Movers Software Specification Document

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February 2018

1 Introduction

1.1 Purpose

The purpose of this document is to describe the implementation of Movers system which is designed for indoor navigation inside different retail's world-wide.This software specification document highlight and defines the functional requirement and how they work in order to give a software development team overall guidance to the architecture and design of the system. [14]

1.2 Scope

The proposed system is an indoor positioning system within a supermarket using both Bluetooth and Wifi.A navigation system that can provide positioning functionality which is beneficial to both customers and supermarkets. A system that will reduce the amount of time spent shopping for groceries in a large retail store by guiding a customer through an optimal and shortest path to travel in order to obtain their needed products.Moreover, movers is designed to support real time tracking and classifies customers and products inside a retail in order to give best recommendations for daily clients and help in managing the product's promotions thus that would increase the marketing strategy of the retail through the facility of indoor positioning. [8]

1.3 Overview

There has been an upward trend in the requirement of indoor positioning systems as people spend a lot of time in indoor places, its a concern now for people and service providers to get exact indoor positioning information.Nowadays location predicated techniques are utilized in various fields such as traffic navigation, map accommodations, health-care ,manufacturing, and airports.There are many technologies to get indoor location information like Wifi,Bluetooth,Radio Frequency Identification.[10] Regardless the importance of IPS there is no a standard principle for IPS techniques.Thus,this proposed project will focus on

improving the performance of indoor positioning systems by enhancing its accuracy.This document introduces "Movers" a mobile application that supports indoor localization within different retails worldwide to give customers a better navigating while shopping in order to find their products faster,take advantages of offers, promotions and optimize their shopping time through the application. Movers will be focusing on improving the indoor localization by using both Wifi access points and Bluetooth beacons in order to achieve better accuracy that will be reflected to the customer while navigating. [11]

