



ASHESI UNIVERSITY

A CUSTOMIZED MOBILE HEALTH APPOINTMENT BOOKING APPLICATION FOR GAMMA HEALTH CONSULT LIMITED, GHANA.

CAPSTONE APPLIED PROJECT

B.Sc. Computer Science

Capstone project submitted to the Department of Computer Science and Information Systems, Ashesi University in partial fulfilment of the requirements for the award of Bachelor of Science degree in Computer Science.

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Supervisor: Mr David Sampah

2021

DECLARATION

I hereby declare that this capstone is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature:



.....

Candidate's Name:

Yvonne Dewortor

Date:

13th May, 2021.

I hereby declare that preparation and presentation of this capstone applied project were supervised in accordance with the guidelines on supervision of capstone laid down by Ashesi University.

Supervisor's Signature:



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Supervisor's Name:

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Date:

13th May, 2021.

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ABSTRACT

According to research undertaken by Gamma Health Center (GHC), the geriatric (elderly) most at times become a burden for most working families as they must be catered for and sent to the hospital for regular routine checks, especially in situations where they have special health concerns. It becomes more challenging for such working guardians who may have to spend virtually all day or most of their working hours at the hospital with their elderly relatives for just a routine medical check-up.

With the advancement in medical care and technology, and especially with a shift to preventive medicine, the geriatric population is expected to increase and with most families becoming a part of the working-class society, this will pose a serious problem in the society and the health sector as well. This project seeks to solve this problem by developing a web and mobile application for doctors and guardians or caretakers of geriatrics to help save their time by allowing them to schedule appointments for the routine checkup of their geriatric relatives.

TABLE OF CONTENTS

TOPICS	PAGES
Declaration	i
Acknowledgements	ii
Abstract	iii
Chapter 1: Introduction	1
1.0 About Gamma Health Consult.....	1
1.1 Project Introduction and Background.....	2
1.2 Related Work.....	3
1.3 Problem Statement.....	4
1.4 Project Objectives.....	4
Chapter 2: Solution Requirement Specification	5
2.0 Scope.....	5
2.1 Application Users.....	5
2.2 Functional Requirements.....	5
2.3 Non-Functional Requirements.....	6
2.4 Use Case Scenario.....	6
2.5 Use Case Diagram.....	7
Chapter 3: Design Methodology & Architecture	8
3.0 System Architecture.....	8
3.1 System Architecture of the Web Application.....	8
3.2 System Architecture of the Mobile Application.....	9
3.3.0 System Architecture Diagrams for GHC Web Application.....	10
3.3.1 Diagram of The Three-Tier Client-Server Architecture.....	10
3.3.2 ER Diagram.....	11
3.3.3 Activity Diagram.....	12
3.3.4 Class Diagram.....	13
3.4.0 APIs Used.....	13
3.4.1 Google Fonts API.....	13
3.4.2 Bootstrap API.....	13
Chapter 4: System and Software Testing Implementation	15

4.0 System Implementation for Gamma Health Consult (GHC) Appointments.....	15
4.1.0 Screenshots of the Mobile Application Folder Structure.....	15
4.1.1 Screenshots of the Web Application Folder Structure.....	16
4.2.0 Snippets of Some Coding.....	17
4.2.1 Screenshots of Snippets of Some Coding for the Mobile Application.....	17
4.2.2 Screenshots of Snippets of Some Coding for the Web Application.....	19
4.3 Implementation Challenges.....	21
Chapter 5: System and Software Testing.....	23
5.0 System Testing.....	23
5.1.0 System Testing for GHC Mobile Application	23
5.1.1 Development Testing and Test Results Table for GHC Mobile Application.....	23
5.1.2 Screenshots of GHC Mobile Application Test Results.....	25
5.2.0 System Testing for GHC Web Application	26
5.2.1 Development Testing and Test Results Table for GHC Web Application.....	26
5.2.2 Screenshots of GHC Web Application Test Results.....	28
5.3 User Testing and Test Results for GHC Applications.....	32
Chapter 6: Conclusion.....	33
6.1 Deployment to Production.....	33
6.2 Project Limitations	33
6.3 Future Work	33
6.4 Summary.....	34
References.....	35

CHAPTER ONE: INTRODUCTION

1.0 ABOUT GAMMA HEALTH CONSULT

Gamma Health Consult (GHC) Limited is a laboratory consultancy firm located in North Legon – Accra, Ghana. Founded in the year 2019 by Dr Paul Oduro, a public health specialist (masters and PhD in public health with special emphasis on infectious disease public health). GHC specializes in the setup of laboratory facilities for new businesses, expansion of existing laboratory facilities, hiring and training of laboratory personnel, quality assurance training, preparation of laboratory facilities for international accreditation, management, and advisory services on management of laboratory facilities.

GHC also offer consultancy services on a wide range of public health issues, scientific writing and medical journalism, professional advice on medico-legal issues; a case of injury or ailment, in which investigations by the law-enforcing agencies are essential to fix the responsibility regarding the causation of the said injury or ailment. (predominantly in diagnostics) as well as healthcare market research.

GHC has a wide experience in establishing and running world-class laboratory facilities within the Ghanaian environment and has both formal and informal relationships with the major players in the industry within and outside the country, i.e., suppliers of equipment and consumables, professionals, etc.

GHC also offers services in geriatric health care and has conducted research in the field of Advances in Preventive Medicine and Health Care which is a cross-disciplinary scholarly, scientific open access publication that covers the significant developments in disease prevention, health promotion, and public health policymaking that aims to encourage

researchers/eminent scholars/students to take health-related research to international levels. [2] The findings from their research show that the geriatric population is expected to increase and with most families becoming working-class, this will pose a serious problem to the ageing generation if not given the necessary attention. The vision of GHC is to ensure that they set up modern and world-class diagnostic facilities as well as upgrade existing facilities to international standards for those facilities to be able to serve their clients with not only accurate, reliable, and reproducible reports but also at a reasonable price.

From their research findings and the vision of GHC, they intend to have a mobile application that will help them reach out to their customers (both the geriatrics and their relatives) because of the increase in their request for services to make their services more efficient and less time consuming on the part of the working class relative. This project seeks to help them make this a reality. GHC believes with the aid of a mobile health application and accessing their current capacity, their vision and where they want to be in future will be achieved.

1.1 PROJECT INTRODUCTION AND BACKGROUND

Geriatrics is a branch in the field of healthcare that focuses on the unique needs of people as we transition and age in life. There are people in the field called Geriatricians and other health professionals in the sector that specialize in the health needs of the ageing generation.[1]

All of us are growing and experiencing changes in our bodies. At the age of 70, we will not be as lively as when we were between 20-40 years. Many of us while ageing will experience unique health conditions and concerns that will require medical health and

attention. Geriatricians and healthcare professionals in this field are specifically trained to help manage the well-being of the ageing group so they can continue to live as healthy and as independent as possible. [1]

The geriatric and the physically challenged always become a burden for most working-class families as they must be catered for in their day-to-day activities. It becomes more challenging for such working guardians who must spend the long hours or eventually a full day at the hospital with their geriatric or physically challenged relatives for just a routine medical check-up.

1.2 RELATED WORK

Although there has been massive growth and industrialization over the past decades in the world of technology and health, just a hand full of the many mobiles and web-based health and hospital applications out there seem to satisfy users. Most user experiences with mobile health applications need improvement as their services do not cater fully for all users of the application. In the case of providing a mobile health application to book appointments for geriatrics, relatives of these individuals have been taking into consideration in the development of the system by providing them with diagnostic features to not limit the application to just the geriatrics and physically challenged. With this, the use of the mobile health application should improve the experience of both the geriatrics and their relatives. With how smartphones have taken over the market and are widely being used among all age groups, coming up with a mobile health application to allow relatives of geriatrics and physically challenged people to book medical appointments to save them from long waiting queues while they also benefit by having access to diagnostic and pharmaceutical services should be possible. This will also help both relatives and doctors keep up with medical

records and reduce the chances of missing scheduled regular routine check-ups for their geriatric relatives.

1.3 PROBLEM STATEMENT

The growing geriatric population needs scheduled or routine medical care and those to care for them are becoming more corporate and thus do not get time to take them on their medical visits or must be absenting themselves frequently from work/school to be able to do that.

1.4 PROJECT OBJECTIVES

To make scheduled routine medical services for geriatrics and the disabled accessible, affordable, and convenient for their working-class relatives.

CHAPTER TWO: SOLUTION REQUIREMENT SPECIFICATION

2.0 SCOPE

There are many mobile health applications out there but just a few seem to bend towards geriatrics. Even those that do, do not make the work for relatives of geriatrics any easy. Most of these apps are in the form of quizzes or tests for geriatrics. As most relatives of geriatrics in charge of taking them for their frequent routine checks are also working in some kind of work/job to make a living, GHC through this project seeks to help them take care of their elderly family members by allowing them to book appointments for the routine checkups of their geriatric family to save them from missing significant working hours.

2.1 APPLICATION USERS

The application users are:

Doctors: Doctors can state their availability (time and date) for appointments.

They can leave comments or feedback for the caretaker of the geriatric concerning next meetings, progress, etc.

Relatives/Guardians: They can sign up and log in to the application to book or cancel appointments for the routine checks of their geriatric loved ones. They can also read comments, prescriptions or feedback left by doctors.

2.2 FUNCTIONAL REQUIREMENTS

- The system should allow doctors and caretakers of the geriatric to register, get authenticated, sign in and log out of the application with ease.

- The system should allow the family of the geriatric to book appointments for the routine medical care of the patient 48 hours before the preferred date.
- The system should inform the client of the status and next scheduled meeting of a patient.
- The system should display prescriptions, feedback or any comments left by the doctor for the caretaker of the geriatric. [3]

2.3 NON-FUNCTIONAL REQUIREMENTS

- Usability and Learnability: The system should allow inexperienced users to learn and find (interacting with the application) their way about in the application with ease.
- Performance (Response Time): The response time should be abrupt and not frustrate the user for waiting for pages to load for a long time.
- Reliability: The system should be a reliable one to both users and administrators and be free of program crashes from bugs.
- Recoverability: Information kept by the system should be easily restored or recovered when the need be.
- Security: The system should protect user information and allow users to feel safe while feeding the system with their details. [3]

2.4 USE CASE SCENARIO

Use case name: Booking an appointment.

Goal: The caretaker of the geriatric can make an appointment before coming to the hospital, so it can reduce the waiting time required at the outpatient department before he or she can take the geriatric to see a doctor.

Primary actors: Caretaker of the geriatric and the Doctor.

