QR-MAP: BYOD INDOOR MAP DIRECTORY SERVICE

BY

ANG JENN NING

A REPORT

SUBMITTED TO

Universiti Tunku Abdul Rahman

in partial fulfillment of the requirements

for the degree of

BACHELOR OF COMPUTER SCIENCE (HONS)

Faculty of Information and Communication Technology

(Perak Campus)

JAN 2013

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DECLARATION OF ORIGINALITY

I declare that this report entitled "**QR-MAP: BYOD INDOOR MAP DIRECTORY SERVICE"** is my own work except as cited in the references. The report has not been accepted for any degree and is not being submitted concurrently in candidature for any degree or other award.

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Date : _____

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I would like to express my sincere thanks and appreciation to my supervisor, Dr. Ooi Boon Yaik who has given me this bright opportunity to engage in QR-Map project. A million thanks to you.

To a very special person in my life, Starcia Chua, for her patience, unconditional support and love, and for standing by my side during hard times. Finally, I must say thanks to my parents and my family for their love, support and continuous encouragement throughout the course.

When I asked for strength, God gave me more burdens to carry.
When I asked for love, God sent me people with problems.
When I asked for wisdom, God gave me more problems to solve.
I see that I did not get the things I asked for but I have been given all the things that I needed.
Thank God.

ABSTRACTS

This project is a QR Code based Indoor Map Directory Service on Mobile Device a.k.a QR Map that allows pedestrian positioning themselves in an indoor environment. Pedestrian can simply capture the QR-code of a location and get to know their current location by using QR-Map. From that, Pedestrian can position themselves from one place to another place.

Concept of" Bring Your Own Device" also known BYOD is introduced to this project. It describes that the user can interact to the system with his/her own device. Hence, in addition of popularised usage of smartphone, the users have encouragingly easy-access to this proposed solution.

With deployment of QR-code, almost zero modification of building has to be done for implementation as with replacentment of a piece paper printed with QR-code, merely. An active approach is introduced in this project to control privacy of user. Besides, anyone can use this system with just a camera-equipped smart-phone and it requires no customised devices installed but a client application. Three main issues are discussed in this project are denoted into the aspect of modification, privacy, usability. With the accomplishment of this project, a system prototype is developed to substantialise idea and concept of this proposed indoor directory service. A followed-up intensive testing is conducted to verify the functionality of the prototype system to attain comfortability of the specification requirement.

Lastly, based on the outcome of this project, the system prototype and test scenario are proven that the map directory service succeed to assist the user to travel one location to another location in an indoor space.

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LIST OF ABBREVIATIONS

IPS	Indoor Positioning System
WIPS	Wireless Indoor Positioning System
QR-code	Quick Response Code
UWB	Ultra-wideband
SDK	Software Development Kit
RF	Radio Frequency
IR	Infrared
RSS	Received Signal Strength
BYOD	Bring your own device

Chapter 1 Introduction

1-1 Motivation

As building construction in our society which constantly has exponential growth in complexity, the indoor positioning service (IPS) has become very useful in such that people want to know “where I am” and “how do I go to that place” (Li,Chun 2005). There are a lot of applications that rely on the locations of these mobile devices, such as navigation, people and assets tracking, location-based security and coordination of emergency and maintenance responses to accidents, interruptions of essential services and disasters, etc. However, the underlying question of it is that why there is no indoor positioning service available in our daily life (Anthea 2010). Although several product has up to market for deployment, none of them can be used by general public for individual purpose [Wiki].

The underlying reason is why IPS is not publicly implemented across public premise. Three main issues are discussed in this project are they are denoted into the aspect of modification, privacy, usability.

To provide the IPS, wireless indoor positioning system (WIPS) is widely recognized best-suited solution for it (Hui,Houshang,Pat, Jing 2007). In order to implement WIPS**,** referring to some existing system, enough sensor tags must be installed physically across the building either visibly or invisibly. Thus, the building is most likely undergone certain renovation to cover up the sensor tags which are not visually good for viewing. In this project, Quick response code (QR-code) is introduced to replace the sensor tags and they are visually presented and needed for commercial and advertisement. Most importantly, it does not require the renovation of building; it eventually addresses the issue of “modification”.

Secondly, the user privacy is highly considerable criteria for system development (Nissanka 2005). The lacks of user privacy may result in user’s sense of uncomfortable or even crimes. Among few studied system, they solely emphasize on the accuracy of

positioning and the cost minimization but the user privacy is dropped from consideration [3]. Thus, they fail to acquire the confidentiality of general public to use the service. In our proposed solution, two hardware and software approaches are suggested to tackle the user privacy issue. QR-code would be served as the hardware components to increase user privacy level whereas the software mechanism would be the filtration of the different content of user access right.

Lastly, with advancement of mobile technology, it make possible of a wide range of mobile service become available and smart phones has become the fast track of user penetration. Even so, majority of existing required custom technology to support the positioning service, specifically they are on demands of custom signal transceiver for the system working [3]. Eventually, it would be unnecessary cost and transition just for deploy the positioning service into their daily work and life. In order to overcome this issue, QR-code is proposed in this project as appropriate technology for indoor positioning system as it has unique characteristic - all smart phone has equipped with built-in camera.

This project presented a QR-code based Map directory service that can be widely implemented on various either public or private premises whereby little modification is required for the building structure. Its technology that uses QR-code allows a high usability nature which most of the smart phone have capabilities to competence with. The content/location filtration and user customizable profiles are two user privacy concepts applied on the proposed system.

1-2 Problem statement

A typical reason why the resistance or failure of implementing indoor positioning system is required modification of building. In order to have a wireless indoor positioning system, full-coverage signal network must be implemented to achieve acceptable accuracy of position estimate. However, the trade-off of it needs a renovation of building for installing the sensor tags and devices into the cover-up area which are considered not visually good in public premise. Yet, its exposure might lead to theft case or vandalism. Thus, it might result as the downtime of positioning service. Thirdly, the renovation can cost the indoor premise's owner on the pre-implementation regardless of the actual system implementation. It especially turns down the interest of biggest potential system owner – business premise's owner. In short, it is essentially considered as the biggest problem among all indoor positioning system where they are not widely being implemented to different indoor premise such as government institute, campus area and business premise.

Second, the user privacy must always be classified as one of primary concerns of every system development. It is common issue for general public and even software developers whom they underestimate the threat of user privacy. This is hilarious when creating a solution to a problem and that solution create other problems. In our location-aware system scenario, the poor management of user privacy fertilizes many issues such as kidnap and harassment. If given such the loophole of the system, the outlaws of society would like to know location of user for some illegal stuff which may or may not harm the respective user. For example, kidnappers would frequently peep on the user and check his/her location routine. From there, the kidnappers can estimate user location and try to kidnap the user.

Thirdly, in order to receive the signal within wireless network, a detector must be carried along with the user. However, most of the existing system proposed an additional device within detector in order to use the positioning service. The additional device is usually treated as an additional cost for the users. The major concern of this criteria is that the detector commonness in general public such that some of existing system use uncommon technology such as UWB (which cannot be easily found to residential use nowadays).

Thus, it could be the reason why the indoor positioning service has yet to be fully commercialized to general public. Although some of the existing systems have adapted the WLAN technology (which are very common in smart phones and everyone has it), it require excessive power consumption for the phone to perform positioning service which can make the phone's battery run off hastily. Hence, it violates the design issue of smart phone and this reason why the direct transition of the wireless technology is not chosen as the best solution for IPS.

Lastly, the always-connected mode is seemed to be reluctant from the user perspective whereby the signal receiver must always listen to signal transmitter and the signal information would be sent to the server for position calculation and estimation. To the best of my knowledge, none of the existing system has provided to encounter such inefficient process. Although the issue is minor to the system, it should be addressed whereby the malfunction of the server would not affect the functionality of IPS. Thus, the service could still be sustained the functionality when there are such accident and disaster happening.

1-3 Objective

With the accomplishment of this project, the following are the detail object description, its aim and goal:

- To develop alternative map solution of map directory service
- To a develop multimedia enabled directory service based on location
- To develop a map directory service that requires zero or little modification of building structure
- To develop a map directory service with high severity of user privacy
    - Where no external party or personnel would know any of the related information.
    - Where users can have the right of being actively use the system.
    - Where users can have the feature of customise their privacy setting
    - Where the owner of location have privacy to customise their location privacy
- To develop an IPS with high usability that perceived by general public
    - A wide range of users can use the system to perform indoor positioning service
    - At least with a mobile device with extra application-compatibility and 3-4 megapixel built-in camera
- To design IPS mechanism that provides enough navigation information with low computational complexity, so that it can be operated on smart phones with the processing of server.
- To implement a thrown away prototype of map directory service.
- To verify the functionalities of proposed map directory service.

1-4 Project Scope

In this project, a working prototype will be delivered and implemented on one mobile device. Such prototype is able to address the challenges and problems mentioned in the previous section.

The working prototype would be specifically developed to be functioned within the UTAR Perak campus compound, especially the block N served as the experimental indoor environment. The two typical users group would be classified as students and the academic staffs for the working prototype. The user account would be pre-created and no registration is needed to done.

Ultimately, the prototype service coverage would be partially established on block N with several chosen lecturer room and hotspot such as elevator, ladder and passage entrance. Given that the stated coverage, there would be no modification of building required.

Next, a prototype tester would use the mobile prototype application to perform indoor map directory service such that he/she is able to position his/her current location and navigate him/her to the selected destination. If destination's owner does not include the tester to be in active list, the test would have no the right to select the destination.

In order to validate usability of the prototype, the largest user group of the mobile device-android phones [10] is chosen to be the prototype operating system platform to be built on top of it. To be more specifically, the operating system version will be operated on Android 4.0 Ice Cream Switch.

Lastly, the prototype would be expected to be functioned without the support of internet connection.

1-5 Contribution

This project proposes and implements QR-code based Indoor Map Directory Service by proposing a simple approach to revolt the excessive technology applied and calculation complexity of existing system. Here are the list of contribution and publication referring to them:

1. Indoor Map Directory Solution: Instead of using wireless sensor to detect the presence and coordination of the user, a passive approach that use the QR Code as medium to trigger the interaction with the server to acquire map information as when the user is on demand of it.

2. Multimedia Content Attached to Location: Multimedia content is able to attached to the location in logical. For instance, concept of BYOD allows the user use their device play video instead of installing a custom Television to play video.

3. Map directory system: A map directory system, which uses the map that pre-download to the phone device to generate guide to destination and give guidance, is developed.

4. No Accuracy context: The proposed solution would be free from the argument of position accuracy and precision issue which any specific calculation. The path is expected to be generated by the navigation system, and then the compass will be served as the orientation to direct the user move to the destination. Unlike the outdoor scenario, for indoor context, the real time routing makes no sense when terrain texture can be easily recognized by the users.

Chapter 2 Literature Review

2-1 Existing Wireless Indoor Positioning System

System/solution	Modification of building	Privacy control mechanism	Custom detector required
Conventional map	√		
Ekahau [8]			√
TOPAZ[3,18]	√		
Cricket[4]	√	√	√
Beep [5-7]	√	√	√

Table 2-1-1 : Comparison of IPS

Table 1.1 summarizes some of the existing WLAN positioning systems that can be accessible to the public. It shows that five out of six required a modification of building in order to implement the indoor positioning system except Ekahau (it use existing WLAN infrastructure to establish the signal network). In addition, only two existing system (Beep and Cricket) has emphasized the privacy control criteria in their documentation. They suggest the positions that obtained from the server must be encrypted before it is transmitted to the mobile devices, in order to protect the privacy of the users. Lastly, three of four existing system are known to require the custom detector to receive signal from the signal transmitter in order to perform position estimate. There are four criteria of indoor positioning system used to compare among the existing system.

1. *Modification of building* – The requirement that the renovation of building structure such as wall, ceiling and floor has to be carried out for the installation of the various sensor tags of wireless technology. The wireless technology includes Wireless LAN (WLAN), unidirectional Ultra-Wideband (UWB), RF (radio frequency), IR (infrared), Bluetooth, etc.
2. *Privacy control mechanism* – The mechanism that secure the user's data and information being recorded and manipulate for other purpose. It reflects user

capability of customize their visibility of audience within the same indoor environment.

3. *Custom detector required* – The needs of custom detector to allow the signal transceiver to detect the transceiver peers in order to perform the position's calculation to estimate the peer's location.