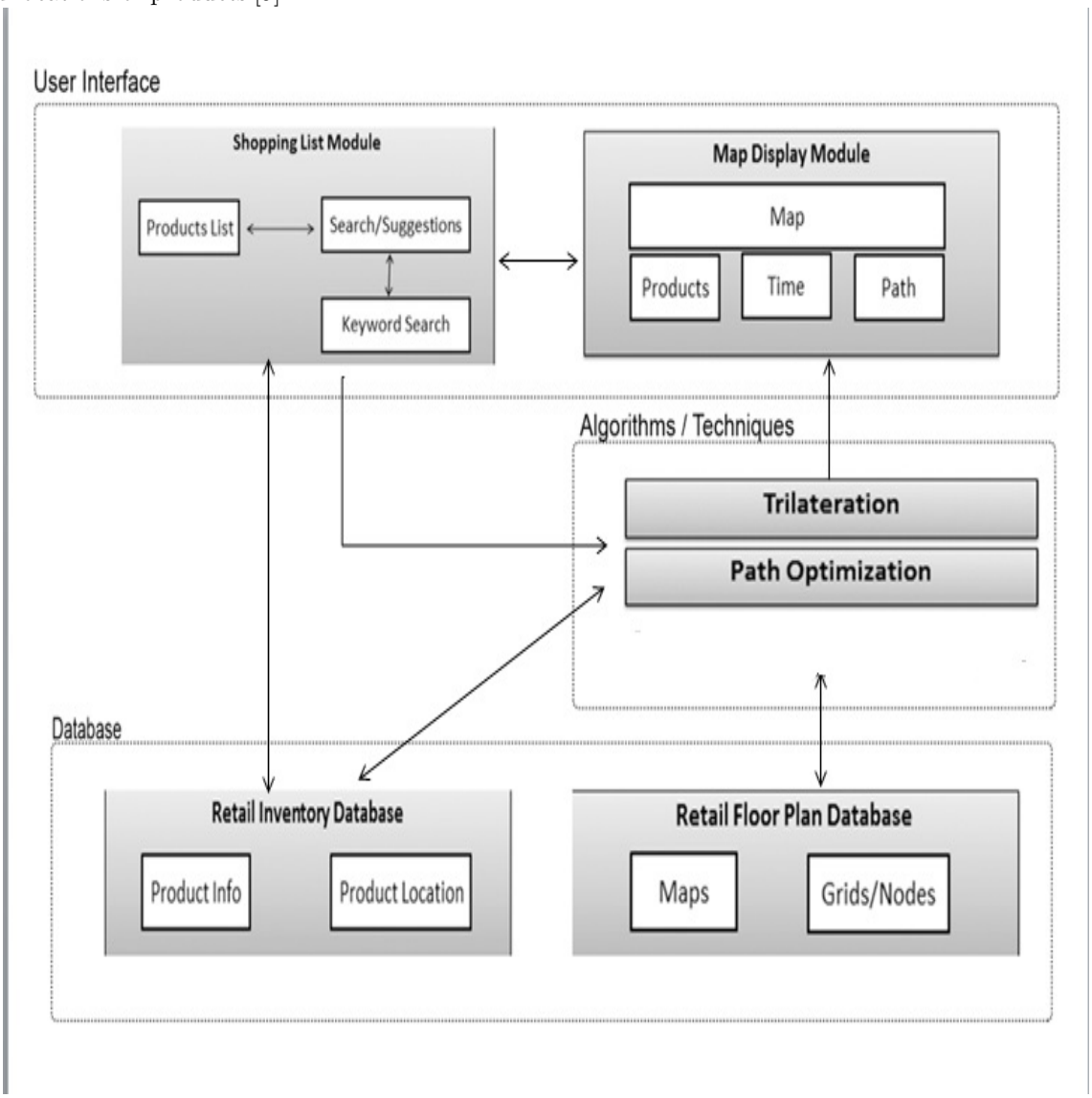
1.4 Definitions and Acronyms

1. Android Studio - An integrated development environment (IDE) for Android platform development.[4]
2. Google Maps API - and API that allows using the google maps functionality elsewhere.[6]
3. MySQL - an open source relational database management system (RDBMS) based on Structured Query Language (SQL).
4. IPS - Indoor Positioning System.
5. Floyd–Warshall - An algorithm for finding shortest paths in a weighted graph,single execution of the algorithm will find the lengths (summed weights) of the shortest paths between all pairs of vertices.
6. A* - Algorithm that is used in path-finding and graph traversal, the process of plotting an efficiently directed path between multiple points.[5]
7. Estimote Indoor Location SDK.: locate users precisely, watch their real-time position on a floorplan, collect attendance data, or deliver way-finding instructions
8. Estimote Location Beacons: They are the next generation of beacons with several improvements compared to Proximity Beacons, including multiple packets support, enhanced conditional broadcasting, GPIO support, support for Indoor Location SDK, and improved battery life (up to 7 years). They even have a long range, up to 200 meters. They are the way to go for more complex deployments when more precise location information is needed. [1]

2 System Overview

Our system consists of three components.The user interface,algorithms, techniques, and database.The user interface consists of a shopping list module and a map module which allows the user to input or search for his desired products and view the map respectively.The search results access the trilateration technique in order to locate the user indoor location and each product sections

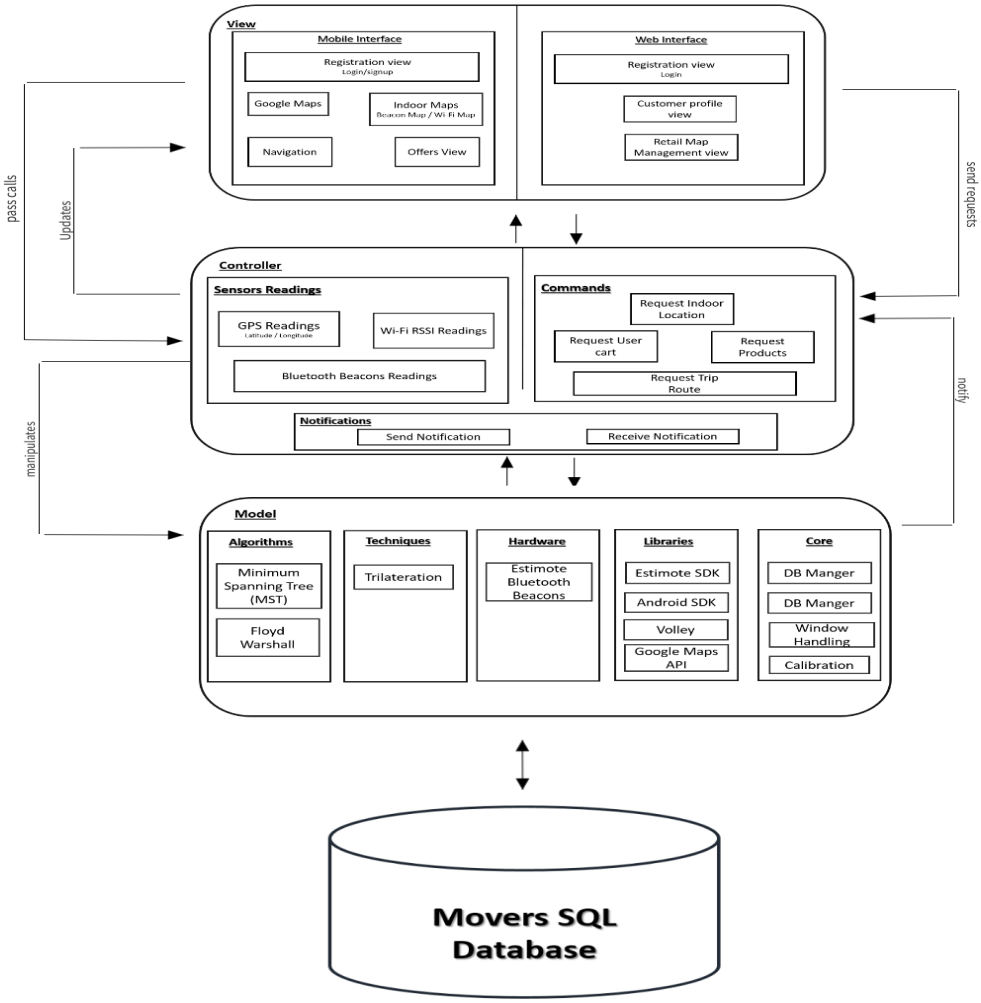
and this data is processed by path optimization algorithms in order to give a shortest path to the user from his indoor location to the product. The database component contains Retail's inventory and Retail's floor plan modules. The Retail's inventory modules interact with the keyword search by gathering the product information and their respective location. The Retail's floor plan modules provide information to the path optimization algorithm to generate maps and locations of products.[9]



System Overview Diagram

3 System Architecture

3.1 Architectural Design



MVC Architecture Diagram

The architecture diagram is based on Model–view–controller (MVC) it divides an application into three interconnected parts.

