing on every module, and cross-verified the results with our expected results.
We could not use MonkeyTalk for our Android application as well, because the Application Server simply does not accept random RSSI values. Hence, we generated our own random sample points and manually tested the component modules.
We performed manual Unit testing, Integration testing and System testing. The strategies for each are described in brief below:

9.1 INTRODUCTION

9.1.1 Goals and Objectives

We designed the test cases for our application with the following goals and objectives in mind:

1. Robustness- The application should work in every environment possible.
2. Scalable - The application should work just as well even if more number of routers are installed.
3. Fault tolerant - The application should give way for minimum errors, and provide effective error handling mechanisms for the ones that are eminent
4. Well defined rollback mechanisms- The application should be able to switch to a primitive method of execution if it detects some missing functionality(e.g. No Wi-Fi detected)

9.1.2 Statement of Scope

Functionality/Behaviour to be tested:

- Administrator RSSI values acceptance

- Storing of correct values in database
- User RSSI values extraction
- Correct execution of algorithm
- Result validity

Functionality/Behaviour not to be tested:

- Connectivity acceptace(Wi-Fi)
- Database stability(SQL injection)
- Security
- Execution Time

9.1.3 Major constraints

Constraints that may hamper the testing procedure:

- Lack of stable high end Routers
- Application server is offline
- Lot of disturbance in the environment
- Incompatible Device

9.2 TEST PLAN

9.2.1 Softwares to be tested

We may view the entire application as a connection between two software modules, namely, the Android application, and the Application server. Hence, the softwares to be tested are:
1. The Android application(Admin and User)
2. The Application Server

9.2.2 Testing Strategy

We will follow the regular **incremental testing** approach. As an overview the overall procedure for testing will be:

- Unit Testing
- Integration Testing
- System Testing

9.3 UNIT TESTING

Unit testing is a software development process in which the smallest testable parts of an application, called units, are individually and independently scrutinized for proper operation.

In the first phase of Unit testing, we tested the extraction of RSSI values from Wi-Fi routers. This testing was useful to exactly optimize the algorithm for successful extraction of signal strength values. We were able to change our approach and algorithm according to these test results.

Module Name: **Wi-Fi RSSI extraction module.**
Test priority: **High**
Test Execution Date: **3/1/2016**

Test Summary: The RSSI values extracted at the User device were sent to the server and stored in the database. The number of times the values were extracted and the delay taken for the communication was changed to find its effect on the RSSI values.

Test Steps: The number of times the signal strength values were extracted was changed from 5-100. The delay between the communication that took place between the server and client device was changed.

Result: The counter used in the system i.e. the number of times the RSSI value is attained did not matter the final result.

The counter was changed from (2-100) but the end result did not change much. The RSSI values attained were almost similar. So, the counter number was ruled out as the optimising factor for the system.

According to our results, the optimizing factor was the **delay given to the system**. As the delay was increased, more accurate results were obtained. This is because of low network bandwidth and slower communication rates. So, the delay given to the system played an important role in making the system more accurate.

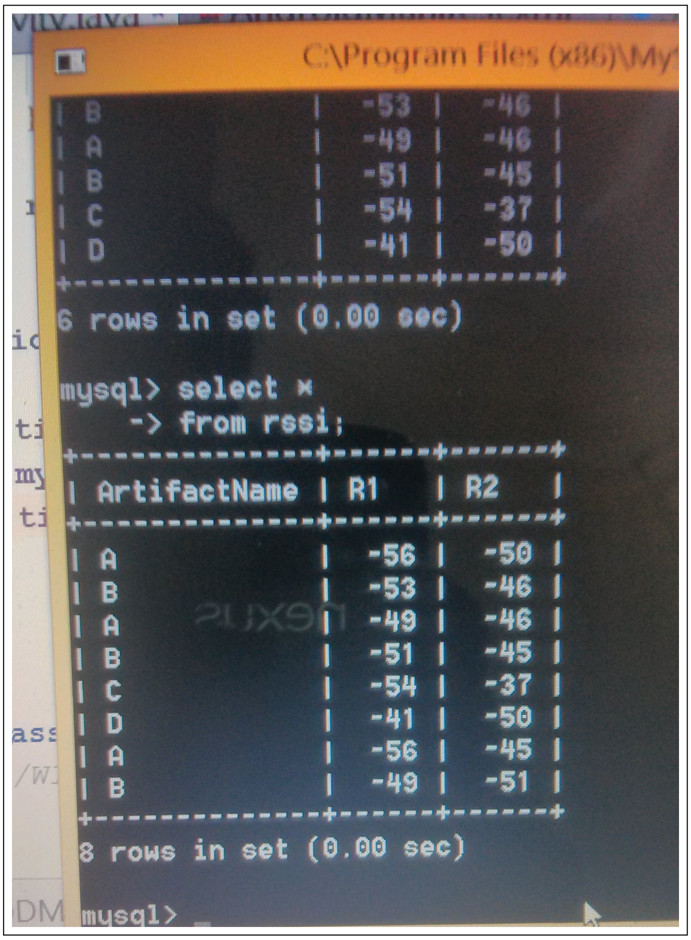

Figure 9.1: Wi-Fi RSSI values

In the second phase of testing, Bluetooth connectivity was tested and the nearest bluetooth module was found via application.

Module Name: **Nearest Bluetooth module identification**

Test priority: **Medium**

Test Execution Date: **20/12/2015**

Test Summary: In this test the nearest Bluetooth module located to the client was found. The signal strength values received were compared and the result was given without connecting the application to the server.

Result: The results were as precedented and the application **worked correctly** to give the precise location where the user is standing.

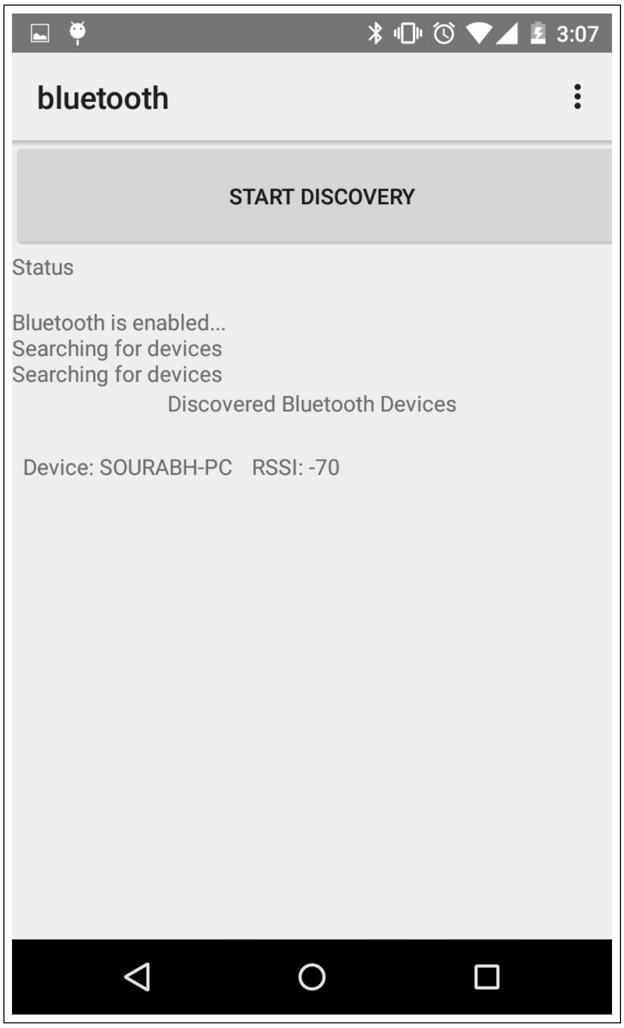

Figure 9.2: Wi-Fi RSSI values

9.4 INTEGRATION TESTING

The project was divided into a number of modules such as Client Server module, Wi-Fi based module, Bluetooth based module. These modules were developed independently and later on integrated together. The bottom up approach was used for the testing of the system. The integration of the Modules required the following testing:

1. **Wi-Fi /Bluetooth Module**: The testing was done to ensure that the Bluetooth and The Wi-Fi RSSI values are available before the data is sent to the server. The Bluetooth Scan and the Wi-Fi scan require different amount of time to execute. Moreover testing was also done to ensure that both the Wi-Fi and the Bluetooth modules will work periodically after a specific time interval. It was necessary to reduce the consumption of battery to the minimum. Testing also included the power consumption of these two modules.