Scenario:

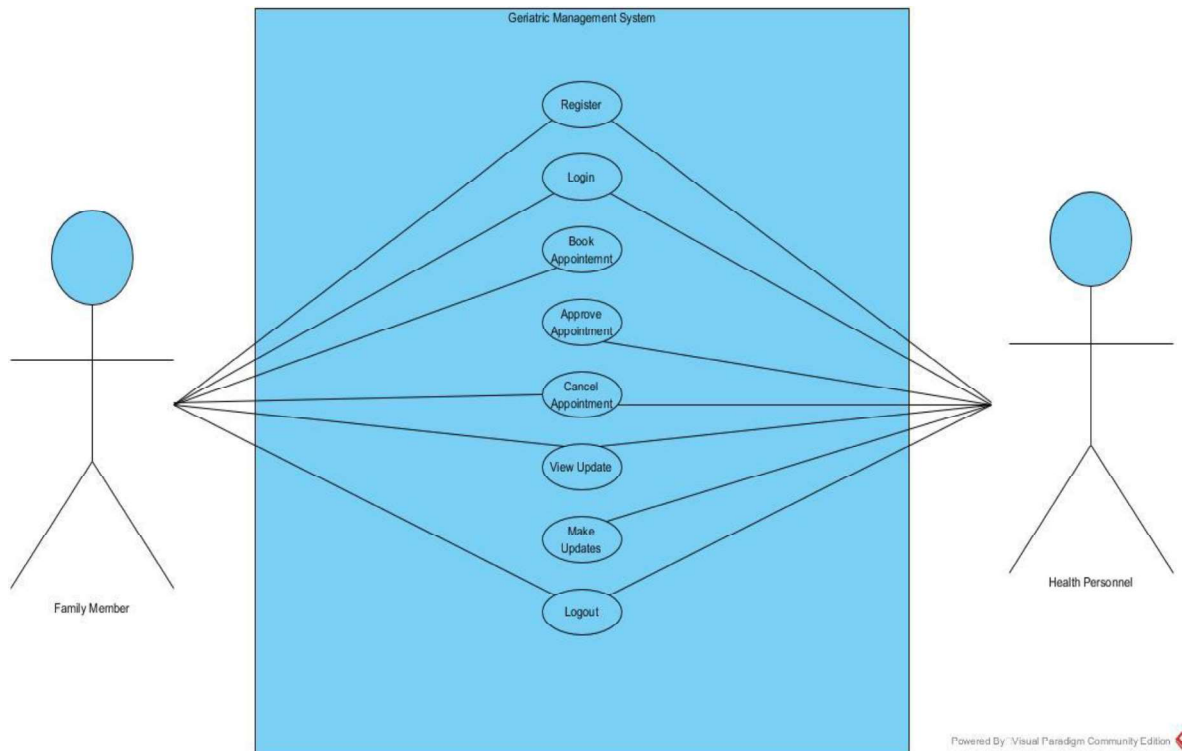
1. Caretaker logs in to the system and get authenticated. (username and password checks).
2. Caretaker check for the available time of the doctor and reserves the time that works for them.
3. Application creates the appointments and records in schedule then updates the system.

Exceptions:

1. If the username and password are incorrect, the system will prompt for re-entry.
2. If there is no available time. The system will prompt that there is no available time.

Post Condition: An appointment will be booked, and confirmation of reservation will be made by the doctor.

2.5 USE CASE DIAGRAM OF SYSTEM



CHAPTER THREE: DESIGN METHODOLOGY & ARCHITECTURE

3.0 SYSTEM ARCHITECTURE

GHC Appointments System will involve two applications which are the mobile application for the geriatric's caretaker and web-based application for the doctor(s) and administrator(s).

3.1 SYSTEM ARCHITECTURE OF THE WEB APPLICATION

The web application of this project will be implemented based on the model of the Three-Tier Client-Server Architecture which is a well-established software application architecture that organizes applications into three logical and physical computing tiers.[5] They are:

- A Client device (Presentation or client tier) which represents the user's interface.
- An Application Server (Application or business logic tier) where data is processed.
- A Database Server (Data tier) where the data associated with the application is stored and managed.

To achieve the functionality of the architecture, it is essential for all tiers to interact with each other.

The most important benefit of the three-tier architecture system is that each tier can be developed independently of the others since they all have their own infrastructure and resources.[5]

They can also be developed or updated simultaneously since a change in a tier does not disrupt the system.[5]

The three-tier architecture also provides an elevated level of security because of the separation of tasks among the different tiers. A breach on the front end of the system does not guarantee a breach on the backend or the database as these are working independently of each other.[5]

The GHC **web application** will be developed using the model of this architecture since it will be in the three parts below:

1. In the web application development for the backend website of this project, the content will be dynamic and developed using HTML, CSS, JavaScript, and the Bootstrap framework, which has responsiveness to CSS and enables adjustments to phones, tablets, and desktop screens.
2. The application server will house the system logic used to process user inputs. This is the tier that will query the database to return results to the customer's profile. This layer will be developed using PHP.
3. The database server is the data or backend tier of the web application.[5] It will run on the phpMyAdmin MYSQL database management software.

3.2 SYSTEM ARCHITECTURE OF THE MOBILE APPLICATION

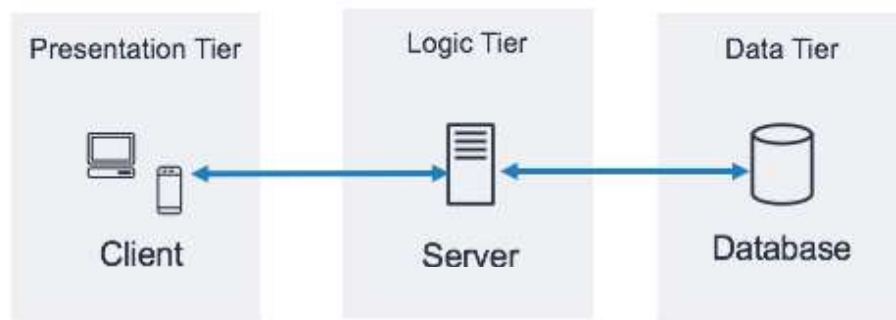
The mobile application will be developed based on the architectural structure of the Ionic framework. Ionic's components are written in HTML, CSS, and JavaScript, making it easy to build modern, high-quality UIs that perform great. Ionic is built on AngularJs (a JavaScript framework that enables the functionality of HTML). Ionic is also wrapped around NodeJS which serves as a prerequisite to using the framework. Apache Cordova is a set of APIs which helps

developers access native functions of iOS or Android platform. Using Ionic CLI (Command Line Utility) it is easy and lightweight to put your app on iOS or Android simulator. For the advantage of developing an application with one executable code to run on both android and iOS platforms, Ionic was chosen for this part of the project.[8]

The mobile application will have its data stored in the central database (which is the the same database for the web application) developed in MySQL in phpMyAdmin to allow easy accessibility and communication between the two applications of this project.

3.3.0 SYSTEM ARCHITECTURE DIAGRAMS FOR GHC WEB APPLICATION

3.3.1 DIAGRAM OF THE THREE-TIER CLIENT-SERVER ARCHITECTURE



[9]

For this project work, Apache HTTP (Hypertext Transfer Protocol) server was chosen amongst many options such as Oracle WebLogic and Nginx. This is because of how easy it is to learn and implement. The Apache HTTP server is a component of the XAMPP service. The Apache web server can host websites that use server-side language code like

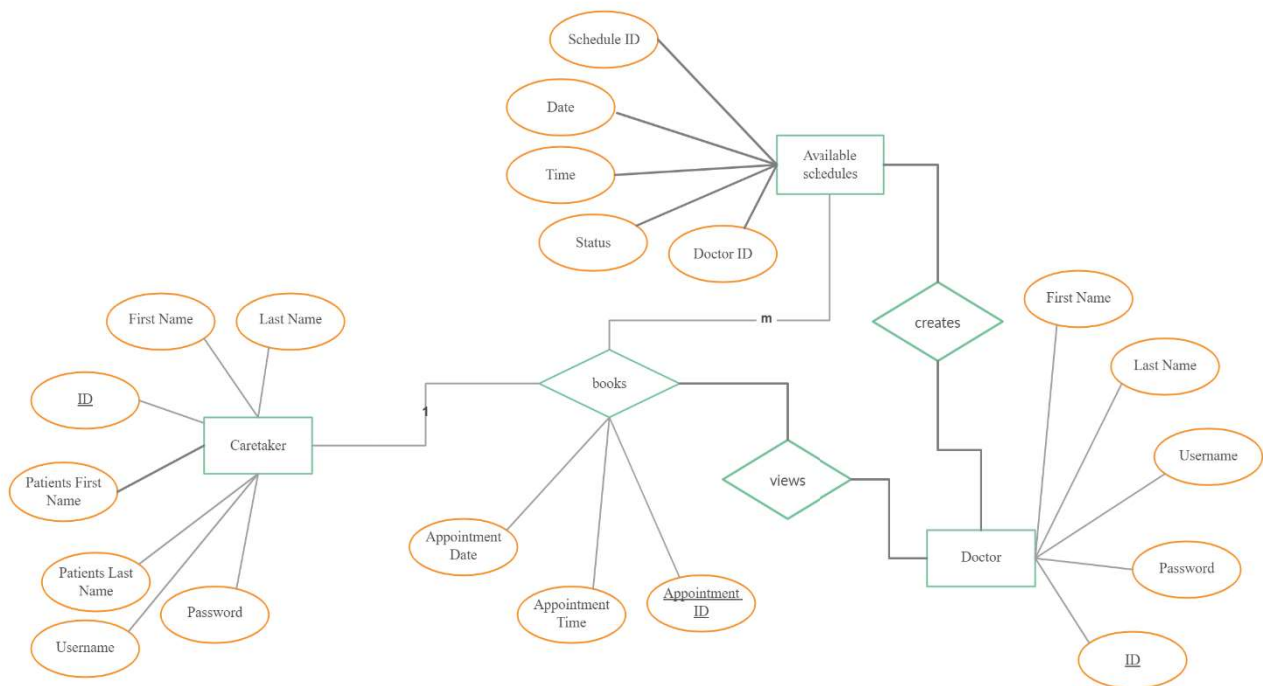
PHP and since the logic for this project was being developed in PHP, this was the best suitable option.

XAMPP stands for x-OS, Apache, MySQL, PHP, and Perl which are used as a stage for coding and designing web pages. The XAMPP software tool was chosen for this project against many options such as WAMP and MAMP. This is because XAMPP has more powerful resources and SSL (Secure Sockets Layer) feature which WAMP for instance does not have.[6] XAMPP does not restrict applications to only native web apps. It is a free and open-source software that empowers technologies, processes, and machines to link and work together. It is established by Apache.