3.1.1 View

A view is the representation of information,triggered by a controller's decision to present the data.It represents users interface here; it is divided into two interfaces. One is an admin web interface and one is mobile application interface for the user.

- Admin Interface: Consists of web screens that allow the admin to control the whole system:
  - Allow admin to login to the system.
  - Allows the admin to view the customers profiles to extract data from it to use it latter in products recommendations and offers.
  - View the indoor map (supermarket map) to track the user's position inside.
  - View and control the retail map which shows the organization of products location in the supermarket in-case of any changes in the arrangement.
  - Make the admin able of viewing a heat-map that shows places where crowd most centralize in the supermarket by customers.
- User Interface: Consists of android screens that:
  - Allows the user to sign-up/login.
  - Locate user's position globally.
  - Locate user's position inside the supermarket.
  - User will choose his desired products.
  - Help user to navigate through his products list in the minimized route.
  - Provide him with products rating/recommendations based on his indoor location.

3.1.2 Model

The model is the central component of MVC pattern. It expresses the application's behavior in terms of the problem domain. It directly manages the data, logic and rules of the application.It is responsible for managing the data of the application by responding to the request from the view and, it also responds to instructions from the controller to update itself.

- Estimote SDK: it is the sdk of our used hardware device (estimote beacons) in order to use it in indoor localization to be presented on mobile app.
- Android SDK: Movers has an android based mobile application which is the users' interface; it is android platform, then it requires the Android SDK to be able to perform the functionalists on the android devices and use the sensors.

- Volley:it is used for interacting with the database.
- Google Maps API: Google Maps is a web mapping service developed by Google. It offers satellite imagery, street maps, 360 panoramic views of streets.

