MTSFB TR 005:2019

TECHNICAL REPORT

ELDERLY CARE IOT PLATFORM AND SOLUTION

Preface

Malaysian Technical Standards Forum Bhd (MTSFB) has awarded Favoriot Sdn Bhd the Industry Promotion and Development Grant to implement the Proof of Concept (PoC) through the Elderly Care IoT Platform and Solution. The duration of this PoC lasts for a period of 13 months starting January 2018.

The PoC is done in partnership with MKM Ticketing Travel & Tours. There are few Umrah pilgrims selected to participate in this PoC. The key objective of this PoC is to remotely monitor the location and basic health parameters of the elderly pilgrims who went for Umrah or Hajj.

This Technical Report outlines the objective, benefit, the scope of work, methodology and result analysis.

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favoriot

In collaboration with:

MKM Ticketing Travels & Tours

MKM TICKETING TRAVEL & TOURS

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Abbreviation

API	Application Programming Interface
BP	Blood Pressure
CRM	Customer Relationship Management
ECG	Electrocardiogram
GPS	Global Positioning System
GSM	Global System for Mobile Communications
iOS	iPhone Operating System
IoT	Internet of Things
MQTT	Message Queuing Telemetry Transport
Node.js	Node java script
PHP	Hypertext Preprocessor
PoC	Proof of Concept
REST	Representational State Transfer
SIM	Subscriber Identification Module
TCP/IP	Transmission Control Protocol/Internet Protocol

ELDERLY CARE IOT PLATFORM AND SOLUTION

1. Introduction

Favoriot has come out with the initiative to develop an IoT ecosystem focusing on the elderly care named as Raqib. Raqib consists of a wearable device and other connected health devices, IoT platform and front-end application. Raqib's main function is to provide real-time monitoring in various activities such as wearer's latest location, basic health parameters including the number of steps, heart rate, Blood Pressure (BP), Electrocardiogram (ECG), SOS and in/out of geofence alerts. The information will also be used to provide a prediction on their health so that precautionary measures can be taken. Raqib was tested to the pilgrims when they performed their Hajj and Umrah in Saudi Arabia. Figure 1 shows the usage of the Raqib by the pilgrims at various locations in Saudi Arabia.

Figure 1. Raqib wearers at various location in Saudi Arabia

2. Target groups and benefits

2.1 Target group

The solution is developed focusing on elderly people, but it may be extended to other groups of people that will be using the system such as follows:

a) family members;

b) travel agencies;

c) caregivers;

d) nursing home;

e) health professionals; and

f) government agencies in charge of health.

2.2 Benefits

This solution provides benefits to the family members as well as to the potential target group which is:

a) improve access to care

   i) the elders' safety concerns are addressed; and

   ii) timeliness help provided during an emergency.

b) increase care quality

   i) improve the health level of the elders

      The health data is continuously monitored without much involvement by the wearer. Data provided would be processed to provide better care quality.

   ii) location tracking

      Accurate localisation of the elders so that they can be found in a timely manner. The location of the elders will be recorded and updated to the platform. Alert will be sent if the wearer goes out of the geo-fence.

   iii) improve personal safety

      Family members would have fewer worries as they can remotely monitor their elders from home in order to ameliorate any adverse effect of unpredictable events such as illnesses, falls and so on.

3. Objectives

The objectives of the project are as follows:

a) to enhance the existing IoT platform for healthcare that provides interfaces for easy integration with a variety of devices;

b) to provide a mobile and web application for caretakers which the application shows vital information of the elderly people;

c) to provide an effective alert and notification engine by using integration with multiple communication channels; and

d) to build a data analysis platform which able to analyse various types of data as well as providing a prediction of health.

4. Scope of work

The scope of work is as follows:

a) to integrate wearable device platform that continuously provides health and location data to the Favoriot IoT platform;

b) enhance the platform to support communication protocols i.e. Message Queuing Telemetry Transport (MQTT), Representational State Transfer (REST), WebSocket and Transmission Control Protocol/Internet Protocol (TCP/IP);

c) to perform data transmission test through Subscriber Identification Module (SIM) roaming;

d) develop a mobile application for iPhone Operating System (iOS) and web application to display relevant information; and

e) to build and integrate the chatbot with the IoT platform and application.

5. Methodology

5.1 System architecture

Raqib system architecture as in Figure 2 is a solution to monitor the location, health and activity of the wearer. It has three main components as follows:

a) Raqib system (a back-end system);

b) Raqib dashboard (mobile and desktop application); and

c) Raqib wearable (hardware).

