ACKNOWLEDGEMENT

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ABSTRACT

GPS was not considered because its signals are unable to penetrate through building obstacles such as walls. Other designs were also discarded such as the ZigBee-based system developed by Sugano. A system that was implemented to achieve indoor tracking of a person by measuring the RSSI of the signal emitted by the system’s ZigBee devices. The reason why this particular technique was overlooked was because its special resolution error of 1.5m-2m was deemed unsuitable for our application.

The aim of this project is to design and build a portable IPS that can be used for monitoring the movements of people indoors, achieving a high level of spatial accuracy (an accuracy of at least 50 cm) while being powered by off-the-shelf batteries. The technology that was proven to achieve the best spatial resolution is ultrasound. According to (Holms, 2012) that resolution can be expected to be in the sub-centimeter levels. The system utilizes the Time-Difference-Of-Arrival (TDOA) technique as it saves on power: the ultrasound emitter only transmits and the target only receives. The system design makes use of custom-built nodes as ultrasound emitters which are placed in the corners of the celling, a custom-built band as a receiver worn around the wrist of a person that is to be tracked, a phone application serving as the user interface to the system and a computer coordinating the devices known as the Hub.

In recent years, the mobility market has experienced a phenomenal growth in the productivity of electronic equipment and development of new telecommunication services. This has given birth to the idea of providing services based on the user's position in several sectors. Although Global Positioning System (GPS) considered as the best solution for an open-air localization (Outdoor), it is inaccurate in urbanized and indoor environments and adaptation of such systems to those contexts are particularly challenging due to the disability of GPS signal to penetrate buildings because it needs to be in sight. Various indoor localization techniques were conducted to provide the best solution to deploy. This paper describes an implementation of Wi-Fi fingerprinting method using RSSI (Received Signal Strength Indicator) from access points to determine the position of users in indoor areas.

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CHAPTER 1

1 INTRODUCTION

Today GPS is the go-to technology for tracking the position of an object or a person. It however does not perform well indoors because its signals are not able to penetrate physical barriers. For that reason, IPS are used instead for indoor tracking applications. Approaches demonstrated to date for IPS include: using Radio frequency techniques such as Wi-Fi or ZigBee. developed a system using three Wi-Fi emitters and a single receiver exploited the relationship between the time-of-flight of electromagnetic signals and their spectral phase. The evaluation of three signals' time-of-flight led to a median localization error of 35cm and 62cm when in line of sight and not in line of sight respectively. (Sugano, 2006) demonstrated, built and tested a ZigBee-based system which boasts both a ZigBee emitter and receiver. Localization of the receiver was made possible by evaluating the strength of the signal generated by the emitter. This achieved a spatial resolution of 1.5m-2m.

The solution proposed by achieved a very high special resolution however this came at the expense of a very complex system. (Sugano, 2006) prioritized simplicity and inexpensiveness yet the achieved resolution was very poor. (Holms, 2012) shows that an ultrasound-based IPS making use of ultrasound Time-Difference-Of-Arrival (TDOA) can achieve a spatial resolution of sub-centimeters to a few centimeters which is already better than both resolutions obtained by the ZigBee and Wi-Fi inspired systems. This advantage is the reason why our solution employs ultrasound to perform positioning based on Time-Difference-Of-Arrival (TDOA) technique.

The overall system consists mainly of ultrasonic transducers, a coordinating unit called Hub, a mobile phone and a band. In addition, the main mechanisms used in our IPS system are grouping and triangulation. The system utilizes the captured ultrasonic signals as the sensory information to unambiguously triangulate the position of a person.

1.1 Motivation

We first introduce the system then we discuss our involvement in this project further which are then illustrated with application use cases. Following this, we discuss the potential localization enabling technologies and the associated techniques to demonstrate why ultrasound was chosen and lastly, we describe our system and its subsystems in detail by providing requirements, design, tests and evaluation

1.2 Problem Statement

To find the actual position of particular person at specific place that place could be any Apartment, Mall or small lanes from villages.

CHAPTER 2

2 LITERATURE SURVEY

This section contains the analysis of different Wi-Fi positioning technologies, analysis several indoor positioning technologies that used by other Wi-Fi-based positioning system and evaluation the existing indoor positioning application

- **RSSI fingerprinting**

RSSI fingerprinting is a technique that determines a location by using the fingerprint of received signal strength indicator (RSSI) [1]. This is a popular technology of Wi-Fi positioning. Figure 2.1 shows the general concept of this technology. Usually, it contains two phases – calibration phase and positioning phase . In other documents, these two phases also are called as offline phase and online phase [1.