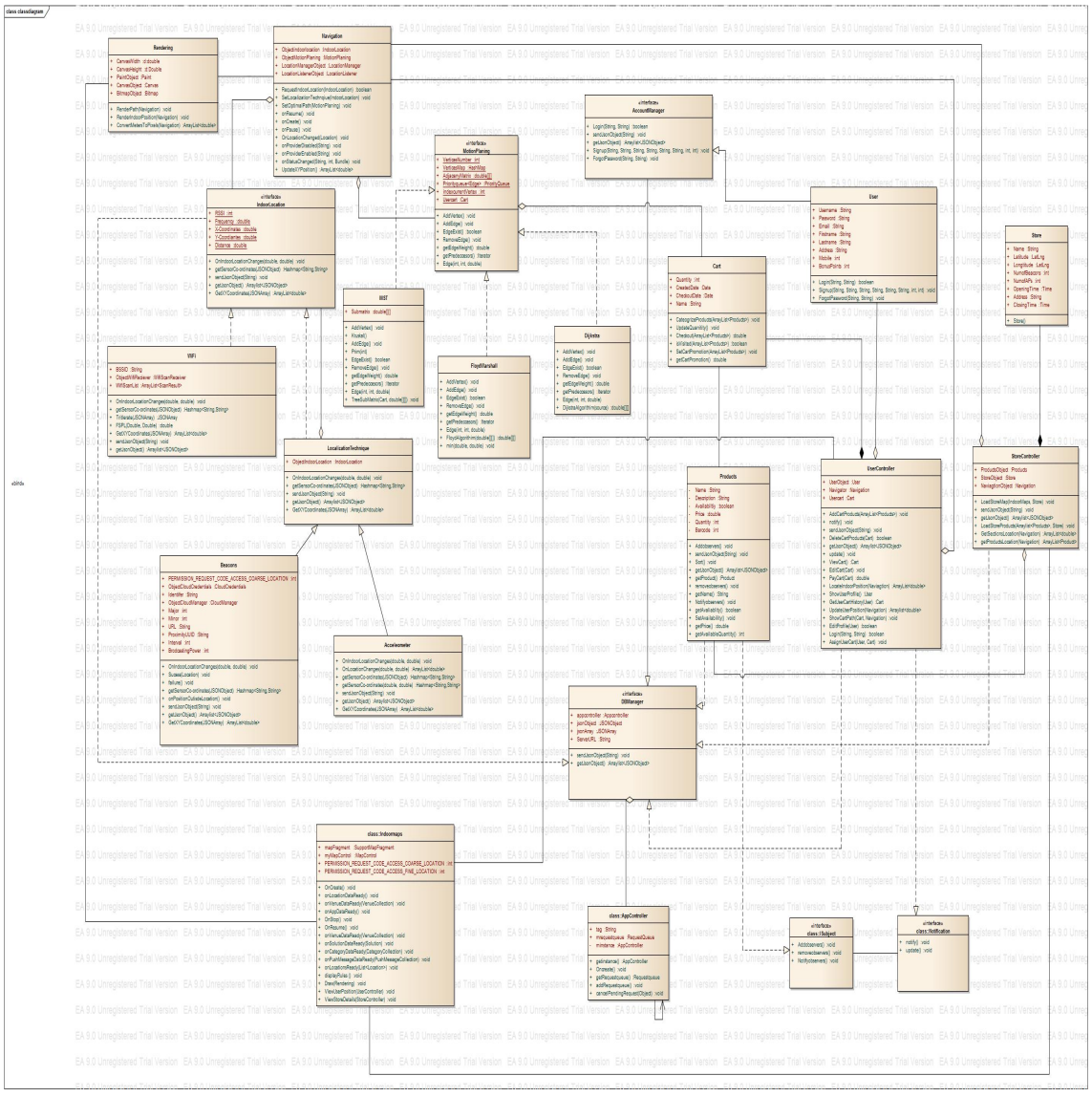
3.1.3 Controller

The controller accepts input and converts it to commands for the model or view, and it is responsible for responding to the user input and perform interactions on the data model objects, it also receives the input and validate it, then performs the operation that modifies the state of the data model.

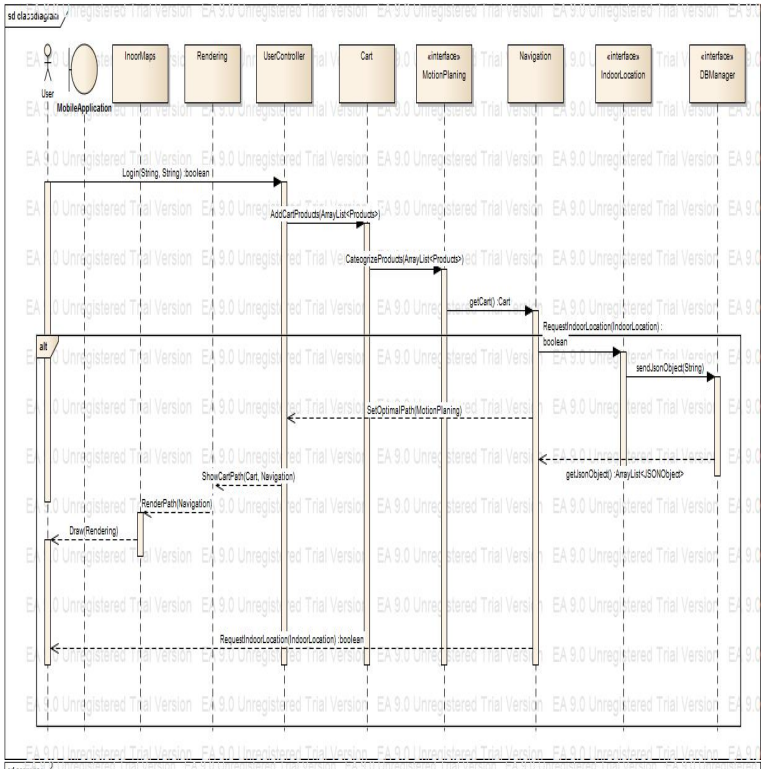
The controller in Movers system combines between the model and the view, it handles the input data from the view that comes from the hardware devices like the WIFI RSSI reading and Bluetooth Beacons readings that is responsible to determine the user's indoor location, sends it to database and retrieves data from model and sends it to the view to preview the user indoor location and the shortest path.

