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Design and Implementation of a Remote Patients' Data Access System

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ABSTRACT
Remote Wireless Patient's Data Access System is a mobile medical data access system, specifically designed for recording and accessing patients' vital information and giving necessary feedback remotely and digitally. However, in most developing countries, paper based system is still in use, which do not allow for global and remote access for both medical personnel and hospital patients. In this research, a model of the secure remote patients' data access system was designed and implemented using XAMPP (an abbreviation for cross-platform, Apache, MySQL, PHP and Perl) which allows offline building and hosting of the site, on a local web server on the computer. MySQL was used to create the database, Hypertext Markup Language (HTML), and Hypertext Preprocessor (PHP), CSS was used for the design of the interface, styling and sending of queries. The performance of the Remote Wireless Patient's Data Access System yielded performance, onload time and total blocking time values of 93%, 556ms and 0ms respectively.

Key words: Data Access**,** Electronic Medical Record, Health, Patient, Remote.

1. INTRODUCTION

In the last two decades, information and communication technologies (ICT) have been advancing at a fast pace and serving as an enabler of various service deliveries including medical services (Amusan, Emuoyibofarhe and Arulogun, 2015). Most of these medical services and systems have moved from the conventional paper form to digital forms. In turn, digital transmission and exchange of medical information has become possible and has been facilitated by rapid advancements in digital telecommunications networks.

A remote patient data is a digital version of a patient's paper chart. Remote patients' data are real-time, patient-centered records that make information available instantly to authorized users. These data are a vital part of health IT and can contain a patient's medical history, diagnoses, medications, treatment plans, immunization dates, allergies, radiology images, and laboratory and test results. One of the key features of a remote patient data is that health information can be created and managed by authorized providers in a digital format capable of being shared with other providers across more than one health care provider and organization such as laboratories, specialists, medical imaging facilities, pharmacies, emergency facilities, and school and workplace clinics – so they contain information from all clinicians involved in a patient's care *(*Healthit.gov 2019*).*

Remote patients' data and the ability to exchange health information electronically can help provide higher quality and safer care for patients while creating tangible enhancements for the hospital. It helps providers better manage care for patients and provide better health care by providing accurate, up-to-date, and complete information about patients at the point of care, enabling quick access to patient records for more coordinated, efficient care**,** securely sharing electronic information with patients and other clinicians, helping medical personnel more effectively diagnose patients, reduce medical errors, and provide safer care, improving patient and medical personnel interaction and communication, as well as health care convenience.

Therefore this research sought to design and implement a remote patient's system as a web application that provides timely and secure access to patients' data for the ultimate purpose of improving the quality of life. With the use of the internet, authorized medical personnel can have access to patients' information globally through any device connected to the Internet.

2. RELATED WORKS

Accessing patient's data remotely have been in existence for many years (Reid, 2010; Stead, 2009) from as early as the year 1958 but it has not been fully explored (Grams, 2009; Stead, 2009). Institute of Medicine endorsed the execution of the online medical record usage according to the U.S Department of Health which had strategized on improving the services in the healthcare sector via the use of IT which is based on healthcare only (Layman, 2008; Simon et al., 2009). As a result, reduction in medical errors, operations in the Remote patient data access system have been related with enhanced care, diminished expenses, guaranteeing of social insurance staff approach – an institutionalized arrangement of data and expanded productivity as to staff workload assignments (Lau et al., 2012). Studies led in the U.S demonstrated that the social insurance framework is as of now confronting an assortment of difficulties, including the need to convey amazing patient care while limiting expenses (Dixon 2007).

The Remote patient data access systems offer a number of benefits in a medical facility such as assisting in data recording, expediting samples from patients so that they can be analyzed and the results discussed with the patients during visits (Hsiao et al., 2009). The ability of the system to enhance analysis, record and store information can eliminate the unnecessary visits to the hospitals and also detect diseases earlier. This capability has proven to be beneficial to improving patient services (Anderson & Bowers, 2008). An investigation of the usage reports showed an expansion in human services use of Remote patient data access system in recent years. (Hing et al., 2014) announced that the national wellbeing insights showed approximately 34% use was by office-based doctors. The statistic demonstrated an expansion of over 90% compared to the 2001 statistics. The usage expanded from approximately 33% to 77% on office-based doctors in the year 2013. Bates (2008) reported that electronic wellbeing record change from paper documents expanded in recent years.

However, just like any other information system, for the Remote patient data access system to work more efficiently, users' involvement is necessary in every step of implementation where possible. Discussions will help the users understand its core basics and design for efficient implementation. In developing countries, the Remote patient data access system has greatly helped in providing accurate results and cost saving (Blaya et al., 2010). Besides, the success of the system lies in its proper implementation. For the implementation of the system to be beneficial, organizations need to have adequate resources for example, infrastructure, computer literate staff, computers and consistent record keeping.

Cybercriminals are attracted to health-related data which makes its security a necessary requirement to be satisfied (Srivastava, Dwivedi and Singh, 2018).

This research further extends existing remote patients' data access system by not only developing a system that provides access to patients' data but has the capability to secure same using the Role-based Access Control Mechanism.

3. MATERIALS AND METHOD

The approach used in the development of the system (see Figure 1) is the waterfall model, which includes requirement elicitation, requirement specification, system framework and design, implementation/ development and system testing/ evaluation. The interview was conducted with some staff, medical personnel and some potential staff to find out what difficulties they encountered with the current system and share their feelings and experiences about the current system. Through this, raw data of the existing system were gathered and analysed. The functional requirements of the system include:

i. The system has 3 main modules for the users; the admin module, doctors' module and patients' module.
ii. The system should employ role-based access control and have different user access level or right for admin, doctors and patients, i.e. these users are granted access based on their roles.
iii. The system should provide a registration interface for new patients and doctors to create a new account in the system and capture their data.
iv. The system should be secured and should only be accessed by providing valid credentials, for admin and patients; the required credentials are username and password while license number and password are the requirement for doctors.
v. Password should be at least 6 characters. .
vi. The system should have "forgot password" functionality in all authentication pages that help users (doctors and patient) recover theirpassword after providing necessary information.
vii. The system should allow for change of password for security purposes.
viii. The Admin should be able to perform the CRUD (Create, Read, Update and Delete) operation on other users' data.
ix. The system should be able to search for patients by name or ID.

