

DESIGN AND IMPLEMENTATION OF A CENTRALIZED PATIENT INFORMATION SYSTEM FOR REAL-TIME DATA ACCESS AND CLINICAL DECISION SUPPORT

by

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ABSTRACT

This research paper presents the design and realization of a Centralized Patient Information System, with the goal to overcome some of the fragmentation, inefficiency, and security challenges of paper-based and decentralized hospital record systems. The infrastructure was designed to facilitate patient data management, enhance access for selected users, and safeguard medical records' privacy and integrity. Built using ASP. NET C# in Visual Studio and Microsoft SQL Server for backend data handling, this includes a full-feature set like role-based access control, multi-factor authentication, appointment scheduling, and EHR management. Development proceeded with a methodology of Object-Oriented Analysis and Design (OOAD) and prototyping where functionality was incrementally refined. System performance was tested with response time (latency) tests, where the average latency was 127.5 milliseconds, suggesting that the system is efficient in accessing the real-time data. This solution led to improved decision support, less duplication of data and better health service delivery through a secure, centralized digital solution.

Keywords/Phrases: Patient information system, prototyping, object-oriented analysis, medical support

I. INTRODUCTION

Digital health is redefining healthcare delivery. New models also help doctors make better decisions and run hospitals more efficiently. One of the key initiators is the collated patient information system, which draws real-time information for prompt action. Centralized records support coordination of care and reduce fragmented information (Tilala et al., 2024). Clinical decision support systems (CDSS) aid professionals in making precise diagnoses and treatments. By utilizing AI and data-driven algorithms, these systems provide evidence-based

recommendations, thereby reducing errors and enhancing patient outcomes (Khalifa et al., 2024).

Studies verify the effectiveness of CDSS in various healthcare settings, emphasizing their ability to minimize unnecessary procedures and improve the quality of care (Musen et al., 2021).

Effective implementation relies on usability management, integration with electronic health records, and compliance with data protection regulations (Shojaei et al., 2024). Adopting zero-trust security frameworks is recommended to address cybersecurity risks (Edo et al., 2024).

There is a revolution in identifying where resources should be allocated at a population level by providing healthcare providers with dashboards of health trends, resource utilization, and unmet needs. This evidence-based approach allows for the most appropriate allocation of resources, benefiting both care delivery and patients (Tilala et al., 2024). A centralized repository of records promotes continuity of care through information sharing among providers and encourages coordinated care for patients with complex medical histories or chronic diseases (Chaparro et al., 2022).

Importantly, this system empowers patients by enabling them to access their health information, engage in informed decision-making, and actively participate in the concept of patient-centered care (Chaparro et al., 2022). While there are strong reasons to favor centralized systems, issues surrounding interoperability, data security, and resistance from healthcare professionals persist (Abel et al., 2023).

II. LITERATURE SURVEY

2.1 Patient Information Systems (PIMS)

A PIMS is a device capable of recording, storing, managing, and transmitting information on the subject's health. "Such systems," Folorunso (2024) states, "are essential in contemporary medicine, as

they help improve data accuracy, coordination in patient care, and the safeguarding of confidential medical data." The growing need for patient information confidentiality and real-time access has made PIMS invaluable to hospitals, clinics, and other medical facilities. Effective management of health information ensures careful consideration of data privacy and ethical issues, and it reduces the risks of data leakage due to unauthorized access and breaches (Rahman & Jim, 2024).

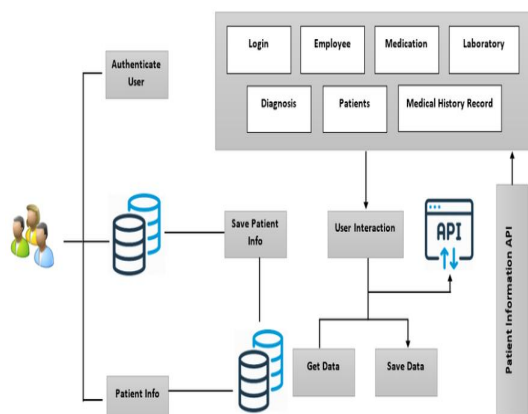


Figure 1: RAD-Based System Architecture for Computerizing Patient Information

It used to be that patient records were stored on paper, leading to problems such as the loss of data or inefficiencies in retrieving and reviewing information. EHR, one of the tools of IT, has brought the revolution in the field of health care, by offering a central pool, real time access, and better interfacing (Kask, Bloom, & Porta, 2024). This shift has been driven by the demand for faster access to data and improved patient care, greater focus on data security and health regulation compliance, and innovations in health informatics, cloud computing, and AI. Despite these advantages, the implementation of EHR has presented new challenges, especially regarding security and privacy issues (Shojaei, Vlahu-Gjorgievska & Chow, 2024). These challenges have contributed to continued investigations and the establishment of security models that are being supported to secure and enhance patient data management.

An integrated PIMS is built using a number of fundamental tools which help in the easy handling of patient data. The repository, where patient demographics, medical history and clinical data are stored, is one of the key components. The system dynamically interfaces with Electronic Health Records (EHRs) to enable access by and the

updating of information by attending healthcare providers (Adeniyi et al., 2024). Security and access control is a crucial aspect of mHealth applications which ensure that no unauthorized access to patient sensitive data can occur through the use of encryption, user authentication and user right (Shojaei et al., 2024).

Aside from data management and privacy, patient information systems also include a clinical decision support (CDS) component to apply machine learning and AI to help clinicians make evidence-based clinical decisions. It also promotes interoperability to facilitate exchange of information among various healthcare providers, laboratories and pharmacists to enable better communication and coordination. Compatibility and extensibility with integration of open software electronic health records (also known as open source software EHR or open source EHR) that easily output common standards to facilitate easily implementation of additional features and functionalities; and insights, auditing, and compliance management that monitor user activity logs and ensure that the site is aware of the legal environment (like health laws and privacy laws) they operate within, creating a situation of compliance and accountability (Folorunso, 2024).