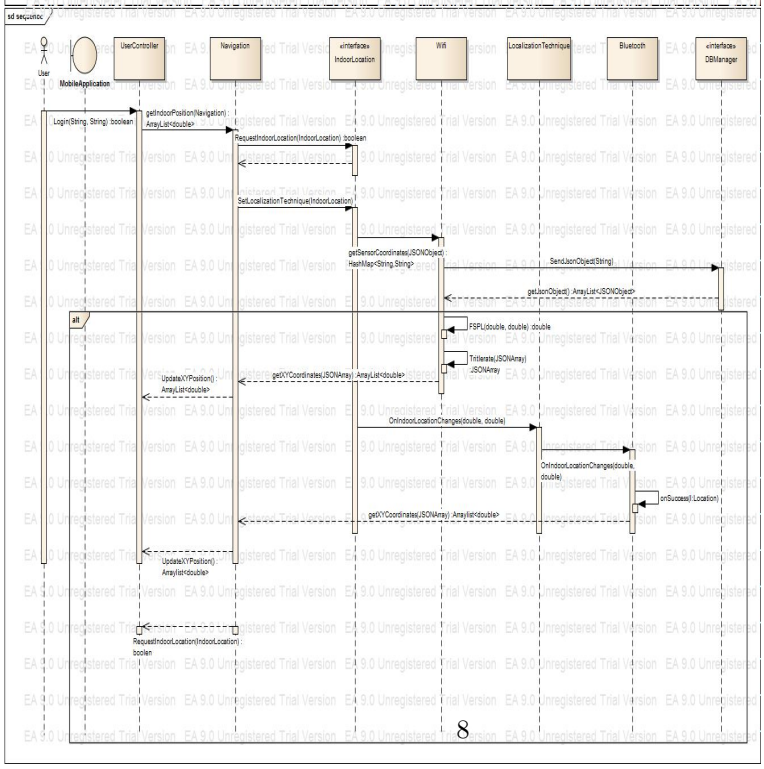
3.2 Decomposition Description

3.2.1 class Diagram

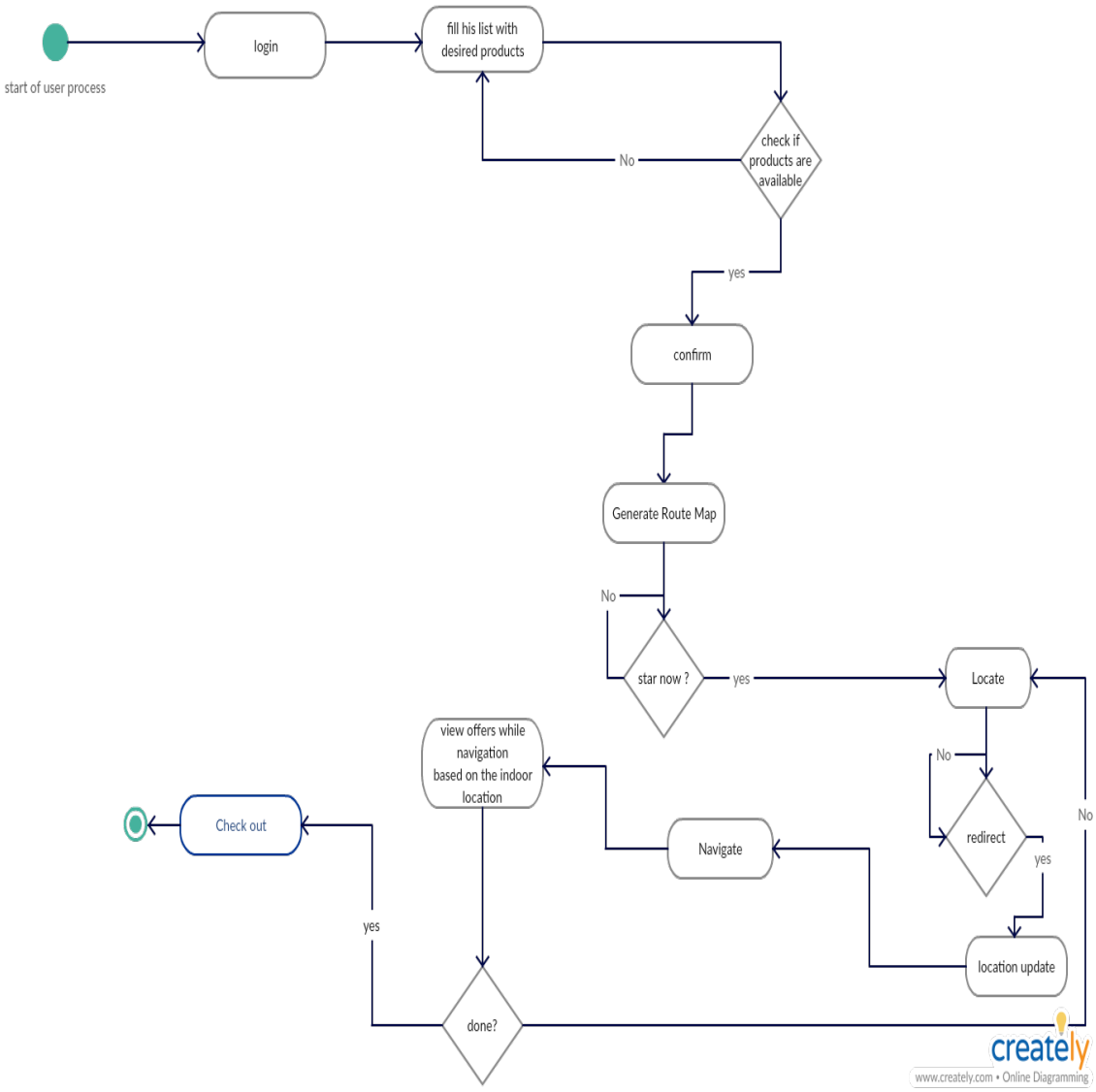


3.3 Sequence Diagrams





3.3.1 Activity Diagram



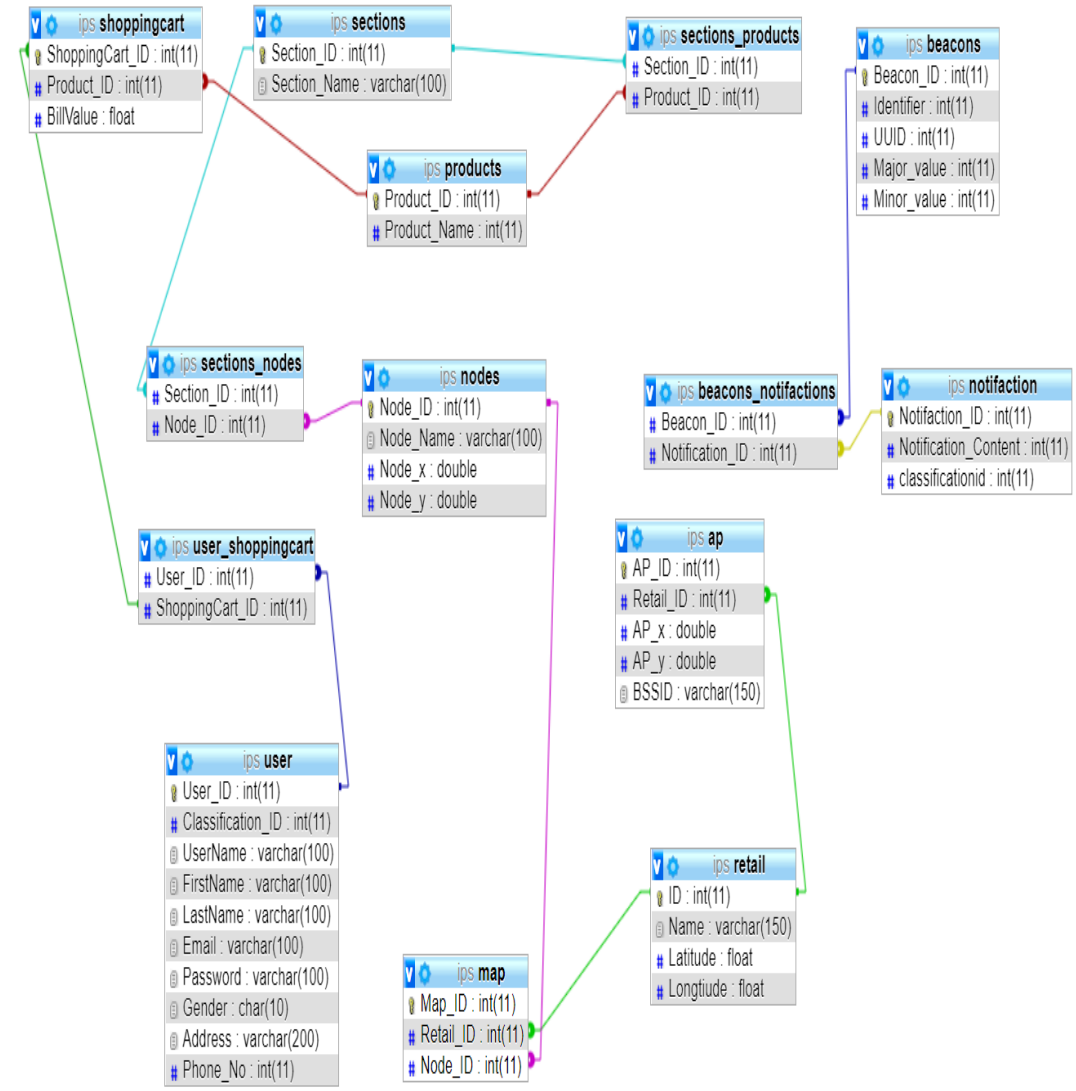
3.4 Design Rationale

Since Movers is based on MVC, it's architecture diagram is in the MVC form. MVC is the separation of Model, View and Controller classes. Main advantage

of MVC architecture is differentiating the layers of a project in Model,View and Controller for the Re-usability of code and better maintenance.[2]

4 Data Design

database

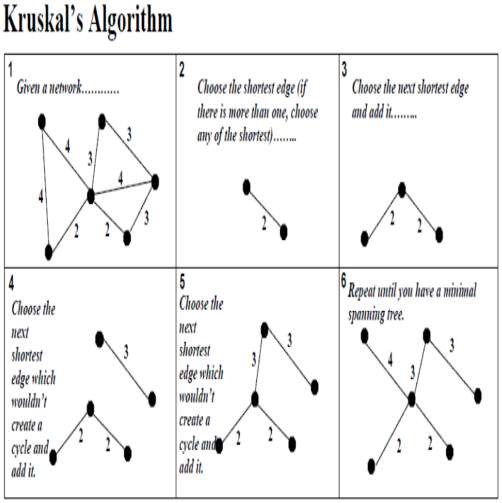


5 Component design

5.1 Navigation Route Algorithms

5.1.1 A minimum spanning tree (MST)

A minimum spanning tree (MST) or minimum weight spanning tree is a subset of the edges of a connected, edge-weighted (un)directed graph that connects all the vertices together, without any cycles and with the minimum possible total edge weight. That is, it is a spanning tree whose sum of edge weights is as small as possible. More generally, any edge-weighted undirected graph (not necessarily connected) has a minimum spanning forest, which is a union of the minimum spanning trees for its connected components. Movers will use MST in order to find a navigation route along certain path which will be based on customer product list as the MST is the optimal solution to make the customer pass by all sections in the customer's desired product list; there will be graph representing (sections of products) connected by this path to represent all sections.[3]



5.1.2 Floyd - Warhall

The Floyd-Warshall is an algorithm for finding shortest paths between a weighted graph with high-quality weights. Floyd-Warshall computes the shortest distances among each pair of vertices among the entered graph. The algorithm relies on the principle of dynamic programming; all possible paths between pairs of nodes are being compared and only keeps the shortest path found shortest Path (i, j, k) = min (shortest Path (i, j, k), shortest Path (i, k + 1, k) + shortest Path (k + 1, j, k)). Movers will use Floyd – Warhall to find navigation route in pairs from a single source node to a single destination. [13]

- Movers will use two algorithms for path finding; the minimal spanning tree

to find the optimal route which will pass by all sections in the customers list. Floyd will be used to find the rout between products in its section.

- For example, MST is responsible for finding route between (Frozen, beverages, electronics, dairy and cereals) sections but Floyd is responsible for finding route between soda, water and juice in the beverages section.

