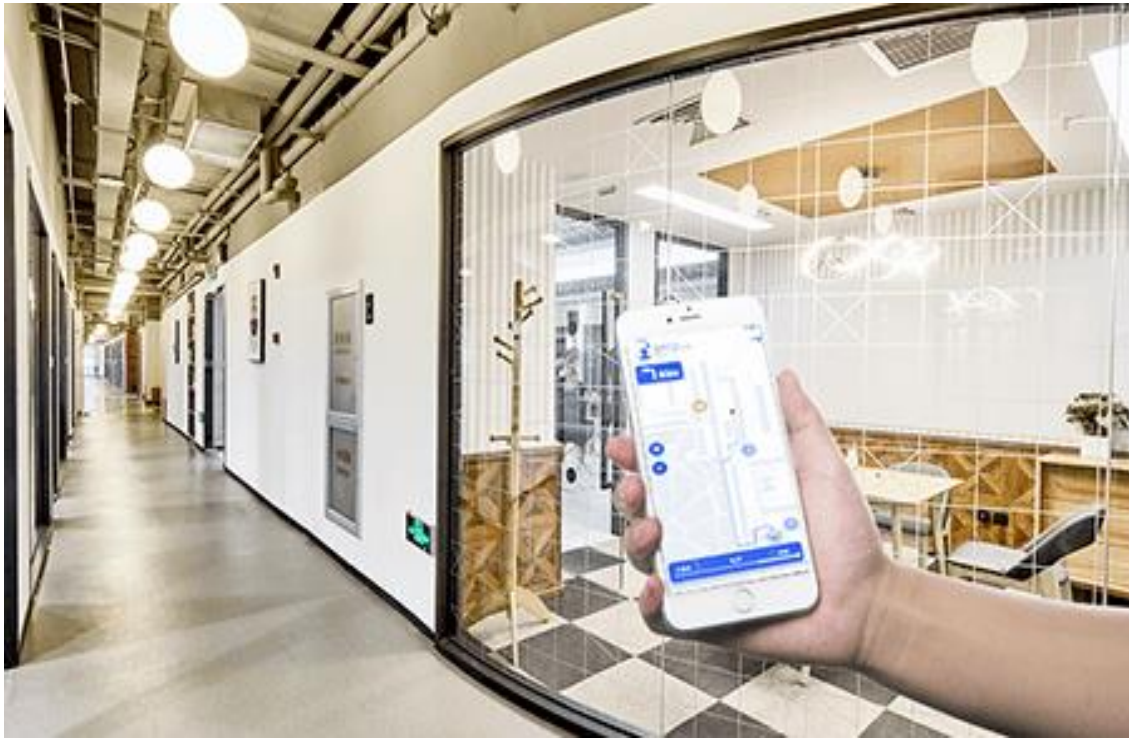


## GAO BLE Positioning & Navigation (BPN) System Description



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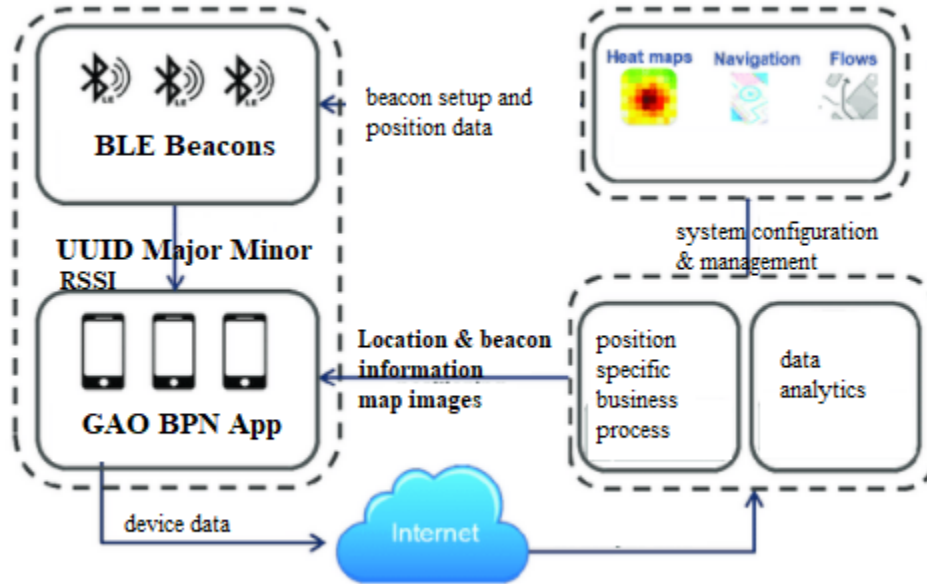
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## 1. Introduction

GAO BPN (BLE Positioning & Navigation) System provides position and navigation solutions based on the Bluetooth Low Energy and cellphone technologies. The position of a user/asset identified by the cellphone device is determined by the beacon positions in the location map. The device position in the location is determined by the scanned BLE messages and measured signal strength, aka received signal strength indicator (RSSI).

GAO BLE system can be used to provide indoor location positioning, navigation guidance to users on smartphone devices and user position tracking for events and trade shows. The system visualizes indoor floor plans and points of Interests with customizable images for floor plans, points of interests and direction pointers.