Chapter 3 Development Analysis

3-1 Methodology

In this project, incremental prototyping is used as the software development methodology where the different prototype version would be built on top of the earlier version incrementally. The initial prototype is started off with a basic system that read QR-code and decodes this message. The following is the detailed milestones of the incremental prototype:

Prototype	Description
1	Sub-System-1:A basic mobile application that read QR-code and decodes this message , re-direct the correspond website URL
	Sub-System-2: The extent of subsystem-1 that support user account and device registration.
	Sub-System-3: A location owner mode that support location owner to administer their respective location information.
2	Integrate the three sub-prototype into one distinct prototype

Table 3.1-T1 Prototyping Milestone

The following is the potential technology deployed into the prototype:

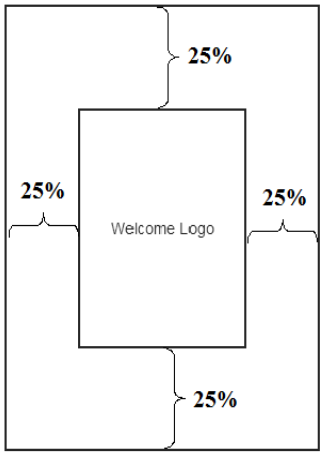
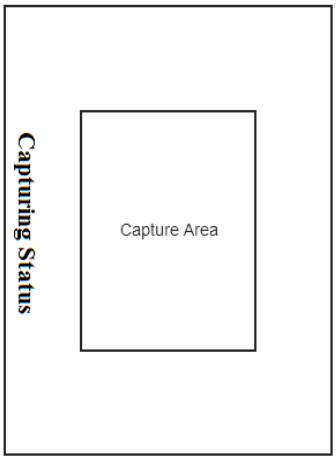
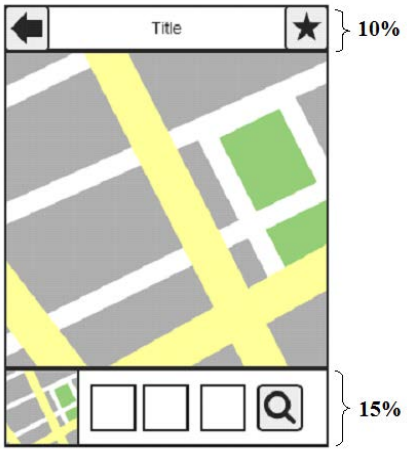
1. QR-code
2. ZXing open-source 2D barcode development library
3. Android OS
4. Android Dev Phone 1 with SDK
5. Phonegap
6. Window 7 OS
7. Apache web server
8. MySQL

3-2 Interface Design

This section describes the interface of QR MAP required for the prototype implementation on mobile device. The application is provided with interfaces for QR code scanning capability and subsequent functions as mentioned earlier in this report.

As this project's intent to demonstrate functionalities of the prototype, the interface is designed to be simple and distinguishable among elements whereby the individual modules are loosely-coupled to each others. Consequently, Majority of the functions are built on basis of button tags. In the other hand, since this prototype is developed on the foundation of the cross platform between web and mobile, the web-based approach is adopted to avoid confusion for terminology and framework.

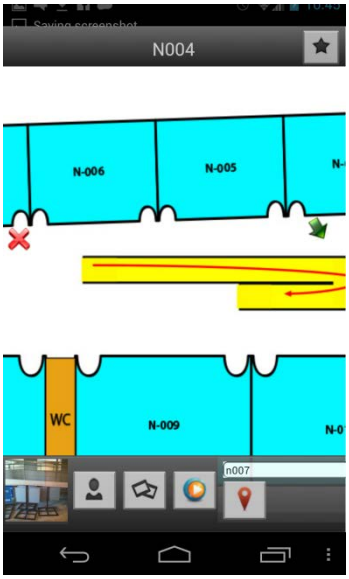
The mobile application consists of three pages: (1) welcome page, (2) scan page and (3) Map page. Due to inconsistent magnitude of phones screen, the percentage property is preferred to be used to achieve dynamic page content .The diagram below illustrates the skeletal blueprints of respective pages via website wireframe:

Welcome page	Scan page	Map Page
		

The following point form sentences describe every page specifically on their properties:

1. Welcome page
    - A welcome logo is placed on the centre of the phone screen.
    - The welcome logo is resizable scaling to the screen size as an image.
    - The image is margined to four directions by 25%.
2. Scan page
    - A scanning area of camera view is placed on the centre of the phone screen.
    - The scanning area is set to normal in visibility whereas the remaining of camera view is slightly darken and less visible.
    - A text of scanning status is placed on the left side of scanning area horizontally.
3. Map page
    - This page consists of two panels and one content area.
    - The top panel is a header div whereby it is vertically sized at 100% and horizontally sized at 10% to the phone screen.
    - The header div have two buttons: back navigation button and features button.
    - The content area is placed on the middle of the two panels; its width and height are 100% and 75% regards to the phone screen.
    - The content area displays the image of the map and the points of interest.
    - The content area is scrollable.
    - The bottom panel is a footer div whereby it is vertically sized at 100% and horizontally sized at 15% to the phone screen.
    - The footer div have a view div and multiple buttons for various functions: owner profile button, event detail button, video button and search button.
    - The footer div is hidden and shown as the toggle triggered by feature button.
    - Both header div and footer div are static regards to scrolling of content area.

The following diagram is the screenshot of the prototype application on mobile phone.

Menu Page	Camera Page	Map Page
		

3-3 Analysis Diagram

3-3-1 Use-case Diagram

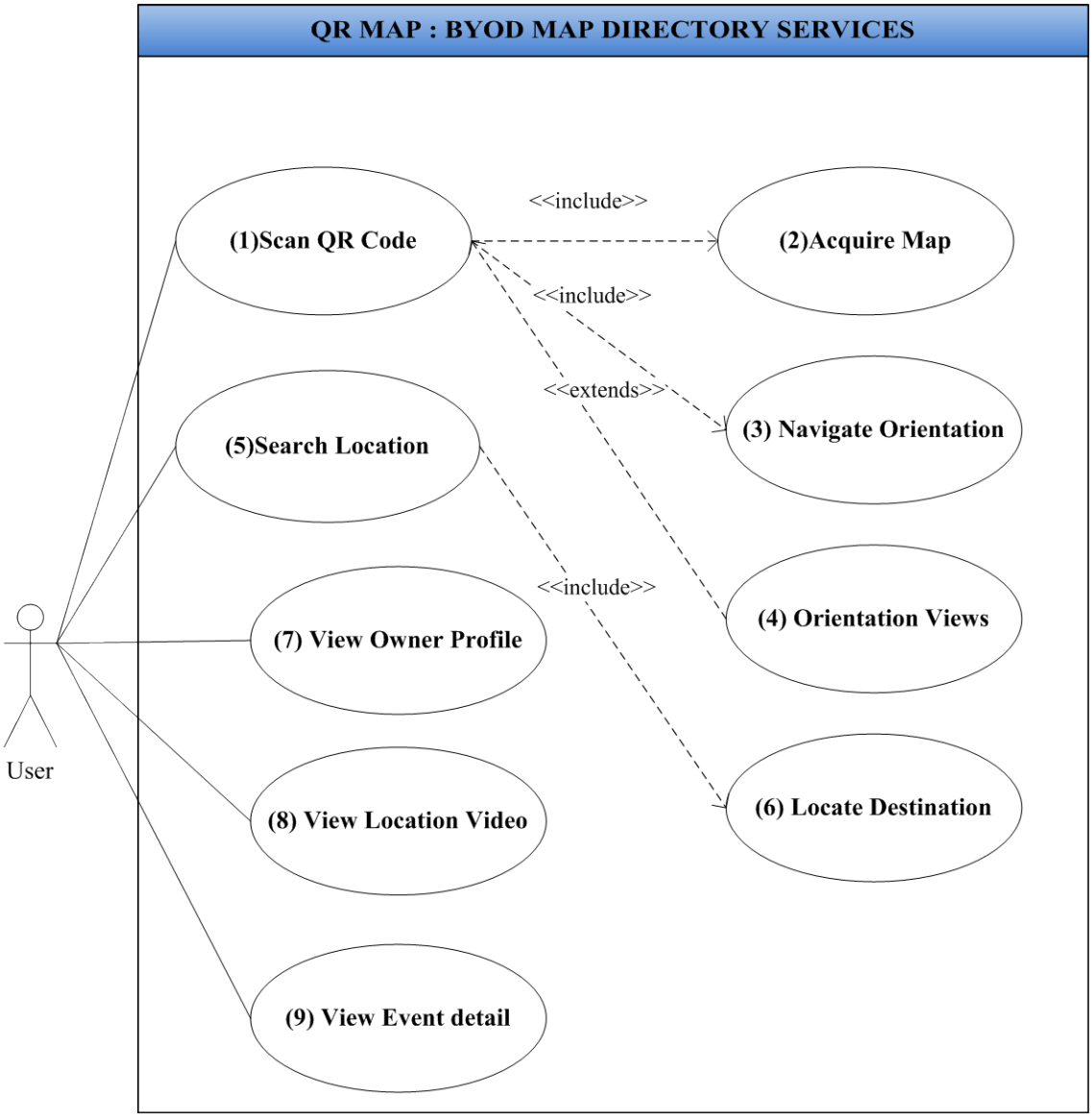


Figure 3-3-1-F1 Use-case diagram of QR-Compass

*3-3-2 **Use-case Description***

Use case name: Scan QR-Code	**ID :** 1	**Importance level:** High
Primary actor: Pedestrian	**Use case type:** Essential	
Stakeholders and interests: Pedestrian – wants to scan the QR-Code at a nearby QR-location in a QR-code implemented building		
Brief description: This use case describes how the QR-code is being scanned by the pedestrian.		
Trigger: A nearby QR-code is encountered by users. **Precondition:** The location is attached with a QR-code. **Postcondition:** The QR-code is remained undamaged.		
Relationships: Extend: (2)Search Destination		
Normal flow of events: 1. User walks into a QR implemented building. 2. User encounters QR location. 3. User scans the QR-code with his/her mobile devices. 4. User's mobile device decodes the QR-code and sends the decoded message to the system.		
Alternate/ exceptional flows: 4A- The QR-code is failed to be decoded due to intolerant damage dealt of OR-code image.		

Table 3-3-2-T2 Use-case Description of Scan QR-code

Use case name: Acquire Map	**ID :** 2	**Importance level:** Medium
Primary actor: Pedestrian	**Use case type:** Essential	
Stakeholders and interests: Pedestrian – wants to know his/her current location on a graphic map basis.		
Brief description: This use case describes how the pedestrian acquires the building map after scanning the QR code.		
Trigger: (1) is performed. **Precondition:** The QR-code is succeeded to be processed by the system. The connectivity does not get interfered. **Postcondition:** The building map is stored in user's mobile device and ready for further usage.		
Normal flow of events: 1. After the decoded message is sent to the system server, the system will match building map with the decoded URL address. 2. Once the relevant map location is matched, the map URL address will be sent back to user's mobile device and displayed.		

Table 3-3-2-T3 Use-case Description of Acquire Map

Use case name: Navigate Orientation	**ID :**3	**Importance level:** Medium
Primary actor: Pedestrian	**Use case type:** Essential	
Stakeholders and interests: Pedestrian – want to update the path with new current location after moving.		
Brief description: This use case describes how user get update with the positioning path from the system,		
Trigger: (1) is performed. **Precondition:** Pedestrian's device is on positioning mode. **Postcondition:** Positioning parameter is updated with current location.		
Relationships: Include: (1) Scan QR-Code		
Normal flow of events: 1. Pedestrian checks the arrival of destination by scanning the QR-code. 2. The application is updated with the latest current location and continued positioning.		
Alternate/ exceptional flows: 2A- The destination is matched with QR-code and Pedestrian is notified with the arrival.		

Table 3-3-2-T4 Use-case Description of Update Current Path

Use case name: Orientation Views	**ID :**4	**Importance level:** Medium
Primary actor: Pedestrian	**Use case type:** Essential	
Stakeholders and interests: Pedestrian – want to register a user account for more features.		
Brief description: This use case describes how pedestrian register account with his/her mobile devices.		
Trigger: Register function is selected from the menu. **Precondition:** Mobile device is connected to internet. **Postcondition:** The application is stayed login with registered account.		
Normal flow of events: 1. Pedestrian input their personal information into the field given. 2. The inputted data are sent back to system server for verification. 3. Pedestrian is notified with the success of the registration.		
Alternate/ exceptional flows: 1A- Pedestrian is prompted for login account if they have an account. 2A- Devices is previously merged with another account and the pedestrian is notified with the message.		

