AITCS

E-Health Registration System Using QR Code

Pang Yu Yang[1]**, Hazalila Kamaludin**[1]*, **Hanayanti Hafit**[1],
Rozanawati Darman[1]

[1]Faculty of Computer Science and Information Technology,
Universiti Tun Hussein Onn Malaysia, Parit Raja, 86400, MALAYSIA

Abstract: E-Health UTHM is an application that was developed to enable students and staff to register for medical or dental services in the health centre by scanning QR code and getting a medical summary from a doctor. The manual process in UTHM Health Centre required staff and students to place their matric card in a box at the registration counter and wait for the medical staff to call them. Therefore, this is a manual process for every patient in the health centre and it is important to digitize the process of registration. Object oriented software development method is used in this project and this application is developed using Android Studio software and Firebase database. Overall, E-Health UTHM may enable patients to register for services by scanning QR code and viewing medical summary.

Keywords: Registration, E-Health, QR Code

1.   Introduction

Mobile Health (m-Health) comes from the intersection among Electronic Health (eHealth) and smartphone technology. It is the practice of eHealth served by smartphones. Healthcare systems provide health-related services to groups and individuals [1]. This project is to create a mobile application for the registration process of the health centre of Universiti Tun Hussein Onn Malaysia. There is no online system to access medical or dental service from the health centre. This application has three main functions which are QR code registration, medical summary and user account. This project is suggested for UTHM to start using m-Health concepts in UTHM Health Centre.

1.1   Problem Statements

In the UTHM Health Centre, patients have to register at the counter of the health centre when visiting there to seek medical or dental advice. Patients have to place their matric card in a box at the registration counter and wait for the staff to call them. After that, they need to write their details and the allocated room in the record book. This is a manual process for every patient in the health centre and it is important to digitize the process of registration. After consulting the doctor, the pharmacists will give medicine to patients and tell them when to consume the medicine. Medical summary is a report containing the details of the consultation session. The patient does not receive a medical summary after consultation. Medical summary can record the past medical history of a person and may be used as a proof of absenteeism. To solve these problems, E-Health UTHM might help. This is a mobile

application that may provide QR code registration, medical summary and user account to resolve the above-mentioned problems. The QR code registration can change the current manual process of registration into digital.

1.2   Project Significance

The objectives of this project are to design, to develop a mobile healthcare application for UTHM Health Centre and perform testing on the functionality of the mobile healthcare application for UTHM Health Centre to the target user. There are three types of users for this project which are patient, doctor and admin. The functional modules of the application includes home module, QR Registration Module, Medical Summary Module, Account Module and Admin Module. This project applies QR code into the registration process of medical and dental services in UTHM Health Centre. With the QR code registration, patients just need to scan the QR code and wait for the turn to meet the doctor. This may save time for staff at the registration counter because they no longer need to manually register patients anymore. The medical summary is useful for patients because it consists of the type of medicine needed to be consumed, comments from the doctor and the duration of the medical certificate. To get the medical summary, a dummy web system named Clinical Master is designed for doctors. Doctors will use the dummy web system to generate medical summary so that patients can view it in the mobile application. Doctors can login into the system and consult the patient based on their registration list.

2.   Related Works

2.1   Mobile application

Mobile application is a program or software that operates on mobile devices and helps users to conduct some work. Mobile applications are rapidly evolving in the world. Almost every smartphone regardless of the price can run and download mobile applications [2].

2.2   m-Health

m-Health comes from the intersection among eHealth and smartphone technology [1]. m-Health is the practice of eHealth aided by smartphones that are used to record, process, investigate and transfer health-based information from biomedical systems and sensors. m-Health is important because it alters the traditional circumstances in which patients consult doctors when they are ill. m-Health allows patients to be monitored continuously and can prevent emergencies. It enables the achievement of a patient-led healthcare model than doctor-led model [3].