System administrators can manage and configure the system, view user activity report on the cloud with web browser interface.



**System Context Diagram**

- The Internet - the system works on the internet environment where GAO BPN smartphone app installed on the user cellphone and GAO BPN server deployed
- BLE beacons - an array of beacons installed on the location, e.g. a floor. Beacons should be configured by system administrator with coordinates for a specific point of interest for a location
- GAO BPN app - Android or iOS app, the Android APK developed with Kotlin programming language installed on the Android smartphone which receives broadcast messages from the BLE beacons.
- By communicating with server, the app downloads a subset of system database and installed on the device local embedded database, the app calculates device position and navigation guidance information to the user.
- GAO BPN server - A cloud server supports HTTP/HTTPS and REST services with CRUD APIs for users, beacons, locations, point of interests, etc.
- System configuration and management by authorized administrators - provide beacons location setting and coordinates, etc.

## 2. Use Cases and features

In general, the system can be used by 1) consumers as a position and location mobile application which allows users to locate where they are and help them navigate to the targeted point of interest and 2) by business as event tracking system which allows participants to register to events and their activities will be reported to the business owners.

Different from GPS position and navigation system, GAO BPN system is designed to provide position and navigation services with Bluetooth Low Energy technology with BLE beacons deployed in the targeted locations. A BLE beacon's position in the location will be used to estimate the user position, i.e., the cellphone device position in the current location. System uses beacons' position information and received beacon signal to calculate the device physical coordinate on the location and display the user location on the location floor plan.

The system supports the following use cases:

#### Beacon system timer

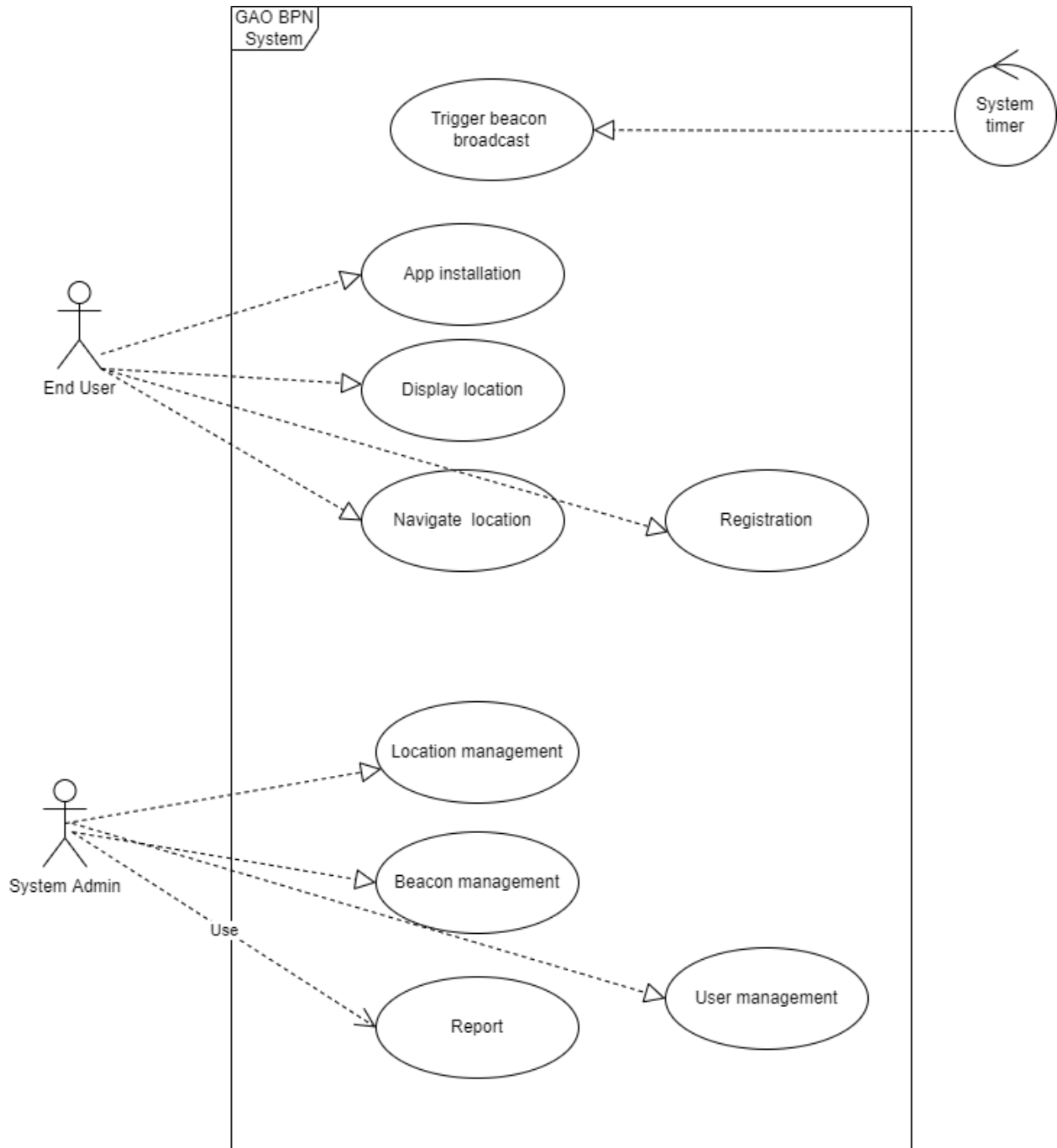
- Broadcast every 20 (or configuration with specific environment) ms with MAC address and RSSI. BLE broadcast can be received by device with BLE scan APIs and there is no connection required between BLE beacon and device