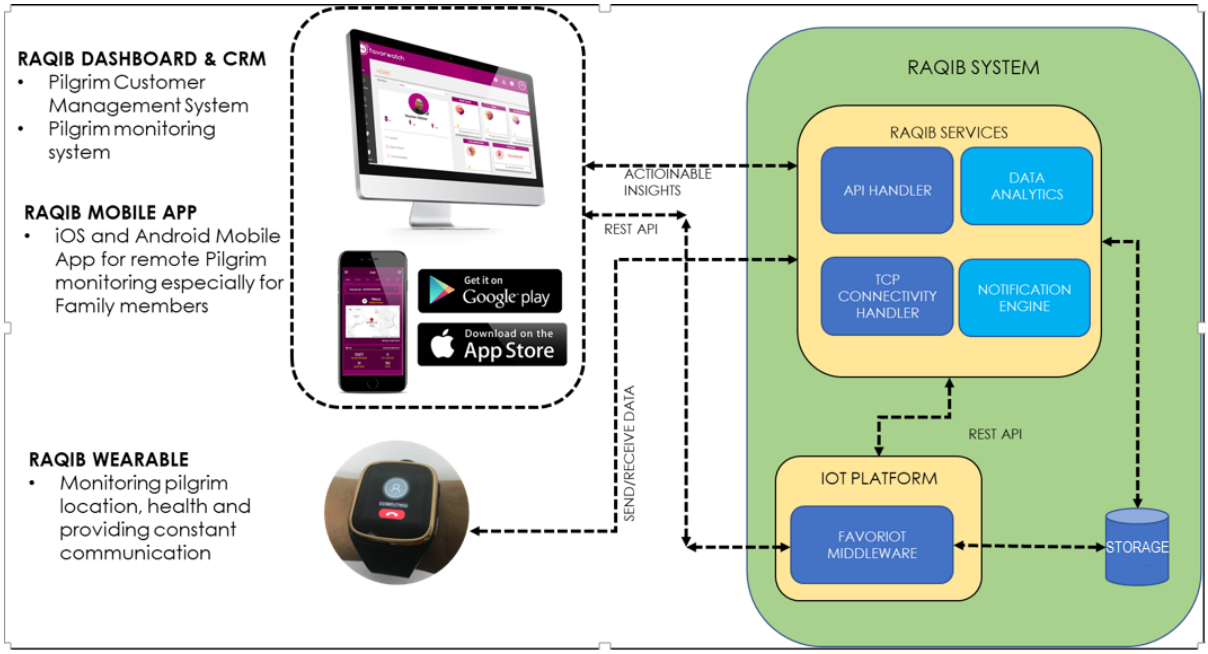


Figure 2. Raqib system architecture

5.1.1 Raqib system

The IoT platform was developed using Node JavaScript (Node.js) programming language with the combination of various other tools and software to support the database, Application Programming Interface (API) management, chatbot and others. All the back-end services are running on the cloud.

The IoT platform was designed to support the integration of various IoT devices in the future such as sensors at home, video feed, and others that can be used to provide comprehensive information to the stakeholders.

All the information about the Raqib can be retrieved from the website, www.raqib.co.

5.1.2 Raqib dashboard

The Raqib dashboard was designed to monitor the elderly and pilgrims remotely using both mobile and desktop applications. The Ionic tool was used for mobile application development whereas angular JavaScript was used for the desktop version. Data streams that were stored in the database are extracted by the front-end applications using predefined API calls. This is achieved using a TCP/IP communication protocol. There are 2 types of dashboards which are customer management system and pilgrim monitoring system. The dashboard of the customer management system will be used by pilgrim operators or authorities while the dashboard of the pilgrim monitoring system will be used by the pilgrim's officer or *mutawwif*.

The dashboard monitors 4 parameters and tracks the pilgrim's location. The 4 parameters used in this monitoring system are as follows:

a) heart rate;

b) ECG;

c) pedometer; and

d) BP.

5.1.3 Raqib wearable

The wearable communicates with the IoT platform using TCP/IP protocol whereas the front-end applications use REST API to interact with the platform.

The wearable sends data in two modes which are as follows:

a) periodically at predefined intervals (2 min - 4 min of intervals)

   In this mode, the Raqib wearable sends the recent number of steps, heart rate, location together with other communication-related information.

b) after measurement of BP and ECG

   In this mode, the wearer must manually measure the BP or ECG. The measurement data will be sent to the IoT platform for further processing and storage.

The sample of the Raqib wearable is illustrated in Figure 3.

Figure 3. Sample Raqib wearable

5.2 Hardware

The technical specification of Raqib wearable device hardware are shown in Table 1.

Table 1. Raqib watch specifications

Features	Details
Global Positioning System (GPS)	Location tracking
Heart rate	Measure heart rate
ECG	Measure ECG with the results of heart rate, psychological age and fatigue level
Pedometer	Collecting daily steps with burned calories and distances
BP	Measure the systolic and diastolic pressure
Geofencing	Triggered when Raqib wearable exits the virtual boundary set up around a geographical location
SOS	Available to send distress signal
Mobile network connectivity	2G
Battery (Lithium)	560 mAh
Waterproof	IP65
Global System for Mobile Communications (GSM) module (MHz)	900/1800
SIM	Nano SIM
Weight	60 g
Product dimension	48.8 mm x 42.5 mm x 14.8 mm

5.3 Software

The software consists of a front-end application and back-end system. The back-end system is also referred to as the IoT middleware. The front-end applications consist of the following items:

a) mobile application (Android and iOS version)

This application is for the next of kin or anyone who wants to monitor the wearer. The user can identify the latest location and other health parameters. The features in this application are similar to the mobile application.

b) web application (for officer/*mutawwif*)

This application, the officer in chargeable to monitor all the pilgrims under his/her guidance and also able to set the geofence for the pilgrim.

c) web application (for administrator/pilgrim authorities)

This application is the same as the application for the officer. For this access, the admin can see all the wearers registered under this account.

d) Customer Relationship Management (CRM) (for operators)

This portal is for the operators or authorities to register and manage the users, wearers and the officer's accounts.

The heart of the solution is the back-end system that aggregates the data for further processing. Some of the components in the backend include big data storage, API handler, communication protocol management and chatbot.

The sample screens of the mobile application, dashboard application and chatbot are given in Annex A.

6. Result analysis

The PoC was conducted during the Hajj and Umrah pilgrimage. The PoC was implemented in 2 stages in Saudi Arabia as follows:

a) the PoC was conducted during the Hajj season in 2018 and some for Umrah. This is to test the SIM roaming and data transmission. In this stage, there were 10 individual pilgrims used the solution.

b) the PoC was successfully implemented from 23 January to 5 February 2019. A total of 5 pilgrims were selected for this stage.

Total pilgrims involved in both PoCs are 15 wearers. The wearers' profile breakdown for each stage is shown in Table 2.

Table 2. Wearers' profile

Wearer number	Stage	Age	Gender	Duration of usage
1	Stage 1	46	Male	22 May - 2 June 2018
2		47	Female	23 May - 3 June 2018
3		48	Female	15 Aug - 25 Sept 2018
4		49	Male	15 Aug - 25 Sept 2018
5		50	Male	29 July - 13 Sept 2018
6		51	Male	23 May - 3 June 2018
7		51	Female	19 July - 3 Sept 2018
8		51	Male	19 July - 3 Sept 2018
9		53	Male	19 July - 3 Sept 2018
10		65	Female	22 May - 2 June 2018
11	Stage 2	23	Female	24 Jan - 5 Feb 2019
12		30	Female	24 Jan - 5 Feb 2019
13		53	Male	24 Jan - 5 Feb 2019
14		57	Female	23 Jan - 5 Feb 2019
15		59	Male	23 Jan - 5 Feb 2019

Total wearers based on age group and gender is given in Tables 3 and 4.