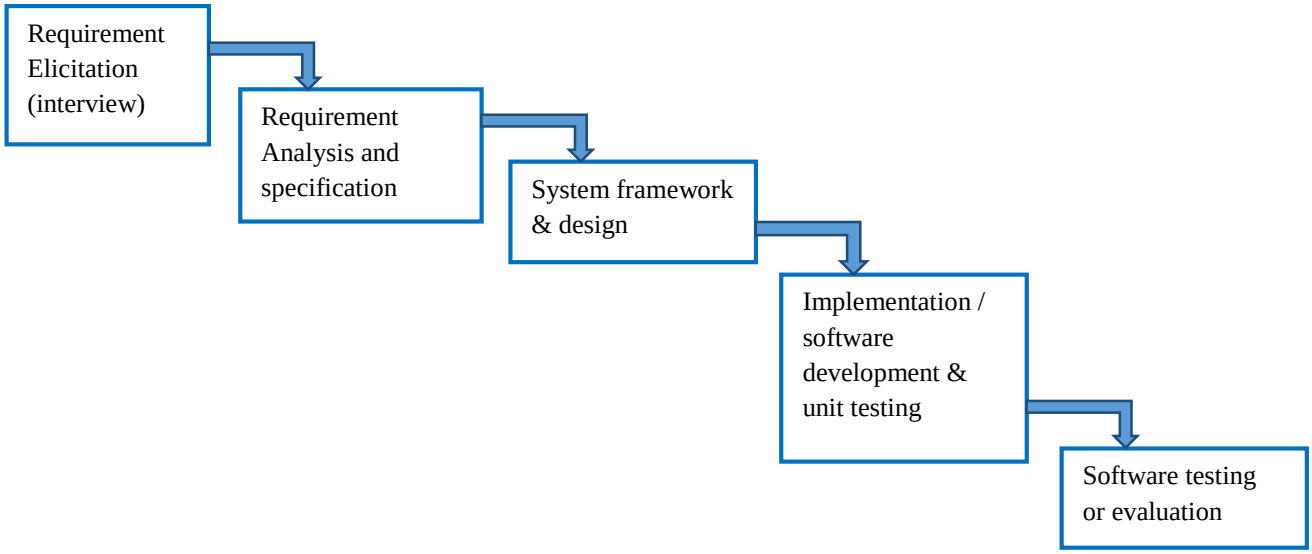

Fig 1: Software Development Approach

3.1 System Framework and Design

The systems design process allocates the requirements to either hardware or software systems by establishing an overall system architecture. Software design involves identifying and describing the fundamental software system abstractions and their relationships. Figure 2 depicts the system architectural framework.

At the core of the proposed system is the Role Based Access Control mechanism that gives access to each kind of user based on their individual role. This implies that each user is given the right to perform specific operations on the system based on their role. For instance a patient can only perform read (medical history), create (registration) and delete (cancelling appointment) operations but cannot update. Apart from this, the system is secured are can only be accessed by authorized users only i.e. (people with valid credentials recognized by the system).

Humans are known to be dynamic beings i.e. they tend to move from one place to another, this system makes provision for this so the users are not limited in its use. For instance, the admin do not always have to be on his desktop computer before accessing the system to perform its role.

The system flowchart represented by Figure 3 graphically illustrates the major processes, inputs and outputs of a system and is primarily the physical modeling of the system.

User authentication plays a significant role in a patient data access system to protect patient privacy and security. A single factor authentication may be compromised by an attack(er), hence, it is not a suitable mechanism for a system handling sensitive information such as this. As such, the Health Insurance Portability and Accountability Act (HIPAA) and ISO 22600-1:2014 have suggested healthcare organizations implement the more robust Multi-Factor Authentication (MFA). Therefore, this study employs the two factor authentication which requires something the user knows (their password) and something they have (their personal mobile phone).

3.2 Development Tools

1. **Visual Studio Code:** Visual Studio Code is a freeware source-code editor made by Microsoft for Windows, Linux and macOS. Features include support for debugging, syntax highlighting, intelligent code completion, snippets, code refactoring, and embedded Git. Version 1.55.0 was used in the edition of program code of this system.

2. **XAMPP:** is an abbreviation for cross-platform, Apache, MySQL, PHP and Perl. It allows one to build software offline, on a local web server on a computer. This simple and lightweight solution works on Windows, Linux, and Mac – hence the "cross-platform" part. XAMPP was used to offer MySQL (Database Server) & Apache (Webserver) in one setup and helps to manage them with the XAMPP starter.

