# GETTING TO REQUIREMENTS: THE CASE OF A HOSPITAL INFORMATION SYSTEM

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# 1. Introduction

This section provides an overview of this document, which is about the Hospital Information System (HIS) designed especially for Thai Hoa Clinic. Thai Hoa Clinic is a large and well-known clinic in Ninh Thuan province, Vietnam. It is transforming into a hospital over the course of the next year, with a focus on providing full health care services to Ninh Thuan residents and Vietnam citizens. In addition, Thai Hoa Clinic specializes in Internal Medicine, with many experienced and popular internists in Vietnam, including Dr. Thai, the owner of Thai Hoa clinic.

One of the biggest problems that the clinic is currently facing is insurance transaction errors. The current HIS software used by the clinic does not provide adequate features for insurance transactions. Due to the lack of features and business disagreements, the contract between the clinic and the software company has ended. Thus, the current HIS software in the clinic is outdated, not supported, and causes many errors of information, especially during insurance transactions.

Insurance transactions are a key business aspect of the clinic. Sixty percent of the clinic's profits come from patient insurance. Thus, the new HIS is designed to improve the clinic's performance and insurance processes with automated applications like billing and payment, patient resources, patient care plans, and more. The applications will have rich features for insurance transactions. The HIS application will be used by administrators, doctors, and other clinic staff members.

The system is divided into two sub-systems: Patient Information System (PIS) and Management Information System (MIS). The PIS is designed with regular applications and sub-systems that are used daily for basic functions of the hospital, like patient registration, storing patient information, insurance transactions, diagnostics, and more. The MIS is used for business management, like financial management, managing providers of hospital services, and the physical facility.

Moreover, designing an HIS application is much more than just programming and installing software. It is about designing a whole system with many considerations such as the usefulness of the system, information security, the organization's culture, patient impacts, and more. Thus, many aspects and knowledge must be covered in the project such as, data analytics, cyber security, strategic

management, enterprise system, and more. In addition, this document will provide and discuss insights, information, fundamentals, and methods used for designing the HIS and applications. It will also address project management, using IDE and database, etc., as well as cloud computing. A great amount of crucial information is needed to design a HIS application, or any other applications. This document will outline the requirement specifications of the project.

## Purpose and Scope of this project

The purpose of this project is to define the requirements of the HIS along with its sub-systems such as, PIS, MIS, financial & budgetary system, clinical information system, administration system, human resource system, etc., with the focus on insurance transactions. In addition, the management information system which is used for business purposes will be discussed briefly in this document. However, the PIS will be discussed in detail with the billing & payment application which is used to improve the quality of patient care and solve the insurance transaction issues. In this document, the user scenarios/use cases are also considered together with functionalities of the application. After the purpose and scope of this project are defined, general information about the application will be provided with product context, user characteristics, constraints, dependencies and more. This document is used as a foundation in the design process of the HIS product. It will be used to manage, verify, or apply changes to the HIS products in the future.

The primary audience of this specification is a developer/development team employed by Dr. Thai, the owner of Thai Hoa Clinic. In order to assist with the interaction between the developer and stakeholder, the document provides an extensive capacity for the project planning and progress assessment since it is used as a framework to design the HIS. The second audience of this specification is Dr. Thai and other stakeholders, such as sponsors and associated staff members. This specification should be presented to and approved by this audience before the implementation process begins.

The new HIS application will be used for the following:

- Managing clinic information (including inpatient and outpatient information)

- Managing insurance transactions
- Managing business information (human resource, payroll, administration, etc.)
- Collaborating between departments
- Managing all clinical documents
- Managing clinic supply
- Improving quality care for patients: tracking doctor's decisions, and using patient data to predict patient behaviors and potential disease to provide the right treatment for patients

The purpose of this document is to introduce the specific requirements of the system, and to demonstrate how the HIS application solves the problem of managing insurance transactions for the clinic.

**In Scope**

There are two sectors of requirements for this project: Functional requirements and non-functional requirements. The functional requirements are technical requirements that are needed on the application, such as features or functions. Each requirement will have unique functionality that is used to solve the clinic's problems or improve clinic performance.