Table 3-3-2-T5 Use-case Description of Register Device

Use case name: Search Location	**ID :** 5	**Importance level:** Medium
Primary actor: Pedestrian	**Use case type:** Essential	
Stakeholders and interests: Pedestrian – wants to position the available destination by inputting keywords.		
Brief description: This use case describes how pedestrian to search targeted destination name after scanning QR-code.		
Trigger: (1) is performed. **Precondition:** (2) is performed. **Postcondition:** The searched destination is selected and ready for positioning.		
Normal flow of events: 1. A search text box is on the interface prompting for search input. 2. User types the keyword to search destination. 3. A list of relevant search result is displayed for user selection to perform selection.		
Alternate/ exceptional flows: 3A- No similar results is found from the keyword.		

Table 3-3-2-T6 Use-case Description of Search Location

Use case name: Locate Destination	**ID :** 6	**Importance level:** Medium
Primary actor: Pedestrian	**Use case type:** Essential	
Stakeholders and interests: Pedestrian – wants to select destination and start positioning.		
Brief description: This use case describes how pedestrian use the device to perform positioning.		
Trigger: (1) is performed. **Precondition:** (2) and (3) are performed. **Postcondition:** The searched destination is selected and ready for positioning.		
Normal flow of events: 1. Pedestrian selects the desired destination from search result. 2. The selected destination's data is sent to system server for process. 3. The positioning data is replied from system server. 4. Pedestrian can view the map and compass arrow for navigation.		

Table 3-3-2-T7 Use-case Description of Locate Destination

Use case name: View owner profile	**ID :**7	**Importance level:** Medium
Primary actor: Pedestrian	**Use case type:** Essential	
Stakeholders and interests: Pedestrian – want to login with their user account for more feature.		
Brief description: This use case describes how user login with their user account.		
Trigger: Login function is selected from the menu. **Precondition:** Mobile device is connected to internet. **Postcondition:** The client's map visibility is refreshed and updated to respective map visibility level.		
Normal flow of events: 1. Pedestrian inputs their username and password into the field. 2. The login data are sent back to system server for authentication. 3. Pedestrian is notified with the success of the login.		
Alternate/ exceptional flows: 2A- The device is not matched with the user account and Pedestrian is notified with the message.		

Table 3-3-2-T8 Use-case Description of Login Account

Use case name: View location video	**ID :**8	**Importance level:** Medium
Primary actor: Location Owner	**Use case type:** Essential	
Stakeholders and interests: Location Owner – customize their location into different visibility level.		
Brief description: This use case describes how location owner set their location to different visibility level.		
Trigger: Location control page is being directed. **Precondition:** Location owner is login with their account. **Postcondition:** The changes of visibility is updated and applied to all system users.		
Normal flow of events: 1. Location Owner selects their location from their owned location list. 2. Location Owner can adjust location visibility from default "public" to "private" or "unlisted". 3. The changes is confirmed by the location owner and updated to system server.		

Table 3-3-2-T9 Use-case Description of Control Location Visibility

Use case name: View event detail	**ID :**9	**Importance level:** Medium
Primary actor: Location Owner	**Use case type:** Essential	
Stakeholders and interests: Location Owner – want to add description to the location.		
Brief description: This use case describes how location owner add description to the location.		
Trigger: Location control page is being directed. **Precondition:** Location owner is login with their account. **Postcondition:** The changes of visibility is updated and applied to all system users.		
Normal flow of events: 4. Location Owner selects their location from their owned location list. 5. Location Owner adds or changes location's description. 1. The changes is confirmed by the location owner and updated to system server.		

Table 3-2-3 T10 Use-case Description of View event detail

*3-3-3 **Activity Diagram***

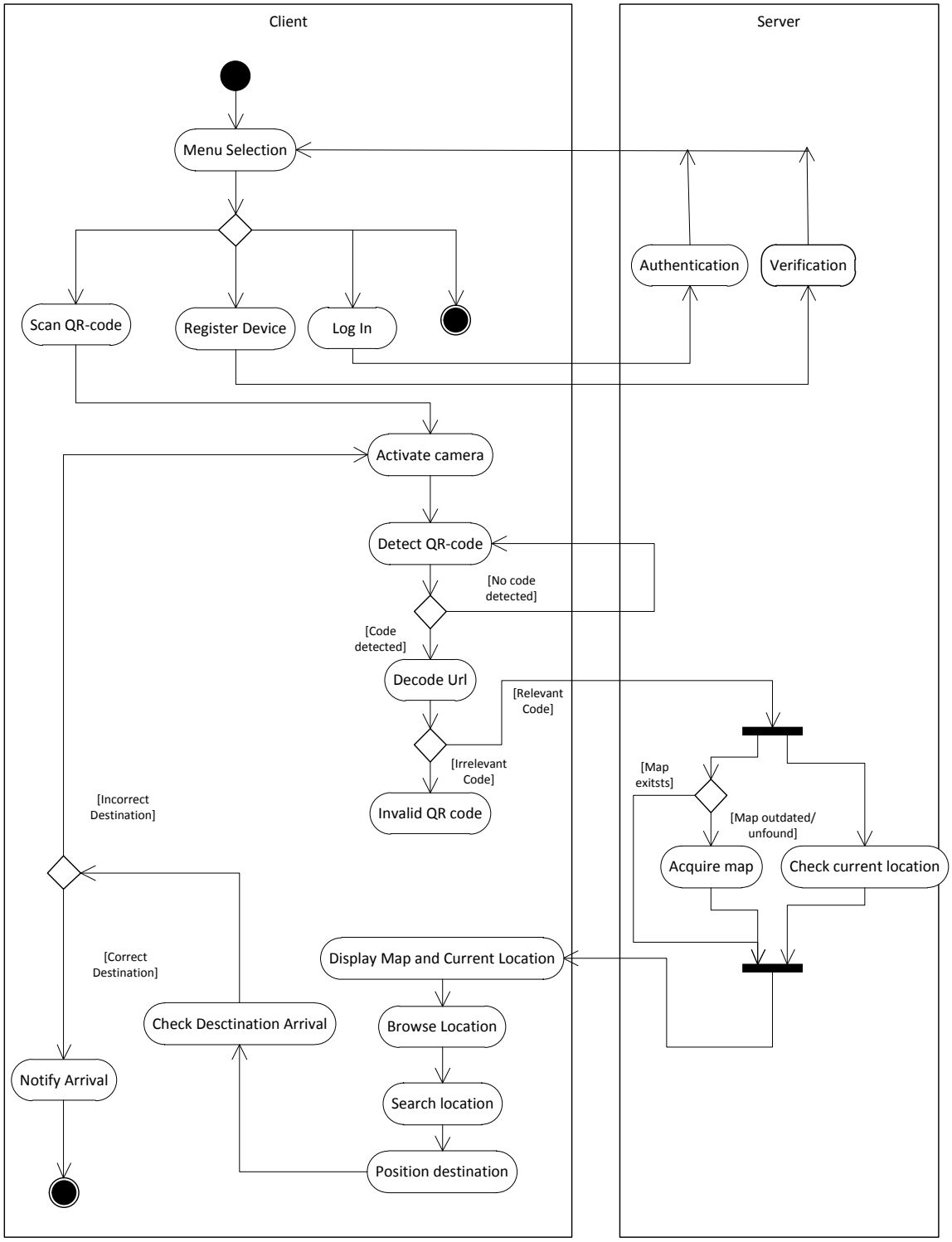


Figure 3-3-3-F2 Activity Diagram of QR-Compass

The diagram above shows the activity flow of the system with the actor pedestrian in use case. At first, the user selects three options once after launch the client application. By default, the QR-Scanning area shall first be displayed once after the loading page. The user is anonymous and they still are allowed to use the service but with limited feature and restricted location visibility. Alternatively, the user can select for login or register device. For the login context, the user shall have account previously either on the same device or different device. In the other mean, the user can register multiple devices with under his/her account if user account is created priorly. Therefore, the device would be unable to login if the device is registered with different account. When user requests for either former or latter, the respective entered inputs are sent to server for verification or authentication.

If the QR-Code Scanning mode is selected, the camera of the device will be activated and up for code detect. The next stage of it constantly detect the presence of QR-Code until it found or video capturing in the other word. Once the code detected, the application will decode it and send the message to the message for checking the current location. Or else, the invalid QR-Code is notified to the user if the damage/unclearness of the QR-code image is intolerant.

The map and current location are displayed prior to the success of server process. Next, the user can search for desired destination by inputting the keywords. The matched result would be displayed and ready for positioning.

The user can check the whether the destination is reached by scanning the QR-code. The notification message would be displayed if the destination is matched with QR-code, otherwise the current location would be replaced with the data of scanned QR-code for re-positioning.

*3-3-4 **Class Diagram***

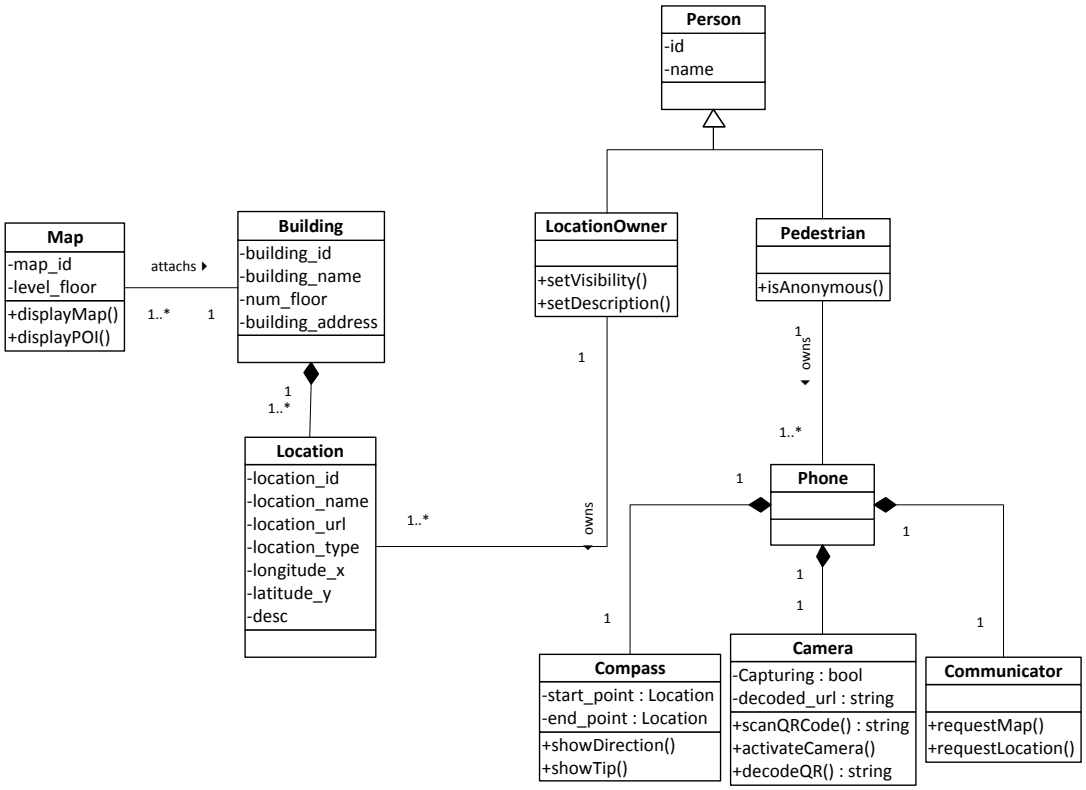


Figure 3-3-4 F3 Class Diagram of QR-compass

The class diagram above is only shows brief required classes in the analysis phase with several examples of attributes and operation. Map Class is initialised for displaying whereas Location class is initialised for pointing location on the map. Building Class is served as a logical connector between location and map as for a building can have multiple floor (multiple 2nd maps is required).

Person Class is an abstract class of LocationOwner and Pedestrian and both of them inherit the attribute from it. LocationOwner Class will have more administration feature to control over location. Pedestrian is served for user registration and login module but the system is allowed to use as a guest for pedestrian.

Compass Class allows the positioning between two points on map. It calculates angle rotation which reacts to the pedestrian's orientation. Thus, the compass over the map can be shown and as well as the tips if the changes of floor is required. Camera Class is used for scanning QR-codes and decodes them. Communicator Class plays the role of communicate (send data and receive data) with the server when the interaction between client and server is required.