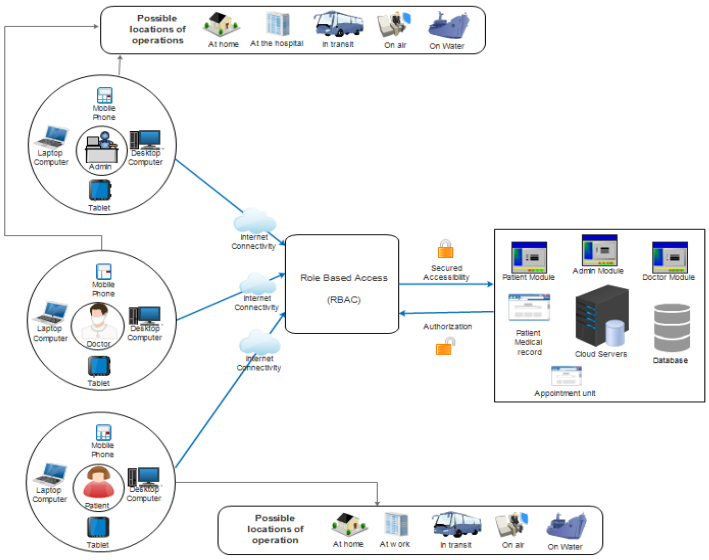

Fig 2: System Architectural Framework

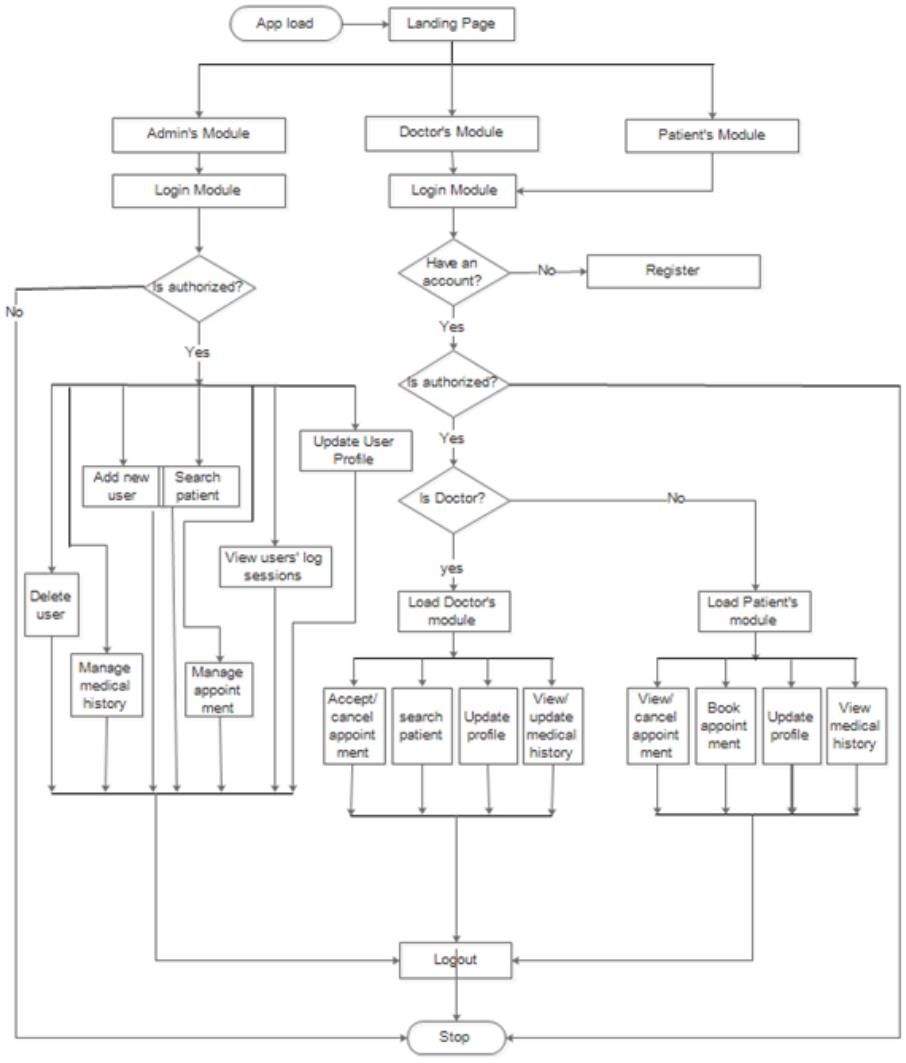

Fig 3: System Flowchart

4. RESULTS AND DISCUSSION

On system load, the landing page (see Figure 4), presents the users with the landing page showing the available role based modules, the admin, the doctor and the patient. This uses the Role Based Access Control (RBAC) security feature to restrict system access to authorized user. Based on user's selection, for admin and patient modules, the login details required are username (email) and password; for doctor's module password and license number is required which is a unique and standard number of a verified and genuine doctor – this license number is just like the matric number of a student in a school settings. Figure 5-7 show the login interface for admin, doctor and patient respectively.