2.2 Review of Past Related Works

Patient information management systems have taken the healthcare industry by storm by offering a more straightforward way to document and process information, bringing administrative workflows closer to perfection, and significantly improving patient care. With the advancement of healthcare technology, advanced security features, artificial intelligence, and blockchain technology will become essential to enhance the effectiveness and dependability of these systems (Kask et al., 2024).

Abughazalah et al. (2024) explored centralized vs. decentralized cloud computing in healthcare, reporting the advantages of decentralized architecture in reducing single points of failure and improving data sovereignty. Additionally, their research did not examine the integration of distributed cloud with currently implemented EHR systems, which must comply with regulatory requirements.

Yaqoob et al. (2022) examined how blockchain is applied to healthcare, noting that decentralized ledgers can enhance integrity and confidentiality, as well as manage patient consent. However, their research failed to address the overhead of

computations and scalability issues associated with using blockchain in large-scale healthcare systems. Solomon T. Adagba (2020) studied a centralized health information system for managing health records. The need for a centralized system is underscored by the observed advantages in data accessibility, patient records, and hospital cooperation. What was missing, however, was information on contemporary cybersecurity threats and strategies to combat them in the context of centralized health record systems.

Omotayo et al. (2021) tracked the role of centralized EHRs in improving healthcare and patient outcomes, as well as readiness for future health emergencies. Nevertheless, their research paper did not address the interoperability issues between centralized and decentralized data sources.

Yogesh (2023) designed a central electronic medical record system to enhance data sharing among health providers and governance authorities. However, their study failed to consider the privacy concerns arising from centralized storage and the risk of data breaches. In their article, Momodu and Susan (2024) examine a secure single-point patient records database system to combat data fragmentation in the Nigerian health domain. Their study, on the other hand, did not analyze the potential of using blockchain and AI-related methods to secure central health records.

The authors (Momodu & Susan, 2024) raised the challenges of data fragmentation in the Nigerian healthcare system and the necessity of such an encrypted single-patient records center. However, they did not evaluate the feasibility of blockchain or AI-influenced security methods to secure the centralized health record.

In 2024 CARTA Healthcare reviewed the importance of meaningful, centralized healthcare data in order to improve the patient experience. In their blog, they started that it would contribute to better clinical decision, patient experience and operational efficiency for healthcare providers and the like. However, the research was not peer-reviewed and the study did not take into account potential privacy concerns of central data storage.

Paculan et al. (2024) proposed solutions for patient data management. Their research provided an example of how automation could facilitate the management of patient data and administrative aspects of a healthcare delivery system. However, the study did not assess the long-term use of RAD-based automation for continued service in the context of large hospital networks.

Khezzar et al. (2019) systematically reviewed blockchain in healthcare and its potential for enhancing data trust, interoperability, and security (Table 1). Their research outlined recommendations for future studies to combine blockchain with new technologies, such as AI. However, they did not demonstrate any real-world use cases or address the computational costs associated with deploying blockchain in healthcare.

III. MATERIALS AND METHOD

3.1 Hardware Material Requirements

- i. Processor (CPU): Intel Core i5 (10th Gen or higher) / AMD Ryzen 5 or higher – Required to run the model, and for applying machine learning models on the captured data.
- ii. RAM: 8GB (16GB recommended) – smooth multitasking and data manipulation with large datasets.
- iii. Storage: At least 256GB SSD (Recommended 512GB SSD or larger) – Offers faster read/write operations to store databases.
- iv. Graphics Processing Unit (GPU): NVIDIA GTX 1650 / AMD Radeon RX 550 or higher (if deep learning models are used).
- v. Network Adapter: High speed Ethernet (or Wi-Fi) adapter: an adapter for network with high stability is also necessary for ensuring smooth operations through the web.
- vi. Power Source: Uninterrupted Power Supply (UPS) – Protects from power spikes and maintains operation.

Screen Resolution: Screen with 1024x768 screen resolution.

3.2 Software Material Requirements

- i. Operating System:
 - a. Host and deploy on Windows 10/11 (64-bit) or Windows Server 2019/2022.
 - b. Linux (Ubuntu 20.04 LTS or later) for server-side deployment if applicable.
- ii. Development Environment:
 - a. Microsoft Visual Studio 2015 or later – Primary IDE for coding and debugging.
 - b. .NET Framework 4.7.2 or later – Required for developing the ASP.NET-web based system.
 - c. C# Programming Language – Used for core logic and functionality implementation.

- iii. Database Management System (DBMS):
 - a. Microsoft SQL Server – Preferred relational database for storing user data and transaction logs.
 - b. SQL Server Management Studio (SSMS) – For database management and query execution.
- iv. Web Technologies:
 - a. ASP.NET Core – Backend framework for web-based functionality.
 - b. HTML5, CSS3, JavaScript, jQuery – For designing interactive user interfaces.
 - c. SweetAlert2 – For enhanced UI pop-ups and notifications.

3.3 Methodology

Object-Oriented Design methodology was chosen for many compelling reasons - the modular nature of it made it easy to design and implement complex workflows; encapsulation provided a natural security check between patient sensitive data; inheritance made it easy to extend system functionality; and polymorphism allowed flexible Clinical Decision Support capabilities. These characteristics made OOD particularly well-suited for building a robust patient information system that is subject to changes in medical practice and medical technology, but has to uphold strong security and performance requirements.

3.4 Collection of Data

The secondary data were used to develop and test our service. This was done to take advantage of already validated databases that closely reflect real-world clinical situations and the needs for management of patient information. The secondary data were derived from research partnerships with healthcare institutions using anonymized electronic health records (EHRs) in accordance with data protection regulations.

The following sources of secondary data were also important:

- a. De-identified patient records, including demographic details, medical history, and treatment plans
- b. CDSS from published medical literature
- c. Documenting healthcare workflows via hospital information systems
- d. Comparison with other patient information systems based on performance benchmarks

Employing secondary data offered several benefits for the present study. First, it provided access to well-curated, professionally collected medical data without the ethical and practical challenges associated with primary data collection. Second, the current datasets were sufficiently large and diverse to adequately test system functionality across a wide range of clinical use cases. Third, it was convenient to compare with some existing systems and reported results available for the same datasets.