Non-functional requirements are "soft skills" that are developed to make the application usable, reliable, and more friendly with users. In addition, it also requires the application comply with government regulations and policies to make sure the clinic can use the HIS application legally.

<u>Functional requirements of the HIS application:</u>

- System management (manage users and system configurations)
- Patient information management (inpatients and outpatients)
- Pharmaceutical management
- Electronic Medical Records (EMR)

- Management of insurance transactions
- Management of hospital supplies
- Ability to view and track doctor's decisions
- Ability to manage appointments and scheduling
- Billing and financial management
- Management of employee information, including doctors and nurses
- Laboratory management
- Statistic and reports management
- User friendly

Non-functional requirements:

- Provide support services
- User documentation
- Sufficient IT staff to manage the system
- Complied with regulations and policies from the government
- Information security management
    - Patient Identification: Be able to recognize patient identity when they are using different devices to log in, and warn them when their account has been used on unfamiliar devices
    - Login ID: Any users who make use of the system need to hold a Login ID and password
    - Modification: Any modifications like insert, delete, update, etc. for the database can be synchronized quickly and executed only by the ward administrator
    - User rights: Front desk, administrator, doctor, etc.

- System performance
    - Response time: The system provides acknowledgment in just one second once the patient's information is checked
    - Capacity: The system needs to support at least 90% of employees in the clinic
    - User interface: The user interface acknowledges within five seconds
    - Conformity: The system needs to be easy to use and can run on various operation systems (OS)
    - Stable: 99.9% - 99.99% uptime. The hospital operates 24 hours per day, and every day all year, so the system should work constantly and should not fail.
- Maintainability
    - Back up: The system offers the efficiency for data backup
    - Errors: The system will track and keep a log of every mistake
    - System log: A system log will be generated for every activity on the system

**Out of Scope**

Additional features could be used to upgrade the HIS and make profits for the clinic. However, due to the budget and time constraints, the following items are out of scope for the application at this time:

- Required password change every 60 days for associated staff and management team
- Two step verifications
- Ability to extend and be integrated into other systems
- Use of cloud technology for the database

# 2. System Architecture

This section will describe the fundamental organization of the system embodied in its components and standards, governing its design and evaluation. It will be used like a plan or blueprint that includes

all the required components and principles applied to design the system. In addition, the Information Technology (IT) infrastructure of the hospital will be discussed generally in this section.

## *2.1 Functions of The System*

The Hospital Information System is a software application that is used to manage and improve the working processes, as well as the patient care quality, of the clinic. A clinic system is very complex and contains many different components, like functions of healthcare facilities and capabilities of information technology. The HIS is used as an integrator of all these components by enabling the collection, storage, and sharing of information. The scope, content, and system structure are used for many different functions. The system contains a set of sub-systems and applications that maximize the user information and communication technology in order to facilitate the quality of services in the clinic.

HIS is a sophisticated system that is used for big facilities like hospitals. It involves many operations, sets of sub-systems and applications. Thus, the system needs to meet the following objectives in the designing process: productivity, effectiveness, appropriateness, efficiency, quality, safety, and privacy and confidentiality of information.

## *2.2 Components of The System*

The system will be built around a multi-tiered client-server Local Area Network (LAN) architecture. The users will enter and retrieve data from clients' computers and display monitors and data input devices such as keyboards and mouses. They could also get various applications from the application server and store the data by the storage server into devices like hard disks. All the tiers are connected by cables through switches and routers. In addition, the management application server is used for the MIS. The business owner, CEO, or managers could use these applications to manage the human resources, hospital supplies, or to make business decisions. A part of the network could be wireless. Below is the HIS structure diagram (Salleh, 2021):