2.3   Healthcare systems

Healthcare systems use the resources of an organization. Healthcare systems are dependent on the relationships with the organizations, infrastructures and stakeholders to work together to achieve common goals. One of the objectives of healthcare systems is giving health-related services to the public and individuals [1]. Healthcare systems does include patient records. The purpose of patient records are for patient care, legal documentation, research and quality management. It is important to keep the complete patient medical record because the record will become the source for health care information that is needed by health care organizations [4].

2.4   Quick Response code (QR code)

In the early 1990s, QR code was at first invented for use in the automobile industry. However, it has become more popular in other industries. QR code is a type of matrix barcode and a machine-readable illustration of data. QR code can store more data than the barcode that people usually see [5]. The characteristics of QR code are high data capacity, fast scanning, small printout size and freedom direction scanning. QR code can store a maximum of 7089 numeric characters, 4926 alphanumeric characters and 1817 kanji characters. It can be scanned quickly and easily by any smartphone that comes

with camera function. QR codes carry data on horizontal and vertical orientation therefore it is better than barcodes in data capacity. QR codes can still be recognized even if 50% areas are damaged and the scanning direction of QR code is freedom [6]. The use of QR codes is an action of object hyperlinking or physical world linking. QR codes are the link between the physical world and virtual world. Users only need to use the smartphone's camera to scan the physical object and will instantly connect to the information of the object. QR codes have been used in product information, food products, transportation, entertainment, vending machines, business cards, retail businesses and tour information. It is like a shortcut to access a webpage [7].

2.5   Android

Android is a Java-based operating system which operates on Linux 2.6 Kernel. The Android system is lightweight with many features. Android applications are developed using Java and can easily be ported to a new platform. Android has many features including database support powered by SQLite, accelerated 3D graphics engine and integrated web browser. Android has another useful feature which is third-party applications are run with the same priority as the applications that are tied with the core system because of its architecture. This will give embedded system apps greater priority to run than the apps created by third-party developers. Every application is run by using a very lightweight virtual machine. Android has a wide variety of software development kits and well-formed libraries that are ready for users to develop applications. This has become a useful feature because Android developers can access anything that can be accessed by the operating system. Users have to access the internal software of the phone to perform specific functions. This has widened the potential for developers to make interesting applications. Besides the above features, Google has given some of its own fascinating features to Android. This enables Android developers to link their applications with Google Services such as Google Search and Google Map. The possibility has become wide with Android if a developer wants to create an application that will open Google Map to search for contact's location and store search results in the contact [8].

2.6   Java Programming

Sun Microsystems funded a research project called "Green" in 1991 to create a programming language for smart electronic devices. The programming language must be extremely portable because processor chips of appliances keep on upgrading by time. The existing programming languages such as C++ were not suitable and a new language has to be developed. In 2007, Java's core code became open source under the terms of GNU General Public License (GPL). In 2009, Oracle acquired Sun which is currently continuing the development of Java. There are few features of Java. Firstly, Java is a compiled and interpreted language. The source code is translated by Java compiler into bytecode instructions. Since the bytecodes are not machine instructions, the interpreter generates machine code that can be directly executed. Java program is platform-independent and portable. It can support programs that handle multiple tasks simultaneously. Users no need to wait for an application to finish before starting another application. For example, users can listen to music while browsing the web. This improves the interactive performance of graphical applications [9]. Developer has to install the Java Running Environment (JRE) on the computer to run the Java program. Java Virtual Machine (JVM) is a major part of JRE which creates an environment to interact with hardware.

2.7   Firebase

Firebase is a Baas (Backend as a Service) cloud platform that has many new features and functions. Firebase provides a service for auto syncing databases. It is a great tool for growing applications, developing consumer base and acquiring monetary value. Firebase is best suitable for application with short development time. Firebase Realtime Database supports different platforms such as Android, iOS and web based. The data in Firebase is stored in JSON (JavaScript Object Notation) format. The

Realtime Database can be adapted into real-time applications easily. All the local data will automatically synchronize to the real-time database when devices become online [10].

