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A Progressive Health Information Management System for Nigerian Primary HealthCare Facilities Using AI Chat Bots

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Abstract : Recent computerized systems, while more effective, are expensive to implement and maintain, limiting their use to mostly robust private hospitals. This paper aims to design and develop an intelligent progressive web-based system for primary health facilities in Nigeria with the goal of improving the efficiency and accessibility of healthcare delivery. The study used web development technologies like HTML, CSS, JavaScript, PHP, and MySQL, and Microsoft's Azure AI service platform and adopted theoretical frameworks like the Socio-Technical Theory and the Active Network Theory, using Unified Modeling Language (UML) and Object-oriented Analysis and Design Methodology (OOADM) as the design methodology. The developed system included features such as an easy-to-use web-based hospital management system, an AI Chat Bot, and a patient-doctor messaging platform for remote medical care, and could be installed on various devices via the web without rewriting and recompiling code. The system was tested for performance, accessibility, and progressive web app features on various platforms using the lighthouse development tool and achieved an average test score of 90% for performance, and 100% for both accessibility and progressive web app features and has the capacity to reduce time in delivering service to patients, reduce cost of hospital management, improve patient management process and the working process of primary healthcare centers across Nigeria.

Keywords: Progressive, Chat Bot, Web Science, Artificial Intelligence, Use Case

I. INTRODUCTION

In Nigeria, there are three levels of healthcare delivery: Primary health care is a community-based management method for providing health care services by the local government and some private hospitals. The state government provides secondary health care. The federal government and some private organizations provide tertiary healthcare in every state in the country, which includes the Federal Medical Centers (FMCs), teaching hospitals, national orthopedic hospitals, the national eye centre, psychiatric hospitals, and the national Ear Nose and Throat (ENT) care centre. In recent years, some healthcare provision centres have begun to use computer/desktop native applications as hospital management systems to solve or reduce problems associated with manual paper-based hospital management. A typical hospital management system primarily performs patient registration, appointment scheduling, and patient admission functions [1]. In some hospitals that utilize these automated systems, adopting automated hospital management systems has enhanced the health care system (in multiple ways, including accuracy in report generation, dependability, and ease of operations). However, this raises the need for special employee training, the provision of compatible systems, and constant electricity to work on these platforms. Regarding advancements in information and communication technology, website intelligence refers to the use of the World Wide Web as a phenomenon of retrieving information from data storage intelligently and efficiently. In recent years, website intelligence has become a well-known research area that combines subjects such as artificial intelligence, databases, web science, semantic web, and information retrieval[2]. Based on its knowledge base and level of intelligence, an intelligent website application can learn from experience and act on user input. A progressive website application (PWA) is software built with standard website technologies such as HTML, CSS, and JavaScript [3]. It works on platforms that support standards-compliant browsers, including desktop and mobile devices. As a result, the introduction of artificial intelligence through the use of Chat Bot and the enhancement of this automated hospital management system from a desktop application to an intelligent, progressive website application will improve the working procedures in healthcare facilities, particularly primary healthcare centres, which, as previously mentioned, are a whole-of society approach to effectively organize and strengthen national health systems to bring services for health and well being closer to communities.

A progressive website application allows the hospital management system to operate over the internet and makes its platform independent. It works on desktop and mobile devices as native apps and on the web using a browser. They are responsive, more user-friendly, and require little or no employee training to use. Using AI Chat Bots and an online medium to chat with doctors, patients can get first aid in an emergency and health tips for minor health problems. Only patients with severe

problems must be at the hospital at a specific appointment time. Since anybody can develop potentially misleading and damaging health resources on the internet, as well as the security issues surrounding the use of patient health information, the internet is replete with erroneous health resources. However, a hospital management system built as an intelligent, progressive web app can be opened on a patient's device by clicking an icon. This improved system lets the patient ask questions and get answers from certified experts in their local hospital, which is more reliable. Additionally, this tool facilitates communication between patients and their doctors [4].

In most Nigerian hospitals, patients must spend considerable time standing in line to pay the registration fee and waiting to see a doctor. They may become distressed due to the crowded environment or the slow operating process. This Intelligent Progressive Website Application has arrived to remedy the situation.

2. RELATED LITERATURE

[5] designed a computerized hospital management system in their study titled "Hospital Management System" to improve the quality of information management and the efficiency of hospital staff. The study successfully produced a module that would administer patient registration and admission details, a module that would manage admission bills and pharmaceutical payments, and a module that would monitor the hospital pharmacy's medicine inventory. Furthermore, the Waterfall Methodology model was employed in the study, which followed a linear structure beginning with preliminary investigation, requirement analysis, design phase, implementation, and maintenance. Each phase guided the researchers through the study's development and assisted them in organizing the workflow of each activity. Finally, the researchers discovered that the approach might improve hospital staff's working progress and productivity. It may also generate hospital reports to assist users in providing an overview of hospital transactions within a given time frame. It also enabled the receptionist module to seek the questioning patient's information. The system can potentially reduce workloads in the hospital, resulting in better management and working performance. Overall, the investigation resulted in better proofing of hospital transactions. It was suggested that there was a need to improve the system's front-end design, add modules for the laboratory and pharmacy, improve the invoicing module, and add functionality to cater to more discounts.

[6] proposed the Progressive Web Application mobile development approach as an m-Health solution in the healthcare market. They presented a mobile health application for dietary evaluation, compared the PWA approach to other traditional approaches using a SWOT Analysis, PWA success stories, the INTCare system (an intelligent decision support system available at the Centro Hospitalar do Porto), and the opportunity to use Progressive Web App in the INTCare's Electronic Nursing Record (ENR), which is a web interface that represents clinical patient information, integrated into a new proposed INTCare.