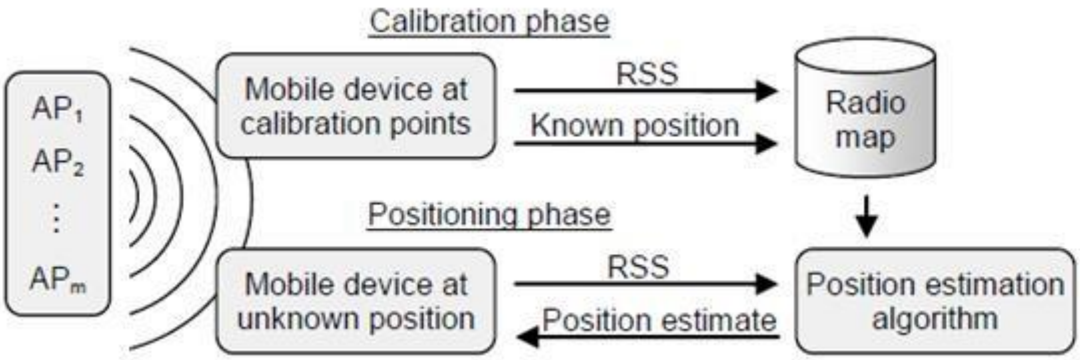


Figure 2.1 Two phase of RSSI fingerprinting [2]

The calibration phase is the process of location survey. The purpose of this phase is to collect RSSI values of access points (APs) from each location in order to construct a radio map. And the positioning phase is the process of location detection. Usually, the location detection is via probabilistic approach or deterministic approach. These two approaches will be explained later.

However, the RSSI fingerprinting is facing a big challenge within RSSI capture. According to Liu et al., three types of physical problems of RSSI capture are scattering, reflection and diffraction. Although, this technology encountered these problems, it still provides high accuracy in location positioning.

- **Probabilistic method**

Probabilistic method is a positioning method used for RSSI fingerprinting. The purpose of this Method is to find out the highest probability of potential location as result. In the positioning phase, Baye' s theorem is applied to calculate the probability of each possible location [3].

The Equation is given by

$$P(L_i|S) = \frac{P(L_i \cap S)}{P(S)} = \frac{P(L_i) \cdot P(S|L_i)}{P(S)}$$

The $P(L_i|S)$ is representing the probability of location L_i. The L_i is representing the possible location. The S is representing the RSSI fingerprint that measured in the positioning phase.

Normally, the probabilistic method can provide the higher accuracy than the deterministic method. It is because all fingerprints in radio map will be used for probabilistic method. Therefore, more fingerprints in the radio map, the probabilistic method provide the higher positioning accuracy.

- **Deterministic method**

Deterministic method is another positioning method used for RSSI fingerprinting. The purpose of this method is to determine the location by considering the degree of similarity between fingerprint and radio map. Three algorithms named Nearest Neighbor (NN), K-Nearest Neighbor (KNN) and K-Weighted Nearest Neighbors (KWNN) are used for location detection in positioning phase [4] too. For matching the
measured fingerprint with radio map, the Euclidean distance has been used.

The Equation is given by

$$d(p,q) = \sqrt{\sum_{i=1}^{n} (p_i - q_i)^2}$$

The p is representing the measured fingerprint in positioning phase. The q is representing the fingerprints in radio map. For each location, the deterministic method calculates the Euclidean distance. Finally, the minimum Euclidean distance location will be determined as the positioning result.

- **Trilateration approach**

Trilateration approach is a simple Wi-Fi positioning technology which aims to determine the location by using the distance between a location and access points. In the positioning phase, this approach calculates the distance by using the RSSI value from access point and draws a circle by using the calculated distance. Then it finds out the overlapping point of circles as result. In Li et al. An experiment result showed that the positioning accuracy of this approach is between four to five meters of error.

However, the experiment was carried out in ideal signal environment. In the real world, lossless signal environment is difficult to achieve. The reasons of signal strength loss may be long transmission distance, building penetration problem and signal interference. Therefore, the calculation of distance between locations and access points may not be accurate. This weakness leads the RSSI fingerprinting technology become more popular.

CHAPTER 3

3 PROPOSED SYSTEM

The result of the localization process is the future location of the users, which are obtained by using a specific localization technique. The previous methods are based on knowledge of reference point positions to Wi-Fi and Wi-Fi ID for each person. In this paper the access point is used, which broadcasts Wi-Fi signal, and the person phone for presuming to have the Wi-Fi connection capabilities that automatically connects to the access point in the building. The result of the system is shown in the interface of an indoor localization system that runs in the server as shown in Fig. 1. The system is based on the connection between the phone and access point to identify the person and related location in allocated floor of the considered building.

3.1 Neural Network

A neural network is a series of algorithms that endeavors to recognize underlying relationships in a set of data through a process that mimics the way the human brain operates. In this sense, neural networks refer to systems of neurons, either organic or artificial in nature. Neural networks can adapt to changing input; so the network generates the best possible result without needing to redesign the output criteria.