Table 3. Wearers based on age group

Age group	Total
20 – 30	1
30 – 40	1
40 – 50	4
50 – 60	8
60 – 70	1

Table 4. Wearers based on gender

Gender	Total
Male	8
Female	7

6.1 Data format and size

Raqib wearable sends different lengths of data depending on the parameters that are being captured. It sends the data using a hexadecimal format with a specific code for each type.

The samples of data stored are shown in Figure 4.

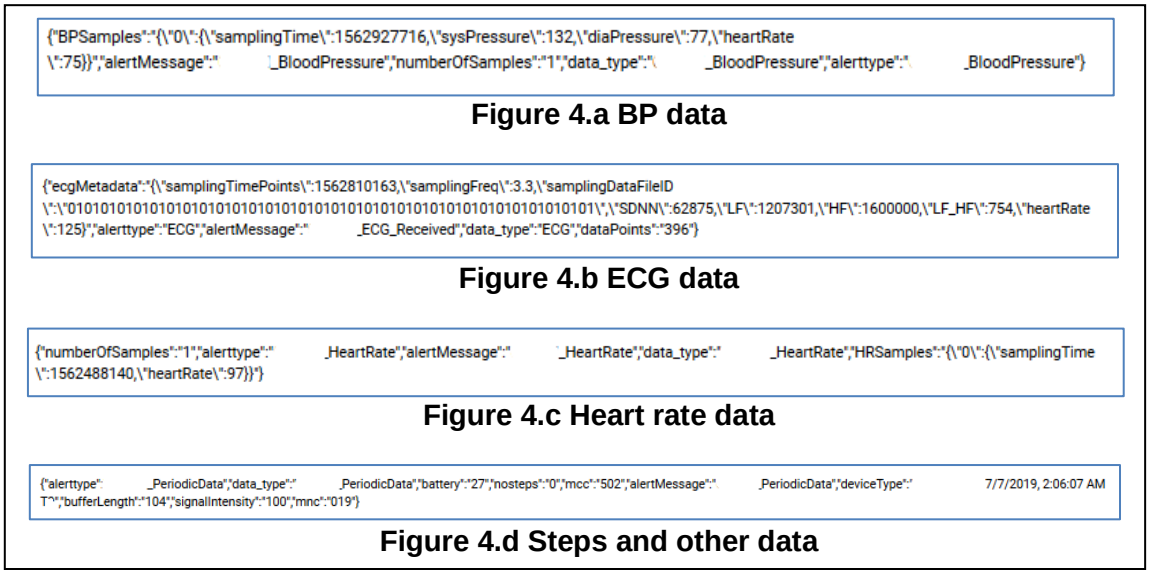


Figure 4.a BP data

Figure 4.b ECG data

Figure 4.c Heart rate data

Figure 4.d Steps and other data

Figure 4. Sample of data stored

All the data received by the server are timestamped using Unix Epoch time. Each data type and the size for each transmission is given in Table 5 below. The raw data for BP, heart rate and steps are smaller compared to data size stored because the data is sent from the device using hexadecimal format with specific code and the data are then translated and stored in the database using various formats (i.e. text, int and float) depending on the parameter type. ECG data are processed first compared to other types of data. That is the reason for the data size stored is smaller than the average raw data received as given in Table 5.

Table 5. Average data size for various data types

Data type	Average raw data from device (Bytes)	Average data size stored (Bytes)
BP data	31	239
ECG data	20 480	12 740
Heart rate data	27	188
Steps data	100	231

6.2 Blood Pressure (BP) data comparison

Raqib device manufacturer stated that the BP data is about 80 % accurate compared to medical-grade devices. The following table shows the BP measurement comparison between Raqib device and BP monitor device for 4 wearers. The readings shown in Table 6 are the average readings.

Table 6. BP data comparison

Wearer	Parameter	Result		Deviation result from BP monitor (%)
		Raqib device	BP monitor	
Wearer 1	BP systolic	117	125	- 6.4
	BP diastolic	74	78	- 5.1
	Heart rate	77	61	+ 26
Wearer 2	BP systolic	101	114	- 11.4
	BP diastolic	66	77	- 14.3
	Heart rate	84	82	+ 2.4
Wearer 3	BP systolic	98	117	- 16.2
	BP diastolic	64	76	- 15.7
	Heart rate	76	70	+ 8.5
Wearer 4	BP systolic	107	130	- 20.7
	BP diastolic	72	80	- 10
	Heart rate	76	70	+ 8.5

Based on the readings, the total average differences from BP monitor are as follows:

a) BP systolic: - 13.67 %;

b) BP diastolic: - 11.28 %; and

c) heart rate: + 11.35 %

The average results are much less the range of the differences given by the manufacturer which is 20 % margin. However, it must be emphasized that the measured data from Raqib wearable cannot be used for health-related diagnosis as it is a consumer-grade device. It is only to provide some guidance for the wearer and stakeholders and can be used for further analysis.

6.3 Sample data from wearers

Various information is captured from the wearer device and stored in the cloud system. There are samples taken randomly from 2 wearer devices. Data given in Figures 5, 6, 7 and 8 are taken from the backend system from wearers 7 and 15 respectively. These data are then extracted and displayed in the mobile and web application dashboard.

6.3.1 Location data

The location data of the wearer can be obtained in 2 methods:

a) Exact location

The locations for wearers 7 and 15 are located through latitude and longitude reading as shown in Table 7 which the full data are shown in Figure 5.