2. **Server/Application connectivity**: The Server and the mobile application integration was tested to ensure the compatibility of the server and Android applications. The server and the Application data interoperability was tested in this phase. The testing required stubs and fakes to verify the transmitting and receiving of the data.

3. **Connectivity**: The Application connectivity and the Wi-Fi/ Bluetooth Modules were then integrated to form a complete android application. The input data was tested for integrity and the packet to be transmitted was tested for data interoperability with the server.

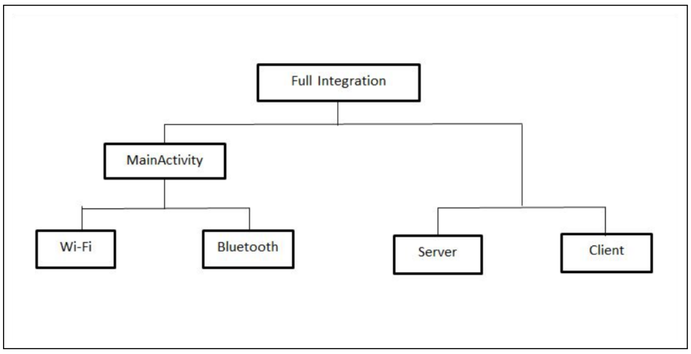

Figure 9.3: Integration Testing

9.5 SYSTEM TESTING

As mentioned in the project implementation section, we have implemented and tested two methodologies in our system and found out which gives better results. Which are namely:

1. K-Nearest Neighbour Algorithm.
2. Simple Statistical Classification.

9.5.1 K-Nearest Neighbour Algorithm

Testing was done by changing various parameters in the system to find the most optimum combination so as to get the fastest and accurate response.

Phase 1:

The delay of RSSI value evaluation was set at 250ms and the counter was set at 50 and the distance between the artifacts was changed to test the various parameters. The counter is the number of times the RSSI values are extracted. The delay was set at 250 so as to get maximum number of values in a second to track immediate movement and the values were taken 50 times so as to minimize the error.

Delay: **250ms**

Counter: **50**

Serial No.	User Location	Result	Distance(ft)	Counter	Ratio
1	A B B A B B	A A B A A B	3	50	4/6
2	A B B B A B	A A A B A A	5	50	3/6
3	A B A A A B	B B B B A A	7	(100) 50	2/6
4	B A B A B A	B A A B B A	10	(100) 50	4/6

Figure 9.4: System Testing 1

Phase 2:

The delay was increased to one second, the counter was changed to 8 and the distance was varied so as to find the minimum distance at which the changes are noticed.

Delay: **1s**

Counter: **8**

Serial No.	User Location	Result	Distance(**ft**)	Counter	Ratio
5	A B A B A B	A B A A B B	7	8	4/6
6	A B A B A B	A A A B A B	10	8	5/6
7	A B A B A B	A B A B B B	13	8	5/6

Figure 9.5: System Testing 2

Phase 3:

Delay was changed to 2 seconds and the counter was changed to 4 from 8. The distance was varied. We found that this combination gave the optimum results according to the user location. The increased delay enabled successful transfer of packets from client to server. It also made it easier to use the system in a low bandwidth network.

Delay: **2s**

Counter: **4**

Serial No.	User Location	Result	Distance(**ft**)	Counter	Ratio
8	A B A B A B	A B A B A B	15	4	6/6
9	A B A B A B	A B A B B B	7	4	5/6
10	A B A B A B	A B A B A B	13	4	6/6
11	A B A B A B	A A A B A B	10	4	5/6
12	A B A B A B	A B A B A B	8	4	6/6

Figure 9.6: System Testing 3

Overall Result of K-Nearest Neighbour Algorithm

It was observed that correct result was produced 2/6 times on an average. All the conditions and explicit constraints are considered in the following result.

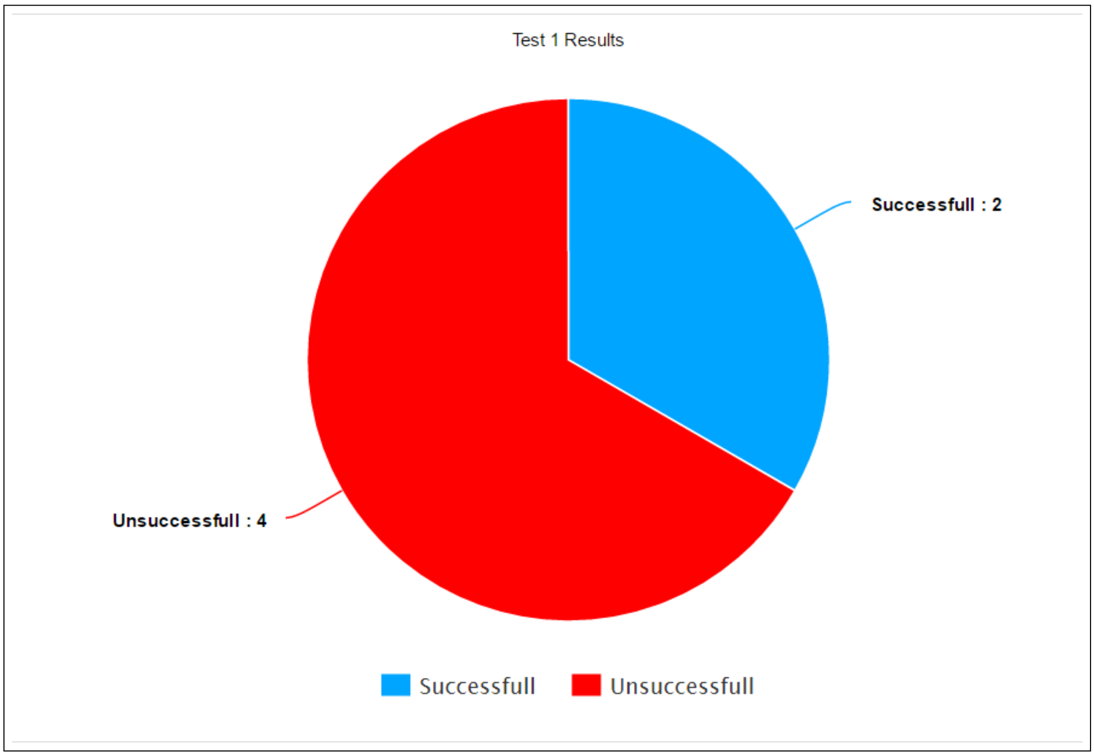

Figure 9.7: K-Nearest Neighbour Testing Results

9.5.2 Simple Statistical Classification Algorithm

Overall Result of Simple Statistical Classification Algorithm

On rigorous testing of this algorithm, it was found that on an average correct result was produced 4/5 times. This enabled us to simplify our approach taken towards the completion of the system as a whole.