[7] created a chat bot for the healthcare system. Before consulting a doctor, artificial intelligence identifies ailments and provides basic information about the disease. A medical Chat bot was intended to help cut healthcare expenses and enhance access to medical knowledge. The Chat bot could identify the sentence keywords, make a query decision, and respond to the question by storing data in the database. The n-gram, TFIDF, and cosine similarity are used to rank and calculate sentence similarity. The given input sentence will calculate a score for each sentence, and additional similar sentences will be found for the query. The third party expert program dealt with any question the bot did not understand or was not in the database. Their study "Hospital Management System Using Web Technology" [8] stated that today's web-based technology offers many online services in almost every field. According to them, online connectivity is now a requirement for all well organized and well-managed establishments, one of which is healthcare, where information digitization should occur quickly and efficiently. Their research paved the way for developing a web-based platform that eliminates the need for paper prescriptions in hospitals. It proposes E Medical Management, which will improve the efficiency of patient management and doctor scheduling and provide universal access to patient data anywhere in the hospital.

[1] were primarily concerned with building an E healthcare management system for government and private institutes to schedule doctor appointments online. HTML, PHP, JavaScript, and CSS are the programming development technologies used. Patients could log in to schedule an appointment with the doctor, and all appointment details were processed and sent directly to a centralized database system. The doctor will then confirm the appointment via their website. Finally, after the confirmation, patients receive an alert from the doctor.

Following a careful review of the previous publications, we discovered that their efforts had centred on essential techniques required to meet the objectives of our study on developing an intelligent, progressive web-based system for Nigerian primary health facilities. Many writers have mentioned several ways of automating operations in the Nigerian healthcare system, including [5], [1]; PHP, MySQL, and JSON [9], the native android health management system of [10], the use of AI chatbots created with AIML and PHP [7], and Progressive website application technology proposed by [6].

3. Methodology

This project adopted object-oriented analysis and design methodology (OOADM) using Unified Modeling Language (UML), a set of standards for system analysis and application design. It analyses and designs information systems using a formal, methodical approach. Object-oriented design (OOD) refines the analytical models to generate implementation specifications. The choice of object-oriented analysis and design methodology (OOADM) is driven by the type of system to be developed, a flexible and usable application.

3.1 Interview

This is a very common method of gathering information. The targeted end users were the medical staffs in various units of the medical facility as well as their patients. As a result, this is the primary method for gathering information. The client was interviewed in order to identify and finalize the requirements. Interviews with medical officers were beneficial in understanding the processes within the unit as well as gaining background knowledge.

Date of the interview :4 / 02 / 2024 – 11 / 02 / 2024

Duration :8 days

Interviewee :1 medical staff from each unit in the medical facility, 1 student from each level in school, and an academic staff of the school.

Purpose : Learn and understand the structure and workflow of the current system.

4.DISCUSSION AND FINDINGS

The design and implementation of an intelligent PWA for hospital patient management in primary healthcare centers required a comprehensive and detailed approach, particularly given the inclusion of an intelligent agent (Chatbot) as a key feature of the system. To guide the design process, actor-network theory and socio-technical theory were used to understand the relationships and interactions between different actors and systems within the healthcare environment. Unified Modeling Language (UML) diagrams, including use case, activity, were used to model the system's architecture and functionality in a way that took into account the needs and perspectives of all relevant actors. This included patients, healthcare providers, and administrators, as well as the technical systems and processes that support patient management.

The key features and functions of the PWA are outlined, including its ability to schedule and manage patient medical visitation, track patient records and vital signs, and provide personalized healthcare recommendations through the use of the Chat bot. The technologies and tools used to build the PWA are discussed, as well as the testing and debugging processes that were followed to ensure its reliability and performance.

Overall, the use of actor-network theory and socio-technical theory helped to create a PWA that is both effective and well-suited to the needs of primary healthcare centers, and it represents a significant step forward in the use of technology to improve patient management, particularly through the use of an intelligent agent.

4.1 Use Case Diagram of the New System: The use case diagram shown Figure 1 and this enables the visualization of the different types of roles in the new system and how those roles interact with the system. These use case diagrams show some of the key functionalities in the new system.

Actor Description

Medical Staff : The medical staff consist of the Admins, Receptionists, Nurses, Doctors, Pharmacists, Laboratory attendants, and wardens at the admission unit with the right to use the system and has certain privileges or functions assigned to him by the admin.

Use case Description

Login: The medical staff would login to their accounts by entering their registration ID and password.

Update Profile: This involves entering the staffs' necessary details and updating their availability status and account pictures.

Fetch Patient : Timeline: This involves viewing patient logs as they visit the various units in the medical facility. The Admin and Receptionists can view logs from all units for auditing purposes and for submission to the health insurance company.

