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Design and Overview of a Navigation Application for the Blind

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Abstract: ***Navigating brings up challenges for people who are Visually Impaired (VI). It is tough for people with Visual Impairment to move both indoor and outdoor on their own. We aim to address these challenges. Our application provides indoor navigation on a smartphone with the help of Bluetooth Beacons and Indoor Atlas technology. The mobile application provides voice assistance to users to navigate to their destination. The indoor component of the app is to assist members of the Xavier's Resource Centre for the Visually Challenged (XRCVC). This application also provides outdoor help for VI individuals and guides them to the nearest bus stop. GPS will be used for this function. The application aims to facilitate a commuter to reach a bus stop of their choice. It provides information such as bus numbers and different routes. Also the application prompts when the arrival of a desired bus stop is expected. The application would be scalable and expandable to add more areas. This application enables VI individuals to travel independently by overcoming many of the obstacles faced by them.***

Keywords: blind, navigation, beacons, magnetic position, visually challenged, GPS, smartphone, bus stop.

I. INTRODUCTION

Regular chores like running grocery errands from the nearby shop, using Public Transport to go from point A to point B, would not be something a person with low/No vision would find easy, but by seamlessly integrating various techniques and technologies we aim at developing a mobile application that not just navigates, but will be eyes to the people who can't see the world around them. The purpose of this project is to foster independence of VI individuals by means of Information Technology by way of a mobile application that helps them locate bus stops near them .We found that while buses were frequently a preferred mode of transit, determining the exact location of a bus stop was a major challenge. It has been noted that locating bus stops is a significant impediment because the bus stops are not clearly marked with indicators, which are non-visual. The same applied to large indoor venues like malls, colleges and large railway stations. Our mobile application assists with navigation in outdoor environments, helping people with Visual Impairment to locate the bus stop where their bus would come and also to alert them as they reach their destination bus stop. The app provides accurate navigation information to the bus stop and the XRCVC centre in the selected venue and also issues an alert on reaching the destination. Revolutionising the way navigation is carried out by streamlining it for low vision and blind users is our way of giving back to the society, aiding them for a better tomorrow.

After having done extensive literature survey for our project, some of the takeaways that we got from our research were

1. Location and position pointing techniques have made a lot of advancements in the past years. [1] While a few years ago this would have been an uphill task with image processing (high cost activity with a huge maintenance overhead), today it is possible to do it just with one's smart phone.
2. The three main mathematic based techniques [2] to be used for navigation are
    a) Triangulation
    b) Proximity
    c) Fingerpoint
    d) Lateration

Another technique that has been used in similar applications includes:

    e) Dead Reckoning

3. Experiments showed that magnetic positioning had an accuracy of less than 3 feet whereas Bluetooth [3] was accurate in the 3-6 feet range, which is comparably much better than WiFi with an accuracy of 40-300 feet.
4. The other big challenge faced is that the users of these applications would not interact with their interface visually and would receive information via TextToSpeech[4] functionality.
5. Applications that cater to the visually blind in outdoor setting also inform the users about the environment and surrounding, providing them with information about the weather, surroundings, landmarks, time Estimated Time of Arrival [5] at destination as this helps them in cognition and perception.

II. PROPOSED SYSTEM

One of the most common problems that many blind and visually impaired people experience is their day-to-day challenge in coping with their impairment. Equipment such as Braille, reading glasses, or a walking stick are just some of the few things that help visually impaired people get along with their lives. With the advancement of technology, a common Android smart phone equipped with specific applications can aid visually impaired and blind people in functioning.

A. Problem Statement

To create a navigation app for the blind. Development of an application, which will have two components Outdoor: Help for VI individuals to locate bus stop (There will be a source area where say few bus stops will be saved and similarly a destination area where a few bus stops will be saved). The application will aim to facilitate a VI commuter to do the following

1. Outdoor:
    a) Reach a bus stop of choice.
    b) Know the bus numbers and routes of the same at said stop.
    c) On boarding a bus of choice, inform the arrival of desired bus stop of de boarding. The application and model of entry would be scalable and expandable to add more areas.
2. Indoor: (Depending on feasibility)
    a) Indoor mapping to guide VI individuals in Viviana Mall or St. Xavier's College, Mumbai for a selected area.
    b) This will be expandable to add more locations within the building.

B. Design

The design of the system has been indicated in the different diagrams given. The block diagram of the system shows the main modules present in the system.

