QR code based navigation system for closed building using smart phones

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***Abstract*— Smart phones are widely used as navigation aid nowadays. Most of the smart phones provide a built-in Navigation or Map application with some sort of GPS capability. These navigation applications provide accurate navigation for outdoor location using GPS unit of the Smartphone. But providing an accurate navigation inside a closed building is still a challenge. Several solutions are available in the market for indoor navigation using Bluetooth, Wi-Fi and AGPS. But their reliability of navigation in all given scenarios is still a challenge. In this paper, we elicit a cost effective and 3D (latitude, longitude and altitude) smart phone solution which helps in indoor navigation with the help of QR codes [1]. QR codes are used in this context to provide location information to the user optically. QR codes will be used all across the building to carry the information required for the navigation system. The mobile application will use the QR codes to provide accurate indoor navigation for the user.**

Keywords- Indoor maps; indoor navigation; navigation using QR code; closed building navigation; GPS; Position Tracking

I. INTRODUCTION

Navigation/Map applications for Smart phones are quite useful in the day-to-day life. There are lots of applications available in market which provides efficient and user friendly navigation to the user. Most of the applications are successful in assisting the user with his current location and providing directions to particular destination for outdoor locations. In most of the scenarios this is achieved using the GPS unit of the Smartphone. But accurate navigation while not in line of sight with GPS satellites is still a challenge. There is a limitation for smart phones to locate their exact position while in covered areas such as shopping malls, airports, railway stations, multi storied buildings, apartments. There are in door navigation systems available in the market which uses Bluetooth, Wi-Fi, AGPS or RFID.

Bluetooth requires expensive receivers and the accuracy of bluetooth navigation depends upon the number of cells used. Wi-Fi also demands expensive access points for indoor navigation. AGPS uses network assistance servers for indoor navigation

Figure 1 Mobile Navigation Application

. 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. RFID requires active tags for indoor navigation, where the accuracy is directly proportional to the number of active tags used. Active tags are self powered and hence costly. Also close pass by is required to sense RFIDs and even the user need to be aware of the RFID position. Most of the existing solutions are far from providing an accurate and cost effective indoor navigation.

II. NAVIGATION USING QR CODE

A. Creating the Floor plan

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 multistoried 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

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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.

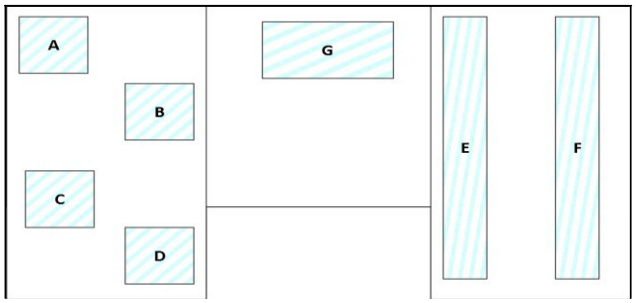

Figure 2 Sample Floor plan

Once the floor plan is created, floor plan is assigned with corresponding geo location co-ordinates. 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. Once the map is made accessible wirelessly, the URL of the floor plan is encoded into the QR code as explained in section 1.2. 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); where 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.

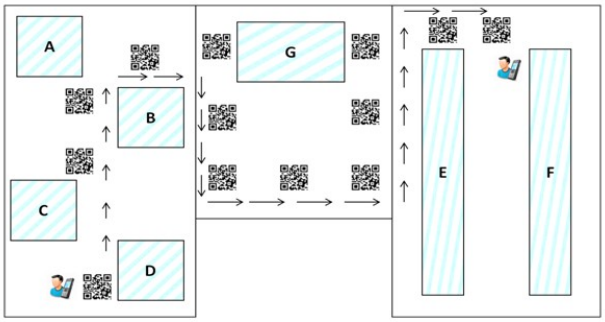

Figure 3 Sample Floor with QR codes placed

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.

B. *Using QR Code*

QR codes are two dimensional codes where the data is encoded in an optically readable format. For indoor navigation QR codes are used for two purposes.

- ☐ To Provide the user link to the map of the indoor location
- ☐ To Provide the location details to the user

QR code for a location contains two parts. First part contains the URL information from where the floor plan could be downloaded. Second part contains location information such as latitude, longitude and altitude. Floor plan here refers to the layout of the particular floor in the in-door location. QR codes can be placed all along the pathways and also on important locations with corresponding latitude, longitude and altitude of the location. The entire floor could be placed with QR codes at strategic locations. Before placing a QR code at a point 'a' inside the floor, the geo location details for the point needs to be found, which is typically provided by civil construction department. Geo location details include altitude, latitude and longitude of the point.

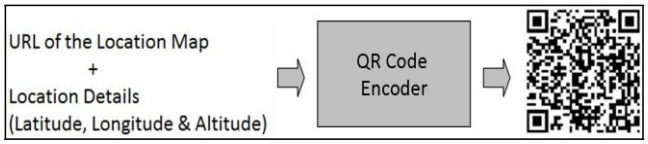

Figure 4 QR code contents

C. *Smart phone Navigation Application*

The navigation application in the mobile uses the camera to read frames continuously. The current visuals of each frame are checked for the presence of a QR code within the frame. Once a QR code is found, the application decodes the QR code and obtains the floor map URL and geo location details. If the floor plan is not present already then application downloads the floor plan using the URL via wireless connectivity. This floor plan is overlaid above the actual geo location map such as Google maps.