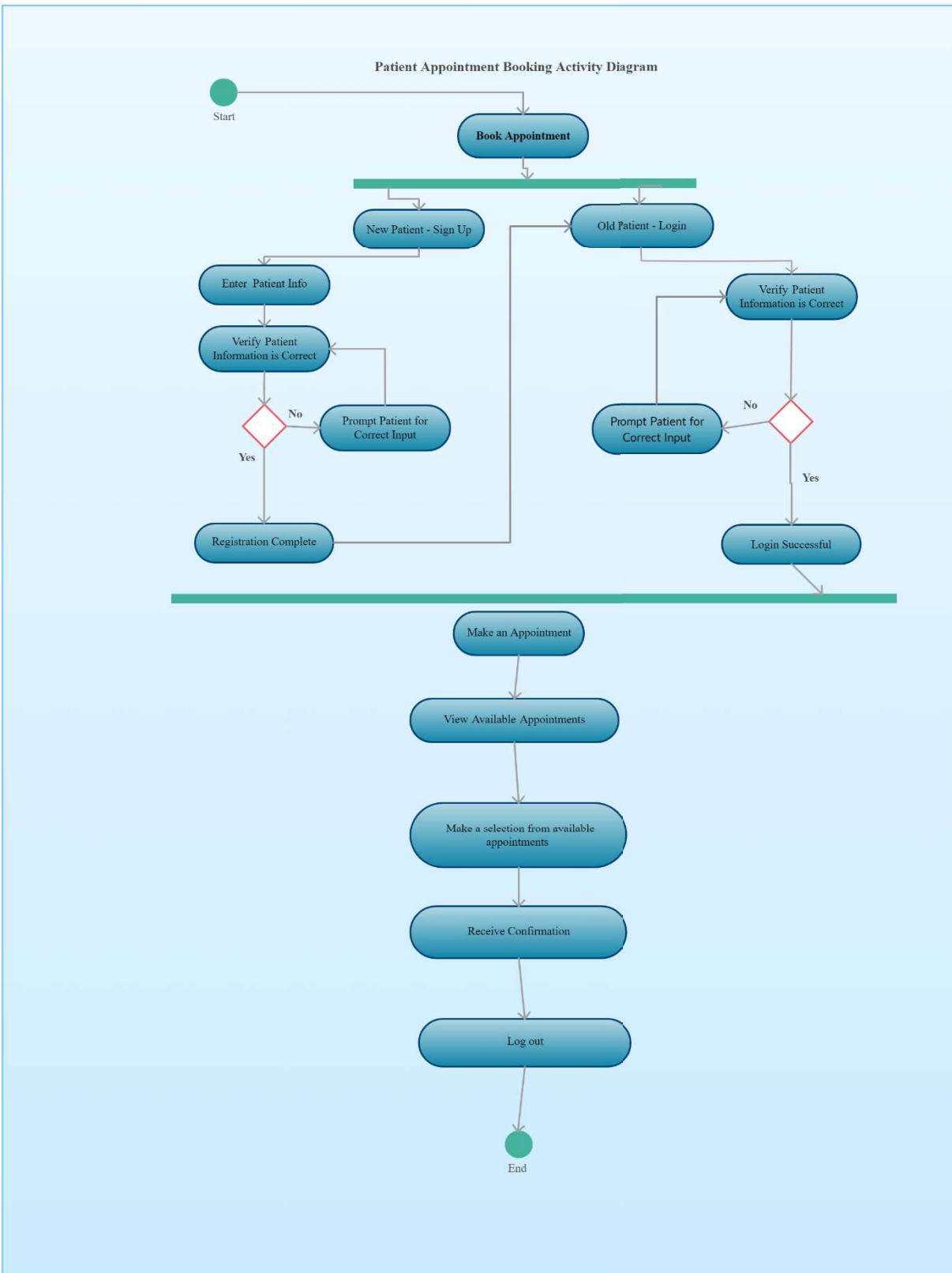
User Interface Design: The design of the user interface will be done by taking each privilege or role i.e., the family member and the doctor role and creating a screen for each.

Each of these users has different privileges and distinct roles to play.

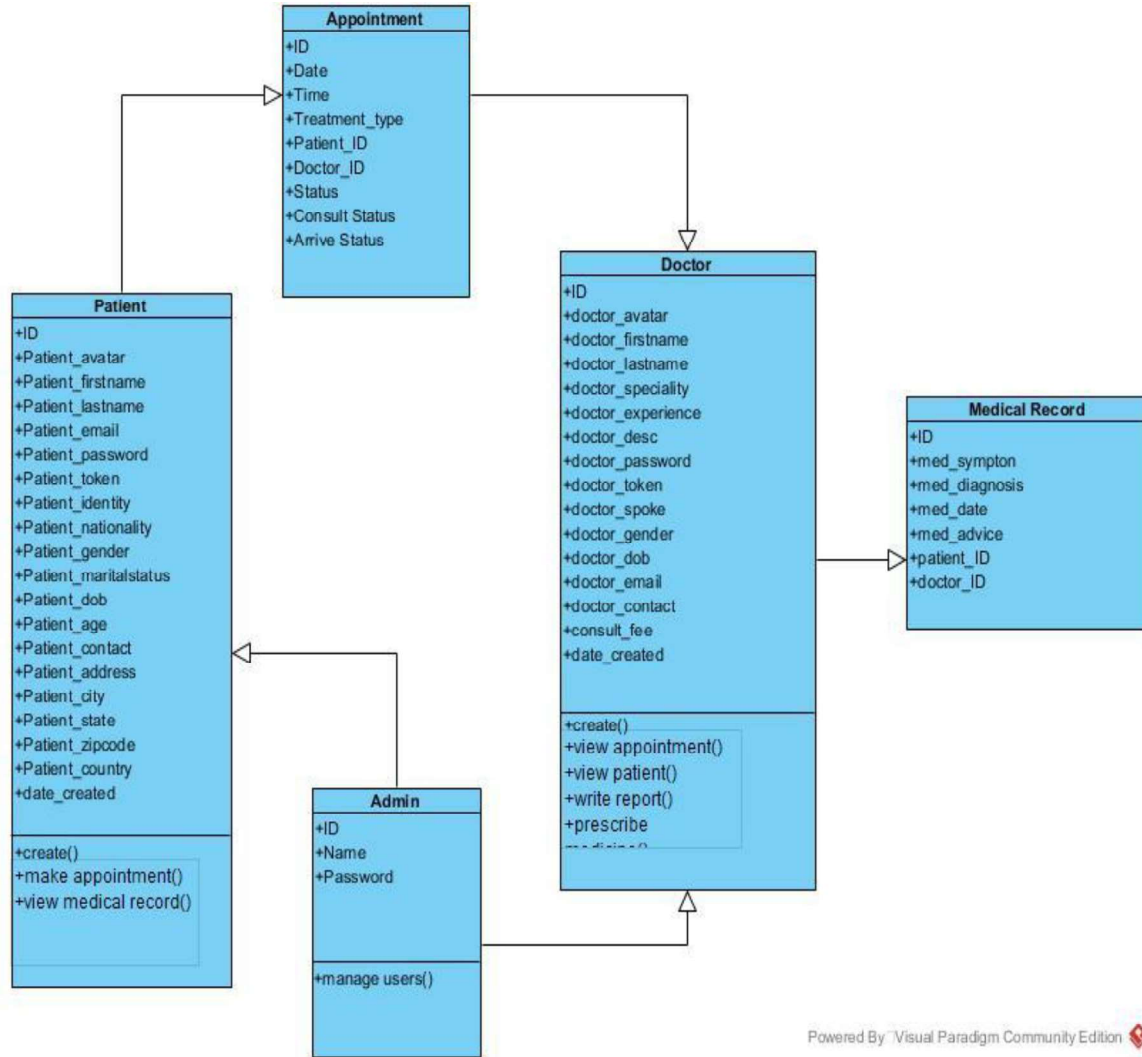
3.3.2 ER DIAGRAM



3.3.3 ACTIVITY DIAGRAM FOR PATIENT APPOINTMENT BOOKING



3.3.4 CLASS DIAGRAM FOR PATIENT APPOINTMENT BOOKING



3.4.0 APIs USED.

3.4.1 GOOGLE FONTS API.

The Google Font API is a web service that supports high-quality open-source font style files that can be used on web application designs. This was incorporated into the GHC web application to enhance the appearance of texts in the application. [11]

3.4.2 BOOTSTRAP API

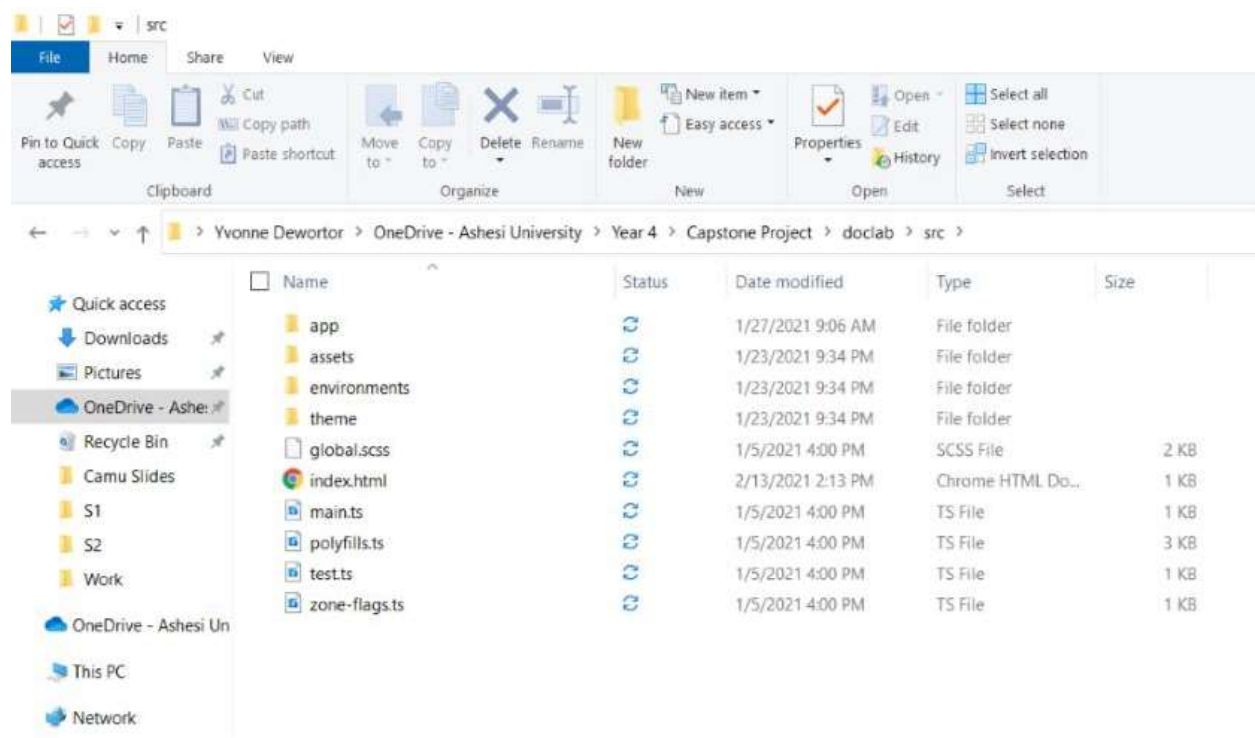
Bootstrap is an open-source and free to use front-end framework used to create aesthetic websites and web applications. It encapsulates numerous HTML and CSS templates for user interface elements such as buttons, forms, and other displays. The API also supports JavaScript extensions in applications. [20]