2.8   Android Studio

The Android Studio is developed by Google in collaboration with JetBrains' IntelliJ. It is the official integrated development environment (IDE) for Google's Android operating system. Android studio is limited to Android app development. Android studio supports two programming languages which are Java and Kotlin. It is a platform for developing Android applications [11]. There are two important tools in Android Studio called Git and Gradle. Git has become the standard for mobile development and software engineering. Android studio has a fully integrated Git tool with an amazing graphical user interface. Gradle can easily manage the libraries of Android Studio. Gradle is also fully integrated with Android studio which allows the Gradle files to be inspected and examined graphically [12].

2.9   Existing Systems Review

The existing application Doctor2U [13] has an advantage which is the medical records. This will let patients view their medical record and it is easier for them to buy medication based on the medical record. The disadvantage of this application is e-commerce function because healthcare management applications should focus on the patient experience in a medical centre.

The existing application Medisafe [14] has an advantage which is the medical reminders. This will let patients know when to take their medicine and will remind them if they forgot to take the medicine. The disadvantage of this application is family scheduling because patients' privacy such as their medication may be exposed to others.

The existing application WebMD symptom checker [15] has an advantage which is the mediation reminder. It will remind the user based on the time they set on the calendar. The disadvantage of this application is it does not have a medical summary to record the condition of the patient.

The proposed application E-Health UTHM may have the medical summary of the patient. This may include the medicine of the patient so that the patient can view it. The proposed application may let users register for medical or dental services by QR code. Due to the proposed application being used in educational institutions, it may have a feature of attaching the serial number of medical certificate in the medical summary. E-commerce is not included in this application because the target users are mostly students and staff. Table 1 shows the comparison between existing system and proposed system.

Table 1: Comparison between existing system and proposed system

Feature	Doctor2U	Medisafe	WebMD symptom checker	Proposed System (E-Health UTHM)
QR Code registration	X	X	X	✓
View medical certificate date	X	X	X	✓
Generate medical summary	✓	X	X	✓
View medical summary	✓	✓	X	✓
Login & logout	✓	✓	✓	✓
Make appointment	✓	✓	✓	X
View medications	✓	✓	✓	✓
E-commerce	✓	X	✓	X
Update user profile	✓	✓	✓	✓

3. Methodology

Object oriented software development method is used in developing this project. An object oriented programming language such as Java is required when using this methodology [16]. Object oriented software development is the combination of systems development life cycle and object oriented programming. The life cycle phase has many iterations [17]. During the object oriented planning phase, the problem statements are identified and the objectives are set to overcome the problems. Scope of the project including target users and functional modules are set. The expected output and the project significance are also discussed. In this phase, a work plan is set to ensure that the project will complete in the given time. The work plan will keep changing to fit the best time. The project Gantt chart that contains the workflow in each phase is done in this phase to estimate the total time needed to complete the project. During the object oriented analysis phase, problems are understood by their responsibilities and relationships and by modelling it in terms and classes of objects. An interview is conducted with the UTHM Health Centre to understand the operational method of the health centre and identify the requirements of the proposed application.

During the object oriented design phase, the design for E-Health UTHM and Clinical Master are made based on the requirements discussed in the previous phase. The design has included database design and user interface design. Wireframe is also created to become the guideline for the user interface design. For database design, all of the entities should be related and the redundancy should be eliminated. The object oriented implementation phase is the logical extension of the design. E-Health UTHM is developed in Android Studio IDE using Java programming language and extensive markup language (XML). Clinical Master is developed in Hypertext Markup Language (HTML) and JavaScript. Firebase database is used for the database of this system. The database will be located on the server of Google Data Center. During the object oriented testing phase, the completed proposed system is tested to check whether it meets the functional and non-functional requirements during the analysis phase. User acceptance test is carried out by users of the completed system. System test and debugging are made to identify and fix the errors of the system. During the object oriented maintenance phase, the proposed application will be maintained and upgraded regularly. This phase will take about three months to complete. However, due to time limitations, this phase is not included in this project.