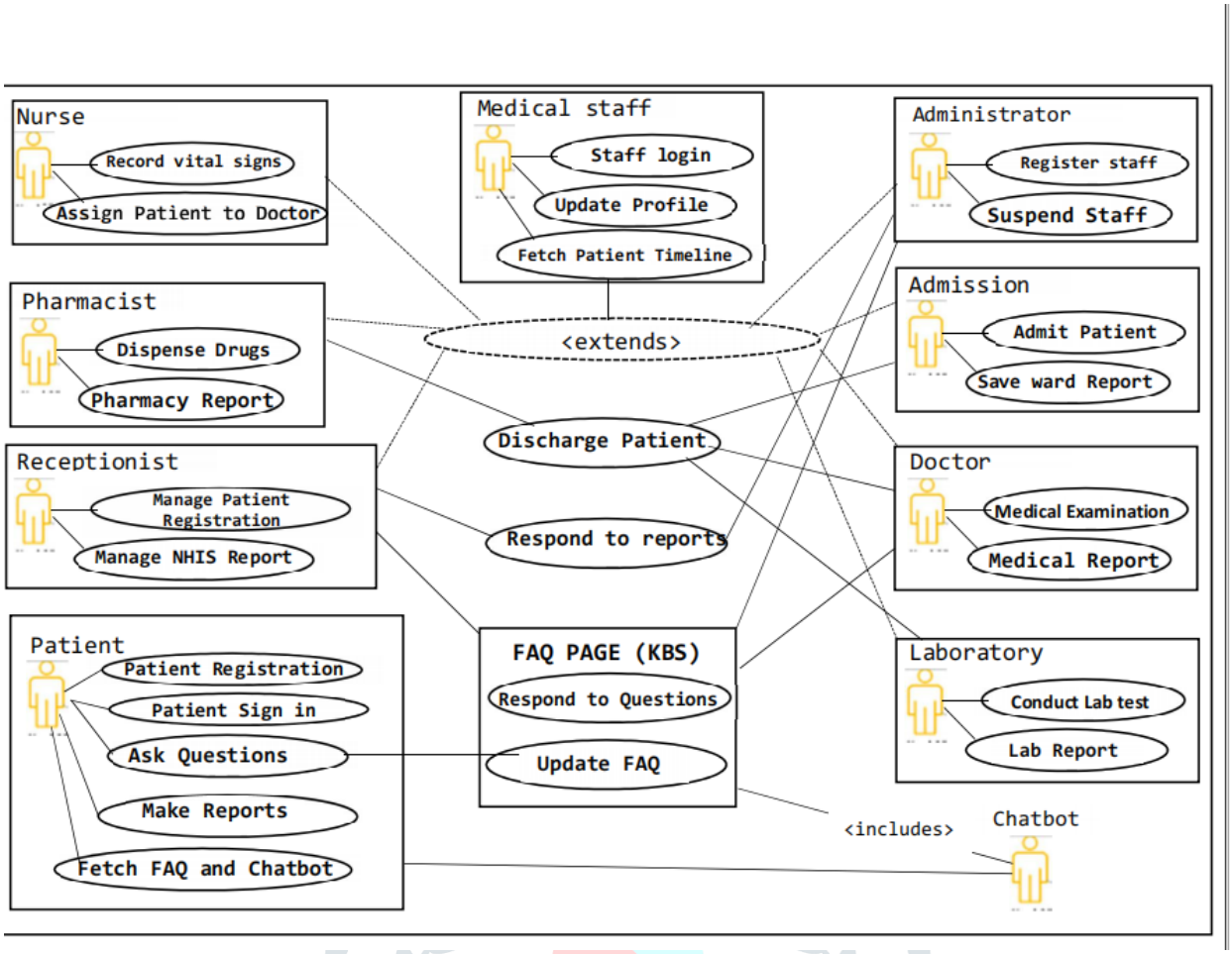

Figure 4.1: High level use case diagram for the new system.

Medical Subsystem Actors Description. **Actor Description**

Administrator: The medical Admin is the system administrator who is super user of the system and is responsible for assigning other medical staffs to their respective modules of the system.

Receptionist: The medical receptionist deals mainly with patient registration, and keeping records sent to the health insurance amongst other roles.

Fetch Patient Timeline

High level use case diagram for the new system.

Medical Subsystem Actors Description. Nurse: Medical care givers dealing mainly with capturing patient vital signs and assigning them to doctors.

Doctor: Medical staff who is qualified to diagnose and treat people who are ill.

They can have different specializations.

Admission: These are the medical staffs attending to patients in the admission ward or unit. They record patients' health improvement until the patient is discharged.

Laboratory: Describes the scientists or attendants at the medical laboratory in the medical clinic. They carryout laboratory tests on patients assigned to them as prescribed by the doctor.

Pharmacist: The pharmacists are medical staffs in the medical pharmacy. They dispense drugs to patients as prescribed by the doctor.

Chat bot: The Chat bot is an intelligent agent that gives medical advice to patients based on questions asked and answers already provided in the knowledge base system.

Use case Description

Register Staff: The admin creates staff accounts for various medical staffs by filling in required details and after which assign roles to the staff.

Suspend Staff: This involves resetting staff status when the staff ceases to be a staff of the medical facility. Details of the staff are still retained in case of future needs.

Manage Patient

Registration: The receptionist manages the patient registration process, from the time the registration commences, through to when the medical examination is completed by the doctors and the account is activated. The receptionist can also reject patient's registration is wrong details are provided by the patient such as fake medical fee receipts.

Manage NHIS

Reports: Reports of patients' visitations are submitted to the health insurance company by the receptionist unit.

Record Vital Signs: This involves capturing patient's vital signs such as the temperature, height and weight and so on, and record on the system by the nurse.

Medical Subsystem Use cases Description. Assign Patient to Doctor:

The nurse assigns patients to the doctors depending on the doctor's specialization and the patient's needs. This involves sending the patient's details to the doctors including the patient's vital signs

Medical Examination: Patients would have to go through series of medical examination carried out by the medical doctors before the patients are fully registered to the system. Doctors are expected to carry out these examinations and update the patient's details.

Medical Report: Doctors are supposed to write reposts for each patient they attend to. The report includes their observations and prescriptions before assigning them to the necessary units.

Admit Patient: Patients are admitted by the admission unit when prescribed by the doctors.

Save Ward Reports: Attendants at the admission wards write timely reports on health status of admitted patients, and services provided to the patients.

Conduct Lab Tests: The Laboratory scientists carry out laboratory tests on the patients as prescribed by the doctor. This involves collecting samples and entering the patient's lab details on the database.

Lab Report: This involves entering the status of medical laboratory tests carried out on patients, and giving reports of the outcome.