It contains the following modules:

1. Determination of position and orientation
2. Tap Map Go System
3. User Interface

The design of our system is depicted in the different diagrams given below

1. Block Diagram

The diagram below is a block diagram showing all the three main modules of our project:

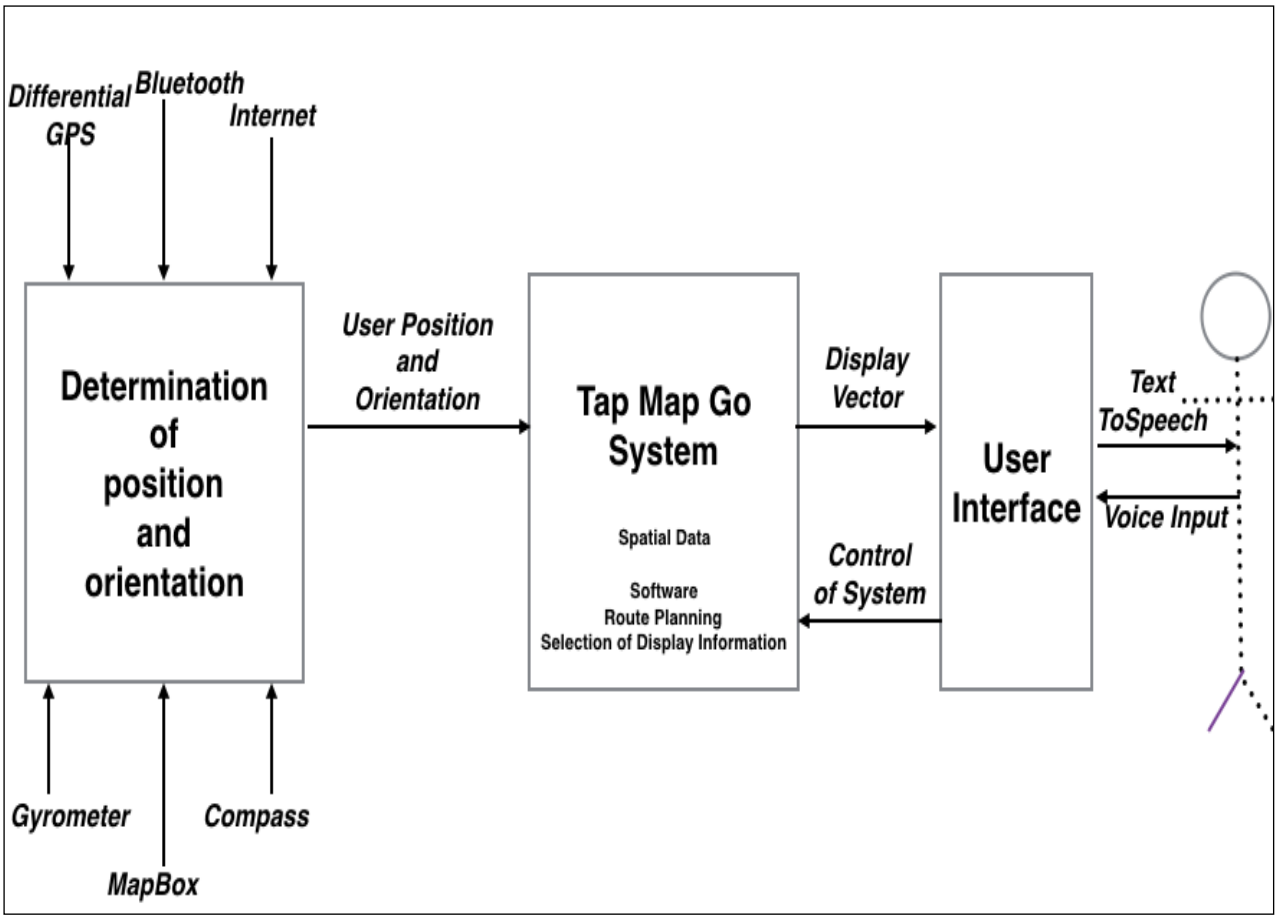

Fig. 1. Block Diagram (Golledge RG, Klatzky RL, Loomis JM, Speigle J, Tietz J. A geographic information system for a GPS based personal guidance system. International Journal of Geographical Information Science.1998[6])

1) Determination of position and orientation: This takes the input of different components such as compass, gyrometer, accelerometer and Bluetooth Beacons for indoors, and GPS for outdoors to determine the position of the user.