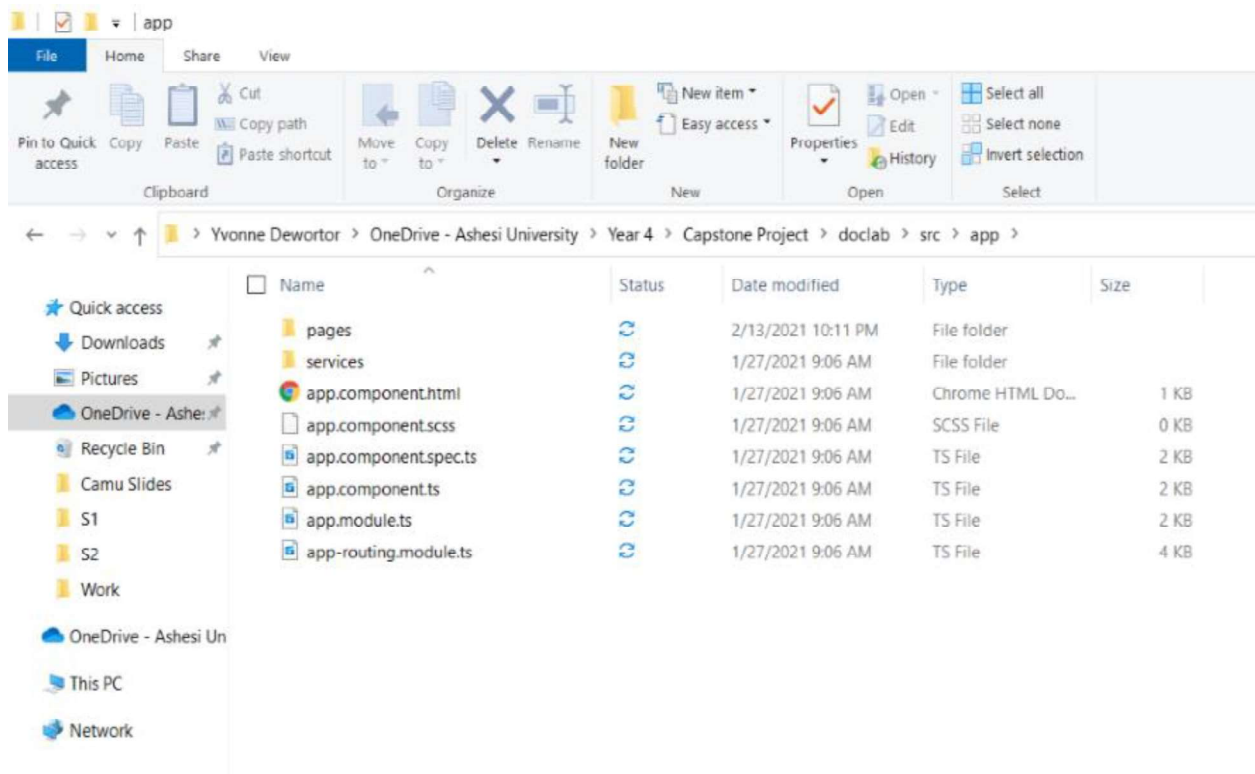
CHAPTER 4: SYSTEM AND SOFTWARE IMPLEMENTATION

4.0 SYSTEM IMPLEMENTATION FOR GAMMA HEALTH CONSULT (GHC) APPOINTMENTS

4.1.0 SCREENSHOTS OF THE MOBILE APPLICATION FOLDER STRUCTURE

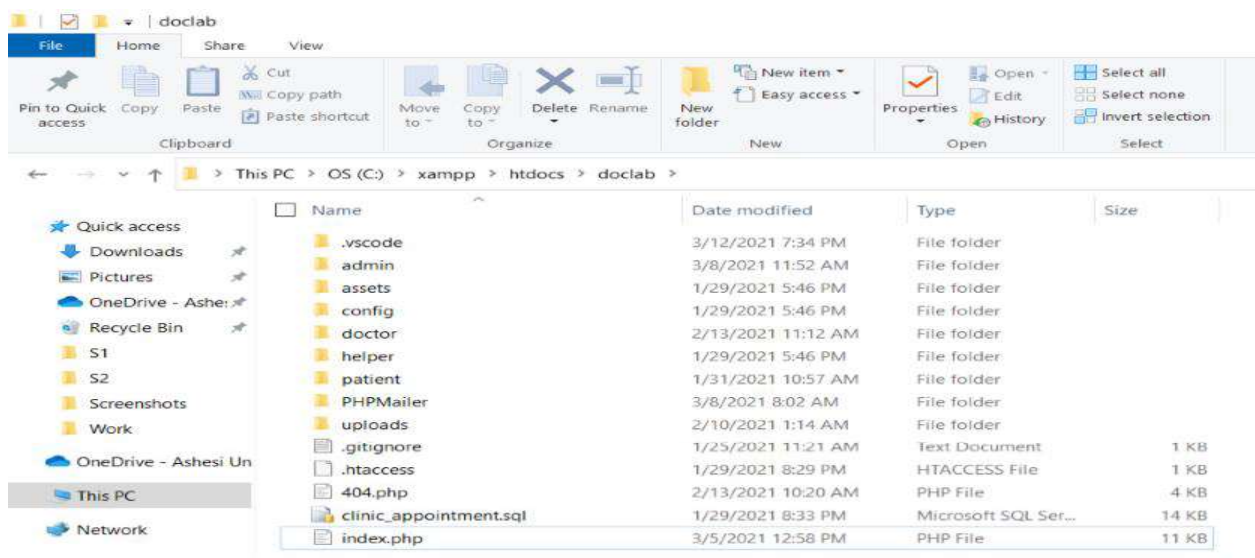
Upon creating the ionic application from the command line, a default folder is created consisting of the ionic format, structures, and models. When a new page is created, ionic automatically creates modules for future package imports and creates a routing flow to connect all other pages in the “...src/app/pages” folder. The file is called “app-routing-module.ts” (as shown in diagram 3 below). With this, the user can easily use the routing page created to direct the flow page from the index/homepage as he or she desires. Below are the ionic folder structures for the GHC mobile application:

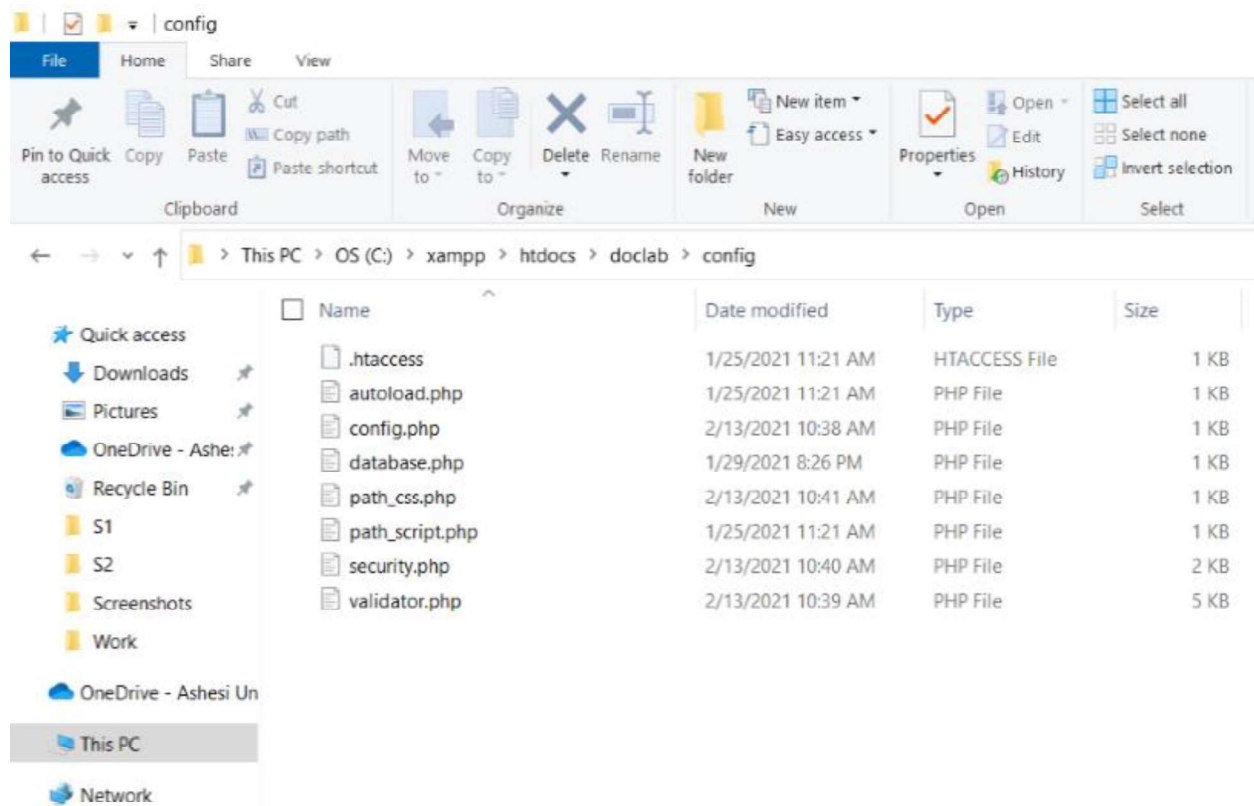




4.1.1 SCREENSHOTS OF THE WEB APPLICATION FOLDER STRUCTURE

The GHC Appointments web application, found in the “doclab” folder as shown below consists of all page folders of the application and their respective PHP files as shown in subsequent diagrams.