5.2 Trilateration

We have chosen the tritleration technique to be able to locate a certain device in an indoor location.Trilateration method is used to determine the relative location of user by measuring distances using geometry.The distances are calculated using various signal measurement techniques such as Received Signal Strength(RSS), Time of Arrival (ToA), Time Difference of Arrival(TDoA).Atleast three wifi Aps are needed to form a circle equation:

$$(x + A_x)^2 + (y + A_y)^2 = d^2$$

Subtracting three circles would give a linear equation which crosses their intersections in one point.Calculating the intersection of three of these linear equations gives the X value of the devices position in between the access points.Additionally this value can then be inserted in one of two linear equations to get the corresponding y-value.

$$X = \frac{\left(\frac{A_x^2 + A_y^2 - B_x^2 - B_y^2 - d_a^2 + d_b^2}{2(A_y - B_y)}\right) - \left(\frac{A_x^2 + A_y^2 - C_x^2 - C_y^2 - d_a^2 + d_c^2}{2(A_y - C_y)}\right)}{\left(\frac{C_x - A_x}{A_y - C_y}\right) - \left(\frac{B_x - A_x}{A_y - B_y}\right)}$$

The Trilateration technique is used in our system to locate users inside the retail.To give an enhanced accuracy of our indoor positioning system it supports the use of Bluetooth beacons between two shelves to give a better navigation

experience to the user and navigate him to the certain destination that he chose. Here are the results below while testing and which showed that using Bluetooth and Wifi gives better accuracy. [12]

5.3 Estimote Location Bluetooth Beacons

Indoor Location is about replicating the GPS technology, but indoors, where there's no satellite coverage. Put up a whole bunch of Location Beacons throughout the space, and they will automatically map it out and create a floor plan—courtesy of the UWB radio they're equipped with, and Estimote Automapping technology. Android apps gain access to precise indoor (x,y) coordinates of the device. [7]

```
IndoorCloudManager cloudManager = new IndoorCloudManagerFactory().create(applicationConte
cloudManager.getLocation("my-kitchen", new CloudCallback<Location>() {
    @Override
    public void success(Location location) {
        // store the Location object for later,
        // you will need it to initialize the IndoorLocationManager!
        //
        // you can also pass it to IndoorLocationView to display a map:
        // indoorView = (IndoorLocationView) findViewById(R.id.indoor_view);
        // indoorView.setLocation(location);
    }

    @Override
    public void failure(EstimoteCloudException e) {
        // oops!
    }
});
```

6 Human Interface Design

6.1 Overview of User Interface

Since there is a web interface for the admin, and an android based mobile application for the user; therefore, we have two different user interfaces.

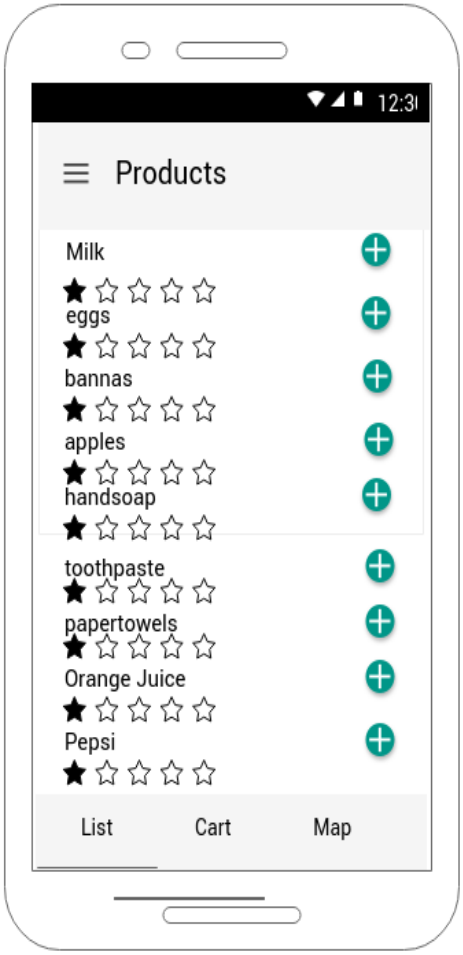
- Admin Web Interface: The admin will be given his/her account to be able to log in. once logged in, he will have multiple options.Beacons screen

which will allow him managing them. Also screen which will him managing the offers. screen that controls the nodes arrangement on the indoor map in case of any changes.

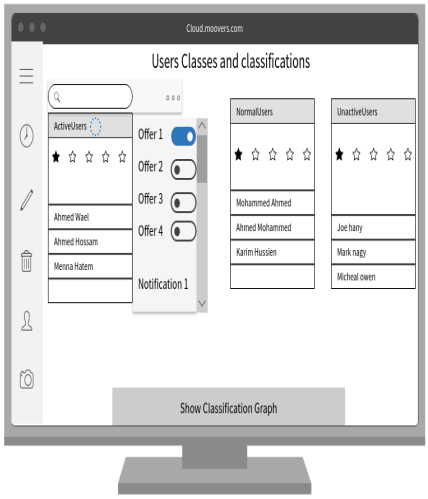
- User Android Application Interface: The user will be able to log in to his/her account and will be shown 2 screens one to choose his products list and the another is navigating.