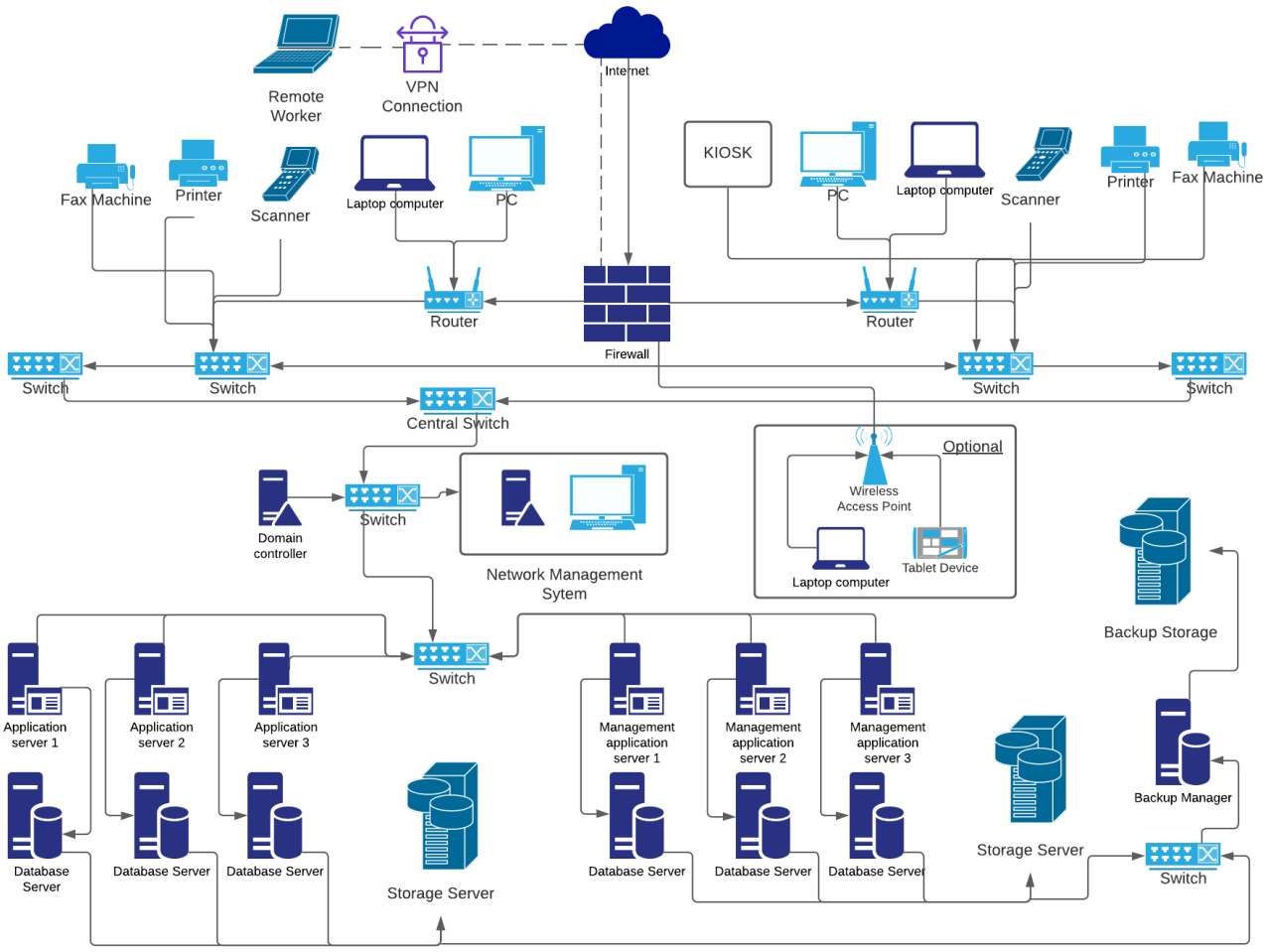



Figure 1. HIS structure diagram.

The computers, like laptop computers and PCs, are called as client in term of communication with servers. They provide the interface between the user and the system. Thus, it needs to have:

- A sufficiently fast processor
- A sufficient Ready Access Memory (RAM)
- A display monitor for viewing data and applications
- Peripheral devices like keyboard, bar-code reader, scanner, mouse, etc. for data input
- A front-end Operating System (OS) that allows all the applications run on the hardware and to facilitate with the servers
- Video/graphic cards in case the computer is used to process complex images

In general, a computer with a high-end Central Processing Unit (CPU) and sizeable memory is preferred for use in the system. The computer will be connected to the network through suitable cables and wireless connections. There are two types of clients in the HIS, thin client and thick client. Thin client is software that is primarily designed to communicate with a server. On the other hand, thick client is software that implements its own features. Since thick client stores and accesses all the necessary data and resources directly from the local drives, it could remain functional when disconnected to the server (Salleh, 2021).