Table 7. Location result using latitude and longitude

Wearer	Latitude	Longitude	Location result
7	21.42991111111111	39.737165	Old Makkah Jeddah Road (Saudi Arabia)
15	21.373666666666665	39.98764333333333	Al Mashair (Saudi Arabia)

b) Country and network code

The locations for wearers 7 and 15 are located through Mobile Country Codes (MCC) and Mobile Network Codes (MNC) parameters. Table 8 shows the MCC and MNC location results for wearers 7 and 15 which the full data are shown in Figure 6. Information regarding MCC and MNC can be obtained from https://www.mcc-mnc.com.

Table 8. Location result using MCC and MNC

Wearer	Location result	
	MCC	MNC
7	502 (Malaysia)	019 (Celcom)
	420 (Saudi Arabia)	004 (Zain)
15	420 (Saudi Arabia)	001 (STC)


```
"user_id": "RaqibHajj1",
"stream_created_at": "2018-08-05T12:41:04.593Z",
"stream_developer_id": "32f9e1bb-19a1-445c-a59c-dbe5e80dd41e@RaqibHajj1",
"device_developer_id": "Umi@RaqibHajj1",
"data": {
    "alertMessage": "Gomtel_PeriodicData",
    "alerttype": "Gomtel_PeriodicData",
    "battery": "50",
    "data_type": "Gomtel_PeriodicData",
    "deviceType": "Gomtel T9",
    "latitude": "21.42991111111111",
    "longitude": "39.737165",
    "nosteps": "5909",
    "signalIntensity": "100"
}
```


Figure 5.a Location data from wearer 7


```
"user_id": "RaqibHajj4",
"stream_created_at": "2018-08-19T21:26:32.388Z",
"stream_developer_id": "cd6c2205-440b-496c-8e68-6dba6b39b029@RaqibHajj4",
"device_developer_id": "Rohan@RaqibHajj4",
"data": {
    "alertMessage": "Gomtel_PeriodicData",
    "alerttype": "Gomtel_PeriodicData",
    "battery": "66",
    "bufferLength": "45",
    "data_type": "Gomtel_PeriodicData",
    "deviceType": "Gomtel T9",
    "latitude": "21.373666666666665",
    "longitude": "39.98764333333333",
    "nosteps": "80",
    "signalIntensity": "100"
}
```


Figure 5.b Location data from wearer 15

Figure 5. Exact location data from backend system


```
"user_id": "RaqibHajj1",
"stream_created_at": "2018-07-19T00:34:38.776Z",
"stream_developer_id": "9bc754d6-bcc6-470c-839f-e1802465908b@RaqibHajj1",
"device_developer_id": "Umi@RaqibHajj1",
"data": {
    "alertMessage": "Gomtel_PeriodicData",
    "alerttype": "Gomtel_PeriodicData",
    "battery": "97",
    "data_type": "Gomtel_PeriodicData",
    "deviceType": "Gomtel T9",
    "mcc": "502",
    "mnc": "019",
    "nosteps": "793",
    "signalIntensity": "100"
```


502	19	my	Malaysia	60	CelCom

Figure 6.a Location data from wearer 7 (Malaysia)


```
"user_id": "RaqibHajj1",
"stream_created_at": "2018-07-19T23:22:13.061Z",
"stream_developer_id": "ba9e77c1-a3e0-4158-a6b7-f68f15d29be6@RaqibHajj1",
"device_developer_id": "Umi@RaqibHajj1",
"data": {
    "alertMessage": "Gomtel_PeriodicData",
    "alerttype": "Gomtel_PeriodicData",
    "battery": "17",
    "data_type": "Gomtel_PeriodicData",
    "deviceType": "Gomtel T9",
    "mcc": "420",
    "mnc": "004",
    "nosteps": "377",
    "signalIntensity": "0"
```


420	04	sa	Saudi Arabia	966	Zain

Figure 6.b Location data from wearer 7 (Saudi Arabia)


```
"user_id": "hasanahjais",
"stream_created_at": "2019-01-24T09:38:26.708Z",
"stream_developer_id": "52caaa6f-cf0e-498f-ab29-774079c79dce@hasanahjais",
"device_developer_id": "Jemaah1@hasanahjais",
"data": {
    "alertMessage": "Gomtel_PeriodicData",
    "alerttype": "Gomtel_PeriodicData",
    "battery": "66",
    "bufferLength": "104",
    "data_type": "Gomtel_PeriodicData",
    "deviceType": "Gomtel T9",
    "mcc": "420",
    "mnc": "001",
    "nosteps": "572",
    "signalIntensity": "70"
}
```


420	01	sa	Saudi Arabia	966	STC/Al Jawal

Figure 6.c Location data from wearer 15 (Saudi Arabia)

Figure 6. MCC and MNC location data

6.3.2 ECG data

Figure 7 shows the captured ECG result data from the backend system for the wearers 7 and 15 which the data displayed into the Raqib dashboard.