Fig 4: Landing Page

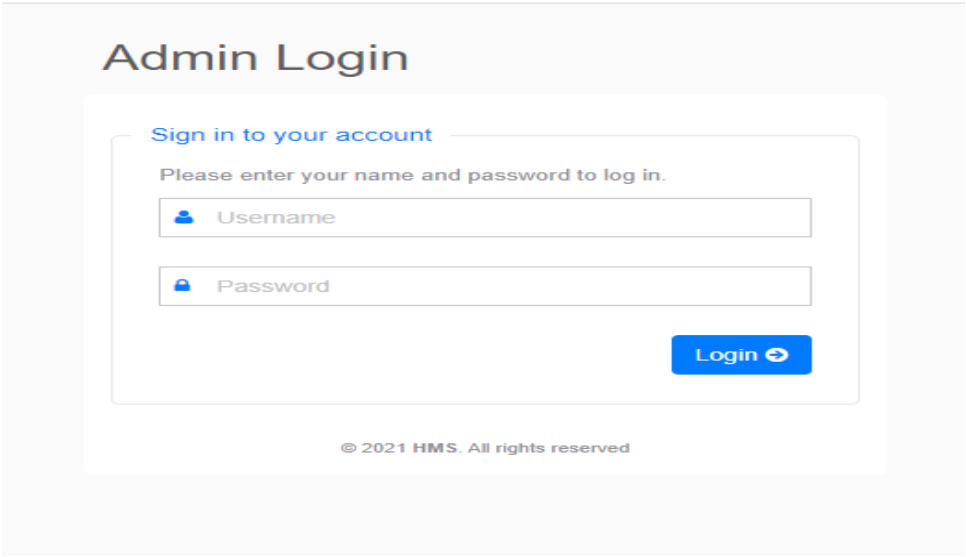

Fig 5: Admin's login Page

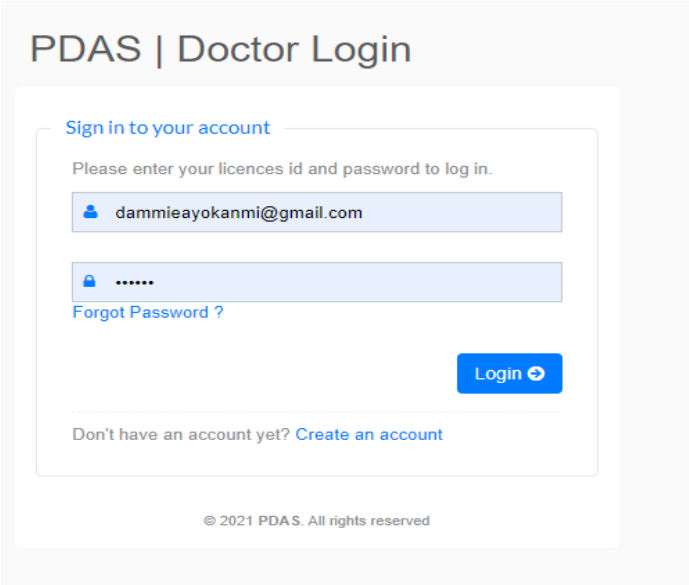

Fig 6: Doctor's login Page

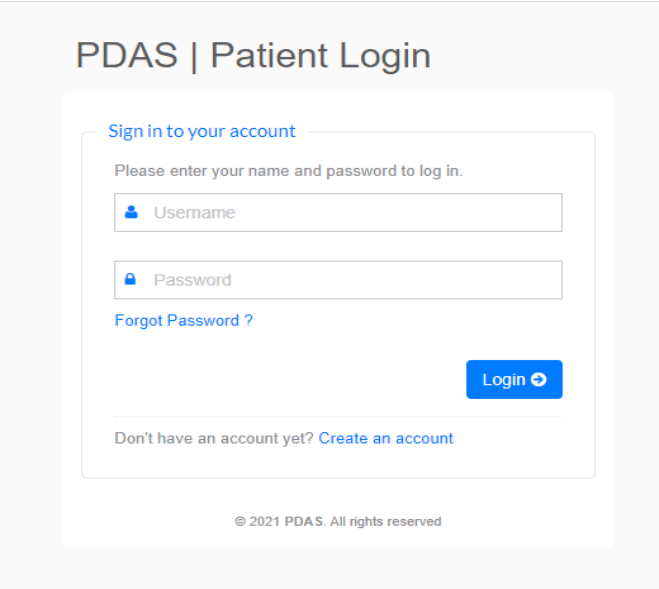

Fig 7: Patient's login Page

Registration is made available for new users of the system, in this case the doctor and patient. This interface provides a form to be filled out by the users in order to capture their information. On a new doctor's registration, a new license number is generated for the doctor on the backend; the admin sends this to the doctor's mail after verifying if the doctor is truly a licensed doctor. The "create new account" link on the log in pages redirects the users to the registration page. (See Figure 8) shows the registration page for patients.

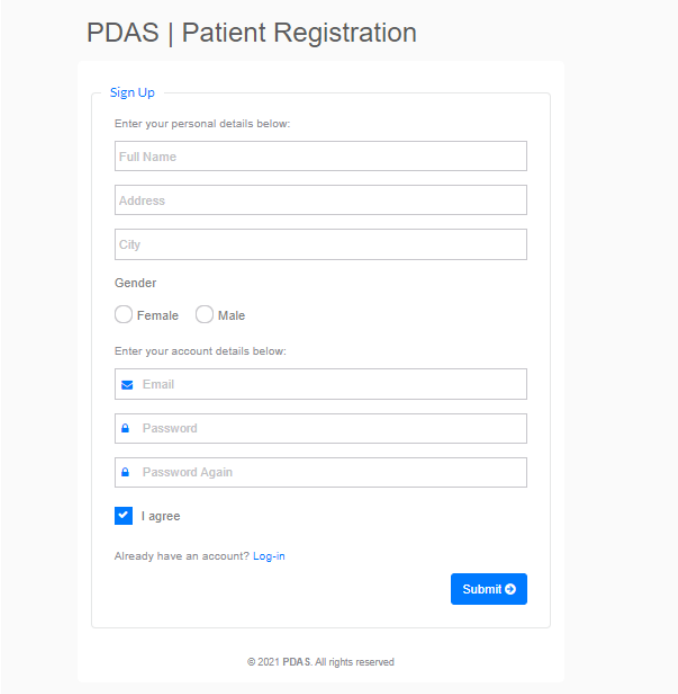

Fig 8: Patient's registration Page

The users are provided with the option of changing their password. This could be due to any reason on the user's part, for instance, when the user's password has being compromised. (See Figure 9)shows the change password screen for all users.

Fig 9: Change password screen

In the Appointment page, a patient can book an appointment, (see figure 10) and has the option of choosing a doctor's specialization which prompts doctors only in that area of specialization, the user is also provide with date input and time. On submission, the doctor sees the appointment made on their dashboard, (see figure 11) and has the option of accepting or declining the appointment made by the patient. The doctor's choice whether acceptance or rejection is also sent to the patient's dashboard, so as to know the availability of the doctor as well as the status of the appointment they had made earlier.(See Figure 12) shows all patients' appointment history on the admin dashboard.