#### End users:

- Download and install GAO BPN on smartphone - a one off activity
- User registration
- Select location – select a location from the location list panel. A system may be configured with many location plans with map images
- Display position - start the app and show the current position in the location map
- User gets location specific information, such as map, name, details, zoom in with lower level on the smartphone
- Navigate - display a navigation map with directions
- Every time the device scans the beacon messages, it will send a short message to the server with the device ID, beacon ID and RSSI – a feature required for event tracking
- Logout system

#### System administrator:

- Location management, populate location parameters, building, floor, set images for location
- Beacon management, broadcast interval, coordinates, relative position in the location map
- Read reports, Data Analytics
- System configurations, such as SMTP server for notification, alert message
- User management – registration, etc..
- View business reports with registered user information based on the device ID, where and when – this could be used for event user tracking, attendance, etc.

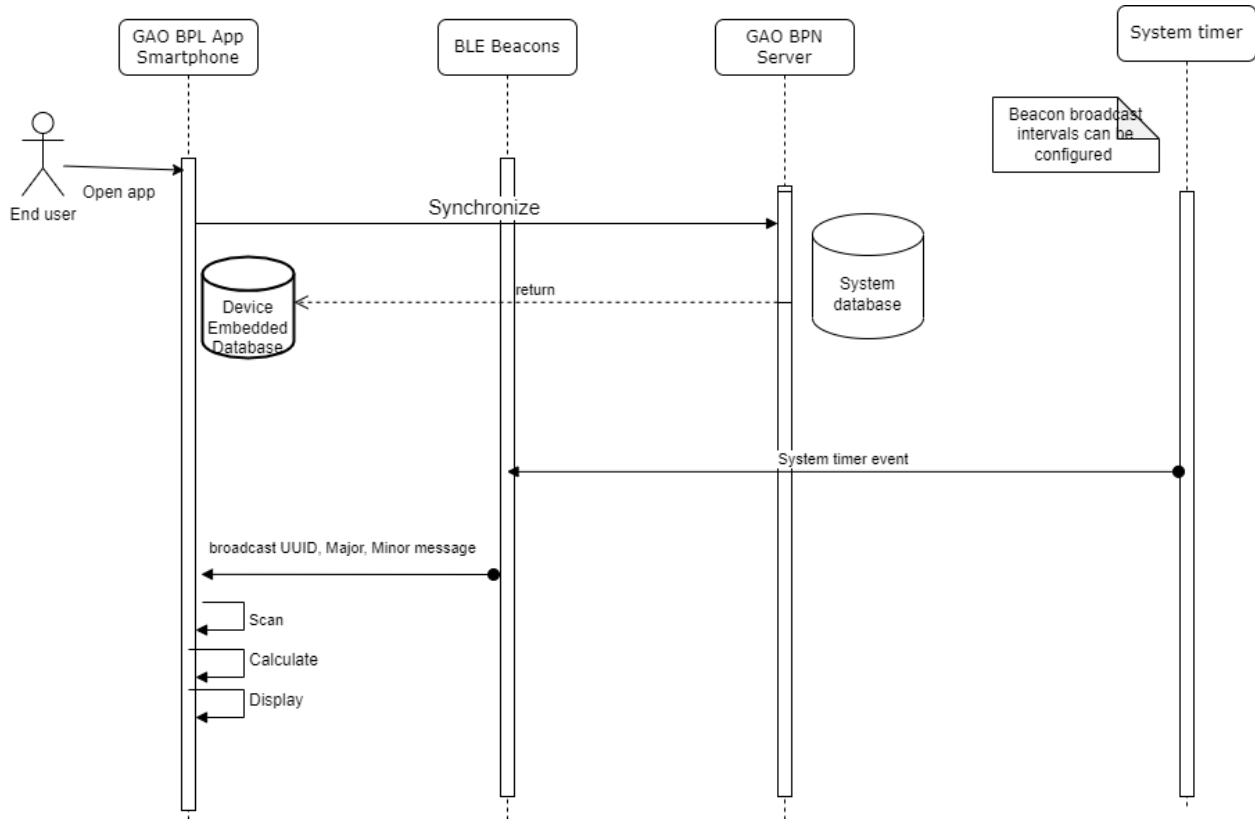


**GAO BPN Use Case Diagram**

### 3. Sequence diagrams & system interactions

#### 3.1 Display Position

After a user open the BPN App, the system will calculate the device position based on the broadcast messages (beacon MAC address and RSSI) received from the beacons deployed on the location and display the current location on the map image.