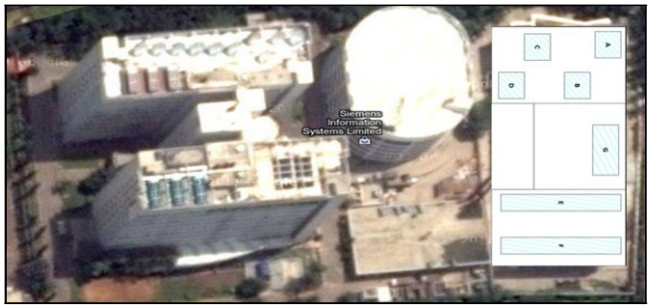

Figure 5 Floor plan overlaid on Geographical map

The navigation application decodes the geo location details from QR code and points the location in the Map.

Figure 6 Floor plan with user's location pointed

D. *Navigation Application Components*

This section provides details about the mobile application components. QR detector processes the visual frames and checks for the presence of a QR code. If a QR code is detected then QR Detector forwards the QR code to QR Decoder. QR Decoder component decodes the QR code and obtains the code contents. This content is being accepted by content parser module and parses to find out the floor plan URL and geo location details. Floor plan handler module uses the URL to download the floor plan and its location coordinates from the floor plan repository. Once the floor plan is downloaded, floor plan handler overlays the plan on top of the geographical map using the location coordinates. As a final step the location details from the QR code is used to provide the user his current location.

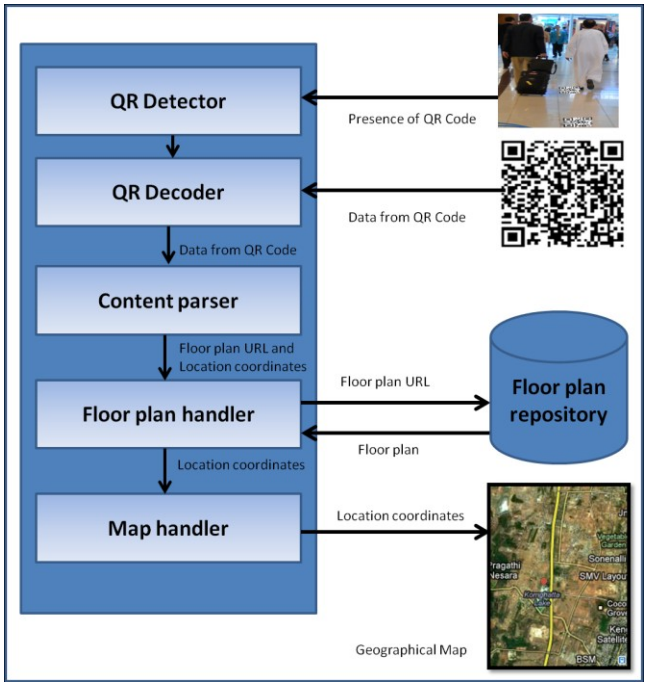

Figure 7 Smart Phone Application components

E. *User Scenario*

This section describes a user scenario for QR code navigation for closed building using smart phone. In addition to the user scenario, the application workflow is also described as according to the user actions.

- User: The user walks along the floor with mobile application active inside a closed building.
  Navigation Application: The application uses the camera sensor to process the current visuals inside the indoor location .iteratively. This is performed to check the existence of a QR code in the current frame. If the application finds a valid QR code, the application checks whether the floor plan is already present in the mobile. If the floor plan is not present then floor plan with corresponding location coordinates is downloaded.
- User: User able to view the floor plan overlaid on the geographical map with his location pointed in the map on the mobile screen.
  Navigation Application: The application overlays the floor-plan on top of the geographical map. Overlaying is performed using the location coordinates of the floor plan. Once the overlay process is completed the location details from the QR code is used to point the location of the user in the overlaid floor plan.
- User: The user continues to walk in the closed building and his position gets updated in the overlaid floor plan on the mobile device.
  Navigation Application: The application uses the camera sensor in background and processes the visual frames. In case any QR code is found, the application processes the QR code and checks whether the floor plan needs to be downloaded or not. If the floor plan is already present and active, the location updates are performed on the floor plan.

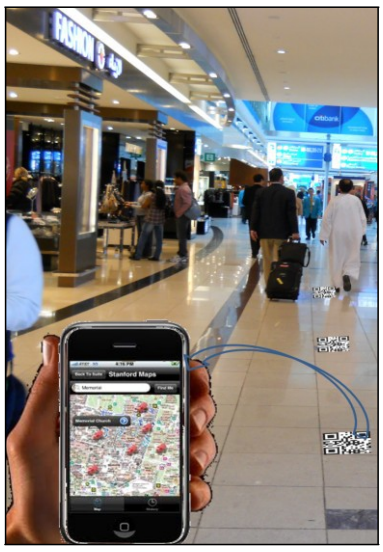

Figure 8 User navigation

III. ADVANTAGES

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.

Table 1 Comparison of different approaches

Technique	Accuracy	Maintenance cost	Infrastructure cost
AGPS	Less	High	High
Bluetooth	Medium	Medium	High
RFID	Medium	High	High
Smartphone and QR code	High	Low	Low

IV. CHALLENGES

The main challenge in this approach would be the impact of handling change in floor layout. Any layout change would lead to repetition the whole process. QR code detecting and decoding depends on the resolution and quality of the camera used by the smartphone. A low quality camera can have a negative impact on indoor location navigation. Also identifying and decoding the QR code while the user moving fast is also a challenge. Another challenge that the service providers might be facing will be in strategically positioning the QR codes along the building for optimum usability.

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