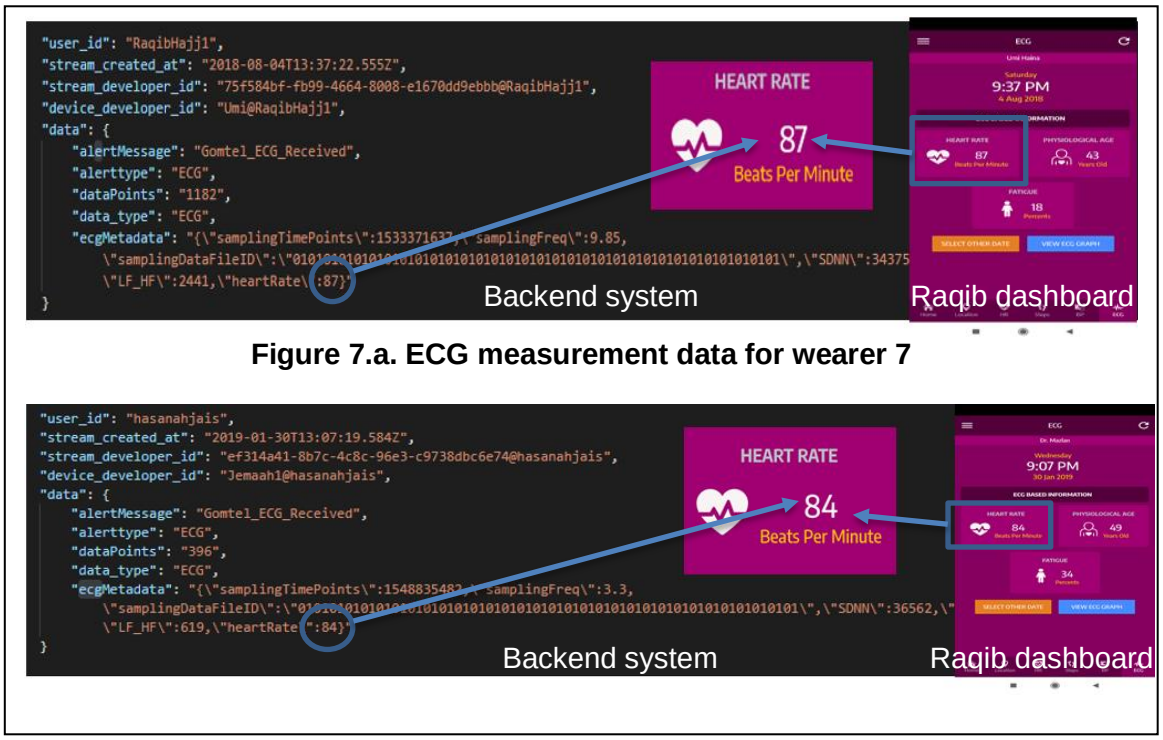


Figure 7.a. ECG measurement data for wearer 7

Figure 7. ECG measurement data

6.4 Power consumption

Raqib wearable uses a 560 mAh battery that can be fully charged in 2 hours from 0 %. During the testing of the battery power consumption, the battery level measurements taken with the following conditions:

a) periodic data sent every 2 minutes;

b) BP was measured once a day; and

c) ECG was measured once a day.

The average range of battery depletion to 0 % is between 36 hours to 48 hours. There are various reasons for the wide range. Some of the reasons are as follows:

a) intermittent network connectivity. In the case of no network coverage, the device will be sending more messages to get the connectivity;

b) data re-transmission. In the case of data transmission failure for BP and ECG data, the device will try to re-send the data. This causes more battery power usage; and

c) some devices are not properly charged. It is best that the device is charged for a minimum of 2 hours.

7. Conclusion

Raqib successfully implemented the IoT platform to provide interfaces in providing a solution to continuously monitor the elderly and pilgrims.

Raqib able to show vital information of elderly people through mobile and web applications. The seamless integrated system between the hardware and software makes it easy to use especially in providing alert and notification for the elderly health status.

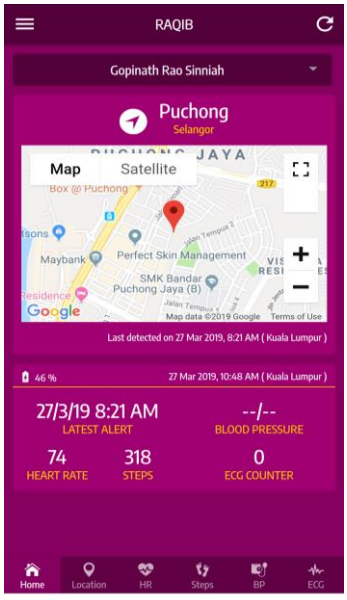
In the next phase of development, Raqib will be enhanced to include data analytics. Data collected from the wearers will be further analysed to provide health score as well as health prediction. Other enhancement may include fall detection and inclusion for more health-related parameters.

Annex A
(informative)

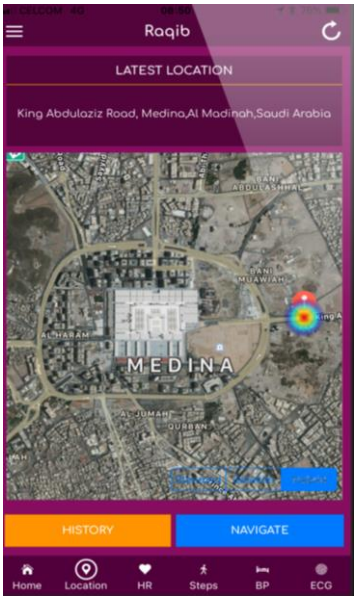
Application screenshot

A.1 Mobile application

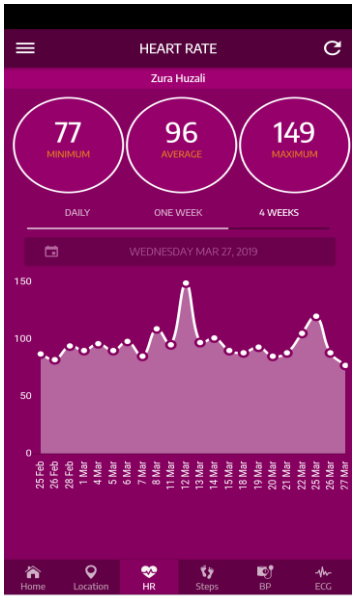
The screenshots of Raqib mobile application are as follows:



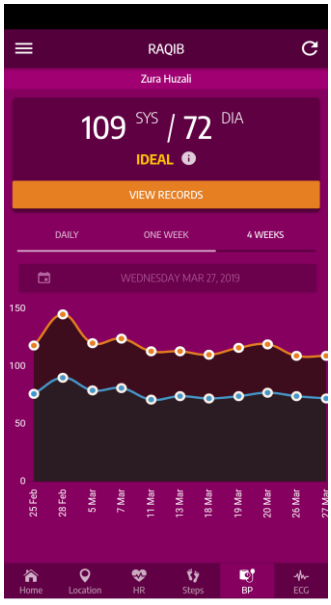
Home



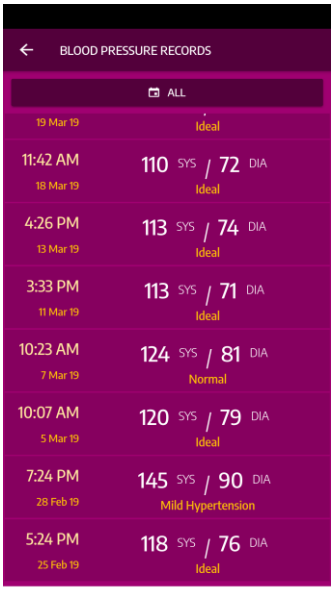
Location



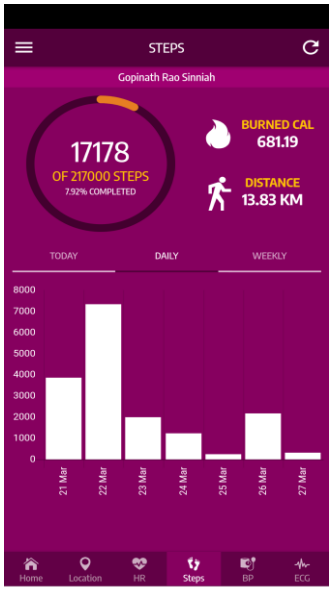
Heart rate



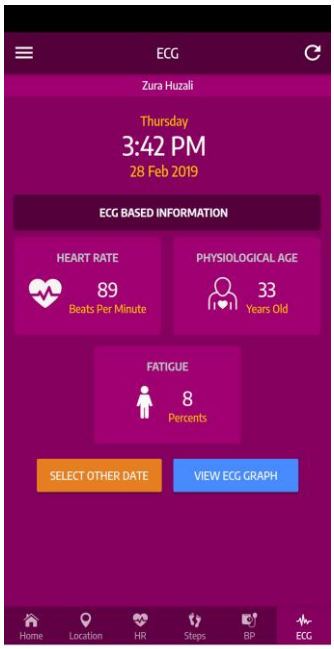
BP



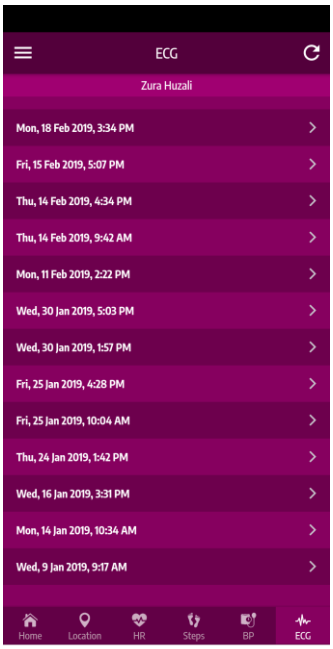
BP history



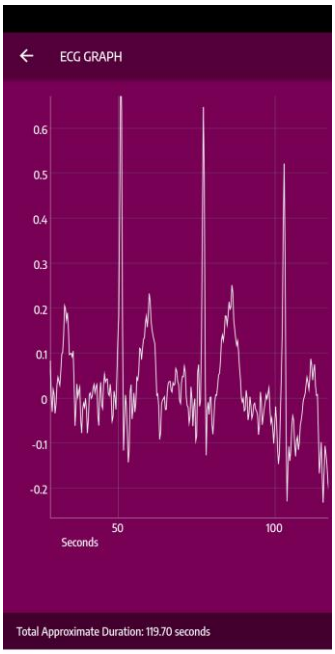
Steps



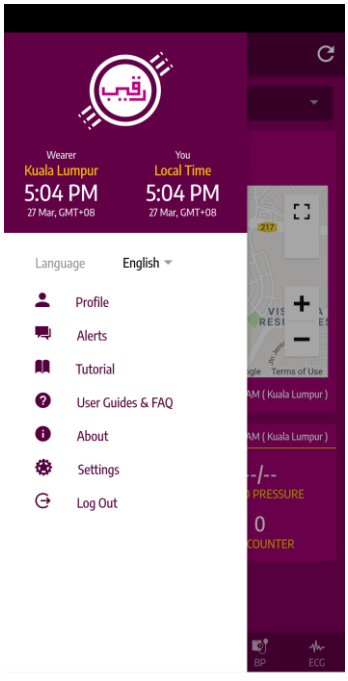
ECG summary