**Display Position Sequence Diagram**

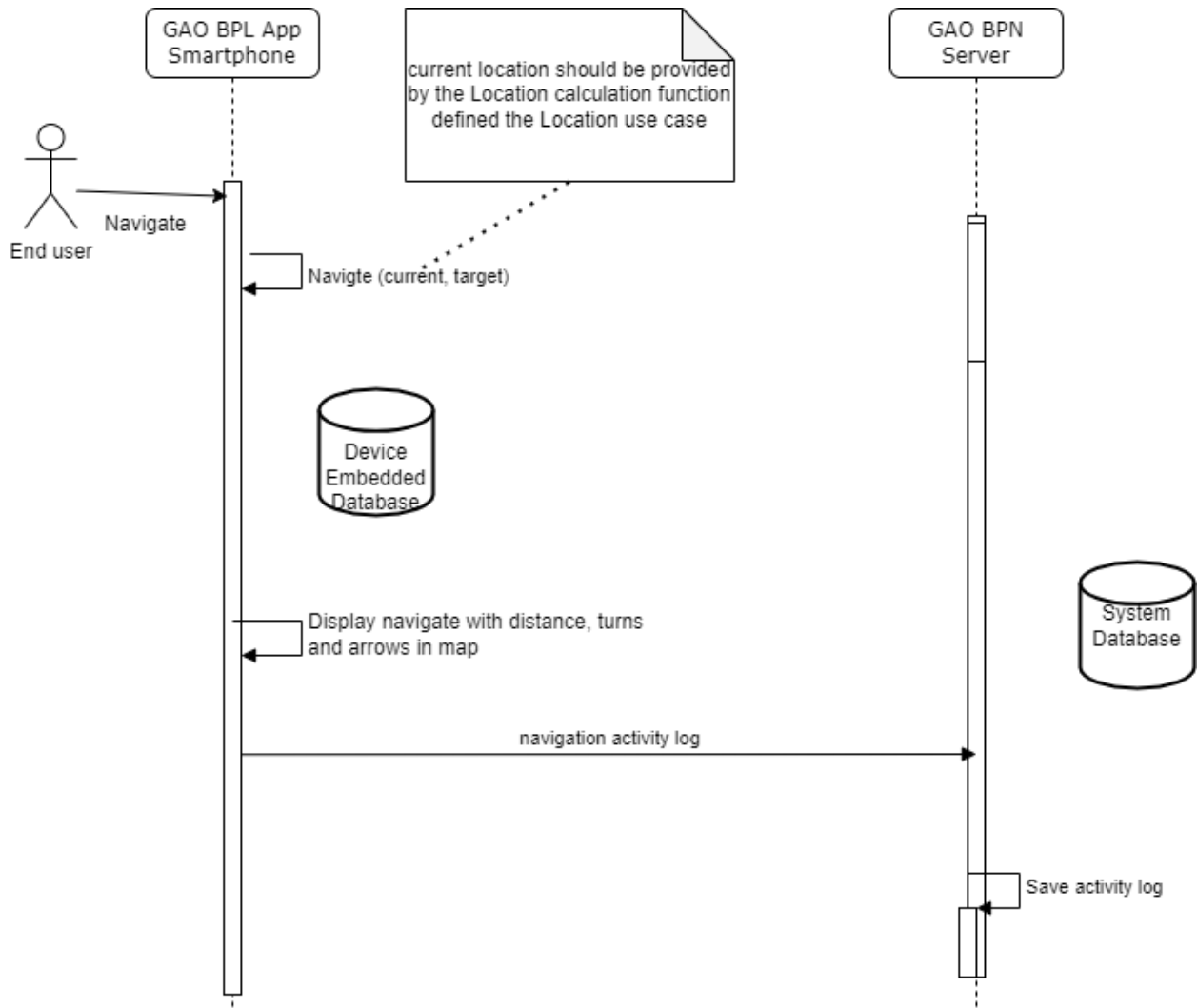
- Open app - end user launches the GAO BPN App from the smartphone device
- Synchronize - GAO BPN App call GAO BPN REST service to synchronize device embedded database<sup>1</sup> with the server database. If the data is synchronized successfully, set the App to Ready status, with locations, beacons information
- System timer triggers BLE beacon broadcast event, beacon device sends broadcast messages with MAC address and RSSI
- Scan - the App scans beacon broadcast message, gets MAC address, RSSI signals
- Calculate – calculates device position with MAC address and RSSI with refereeing embedded database for location and beacon configuration information

<sup>1</sup> Embedded database should be a subset of the server database with location information, beacon configuration, etc.

- Display - the App displays device position on the map image. Location image map should be provided in the embedded database

### 3.2 Navigation

After a device location has been identified by the system, the user may select a target destination on the location map. The system will provide directions with distance, turns and arrows to help user navigate to the target location. Navigation can be dynamically adjusted based on the user current position.