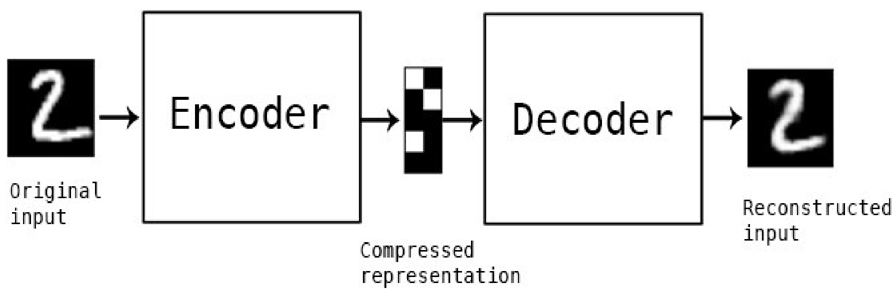
3.1.1 Why Neural Network

A typical use of a Neural Network is a case of supervised learning. It involves training data which contains an output label. The neural network tries to learn the mapping from the given input to the given output label. But what if the output label is replaced by the input vector itself? Then the network will try to find the mapping from the input to itself. This would be the identity function which is a trivial mapping.

But if the network is not allowed to simply copy the input, then the network will be forced to capture only the salient features. This constraint opens up a different field of applications for Neural Networks which was unknown. The primary applications are dimensionality reduction and specific data compression.

3.2 Auto Encoders

1. Auto encoder is an unsupervised artificial neural network that learns how to efficiently compress and encode data then learns how to reconstruct the data back from the reduced encoded representation to a representation that is as close to the original input as possible.
2. Auto encoder, by design, reduces data dimensions by learning how to ignore the noise in the data.



3.2.1 Advantages

1. Auto encoders can be great for feature extraction.
2. Auto encoders will give you filters that may fit your data better, in general.

3.2.2 Limitation

1. Lot of data, processing time, hyper parameter tuning, and model validation require before building the real model

CHAPTER 4

4 SOFTWARE REQUIREMENT SPECIFICATION

4.1 Introduction

This software requirement specification (SRS) expresses complete description about proposed system. This document includes all the functions and specifications with their explanations to solve related problems.

4.1.1 Project Scope

The main purpose for preparing this document is to give a general insight into the analysis and requirements of the existing system or situation and for determining the operating characteristics of the system. This document plays a vital role in the Software Development Life Cycle (SDLC) and it describes the complete requirement of the system. It is meant for use by the developers and will be the basic during testing phase. Any changes made to the requirements in the future will have to go through formal change approval process.

4.1.2 Objectives

(1) To provide the history of the seismic waves of the area, given the latitude andlongitude.

(2) To provide the average wind speed of the area, given the latitude and longitude.

(3) To design prediction system for earthquake in that area.

(4) Provide assistance in finalizing the structure of the building.

4.2 FUNCTIONAL REQUIREMENTS

System Feature 1

User requirement: The latitude and longitude of the particular area.
Output from the system: The zonal specification of the area

System Feature 2

User requirement: The latitude and longitude of the particular area.
Output from the system: The seismic activity of the area.

System Feature 3

User requirement: The latitude and longitude of the particular area.
Output from the system: Predicting the seismic activity at that region for a particular time instant.

System Feature 4

User requirement: The latitude and longitude of the particular area.
Output from the system: The wind activity with the height parameter indicating the zonal wind specification.

4.3 EXTERNAL INTERFACE REQUIREMENT

4.3.1 User Interfaces

A well designed web service as the front-end of the system inducing the user to take input from CSV (comma separated file) containing information about fingerprints of specific workspace.

4.3.2 Hardware Interfaces

A networking device (access point) such as a router or bridge.

4.4 NON-FUNCTIONAL REQUIREMENTS

4.4.1 Performance Requirement

1. The software should be able to handle multiple requests and should provide a consistent view to all users.
2. There should be an efficient error reporting mechanism when the access to the information fails for some reason.
3. The software should be efficient.

4.4.2 Availability Requirements

1. Application should be available 24 hours in order to provide access to user withoutany server down / fail.
2. Database backup and recovery plan should be proper in order to avoid any unexpected downtime of Application.

4.4.3 Security Requirements

1. Normal user can just read information but they cannot edit or modify anything except their residential information.

4.4.4 Software Quality Attributes

1. Runtime System Qualities: Runtime system qualities can be measured as the system executes. like reliability, efficiency

2. Functionality: The ability of the system to do the work for which it was intended.

3. Performance: The response time, utilization, and throughput behavior of the system.

4. Security: A measure of system's ability to resist unauthorized attempts at usage or behavior modification, while still providing service to legitimate users.

5. Availability :(Reliability quality attributes falls under this category) the mea- sure of time that the system is up and running correctly; the length of time between failures and the length of time needed to resume operation after a failure.

