DATABASE DESIGN DOCUMENT

FINAL YEAR PROJECT

Smart Guide: A smart campus guide using BLE based indoor localization

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1. INTRODUCTION

1.1 PURPOSE

Outdoor localization has been formalized by using satellite-based technologies i.e. GPS [1], BeiDou[2], GLONASS[3], and GALILEO[4]. It is hard for finding the indoor location by using conventional GPS technology because of no direct (Line of Sight) [5] in indoors, so we cannot use these technologies for indoor positioning. Up to date, the technologies used for indoor localization approach are: TOA (Time of Arrival), TDOA (Time Difference of Arrival), AOA (angle of arrival) but they have some limitations. TOA and TDOA require precise clock count and its synchronization and AOA-based systems require special antennas for their propagation. By keeping in view the evergreen trend of engaging users towards something is through mobile computing. So, there exists some systems which used magnetic rays, time of arrival of specific signals, some used WiFi based localization and also deployed on Apple and Android smart phones but due to coherence and interference of different signals in determining the RSSI of fixed WAPs, crucial errors occurred. By analyzing these calculations, we are able to avoid multiiteration(which predict location of device by determining the distance between the AP and mobile device) and capture fingerprints from multiple mobile devices.

The indoor positioning system which we are using is communicating with hardware device so we require a technique which translates the signal into a location. There are three categories to transform this: proximity, geometric and scene analysis. Proximity methods create zones and assign the users location when they enter that zone. Geometric method uses signal measurements from device locations and put them in geometrical equations to predict the location but scene analysis method measures the signal from different reference points by standing at one location and then predicts location by passing that fingerprint to trained model which is called fingerprinting technique. A fingerprint is a collection of signals received at a certain location in the scene, in this way they aim to make the fingerprint location specific, such fingerprints are often based on the RSSI values collected from beacons.

So, we are going to implement a system which employs suitable machine learning approach to find the location by using RSSI (Received Signal Strength Indicator) fingerprinting technique because there is less hinderance of other signals in using this technique.. This RSSI values will pass to the trained model (a model which is trained on a given set of input and output values by using appropriate machine learning algorithm) which gives the location of the user's mobile device.

1.2 SYSTEM OVERVIEW

Outdoor and indoor localization is an integral component of IoT (Internet of Things) in this era of mobile computing. Indoor localization can open new horizons for ubiquitous applications targeting university departments, government small institutes, software houses, airports, shopping malls, museums etc. Our project will find the location of a specific person by using appropriate machine learning approach using BLE based Android

application. This location will be used to provide guided tour of the indoor building (Computer Science and Engineering Department at UET, Lahore) we will use to validate our work.

This project will guide persons who are not much familiar with visiting place. It has an android application that will predict the indoor location of a person at room level and also gives information of current room location and nearby rooms in the form of text, images, audio and videos. In our case visiting place will be CSE dept at UET LHR. For room prediction, RSSI fingerprints of BLE beacons will be captured for training of model. After finding the location of the person, guidelines of that certain room/area will be provided to the user on user end Android application. Indoor positioning has numerous applications. We can use indoor positioning of people to guide them inside shopping malls, airports or museums.

Indoor positioning systems can be broadly classified into two main parts: Systems that need some infrastructure which are further categorized into those which needs ad-hoc deployment like BLE beacons and systems which takes profit of previously installed infrastructure like WiFi fingerprinting technique. Those technologies which do not need any infrastructure deployment are based on magnetic field fingerprinting. Ad-hoc deployment can be initiate in new areas where there is need to save environment from magnetic rays or in those areas where WAPs are weak so we choose to detect indoor location using BLE beacons. Also, BLE based indoor localization is wireless, consumes low power because it works on battery and mostly available in smart mobile devices.

BLE can be used from two different approaches: trilateration and fingerprinting. In tilateration relationship between the user's RSSI measurement and its distance to the BLE beacon station is considered. By estimating distances to multiple beacon stations, the user's location can be predicted using a least square algorithm. The fingerprinting approach is implemented in two phases: an offline phase and an online phase. The offline phase is called the training phase. During this phase, fingerprint RSSI values are determined of every beacon from each device location. The online phase is known as the localization phase which is the actual prediction of the user's device location.

1.3 Design Constraints

There are some constraints of our user app that is:

- It only tells the indoor location of CSE department because we need BLE beacons for deployment which predict room location. Actually, BLE beacons are very expensive. That's why; it is implemented in specific area.
- User can only use this app for CSE department.
- This app cannot tell about the outdoor location.
- Only visitors and new student of CSE department use this app.
- If we have more resources such as BLE beacons, we can enhance the scope of the project such as we can implement this in other departments and other locations.
- We are not providing information in video form

1.4 Roles and Responsibilities

The following table defines the System Design roles and responsibilities.

Team Member Name	Roles	Activities
Tooba Naseer (2016-CE-72)	Group Manager + Developer	Android application development backend, machine learning, Report Compiling
Rida Mahmood (2016-CE-54)	Researcher + Designer	Android application development frontend, machine learning, Report Writing
Ayesha Jabbar (2016-CS-159)	Developer + Researcher	Android application development backend, Data Handling, Document design
Rabeya Hamood (2016-CE-81)	Researcher + Quality Assurance	Research work, Quality Assurance, Market Survey

Figure 13: Roles and activities of Team Members

2. System Architecture

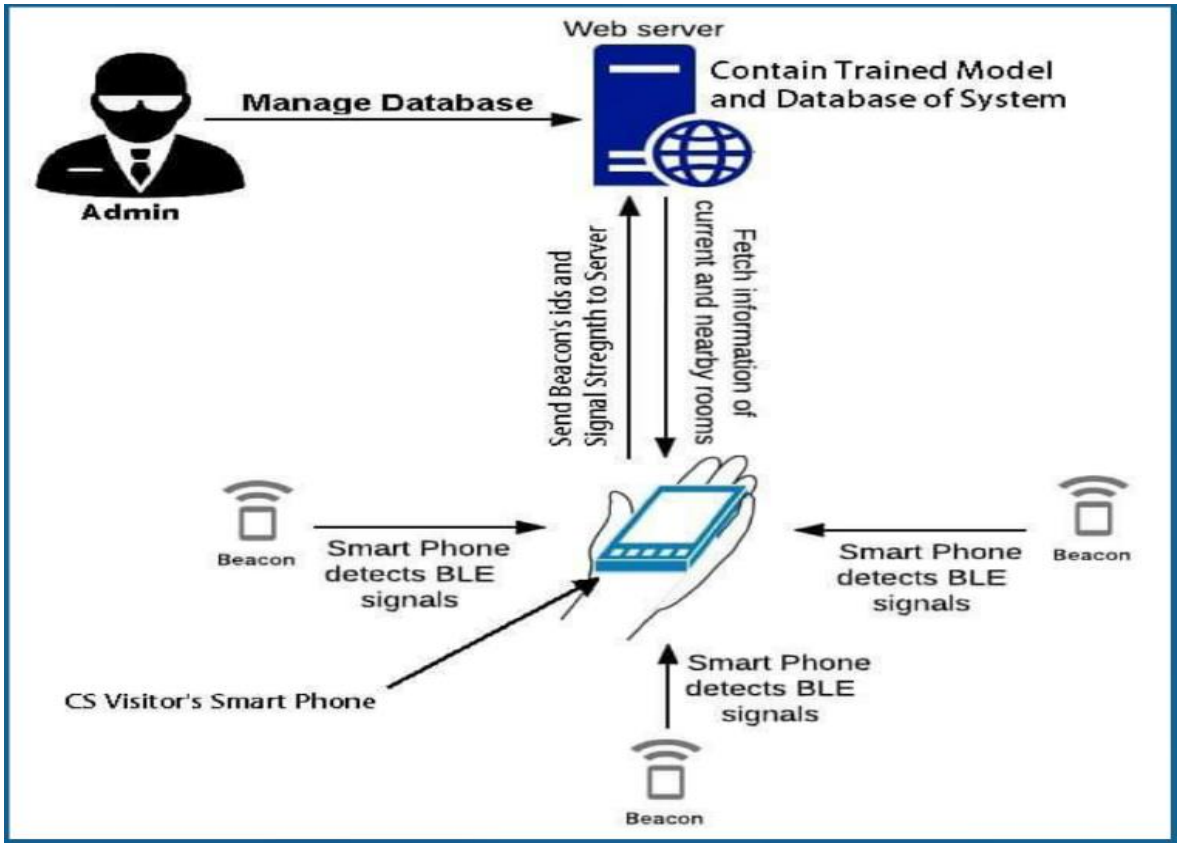
The system architecture of our system is Android application provide guidance to university visitors and make them familiar with university. Application will not only tell the current indoor location of user but also the information about current indoor location and nearby rooms in textual, image, audio or video form.