Dispense Drugs: The pharmacist unit receives drug prescriptions for each patient and dispense the drugs.

Pharmacy Reports: The pharmacy unit generates reports for each patient that is attended to by the unit. This contains the drugs collected by the patient and the pharmacist's remark.

Discharge Patient: This is the end of the patient management lifecycle. Patients are discharged after being attended to by the admission, laboratory, and pharmacy as prescribed by the doctor, or directly by the doctor if there's no need for assigning the patient to other units.

Respond to Reports: Reports of emergency or complaints are attended to by the Admin and Receptionist units. Respond to Questions: Questions about health are responded to by the doctors, while that specific to the medical facility can be responded to by the receptionists and the admin units. The admin unit can also edit patient's questions when there are mistakes.

Update FAQ: The frequently asked questions are used as knowledge base to inform the chat bot which can be of help when there are no doctors available to answer urgent questions. The FAQ page can be updated by the doctors, receptionist or admin.

4.2 Activity Diagram

The activity diagrams of the new system drawn below show the workflows of stepwise activities and actions, it also describes the flow of control in the new system. The activity diagrams show both the computational and organizational processes of the system for the registration, medical visitation and remote service provision processes respectively.

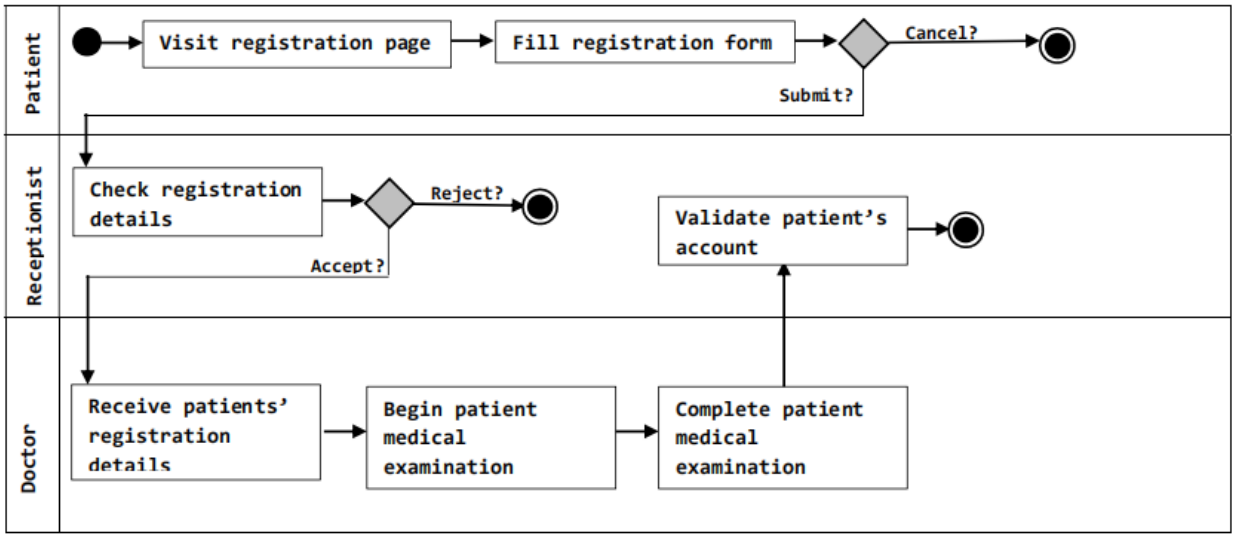

Figure 4.2: Patient registration activity diagram for the new system.