Because of the client's characteristics, there are two approaches when setting up the system: thin client approach and thick client approach. In the thin client approach, the client is loaded only with a browser. All the applications are retrieved from the application server when needed. In this approach, lower CPU can be used, and less RAM is required. However, it is not a reliable way to set up the HIS, due to the large number of transactions, work, and image processing required for the system. Thus, thick client approach is usually used to set up the HIS. In thick client approach, faster CPU and sizeable RAM is required for client computers. They are loaded fully or partially with application software. Both approaches are used in this project (Salleh, 2021).

Each client can be used for different PIS and MIS applications such as office automation, email, image viewer, dashboard report, etc. In addition, the system will have an option to adopt web technology within the local area network. Similar to thin client, a web client will be used to host the browser. When a care provider requires an access to HIS via clients at locations outside of the hospital, it will be connected to the hospital's LAN through a secure network like a Virtual Private Network (VPN).

Moreover, the application server is connected to the database server for both the PIS and MIS. These database servers will be connected to a storage server. The storage servers need to be able to cater to both the PIS and MIS applications to keep the HIS running constantly. Also, in order to keep the uptime of 99.99% for the HIS, the applications need to be duplicated to make it available at all times and ensure that data can be saved without interruptions. It will give the system the ability to function if one part fails. That is called redundancy. In addition, both applications and database servers must have

sufficient processing power and memory in case of heavy data traffic caused by numerous users requesting data at a same time. The data required is usually great and a large amount of data accumulates over time, so the storage devices need to have a large storage space and be able to accept and release data efficiently (Salleh, 2021).

A Domain Controller (DC) is a server that validates user access and verifies authentication requests on a computer network. It helps to organize users and computers that work together on the same network. Thus, it keeps all the data organized and secured. It is also used to detect cyberattacks in process. Attackers usually try to gain elevated access to networks, and they often attack the DC to do that, so the DC is used as a detecting tool for cyberattacks. In addition, the primary function of the DC is to authenticate and validate users' access on the network. It will check the username, password, and other credentials when users try to login to their domain. A DC is very important, especially in terms of information security, because it contains everything that could be used to cause massive damage to the data and network system during a cyberattack. In addition, the DC may reside on a separate computer (stand-alone) or within the main server, but it needs to be placed between the front end and the main servers, such as application servers, database servers, and storage servers. Together with a set of network applications, it will create a network management system (Petters, 2020).

Moreover, like DC, there are many different domains that are used for the protection of the HIS. The system is used for day-to-day operations. Thus, copies of applications and systems need to be provided for other uses. Alternative versions of PIS applications and databases are often called domains, such as production domain, analytical domain, test domain, and more. To protect the HIS, a backup manager and backup storage are also needed. A backup manager is used to schedule, manage, and operate data backup processes on the database server and application server. It is an integrated application that is installed on each computer or server that requires backup and provides duplication, compression, and other operations. The backup data will be stored on backup storage by using backup manager to enable and send data from client devices based on predefined schedules or manually. The backup manager is used for disaster recovery operations (Techopedia, 2019). Domains

are created strictly for IT managers because of the critical and sensitive nature of the stored information in these domains. Privileged access is separated based on job category and individual person. System administrator staff roles, permissions, and activity tracking will be used to track and protect against unauthorized network configuration changes to avoid the risk of leaking data or compromising the system (Salleh, 2021). By doing that, the system is able to comply with hospital regulations and policies in Vietnam, similar to HIPAA and PCI in the United States.

## *2.3 Database Management*

Database management is one of the critical requirements for the HIS. Without data, none of the applications will work properly. In addition, the biggest advantage of database management is that the storage of data in a database with relevant data can be extracted and manipulated to create views and reports for specific purposes.