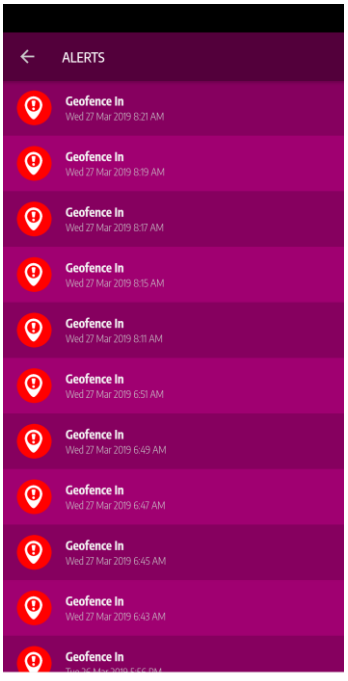
ECG history



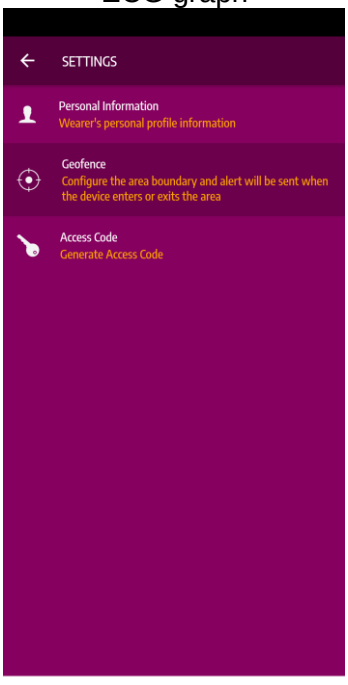
ECG graph



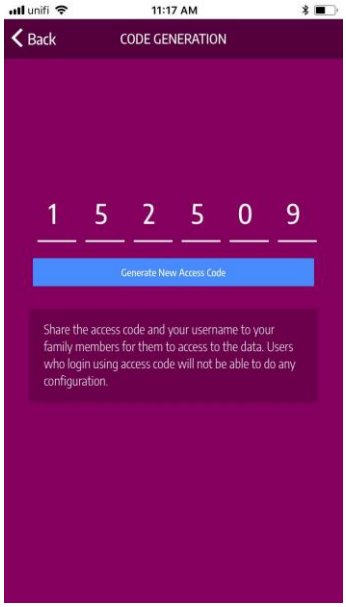
Side menu



Alerts



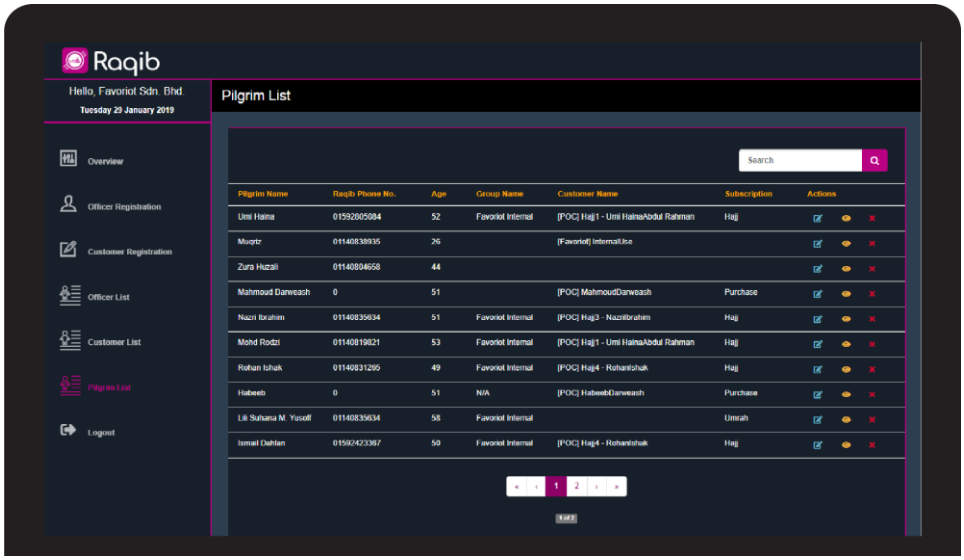
Settings



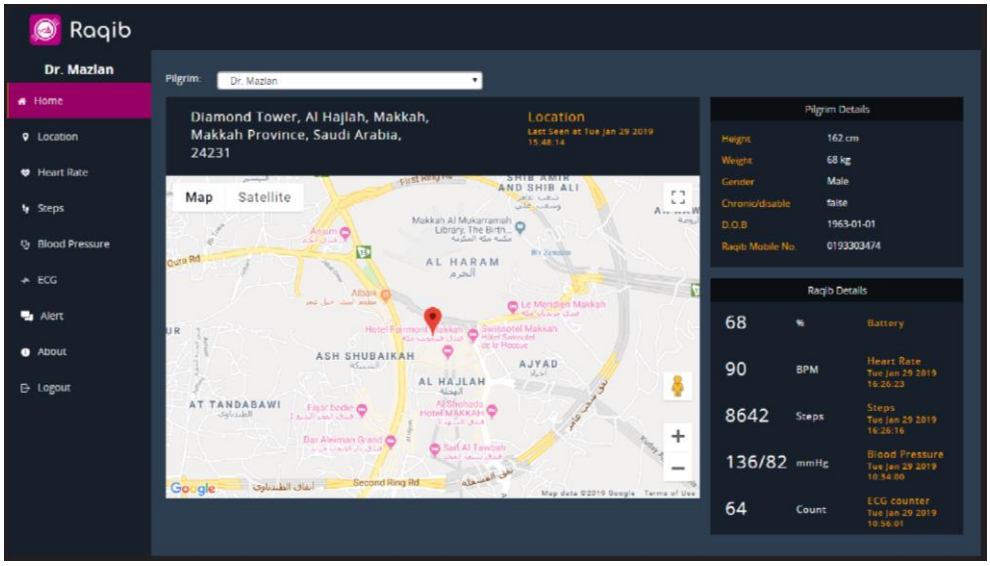
Code generation

A.2 Dashboard

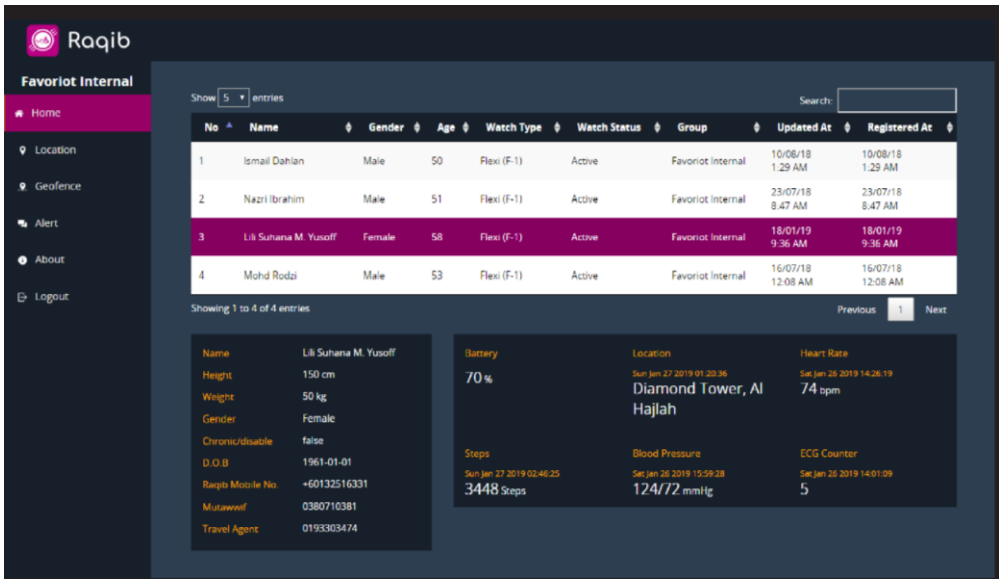
The screenshots of Raqib dashboard are as follows:



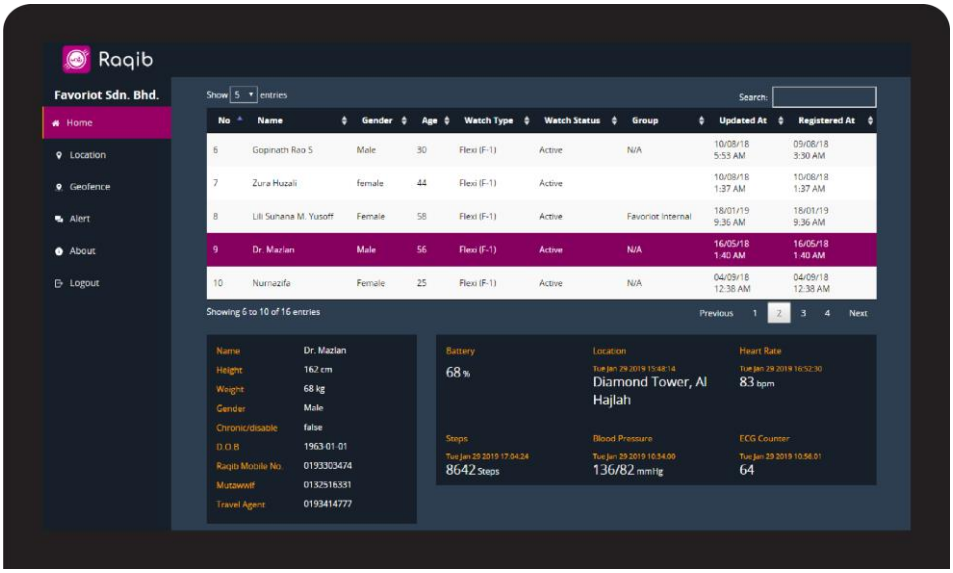
CRM - For user creation and management



User dashboard



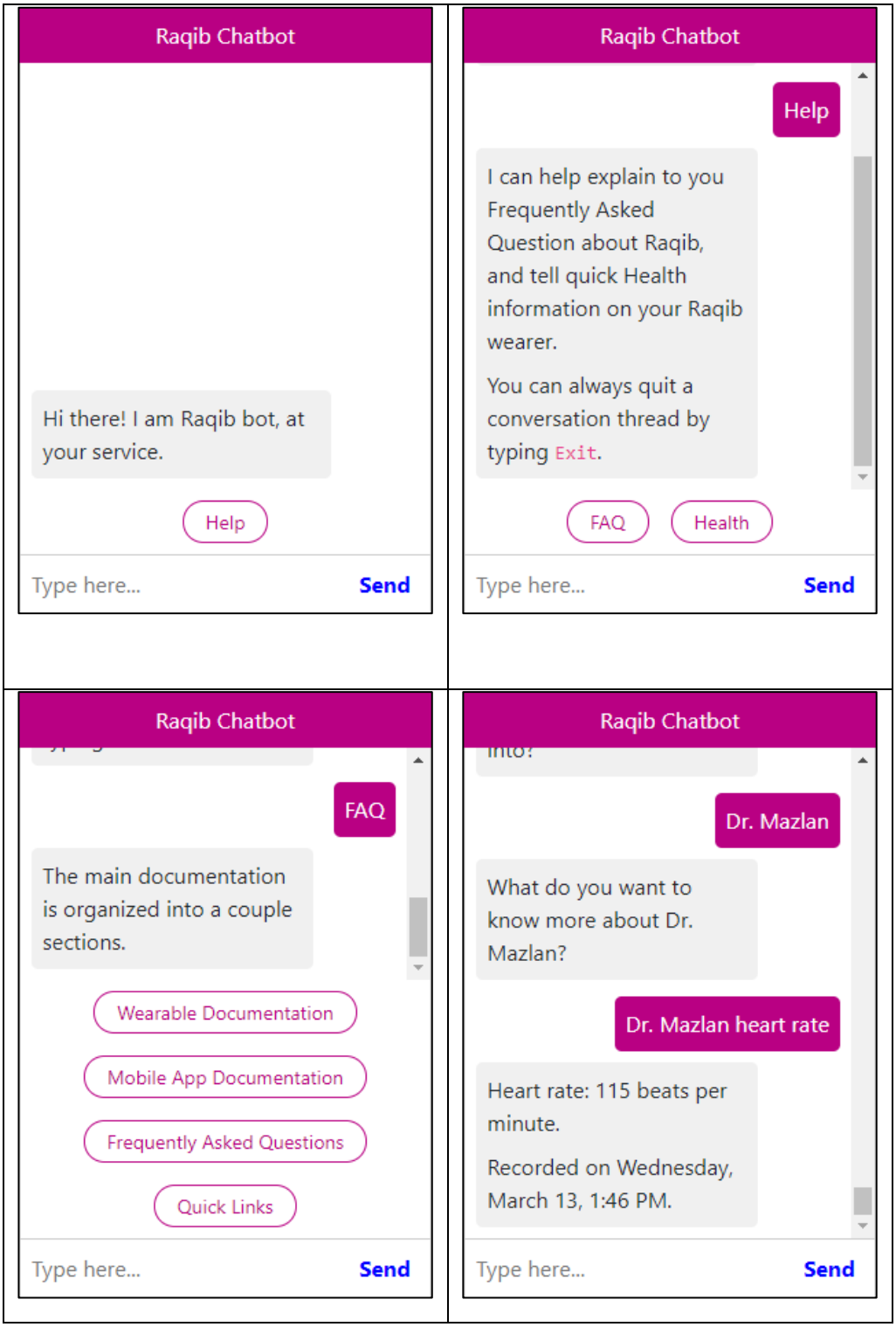
Officer Portal



Admin Portal

A.3 Chatbot interfaces

The screenshots of Raqib chatbot interfaces are as follows:



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