4.5 SYSTEM REQUIREMENTS

4.5.1 Database Requirements

A CSV (comma separated file) containing all the required access points' details (RSSID, BSSID, strength, security).

4.5.2 Software Requirements (Platform Choice)

1. Operating System - Windows 10
2. Programming Language - Python/ JavaScript
3. Software Version - Python 3.6 or above
4. Tools - Python IDE / Sublime Text
5. Front End - Angular / React
6. Backend - Django

4.5.3 Hardware Requirements

1. Processor - Pentium V/Intel I3 core
2. Speed - 2.8 GHz
3. RAM - 4 GB (min)
4. Hard Disk - 20GB
5. GPU - NVDIA 1080ti

4.6 SOFTWARE DEVELOPMENT LIFE CYCLE

The SDLC life cycle model starts with the requirement gathering of the particular domain which is selected. This makes a firm base for the further life cycle methods which are designing, coding, testing, deployment. This makes up for various flows of the model making it a very comprehensive model to complete a particular methodology.

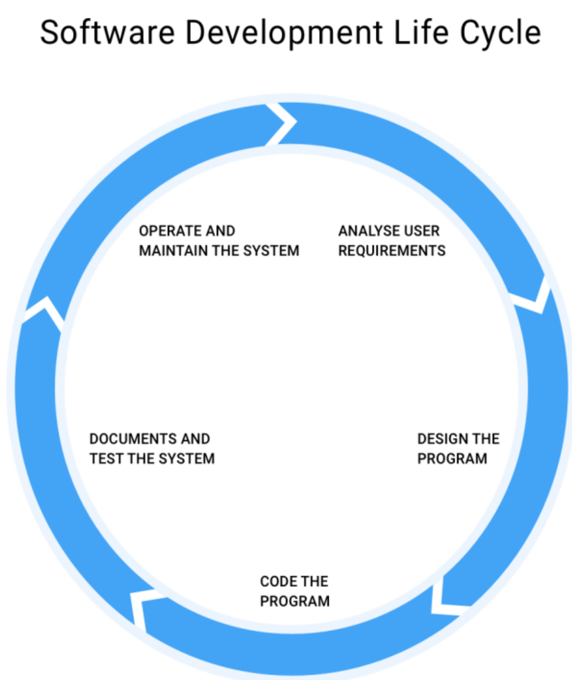


Figure 1: Phases in Software Development Life Cycle

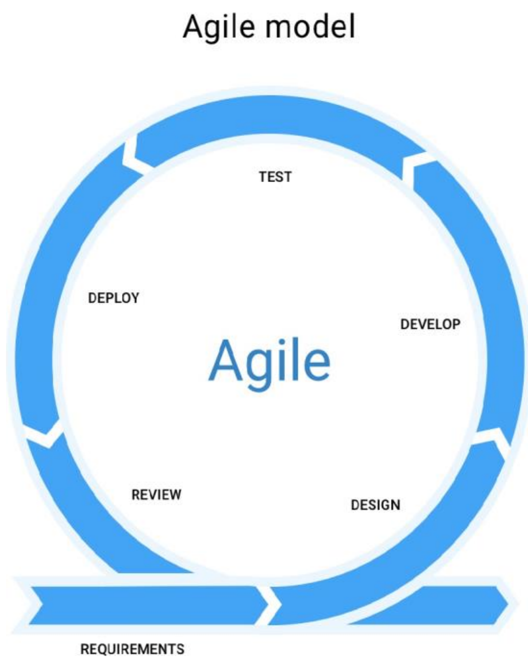


Figure 2: Agile Development

Agile project management is a value-driven approach that allows project managers to deliver high-priority, high-quality work and look like rock stars to their stakeholders.

It is nothing like the plodding, costly and error-prone approach to project management, which has delivered inconsistent results for years.

Software projects change constantly. When customers are expected to finalize requirements before they can test-drive the prototypes, overhead and long delays often cripple the project. Agile Project Management is about embracing change, even late in the development stage.

Its about delivering the features with the greatest business value first, and havingthe real-time information to tightly manage cost, time and scope