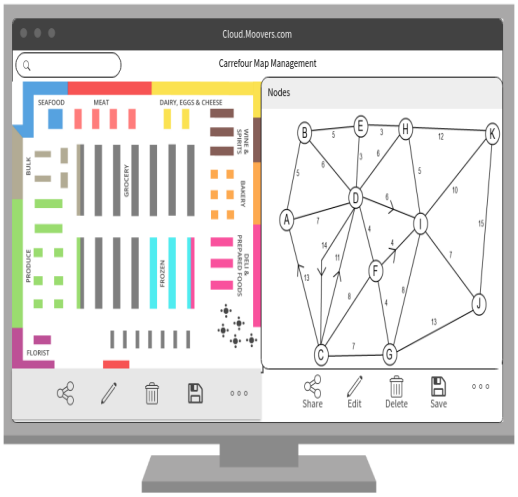
6.2 Screen Images

6.2.1 User Mobile Application

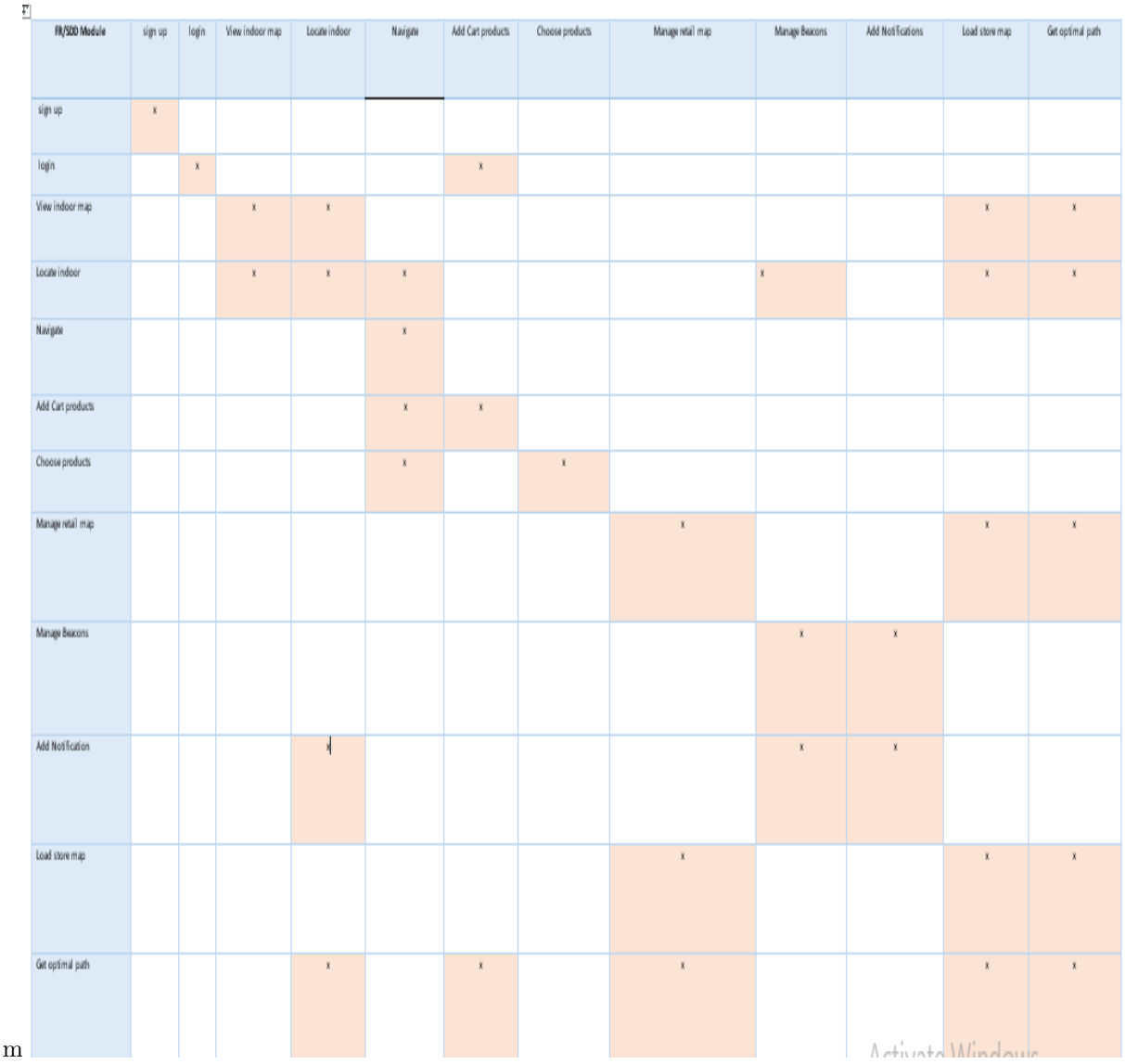


6.2.2 Admin Web Application





6.3 Requirement Matrix



FR/SDD Module	sign up	login	View indoor map	Locate indoor	Navigate	Add Cart products	Choose products	Manage retail map	Manage Beacons	Add Notifications	Load store map	Get optimal path
sign up	x											
login		x				x						
View indoor map			x	x							x	x
Locate indoor			x	x	x				x		x	x
Navigate					x							
Add Cart products					x	x						
Choose products					x		x					
Manage retail map								x			x	x
Manage Beacons									x	x		
Add Notification				x					x	x		
Load store map								x			x	x
Get optimal path				x		x		x			x	x

7 References

References

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