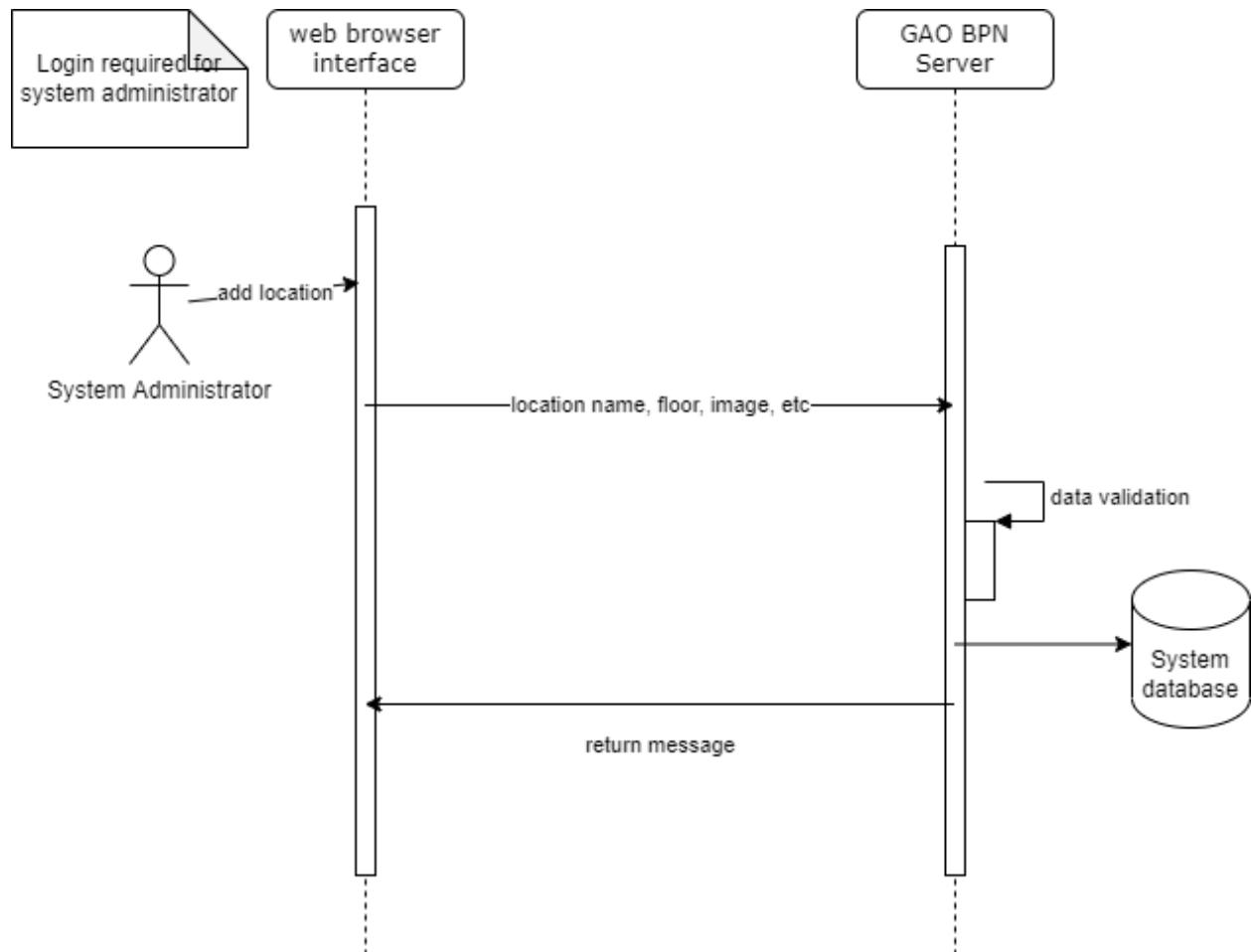


**Location Navigation Sequence Diagram**

### 3.3 System Administration

A location object is identified with a location name with a unique location ID, a location can be associated with multiple sub areas (e.g., a building may have multiple floors), and a sub area can have multiple points of interest. name and location map image.

System administrators can manage with CRUD operations for locations, sub locations, points of interest and user accounts from the web browser interface.



**Location Management Sequence Diagram**

- Add location – from the browser interface, system administrator (authentication required) input location information: name, floor, image map, etc.
- Send request to the server to add the location
- After validation, server persists the location information to the database
- Return the request with status.



### 3.4 Beacon Management

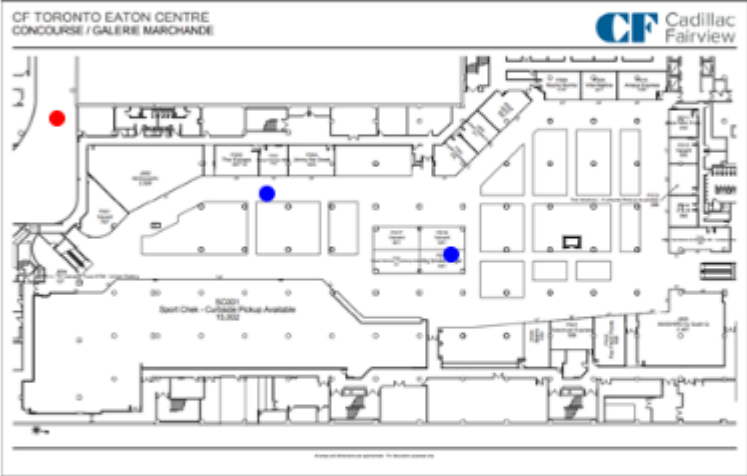
This feature is an extension to the current GAO RFID web server code 3.x. The system administrators can login to the server and add BLE Beacons to specified locations. The beacon will be deployed to the position based on the floor image with the referenced “red” dot (●). X position and Y position will be converted into real world distance in the graphic coordinates with top left corn as the point of origin:

**Add New Tag** ✕

Beacon ID

Location  ▼

Select a floor  ▼



X Position

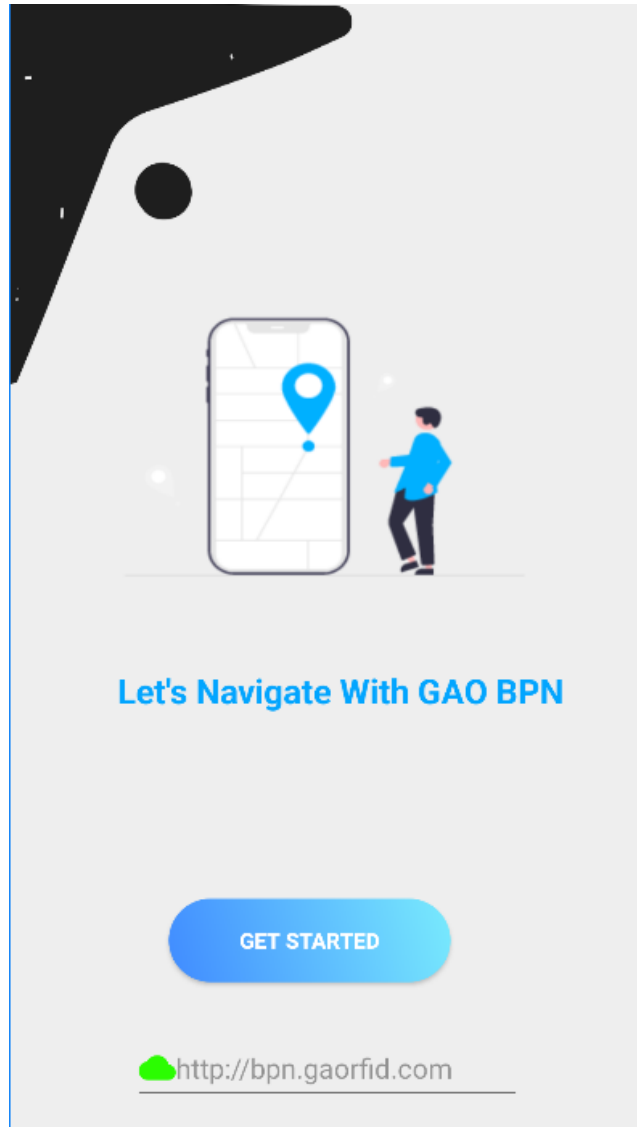
Y Position

Comment

The blue dots (●) in the image are deployed BLE beacons in the system.

## 4. BPN App User Interface Design

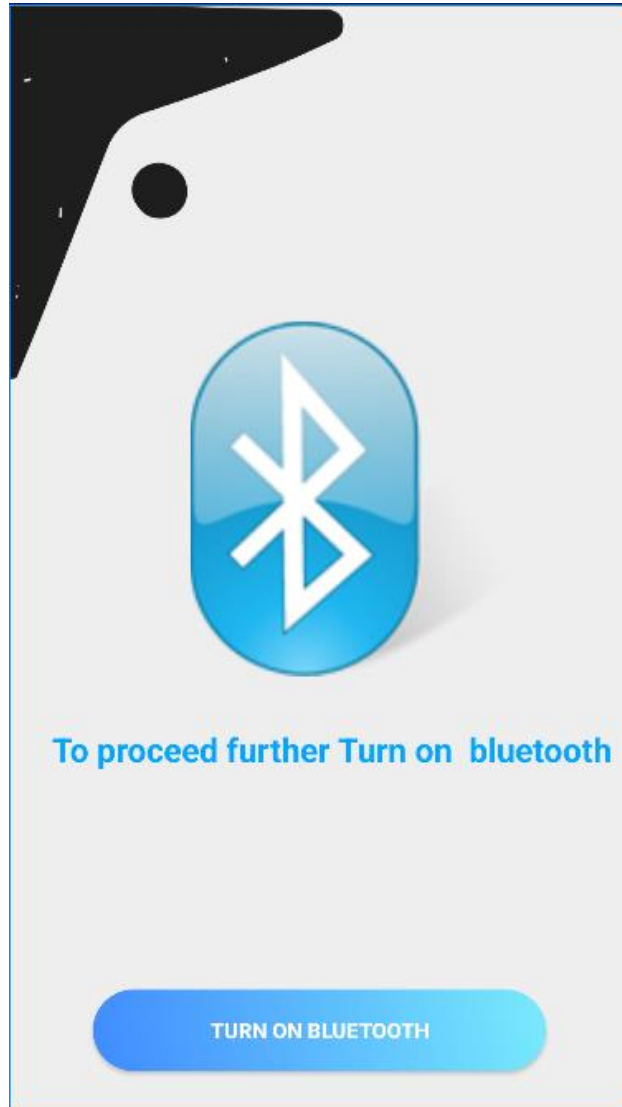
### 4.1 Home Panel



The initial panel after user launched the application from the device, by default, there is a server URL will be provided in the Server URL field. If the user wants to synchronized the device data with the GAO BPN server, he/she may check the box and device will refresh the local data with the server.