Validation checks of secondary data were conducted to ensure their quality and applicability. This included completeness checks of the data, validation of consistency between different sources, and confirmation that the data quality parameters met the system's requirements. The data captured were then organized based on an object-oriented approach in the aid of system development and testing.

The analysis process involves a detailed study of the present system and the aims of the proposed system, resulting in a well-documented definition of the users' requirements. This analysis entails examining the pros and cons of the current centralized patient database system. The results of this analysis illustrate the deficiencies that the new centralized patient information system is designed to address. The research here is a user requirement biosystem (by describing requirements from users, the system is being built with greater efficiency and efficacy that will comply with users' expectations and can overcome the challenges that exist in the current systems).

3.5 Analysis of the Existing System

The way patient data is handled in healthcare today exposes inefficiencies based on systems currently working in isolation. The vast majority of the institutions still use paper or separate computerized patient record, which are for the most part obstacles for real-time data access. This fragmentation delays clinical judgement process as clinicians find it hard to get patient records very fast. As there is no universal framework, interoperability problems arise, limiting data sharing between departments and medical facilities. Additionally, the inconsistent utilization of EHRs further compounds these issues. The treatment protocols are multidisciplinary technological applications, and differences among treatment protocols can be expected to occur, in part the result of differences in adoption and

implementation of systems, which might also impede the efficacy of clinical decision support systems. With the absence of an integrated system to support real-time patient information, healthcare providers are unable to deliver timely, coordinated care, that in turn can result in poor patient outcomes.

System-level shortcomings have a cumulative impact, manifested through greater hazards of medical errors, unnecessary procedures, and repetitive care. The challenges highlight the urgent need for an integrated patient data system that is more than just a “data repository,” but rather, one that can also retrieve real-time information and offer clinical decision support. Closing these gaps is critical for promoting health system efficiency, minimizing distribution and treatment use errors, and achieving interoperability at the level of the health ecosystem.

This model emphasizes the need for a shift from the current disjointed array of systems to the unified CPIS, which aims to (1) enhance high-quality clinical workflows, (2) support the quality of data on the patient, and (3) promote evidence-based decision making.

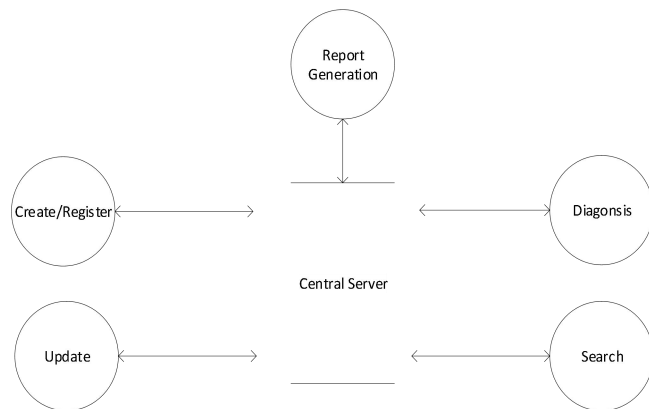


Figure 2: Data Flow Diagram for Patient Information System

Figure 2 presents the design of the Centralized Patient Information System in relation to a central server, specifically from a core functionality perspective. The software is aimed at managing patient data and facilitating healthcare practitioners' access to such data.

- a. Central Server: This is the main part of the system with which all user systems operate. It stores patients' details and files them

correctly. It serves as a central point and connector for various features.

- b. Register/Create: This module is dedicated to creating and registering new patient cases within the system for healthcare providers.
- c. Update: This allows authorized users to update and edit patient records with new data, including medical history, test results, and prescriptions.
- d. Diagnosis: Enables health workers to capture and retrieve diagnostic information based for making clinical decisions.
- e. Search: There is an option to search the patient information to obtain the details of the patient and maintain their historical data in real time.
- f. Report Generation: Support for the production of medical reports, summaries, and analytics by reference to patient data, enabling clinical assessment and administrative reporting.

3.6 Activity Diagram for the Proposed System

Figures 3 and 4 illustrate various Activity Diagrams of the centralized Patient Information System, representing different workflows carried out by users such as doctors, nurses, lab technicians, administrators, and patients. These diagrams depict the flow of activities, from user authentication to patient record management, diagnosis updates, and report generation. The process begins with user authentication, where users log in using Multi-Factor Authentication (MFA), which includes passwords and one-time passcodes (OTP), combined with Role-Based Access Control (RBAC) to ensure secure and restricted access. Once authenticated, users can carry out specific tasks based on their roles:

- i Doctors access patient records, update diagnoses, prescribe medications, and request lab tests.
- ii Nurses assist in updating patient vitals, administering treatments, and monitoring patient progress.
- iii Lab Technicians manage diagnostic tests, update test results, and send reports to doctors.
- iv Administrators manage user accounts, generate system reports, and oversee data security.
- v Patients can view their medical history, prescriptions, and scheduled appointments.