3-3-5 ***ER-Diagram***

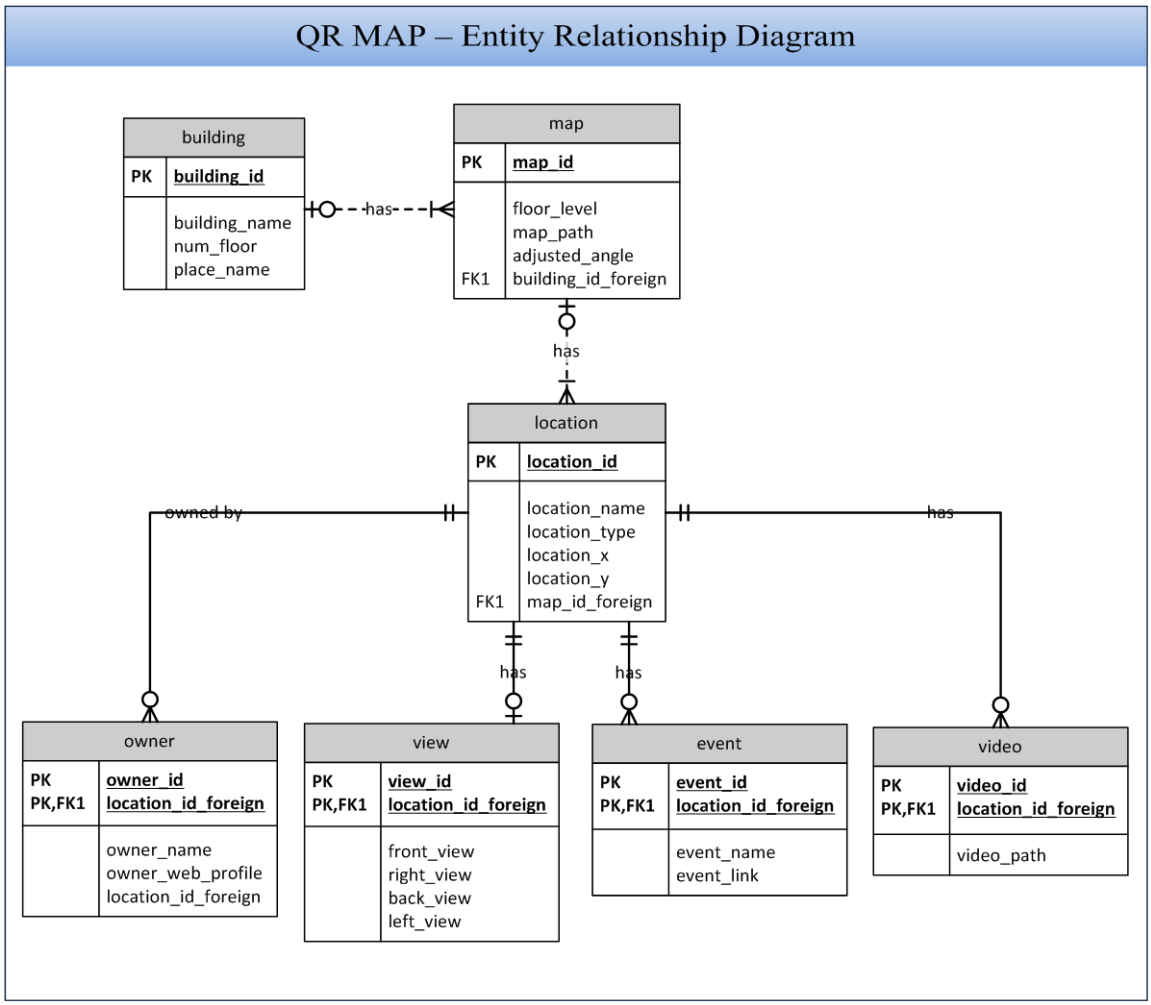


Figure 3-3-5 F4 ER-diagram of QR-Compass

The ER-diagram above shows the database structure on the server unlike to previous class diagram (client-side). PedestrianGroup is used for user-privacy control; when a location is set to private mode, the pedestrian entry in PedestrianGroup is only allowed to view the location.

3-3-6 ***Data Dictionary***

building Entity Store system-required information of buildings		
Attributes	**Data Type**	**Description**
building_id	Integer	Unique identifier for the building
building_name	Varchar(20)	Name of the building
num_floor	Integer	Number of floor for the building
place_name	Integer	Name of place that particular building is located

map Entity Store system-required information of maps that attaches to particular building		
Attributes	**Data Type**	**Description**
map_id	Integer	Unique identifier for the map
floor_level	Varchar(10)	Level of floor for the building
map_path	Text	URL of the map that links to web server
adjusted_angel	Integer	Normalized value of angel for the map
building_id_foreign	Integer	Referential identifier for the map toward building

location Entity Store system-required information of locations that attaches to particular map		
Attributes	**Data Type**	**Description**
location_id	Integer	Unique identifier for the location
location_name	Varchar(20)	Name of the location
location_type	Varchar(20)	Categorisation of type for location
location_x	Integer	X-coordination of location on map in pixel
location_y	Integer	Y-coordination of location on map in pixel
map_id_foreign	Integer	Referential identifier for the location toward the respective map

owner Entity Store system-required information of owner that owns particular location		
Attributes	**Data Type**	**Description**
owner_id	Integer	Unique identifier for the owner
owner_name	Varchar(50)	Name of the owner
owner_web_profile	Text	URL of online profile of the owner
location_id_foreign	Integer	Referential identifier for the owner toward the respective location

view Entity Store system-required information of view that is owned owns particular location		
Attributes	**Data Type**	**Description**
view_id	Integer	Unique identifier for the view
front_view	Text	URL of the front view's image for the location
right_view	Text	URL of the right view's image for the location
back_view	Text	URL of the back view's image for the location
left_view	Text	URL of the left view's image for the location
location_id_foreign	Integer	Referential identifier for the view toward the respective location

event Entity Store system-required information of event those are owned owns particular location		
Attributes	**Data Type**	**Description**
event_id	Integer	Unique identifier for the event
event_name	Varchar(20)	Name of the event
event_link	Text	URL of event detail
location_id_foreign	Integer	Referential identifier for the event toward the respective location

video Entity Store system-required information of video those are owned by particular location		
Attributes	**Data Type**	**Description**
video_id	Integer	Unique identifier for the owner
video_path	Text	URL of video in server
location_id_foreign	Integer	Referential identifier for the video toward the respective location

3-3-7 ***Sequence Diagram***

3.3.7.1 Sequence Diagram for Use Case (1) and (2)

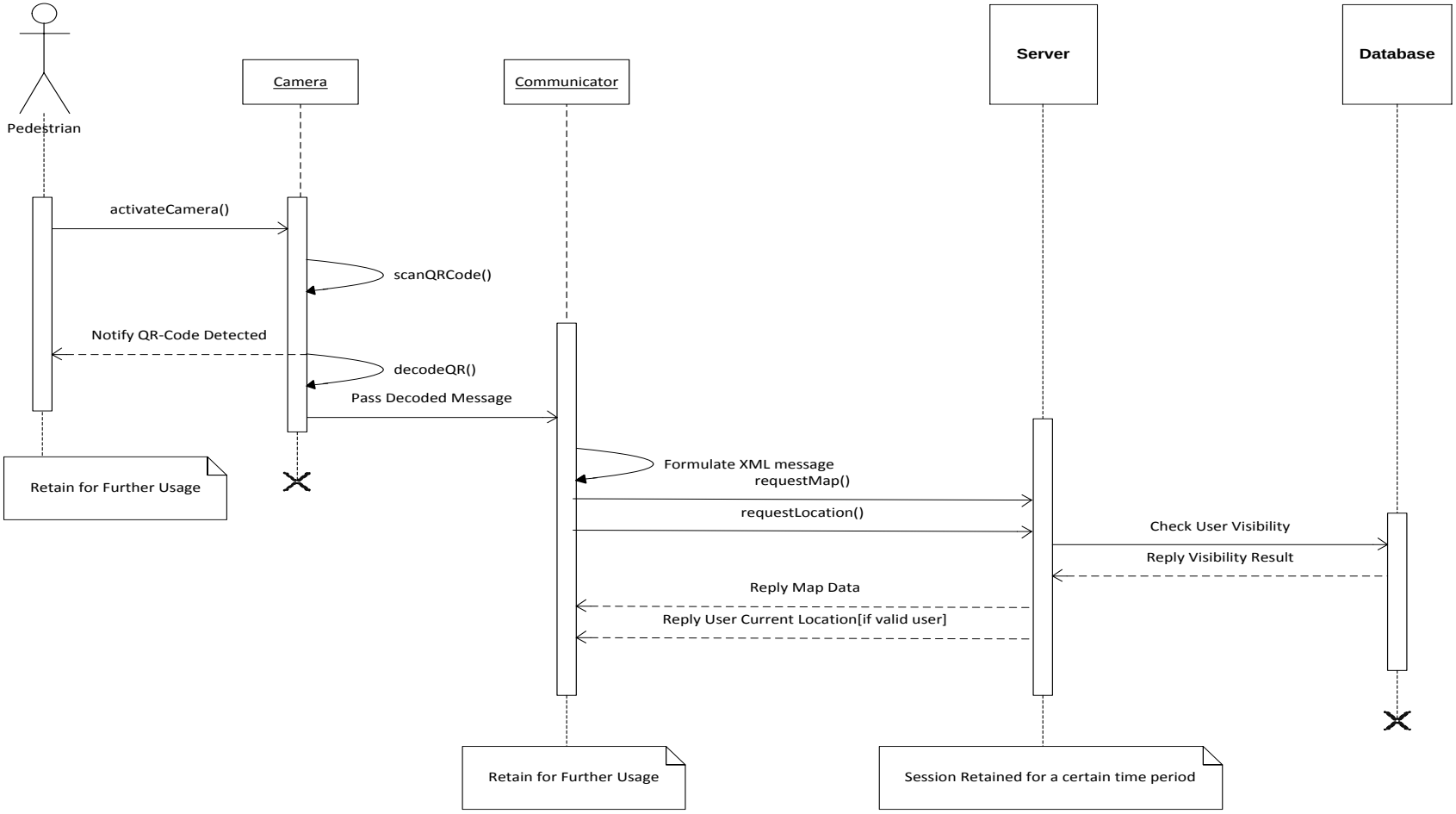


Figure 3-3-7 F5 Sequence Diagram of Use Case (1) and (2)

3.3.7.2 Sequence Diagram for Use Case (3)

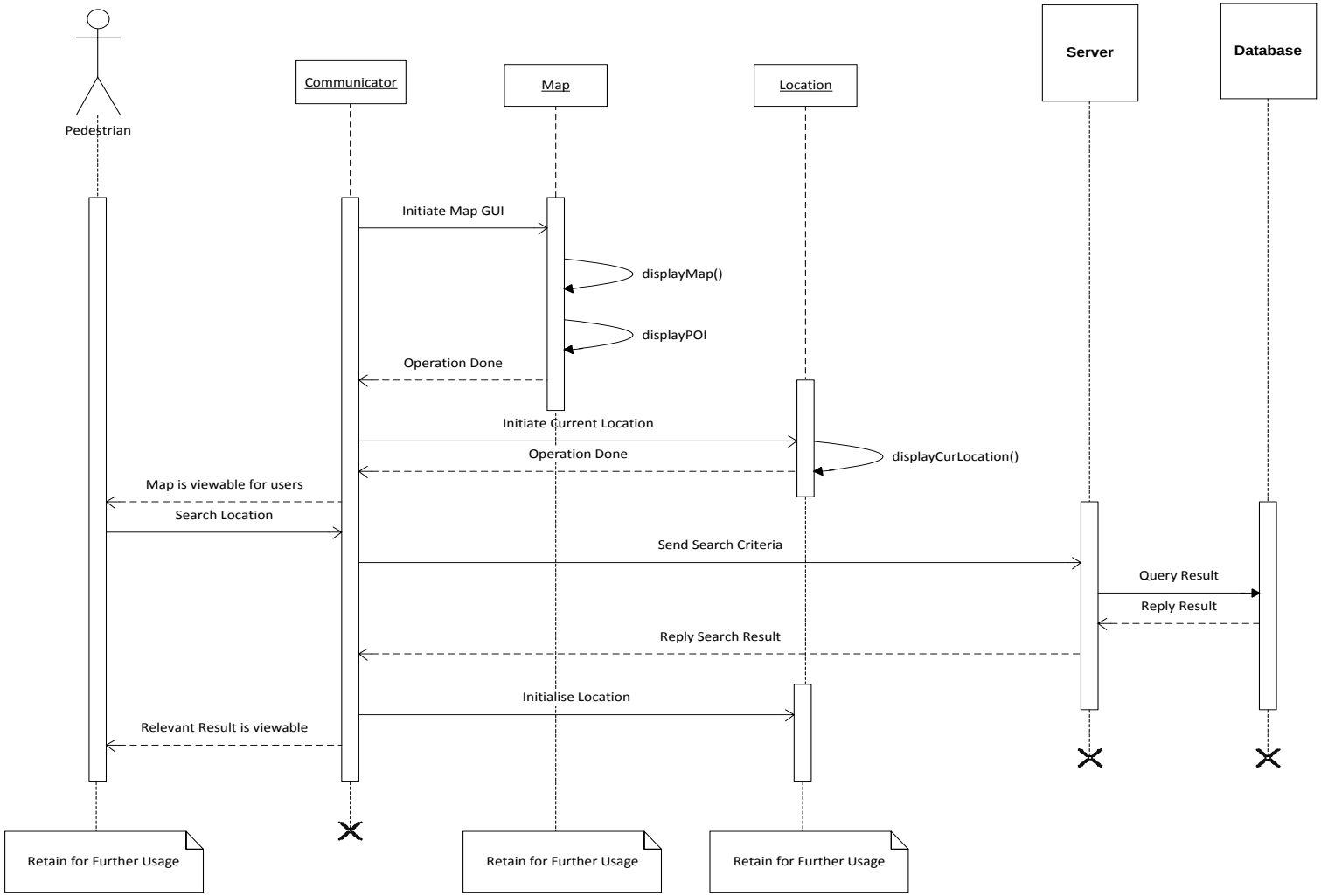


Figure 3-3-7 F6 Sequence Diagram of Use Case (3)