4. Performance Analysis

Before developing a proper system, the analyst should clearly identify the system requirement. Requirement analysis is needed to obtain and define the requirements of users for the development of a new application. The system requirements should explain clearly the functions to be implemented. System requirements explained about the detailed descriptions of the system services which include functional requirements and non-functional requirements. The functional requirements of the system includes register, login, home page viewing, QR registering, medical summary viewing, user account updating and logout. The non-functional requirements of E-Health UTHM includes performance, operational, security and data integrity. Performance requirements focus on the system should only allocate a patient to a doctor at a time. Operational requirement describes the system should be available 24/7 for users to use it. The system should also protect the user data with a password.

Unified Modelling Language (UML) is a language for visualizing and documenting the system in a graphical way. UML is used to illustrate the relationships between target users and the system, detailed information for each system's activities and function, and the overall activity flows of the system. There are four types of UML diagrams which are use case diagram, activity diagram and class diagram.

4.1 Use case diagram

Use case diagram illustrates the users of main functions of the system interacting with it in a simple way. It contains three main components which are requirements, actors, and relationships. Figure 1 shows the use case diagram for E-Health UTHM.
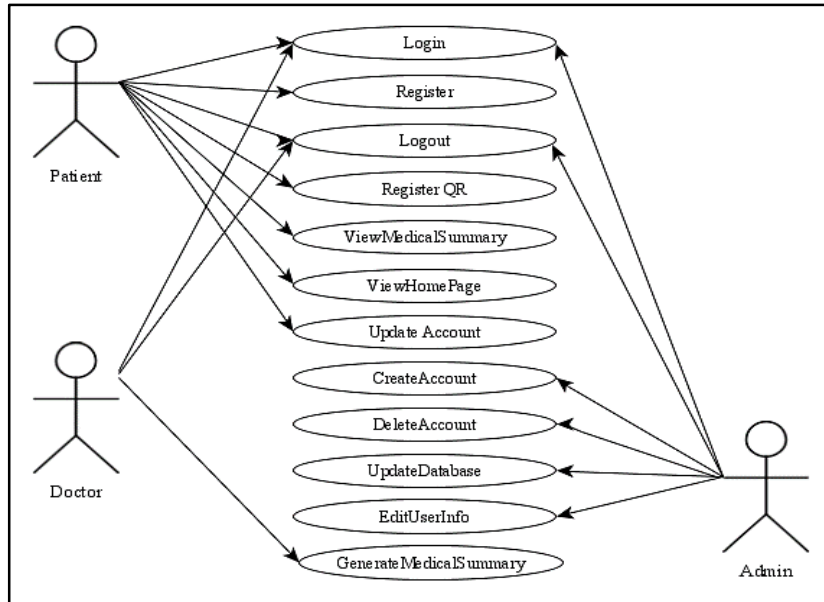