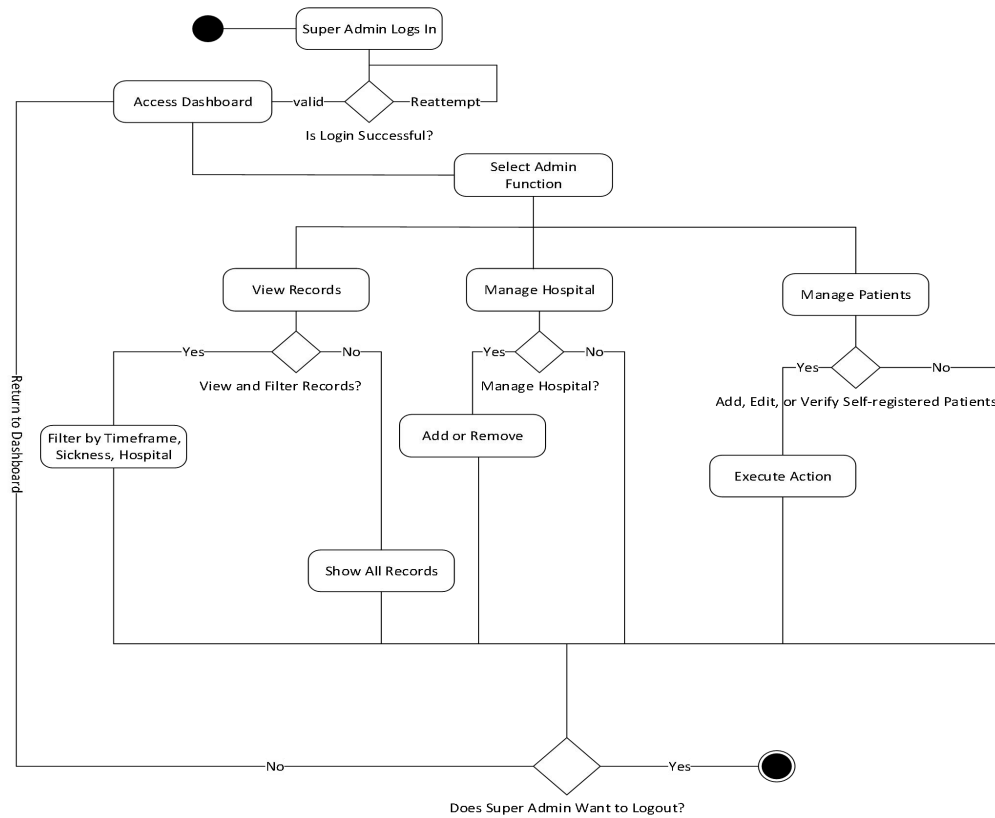


Figure 3: Super Administrator (Ministry of Health) Activity Diagram

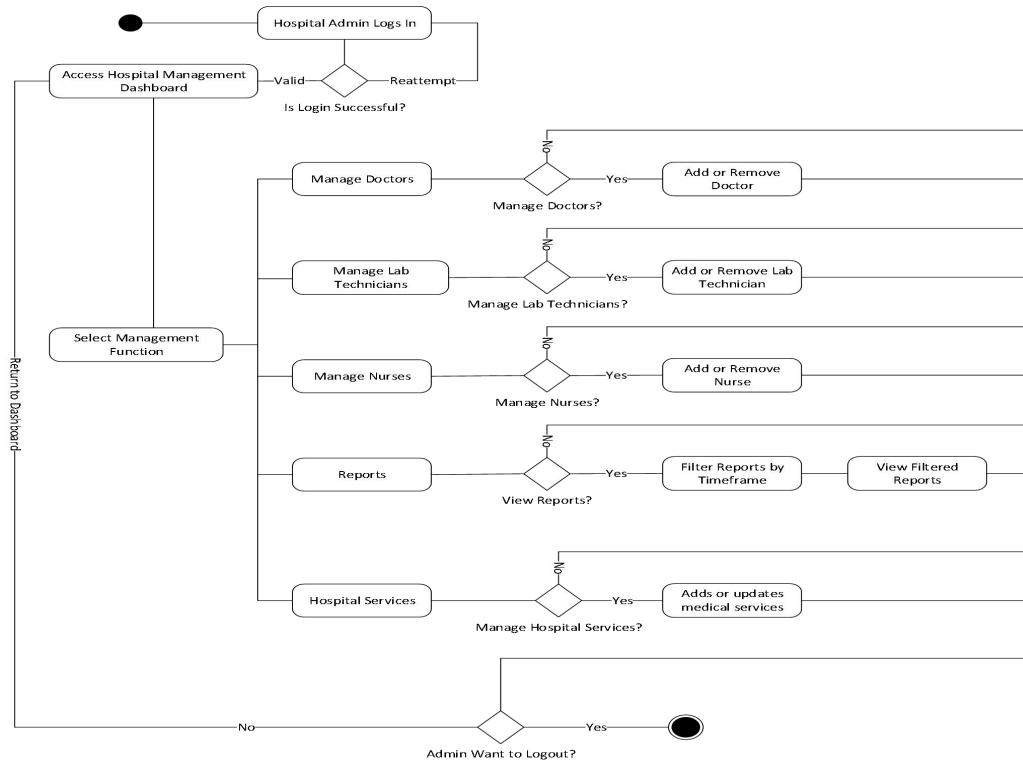


Figure 4: Hospital Management Activity Diagram

3.7 Use Case Diagram for the Proposed System

Figure 5 illustrates its Use Case Diagram, specifying the interactions between users and the system. At a glance, the diagram shows the Doctors, Nurses, Lab Technicians, Administrators, Patients, and the System Database, highlighting how each interacts with patient data.

It employs password and one-time passcode (one-time password, or OTP) Multi-Factor Authentication (MFA) along with Role-Based Access Control (RBAC) to secure access. When connected, here is what individuals may do:

- i Doctors can log in, access patient records, update diagnoses, prescribe medications, and request lab tests.
- ii Nurses assist with updating patient vitals, treatments, and assessing their condition.
- iii Lab technicians conduct diagnostic tests, maintain test results, and route reports to physicians.
- iv An administrator is then responsible for managing users, reporting, and securing the system.
- v Patients have access to their medical history and prescriptions, and they can also schedule appointments.