4.7 SYSTEM DESIGN

SYSTEM ARCHITECTURE

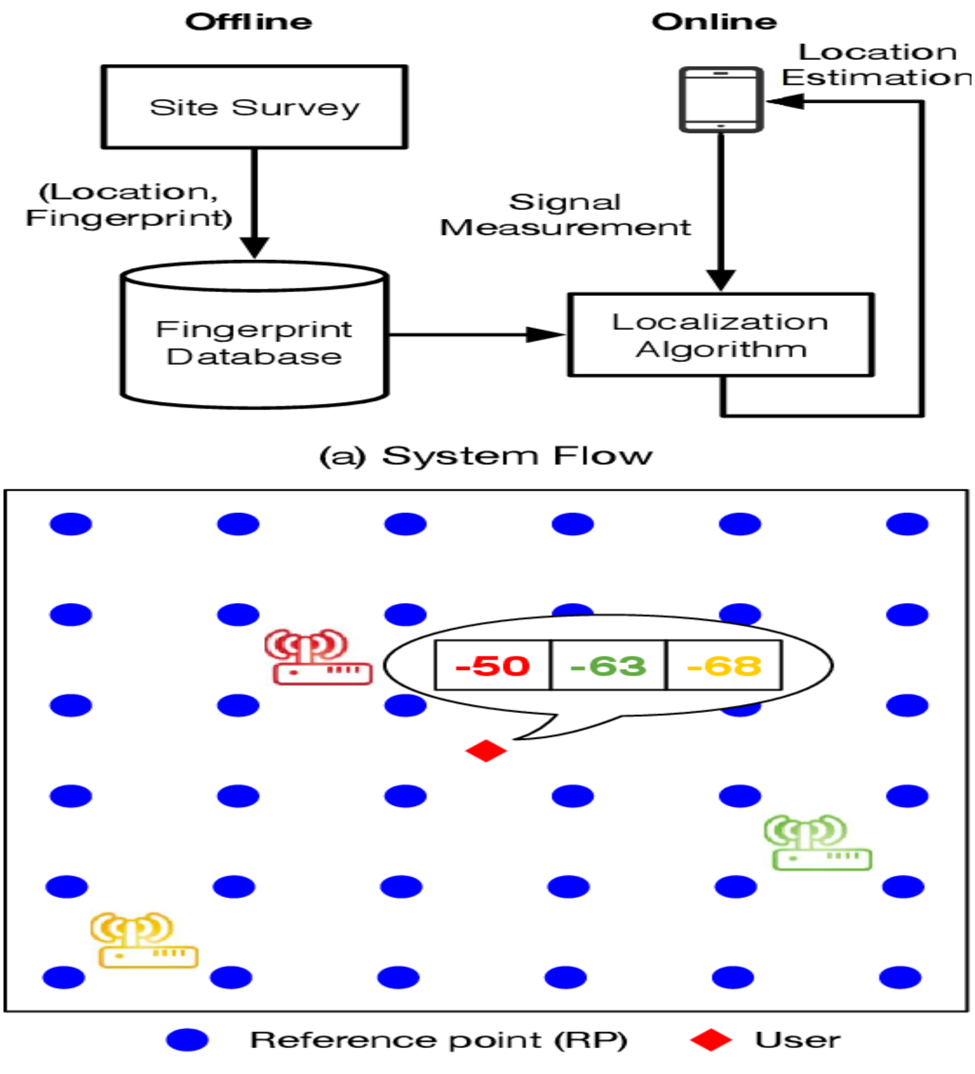


Figure 3: System Architecture

4.8 DATA FLOW DIAGRAMS

Figure 4: DFD Level 0

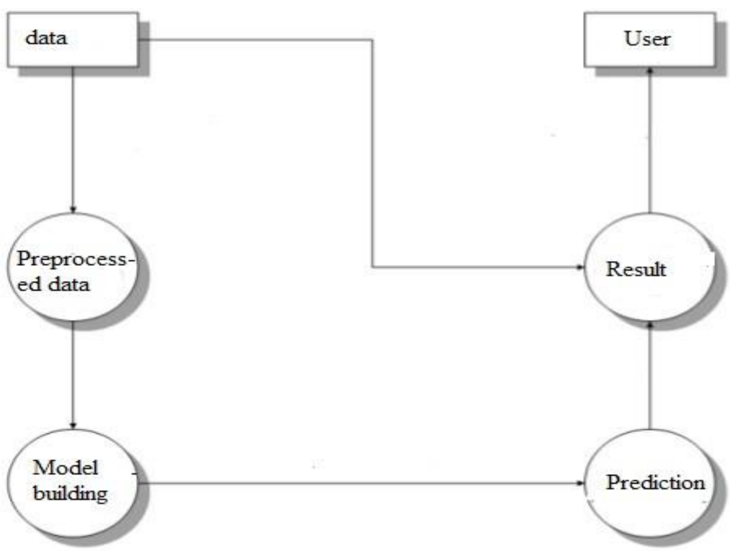


Figure 5: DFD Level 1

4.9 UML DIAGRAMS

4.9.1 Use Case View

The use case view models functionality of the system as perceived by outside users. A use case is a coherent unit of functionality expressed as a transaction among actors and the system.