Figure 1: Use case diagram of E-Health UTHM

4.2 Activity Diagram

Activity diagram describes the coordination among activities of the system. The purpose of the activity diagram is to illustrate the activity flow in a more detailed method. Figure 2 shows the patient activity diagram of E-Health UTHM.
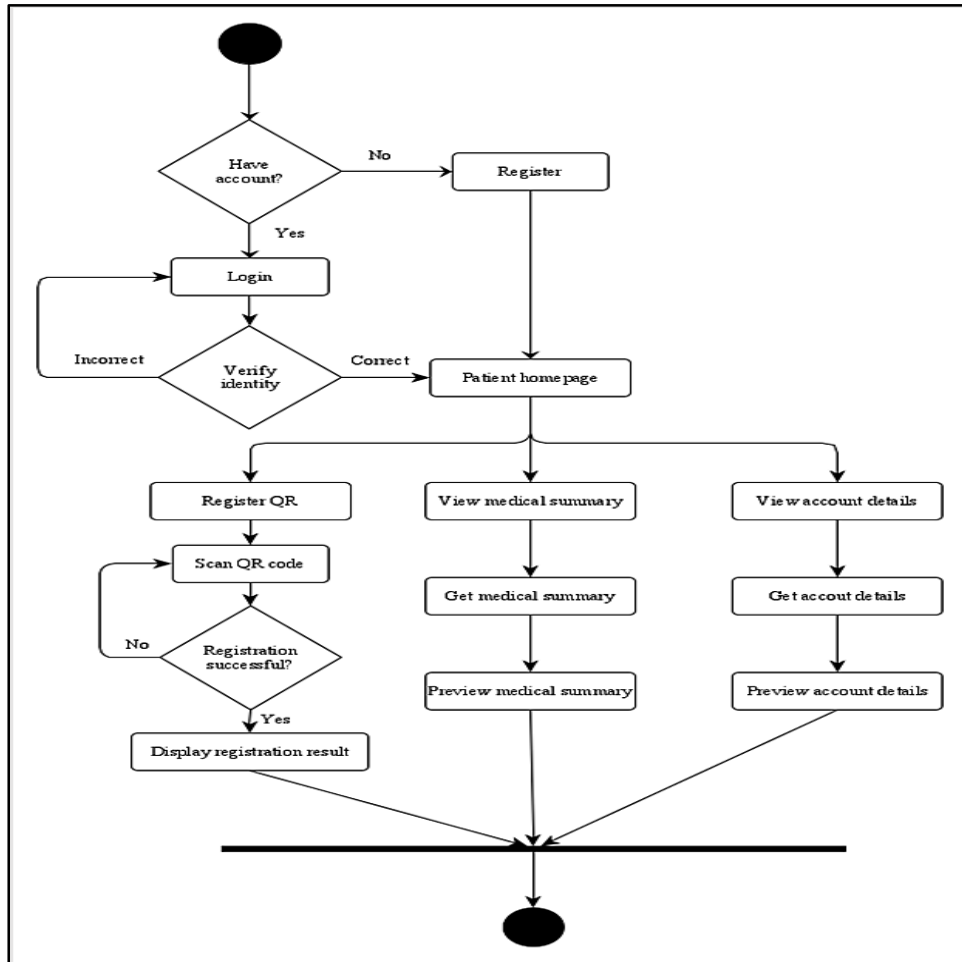
Figure 2: The patient activity diagram of E-Health UTHM

4.3   Class Diagram

Class diagram is a static model that supports the static view of the system. Class diagram shows the classes, attributes, methods and relationships. Figure 3 shows the class diagram for E-Health UTHM.
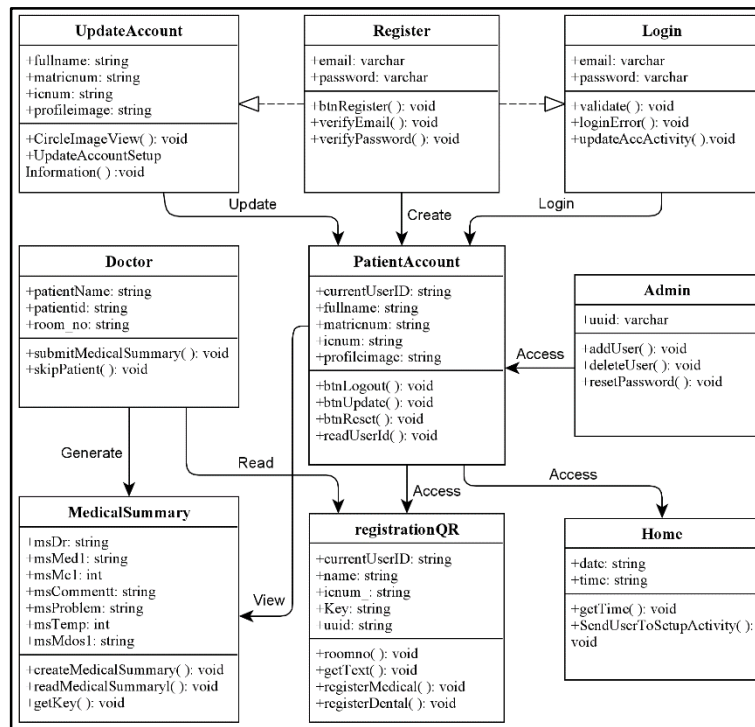
Figure 3: Class diagram for E-Health UTHM

5.   Implementation and Testing

Implementation phase is important to ensure that the application being developed meets the specified specifications while the testing phase is important to ensure that the application is free of errors.