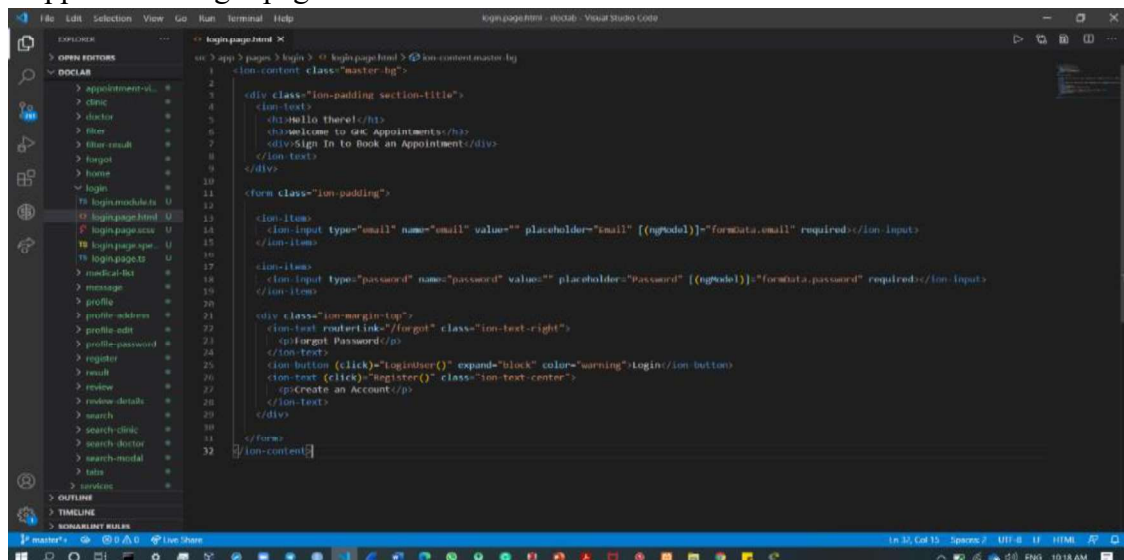




4.2.0 SNIPPETS OF SOME CODING

4.2.1 SCREENSHOTS OF SNIPPETS OF SOME CODING FOR THE MOBILE APPLICATION

Code snippet of the login page.html



The above lines of code are responsible for the creation of the HTML page for the GHC mobile application's login page. An HTML5 form was created to accept the user's input (email and password). An option to register if the user does not already have an account is made available via the “Register” button available at the bottom of the page. These details are later passed on to the “login.page.ts” file where they are authenticated and verified with details in the database before the user can successfully log in. Should the details not match records in the database, the login will fail, and the user will be prompted to input the enter the correct information.

Code Snippet of the app-routing.module.ts page

```

1  import { NgModule } from '@angular/core';
2  import { PreloadAllModules, RouterModule, Routes } from '@angular/router';
3  import { AuthGuardService } from './services/auth-guard.service';
4  const routes: Routes = [
5    { path: '', redirectTo: 'login', pathMatch: 'full' },
6    { path: '',
7      canActivate: [AuthGuardService],
8      loadChildren: './pages/tabs/tabs.module#TabsPageModule' },
9  ],
10  { path: 'login', loadChildren: './pages/login/login.module#LoginPageModule' },
11  { path: 'register', loadChildren: './pages/register/register.module#RegisterPageModule' },
12  { path: 'profile', loadChildren: './pages/profile/profile.module#ProfilePageModule' },
13  { path: 'forgot', loadChildren: './pages/forgot/forgot.module#ForgotPageModule' },
14  { path: 'result', loadChildren: './pages/result/result.module#ResultPageModule' },
15  { path: 'doctor/did', loadChildren: './pages/doctor/doctor.module#DoctorPageModule' },
16  { path: 'message', loadChildren: './pages/message/message.module#MessagePageModule' },
17  { path: 'profile-edit', loadChildren: './pages/profile-edit/profile-edit.module#ProfileEditPageModule' },
18  { path: 'profile-address', loadChildren: './pages/profile-address/profile-address.module#ProfileAddressPageModule' },
19  { path: 'profile-password', loadChildren: './pages/profile-password/profile-password.module#ProfilePasswordPageModule' },
20  { path: 'appointment-view/aid', loadChildren: './pages/appointment-view/appointment-view.module#AppointmentViewPageModule' },
21  { path: 'appointment-detail', loadChildren: './pages/appointment-detail/appointment-detail.module#AppointmentDetailPageModule' },
22  { path: 'review', loadChildren: './pages/review/review.module#ReviewPageModule' },
23  { path: 'review-details', loadChildren: './pages/review-details/review-details.module#ReviewDetailsPageModule' },
24  { path: 'medical-list', loadChildren: './pages/medical-list/medical-list.module#MedicalListPageModule' },
25  { path: 'search-modal/searchid', loadChildren: './pages/search-modal/search-modal.module#SearchModalPageModule' },
26  { path: 'search-clinic', loadChildren: './pages/search-clinic/search-clinic.module#SearchClinicPageModule' },
27  { path: 'search-doctor', loadChildren: './pages/search-doctor/search-doctor.module#SearchDoctorPageModule' },
28  { path: 'filter', loadChildren: './pages/filter/filter.module#FilterPageModule' },
29  { path: 'filter-result/lowerprice/higherprice/gender', loadChildren: './pages/filter-result/filter-result.module#FilterResultPageModule' },
30  ],
31  @NgModule({
32    imports: [
33      RouterModule.forRoot(routes, { preloadingStrategy: PreloadAllModules })
34    ],
35    exports: [RouterModule]
36  })
37  export class AppRoutingModule { }
38

```

The above lines of code are responsible for the routing (navigation) of pages in the application. All page redirection activities are set here. The current page the user may have opened is the “path” and where the user may go from the is specified in the “loadChildren”.

Code Snippet of the Search Doctor Result Page


```

1  import { Component, OnInit } from '@angular/core';
2  import { HttpClient } from '@angular/common/http';
3  import { Router } from '@angular/router';
4  import { ProviderService } from 'src/app/services/provider.service';
5  @Component({
6    selector: 'app-result',
7    templateUrl: './result.page.html',
8    styleUrls: ['./result.page.scss'],
9  })
10 export class ResultPage implements OnInit {
11   itemsDoctor: any;
12   searchTerm: string = "";
13   imgURL: string = this.providerSvc.imgURL;
14   constructor(public http: HttpClient, public router: Router, public providerSvc: ProviderService) {}
15   ngOnInit() {
16     this.loadData();
17   }
18   loadData() {
19     this.providerSvc.getData("result_doctor.php")
20     .subscribe(data => {
21       if (data != null) {
22         this.itemsDoctor = data;
23         console.log(data);
24       } else {
25         console.log("No Result");
26       }
27     }, error => {
28       console.log("Load Data failed:", JSON.stringify(error));
29     });
30   }
31   doctorProfile(id: number) {
32     if (id != null) {
33       this.router.navigate(['/doctor', id]);
34     } else {
35       console.log("Error");
36     }
37   }
38 }

```

The above lines of code are the activities that take place when a user uses the “search button” on the tabs or clicks on the “Book Appointment” feature on the dashboard. This makes an API call to the “result-doctor.php” file in the backend which queries the database for the list of all available doctors and displays this back to the user on the “Doctor Result Page”. From there, the user can choose a preferred doctor and book a slot from his or her available time slots.

4.2.2 SCREENSHOTS OF SNIPPETS OF SOME CODING FOR THE WEB APPLICATION

Code Snippet of the Home Page

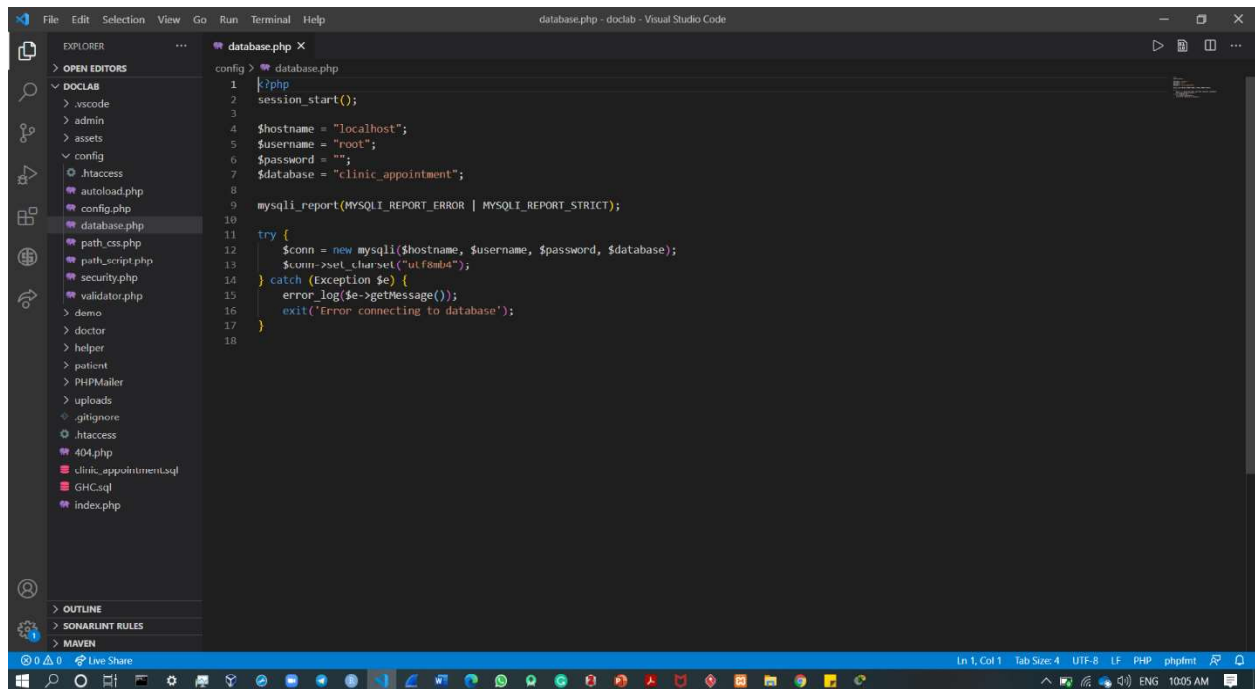
```

1  <!DOCTYPE html>
2  <html lang="en">
3  <head>
4    <meta charset="UTF-8">
5    <meta name="viewport" content="width=device-width, initial-scale=1.0">
6    <meta http-equiv="X-UA-Compatible" content="ie=edge">
7    <link rel="icon" href="assets/img/icon/favicon.ico" type="image/x-icon" size="16x16">
8    <title>GSK Appointments</title>
9    <link rel="stylesheet" href="https://stackpath.bootstrapcdn.com/bootstrap/4.3.1/css/bootstrap.min.css">
10    <link rel="stylesheet" href="https://font.googleapis.com/robots.txt/manifest.json" type="font/robots">
11    <link href="https://font.googleapis.com/css?family=Roboto:400,500,700,900" rel="stylesheet">
12    <link href="https://font.googleapis.com/css?family=Roboto:400,500,700,900" rel="stylesheet">
13    <link href="https://font.googleapis.com/css?family=Roboto:400,500,700,900" rel="stylesheet">
14  </head>
15  <body>
16    <div class="container">
17      <div class="row">
18        <div class="col-md-12">
19          <div class="card">
20            <div class="card-body">
21              <div class="text-center">
22                <h1>GSK Appointments</h1>
23                <h2>Book Appointment</h2>
24              </div>
25            </div>
26          </div>
27        </div>
28      </div>
29    </div>
30  </body>
31 </html>

```

The above lines of code are responsible for all features seen on the homepage of the GHC Appointments web application. It makes a call the Bootstrap API and Google Fonts API which is responsible for the aesthetics of the page. All other features such as “login” have redirections to take the user to the appropriate page to proceed.