2) Tap Map Go System: This is the android app which will be on the smartphone. It will use the floor plans uploaded on the database along with the information received by the first module to compute the navigation for the user.

3) User Interface: The user will communicate with the smartphone via this interface and since the users will be VI individuals, Text to Speech and acceptance of Speech Input will form major parts of the UI.[7]

2. Class Diagram

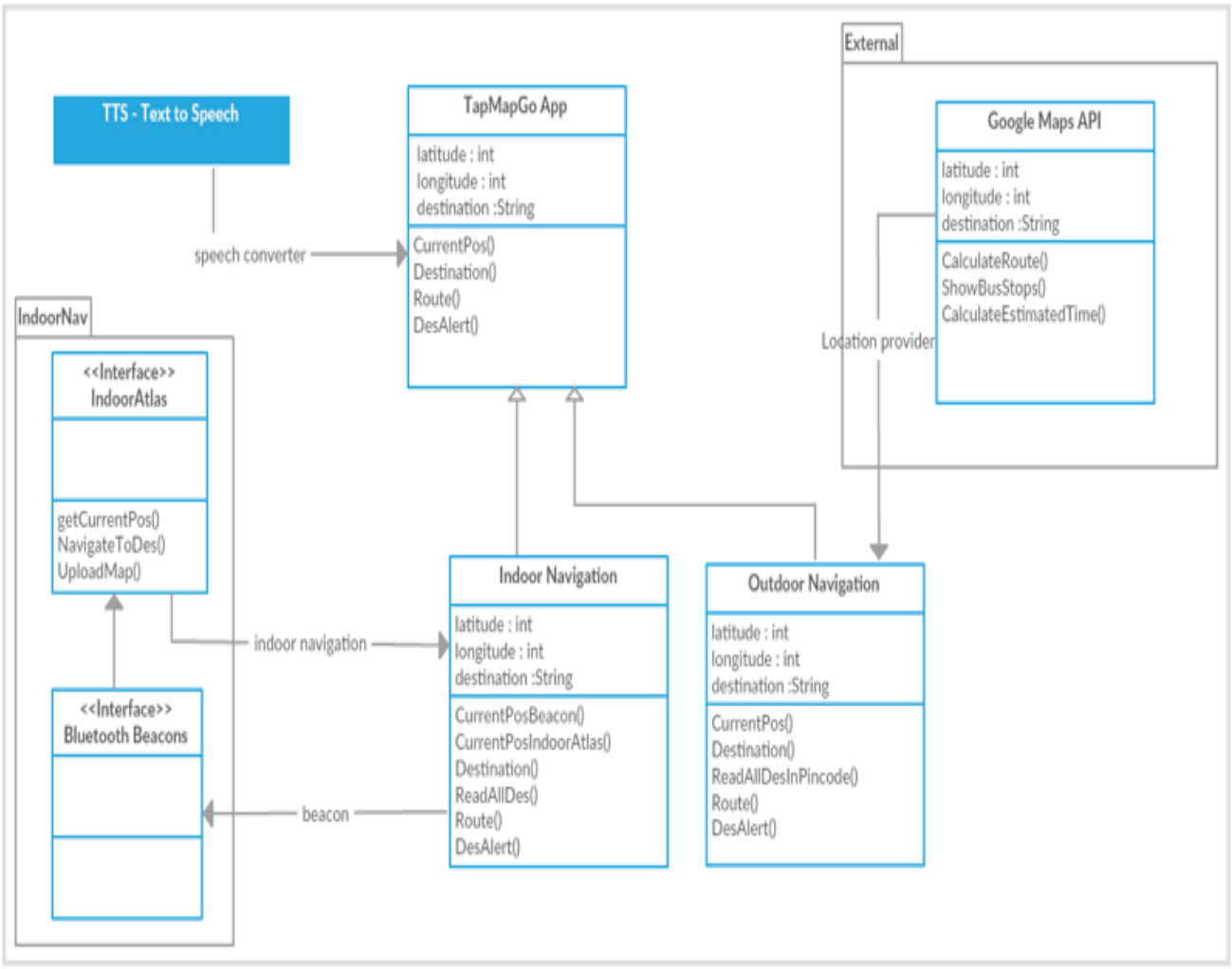

Fig. 2. Class Diagram

The indoor navigation determines location using

1. Bluetooth Beacons: Bluetooth beacons are devices that broadcast signals that can be heard by smart devices nearby.[5] The Bluetooth Beacons is a part of the IndoorNav Package that is used by Indoor Navigation. (Fig. 2)
2. Indoor Atlas: It is the Indoor positioning systems (IPS) located inside a building using radio waves, magnetic fields, acoustic signals, or other sensory information collected by a smartphone device or tablet.[8] The IndoorAtlas is a part of the IndoorNav Package that is used by Indoor Navigation(Fig. 2). IndoorAtlas functions complimentarily with BluetoothBeacons (Fig. 2) to arrive at a faster estimate of the indoor position. Before using the IndoorAtlas, a magnetic field map of the building where the location service is uploaded onto IndoorAtlas and it collects magnetic field data. The Indoor Location is calculated using both or either of them and location is ascertained.

The elements in the above class diagram:

A. TapMapGoApp (Class): Interacts between the user and the other classes (components).It is a super class that has two subclasses

1. Indoor Navigation
2. Outdoor Navigation

B. Indoor Navigation (Subclass): Deals with the navigation within an internal area. Uses the classes of the Package: IndoorNav

1. Indoor Atlas

2. Bluetooth Beacons

C. Bluetooth Beacons (Interface): Uses the SDK of Bluetooth Beacons in order to ascertain the position of the user using the closest beacon. The IndoorNavigation class uses the Bluetooth Beacon interface even when the IndoorAtlas is not functioning.

D. IndoorAtlas (Interface): This is used to upload the Maps and give the routes. The IndoorAtlas uses SDK compatible with the Bluetooth Beacons and can perform tasks simultaneously handing over to Bluetooth Beacons when not functioning due to the mapping precision.