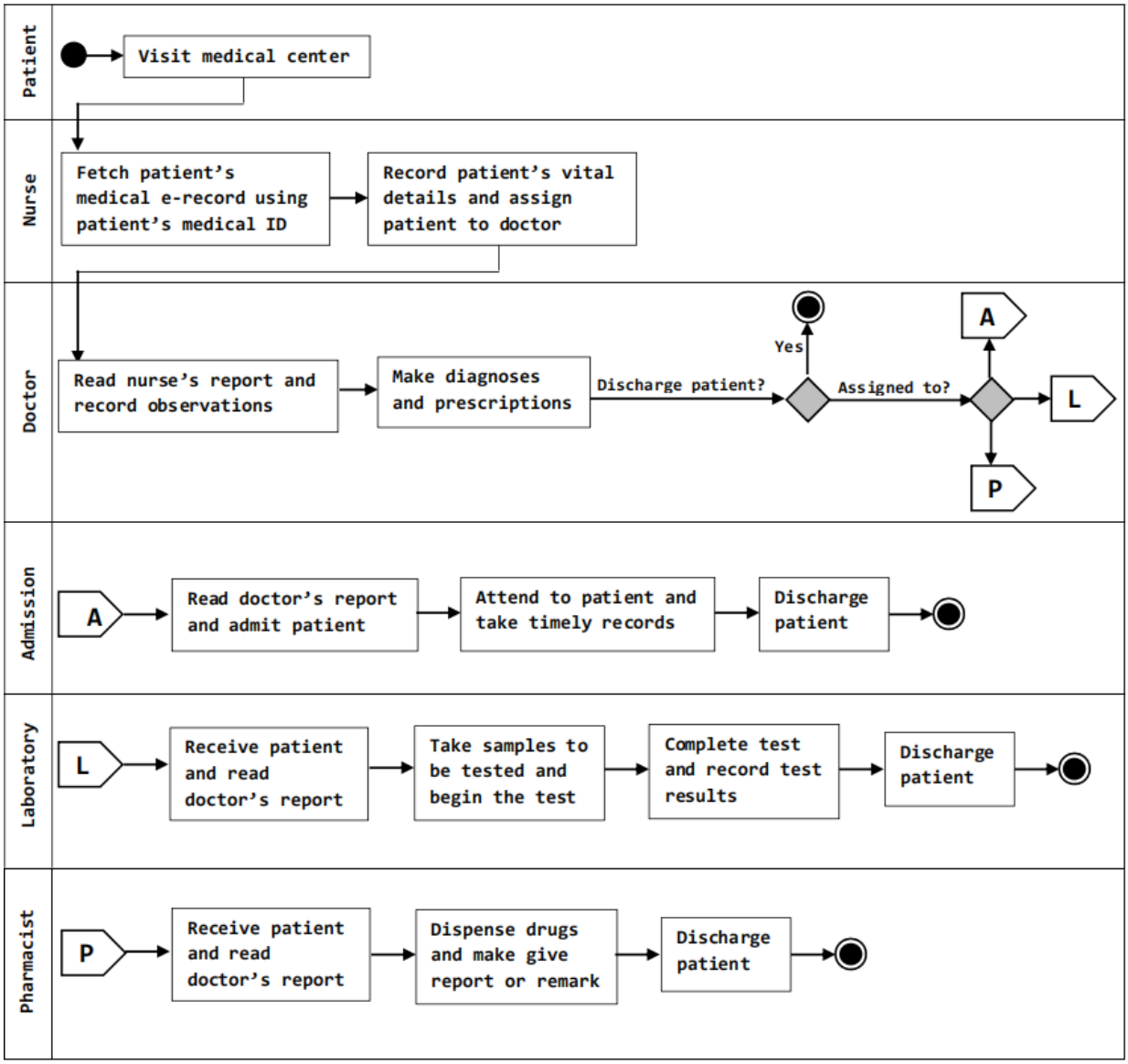

Figure 4.3: Patient medical visitation activity diagram for the new system.

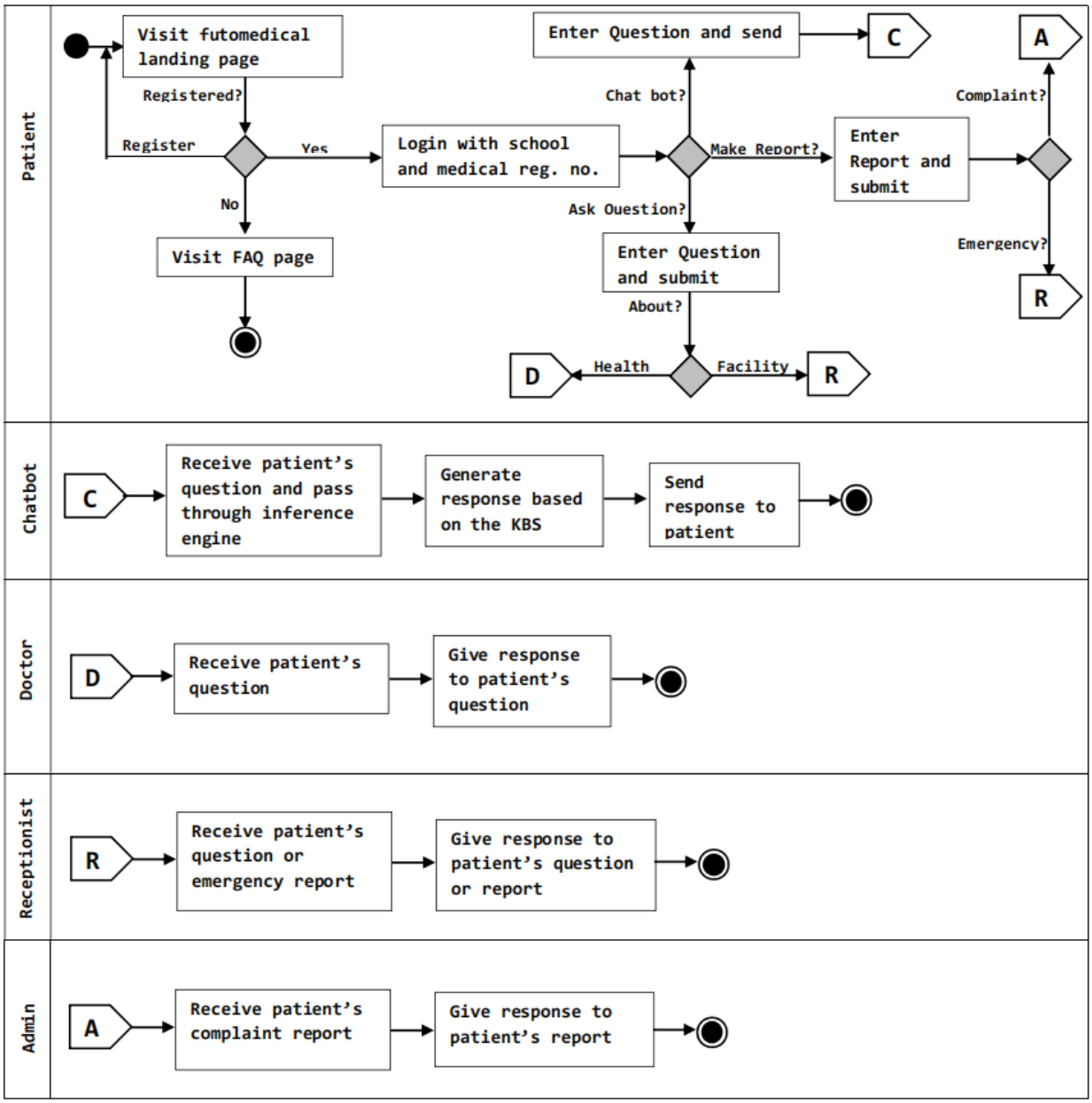

Figure 4.4: Patient's remote service activity diagram for the new system.