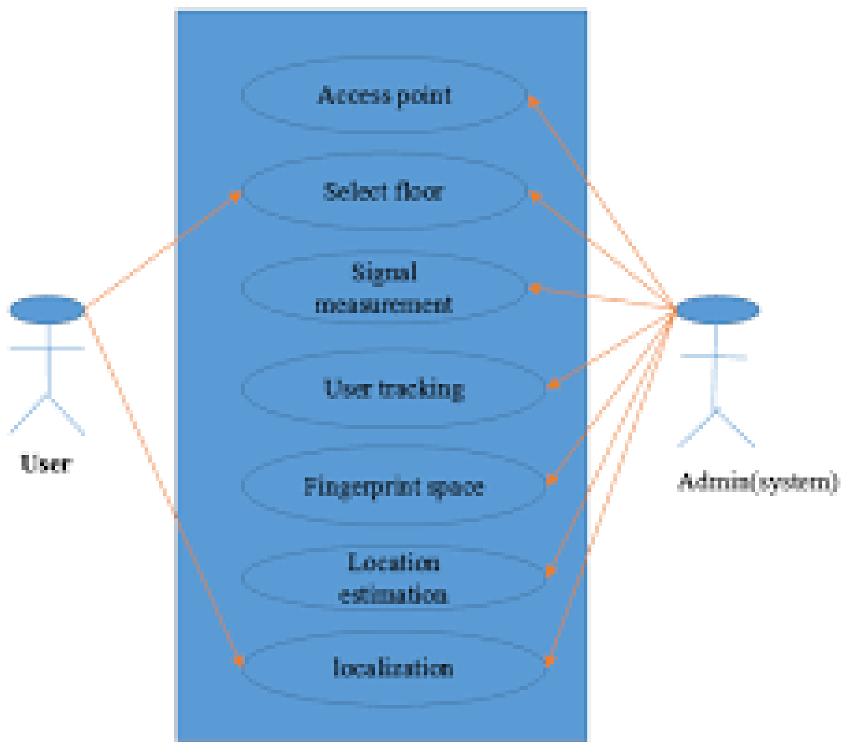


Figure 6: Use Case Diagram

4.9.2 Class Diagram

The Class diagram captures the logical structure of the system; the classes and things that make up the model. It is a static model, describing what exists and what attributes and behavior it has, rather than how something is done. Class diagrams are most useful to illustrate relationships between classes and interfaces. Generalizations, aggregations, and associations are all valuable in reacting inheritance, composition or usage, and connections, respectively.

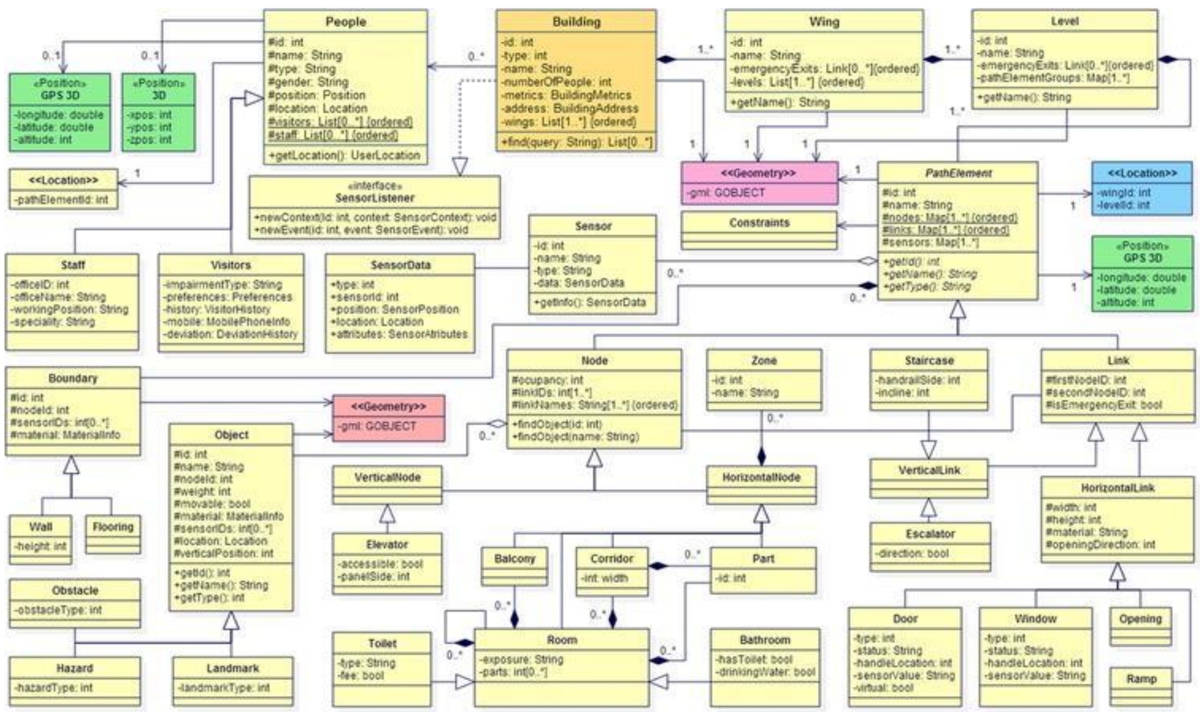


Figure 7: Class Diagram

4.9.3 Activity Diagram

Activity diagrams show the sequences of states that an object object goes through various events that cause a transition from one state to another and the actions that result into an activity diagram. The system would consist of two panels of users operating through the interface. The user could search in for the location of the coordinates of the place to get the required stats of the area.