Our system consists of these modules:

- **Deployment of BLE Beacons**
  BLE beacons will be deployed in the rooms. BLE beacons will be installed on the ceilings of rooms.
- **Data Acquisition**
  BLE beacons broadcasts signals and these signals in the form of RSSI values will be captured at different positions by using Android application and then csv file will be generated.
- **Data Pre-processing and Training**
  Data will be pre-processed and trained by using machine learning algorithm and then trained model will be deployed on server.
- **Room Level Prediction**
  An Android application for common users will be developed that capture RSSI signals and send to server. Then trained model will take these values as input for the purpose of prediction of room and then send back this information to application.

- **Location Information**
  Application will fetch information data of current room and nearby rooms from server and then display these information to screen.

Here is the proper architecture of our system:



2.1 Hardware Requirement:

In this section, we will discuss the software and hardware requirements in implementing and using the system. The hardware consists of the following components:

Sr. No.	Component	Description
1	BLE Beacons	Range between 10-100 meters
2	Hard Disk space	Minimum 250GB
3	Processor	Minimum i7core@2.2GHz
4	RAM	4GB or above

2.2 Software Requirements:

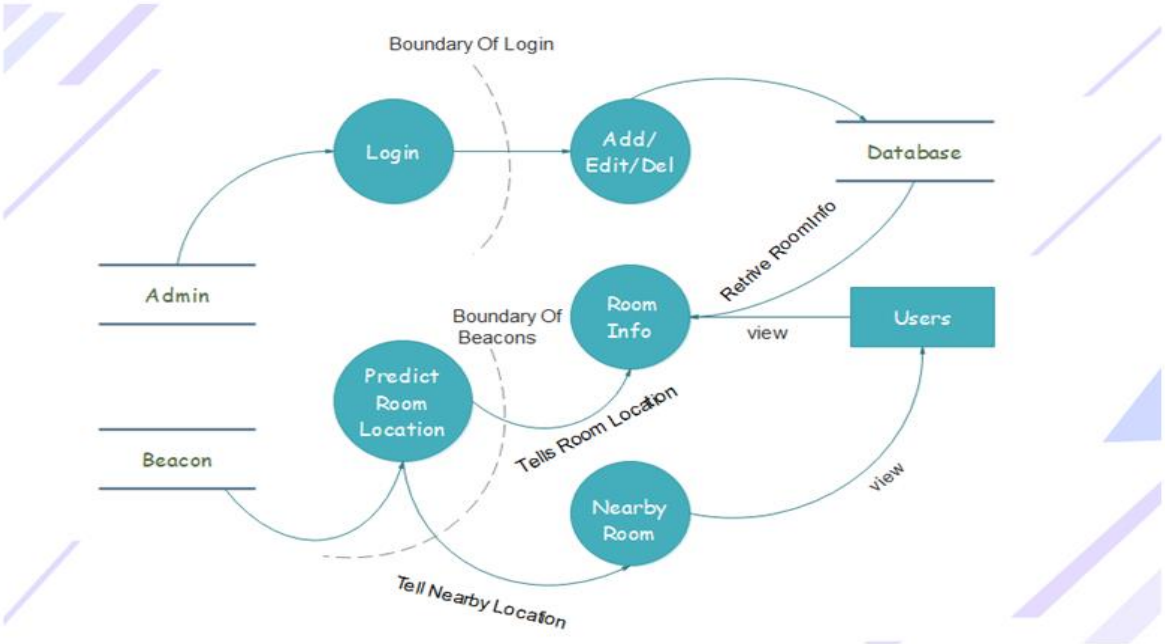
1. **Software Requirements for Users**
   Installed Android application and Bluetooth technology
2. **Software Requirements for Development**

Sr. No.	Component	Description
1	Operating System	Windows10(64-bit)
2	IDE	Android Studio 3.5 and above with JAVA
3	API for machine learning	Weka (Java API for ML)

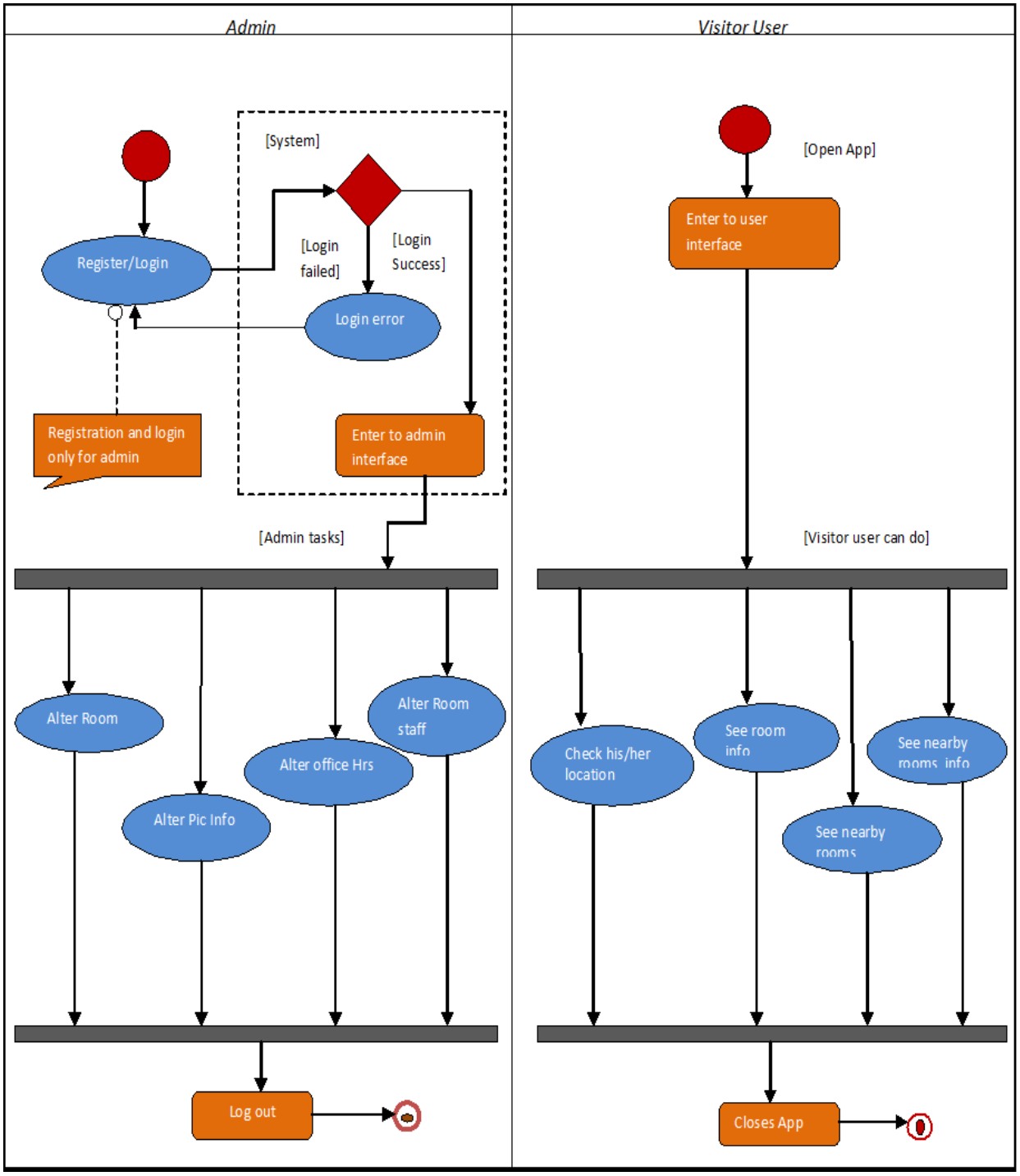
3. DESIGNS

Here we show some designs which show the database of our system such as data flow diagram (DFD), Entity Relationship Diagram (ERD), Activity Diagram, Database design diagram and class diagram.