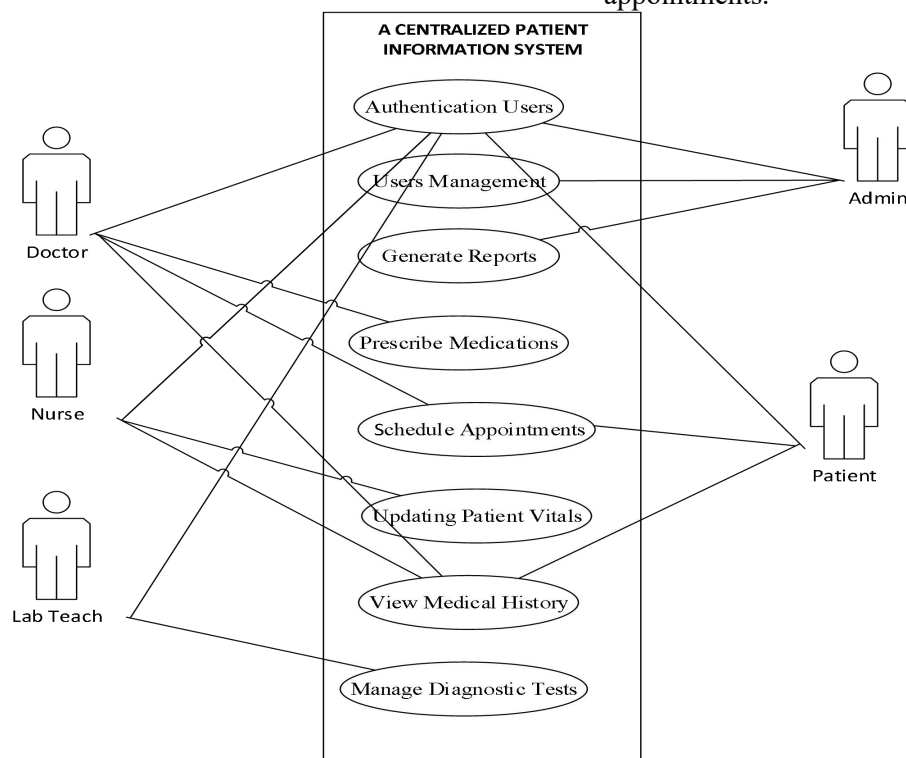


Figure 5: Use Case Diagram of the Centralized Patient Information System

The System Database houses patient records in a secure environment, provides real-time data availability, and promotes data integrity. The described use cases illustrate how the system adds value by enabling efficient management of medical records, enhancing clinical decision-making, and securing data through MFA and RBAC, which ultimately prevents unauthorized access and improves workflow efficiency.

3.8 System Design

Figure 6 shows the system structure of the Central Patient Information System. The code is structured in a tier-based architecture, involving the User

Interface (Presentation Layer), the Business Logic Layer (Application Layer) and the Data Layer (Database). The system is accessed by people who are employed in the system, as doctors, nurses, laboratory technicians and administrators, in addition to the patients, through secure interfaces. The application layer is responsible for receiving user commands, applying business rules, and then interacting with the data layer responsible for reading and writing patient information. Security is also incorporated, with features such as Role-Based Access Control (RBAC) and Multi-Factor Authentication (MFA) to provide secure access and protect your data.

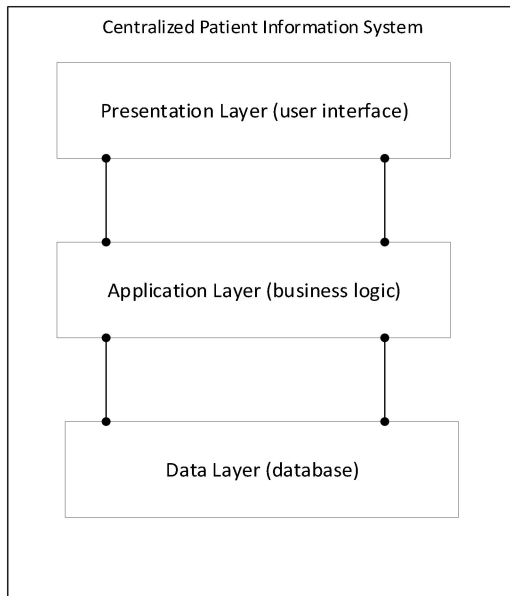


Figure 6: System Architecture Design

3.9 System Specifications

System requirements describe the technical tools and specifications for the design and development of the CPIS. Microsoft SQL Server is used on the backend to store the patient health records securely and efficiently. You develop in Visual Studio, with ASP. NET with C# to develop stable server-side features and smooth client-server communication.

The system works on desktop and mobile, and can be accessed by both healthcare providers and patients. Medical data is protected by integrated security measures, such as encryption and user authentication. Together, these requirements guarantee a reliable, scalable, and user-friendly system corresponding to its healthcare goals.

3.10 Database Development Tool

From a database point of view, Microsoft SQL Server was used in development because of its capability to handle huge amount of susceptible-required health data of the patients. SQL Server, with its support for high data storage and retrieval capabilities and enabling management, coupled with basic functions that it provides, such as, data encryption, role-based access, and auto backups, which are necessary to maintain the security and integrity of the data especially in the healthcare systems.

Its system has the alternative analysis to directly expose the relational database structure and integrates machine learning models to apply predictive analytics effectively to patient data. In addition, its support for ASP. NET C# in Visual Studio makes it easy to develop and communicate between the front end and back end. In general, SQL Server provides the scalability, and secure, and reliable database that makes it suitable for the Centralized Patient Information System.

3.11 Data Dictionary

Table 1: SuperAdminTable

Field Name	Data Type	Field Type	Description
SuperAdminID	Int	PK	Unique identifier for Super Admin
Name	Varchar	-	Name of the Super Admin
Email	Varchar	-	Email of the Super Admin
Password	Varchar	-	Login password
HospitalID	Int	FK	References associated hospital

Table 2: SubAdminTable

Field Name	Data Type	Field Type	Description
SubAdminID	Int	PK	Unique identifier for Sub Admin
Name	Varchar	-	Name of the Sub Admin
Email	Varchar	-	Email of the Sub Admin
Password	Varchar	-	Login password
HospitalID	Int	FK	References associated hospital

Table 3: HospitalTable

Field Name	Data Type	Field Type	Description
HospitalID	Int	PK	Unique identifier
Name	Varchar	-	Name of the hospital
Location	Varchar	-	Address or location
Contact	Varchar	-	Contact number or info

Table 4: PatientTable

Field Name	Data Type	Field Type	Description
PatientID	Int	PK	Unique identifier
Name	Varchar	-	Full name of the patient
DOB	Date	-	Date of birth
Gender	Varchar	-	Gender
Email	Varchar	-	Email address
PhoneNumber	Varchar	-	Contact number
Password	Varchar	-	Login password
HospitalID	Int	FK	References associated hospital

Table 5: NurseTable

Field Name	Data Type	Field Type	Description
NurseID	Int	PK	Unique identifier
Name	Varchar	-	Name of the nurse
Email	Varchar	-	Email address
Password	Varchar	-	Login password
HospitalID	Int	FK	Associated hospital
PatientID	Int	FK	References assigned patient