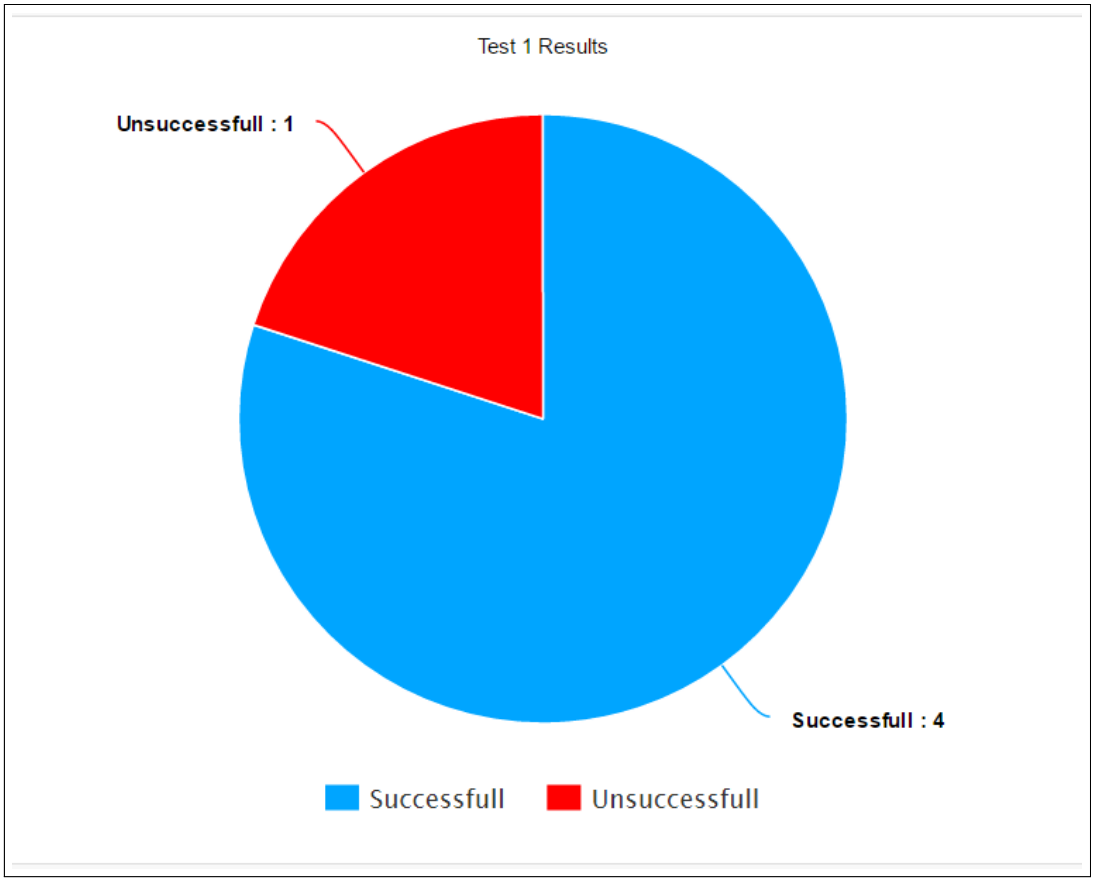

Figure 9.8: Simple Statistical Classification Algorithm

CHAPTER 10

RESULTS

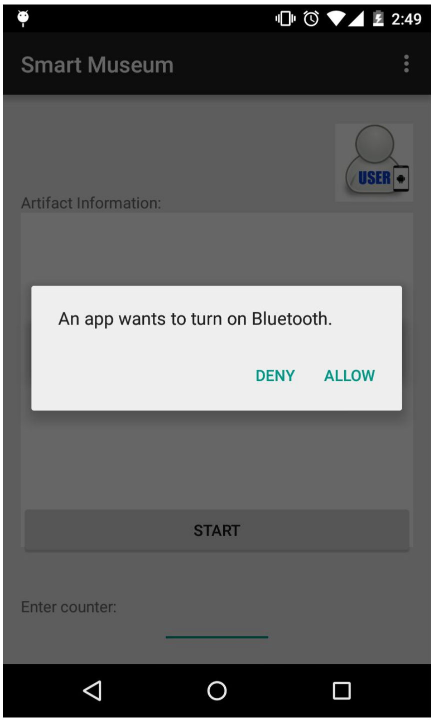

Figure 10.1: Bluetooth

Figure 10.2: Bluetooth

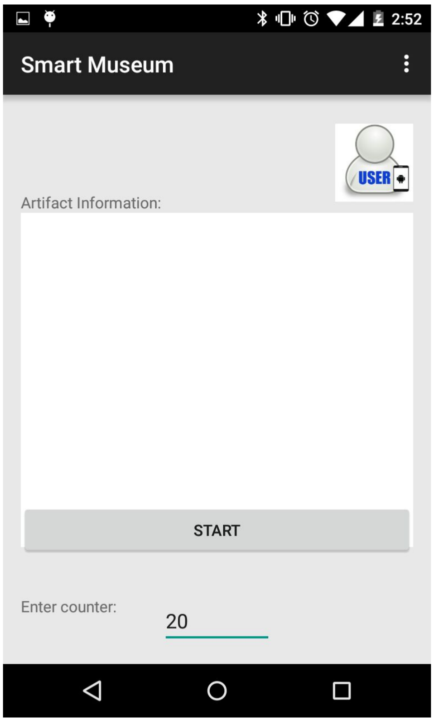

Figure 10.3: User Application

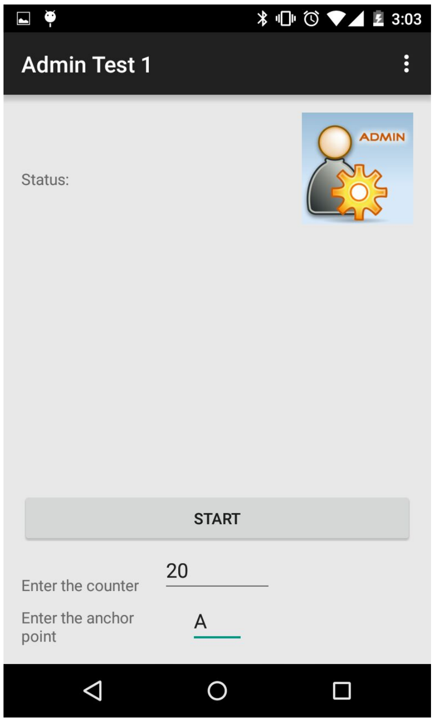

Figure 10.4: Admin Application

10.1 ANDROID APPLICATION RESULT

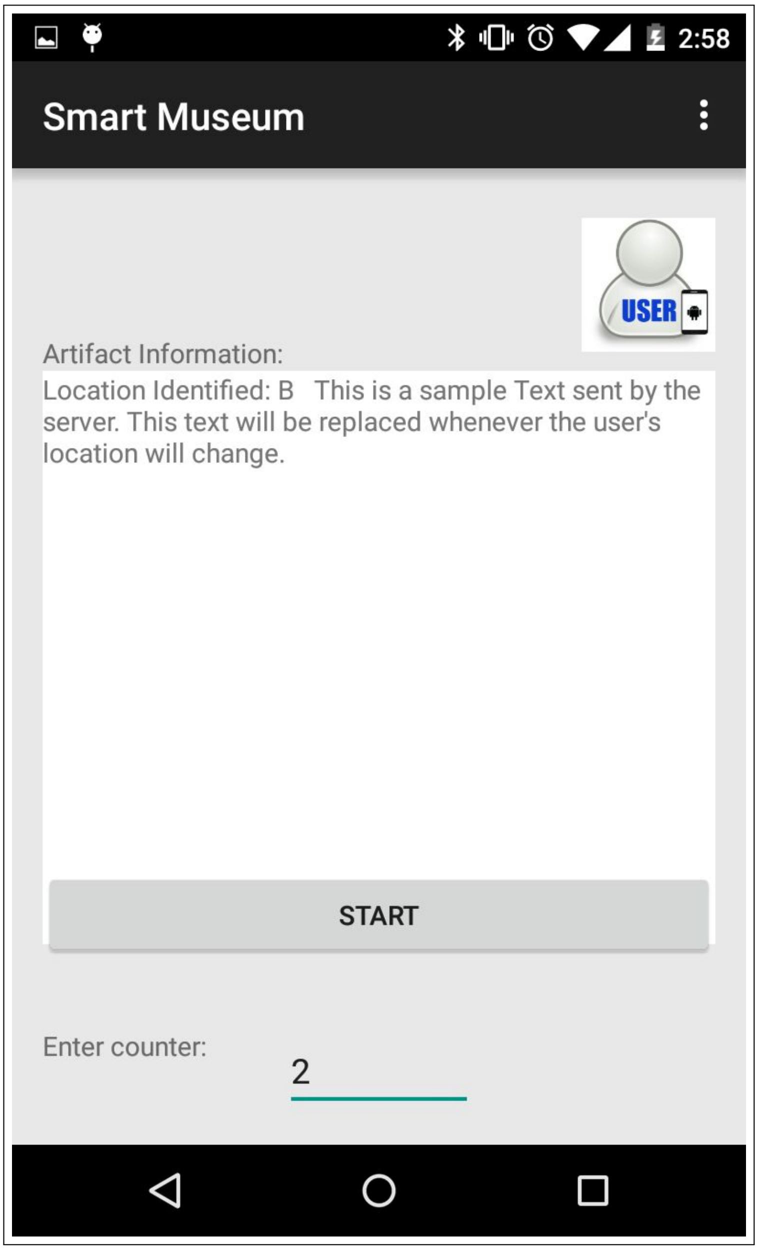

Figure 10.5: User Application Result

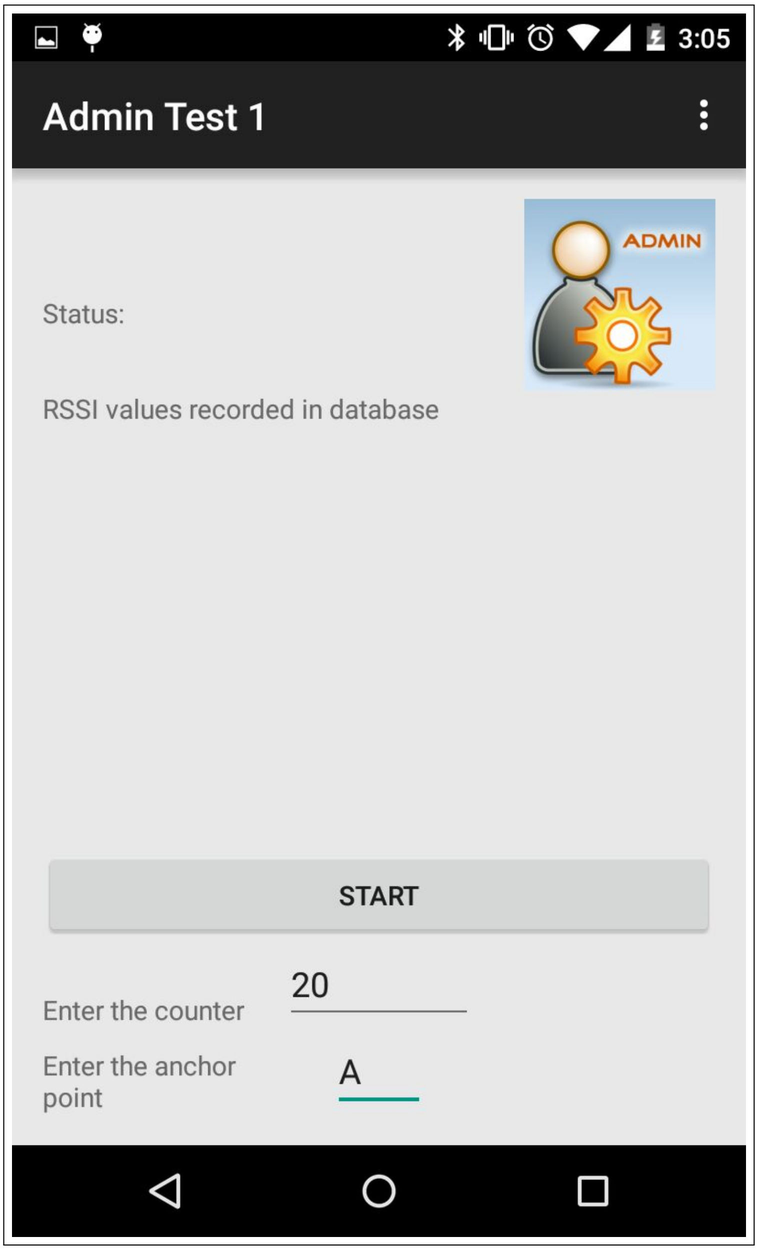

Figure 10.6: Admin Application Result

10.2 SERVER RESULT

Figure 10.7: Admin Application Result

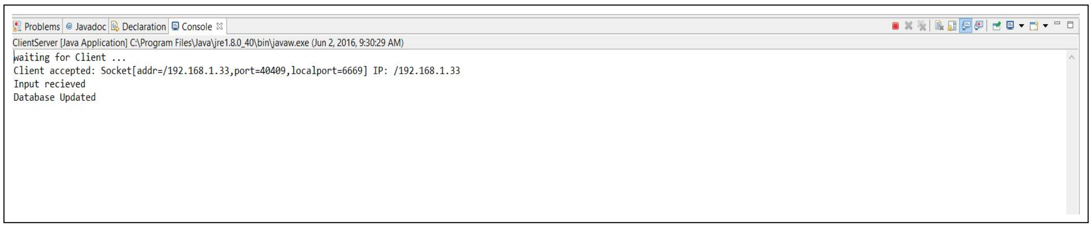

Figure 10.8: Admin Application Result

Figure 10.9: Admin Application Result

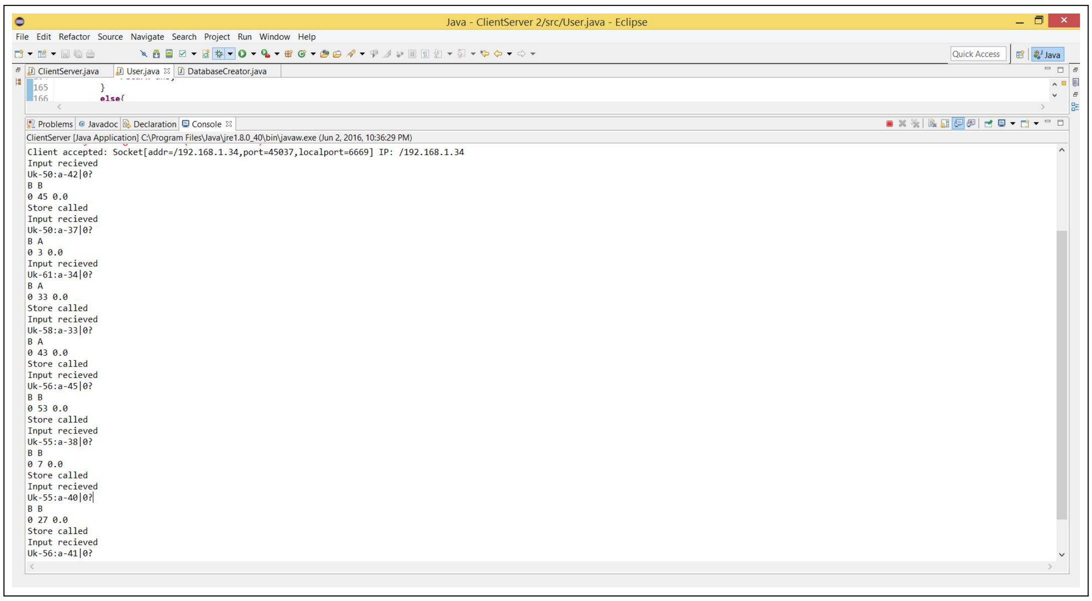

Figure 10.10: Server execution

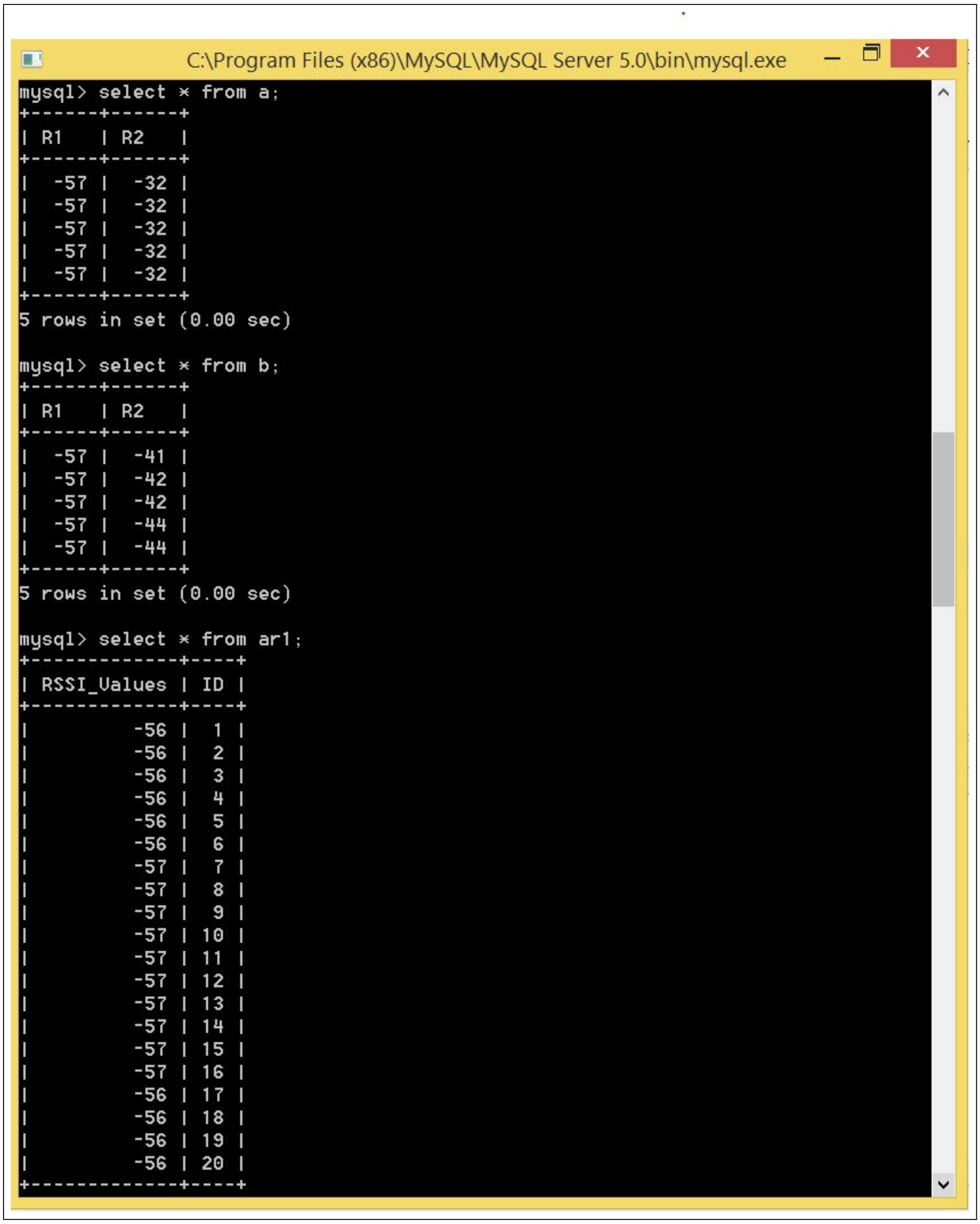

Figure 10.11: MySQL Database

CHAPTER 11

DEPLOYMENT AND MAINTENANCE

11.1 INSTALLATION AND UN-INSTALLATION

Installation:

1. Install latest Java version on your Computer running on Windows or Ubuntu Operating system (Ubuntu preferable for the ease of programming) from https://java.com/en/download/.