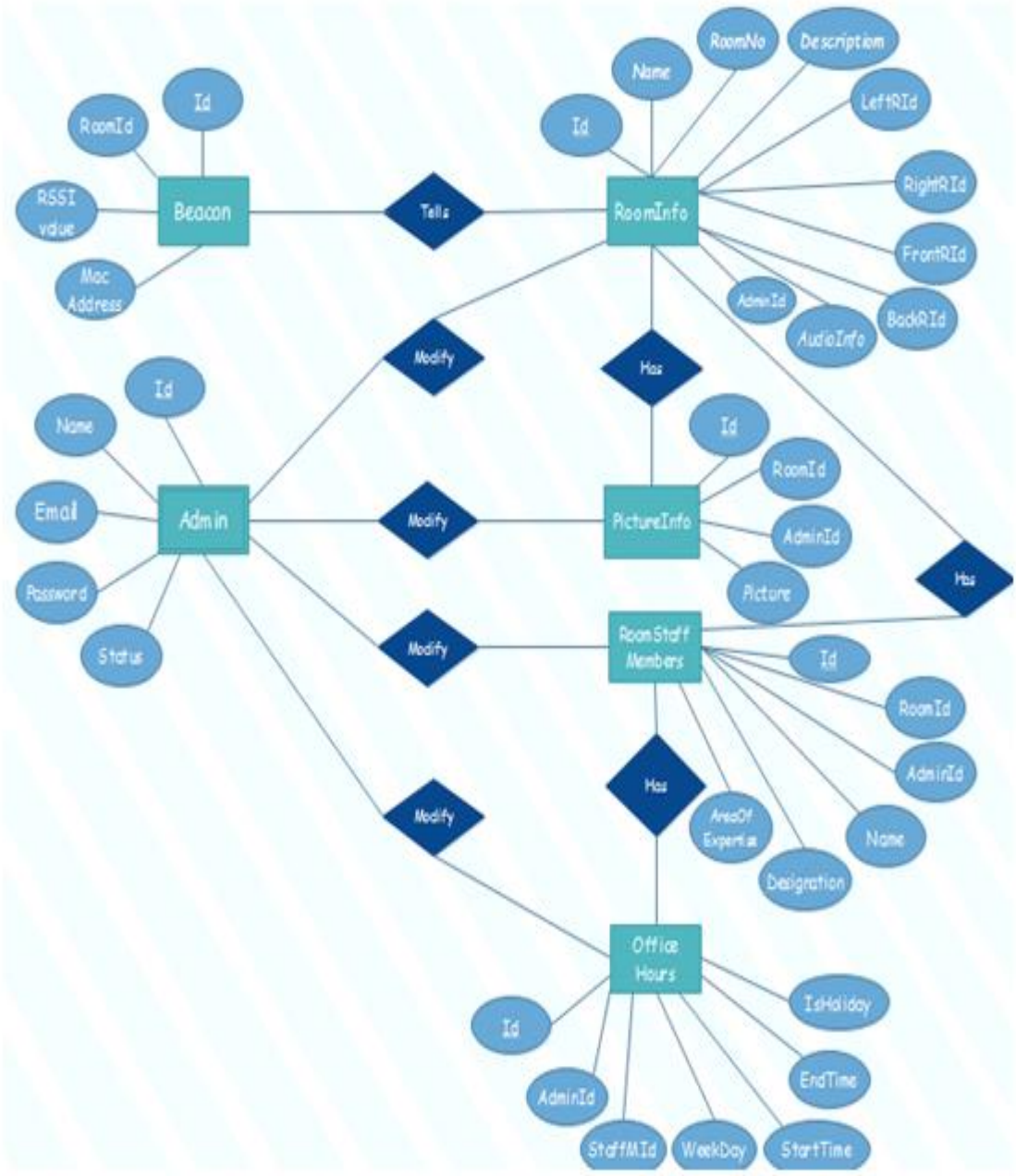
3.1 Data Flow Diagram:



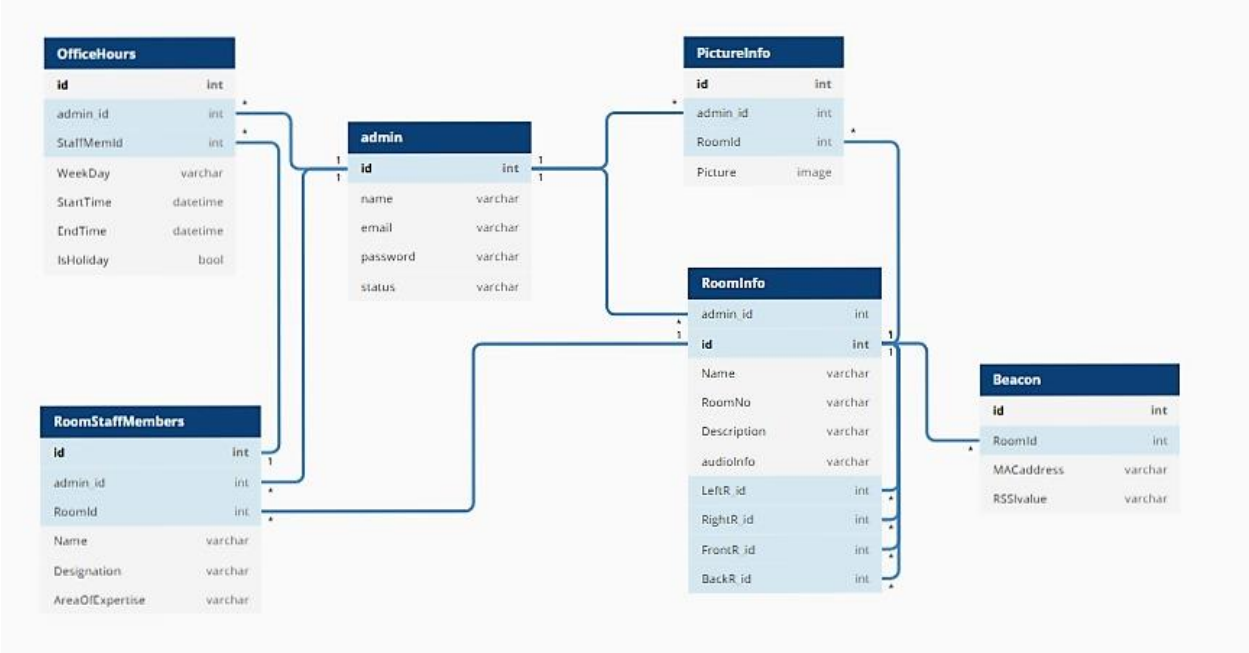
3.2 ACTIVITY DIAGRAM:



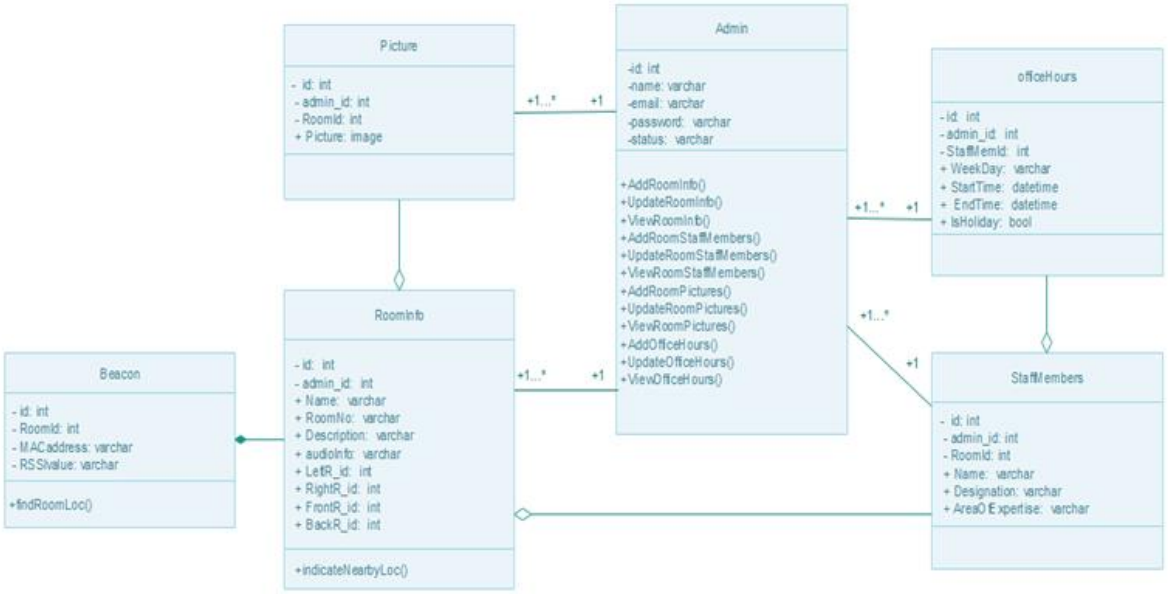
3.3 ER DIAGRAM



3.4 DATABASE DIAGRAM



3.5 CLASS DIAGRAM



4. HARDWARE AND SOFTWARE DETAILED DESIGN

4.1 Hardware:

BLE beacons are Bluetooth low energy beacons. Classic Bluetooth consumes more power than BLE beacons and transmits to long ranges. On the other hand, BLE consuming much less power because it transmits data over the small range. Bluetooth having version greater than 4.0 are BLE.BLE Beacon is a tiny device with a massively used for broadcasting of signals. It has unique ID. A beacon has three major components: a small ARM computer, a Bluetooth Smart connectivity module and batteries for powering the entire circuit. The CPU of the ARM computer has an antenna attached to it. It broadcasts electromagnetic waves with specific length hand frequency. We develop Data Capturing Application that will interface with beacons in order to capture the signal strength of BLE beacons in the form of RSSI values. These value used for the prediction of room.

4.2 Software:

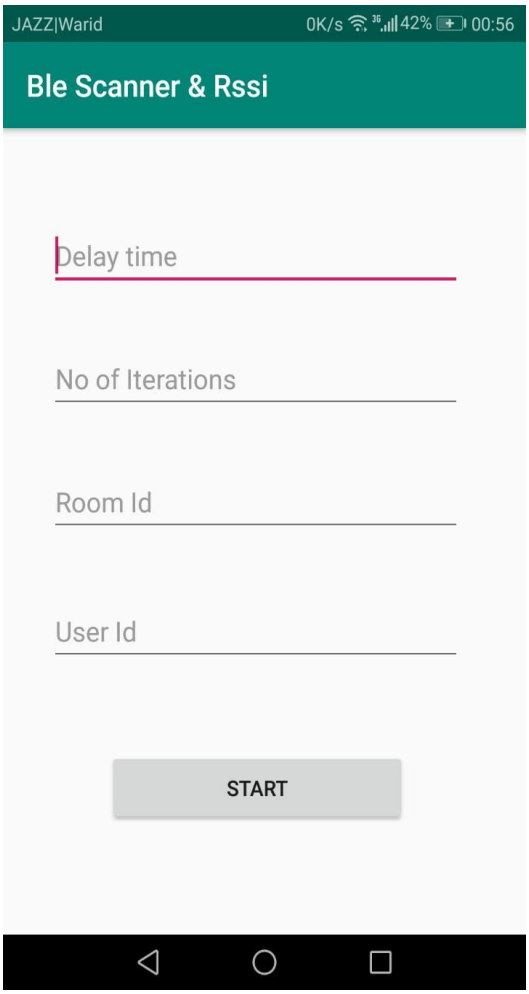
Actually, our proposed system has three Android applications.

- Data Capturing App
- Admin Android App
- User Android App

4.2.1 Data Capturing Application:

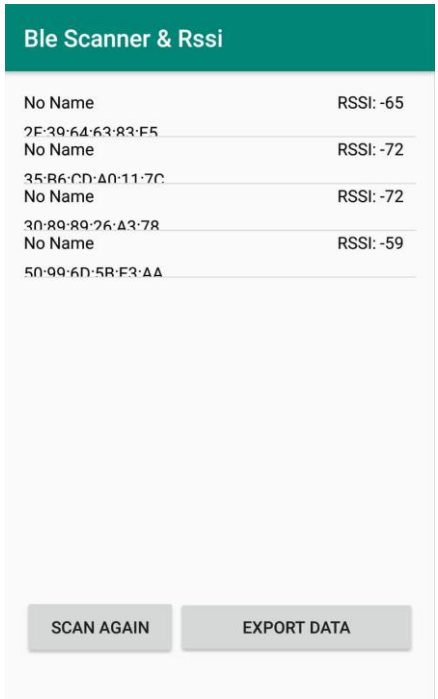
The functional requirements and the implementation of Data Capturing Application are as follows:

User can enter his name or ID or delay process:



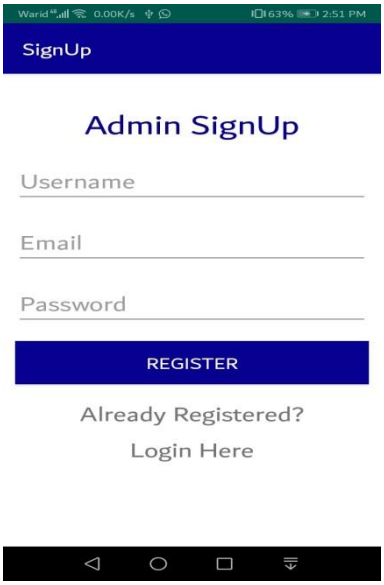
Turn on Bluetooth for scanning

Scanning of nearby BLE Bluetooth devices:

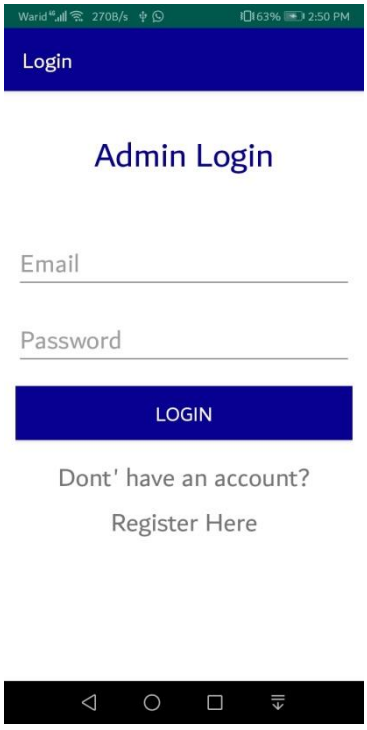


4.2.2 Admin Android Application

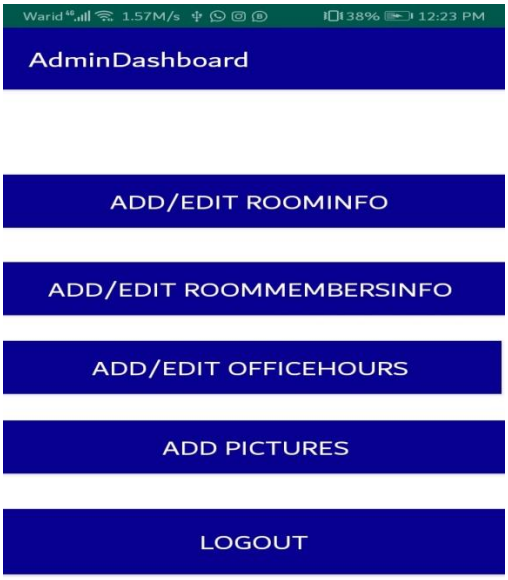
Admin Signup:



Admin Login:

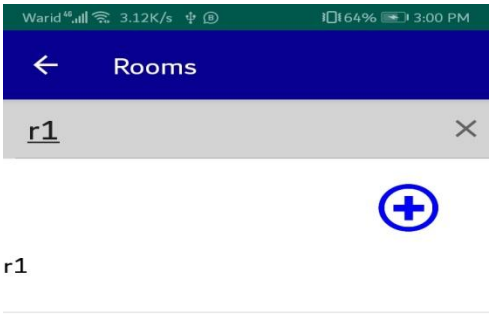


Admin Dashboard

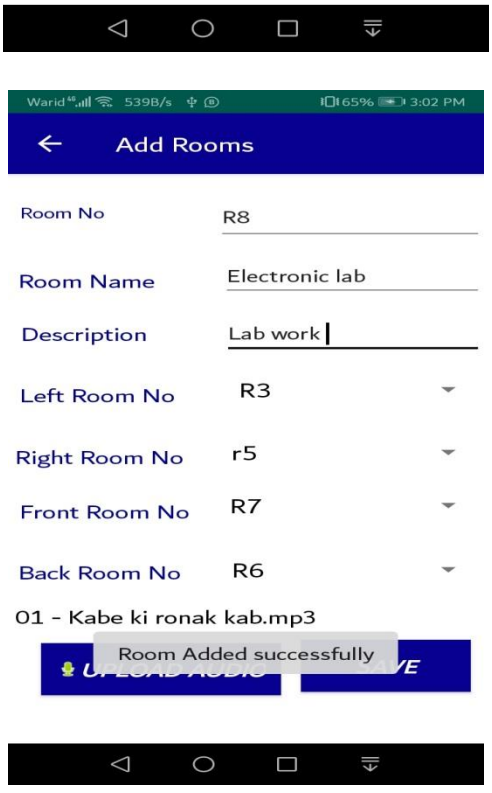


Room Main Page:

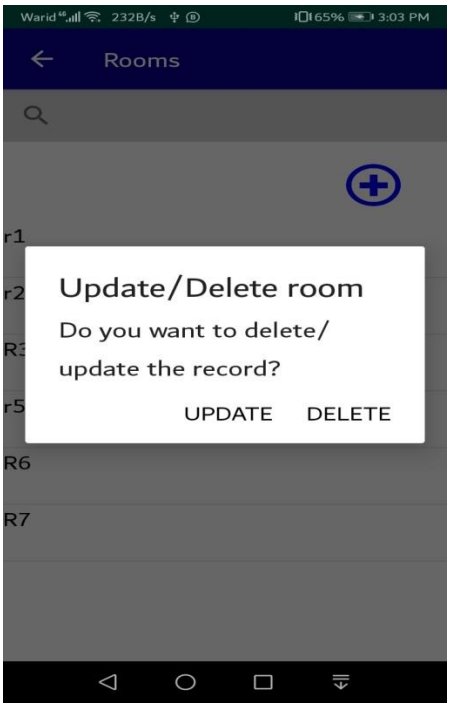
Search view Room Main Page:



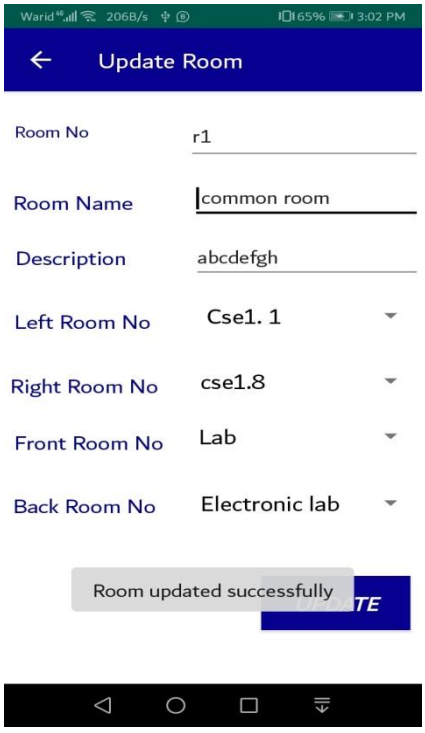
Add Room:



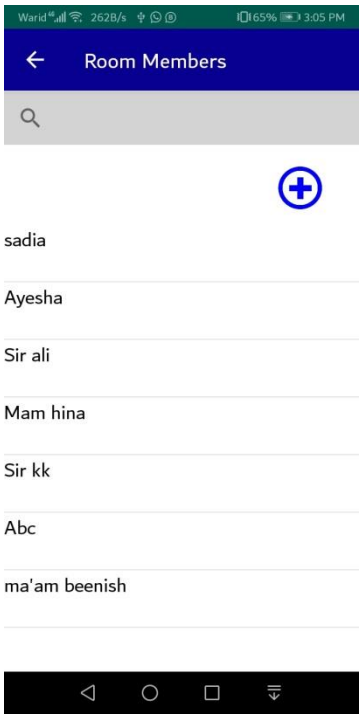
Delete Room:



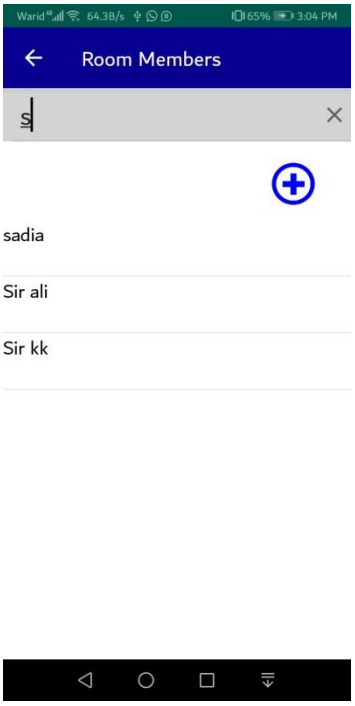
Update Room:



Room Member Main Page

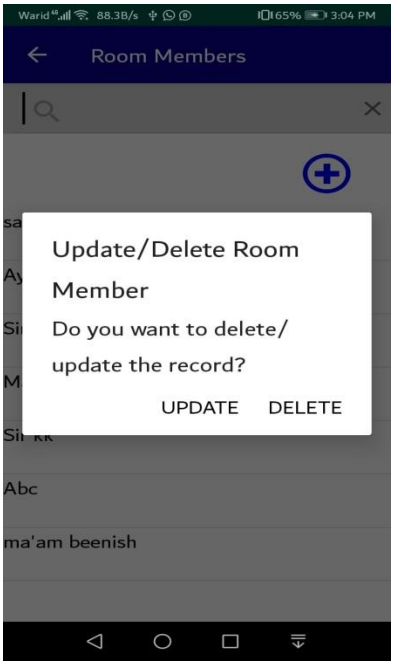


Search View of Room Member:



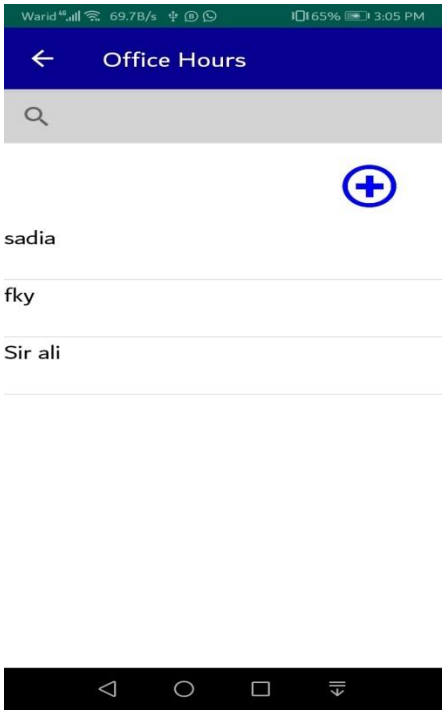
Add Room Member:

Delete Room Member

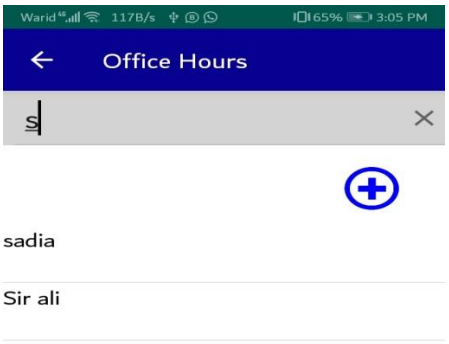


UPDATE ROOM MEMBER

Office Hours Main Page:

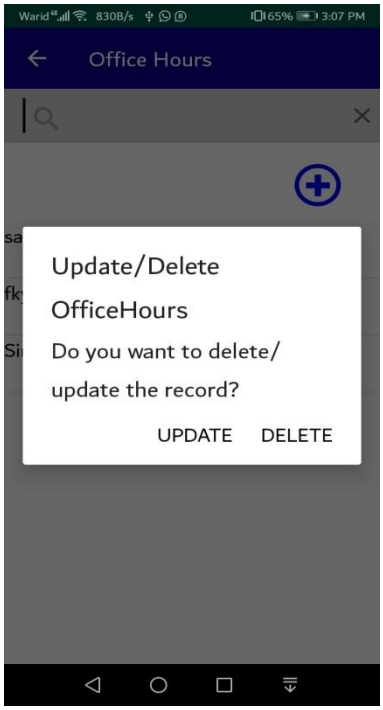


Office Hour Search View:

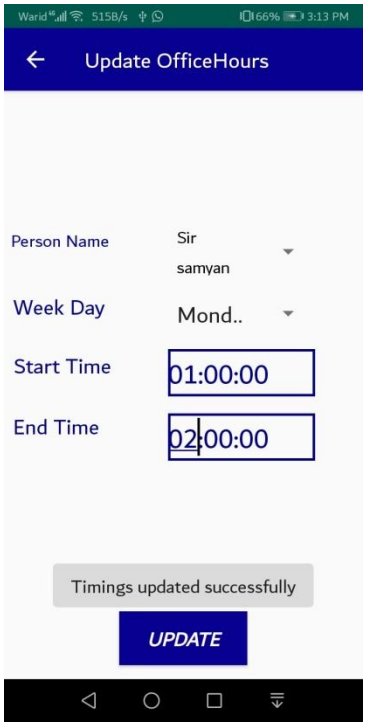


ADD OFFICE HOUR:

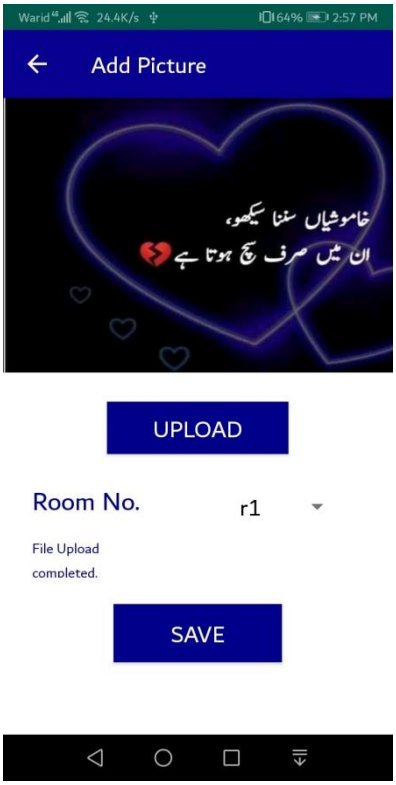
DELETE OFFICE HOUR



UPDATE OFFICE HOURS



ADD PICTURE:

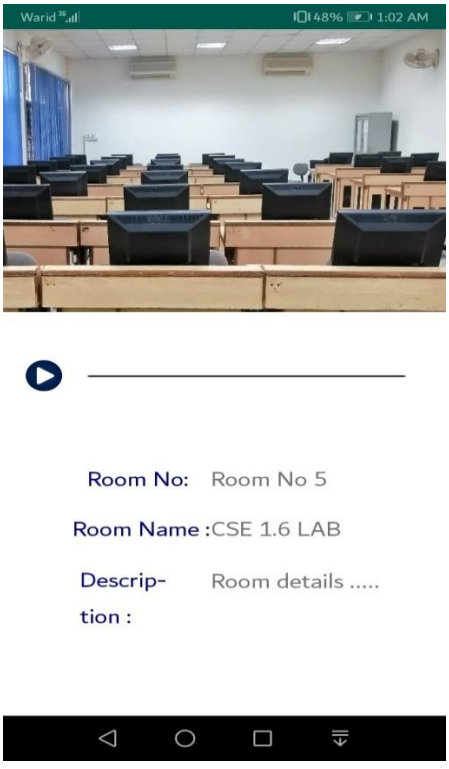


4.2.3 USER ANDROID APPLICATION:

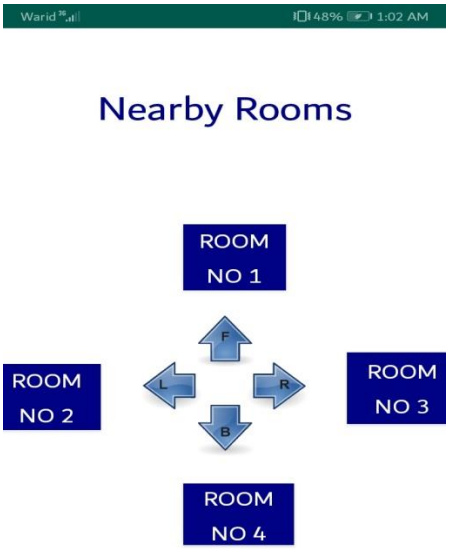
Here we show the screens of our user app.
Main Screen:

CURRENT LOCATION OF ROOM:

ROOM INFORMATION:

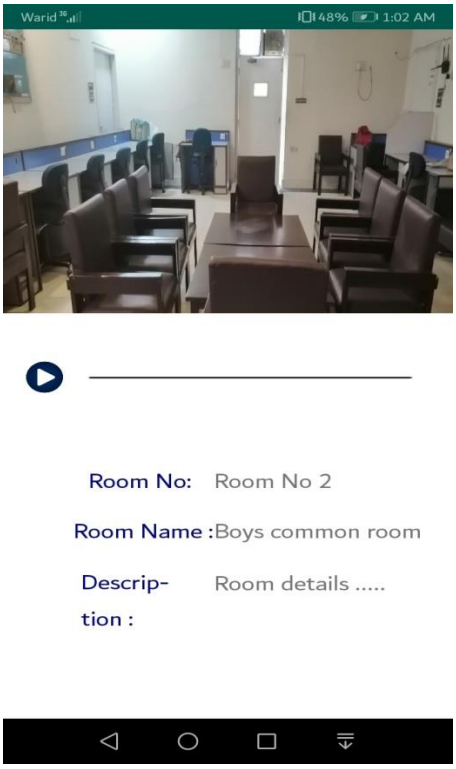


NEARBY ROOM INFORMATION:

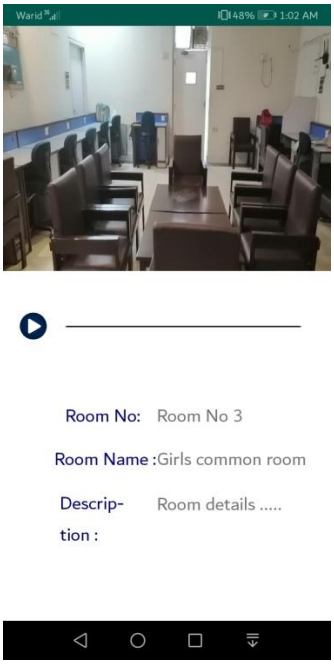


NEARBY ROOM NO 1:

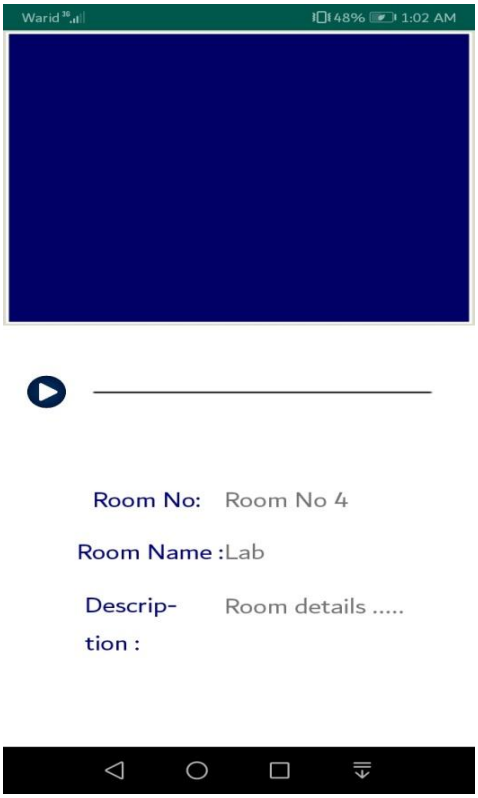
NEARBY ROOM NO 2:



NEARBY ROOM NO 3:



NEARBY ROOM NO 4:

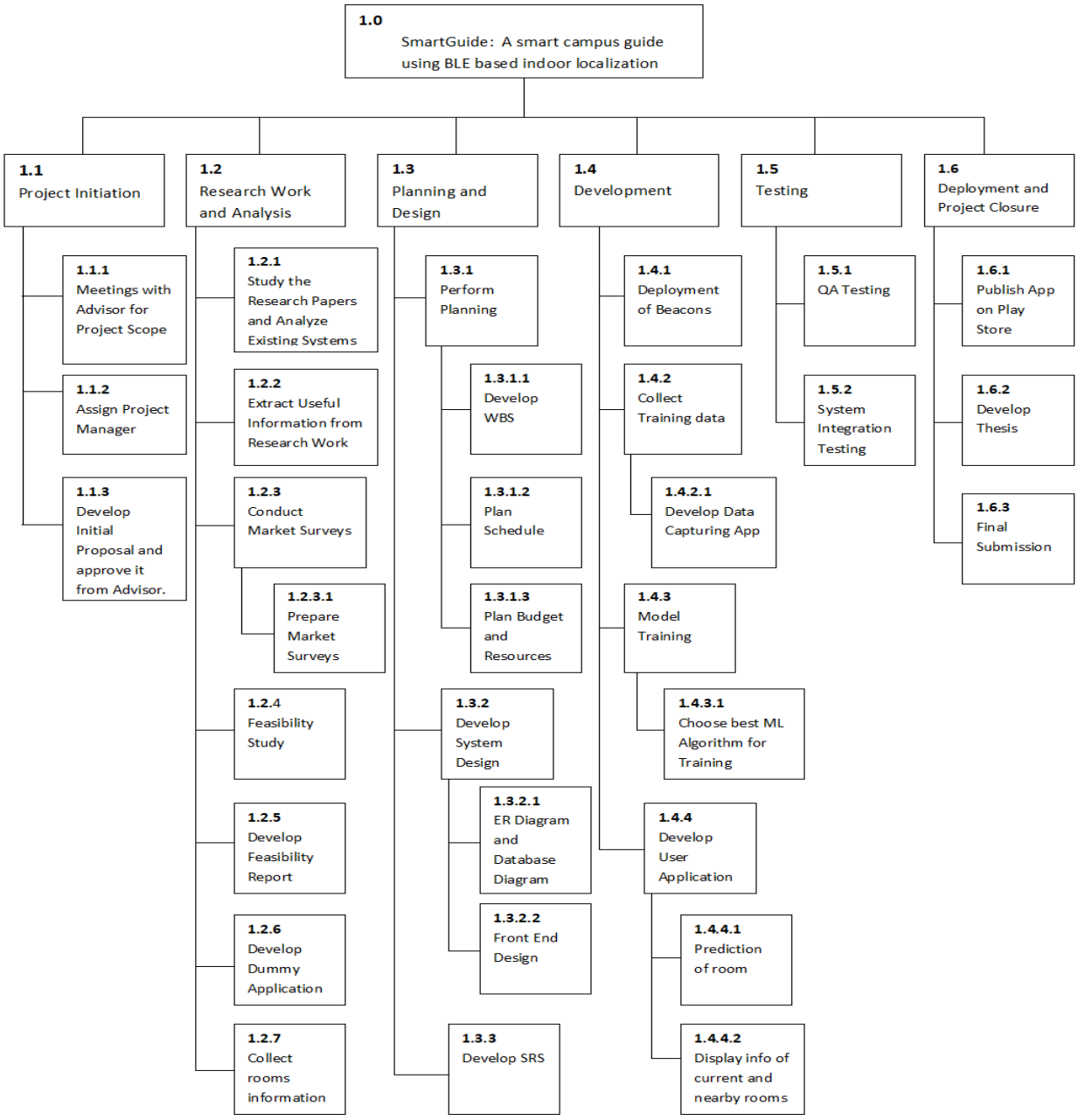


PLANNING

MILESTONES:

Milestone No.	Milestone	Completion Date
001	Project Kick-Off	20 Sep 2019
002	Research Work and Complete Analysis	01 Nov 2019
003	Complete Planning and Design	20 Nov 2019
004	Complete Backend Coding	15 Jan 2020
005	Complete Testing	01 Feb 2020
006	Complete Implementation and Deployment	15 Feb 2020
007	Project Closure	01 Mar 2020