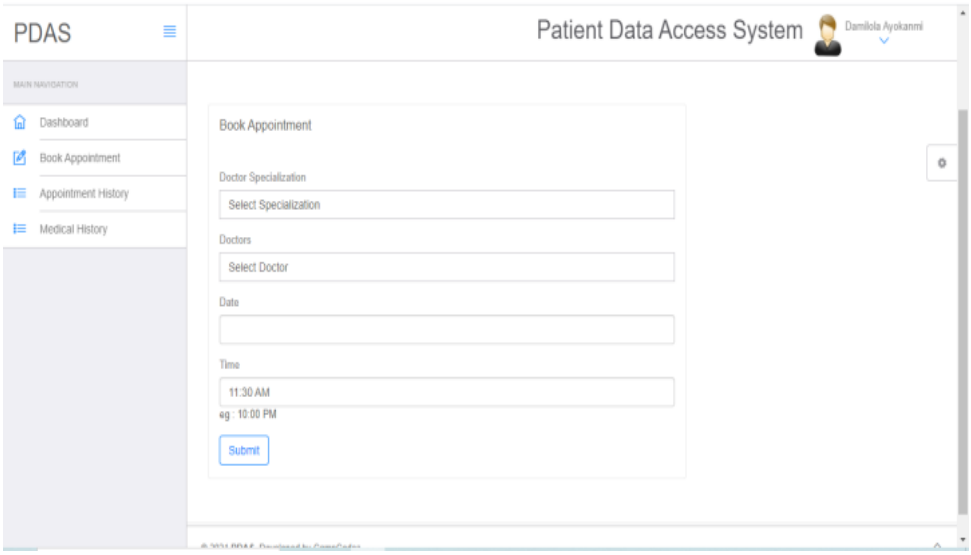

Fig 10: Appointment booking by patient

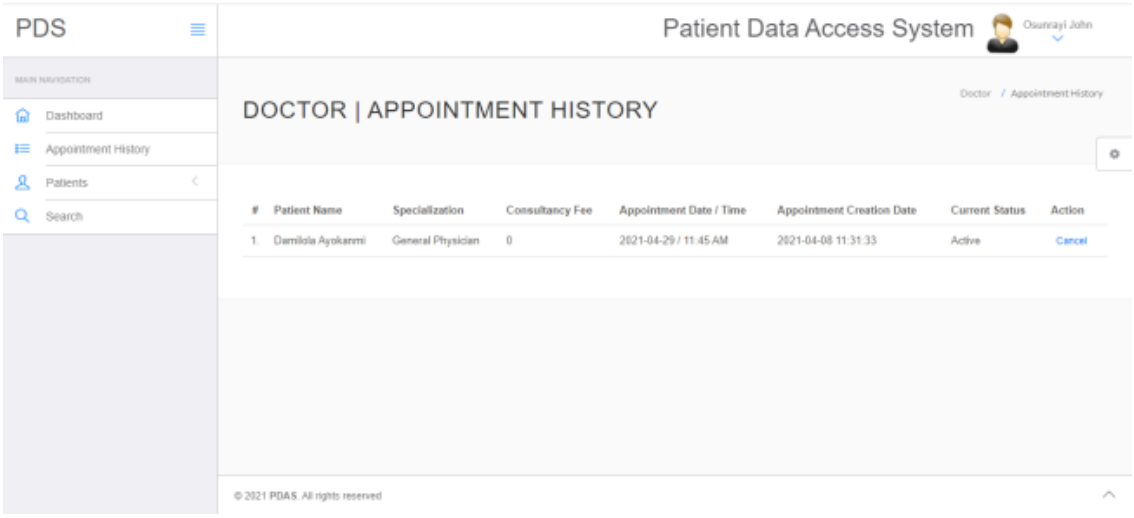

Fig 11: Appointment interface on the doctor's dashboard

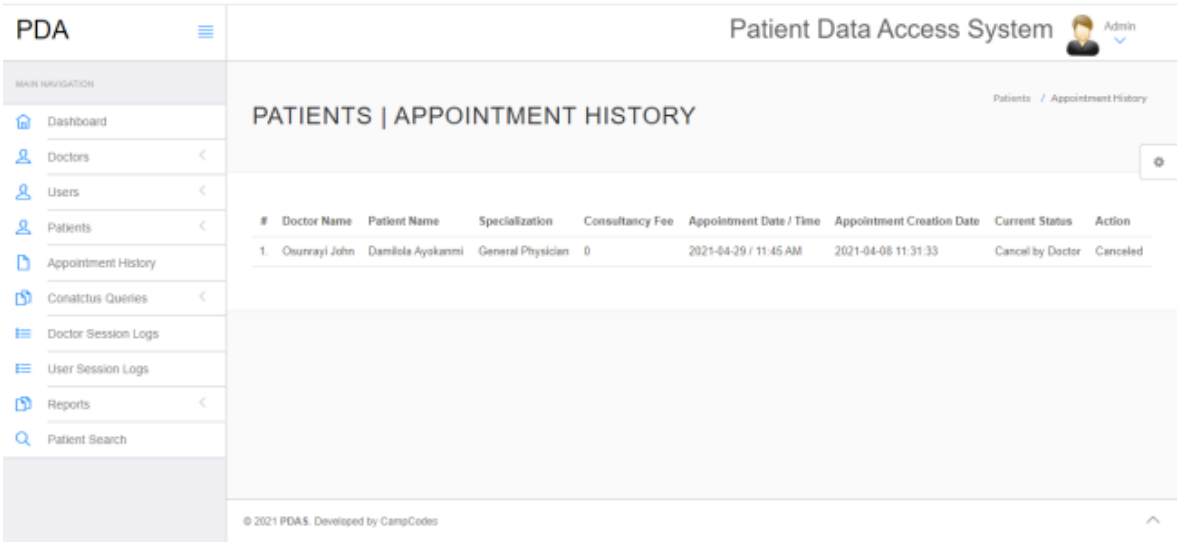

Fig 12: Appointment history screen

People change as well as the information about them; this is one of the reasons for the provision of updating profile for the doctor and patient. (See Figure 13) and (see figure 14) shows the update profile screens respectively.