2. Download an IDE which is suitable for java programming. In our project we have used the latest version of eclipse IDE and Android studio for developing android applications. You can download the IDE depending upon your operating system from the below mentioned hyperlinks.
   http://www.eclipse.org/downloads/packages/eclipseidejavadevelopers/mars/ (Eclipse IDE)
   https://developer.android.com/studio/index.html(Android Studio)
3. Create a suitable server which will store information about the artifacts and will communicate with the android application by sending the required information about the artifact to the Users.
4. Create a database that will communicate with the android application to store values extracted from the Routers and Bluetooth modules and also from the Users. This can be done by using some popular JDBC.(Java DataBase Connectivity)
5. Now, coming towards the hardware part. Install WiFi routers at intermediate locations inside the museum and plug them into a power source to power them on. When the lights on the router start blinking it indicates that the router is turned on.
6. Connect Arduino microcontroller to a power source and interface bluetooth module to it. Place the bluetooth modules near the artifact for better accuracy. Try connecting a bluetooth enabled smartphone to the module so as to check whether the bluetooth modules are working perfectly.

7. Install APK(Android Application Package) on admin side and record the RSSI values near the artifacts which will get stored in the database.
8. Distribute the APKs to the museum visitors(Users) and install them on their android smartphones inorder to communicate with the system.
9. When the users location is searched inside the museum, depending upon the vicinity of the artifact the server will communicate with relevant information regarding the artifact to the user through the android application.

Uninstallation:

Powering all the devices off like arduino and Wi-Fi Routers will turn the system off. The android application can also be simply uninstalled from the smartphone.

11.2 USER HELP

- If there is any problem, the user can simply restart the application which is installed on his smartphone.
- If there is any problem with connectivity, the server should be restarted.
- If bluetooth modules are not working properly, arduino interfacing should be checked along with their battery.
- The user can contact the administrator for further assistance.