4. RESULTS / DEPLOYMENT DIAGRAM OF THE NEW SYSTEM

In this deployment diagram, the client represents the user's device or web browser, which is used to access the hospital management system. The load balancer is a server that distributes incoming traffic across multiple servers, to improve performance and reliability. The application server is the server that hosts the hospital management system software, and the database is a server that stores the data for the proposed system. The client communicates with the load balancer, which forwards the request to the appropriate application server. The application server processes the request and retrieves data from the database as needed, and then sends a response back to the client via the load balancer. This deployment diagram shows a simple, three-tier architecture, with the client.

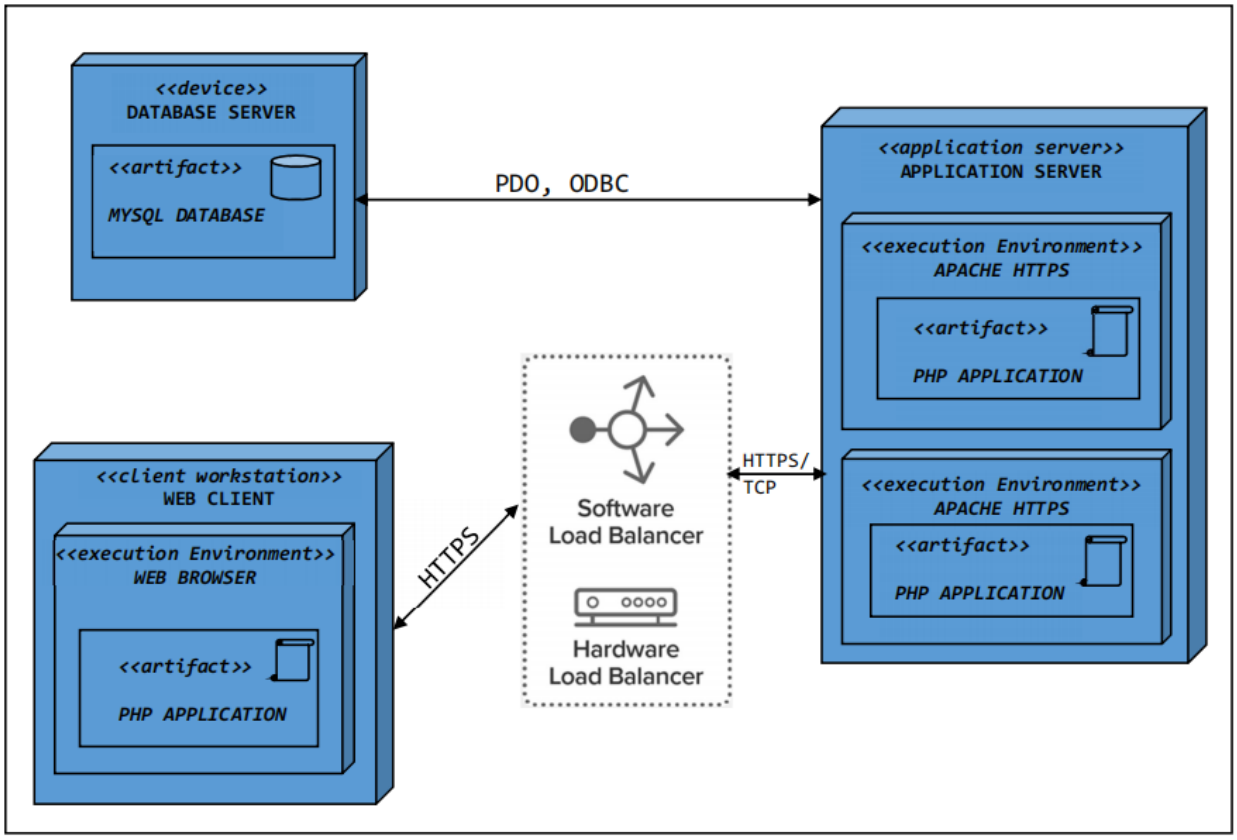

Figure 5.1: Deployment diagram showing a simple, three-tier architecture, with the client.

5.1 Development Tools

5.1.1 Front-End Development Tools

1. HTML (HyperText Markup Language) and CSS (Cascading Style Sheets) are two of the core front-end technologies for building this web app. HTML is used to structure content on the web, while CSS is used to style that content.
2. JavaScript was used in conjunction with HTML and CSS to create interactive and dynamic user experiences on the web app, and also used in scripting the service worker. By using JavaScript, and these key feature, it was possible to build a PWA that provides a native app-like experience for users on the web.
3. Service workers: Service workers are JavaScript files that run in the background and allow PWAs to function offline or with a poor network connection.
4. Web App Manifest: The Web App Manifest is a JSON file that specifies the name, icons, and other metadata for a PWA.

5.1.2 Back-End Development Tools

1. PHP is a server-side programming language used for building the web application. It is especially useful for creating dynamic websites and can be embedded in HTML. PHP has variables, functions, control structures, and can process forms and access databases.
2. MySQL is a popular open-source relational database management system that is used to store and retrieve data for a wide range of applications. It is known for its reliability, ease of use, and performance, and supports a wide range of programming languages, operating systems, and storage engines. MySQL supports transactions and triggers, and is particularly well-suited for use with web-based systems.