3. *Use Case Diagram*

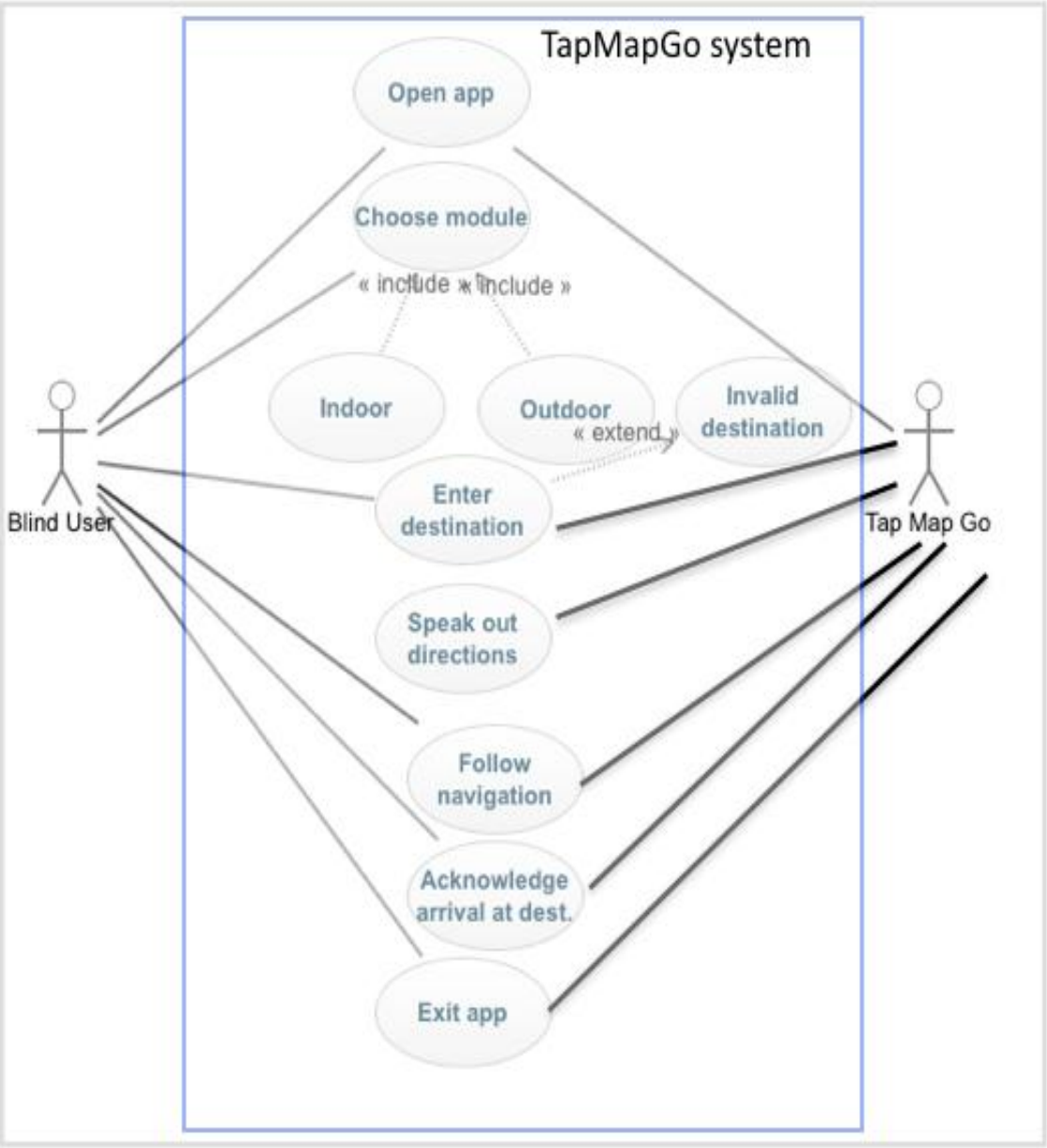

Fig. 3. Use Case Diagram

The actor Blind User Opens the TapMapGo App to begin using. Blind User chooses the module using Choose Module to select the Indoor or Outdoor Navigation.The destination is entered. If not valid, it goes to Invalid destination. TapMapGo gives direction using Voice by Speak out directions. It has a Text-to-Speech module that will convert it to Speech. Blind User Follows navigation.Alert is given on reaching destination by Acknowledgement arrival at destination. The Blind User can exit TapMapGo once the destination is reached.