CHAPTER 12

FUTURE ENHANCEMENT

The system can be enhanced a lot more to increase its applicability and outcome. Some of the few possible enhancements are mentioned below:

- Machine Learning:

  Machine learning can be implemented in the system so that the system can identify its users and give results accordingly. The system will be able to create analytical data according to the location of the users which will help the companies which have implemented the system. It will produce graphs and pie charts with respect to the location of the user to find out where does the average customer spend most of his time in the respective company. This data can be further used to improve the outcome of the company by making necessary architectural changes. For example in shopping malls, airports, etc.

- Dynamic information:

  The database can be directly connected to the internet to produce and give dynamic information to the user. This information will be useful in businesses which are more customer oriented. For example hotel ratings, device information, etc can be directly accessed and given to the user when it is needed.

- Cloud based Location Identification:

  The location can be identified via cloud based databases. The device and the cloud will interact with each other through Internet and the result will be given from the cloud. This will enable users to use the system anywhere where internet is available and where the coordinates are stored as data items in the cloud.

- Gyroscope interfacing:

  The gyroscope present in almost all mobile devices can be used to track user's motion which can be used to track his location for better accuracy. The gyroscope can be used to establish an inbuilt pedometer in the system. The pedometer will be able to count the steps taken by the user. The number of the steps and the direction in which they are taken can be used for increased accuracy in our system.

CHAPTER 13

SUMMARY AND CONCLUSION

Thus we have successfully implemented the system which detects the user's location and gives information accordingly. We implemented two methodologies which are namely 'K-NN algorithm approach' and 'Simple Statistical Classification'. Both the methodologies were thoroughly tested and results were produced accordingly.
It was found that 'Simple statistical classification' gave much more accurate results than its counterpart and we were able to successfully implement the system.

CHAPTER 14

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ANNEXURE A

LABORATORY ASSIGNMENTS ON PROJECT ANALYSIS OF ALGORITHMIC DESIGN

- To develop the problem under consideration and justify feasibilty using concepts of knowledge canvas and IDEA Matrix.

I	D	E	A
Increase	Drive	Educate	Accelerate
Improve	Deliver	Evaluate	Associate
Ignore	Decrease	Eliminate	Avoid

Table A.1: IDEA Matrix

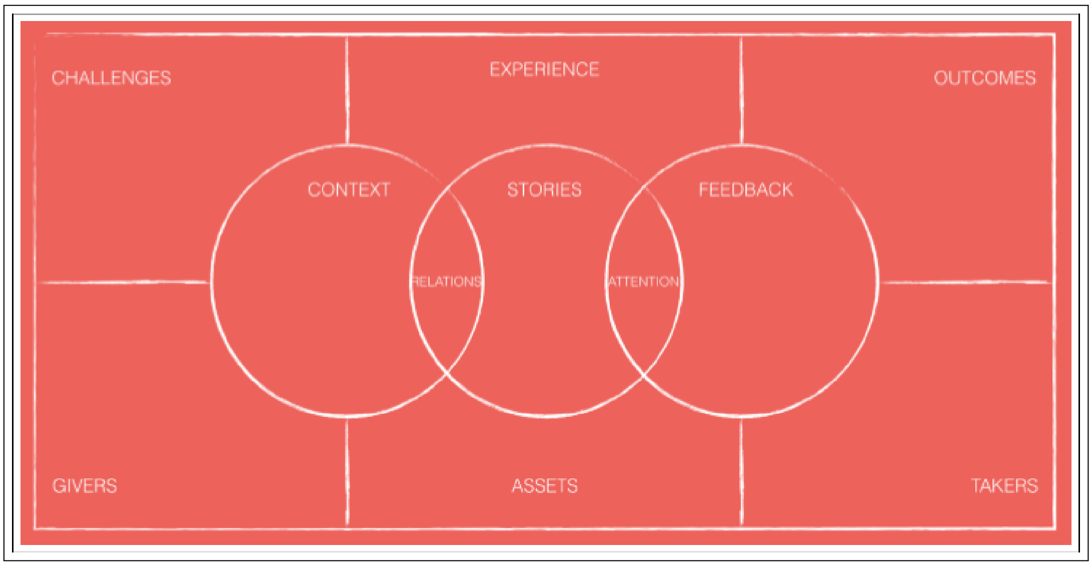

Figure A.1: Knowledge Canvas

1.Polynomial (P):

The system accepts input, and we get the output in fixed polynomial time, the input large or small , or simple or complex. Applications of polynomial type are rare. One such example is hash table. An hash table finds index for a data to be inserted in fixed amount of time because its uses hash function to find index.

Our application is not of type P because if does not give result in fixed polynomial time.

2.Non-Polynomial (NP):

There are two sub-types of NP Problems:

A] NP-Hard:

The system accepts input, but there is no guarantee that we will get the output. Such

systems do not exist because no one will use the system if there is no guarantee the system works for any inputs. Hence our application is again not of NP-Hard type because we want to build a system that never fails and guarantees output.
E.g.: Turing Machine Halting problem.

B] NP-Complete:

The system accepts input, and there is guarantee that we will get the output. Output is generated in variable non-polynomial time.Our application of localization of user is neither P nor NP-hard.The system accepts input, and we get the output in variable non-polynomial time. Almost all or maximum systems are of NP-Complete type. Even our application is of NP complete type because it guarantees output but not in fixed amount of time. Now our output time varies because of the input. Thus our application guarantees output but not in fixed time.
The details regarding the position of the user are sent to the server for comparing the values with the database. The values are compared and thus the location of the user is identified. According to the location, the user is provided with specific services. Thus in our application there is guarantee that we get output.
Hence our application is NP-complete.

ANNEXURE B

LABORATORY ASSIGNMENTS ON PROJECT QUALITY AND RELIABILITY TESTING OF PROJECT DESIGN

Use of divide and conquer strategies to exploit distributed/parallel/concurrent processing of the above to identify object, morphisms, overloading in functions.