5.1   Implementation Phase

E-Health UTHM is developed in Android Studio IDE using Java programming language and extensive mark-up language (XML). Firebase database and firebase authentication are used as the storage platform for the application E-Health UTHM. Java programming language is used to provide the logic part for the application. Figure 4 shows the Java editor for this project.

Figure 4: Java editor

Firebase provides authentication services that will authenticate the user to login into the application. It creates users by email and password. Figure 5 shows the code segment for authenticating and registering users.

```
public void regUser(){
    String email = emailReg.getText().toString().trim();
    String password = passwordReg.getText().toString();
    Toast.makeText( context: Register.this, text: "Registering in process...",Toast.LENGTH_LONG).show();
    //creating a new user
    firebaseAuth.createUserWithEmailAndPassword(email, password)
            .addOnCompleteListener( activity: this, (task) → {
                    //checking if success
                    if(task.isSuccessful()){...}else{...}
            });
}
```

Figure 5: Firebase createUserWithEmailAndPassword( ) function to register user

Figure 6 shows the code segment for QrRegistration activity.

```
CodeScannerView scannerView = findViewById(R.id.scanner_view);
//scan qr
codeScanner = new CodeScanner( context: this, scannerView);
codeScanner.setDecodeCallback((result) → {
        runOnUiThread(() → {
            String resultString = result.getText();
            Toast.makeText(getApplicationContext(), resultString, Toast.LENGTH_SHORT).show();
            //verify qr
            if (resultString.equals("Medical")) {
                Toast.makeText( context: QrRegistration.this, text: "Registered Medical successfully.", Toast.LENGTH_SHORT).show();
                registerMedical();
                SendUserToHome();
            } else if (resultString.equals("Dental")) {
                Toast.makeText( context: QrRegistration.this, text: "Registered Dental successfully.", Toast.LENGTH_SHORT).show();
                registerDental();
                SendUserToHome();
            } else {
                Toast.makeText( context: QrRegistration.this, text: "Registered unsuccessful.", Toast.LENGTH_SHORT).show();
                SendUserToHome();
```

Figure 6: Code segment for QrRegistration activity

Figure7 shows the code segment for function registerMedical.

```
@Override
public void onDataChange(DataSnapshot dataSnapshot) {
    for (DataSnapshot childSnapshot : dataSnapshot.getChildren()) {
        Key = childSnapshot.getKey();
        Toast.makeText( context: QrRegistration.this, text: "Your allocated room is " + Key, Toast.LENGTH_LONG).show();
        String currW = childSnapshot.child("currWaiting").getValue().toString();
        int currW1 = Integer.parseInt(currW);
        int currW2 = currW1+1;
        String currW3 = String.valueOf(currW2);
        HashMap userMap = new HashMap();
        userMap.put("currWaiting",currW3);
        UsersRef = FirebaseDatabase.getInstance().getReference().child("allocation").child(Key);
        UsersRef.updateChildren(userMap);
        UsersRef2 = FirebaseDatabase.getInstance().getReference().child("Users").child(currentUserID);
        UsersRef2.addListenerForSingleValueEvent(new ValueEventListener() {
            @Override
            public final void onDataChange(@NonNull DataSnapshot dataSnapshot) {
                if (dataSnapshot.exists()) {
                    useraccount u = dataSnapshot.getValue(useraccount.class);
                    icnum_ = u.icnum;
                    name = u.fullname;
                    uuid_ = u.uuid;

                    //reg user
                    String timeNow = String.valueOf(System.currentTimeMillis());
                    UsersRef = FirebaseDatabase.getInstance().getReference().child("allocation").child(Key).child("nextuser");
                    final String uuid = UsersRef.push().getKey();
                    RegUser regUser = new RegUser(uuid_, name, icnum_, timeNow);
                    UsersRef.child(uuid).setValue(regUser);
```