4. *Activity Diagram*

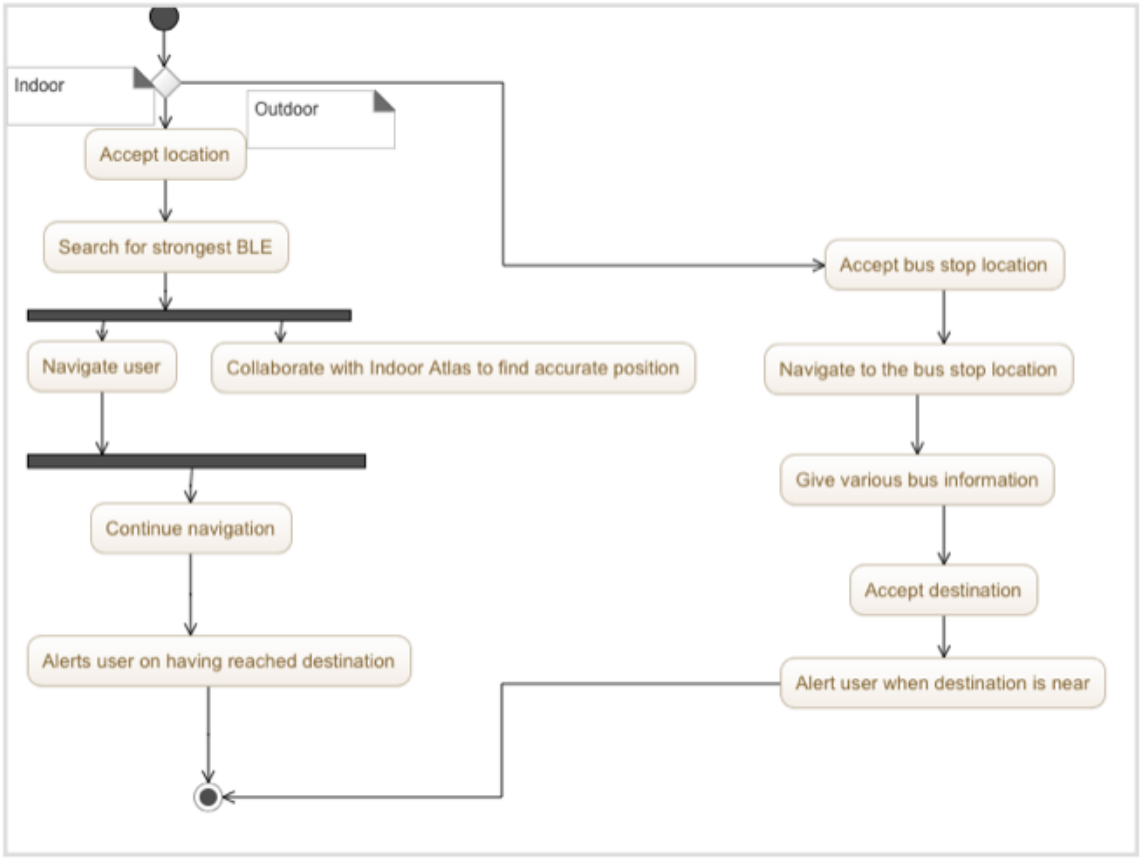

Fig. 4. Activity Diagram

1. The initial state is the state of the app before any events in the diagram have acted upon it that is before user has initialised the app.
2. The user is to select between indoor and outdoor component.
3. Once in the indoor component select the destination in the venue.
4. The nearest bluetooth beacon must be located.
5. While the user is navigated to the nearest Bluetooth beacon, the indoor atlas also determines the accurate position of the user in the venue using Indoor Atlas and as this happens in parallel, it has been indicated using fork transition.
6. After this using both BLE and indoor atlas continue navigation to the destination.
7. Now alert the user on having reached the destination.
8. The final state represents the completion of activity in the situation the diagram represents.
9. The location where the user wants to go will first be accepted.
10. Then the user will be assisted with GPS navigation to the desired bus stop where buses to the desired destination arrive.
11. Once the user has reached the bus stop of choice, various bus information such as bus numbers, bus timings busroutes will be provided to the user.
12. The user can then board a bus and enter the choice of destination.
13. The user will be alerted when the desired destination is near.

C. Scope

The scope of the Project is to plan, design, build, and implement a Navigation app for VI individuals. Various access and permissions will be granted to the app in order to update, manage, and view information such as GPS, Bluetooth and the geomagnetic position which will be accessed on the Smartphone. The app will also include a voice over facility as the app is being made keeping in mind VI users. The XRCVC Project includes all work associated with planning, designing, building, and implementing the app for XRCVC. This includes requirements gathering, gathering user data from XRCVC, conceptual and technical design and coding work, server configuration testing, troubleshooting, and deployment of the app. This also includes training manuals and materials associated as we aim to develop a product that is scalable and expandable. Not included in the scope of this project are: ongoing maintenance of the system, implementing commercial database products, ongoing help desk and/or service support, or hardware/software upgrades.