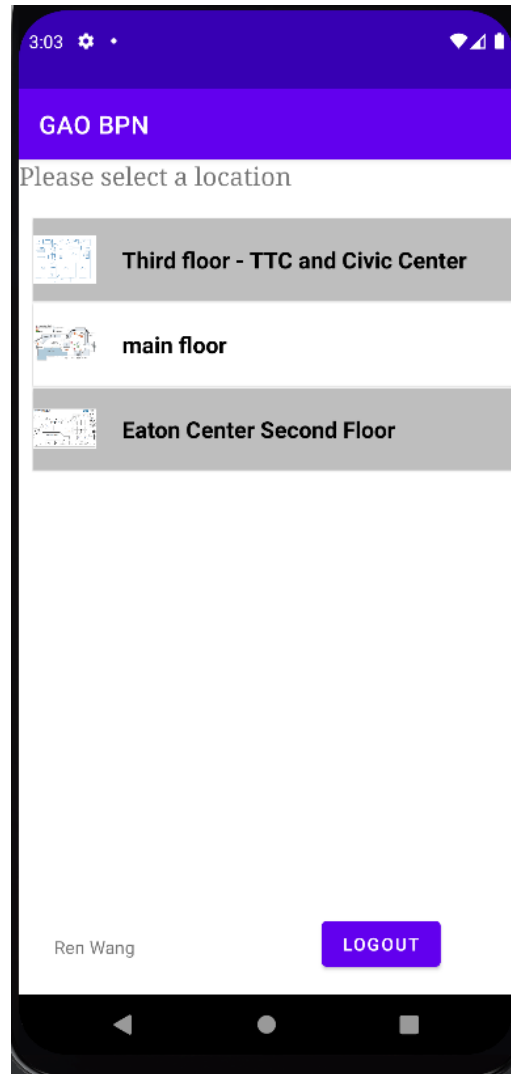
If the user has signed in before, the system will launch the Location List panel, if it is the first time, the system will launch user Sign in/Sign on panel.

## 4.2 Enable Bluetooth Panel



The panel will be displayed if the Bluetooth is disabled on the device. If the user clicks on the Turn On Bluetooth button, the Bluetooth scan feature will be enabled, the system will display the Location List panel.

### 4.3 Location List Panel



If the user has selected a location from the list box, the location panel will be displayed with the floor map image. The user may click on the Logout button to logout from the system.

## 4.4 Location Panel



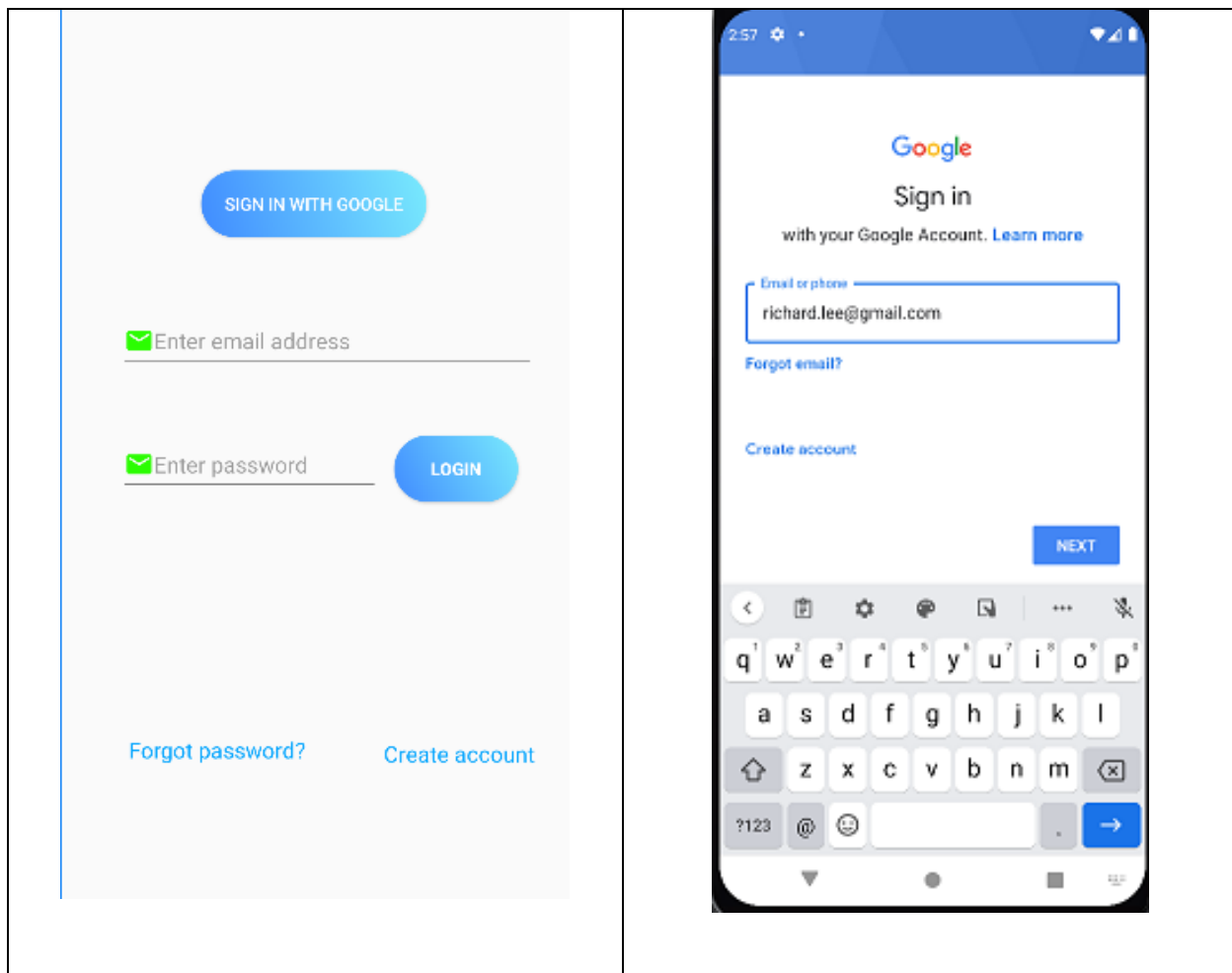
The “Search” entry box is auto-complete enabled (?)