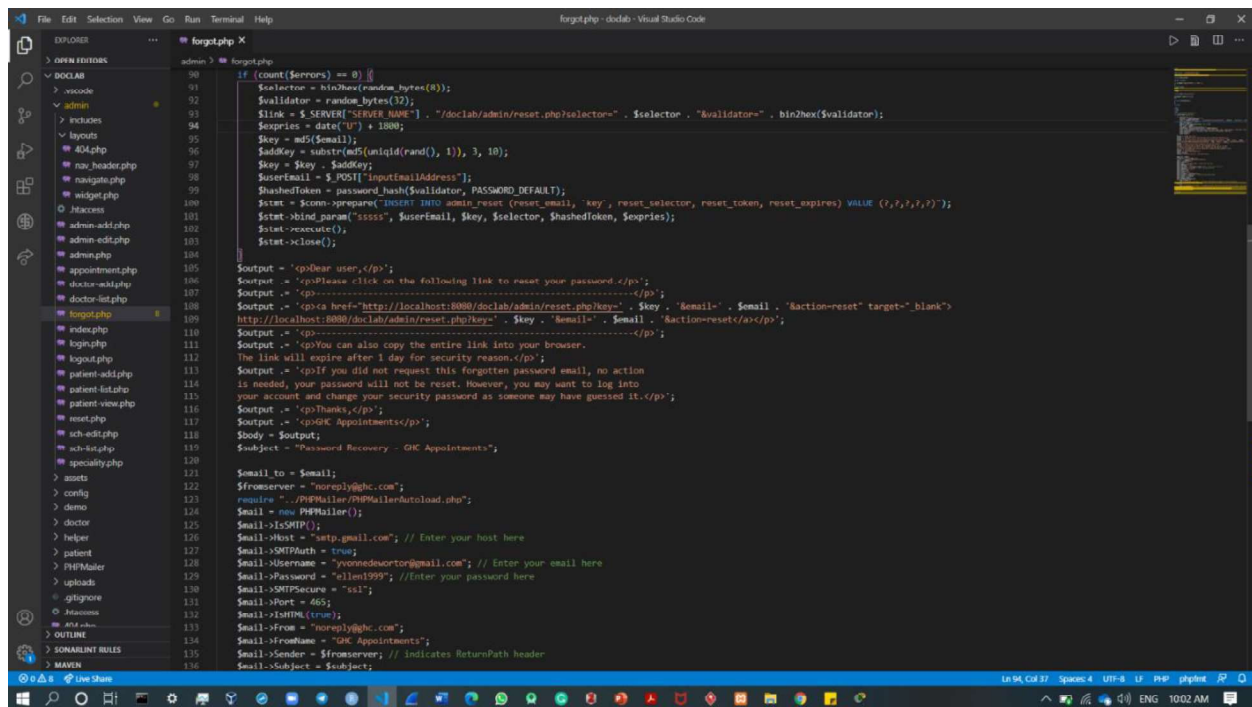
Code Snippet of the Database Configuration Page



```
1  <?php
2  session_start();
3
4  $hostname = "localhost";
5  $username = "root";
6  $password = "";
7  $database = "clinic_appointment";
8
9  mysqli_report(MYSQLI_REPORT_ERROR | MYSQLI_REPORT_STRICT);
10
11 try {
12     $conn = new mysqli($hostname, $username, $password, $database);
13     $conn->set_charset("utf8mb4");
14 } catch (Exception $e) {
15     error_log($e->getMessage());
16     exit('Error connecting to database');
17 }
18
```

The above lines of code are responsible for the database configuration in the GHC Appointments web application. This establishes a connection between the application and the database permitting the application to query the database as and when it needs to.

Code Snippet of the Forgot Page



```
100 if (count($errors) == 0) {
101     $selector = bin2hex(random_bytes(8));
102     $validator = random_bytes(32);
103     $link = $SERVER["SERVER_NAME"] . "/doclab/admin/reset.php?selector=" . $selector . "&validator=" . bin2hex($validator);
104     $expires = date("U") + 1800;
105     $key = md5($email);
106     $addkey = substr(md5(uniqid(rand(), 1)), 3, 10);
107     $key = $key . $addkey;
108     $userEmail = $_POST["inputEmailAddress"];
109     $hashedToken = password_hash($validator, PASSWORD_DEFAULT);
110     $stmt = $conn->prepare("INSERT INTO admin_reset (reset_email, key, reset_selector, reset_token, reset_expires) VALUES (?, ?, ?, ?, ?)");
111     $stmt->bind_param("sssss", $userEmail, $key, $selector, $hashedToken, $expires);
112     $stmt->execute();
113     $stmt->close();
114 }
115 $output = "<p>Dear user,</p>";
116 $output = "<p>Please click on the following link to reset your password.</p>";
117 $output = "<p>-----</p>";
118 $output = "<p>a href='http://localhost:8080/doclab/admin/reset.php?key=" . $key . "&email=" . $email . "&action=reset' target='_blank'";
119 $output = "<p>http://localhost:8080/doclab/admin/reset.php?key=" . $key . "&email=" . $email . "&action=reset/as</p>";
120 $output = "<p>-----</p>";
121 $output = "<p>You can also copy the entire link into your browser.</p>";
122 $output = "<p>The link will expire after 1 day for security reason.</p>";
123 $output = "<p>If you did not request this forgotten password email, no action";
124 $output = "<p>is needed, your password will not be reset. However, you may want to log into";
125 $output = "<p>your account and change your security password as someone may have guessed it.</p>";
126 $output = "<p>Thank you.</p>";
127 $output = "<p>GHC Appointments</p>";
128 $body = $output;
129 $subject = "Password Recovery - GHC Appointments";
130 $email_to = $email;
131 $fromserver = "noreply@ghc.com";
132 require "../PHPMailer/PHPMailerAutoload.php";
133 $mail = new PHPMailer();
134 $mail->isSMTP();
135 $mail->Host = "smtp.gmail.com"; // Enter your host here
136 $mail->SMTPAuth = true;
137 $mail->Username = "yvonnedawortor@gmail.com"; // Enter your email here
138 $mail->Password = "ellen1999"; //Enter your password here
139 $mail->SMTPSecure = "ssl";
140 $mail->Port = 465;
141 $mail->isHTML(true);
142 $mail->From = "noreply@ghc.com";
143 $mail->FromName = "GHC Appointments";
144 $mail->Sender = $fromserver; // indicates ReturnPath header
145 $mail->Subject = $subject;
```

The above lines of code are responsible for the activities that take place if a user (doctor or admin) of the GHC web application has forgotten their password and hence cannot log into the application. Should they click “forgot password” on their login page, it will redirect them to a “forgot password” page where their registered email address for the application will be requested. An email with the content and link in the image above is sent to them with instructions to reset their passwords.

4.3 IMPLEMENTATION CHALLENGES

In the process of implementing the mobile and web application for GHC Appointments, a few challenges were encountered:

- Firebase database configuration leading to switch of database platform to phpMyAdmin.
- Problem with java-path leading to failed build on mobile app application.
- Difficulty in running the mobile application on an emulator/android device.

- Ionic CORS policy preventing the mobile application from receiving email from the PHP backend.
- PHPMailer configuration difficulty.

CHAPTER 5: SYSTEM AND SOFTWARE TESTING

5.0 SYSTEM TESTING

For the sake of customer satisfaction and software quality assurance of the products from this project, system testing was considered an important activity to carry out. It is a process by which we try to clear the system of all possible errors or bugs by using the program intensively to find an error. [10] A system is usually not considered to be complete without this process. System testing is next after the implementation of the system to make sure that the system is working fine and meets the requirements. Testing is done to demonstrate to both the developer and the customer that the software meets its requirements. This leads to **validation testing** where the system is expected to perform correctly using a given set of test cases that reflect the system's expected use. Secondly, testing is done to discover situations in which the behaviour of the software is incorrect, undesirable or does not conform to its specification.[10] Testing for this project will be done in 2 stages:

1. Development testing, where the system is tested during development to discover bugs and defects.
2. User testing, where users or potential users of a system test the system in their own environment.

5.1.0 SYSTEM TESTING FOR GHC MOBILE APPLICATION

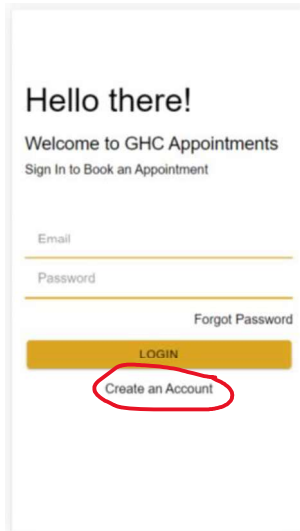
The table displayed below in the next section shows the results of the tests obtained after carrying out development testing on the GHC mobile application.

5.1.1 DEVELOPMENT TESTING AND TEST RESULTS TABLE FOR GHC MOBILE APPLICATION

Test Case ID	Test Case Name	Precondition	Priority	Input Test Data	Steps to be executed.	Expected Result	Result Successful (Yes or No)
1	Registration (Patient)	None	High	Valid email address and other inputs	Need to fill the registration form and submit it.	Registration successful	Yes
				Invalid email address or other inputs		Registration Failed (Error Message)	No
2	Login (Patient)	Must be registered.	High	Valid username and password	Enter username and password and submit.	Login Successful	Yes
				Invalid username and password		Login Failed	No
3	View Appointment	Must be logged in	High	Click the “Appointments” button on the tab bar	Appointment(s) found	Display list of appointments booked	Yes
					No appointment(s) found	Display “no appointments booked” message	No
4	Search Doctor	Must be logged in	High	Click the “Search” button on the tab bar and select “Doctors” from the list displayed	Doctors found	Display list of Doctors	Yes
					No Doctors found	Display “No Doctors Available” message	No
5	Forgot Password	Open GHC Appointments application	Low	Click the “Forgot Password” button	Fill forgot password form and submit it.	Valid email: Password reset email sent.	Yes
						Invalid email: “Invalid email” message pops up.	No

5.1.2 SCREENSHOTS OF GHC MOBILE APPLICATION TEST RESULTS.

TEST
CASE
ID: 1

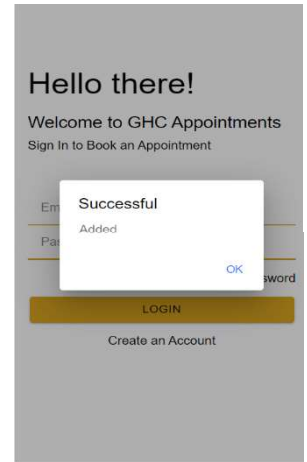


Register Here

Sign Up Now to Book Appointment

Ama
Ponko
GH0321
amaponko@gmail.com
.....
.....
REGISTER

Already have an Account? Sign In

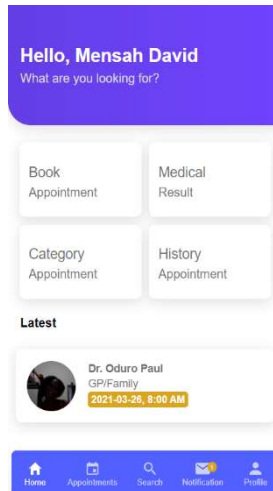


TEST
CASE
ID: 2

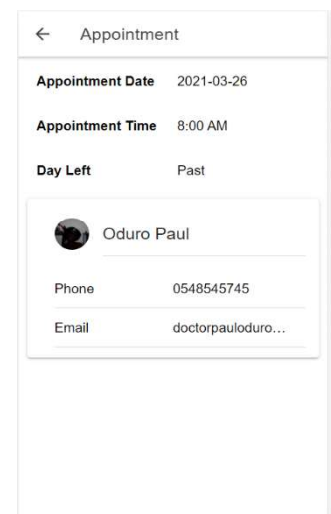
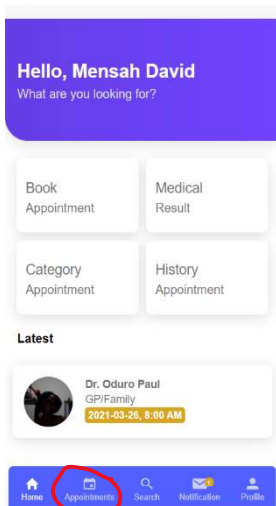
Hello there!