3.3.7.3 Sequence Diagram for Use Case (4)

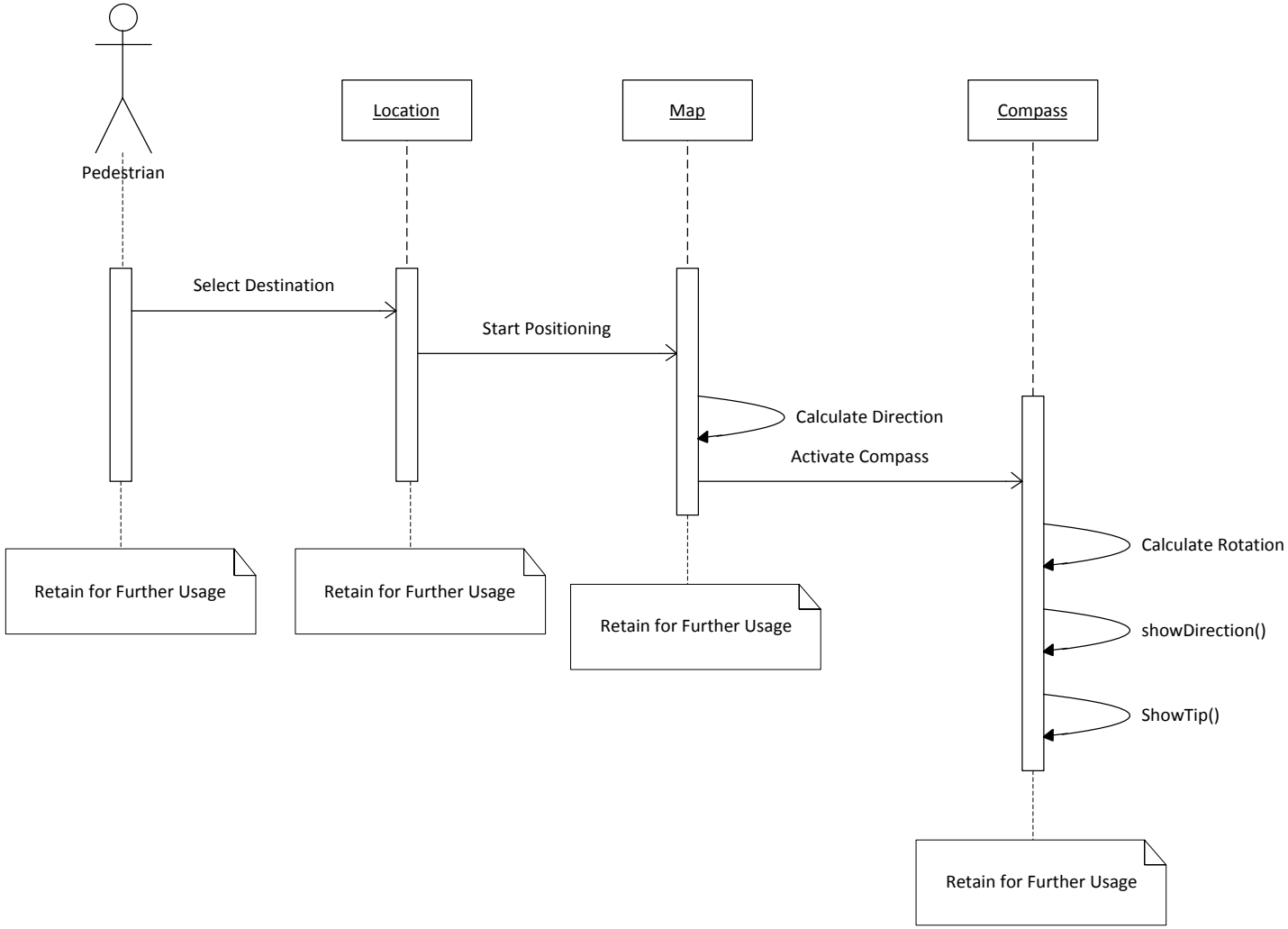


Figure 3-3-7 F7 Sequence Diagram of Use Case (4)

3.3.7.4 Sequence Diagram for Use Case (5)

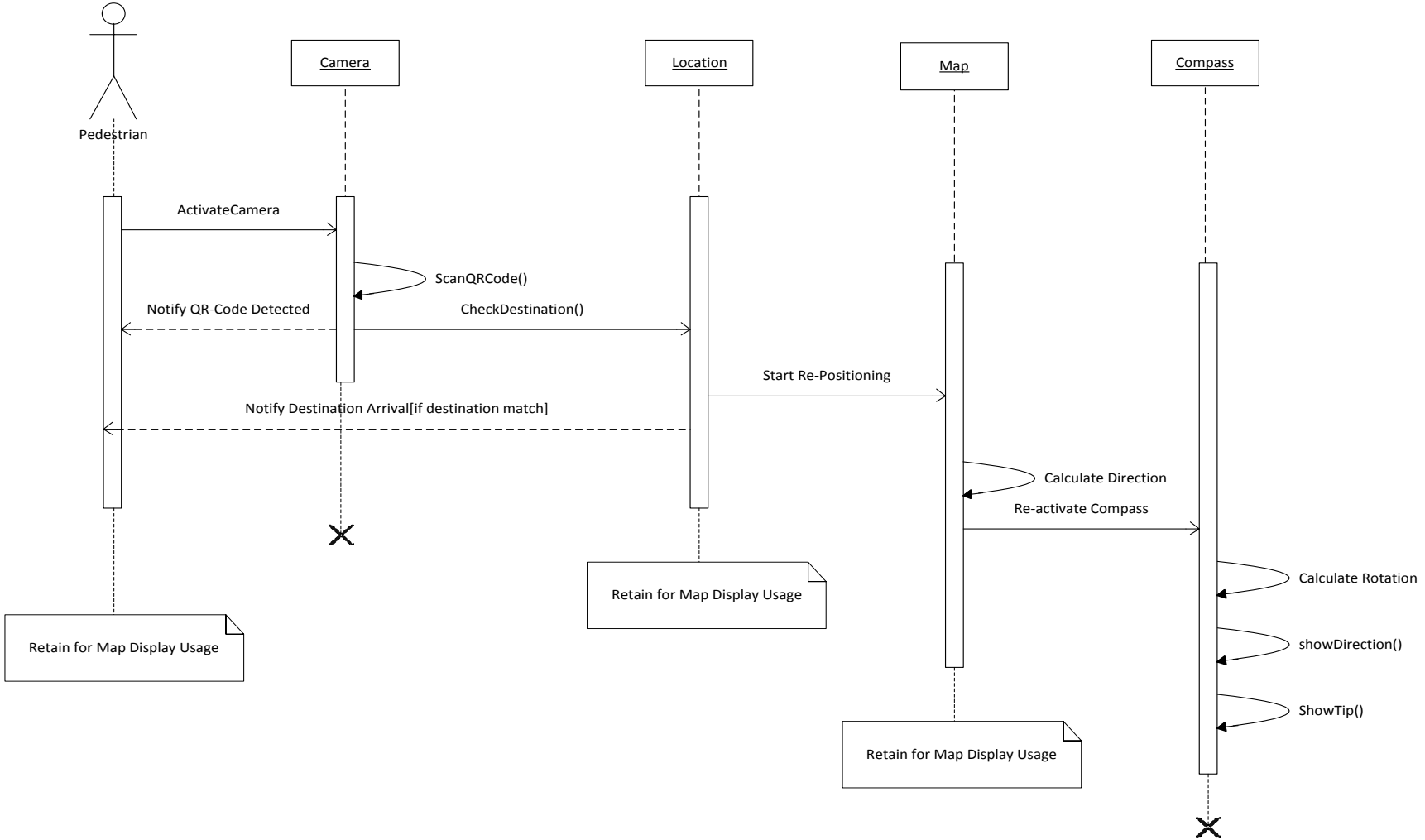


Figure 3-3-7 F8 Sequence Diagram of Use Case (5)

3.3.7.5 Sequence Diagram for Use Case (6)

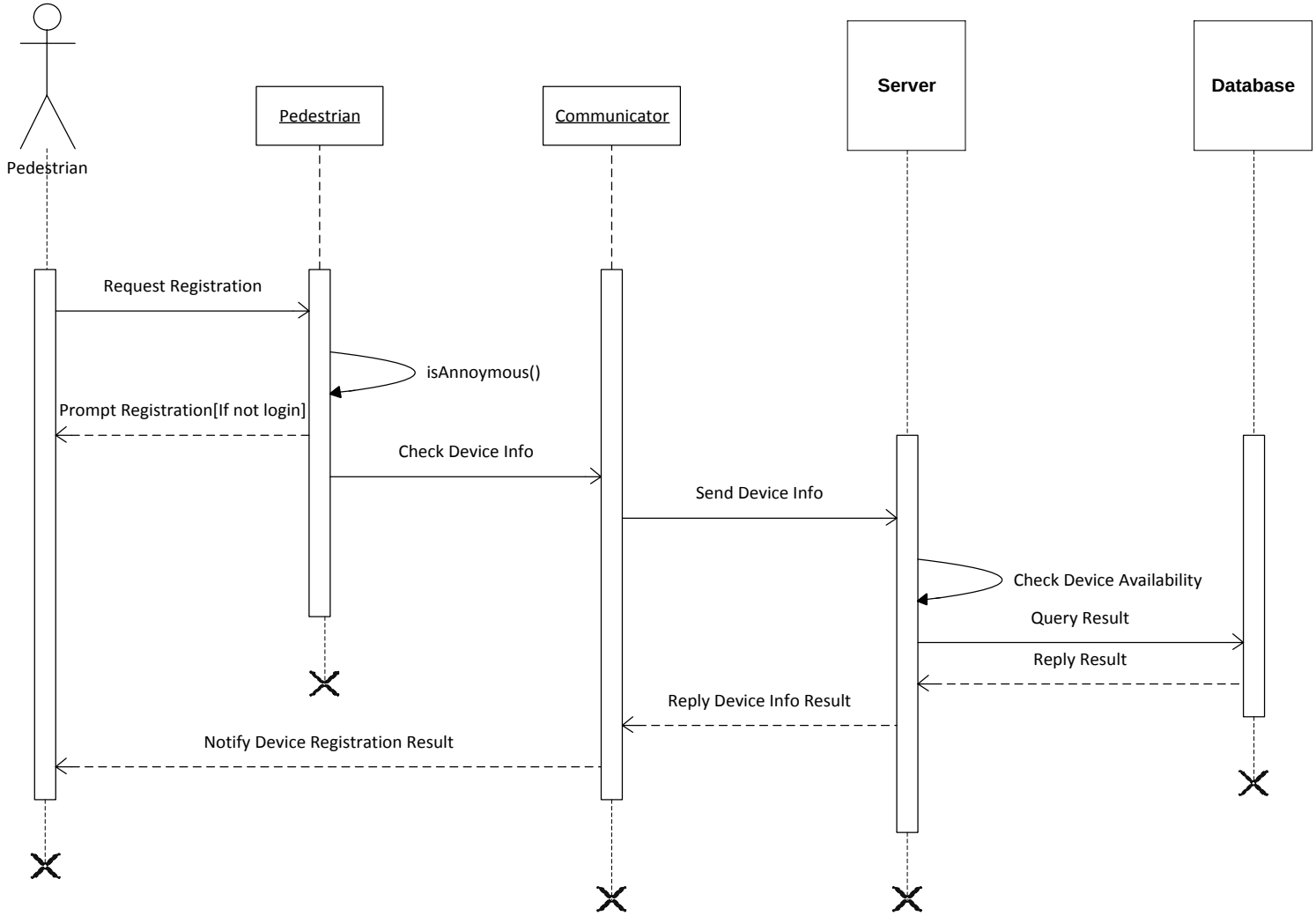


Figure 3-3-7 F9 Sequence Diagram of Use Case (6)