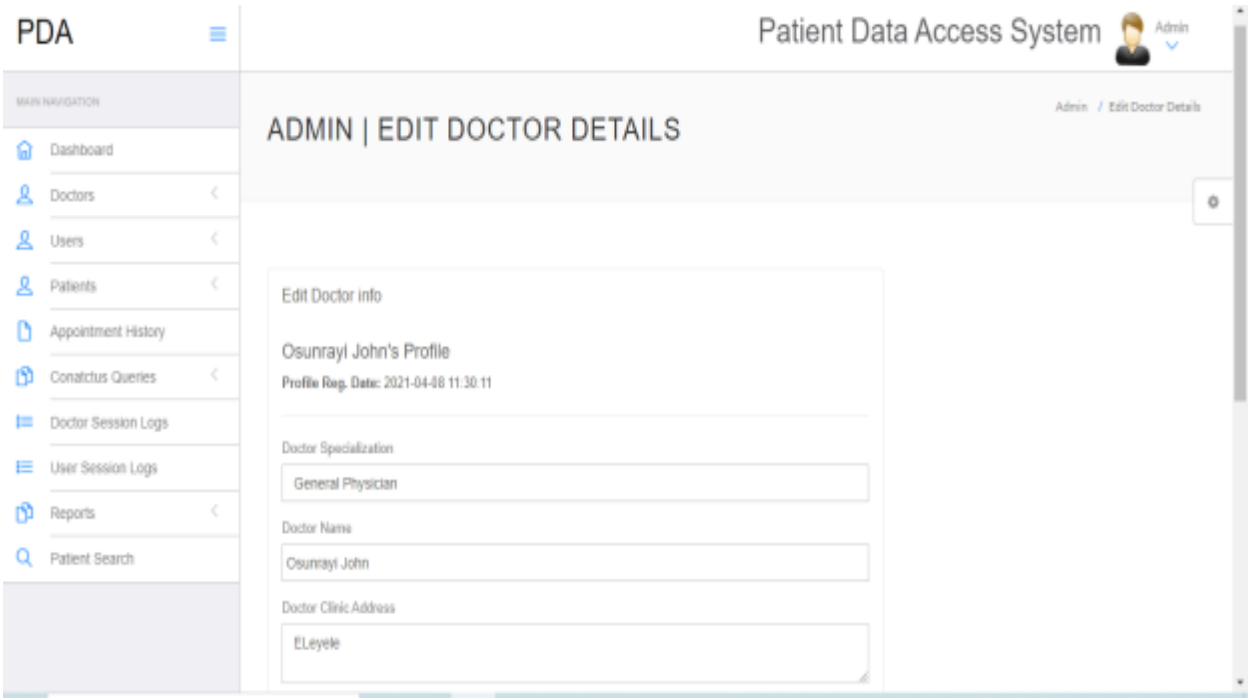

Fig 13: Doctor Update profile screen

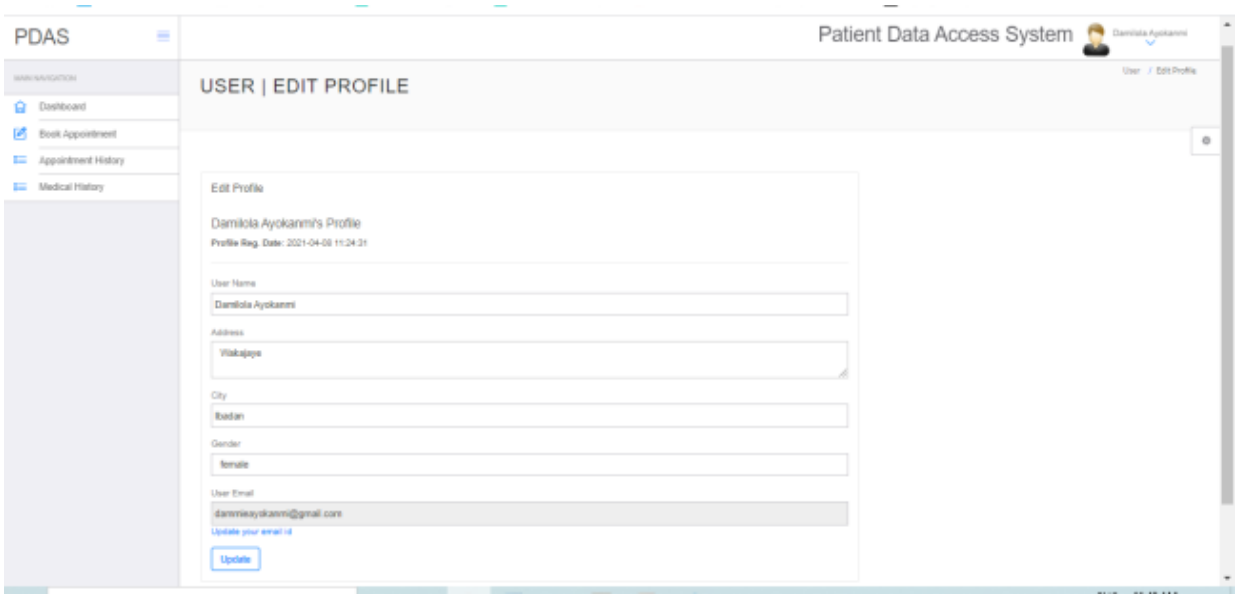

Fig 14: Patient Update profile screen

The admin can perform several operations in the system amongst which are (see figure 15) adding new doctors, (see figure 16) adding new patient, (see figure 17) users' log sessions, and (see figure 18) search patient screen.