Welcome to GHC Appointments
Sign In to Book an Appointment

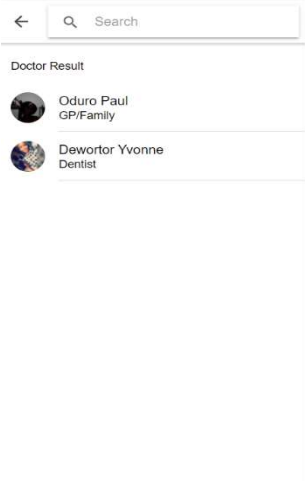
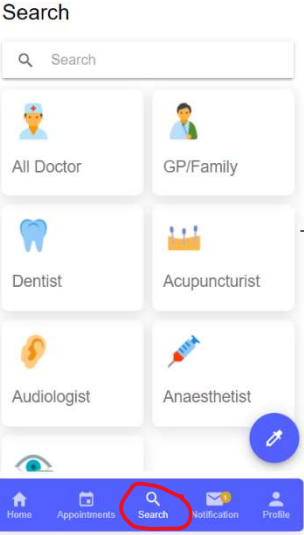
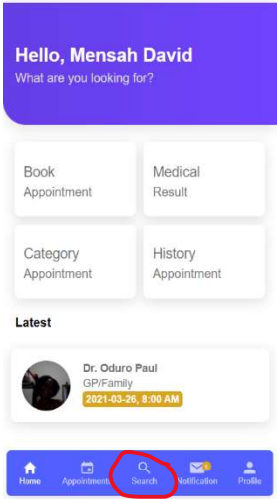
david@gmail.com
.....
Forgot Password
LOGIN
Create an Account



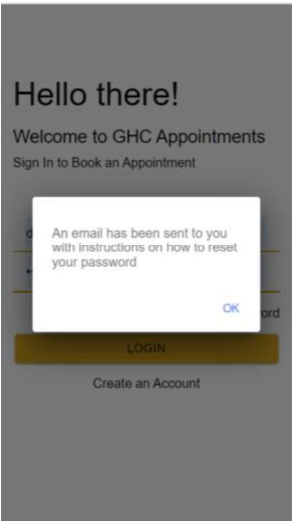
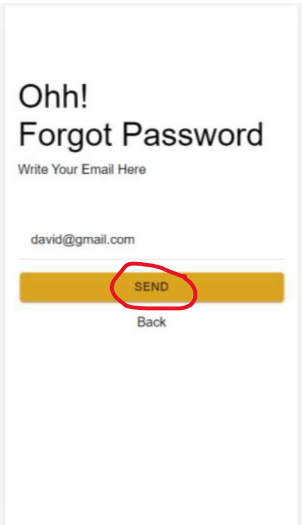
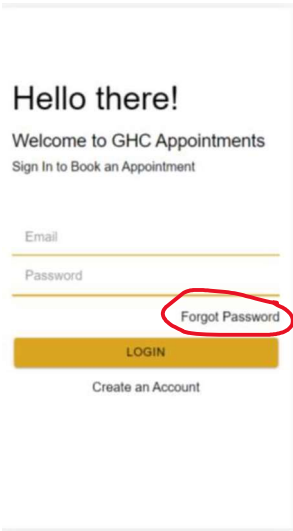
TEST
CASE
ID: 3



TEST
CASE
ID: 4



TEST
CASE
ID: 5



5.2.0 SYSTEM TESTING FOR GHC WEB APPLICATION

The table below shows the results of the tests obtained after carrying out development testing on the GHC web application.

5.2.1 DEVELOPMENT TESTING AND TEST RESULTS TABLE FOR GHC WEB APPLICATION

Test Case ID	Test Case Name	Precondition	Priority	Input Test Data	Steps to be executed.	Expected Result	Result Successful (Yes or No)
1	Registration (Doctor)	None	High	Admin feels registration form with Doctor details.	The doctor uses forgot password feature to set his password.	Registration successful	Yes
				Some fields of the registration form empty		Registration Failed (Error Message)	No
2	Login (Doctor or Admin)	Must be registered.	High	Valid username and password	Enter username and password and submit.	Login Successful	Yes
				Invalid username and password		Login Failed	No
3	View Patients (Doctor or Admin)	Must be logged in	High	Click "Patients" button on the side bar	Patient(s) found	Display list of patient(s).	Yes
					No patient(s) found	Display "no patients found" message.	No
4	Edit Profile (Doctor or Admin)	Must be logged in	High	Click the "Profile" button on the sidebar and select "Edit Profile" next	Fill in all required fields on the form	Display profile updated successfully message.	Yes
					Fail to fill in all required fields on the form	Highlight field with missing information to alert the user to input the data	No
5	Forgot Password (Doctor or Admin)	Open GHC Appointments application	Low	Click the "Forgot Password" button	Fill forgot password form and submit	Valid email: Password reset email sent	Yes
						Invalid email: "Invalid email" message pops up.	No
6	Login (Patient)	Open GHC Appointments application	High	Choose "Patient" from the login drop-down menu	Get redirected to a section on the page to inform the	User reads and understands information	Yes

7	View Doctors (Admin)	Must be logged in	High	Click the “Doctors” button on the sidebar	user of the GHC mobile application	Doctors(s) found	Display list of doctors(s).	Yes
						No doctors(s) found	Display “no doctors found” message.	No

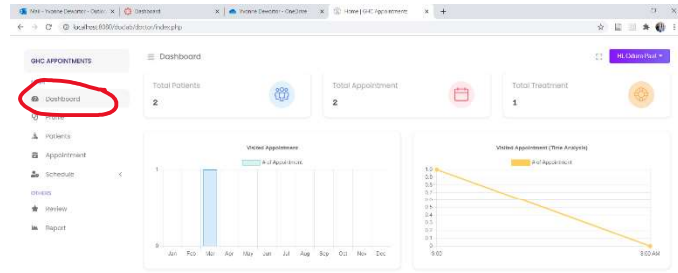
5.2.2 SCREENSHOTS OF GHC WEB APPLICATION TEST RESULTS

TEST CASE ID: 1

TEST
CASE
ID: 2

GHC Appointments
Hello there, Sign in your Account
Email address
Password
Forgot Password?
Don't have an account? Sign up

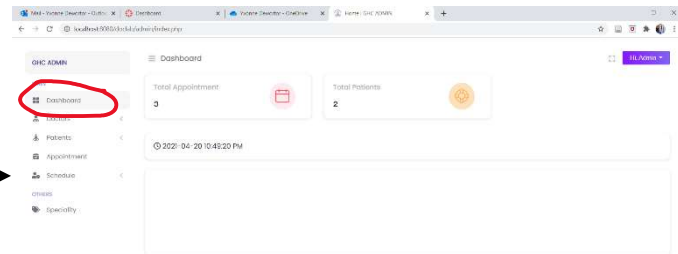
Log In



TEST
CASE
ID: 3

GHC Appointments
Hello there, Sign in your Account
Email address
Password
Forgot Password?
Don't have an account? Sign up

Log In

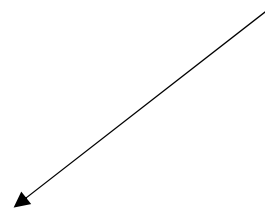


GHC APPPOINTMENTS

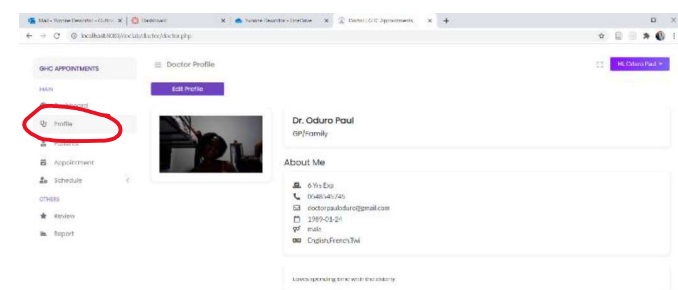
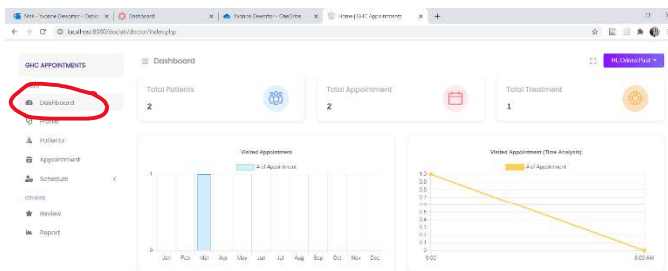
Patient List

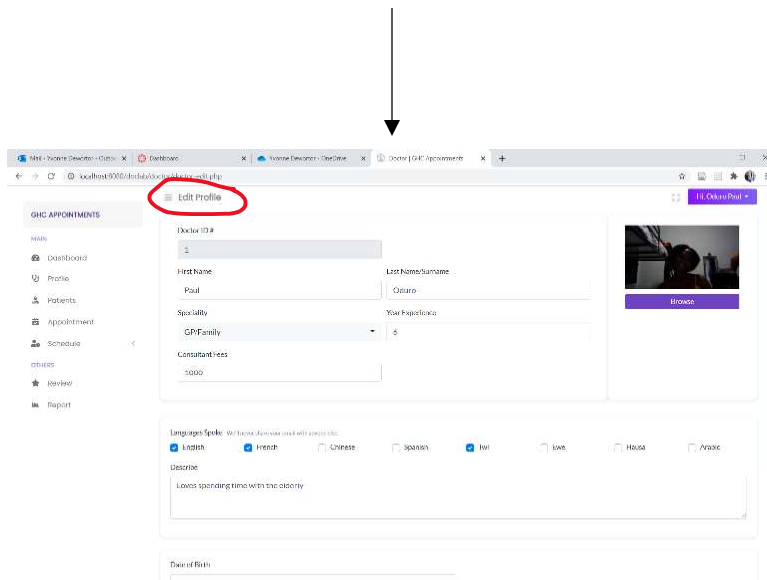
Name	ID/Patient Number	Phone	Email	Action
Devonator Thorne	GH1599	0229171592	youmedevonator@gmail.com	View
Mereah Dever	GH1001	0229171592	devonator@gmail.com	View