5.1.3 Other Development Tools

1. Apache is an open-source web server that was used to host web applications. It is fast, reliable, and secure, and is able to handle a large number of requests simultaneously. Apache is highly configurable and can be extended through the use of modules, which allow users to add additional functionality to the server.
2. phpMyAdmin is a free and open-source web-based tool that was used to manage the MySQL database. It provides a graphical user interface (GUI) that allows you to create and modify databases, tables, and other database objects, as well as execute SQL statements and manage users and permissions. phpMyAdmin is written in PHP and runs on a web server (such as Apache), making it accessible from any device with a web velopment to make the web applications more interactive and engaging, and is supported by a large and active community of developers. Together, Apache and phpMyAdmin are often used to set up and manage web-based applications that use a MySQL database as a backend.
3. jQuery is a fast, small, and feature-rich JavaScript library that makes it easy to manipulate the DOM, handle events, and create animations.
4. GitHub is a web-based platform that provides version control and collaboration tools for software development. It allows developers to store and manage their code repositories, collaborate on projects, and track changes to their codebase using the Git version control system.
5. Visual Studio Code (VS Code) is a popular, free, and open-source code editor developed by Microsoft. It supports debugging, version control, and integrated terminal and can be customized with a wide range of extensions to add additional functionality.

5.2 Chat Bot Testing

The chatbot was tested to ensure that it was able to understand and respond to user input accurately. A variety of different inputs were tested, including natural language queries and specific commands. The results of these tests showed that the chatbot was able to understand and respond to user input with a high degree of accuracy.

5.2.1 Lighthouse Testing

Lighthouse testing tool on the Chrome and Edge DevTools was used to evaluate the performance, accessibility, and progressive web app features of the new system on both mobile and desktop platforms. The Lighthouse testing tool was run multiple times to ensure the reliability of the results.

1. Performance testing: The performance testing results of these tests showed that the PWA had a fast loading speed and was able to handle a high volume of users simultaneously. The PWA scored well in the Lighthouse performance metrics, with an average score of 89 out of 100 on mobile devices and 90 out of 100 on desktop devices.

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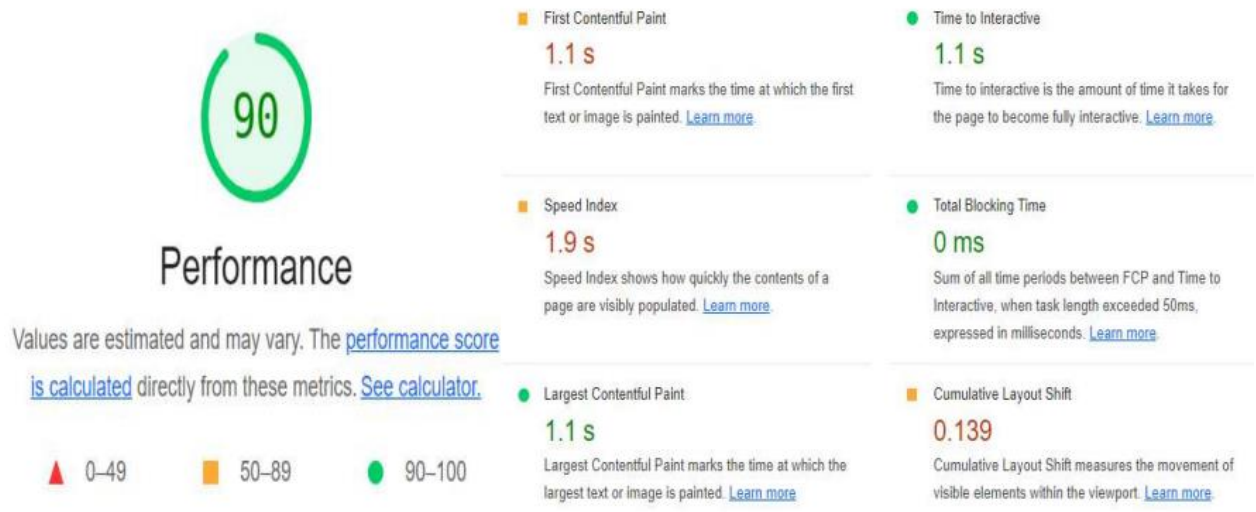

Figure 6:Lighthouse Performance testing score for desktop devices.

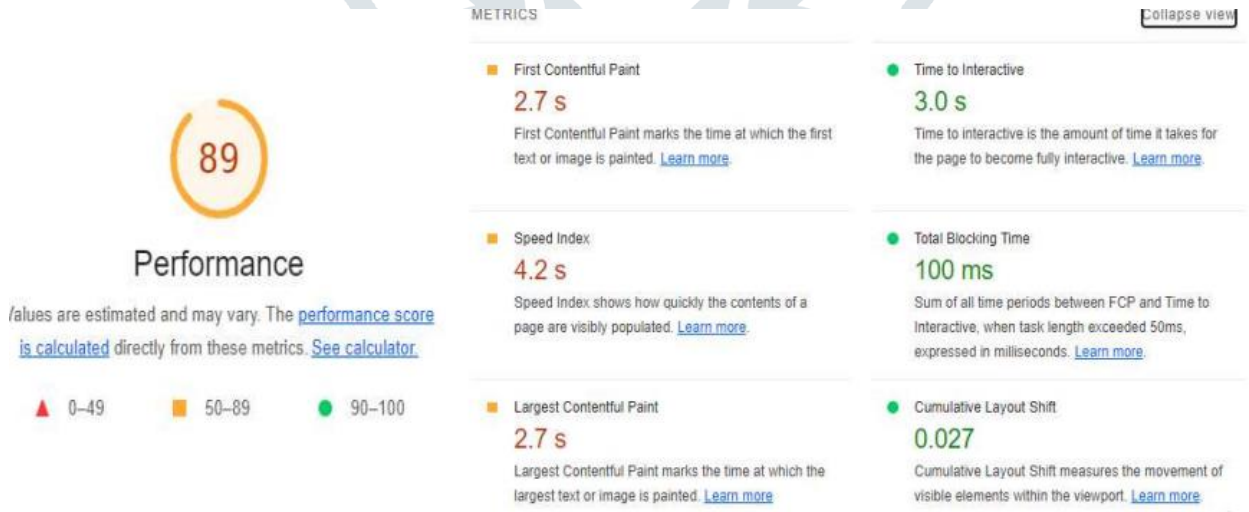

Figure 5.2: Lighthouse Performance testing score for mobile devices.