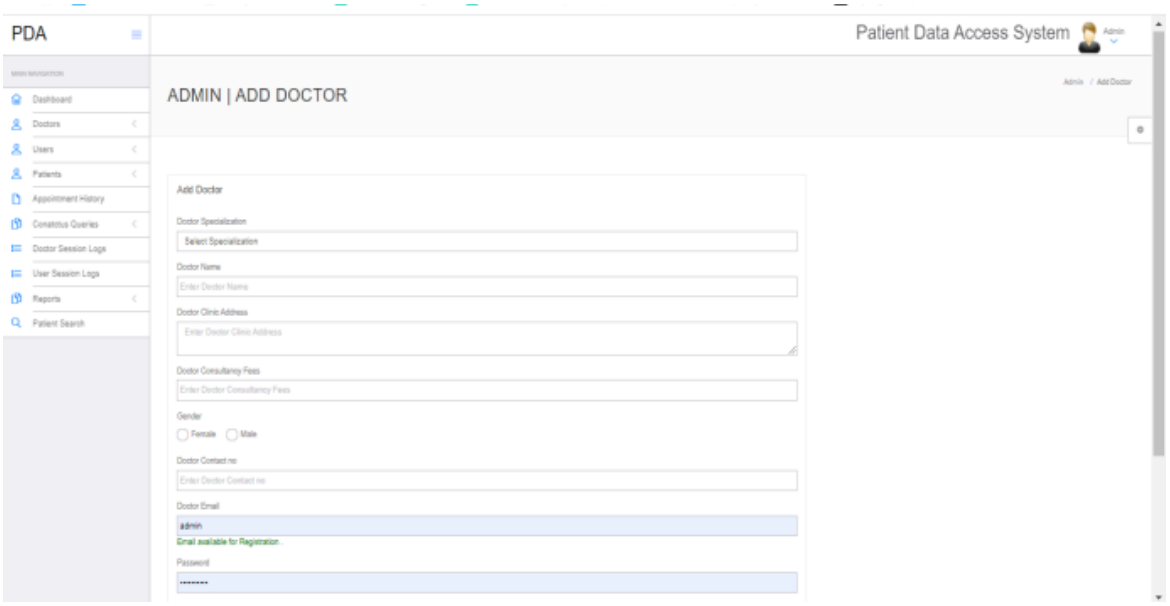

Figure 15: Add new doctor on admin dashboard

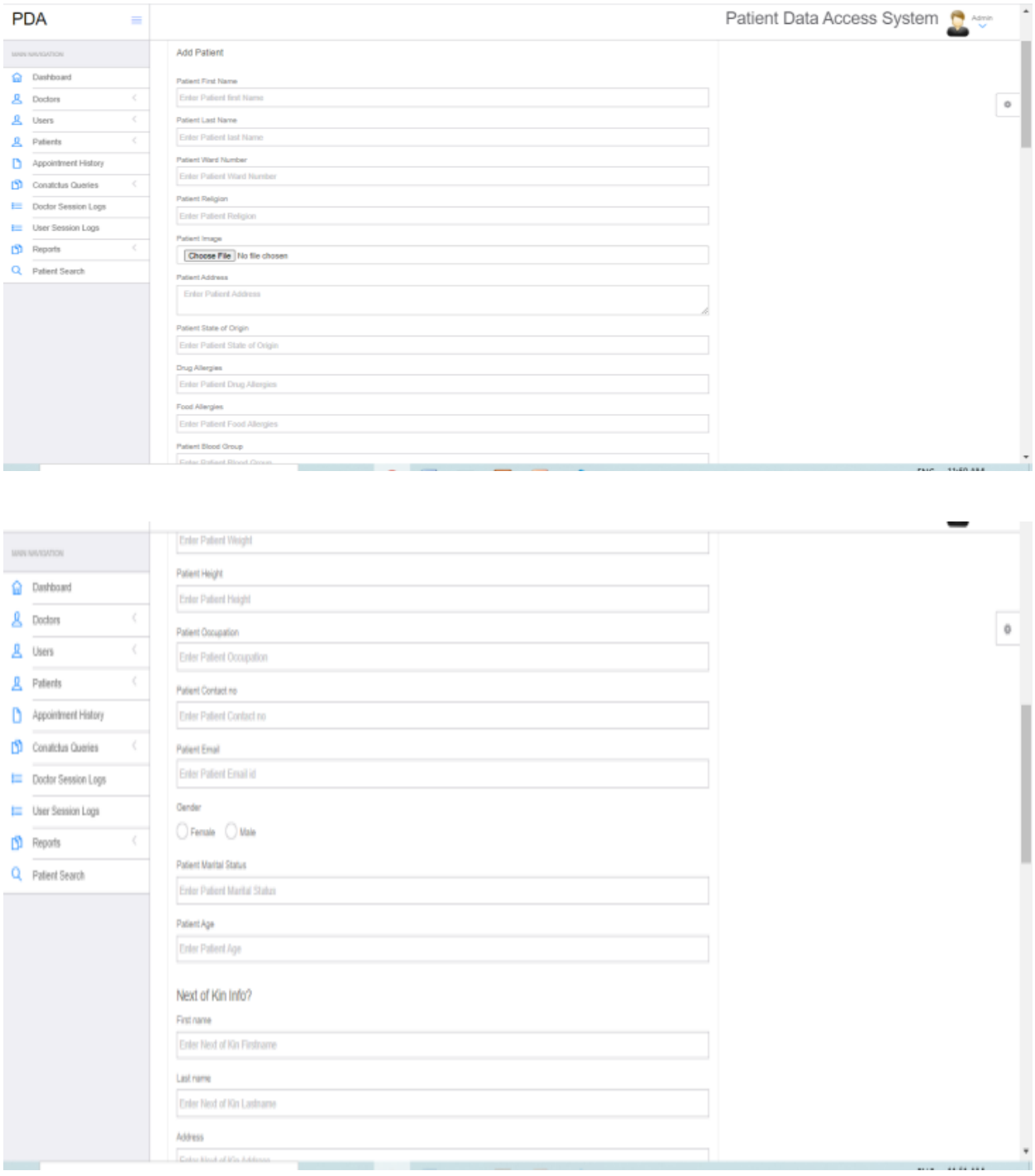

Fig 16: Add new patient on admin dashboard

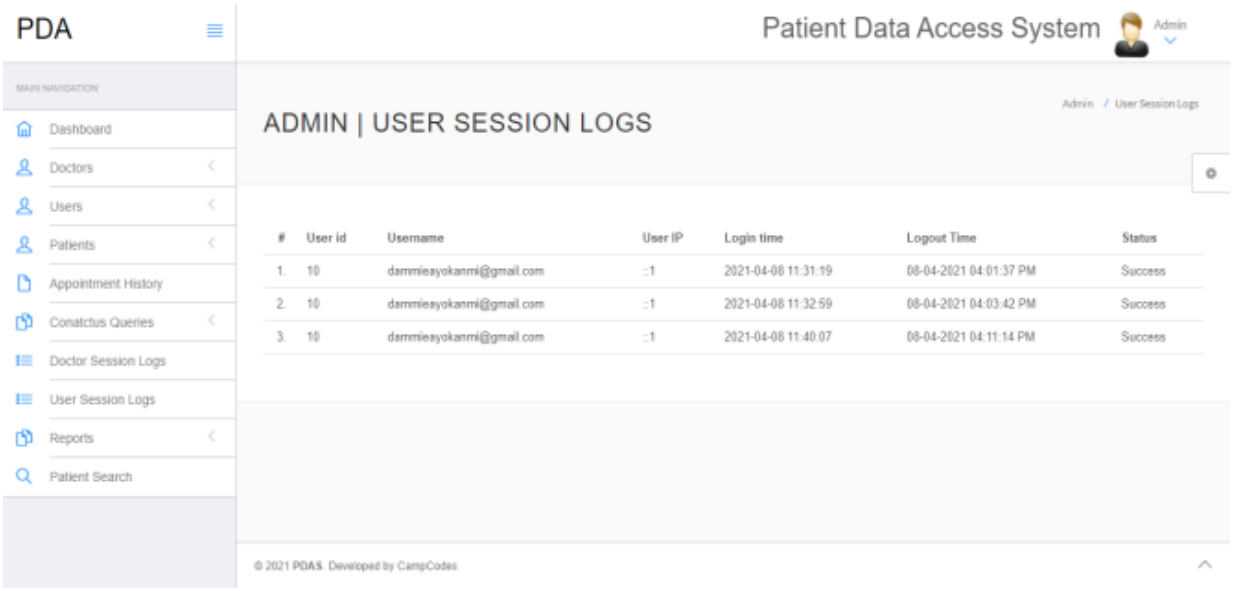

Fig 17: User's log sessions

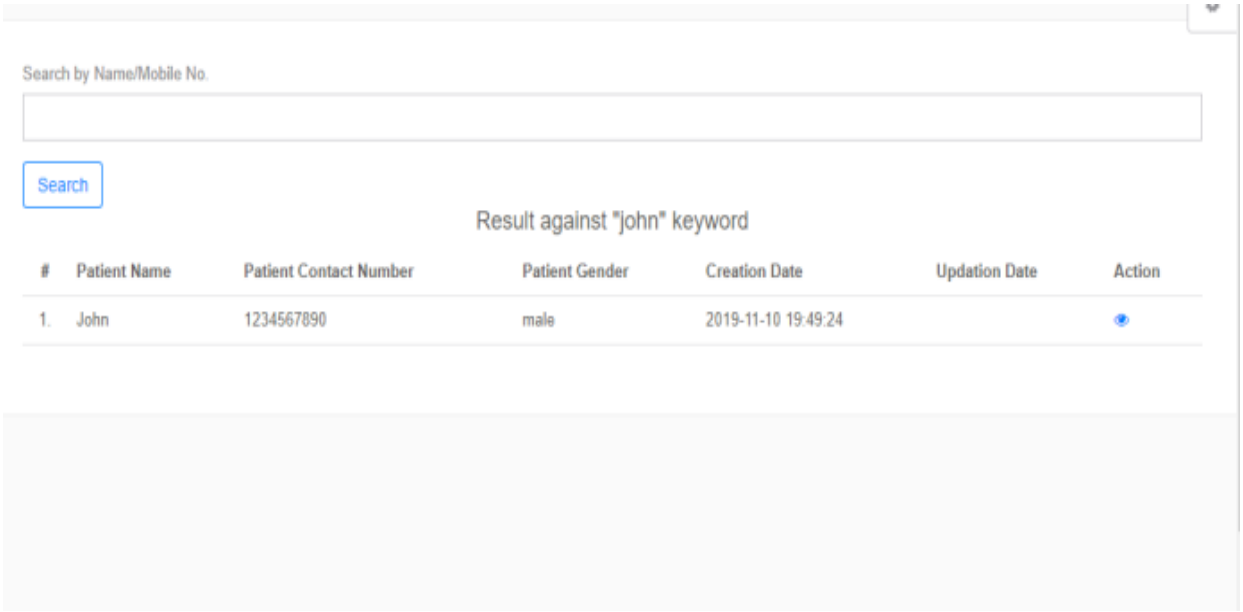

Fig 18: Search patient screen

5. SYSTEM PERFORMANCE EVALUATION

The developed system was evaluated using *GTmetrix* analytic tool with performance, loadtime and total blocking time as standard metrics which yielded 93%, 556ms and 0ms respectively as shown in Figure 19. Load Time is a web performance metric that directly impacts user engagement and a business's bottom line. It indicates how long it takes for a page to fully load in the browser after a user clicks a link or makes a request.

Total Blocking Time (TBT) is an important lab metric for measuring load responsiveness because it helps quantify the severity of how non-interactive a page is prior to it becoming reliably interactive—a low TBT helps ensure that the page is usable.

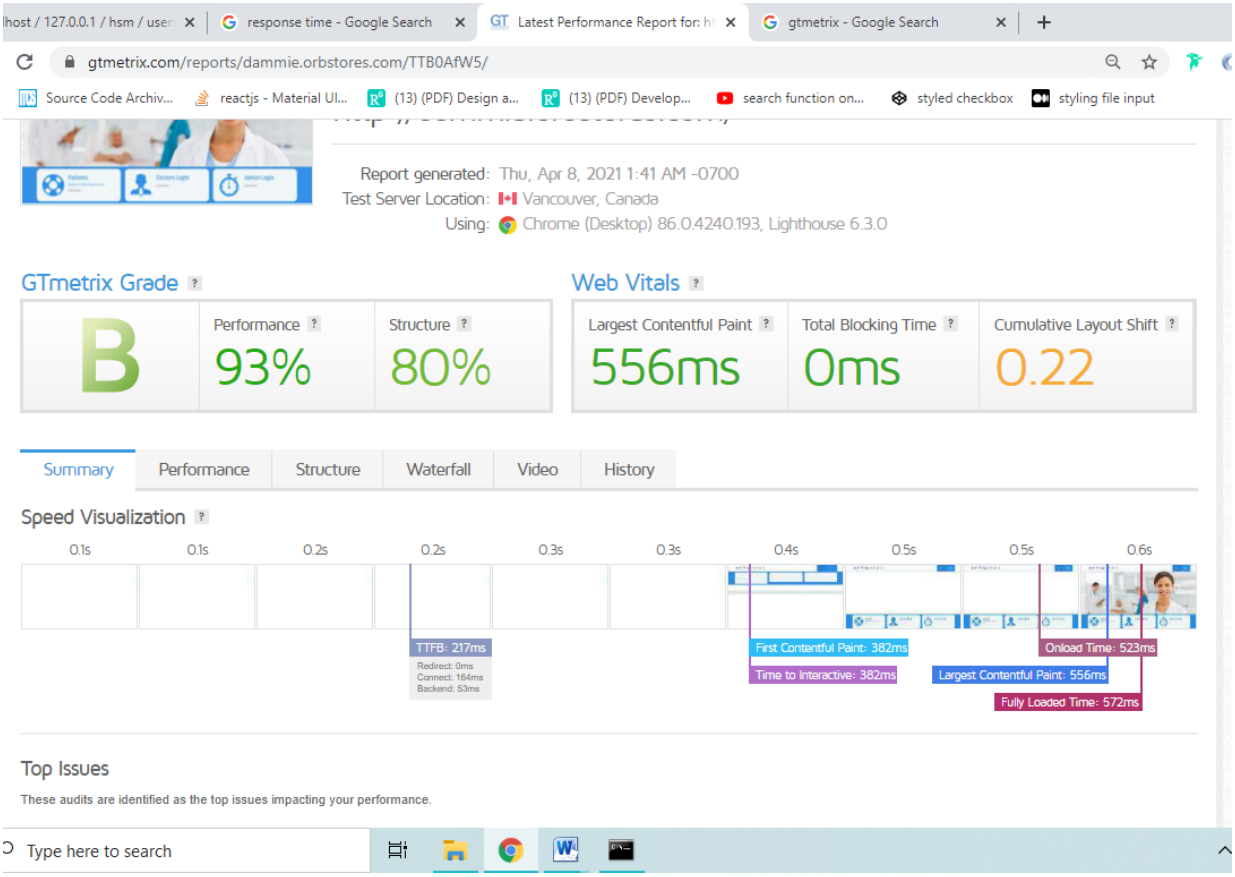

Figure 19: System Performance Evaluation Metrics

6. CONCLUSION

Remote patient data access systems in hospitals have great benefits. Not only does it decrease medical errors present in manual activities but it also provides a paperless friendly environment which improves the transfer of information amongst healthcare providers. This system allows for secured access to patients' medical record which may be needed during the consultation in the case where the experts are distant. Other benefits include the elimination of credibility issues, faster methods of quality storage for easier retrieval of information. Importantly, the Remote patient data access system facilitates the continuity of patient care. Subsequently, the Remote patient data access system assists the society as well as the organization. In managing day to day operations, the system offers a platform for smooth operations. This work is efficiently helpful at this time in the world at large, knowing well of the rampant pandemic (Covid-19) demands social distancing at every sector in the world especially the medical sector where there is more risk at contacting the virus.

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