



typical distance of less than 10 cm which is suitable for crowded places and safer in terms of its application.

The authors in this paper [5] have designed an indoor map guidance application that utilizes NFC technology in order to locate the users inside the building. The main idea is to orient users by NFC enabled mobile phones which also have an embedded indoor navigation application [5]. While application orients the user by gathering destination point from user; mobile device gathers the current position from NFC tags and shares the coordinate data with the application. Thus a user can determine her current position inside a building by touching her mobile device to the tags which are spread inside building. The developed application is able to find the shortest path to selected destination, however, it does not provide other features and it only operates in phones that have NFC reading capability [5].

The authors of paper [2] describes an Android based indoor map guidance system [2] that assists and guides visitors inside public buildings (e.g. schools, shopping malls, airports, museums, exhibition centres). It utilizes NFC (Near Field Communication) technology [5] and QR (Quick Response) Codes [7], which are low cost, to determine the location as well as to provide navigation within the buildings. In addition, the system is bilingual and available in both English and Arabic versions. The developed system relies on a server that contains its web server, map server and spatial database. The map of the building should be laid out and stored in a Map Server so as to be available to the users. The user, using the system, can then read the URL of the map from one of the NFC tag inside the building. With that, the system will request the map from the server and download it to the mobile. The user can then view the downloaded map.

The author of paper [3] describes a new Navigation technique to assist the blind and people with low vision to reach their destinations in an indoor environment. The technique is based on previous positioning technique using active Radio-frequency identification (RFID) technology [3]. This research produced a navigation service for sighted and blind people to assist them to reach their destination of interest via the shortest path. Tags were distributed at known locations and the mobile reader was carried by a user. The system role is to determine the shortest path to the destination which was indicated by a user. When the shortest path is calculated, the system indicates way points in the path which were represented by active tags in this scenario. Then the users are navigated to these points one by one via QR-Code till they reach their destinations. It was implemented in an indoor environment as a simulation system to navigate the user to particular offices with a successful shortest path identification rate and satisfactory navigation results were achieved.

The most common used navigation technology is Global Positioning System (GPS). This technology is based on the satellite positioning system, and line of sight of the signal is required. It has a good accuracy in open space environment, but unfortunately it does not work well in an indoor environment due to the absence of line of sight of the satellites' signals. Much effort has thus been conducted in

order to overcome this problem. With the use of Assisted-GPS (A-GPS) [2] where a data server with reference receiver is employed in order to assist the signals of the GPS – but the drawback with this solution is that using AGPS technique, accuracy is very much limited because of approximation. Information provided by the system is 2D. It involves infrastructure cost for provider and the user.

### 3. Module Description

The indoor navigation system using QR codes [1] are used for these purposes.

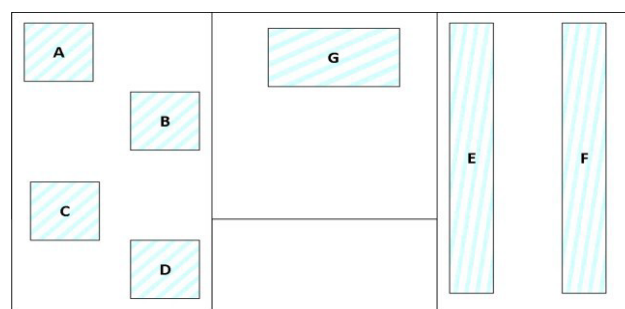
- To Provide the user link to the map of the indoor location
- To Provide the location details to the user
- To provide a voice response of the current location

The modules in the system are:

#### 3.1 QR Code Encoding

To provide proper navigation to the user, the indoor location plan should be made available to the user. A floor plan needs to be created for the indoor location. For multi storied building separate plan is required for each floor. The floor plan essentially represents the layout of a particular floor. Figure 2 depicts a sample floor plan, where areas A to F denote important places in the floor. These areas could represent a shop, escalator, lift, washroom, entrance/exit areas and so on.

Once the floor plan is created, floor plan is assigned with corresponding geo location co-ordinates [2]. These location coordinates are used to overlay the floor plan on top of the geographical map. Once the floor plan is created, the floor plan is made available for the user through a URL link. Each floor should have the corresponding floor plan. This could be made accessible using any of the wireless technologies.



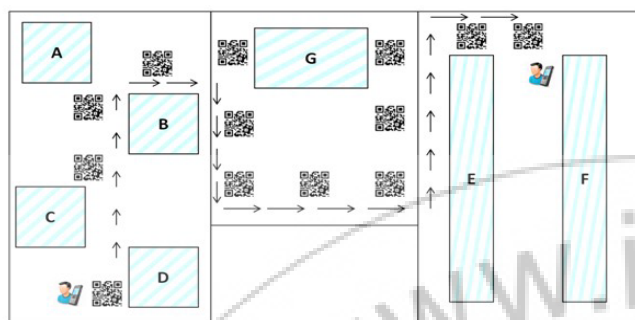
**Figure 2:** A Sample Floor Plan

Once the map is made accessible wirelessly, the URL of the floor plan is encoded into the QR code. Once the floor plan is created, points are identified where the QR code needs to be placed. QR code for a floor  $X$  at point  $a$  could be defined as

QR code( $X, a$ ) = URL for floor plan( $X$ ) + Location Details( $a$ )

Location Details ( $a$ ) = Latitude, Longitude and Altitude of the geographical point  $a$

Figure 3 depicts a sample floor plan with points identified to keep QR codes. These QR codes aid the user for indoor navigation. QR codes can be placed all along the pathway to provide the user accurate navigation.



**Figure 3:** Sample Floor with QR Codes Placed

Any change in the floor layout would require the floor plan to be recreated. If a single floor is too large and contain lots of important points then floor plan could be divided into multiple floor plans each having separate URLs.