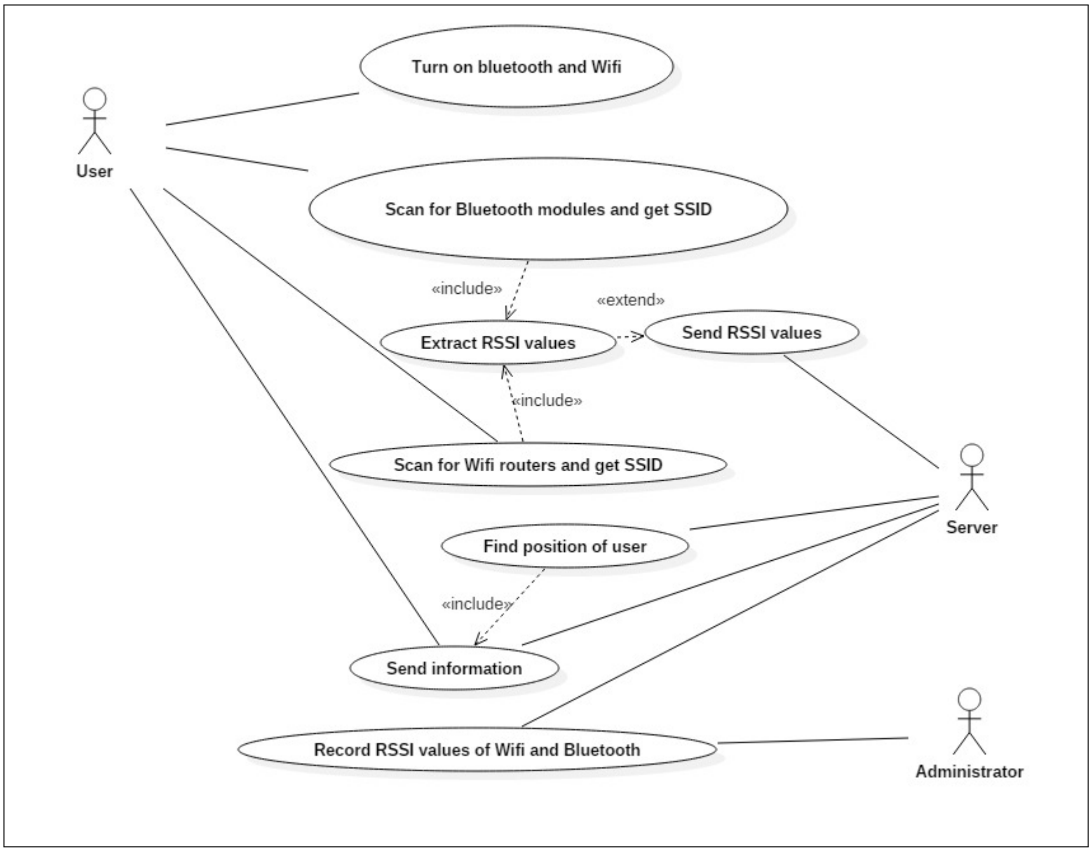

Figure B.1: Use-case Diagram

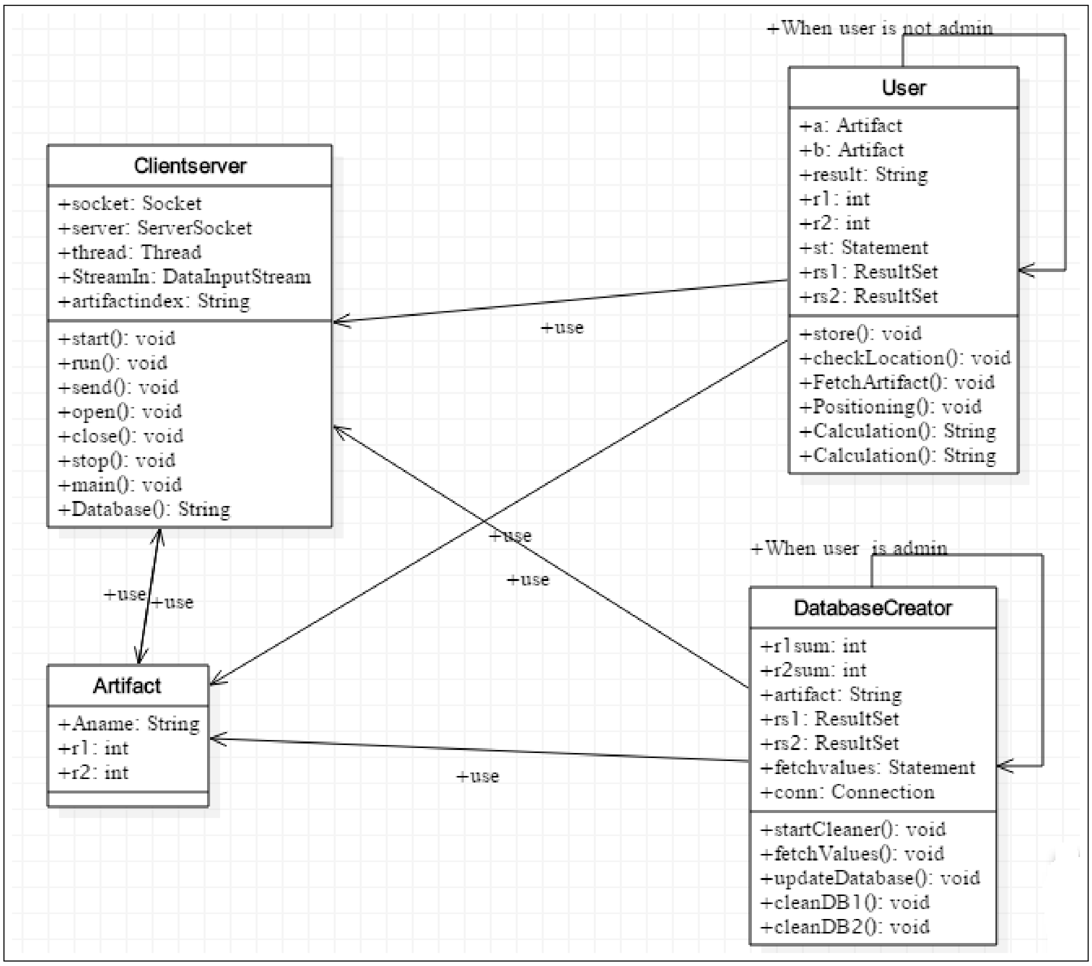

Figure B.2: Server Class Diagram

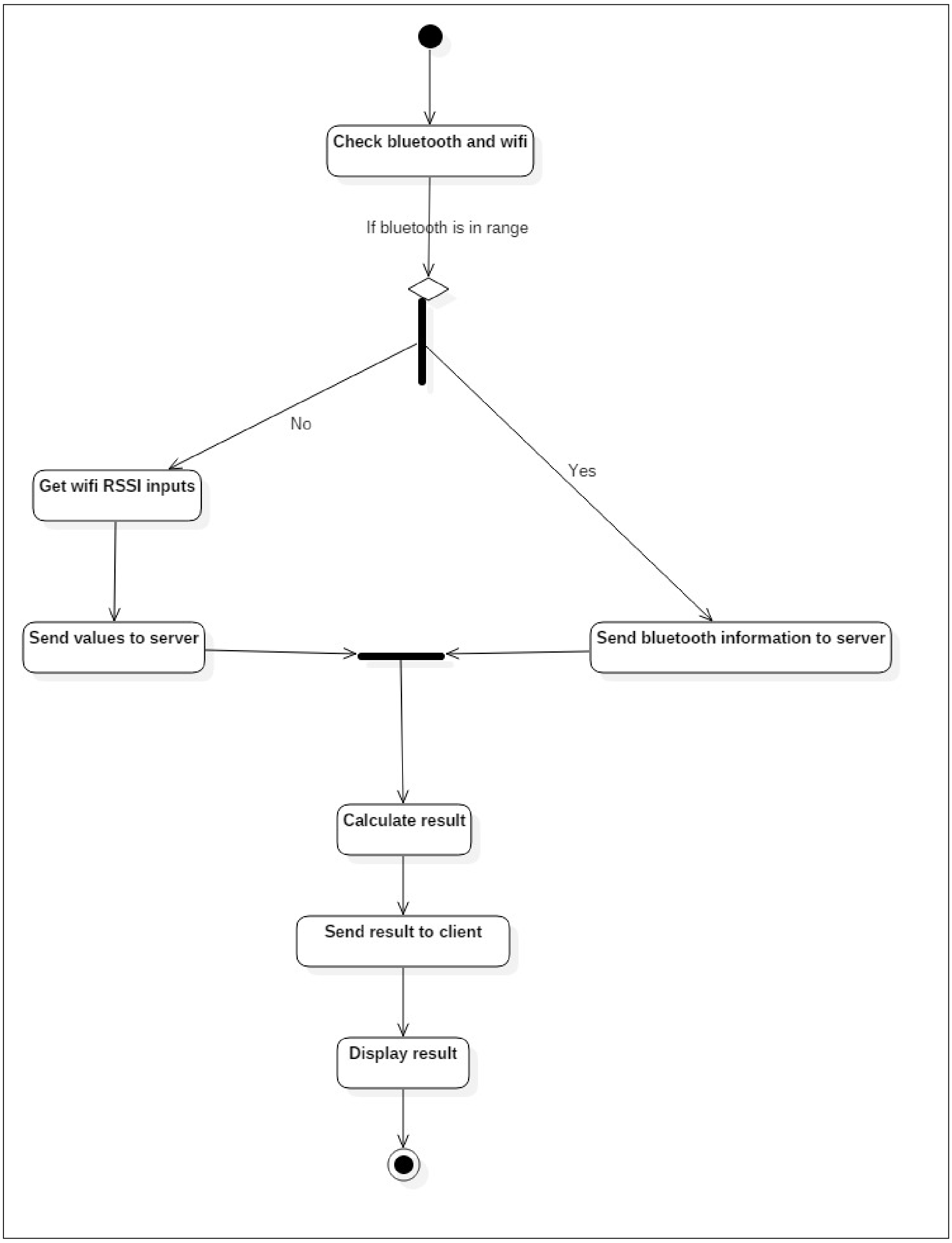

Figure B.3: Activity Diagram

ANNEXURE C

PROJECT PLANNER

June,2015 - July,2015	1. Studying Internet Of Things. 2. Finalizing the topic
July,2015 - August,2015	1. Deciding the topic in the domain of Internet Of Things. 2. Searching for relevant IEEE papers for the project topics. 3. Presentations on the selected topics for approval.
August,2015 - September,2015	1. Literature Survey 2. Synopsis Preparation
September, 2015 November, 2015	1. Designing the architecture. 2. Collecting relevant information, hardware (IEEE papers and study material) for implementation of the project.
December, 2015 March, 2015	1. Assembling the hardware. 2. Developing a smartphone application. 3. Data Analysis.

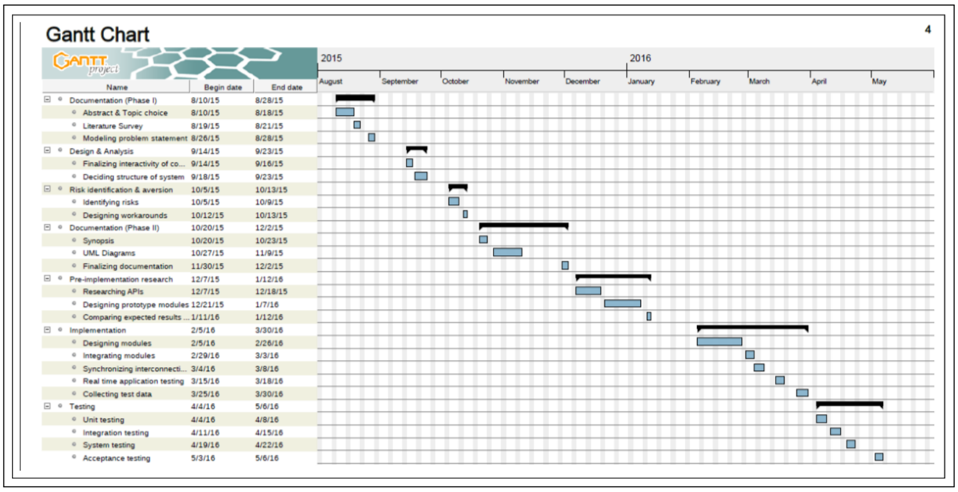

Figure C.1: Project Planner

ANNEXURE D

REVIEWERS COMMENTS OF PAPER SUBMITTED

1. Paper Title:Smart Museum Design based on Indoor Localization
2. Name of the Conference/Journal where paper submitted :IJCSN International Journal of Computer Science and Network, Volume 5, Issue 2, April 2016
3. Paper accepted/rejected : Paper accepted
4. Originality: Good
5. Innovation: Very Good
6. Technical merit: Very Good
7. Applicability: Good
8. Presentation and English: Good
9. Match to Journal Topic: Very Good
10. Corrective actions if any : No corrective actions

ANNEXURE E

PLAGIARISM REPORT

Plagiarism Scan Report

Summary	
Report Genrated Date	01 Jun, 2016
Plagiarism Status	95% Unique
Total Words	876
Total Characters	5501
Any Ignore Url Used	

Content Checked For Plagiarism:

Statistical classification is the problem of identifying to which of a set of sub-populations a new observation belongs, on the basis of a training set of data containing observations (or instances) whose category membership is known. An example would be giving the classification if the new data based on the history of the training dataset.\\
Statistical algorithm also works in two phases as mentioned below:\\
\begin{itemize}