2. Accessibility testing: The Accessibility of the system was tested compliance with web accessibility standards, including the WCAG 2. On both the mobile and desktop platforms, the website scored an average of 100 out of 100 for accessibility, with good color contrast,

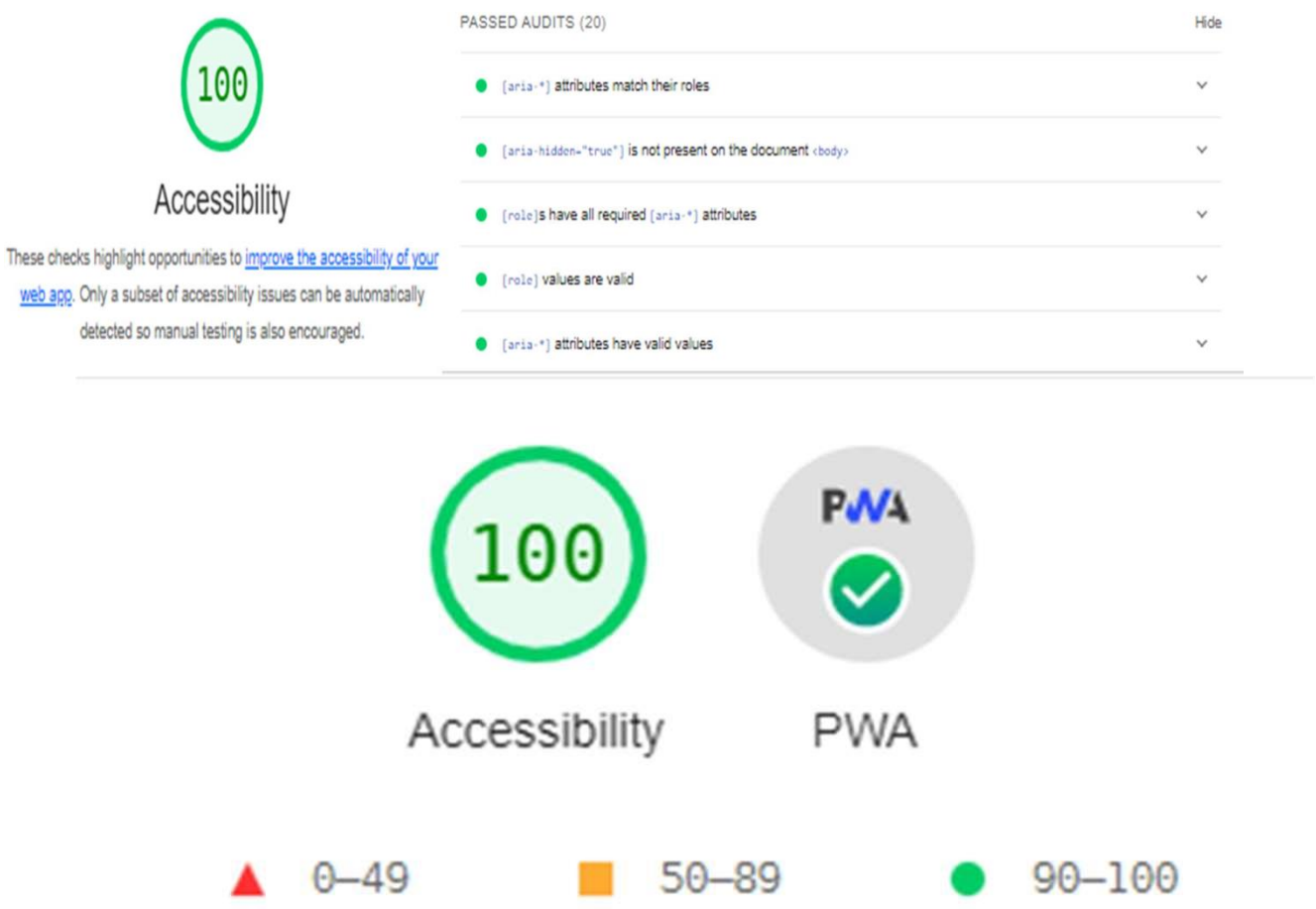

Figure5.3: Lighthouse Accessibility testing score for mobile devices.

6.CONCLUSION, RECOMMENDATIONS AND SUGGESTION FOR FURTHER STUDY

In this study, feasibility and potential benefits of using an intelligent progressive web-based application for patient management in primary healthcare centers were demonstrated. The PWA provides a convenient and efficient platform for managing patient registration, medical visitation and records, and the inclusion of an intelligent chatbot allows for personalized healthcare recommendations and improved patient-provider communication.

6.1 Recommendations /Areas of Application of Work

This study can be applied in not just the primary healthcare centers, but also in various hospitals, healthcare centres, and any other healthcare parastatals.

6.2 Suggestions for Further Work

Based on this work, the following actions are recommended for further research and development on the use of intelligent PWA systems for patient management in primary healthcare centers:

1. Consider the integration of various management systems for various hospital needs and meet special policies of the hospital.
2. Explore the potential of the chatbot to support a wider range of healthcare-related tasks, such as medication reminders or symptom tracking.
3. Study the long-term impact of the PWA on patient outcomes and satisfaction, including any potential cost savings or improvements in healthcare quality.
4. Investigate the use of the PWA in different primary healthcare settings, such as rural or underserved areas, to understand how it might be adapted to meet the needs of different populations.
5. Consider the integration of additional features or functions into the PWA, such as support for telemedicine.

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