D. Advantages

The advantages of using the Tap Map Go app are:

- It uses the magnetic positioning technology, which provides the most accurate position of the user in an indoor location compared to WiFi, Bluetooth and RFID systems.
- The Bluetooth Beacons act as a backup mechanism while the Magnetic Positioning technology calibrates initially and hence the user faces no lag.
- The System is built using ReactNative so it is possible to create an iOS app from our Android app as ReactNative is cross-platform.
- We will provide an audio map to the user to aid in better guidance to the destination.
- System is highly scalable to accommodate multiple destinations in an indoor venue.

E. Disadvantages

- For two bus stops with proximity less than 10 meters, distinguishing between the two bus stops is difficult without the use of external beacons or other hardware.
- If such hardware is used, the cost of the system increases as external beacons are very expensive and other sensors are highly dependent on weather conditions.
- For Smartphones having Android versions below Android Jellybean , the use of internet is necessary for TextToSpeech.

F. Applications

The Tap Map Go application can be used for the following purposes:

- Indoor Navigation in St. Xavier's College and Viviana Mall. Model is scalable and can be extended for navigation in other indoor locations as well.
- The outdoor component will assist Visually Challenged users for public transport via buses and will help them get to their intended bus stop and let them know on destination arrival.

III. CONCLUSION

The Tap Map Go application provides seamless navigation in an outdoor and indoor environment for VI individuals. It has been created using the latest technological advancements in the field such as indoor positioning technique at minimal infrastructure costs. Unlike traditional navigation assistance systems for the blind, we use no hardware or sensor on the user

physically. All that the User needs is a Smartphone. While the app uses Bluetooth Beacons, it is just a fall-back mechanism in the system and compensates for the lag in initial Indoor Atlas calibration if any.

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