Or clicking on the point of interest to select a destination, the system will highlight the selected point of interest and display the target on the location map

Clicking on the Navigate button to ...?

## 4.6 User Sign In Panel

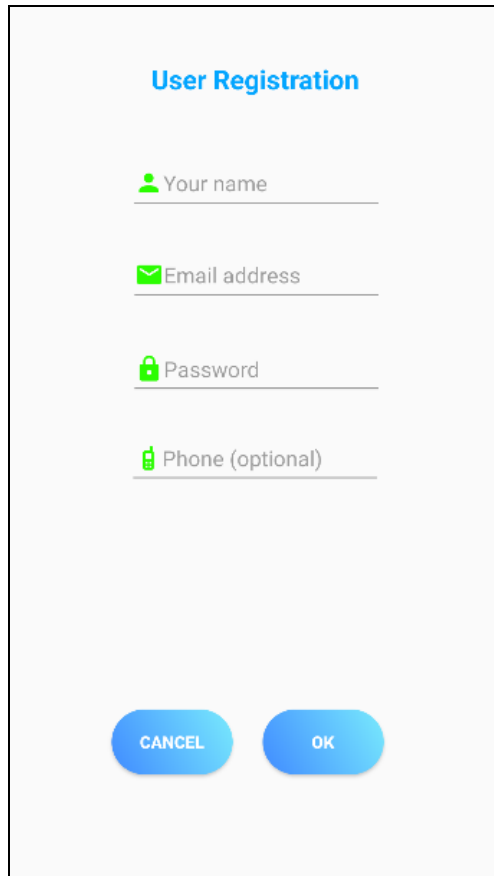
The user may login to the App with a valid Google ID (email or phone number), or register an ID to the GAO BLE system or if already has a user ID in the system, may enter it with a password in the text boxes and click on the Login button



User may login with a Google ID, the Google login panel will be displayed if the user select Sign In With Google. New user may create a new account by clicking on the Create Account link.

## 4.7 User Registration Panel

User has to provide a valid email address in order to registered to the GAO BPN system or optionally, user may use his/her Google account to login to the system. After register an account from the panel, the system will send an activation message to the user email address. User account will be activated after the user confirmed registration from his/her email activation link.



The image shows a user registration panel with the following elements:

- User Registration** (Title)
- Your name** (Input field with a person icon)
- Email address** (Input field with an envelope icon)
- Password** (Input field with a lock icon)
- Phone (optional)** (Input field with a phone icon)
- CANCEL** (Button)
- OK** (Button)

## 4.8 Password Reset Panel

User may reset his/her password by clicking on the “Forgot password” link from the login panel. The system will prompt the user to provide his/her email address and will send a PIN code to the email address to authenticate the user to reset a new password.

The image displays two sequential steps of a password reset process in a web interface.

**Left Panel: Request for PIN**

- Header: **Click on the Request to get a PIN**
- Input field 1:  Enter your email (with a green checkmark icon)
- Input field 2:  Enter the 6 digits PIN (with a green PIN icon)
- Buttons: **Request** (text) and **VALIDATE** (blue button)

**Right Panel: Reset Your Password**

- Icon: A red padlock icon with a keyhole.
- Header: **Reset Your Password**
- Input field 1:  New Password
- Input field 2:  Confirm Password
- Button: **RESET PASSWORD** (blue button)

## 4.9 User Interface Design for system administration

All user interfaces involving system administration will be supported with web browser. The GAO BPN server is an extension to the GAO RFID System 3.x.