Figure 7: Code segment for function registerMedical( )

Figure 8 shows the user interface of the mobile application.
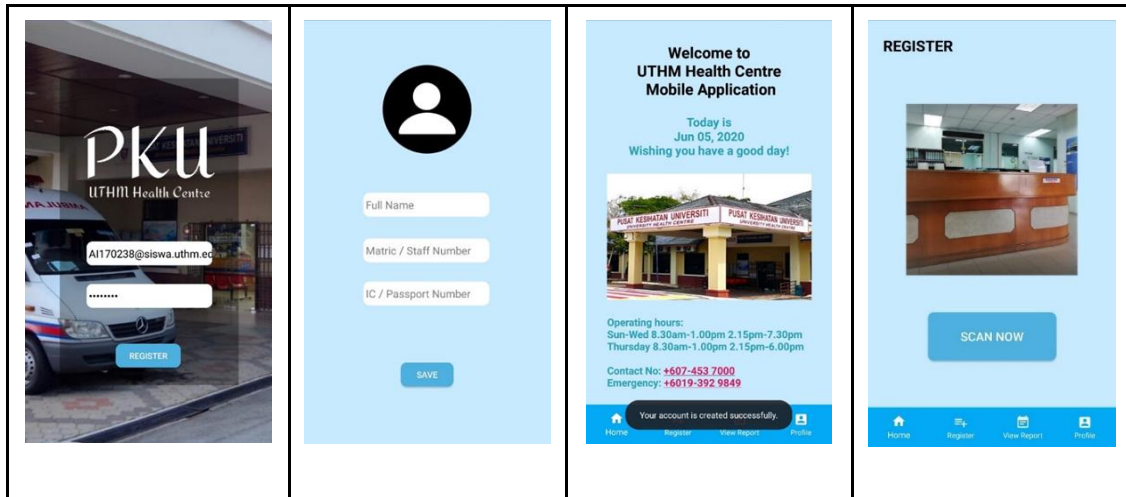
Figure 8: User interface of E-Health UTHM

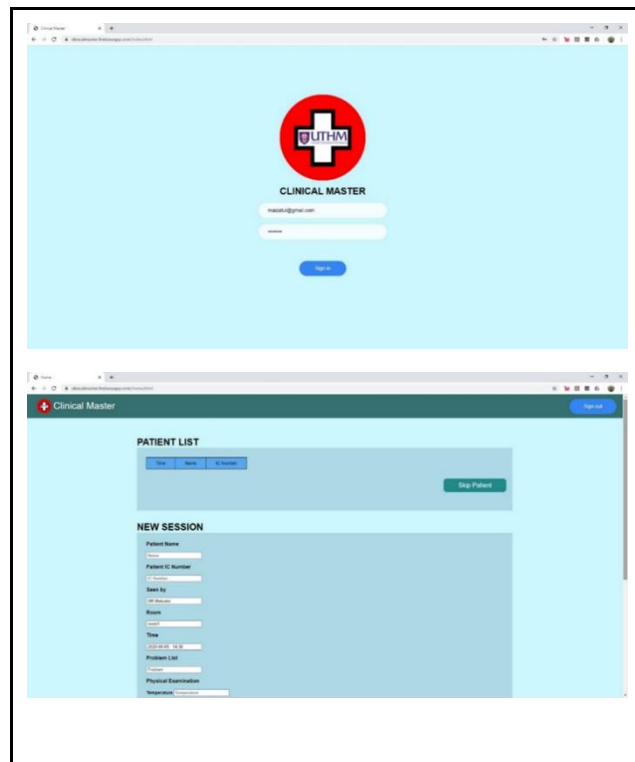Figure 9 shows the user interface of the dummy web application.

Figure 9: User interface of Clinical Master

5.2   Testing Plan

Table 2 shows the functional testing of E-Health UTHM. The purpose of the test plan is to ensure that each module functions well according to the expected results. The actual result of the test plan has passed for each module.