3.3.7.6 Sequence Diagram for Use Case (7)

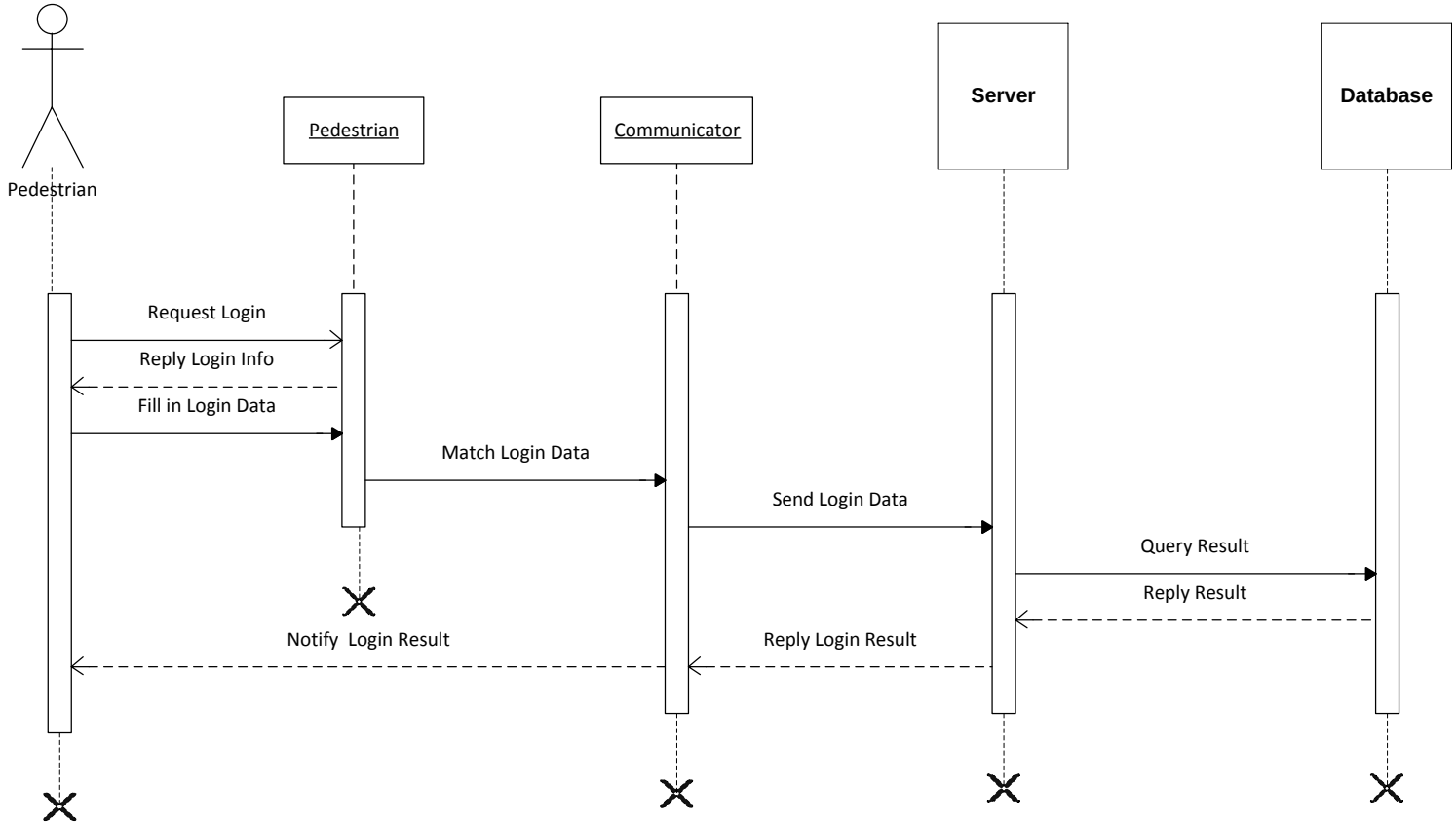


Figure 3-3-7 F10 Sequence Diagram of Use Case (7)

3.3.7.7 Sequence Diagram for Use Case (8) and (9)

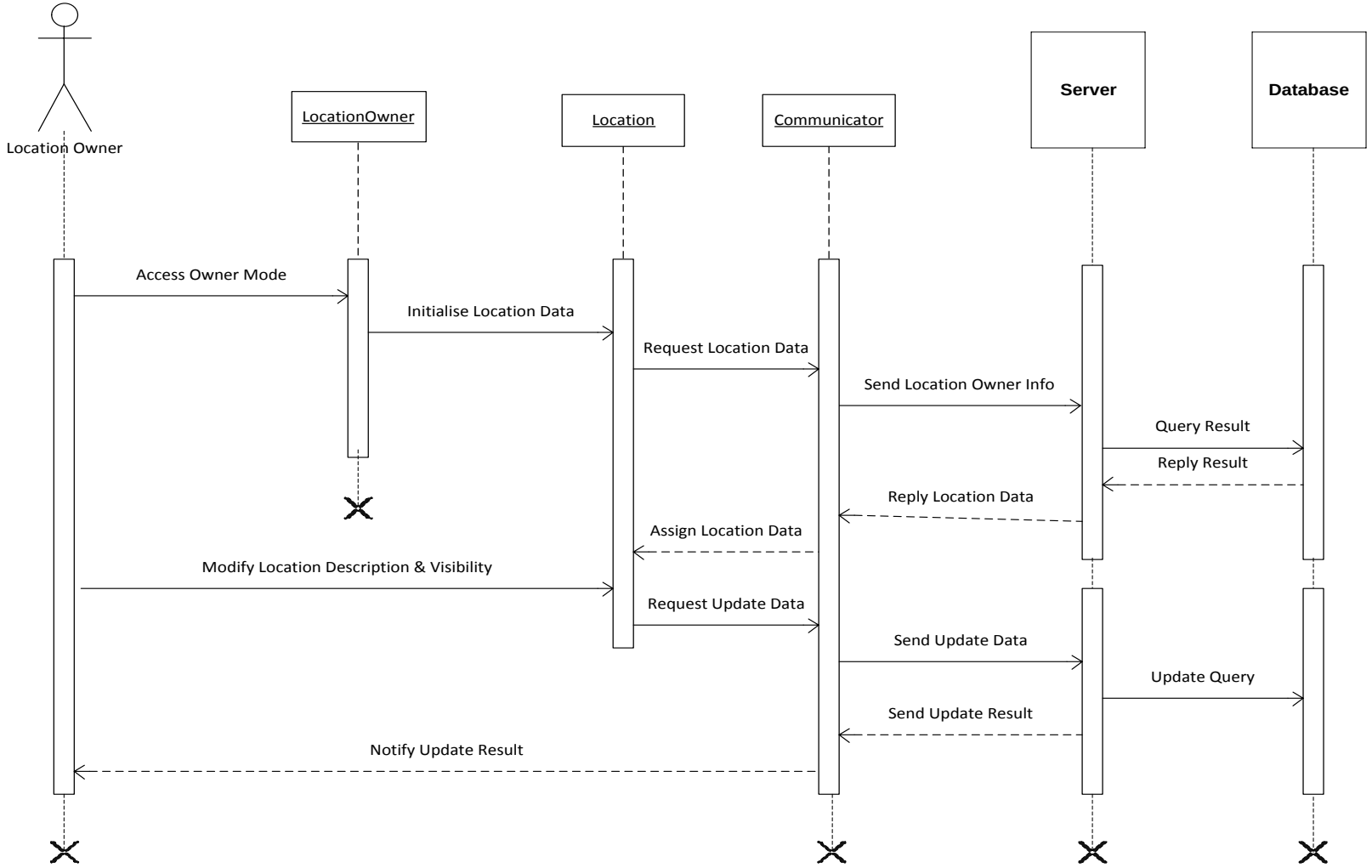


Figure 3-3-7 F11 Sequence Diagram of Use Case (8) and (9)

Chapter 4 Implementation

4-1 Architectural Model – Physical implementation

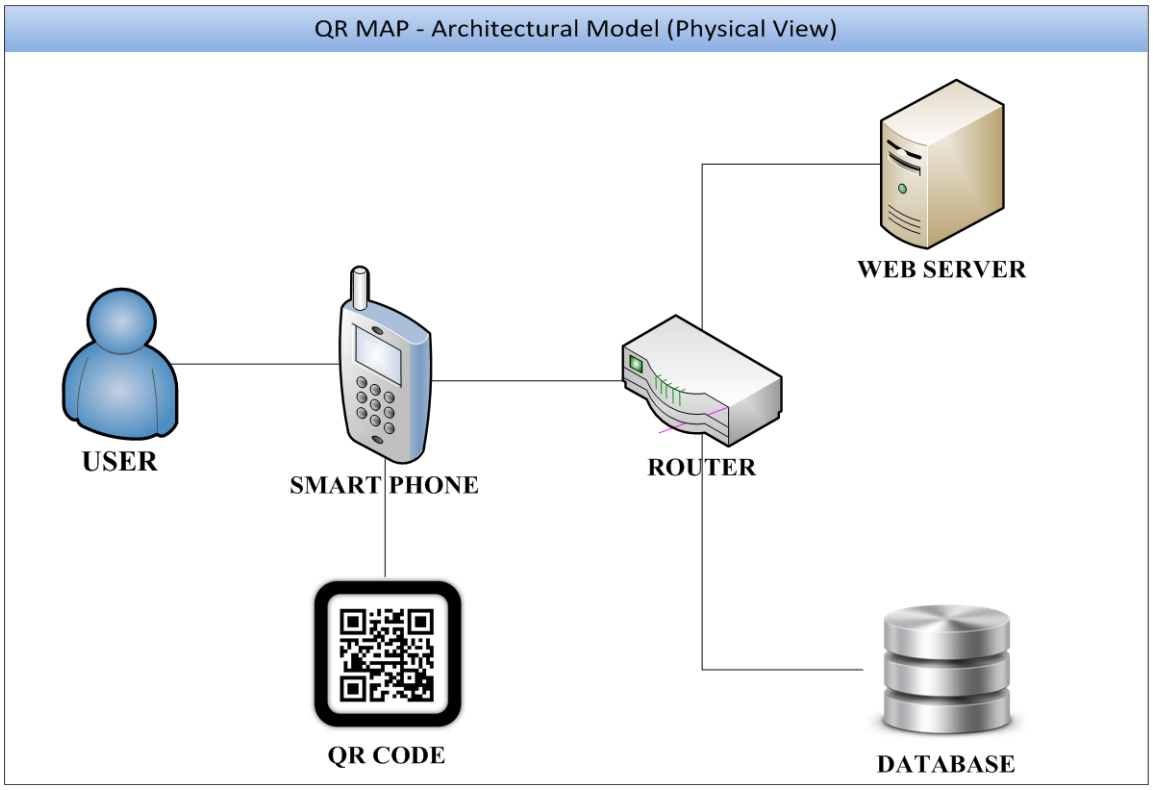


Figure 4-1-F12 Architectural Model – Physical Implementation

The diagram above illustrates the physical components those are involved in the prototype system. A client-server network model is implemented to connect the devices logically.

By giving a scenario to describe the relationship among the components, user would operate the prototype application on the smart phone. Next, the application would prompt user to scan QR code. After the decoding, the decoded message would be encapsulated to respective request message and then query to the server and database. The router would serve the connection medium between both client and server. Although both database and web servers are two different entities conceptually, they are installed on the same physical machine in this prototype system.

Client-server model is adopted in the prototype for various reasons. First, in order to verify the practicality of this navigation solution, this simple model is best fit to the scope.

The architecture is designed just nice enough for the functionalities without invoking unnecessary components. Users are allowed to use the client application only within network coverage and the server can directly response to client devices without interference of other network activities. From that, the user is able to resolve their navigation problem compared to existing solution. Secondly, the responsive of system performance is assumed to be in the best condition as to establish a good testing environment for yielding consistent test results. Hence, local area network connection is setup during testing phase and prototype demonstration.