Table 6: DoctorTable

Field Name	Data Type	Field Type	Description
DoctorID	Int	PK	Unique identifier
Name	Varchar	-	Doctor's full name
Specialization	Varchar	-	Area of expertise
Email	Varchar	-	Contact email
Password	Varchar	-	Login password
HospitalID	Int	FK	References hospital

Table 7: LabTechnician Table

Field Name	Data Type	Field Type	Description
LabTechID	Int	PK	Unique identifier
Name	Varchar	-	Lab technician name
Email	Varchar	-	Email address
Password	Varchar	-	Login password

Table 8: MedicalRecord Table

Field Name	Data Type	Field Type	Description
RecordID	Int	PK	Unique identifier
PatientID	Int	FK	References patient
DoctorID	Int	FK	References doctor
Diagnosis	Text	-	Diagnosis details
Prescription	Text	-	Medications prescribed
Date	Date	-	Record creation date

Table 9: Appointment Table

Field Name	Data Type	Field Type	Description
AppointmentID	Int	PK	Unique appointment identifier
PatientID	Int	FK	References patient
DoctorID	Int	FK	References doctor
Date	Date	-	Scheduled appointment date
Status	Varchar	-	Appointment status

Table 10: LabTestTable

Field Name	Data Type	Field Type	Description
TestID	Int	PK	Unique test identifier
PatientID	Int	FK	References patient
LabTechID	Int	FK	References lab technician
DoctorID	Int	FK	References doctor
TestName	Varchar	-	Name of the test
Date	Date	-	Test date
Status	Varchar	-	Test result status

3.12 Program Module Specification

The CPIS is structured into multiple program modules to support effective healthcare data management and interaction among users. Each module is designed to handle specific operations based on user roles and functional requirements. Below is the specification of key modules:

- i. Authentication Module
 - a. Purpose: To validate and authenticate users based on their role and credentials.
 - b. Functions:
 - Login and logout for Super Admin, Sub Admin, Doctor, Nurse, Patient, and Lab Technician.
 - Password encryption and verification.
 - Role-based redirection upon successful login.
- ii. Hospital Management Module
 - a. Purpose: To allow Super Admins to manage hospital information.
 - b. Functions:
 - Add, update, and delete hospital records.
 - Assign Sub Admins to hospitals.
 - View registered users within a hospital.
- iii. User Management Module
 - a. Purpose: To manage users including doctors, nurses, patients, and lab technicians.
 - b. Functions:
 - Registration and profile management.
 - Assigning patients to nurses and doctors.

- Viewing user lists and details per hospital.
- iv. Appointment Management Module
 - a. Purpose: To make it easier to schedule patients and track appointments.
 - b. Functions:
 - Patients may request visits with doctors.
 - Doctors can approve or reschedule appointments.
 - Display of appointment status (Pending, Approved, Completed).
 - v. Medical Record Module
 - a. Purpose: To manage and store patient medical records.
 - b. Functions:
 - Doctors can add, update, and view patient medical records.
 - Records contain diagnosis, prescription and treatment history.
 - Patients and authorized personnel can view records.
 - vi. Lab Test Management Module
 - a. Purpose: To manage the testing and reporting of lab results.
 - b. Functions:
 - Lab technicians can record and update test results.
 - Doctors can request tests for patients.
 - Test status tracking and historical test data viewing.
 - vii. Notification and Communication Module

- a. Purpose: To promote internal communication and notify users of must-know events.
- b. Functions:
 - Notify users of upcoming appointments, test results, or updates.
 - Messaging between patients and assigned medical staff.
- viii. Security and Access Control Module
 - a. Purpose: The purpose is to maintain data security, data privacy, and role-based access.
 - b. Functions:
 - Role-based access permission to view and edit data.
 - Logging user activity and system access.
 - Enforcing data encryption for sensitive information.
- ix. Reporting and Analytics Module
 - a. Purpose: To generate statistical and analytical reports.
 - b. Functions:
 - Generate reports on appointments, patient counts, test results, and system usage.
 - Dashboard for visual representation of key metrics.

3.12.1 Input Design

- i. User Identification Details:
 - a. Description: Unique identifiers provided by users to recognize their identity, such as username or patient ID number.
 - b. Format: Alphanumeric string (e.g., username or ID number).
 - c. Source: User entry via the user interface module.
- ii. Patient Health Data:
 - a. Description: Information related to the patient's health including medical history, symptoms, results from laboratory tests and lifestyle information.
 - b. Format: Numeric fields for which value is reported (e.g., blood pressure), or value reported is a number (e.g., age, weight, height), or value reported can be mapped on to a numeric type, etc. – Alphanumeric fields.
 - c. Source: Data entered by patient input via questionnaires or health surveys.

3.12.2 Output Design

- i. Clinical Report Generation:
 - a. Description: Condensed reports with the patient's health data, diagnosis, treatment background, patient's clinical data and recommendations results.
 - b. Format: Interactive HTML report, organized by section headings for patient information, diagnosis, treatment plans, and follow up care instructions.
 - c. Destination: Stored in the database and available for reporting.
- ii. System Alerts and Notifications:
 - a. Description: Alerts about abnormal patterns, critical health conditions, or any other anomalies that need urgent attention.
 - b. Format: Visual alerts in the form of color-coded notifications
 - c. Destination: Displayed on the user interface and recorded in the system logs.
- iii. User Interface Feedback:
 - a. Description: Responses and status updates are provided to users through the user interface.
 - b. Format: Textual or visual feedback (e.g., messages, alerts).
 - c. Destination: Displayed on the user interface to inform users of actions or statuses.

IV. RESULTS AND DISCUSSION

4.1 Program Testing

Program testing is important to verify the reliability as well as the correctness of the system. A structured methodology has been used, and that covers desk checks, unit tests, and integration tests.