Table 2: Test plan of the system module and results

Module	Test	Expected Result	Actual Result
Register module	Users are allowed to register the application.	Message "Please enter email." or "Please enter a password." will display if the text field is empty.	Pass
	Users enter weak passwords that are less than 8 characters and not including at least one capital letter, small letter, a number.	Message "Password must contain at least with at least 1 capital letter, 1 small letter and 1 number" is displayed.	Pass
	Users enter email that has been registered before.	Message "Email already exists".	Pass
Login module	Users are allowed to login the application by using email and password.	System will redirect to the setup account page of the application if the user has not set up their username.	Pass
QR registration module	Users can scan QR code to register for medical or dental service.	Message "Registered unsuccessful" if the result is not "Medical" or "Dental".	Pass
View medical summary module	Users can view the medical summary.	The information of the medical summary will display.	Pass
Account module	Users can edit or update their profile.	The latest user information will be stored in the Firebase.	Pass
Logout module	User can logout the application	The system will clear information and redirect to the login page.	Pass

6. Conclusion

In conclusion, the application E-Health UTHM has been developed successfully. However, there are still some limitations for this application. The limitations of the application are patients cannot cancel the registration after they have scanned the QR code, the details of medical summary is a non-responsive design and patients still will be allocated to the respective room if the doctor is absent.

To improve the usability of application E-Health UTHM, some improvements can be carried out in the future. The recommendation for improving the application is to have a cancel option for the patients who have scan the QR code to register dental or medical services. Besides, there is also a plan of including doctor's attendance in the application so that the patient will not be assigned to the room if the doctor is absent. Furthermore, the details of the medical summary is planned to become a responsive view so that if the value is null the field is not shown in the report.

Acknowledgement

References

[1]   S. Adibi, Mobile Health: A Technology Road Map. Burwood: Springer, 2015.

[2]   Z. L. Wang, An Explorative Study of the Mobile App Ecosystem from App Developers' Perspective, April 2017.

[3]   S.H. Robert and B.W. Istepanian, m-Health: Fundamentals and Applications. New Jersey: John Wiley & Sons, Inc., 2017.

[4]   A. Karen and F. W. Wager, Managing Health Care Information Systems: A Practical Approach for Health Care Executives. San Francisco: John Wiley & Sons, Inc., 2005.

[5]   S. G. Jeff McWherter, Professional Mobile Application Development. Indianapolis: John Wiley & Sons, Inc., 2012.

[6]   Jun-Chou Chuang, Y.-C. H.-J. A Novel Secret Sharing Technique Using QR Code. International Journal of Image Processing (IJIP), pp. 470, 2010.

[7]   M. Winter, Scan Me - Everybody's Guide to the Magical World of Qr Codes. Napa: Weston Publishing, 2010.

[8]   L.D. Joseph Annuzzi Jr., Advanced Android Application Development. New Jersey: Pearson Education, 2015.

[9]   E. Balagurusamy, Programming with Java. Chennai: McGraw Hill Education (India) Private Limited, 2019.

[10]   A. Kumar, Mastering Firebase for Android Development. Birmingham: Packt Publishing, 2018.

[11]   B. Hohensee, Getting Started with Android Studio. Scott Valley: CreateSpace Independent Publishing Platform, 2013.

[12]   A. G. Clifton Craig, Learn Android Studio: Build Android Apps Quickly and Effectively. New York: Apress, 2015.

[13]   B. C. Chuan, BP Healthcare. Retrieved from BP Healthcare: https://www.bphealthcare.com, 2012.

[14]   O. Shor, Medisafe. Retrieved from Medisafe: https://www.medisafeapp.com, 2012.

[15]   J. Arnold, Symptom Checker from WebMD. Check Your Medical Symptoms, 2014, retrieved from WebMD Symptom Checker: https://symptoms.webmd.com.

[16]   R. A. Johnson, An Introduction to Java Programming and Object-Oriented Application Development. Boston: Cengage Learning, 2012.

[17]   M. S. Ralph, Fundamentals of Information Systems. Boston: Cengage Learning, 2012.