4-2 Architectural Model – Logical implementation

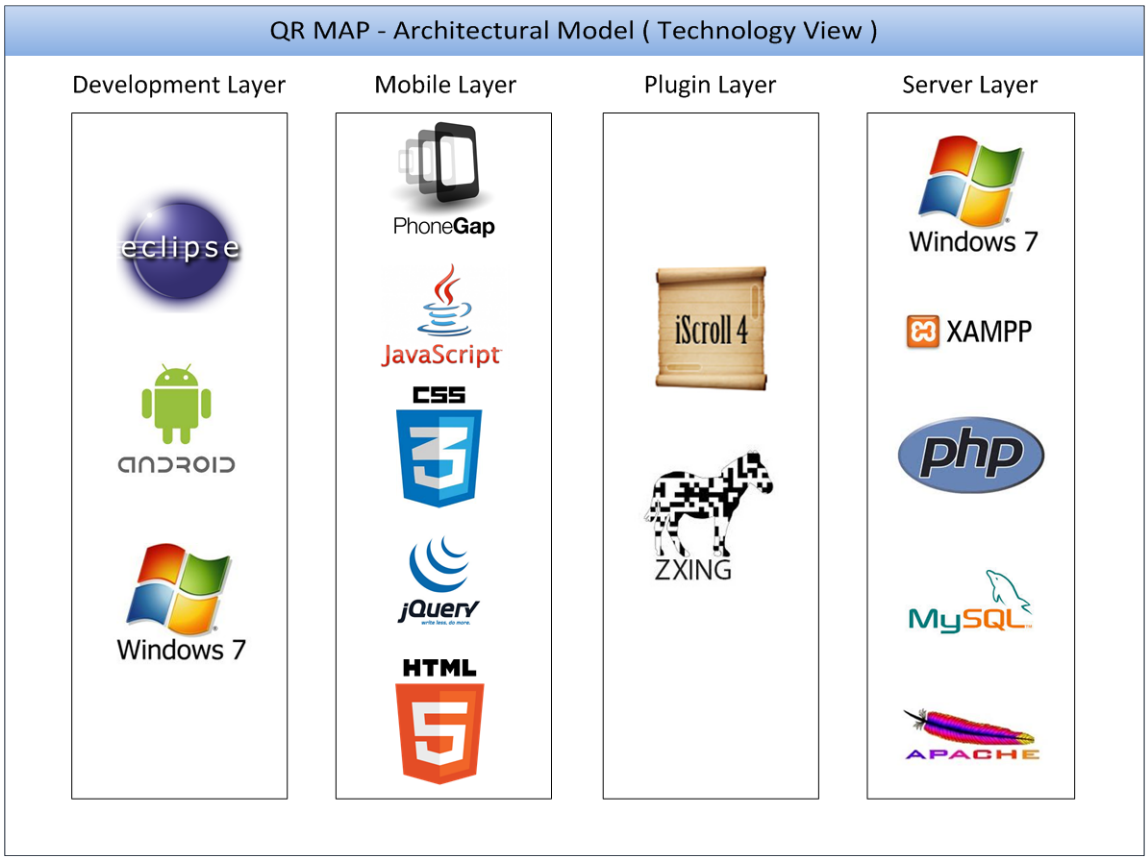


Figure 4-2 F13 Architectural Model – Logical Implementation

The diagram above illustrates the technology that has been adopted during implementation. They are classified into four layers: development, mobile, plug-in, and server. In collaboration of the layers, the system prototype comes into existence along within the physical components which are discussed on previous section.

4-2-1 ***Development layer***

In development layer, it is comprised of integrated development environment (IDE) and operating system for the application. Android OS is chosen as the mobile platform to deploy the application whereas the Eclipse on Window is chosen as the IDE to develop the application.

4-2-2 ***Mobile Layer***

As system prototype, hybrid cross-platform approach is used to develop the mobile application. Phonegap mobile development framework is placed on the mobile layer as it

allows the platform connection between Android OS and web development framework. Hence, the application can be easily built as similar like creating a website. In the application, HTML5 is responsible for the backbone structure of application UI. It uses tags to initialise the interface components. With the advancement of HTML5, as one of the function the media player can be implemented without invoking external plug-in. CSS3 plays the part of positioning for the interface components. Notably, it is the core technology that drives the orientation function being working which CSS is not capable of. Lastly, Javascript and Jquery are used to create the functionality of the application by interacting with the mentioned formers.

4-2-3 Plug-in layer

Two useful plug-in libraries are implemented in this system. iScroll is a mobile webkit library that provide web content a native-like interface. It prevents excessive custom use of CSS to have header tab, footer tab and scrolling central area for content. Second plug-in is the ZXing. It is famed open source barcode image processing library for Android and java. With the implementation of both libraries, it significantly boost the development time with the referential functionality.

4-2-4 Server layer

This layer provides the cooperated server components to make service and resources available to mobile client. In the system prototype, the server is operated at Window 7 Professional OS 64 which is the same machine at development layer. In this project, the focused objective is on the navigation solution and therefore we want to optimize time for the server configuration by implement the XAMPP package. It consists of Apache HTTP server, MySQL database, and phpmyadmin. Apache HTTP provides the functionality on response to the resource requests and the web service. With attention to the web service, the mobile layer does not support for the sql query toward the database. Thus, an alternative approach is applied on the server layer which hosts the php web service on the HTTP server. For this purpose, the JSON calling function can be implemented on the mobile layer to acquire marshalled data by calling the web services accordingly. In addition, MySQL is implemented for data storage whereby phpmyadmin

together with XAMPP package allow a graphical user interface to easily manage the database.

4-3 Implementation of Custom QR Code

In this project, a custom QR code encoding syntax has been specifically designed to provide organized representation syntax toward the location. First and foremost, since this is a geo-location related project, the identification of location from real world perspective is recognized to the system as an object. Hence, the objects have been specialized in four identical levels to reduce complexity of geo-location. The levels are place, building, floor and location whereby the levels are arranged in descending scope. The diagram above describes the syntax of QR code encoding by distinguishing into different colours. By applying set theory, the concept behind derives the instance in the following diagram:

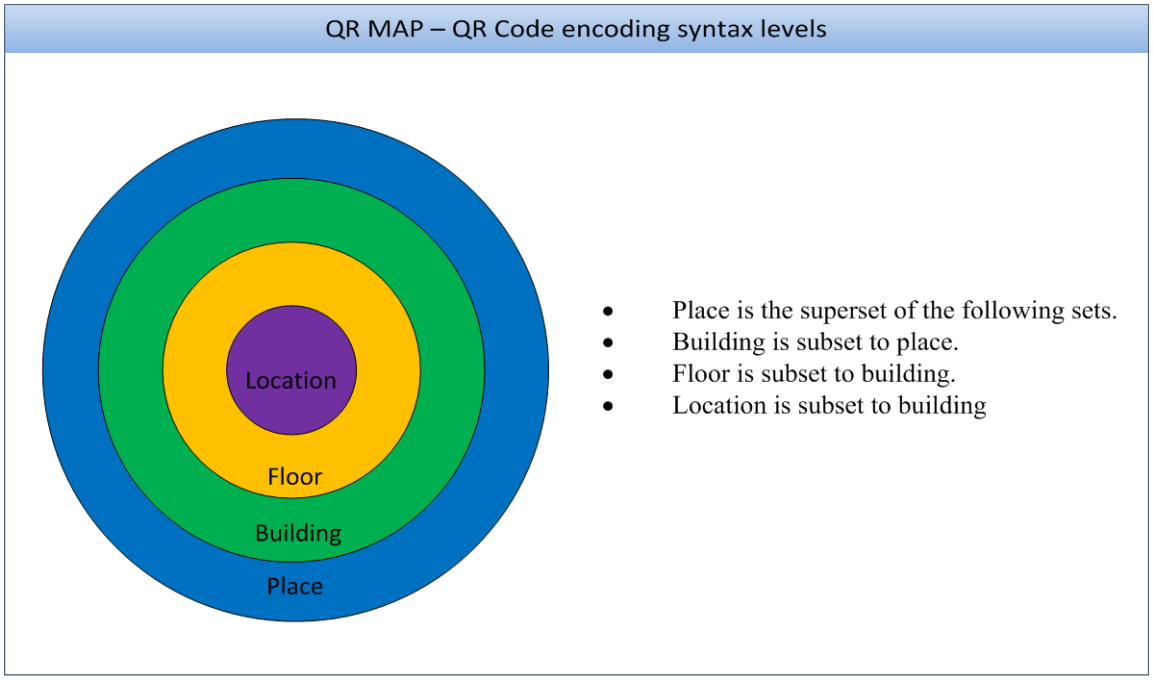


Figure 4-3 F14 QR-Code Encoding

With this concept, the geo-location objects have organized from high level to low level in a descending order. In my proposed practice, the geo-location information is encoded into a string by splitting them with hash tags. Thus, the decoding function could be done by identifying the hash tags vice versa.

4-3-1 Relationship among geo-location objects in database

In addition, this concept also provides a conceptual relationship among the entities toward database design issue. A tree structure is established where one-to-many

relationship is attained from the top level to low level. For example, a building has multiple floors.

4-3-2 Sustainability of QR Code

The sustainability of QR Code becomes an issue in which the period of time can the QR Code represents the location. In my proposed implementation, the static information about the location is only encoded to the QR Code such as building name and location name. These are the information that is not alterable without reconstruction of the physical structure. It becomes the identical representation of location toward respective QR Code and the printed version would not be discarded due to any modification. On the other hand, the dynamic information of the location is resided on the database upon the QR Code.

4-3-3 Authentication and Transparency of QR Code

The red part of encoding syntax exists for the authentication mechanism. Generally, the QR Code has been widely implemented to various other kind of system. Thus, this is the part where the QR Code is uniquely recognised by my proposed system. Although, the other system still able to decode the QR Code; it rather would be recognised blanked text by the systems. At the application side, after the QR Code being decoded, it would be authenticated by the program before proceed to requesting resources from the server. It results that the transparency of the server address is only appeared code level. Unlike the other standard, the server address is encoded without masking.

Chapter 5 Testing

5-1 Test planning and Objective

During testing phase of this prototype development, functional and non-functional testing are primarily focused in order to validate and verify with objectives of this project but some other testing is followed to be conducted to strengthen the overall conceptual idea with credible test reporting. Since this is a system prototype, some of the testing is omitted because results of the testing would not reflect toward project objective and it is out of the scope. At last, a user acceptance testing in alpha level is conducted. This generally aims to collect the feedbacks from potential users towards the prototype and the proposed navigation solution. From the feedbacks, we can analyse it and then uncover the incognito region of this project.

5-2 Test strategy

During the functional testing, the testing is divided into three levels with bottom-up approach – unit testing, integration testing, and system testing. Along with the prototype development, every individual function is immediately tested in unit level after the code completion. After the completion of all required functions, the integration testing is followed up. Since the adopted methodology is an incremental model, the functions are integrated from the foundation level toward high level. Thus, the integrated functions would be tested in a stack model whereby the tested function would be discarded from the integration stack if this function is no longer a pre-requisite to any latter correspond functions. Lastly, a system testing is conducted to overall functionality. In this functional testing, the test method is white box basis in which both the implementation and testing are performed the same person, as the author of this document. Basically, once the function is failed to pass the testing, it is immediately sent back to development for correction. For this reason, the corrected functions would be sent for defect retesting according to different level. This testing process is cycled until good to be closure once all functions is passed.

Second testing is non-functional testing. It generally assess on the performance of the prototype from achieving certain tolerant level. Most importantly, the accuracy of the

direction orientation must be exceeded certain level of tolerance to fulfil its credibility to be navigation information. However, it does not reflect much on the objective of the system. The responsive toward user's interaction would be tested as well as the performance of data transmission and processing. Generally, the test is conducted together with the test scenario which is described in following section.

5-3 Test Scenario

As similar to cope of this project, the building structure of UTAR Block N is used as the indoor scenario toward the system prototype. Be more specifically, the locations on ground floor are only established with the functionalities. In total, there are 59 distinct locations in which consist of lecture hall, labs, and lecturers' offices. Thus, certain functionalities do not apply to every location. The appendix is attached with a completed list of functionalities after scanning the QR Code correspondence to respective locations. On the other hand, a floor plan map is printed on an A1-sized paper in order to stimulate the scanning scenario. Therefore, there are two set of map – one with clear map and another one with QR Code attached. The diagram below is the captured image of the floor plan.