\item Training data: To collect the Training dataset an Admin application is developed. The Admin application includes a simplistic interface along with the Wi-Fi RSSI, Bluetooth RSSI and the Client Server modules. The Wi-Fi module makes use of android's WifiManager data type to extract the RSSI values. Similarly the Bluetooth API framework provides RSSI values of the Bluetooth nodes. RSSI values are known to be highly volatile. Therefore to minimize the error the RSSI values are recorded continuously at a fixed interval of two second over stipulated amount of time. A TimerTask is employed to implement this in the algorithm. The TimerTask has a overridden run method which contains the code which is to be run at a specific interval. The specifications of the intervals and the iterations are explained in detail in the testing phase. The value at every interval is sent to the server. The RSSI values are first combined in a string which is then sent to the server. This string is used by the server to differentiate between the values of different routers. The format of the string is

Figure E.1: Plagiarism Report

ANNEXURE F

INFORMATION OF PROJECT GROUP MEMBERS

1. Name: Sourabh Khasbag
2. Date of Birth : 07/04/1994
3. Gender : Male
4. Permanent Address : K-19 Swapnashilp, near City Pride Kothrud, Pune.
5. E-Mail : khasbagsourabh.comp@mmcoe.edu.in
6. Mobile/Contact No. : 7588600809
7. Placement Details : L&T Infotech
8. Paper Published : **Smart Museum Design based on Indoor Localization**

1. Name: Shubhankar Ranade
2. Date of Birth : 30/07/1994
3. Gender : Male
4. Permanent Address : BMCC Road, Nandadeep Apt, Flat no.8, Shivajinagar, Pune
5. E-Mail : shubhankarranade.comp@mmcoe.edu.in
6. Mobile/Contact No. : 9552944698
7. Placement Details : -
8. Paper Published : **Smart Museum Design based on Indoor Localization**

1. Name: Abhijeet Wani

2. Date of Birth : 12/01/1994

3. Gender : Male

4. Permanent Address : 759/94C,Jaltarang,Prabhat Road,Lane No-1, Pune

5. E-Mail : waniabhijeet.comp@mmcoe.edu.in

6. Mobile/Contact No. : 9823563996

7. Placement Details : -

8. Paper Published : **Smart Museum Design based on Indoor Localization**

1. Name: Parth Hiralikar
2. Date of Birth : 11/08/1994
3. Gender : Male
4. Permanent Address : 824D, Chintamani Apt,Bhandarkar Road,Lane np.13,Shivajinagar Pune
5. E-Mail : hiralikarparth.comp@mmcoe.edu.in
6. Mobile/Contact No. : 9028776733
7. Placement Details : iGate
8. Paper Published : **Smart Museum Design based on Indoor Localization**