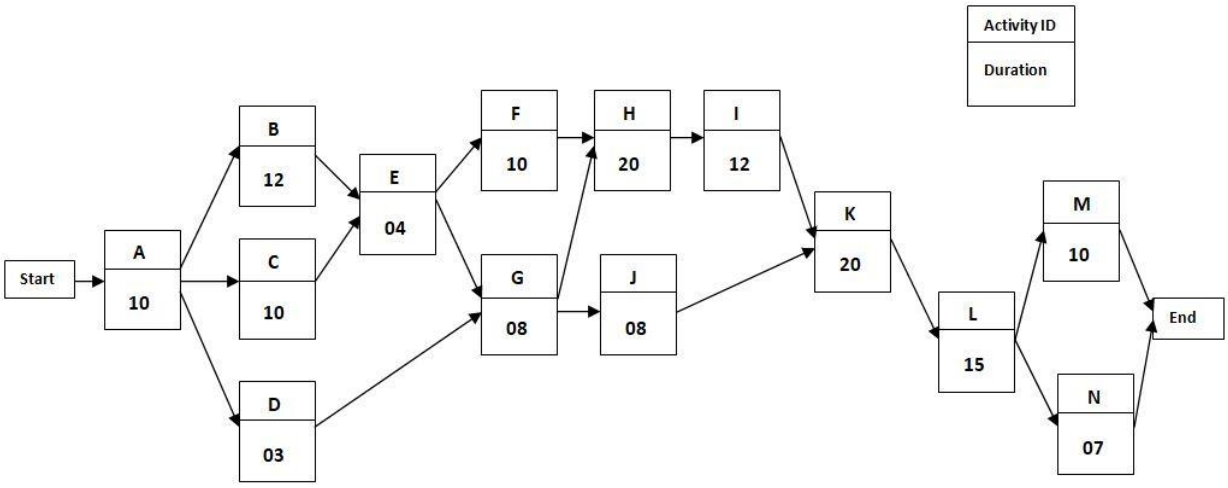
WORK BREAKDOWN STRUCTURE:



NETWORK DEPENDENCY DIAGRAM:

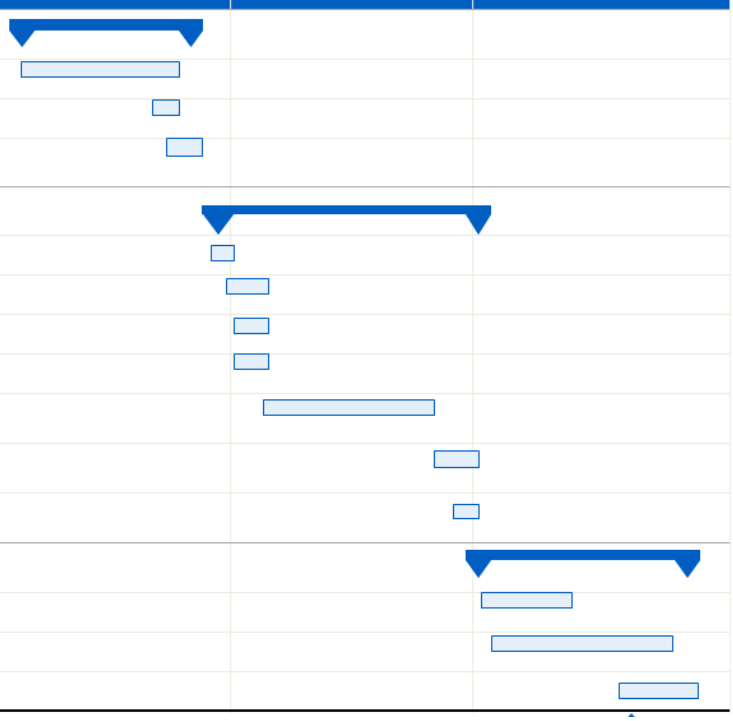
Activities	WBS ID	Predecessor	Duration (days)
A	1.1.1		10
B	1.2.1	A	12
C	1.2.3	A	10
D	1.2.7	A	03
E	1.2.4	B, C	04
F	1.3.1	E	10
G	1.3.2.1	E, D	08
H	1.4.2	F, G	20
I	1.4.3	H	12
J	1.3.2.2	G	08
K	1.4.4	I, J	20
L	1.5	K	15
M	1.6.2	L	10
N	1.6.1	L	07

NETWORK DIAGRAM:

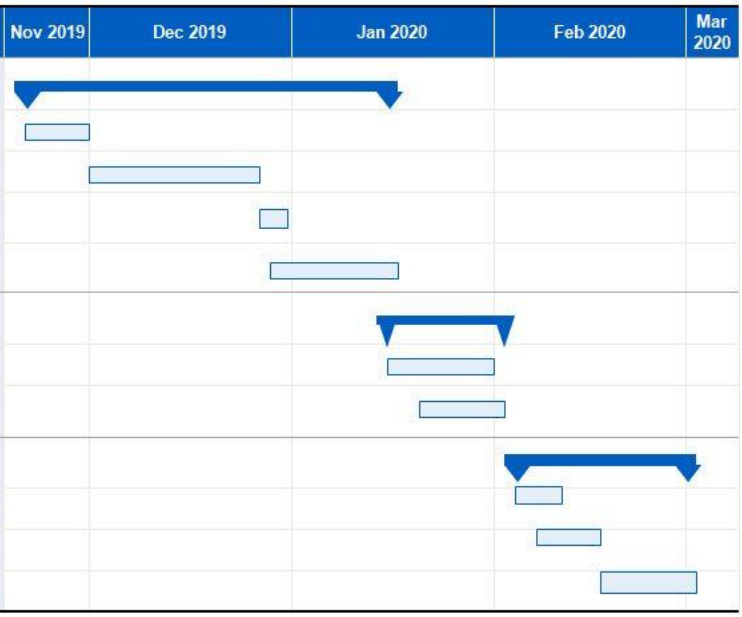


GANTT CHART:

WBS ID	Start – End Date	Status	Duration
1.1	Sep 10 – Sep 20	100%	10
1.1.1	Sep 10 - Sep 19	✓	10
1.1.2	Sep 16 - Sep 19	✓	04
1.1.3	Sep 17 - Sep 20	✓	04
1.2	Sep 21 – Nov 01	100%	42
1.2.1	Sep 21 - Oct 02	✓	12
1.2.2	Sep 26 - Oct 09	✓	14
1.2.3	Sep 30 - Oct 09	✓	10
1.2.4	Oct 03 - Oct 06	✓	04
1.2.5	Oct 05 - Oct 23	✓	19
1.2.6	Oct 23 - Nov 1	✓	10
1.2.7	Oct 30 - Nov 1	✓	03
1.3	Nov 2 – Nov 20	100%	19
1.3.1	Nov 2 - Nov 11	✓	10
1.3.2	Nov 3 - Nov 18	✓	16
1.3.3	Nov 14 - Nov 20	✓	07



WBS ID	Start – End Date	Status	Duration
1.4	Nov 21 – Jan 15	0%	55
1.4.1	Nov 21 - Nov 30	⚠	10
1.4.2	Dec 01 - Dec 20	⚠	20
1.4.3	Dec 20 - Dec 31	⚠	12
1.4.4	Dec 26 - Jan 15	⚠	20
1.5	Jan 16 – Feb 01	0%	17
1.5.1	Jan 16 - Jan 30	⚠	15
1.5.2	Jan 20 - Feb 01	⚠	13
1.6	Feb 02 – Mar 01	0%	29
1.6.1	Feb 02 - Feb 08	⚠	07
1.6.2	Feb 04 - Feb 13	⚠	10
1.6.3	Feb 14 - Mar 01	⚠	17



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[1] Galileo european global navigation satellite system [Online] Available at:. https://www.gsa.europa.eu/ european-gnss/galileo/galileo-european-global-satellite-based-navigationsystem.

[2] Global positioning system [Online] Available at:https://www.intechopen.com/books/NewApproach-of-Indoor-and-Outdoor-Localization-Systems.

[3] Loco guided video [Online] Available at:.https://www.youtube.com/watch?v=bjbSwUveuXs.

[4] Beenish Ayesha Akram, Ali Hammad Akbar, and Ki-Hyung Kim. Censloc: Infrastructure-less indoor localization methodology using gmm clustering-based classification ensembles. Mobile Information Systems, 2018, 2018.

[5] Matthew Cooper, Jacob Biehl, Gerry Filby, and Sven Kratz. Loco: boosting for indoor location classification combining wi-fi and ble. Personal and Ubiquitous Computing, 20(1):83–96, 2016.