4.2 Interfaces of the Centralized Patient Information System



Figure 7: Default Interface

Figure 7 shows the Default Interface of the Centralized Patient Information System which is the primary entrance to the system. It offers users an easy to user friendly and straightforward interface that comes with login option for various user roles including Super Admin, Sub Admin, Doctor, Nurse, Lab Technician and Patient. Its user interface was made to be user-friendly featuring labelled buttons and a secure log in section with Multi-Factor Authentication (MFA) support. It is all well and responsive designed, making desktop and mobiles browsing a pleasurable experience with high security standards of course.

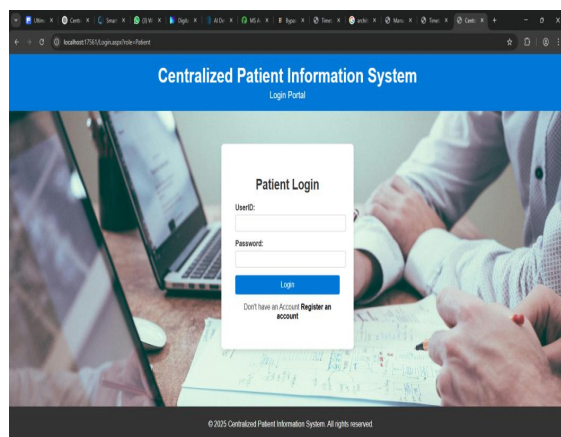


Figure 8: Login Interface

Figure 8 shows the Login Interface to the Centralized Patient Information System, here users login to access systems with their assigned roles. Users log-in with their credentials of choice which are normally a userID (Auto generated IDs or Phone Number or Email) and a password. This adds a layer of security

to the system by allowing access to sensitive health data only to the individuals who are authorized. Clean and responsive with well-defined input fields and role options, Kiwi's design offers an excellent authentication process for doctors, nurses, lab tech or any other medical professional and patient.

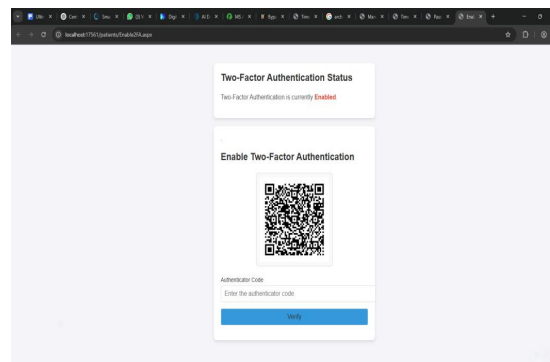


Figure 9: Multi-Factor Authentication Interface

MFA interface of the Centralized Patient Information System is shown in Figure 9. So, when a user login with their proper credentials, Small tokens to be used Such as OTP (One Time Passcode). This would be their phone serving authenticator. This extra security measure helps to ensure that the right person is accessing the data, helping to protect valuable medical information from unauthorized access. The interface is intuitive, with simple guidance and holds that support the system's rigorous data protection and user trust principles.

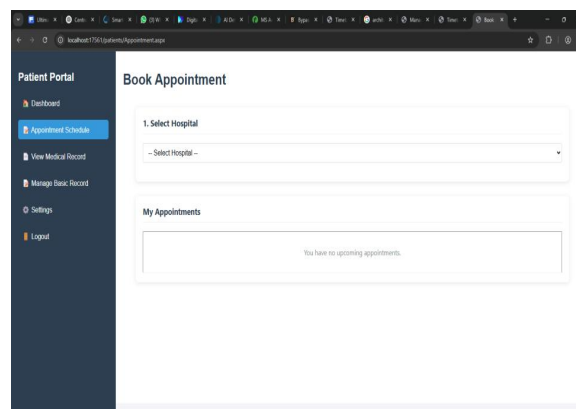


Figure 10: Appointment Scheduling Interface

Figure 10 shows an Appointment Scheduling Interface of the Centralized Patient Information System. Patients can schedule, check, or cancel appointments with doctors from this interface. With a simple and humanize UI, Users can choose date, time and service department easily. Through the UI, patients and providers are seamlessly connected

which minimizes waiting times and improves the efficiency of services. The instant scheduling updates and confirmation notifications support the keeping of an orderly and timely appointment schedule.

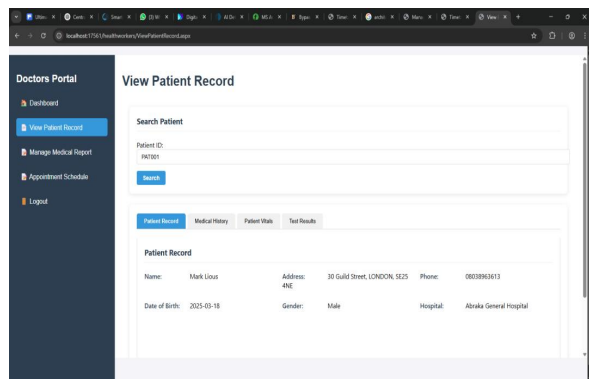


Figure 11: View Patient's Medical Record Interface

Figure 11 shows the View Patient's Medical Record Interface provides a means for authorized users (doctors, nurses, and patients) to view well-didactic medical history. This is an interface that shows vital information relative to patients' health such as former medical conditions, medications, lab reports, and proposed treatments. It is designed to be intuitive and make navigation straightforward, making finding patient data simple and fast and helping the user to make informed clinical decisions. Built-in access control makes sure that confidential information is kept safe from unauthorized access by only allowing the data access rights to users with appropriate access privileges.

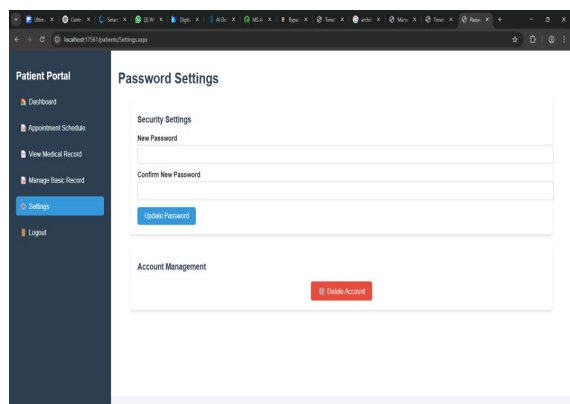


Figure 12: Password Settings Interface

Figure 12 shows the Password Setting Interface- The Password Setting Interface is presented so that user can securely update their login information. It also allows changing and resetting of passwords, which is part of the system's security measures to

keep privacy-protected health information safe and secure. It includes validation checks to require strong passwords and may add validation methods such as current password confirmation. With usability in mind, the tool enhances system security and offers users a simple way to adjust their authentication settings.