Figure 8: Activity Diagram

4.9.4 Component Diagram

A Component diagram illustrates the pieces of software, embedded controllers and such that make up a system. A Component diagram has a higher level of abstraction than a Class diagram; usually a component is implemented by one or more classes(or objects) at runtime. They are building blocks, such that eventually a component can encompass a large portion of a system.

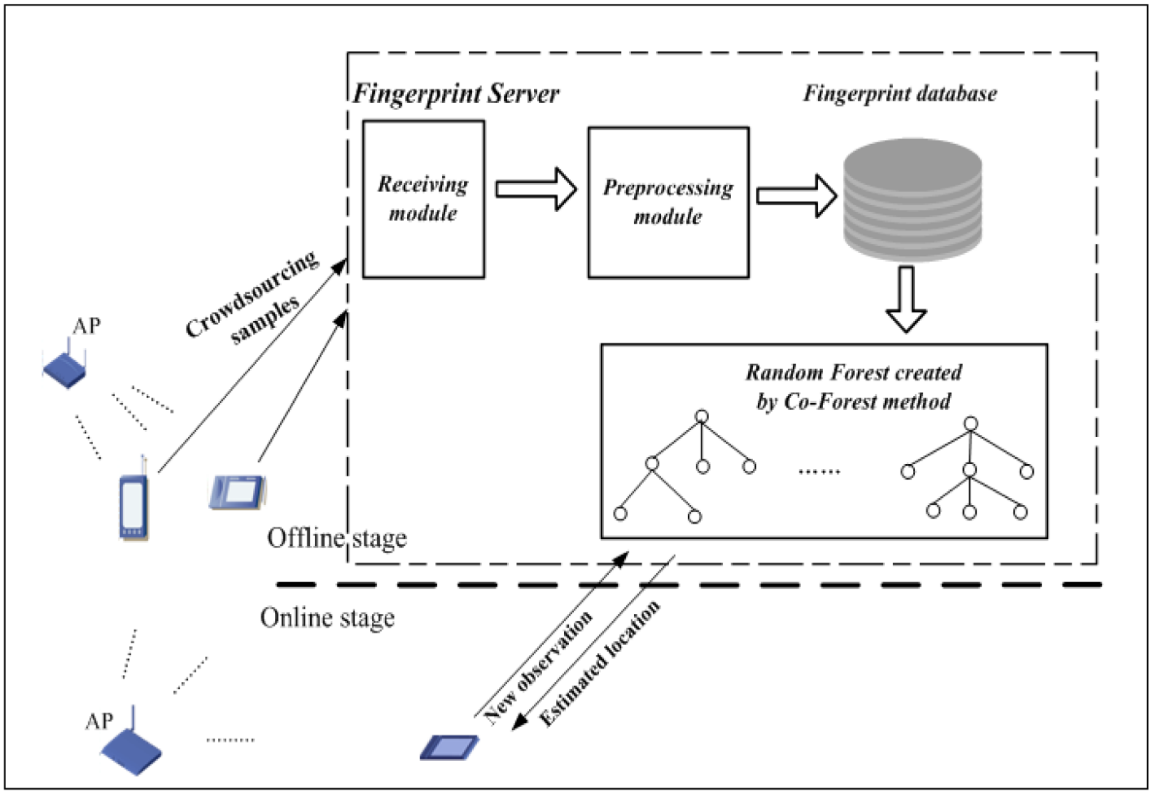


Figure 9: Component diagram

4.9.5 Deployment Diagram

Deployment diagrams are used to visualize the topology of the physical components of a system where the software components are deployed. So deployment diagrams are used to describe the static deployment view of a system. Deployment diagrams consist of nodes and their relationships.