Showing 2 of 2 of Results

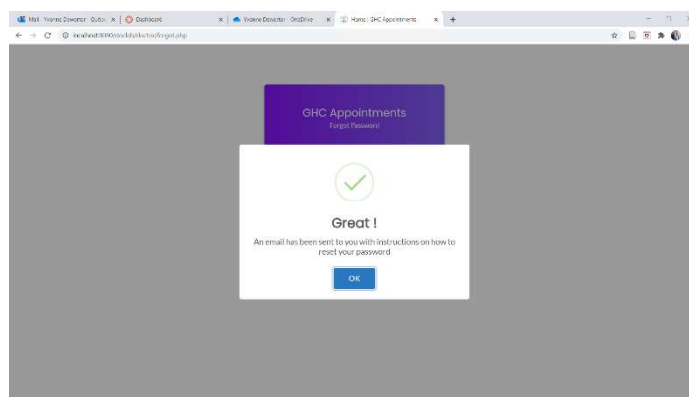
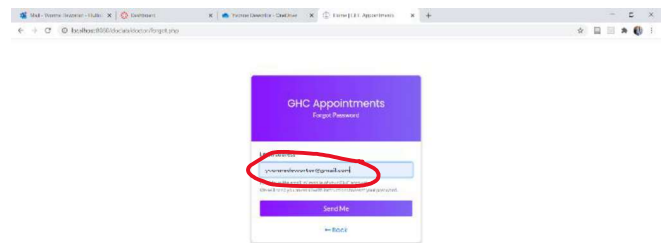
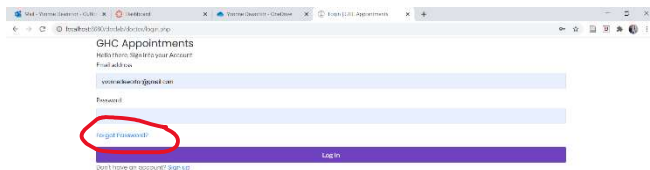


TEST
CASE
ID: 4

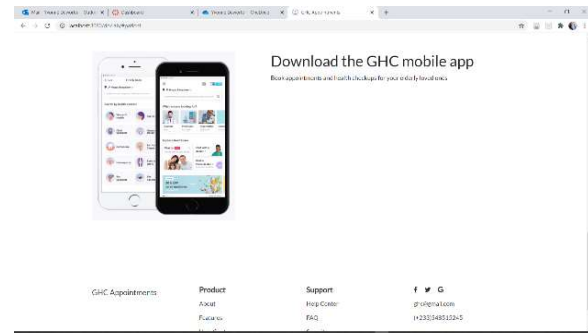
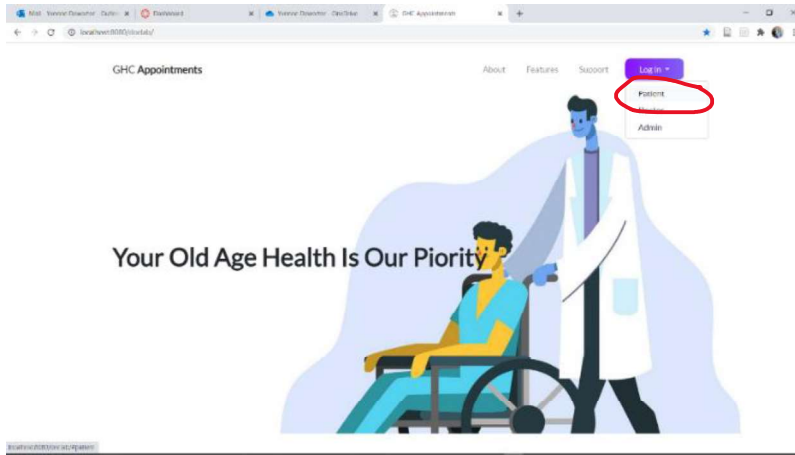




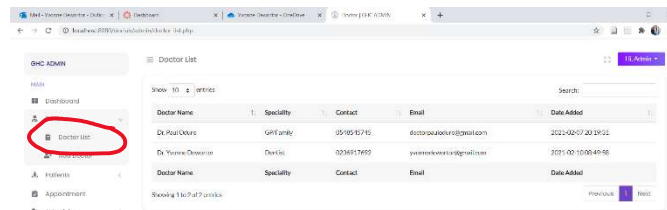
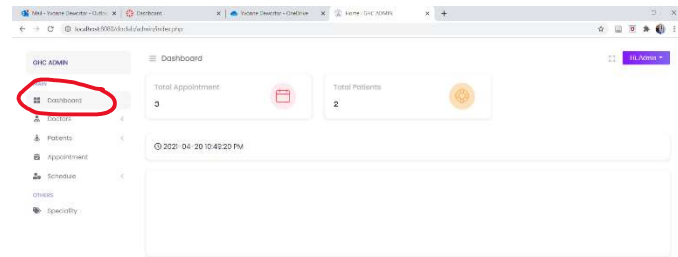
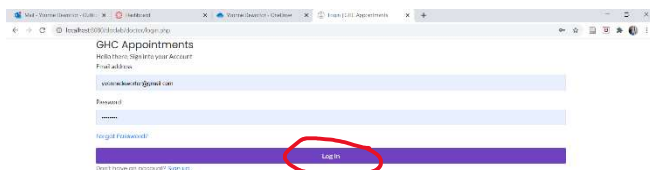
TEST
CASE
ID: 5



TEST
CASE
ID: 6



TEST
CASE
ID: 7



5.3 USER TESTING AND RESULTS FOR GHC APPLICATIONS

Both web and mobile application were made available to the client (Dr Paul Oduro) via a zoom meeting, where he was given control over the developer's screen to test the features of both applications. In general, he was quite impressed by the work done so far and had a few changes he suggested to be done to the applications. For example, he suggested the ID field in the mobile application user registration be made to accept null values to accommodate for the unique identification that would be generated by the health consult for patients. He also requested the entire system be allowed to have two administrators instead of one in the case of an unforeseen circumstance. All these suggestions have been taking into consideration and will be worked on to improve customer satisfaction.

CHAPTER 6: CONCLUSION

6.1 DEPLOYMENT TO PRODUCTION

Both web and mobile applications for this project are currently running on the developer computer's local host server via XAMMP. Time constraints made it impossible to go through the necessary stages of deploying and producing the project applications on a live server.

6.2 PROJECT LIMITATIONS

- Web application of the GHC Appointments system could not be hosted on a live server due to time constraints.
- Mobile application apk of the GHC Appointments system could not be made available for public use due to some demands of the ionic framework. The host address used in configuring the application to enable it to run off the web and on an emulator is the developer computer's IPv4 address. This restricts the application and makes it possible for anyone with the apk currently, to successfully log into the application from their mobile device which also has its own unique IP address. In order to fix this unfortunate situation, the host server on which this mobile application is deployed should be made live and public to make the application accessible to all others with the apk. This host server happens to be the developer computer's server and can therefore not be made public for the use of the application as this exposes it to threats and other vulnerabilities.

6.3 FUTURE WORK

Beyond this school project and in the near future, I seek to get both applications deployed successfully on live servers for their expected use by Gamma Health Consult. Alternative options of hosting the ionic mobile application will be analyzed to see how the application could be hosted off the developer's computer for use by others. Any best other additional features such as application bots, chat boxes or sending appointment notifications to users prior to their appointments may be taken into consideration in the near future to enhance the usability of the applications.

6.4 Summary

In general, both the mobile and web applications developed for this project have met a majority of the requirements set by Gamma Health Consult and are functioning as expected. Unfortunately, the time constraint and lack of resources now to host both applications on live servers, makes it quite impossible for interested users to have the applications running successfully on their end devices.

REFERENCES

- [1] Basic Facts about Geriatrics | Aging & Health A-Z | American Geriatrics Society | HealthInAging.org. Retrieved October 13, 2020 from <https://www.healthinaging.org/a-z-topic/geriatrics/basic-facts>
- [2] Advances in Preventive Medicine and Health Care (ISSN: 2688-996X) – Gavin Publishers. Retrieved October 13, 2020 from https://www.gavinpublishers.com/journals/journals_details/advances-in-preventive-medicine-and-health-care
- [3] Functional vs Non-functional Requirements: List & Examples. Retrieved October 19, 2020 from <https://theappsolutions.com/blog/development/functional-vs-non-functional-requirements/>
- [4] O'Reilly Media. Three-tier client-server architecture - Architectural Patterns. Retrieved January 30, 2021 from <https://learning.oreilly.com/library/view/architectural-patterns/9781787287495/df0e98f1-0190-42e2-a9b1-69f050a03a4e.xhtml>
- [5] 2020. What is Three-Tier Architecture. Retrieved January 30, 2021 from <https://www.ibm.com/cloud/learn/three-tier-architecture>
- [6] 2019. A Comparative Study of WAMP vs XAMPP: Which is the Best Suitable Local Server for Web Development? | Temok Hosting Blog. Retrieved February 20, 2021 from <https://www.temok.com/blog/wamp-vs-xampp/>
- [7] 2018. A deeply detailed but never definitive guide to mobile development architecture. freeCodeCamp.org. Retrieved February 20, 2021 from <https://www.freecodecamp.org/news/a-deeply-detailed-but-never-definitive-guide-to-mobile-development-architecture-6b01ce3b1528/>

- [8] Sumit Jaju. 2016. Ionic overall architecture and its cheat sheet. Medium. Retrieved February 20, 2021 from <https://medium.com/@sumitjaju/ionic-overall-architecture-and-its-cheat-sheet-a2794b56273a>
- [9] Title: Three-Tier Architecture Overview - AWS Serverless Multi-Tier Architectures with Amazon API Gateway and AWS Lambda. Retrieved March 5, 2021 from <https://www.google.com/imgres>
- [10] Ian Sommerville. 2011. *Software engineering* (9th ed ed.). Pearson, Boston.
- [11] William Craig ~ 6 minutes to read. A Guide to Google Font API | Webpage FX. WebFX Blog. Retrieved April 22, 2021 from <https://www.webfx.com/blog/web-design/google-font-api-guide/>
- [12] What is Bootstrap? A Short Bootstrap Tutorial on the What, Why, and How. Toptal Engineering Blog. Retrieved April 22, 2021 from <https://www.toptal.com/front-end/what-is-bootstrap-a-short-tutorial-on-the-what-why-and-how>