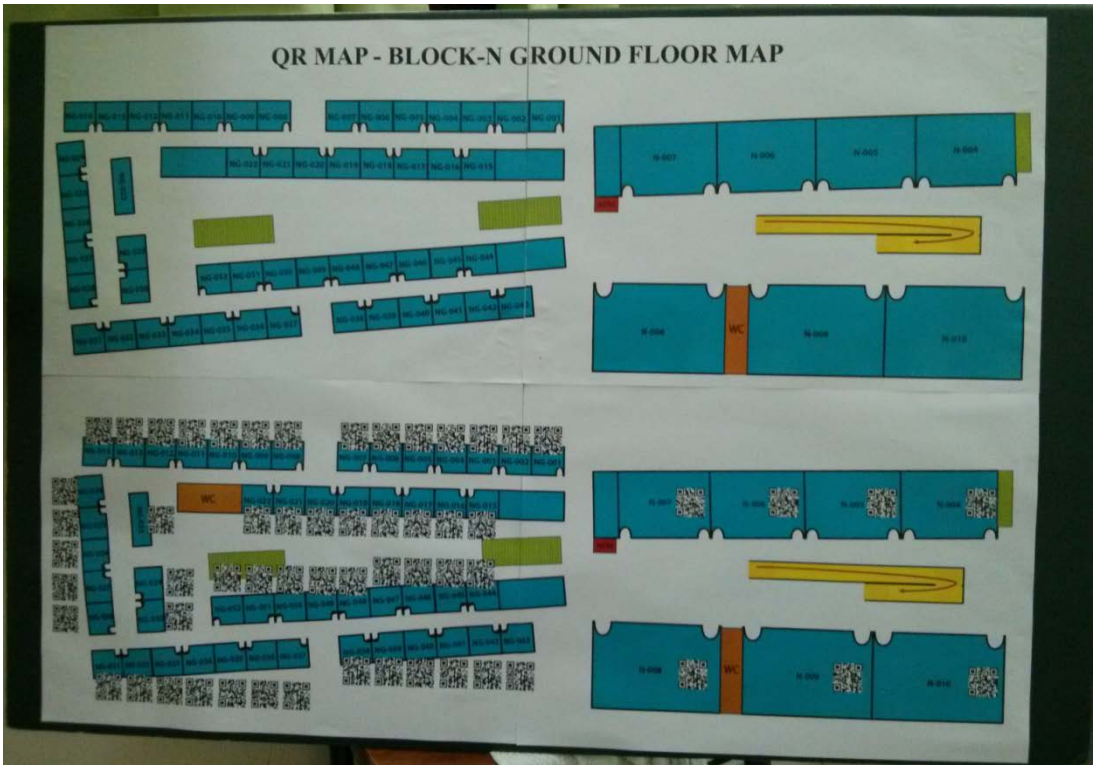


Figure 5-3-F15 Floor Plan of Block N Ground Floor

With this provided, the testing can be conducted on the simulated floor plan map without requiring user go to the actual location to scan QR-Code. Notably, the printed map is not positioned to north by itself and therefore the map must be adjusted to its corresponding angle (in which it is 50 degree to east) during demonstration.

5-4 Test environment

It's basically the same configuration with development as in the server, database, and router. Particularly, the prototype application is deployed on a LG Nexus 4 E960 which is official phone by Google and often first being updated with the latest OS release.

5-5 Test reporting

5-5-1 Unit testing

The test basis of the follow test report is on functionality and requirement of respective components, and test objects are the uses cases.

Test Module : (1) Scan QR Code			
Test Case	**Test Description**	**Expected Result**	**Test Result**
1	Scan QR Code with camera view	Decoded text is displayed.	PASSED
2	Split Decoded text into variables	Value of variables are separately displayed	PASSED
3	Scan product Bar Code	Error Message is displayed.	PASSED
4	Scan non-QR Map Code	Error Message is displayed.	PASSED

Test Module : (2) Acquire Map			
Test Case	Test Description	Expected Result	Test Result
1	JSON Request URL of map image from server	Message of establish connection is displayed.	PASSED
2	PHP web service establishes connection to database.	Message of establish connection is displayed.	PASSED
3	Call SQL query to database with JSON parameters	URL of map image is displayed.	PASSED
4	JSON function receives query result from server.	URL of map image is displayed.	PASSED
5	Link the map image via URL	Map image is displayed	PASSED
6	Display direction pointer	Direction pointer is displayed and hidden on map.	PASSED

Test Module : (3) Navigate Orientation			
Test Case	**Test Description**	**Expected Result**	**Test Result**
1	Acquire Compass reading from device sensor.	Compass reading is displayed.	PASSED
2	Adjust the compass reading with normalized value.	Normalized compass reading is displayed.	PASSED

3	Transform the angle of direction pointer with normalized compass reading.	Direction pointer point to the angle of compass reading.	PASSED
4	Transform the angel of direction with normalized compass reading in every time interval.	Direction pointer is periodically transformed to the angle of compass reading..	PASSED

Test Module : (4) Orientation Views			
Test Case	**Test Description**	**Expected Result**	**Test Result**
1	JSON Request URL of view images from server	Message of establish connection is displayed.	PASSED
2	PHP web service establishes connection to database.	Message of establish connection is displayed.	PASSED
3	Call SQL query to database with JSON parameters	URL of view images is displayed on server.	PASSED
4	JSON function receives query result from server.	URL of view images is displayed on mobile device.	PASSED
5	Display front view image in interval of degree of (316 to 45)	Front view image is displayed.	PASSED
6	Display front view image in interval of degree of (46 to 135)	Right view image is displayed.	PASSED
7	Display front view image in interval of degree of (136 to 45)	Back view image is displayed.	PASSED
8	Display front view image in interval of degree of (226 to 315)	Left view image is displayed.	PASSED
9	Receive no parameters from query	Construction image is displayed.	PASSED

Test Module : (5) Search Location			
Test Case	**Test Description**	**Expected Result**	**Test Result**
1	JSON Request search terms from server.	Message of establish connection is displayed.	PASSED
2	PHP web service establishes connection to database.	Message of establish connection is displayed.	PASSED
3	Call SQL query to database with JSON parameters	Search terms are displayed on server.	PASSED
4	JSON function receives query result from server.	Search terms are displayed on mobile device.	PASSED
5	Add owner names into search list	Search list is added with owner names.	PASSED
6	Add event names into search list	Search list is added with event names.	PASSED
7	Add location names into search list.	Search list is added with location name.	
8	Select option from select list.	Option is added into current	PASSED

		choice.	

Test Module : (6) Locate Destination			
Test Case	**Test Description**	**Expected Result**	**Test Result**
1	Load destination icon into map image	Destination icon is displayed on map image.	PASSED
2	Locate the destination icon to the selected destination from search list.	Destination icon is located to the destination.	PASSED
3	Relocate the destination icon to a new selected destination from search list.	Destination icon is relocated to the destination.	PASSED

Test Module : (7) View Owner Profile			
Test Case	**Test Description**	**Expected Result**	**Test Result**
1	JSON Request URL of owner profile from server.	Message of establish connection is displayed.	PASSED
2	PHP web service establishes connection to database.	Message of establish connection is displayed.	PASSED
3	Call SQL query to database with JSON parameters	URL of owner profile is displayed on server.	PASSED
4	JSON function receives query result from server.	URL of owner profile is displayed on mobile device.	PASSED
5	Click the owner profile button	An external browser is opened and owner profile is shown.	PASSED
6	Return to application by clicking device back button.	Screen is back to previous application user interface.	PASSED

Test Module : (8) View Location Video			
Test Case	**Test Description**	**Expected Result**	**Test Result**
1	JSON Request URL of video from server.	Message of establish connection is displayed.	PASSED
2	PHP web service establishes connection to database.	Message of establish connection is displayed.	PASSED
3	Call SQL query to database with JSON parameters	URL of video is displayed on server.	PASSED
4	JSON function receives query result from server.	URL of video is displayed on mobile device.	PASSED
5	Click the video button	An external video player is opened and video is ready to be played.	PASSED

6	Return to application by clicking device back button.	Screen is back to previous application user interface.	PASSED

Test Module : (9) View event detail			
Test Case	**Test Description**	**Expected Result**	**Test Result**
1	JSON Request URL of event page from server.	Message of establish connection is displayed.	PASSED
2	PHP web service establishes connection to database.	Message of establish connection is displayed.	PASSED
3	Call SQL query to database with JSON parameters	URL of event page is displayed on server.	PASSED
4	JSON function receives query result from server.	URL of event page is displayed on mobile device.	PASSED
5	Click the event button	An external browser is opened and event detail is shown.	PASSED
6	Return to application by clicking device back button.	Screen is back to previous application user interface.	PASSED

5-5-2 Expected Result of Integration and System Functionality Testing

Location Name	Orientation	Search by Owner	Search by Event	Search by Name	Video	Event	View
n004	✓		✓	✓	✓	✓	✓
n005	✓		✓	✓	✓	✓	
n006	✓		✓	✓	✓	✓	
n007	✓		✓	✓	✓	✓	✓
n008	✓		✓	✓	✓	✓	
n009	✓			✓	✓		
n010	✓			✓	✓		✓
ng001	✓			✓			
ng002	✓			✓			
ng003	✓			✓			
ng004	✓			✓			
ng005	✓			✓			
ng006	✓			✓			
ng007	✓			✓			
ng008	✓			✓			
ng009	✓			✓			
ng010	✓			✓			
ng011	✓			✓			
ng012	✓			✓			
ng013	✓			✓			
ng014	✓			✓			
ng015	✓			✓			
ng016	✓			✓			
ng017	✓			✓			
ng018	✓			✓			
ng019	✓			✓			
ng020	✓			✓			✓
ng021	✓			✓			
ng022	✓			✓			
ng023	✓			✓			
ng024	✓			✓			
ng025	✓			✓			
ng026	✓			✓			✓
ng027	✓			✓			
ng028	✓			✓			
ng029	✓			✓			
ng030	✓			✓			
ng031	✓			✓			
ng032	✓			✓			
ng033	✓	✓		✓			
ng034	✓	✓		✓			
ng035	✓	✓		✓			
ng036	✓	✓		✓			
ng037	✓	✓		✓			
ng038	✓	✓		✓			
ng039	✓	✓		✓			
ng040	✓	✓		✓			
ng041	✓	✓		✓			
ng042	✓	✓		✓			
ng043	✓	✓		✓			
ng044	✓	✓		✓			
ng045	✓	✓		✓			
ng046	✓	✓	✓	✓	✓	✓	
ng047	✓	✓		✓			
ng048	✓	✓		✓			
ng049	✓	✓		✓			✓
ng050	✓	✓		✓			
ng051	✓	✓		✓			
ng052	✓			✓			
Count			6		8	5	6

Chapter 6 Conclusion

6-1 What has been achieved

The proposed map directory service has provided an alternative map navigation solution toward the three mentioned problem statements in chapter one – modification of building, issue of user privacy and custom device required. In this project outcome, a prototype of QR Code Map directory service on scenario of UTAR Block N building. With this prototype, the user can install a mobile application to test on the system. The system is more feasible to be widely implemented in various indoor environments with elimination of mentioned problem. QR-Compass employs QR-code to obtain the current position of user. Once that position is available, with the help of server, the client device displays a custom map for the position. It helps user to find the point of interest via compass direction, and show them how to reach the destination within map. QR-code would ultimately become the best alternative in solving the problems after the comparison in chapter two. Among all the WIPS, the proposed system can provide location service without relying on the support of wireless technology which is main stream track of location service research. Thus, it could be possibly revolution of location service method. To the certain extend, the proposed solution can be built incrementally with wireless technology to become hybrid system that could support the real time routing.

6-2 What has not been achieved

6-2-1 Heavy access of QR Code

One of the limitations of this proposed solution is that multiple users would have the problem in waiting for scanning the QR Code to interact with the system. It takes up around minimum 3 second to scan the code but its not major issue to this context whereby the users can eventually queue up for the system such as the well implemented ATM machine. One of the possible solutions for this limitation is that, the QR code can be just duplicated in number on the heavy loaded location which is often accessed by user. Thus, it can be solved without adding technical difficulty on top of the system.

6-3 Future development

6-3-1 Improve efficiency of orientation and offset of the map image

In our proposed solution, we adopt the pixel approach to locate every particular location on image of map. Thus, the location is determined based on the basis of pixel by pixel in Cartesian coordination. This method can be improved by using vector graphic to allow location be perceived to user in an efficient manner. Orientation icon can be replaced with vector graphic as well and therefore the orientation can be rotated precisely.

6-3-2 Intelligent Search function

An interactive search function can be the future development for searching location. Instead of using select list in my proposed prototype, it can make fast the process for user to search their desired destination. As the search terms are not just location name , the system should allow user search any keyword.

6-3-3 Implementation of full system

A full system can be implemented to deploy on actual building. By throwing the prototype, the full system is implemented in a bigger scope with the similar concept and design. From this, by release the application to publics, more testing, observation, and requirement verification can be conducted on them to obtain measurable analysis data.

6-3-4 Indoor positioning system

This proposed solution is an early stage research on providing indoor navigation solution. On this basis, a chance of adding a more sophisticated method can be achieved to guide the user with direction in other way such as path navigation (Travel salesman algorithm), real-time positioning on move, and voice-over navigator. These are the possible area of this project can be evolved.

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