### 3.2 Server

A centralized server [1] is used to store the floor plan details of the building. This server is the main floor plan repository of the building. It contains the full floor plan details of the building. This floor plan is used as an overlay on the geographical map while navigation. If the floor size is bigger than the map it will be split and store as more than one part.

### 3.3 Capturing QR Code

Application will capture the QR Codes placed somewhere in the indoor places of the building where the user need to navigate. Once the capturing device found any QR code image, the system will start to analyze the code to check whether the QR code contains the required data. The smart phone camera can be used as the capturing media.

### 3.4 Decoder

The decoder of the system will decode the data contained in the QR Code. Extracting the QR Code will result into the retrieval of URL and the location details. URL corresponds to the floor plan. Location details contain the latitude and longitude of the current location of the user.

### 3.5 Map Handler

The extracted QR Code details are used for indoor navigation [1][2]. Using the URL the floor plan of the building can be downloaded from the floor plan repository server and can be overlaid on the geographical map. The location details are used to plot the exact latitude longitude geo position on the map. This will help the user to know the exact position of the user.



**Figure 4:** Floor Plan with User's Location Pointed

### 3.6 Voice Response and Tracking

For the blind and people with low vision, determining their current location is a significant challenge [3]. If the user will get voice response when he approaches to some important places in the building, then the blind people can easily reach their destination in an indoor environment. This module contains the voice response system. The user will get voice response when he approaches to some important places in the building. This will help the blind people to get the advantage of the indoor navigation and can easily navigate to their desired destination.

## 4. Experimental Results

In the project titled QR Code based indoor navigation with voice response; the web based client interface is implemented using JSP and MySQL. This interface has an admin module and a user module. The mobile application interface and the navigation modules are implemented in android; the navigation module includes downloading the floor plan, pointing the current location in the floor plan and a voice response about the current position of the use.

The proposed system is implemented in our college campus. The image of the floor plan is stored into the map server. The URL of the floor plan and the location details are encoded in the QR code. The encoded QR Code in figure 5 is the input to the application.



**Figure 5:** Generated QR Code Input

The navigation application uses a barcode scanner for capturing and decoding the QR code placed inside the building. If the smart phone has an inbuilt barcode scanner the application will use that for QR code capturing. Otherwise a barcode scanner is downloaded from the Google play store when the user presses the scan button in the navigation application. The barcode scanner will start the smart phone camera and capture the QR code. The captured code is then decoded to get the information encoded in the QR code. This decoded information contains the URL of the floor plan and the location details of the user. The floor plan URL is used to download the floor plan image to the smart phone from the apache tomcat server. The downloaded floor

plan can be overlaid on the geographical map. The location details are used to plot the exact latitude longitude geo position on the map. The application also provides a voice response about the current location of the user. This will help the blind people to get the advantage of the indoor navigation. Figure 6 shows the output of the navigation application in the smart phone.

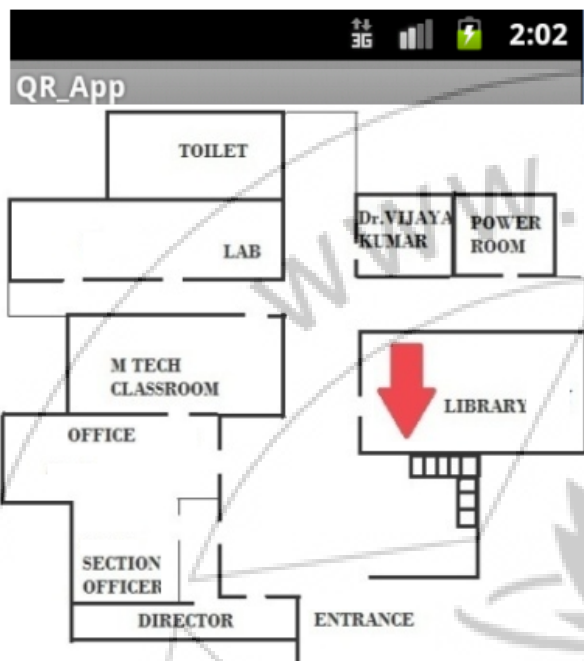


Figure 6: Application Output

## 5. Conclusion

QR code based indoor navigation is an indoor map guidance system via the use of portable mobile devices. It is a mobile application for Android platform that allows the users to readily localize, navigate, and view the map of the building on their smart phone. The system is also able to assist and guide visitors within any public buildings such as shopping malls, airports, hospitals, museums, exhibitions centres, etc. It utilizes QR codes in order to determine the current location of the visitors. The QR Codes are distributed with known and in readily-accessible positions within the buildings and the users of the system can then scan these codes to find their current location. The system also provides a voice response module which allows blind people to determine their current position inside the building.

Main advantage of this approach is that it is cost effective for the service provider. Users/visitors do not have to make any investment for this indoor navigation. Complexity and time to implement is less for this approach. There are no additional configurations which the users have to maintain for indoor navigation. Access to navigation system even for moderately equipped phones with Satellite communication is avoided (which is not possible in closed environments) for getting the location information.

In the implementation, the Android SDK is used to develop the smart phone client interface, the Apache Tomcat server is used for the web server, JSP is used as the front end and

MySQL is used as the database server for providing a web based client interface.

## 6. Future Scope

Even though the application is cost effective for the service provider and requires less complexity and time to implement, it has some drawback. The application works only in smart phones which has android operating systems. A future enhancement is to make the navigation application working in all platforms.

## 7. Acknowledgement

I express my sincere gratitude to School of Computer Sciences, M.G. University for providing all the facilities especially Library and Laboratory for all the time which helped me in completing my work successfully.

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