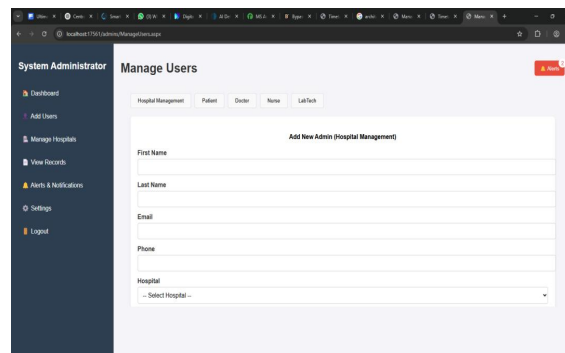


Figure 13: Users Account Management Interface

Figure 13 shows the Users Account Management Interface, which is mainly used by an Administrator/Admin interface or subadmin. This interface provides functionality to add, update, enable, disable and delete users such as doctors, nurses, laboratory technicians and patients. It provides role assignment using Role-Based Access Control (RBAC) in order to accumulate permission on each user. Usability and security of the developed solution are focal points, aiding effective user management and facilitating management of the system environment within the health-care domain.

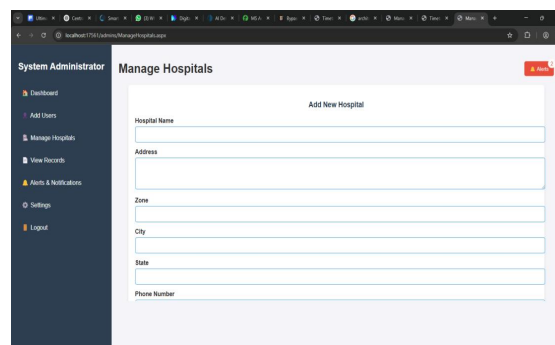


Figure 14: Hospital Management Interface

The sub-admins or the hospital management team access the Hospital Management Interface, as shown in Figure 14. This provides the administrative interface to add and remove Hospitals to the Centralized Patient Information System. It is an enterprise-level control center that augments coordination, maintains policy enforcement and

facilitates smart decision making for the hospital's digital infrastructure.

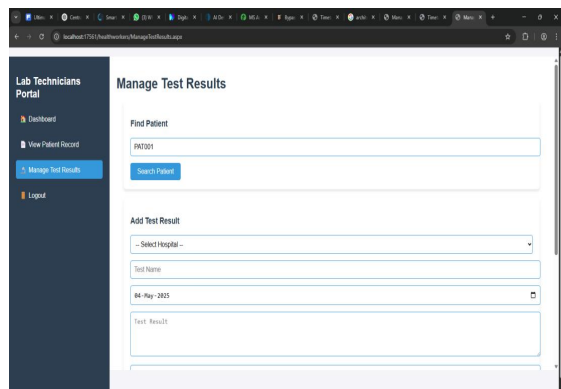


Figure 15: Manage Test Result Interface

Figure 15 shows the Manage Test Result Interface, which is mostly employed by lab technicians and doctors in the Centralized Patient Information System. With this interface, lab technicians can upload, update and review diagnostic results. Lab technicians are able to enter test data, while doctors can consult and interpret results in order to make informed medical decisions. The user interface guarantees that findings are correctly associated with the right patient history, enables dynamic updates, and enforces data privacy by imposing controlled access to the data.

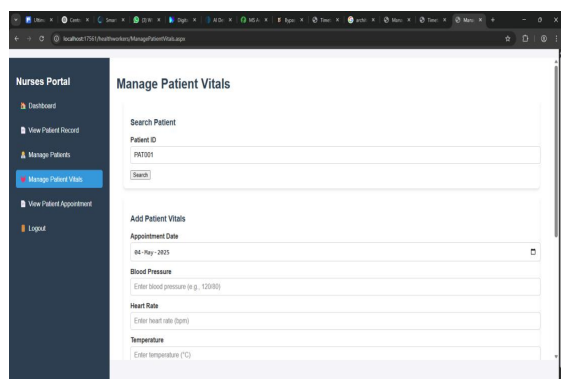


Figure 16: Manage Patients' Vitals Interface

Figure 16 shows the Manage Patients' Vitals Interface. This interface is created for nurses or healthcare professionals to enter, edit, and check the vitals of a patient: blood pressure, temperature, heart rate, and respiratory rate. This is an interface that provides both real time input of data and a real time visualization, enabling a fast response to any changes in a patient's condition. It provides accurate tracking across time and guarantees the continuity to always

keep essential information up to date and stored securely to support clinical logic and patient care.

IV. CONCLUSION

5.1 Conclusion

The developed Centralized Patient Information System implemented in this research paper overcomes the problem of the fragment and unproductive way of processing of the healthcare data. The system joined multiple user roles with secured access via Multi-Factor Authentication (MFA) and Role-Based Access Control (RBAC) to guarantee privacy, integrity, and operational capacity of data. The platform integrates with EHRs and empowers healthcare providers in accessing patient records in real-time and supports healthcare providers in easing administrative workflow and patients in meaningful data interactions with their health records. On the whole, the system improves the efficiency of operation, assists in clinical decision making, and contributes to a more connected and reactive health care system.

5.2 Recommendation

AI in centralized Patient Information Systems for predictive diagnosis, telemedicine for remote assistance, and IoT for real-time healthcare reporting would be the key in the next. The whole system could be made even more secure by the blockchain with taint-proof records and biometric access to the market to carry out all operations securely. Integrations with national health systems (HL7, FHIR) will allow automatic and frictionless data transmission, and automation of workflows and medication alerts will improve hospitals' operation and guarantee patients' safety. These efficiencies will help the system overall to be more robust and scalable.

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