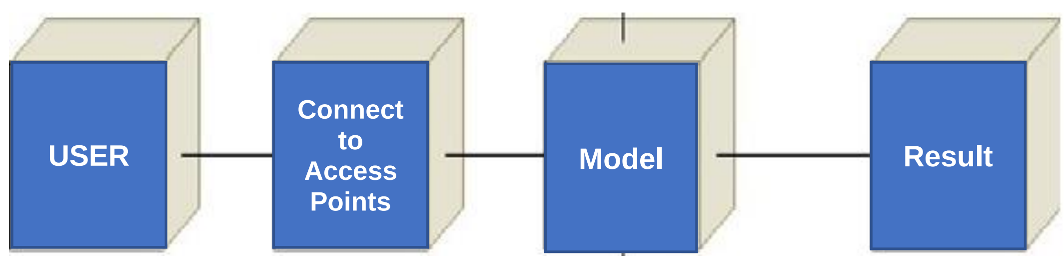


Figure 10: Deployment diagram

4.9.6 Sequence Diagram

A Sequence diagram is an interaction diagram that shows how processes operate with one another and in what order. It is a construct of a Message Sequence Chart. A sequence diagram shows object interactions arranged in time sequence. It depicts the objects and classes involved in the scenario and the sequence of messages ex- changed between the objects needed to carry out the functionality of the scenario. Sequence diagrams are typically associated with use case realizations in the Logical View of the system under development. Sequence diagrams are sometimes called event diagrams or event scenarios.

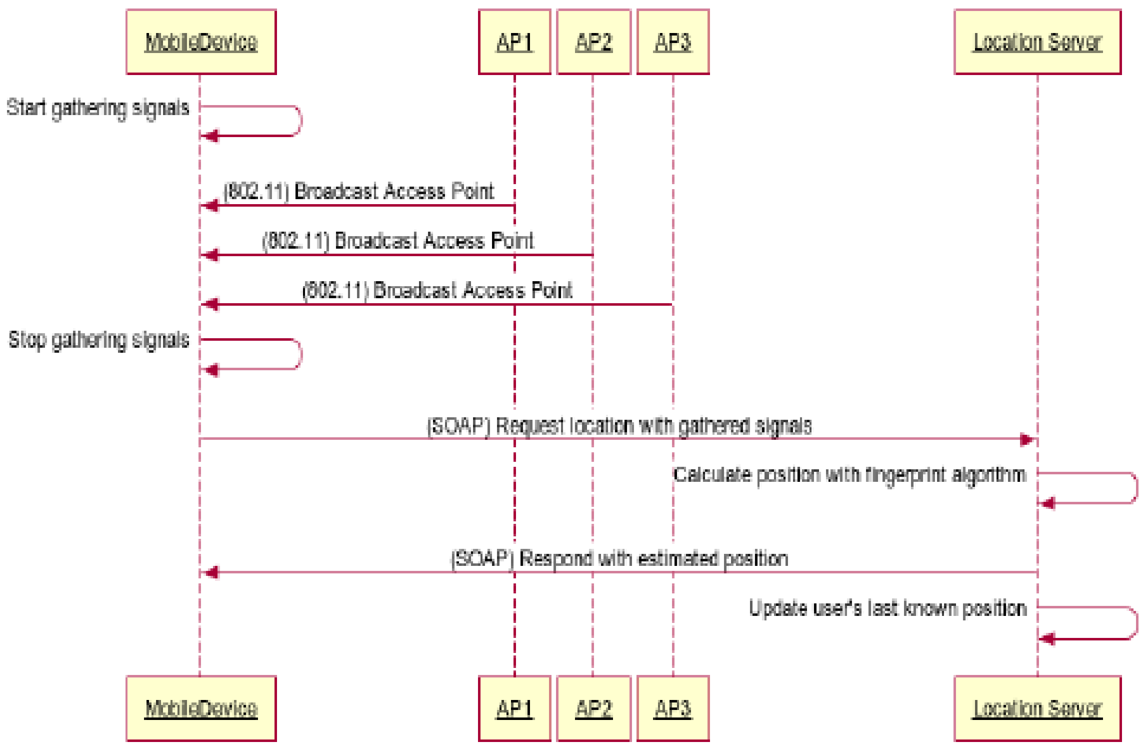


Figure 11: Sequence diagram

CONCLUSION

To conclude, nodes and band have been built to meet their designed frequency responses, amplification gains and ADC sample handling. They have also successfully been incorporated into the Wi-Fi network As for the controller android application, it has achieved at enabling the user interaction with the system. Furthermore, the hub has successfully implemented both grouping and triangulation protocols and as a result, it has been able to position the band to an accuracy within 27cm.In closing we have produced a system that can achieve a very good distance measurement accuracy which has surpassed our initial requirement of 50cm. Unlike existing system, it allows portability (As the grouping protocol allows nodes to be reconfigured and re-positioned), flexibility (As the Hub allows for the addition and removal of bands) and ultrasonic transmission synchronised via Wi-Fi broadcasts. With regards to future implementations, the hub is expected to become a Raspberry Pi 2 and will require the conversion of its MATLAB code into Python. The android application could also be implemented for 10S and Windows allowing it to be compatible with more devices. The triangulation algorithm currently outputs the position of the band relative to a pre-defined coordinate system however, it could be then shown on a map, making it more user friendly.

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