The package of applications and databases needs to be evaluated to determine the suitability for use before making it available on the system. The data needs to be stored in a designated database. The data structure will be formulated by defining entities, relationships, and naming of data elements, including possible values attributed to each data element. Using a unique name for the clinic is also important in the database. Common names that are used for the hospital database include: services, locations, care provider categories, visits, encounters, and events. The standard nomenclature that is accepted universally, such as Snomed CT, LOINC, or ICD 10 Classification of Diagnosis, is used for variable data to facilitate data sharing and data analysis. Below is the database capabilities diagram (Salleh, 2021),

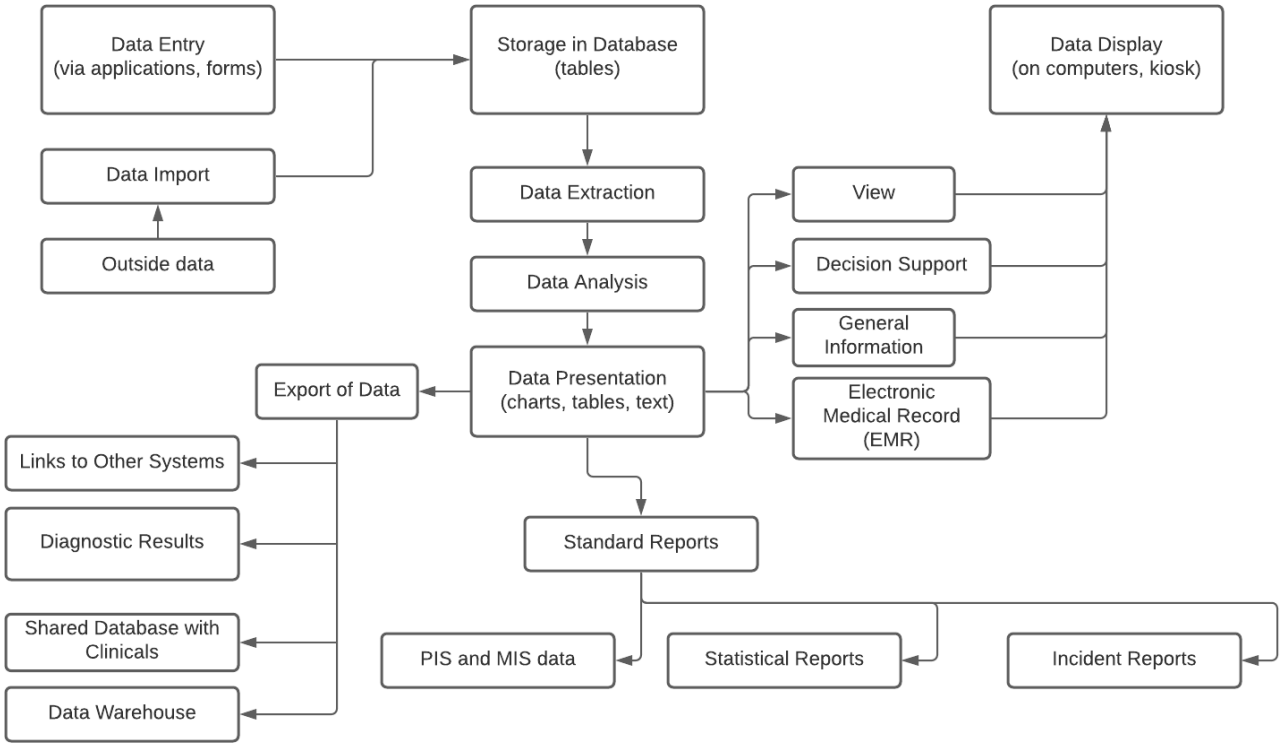



Figure 2. Database Management Capabilities Diagram

## *2.4 Assumptions*

Below are assumptions for the system:

- Mobile devices are already installed in the clinic
- The clinic already has a website
- The clinic already has some employees who are partly to highly skilled users
- The target hardware will provide a capacity for stand-alone program/application deployment and will not require customized embedded firmware to be written
- Tablet PCs /mobile devices with sufficient processing capability and battery life will be utilized
- The deployment environment is capable of supporting an IEEE 802.11 wireless network for system communication
- All the hardware and software resources are provided

These assumptions are critical for preventing errors when experts implement and run the system. The clinic needs to have mobile devices installed with sufficient processing capability and a good battery life in order to test the system on these devices. In addition, the system is an integrator of many sub-systems and applications, including the clinic website. Thus, the clinic needs to have a website in place. When performing the testing and implementation of the system, the clinic should have some partly to highly skilled users to do the tests and troubleshoot the system errors if needed.

Moreover, all the hardware like kiosk, PCs, printers, etc. need to have a capacity for stand-alone program/application deployment and should not require any customized embedded firmware to prevent any conflict between the system with third-party software or firmware. Some parts of the system could be wireless, so it is required that the deployment environment be able to support an IEEE 802.11 wireless network for system communication.

## *2.5 Constraints*

The HIS application is written in an object-oriented language with strong Graphic User Interface (GUI) links and a simple, accessible network API. The primary options of written language are Java, JavaScript, C#, or Python. The system should be able to provide parallel operations without any scalability issues regarding the number of mobile devices connected at any given time. The system must be able to allow seamless recovery, without data loss due to the failure of individual devices. It must have a strong audit chain with all system actions logged. One of the application's criticalities is that it should be reliable and glitch free. Since the system is live (on website and kiosk), patients must not notice if the system is down because of its quick recovery. The HIS is a hospital system, so another criticality of the system is that the design should be easy to use and make users, such as front desk staff, doctors, and nurses, feel comfortable and able to use available resources to perform their tasks (Salleh, 2021).

## *2.6 Dependencies*

Below is the list of dependencies that affect the requirements:

- The application will require access to updated information for patients and associated staff from a database
- A database that contains information about services, drugs, supplies, or any changes of the clinic, needs to be built before the system
- A test plan for the software needs to be created before the implementation process
- A plan for how to conduct/deliver the system needs to be created before starting the project
- The clinic already has some software and hardware resources that meet these requirements:
    - A sufficiently fast processor
    - Sufficient ready access memory (RAM) to retain data temporarily while being viewed or entered
    - A display monitor for viewing both applications and data
    - Data input tools such keyboard, touch screen, bar-code reader and image scanners, and pointing devices
    - A front-end Operating system (OS) that allows all the above hardware to function and to facilitate interaction with the server
    - Video/graphic cards for locations where complex images are used

The system will rely on the above dependencies in order to perform its functions properly. There are many factors that could affect the system such as the database, test plan, software and hardware, and more. A database is one of the most important components that is required for the HIS. Without the database, the HIS is just an application that cannot operate fully. Thus, it needs a database that contains all the information about patients, associated staff members, clinic supplies, and any other related information.

Before implementing the system, a test plan needs to be created with steps and procedures for how to test and install the application properly. In addition, a plan for how to deliver the system should be created before starting the project. Last but not least, the capabilities of the software and hardware are also important to the system. The system needs to be installed on software and hardware that meets certain requirements.

# 3. System Characteristics

The Software Development Life Cycle (SDLC) is used for designing the system. There are six phases of the SDLC: planning, analysis, design, implementation, testing & integration, and maintenance. Due to the time limit and purposes of the course, only phase one, two, and three will be applied and discussed in this document. The requirement analysis is conducted during the first phase of the SDLC – Planning. It is a process of gathering requirements and information from business partners, owners, and different departments in the clinic to make a plan for approaching the project with the best interest to operations, quality, economic and technical areas. In addition, quality assurance requirements and risk management will be created at this process.

During the second phase of the SDLC, analysis, all the collected data, including requirements and related information, is analyzed, defined, and documented as the product requirements. The deliverable of this process is the Software Requirement Specification (SRS) document. The document has to be signed off by the owner at the end of this phase. Moreover, the next phase is designing the project. Once all the requirements have been signed off by the owner, the project will be moved to the designing phase. All the technologies, methods, strategies, software and hardware will be considered to use for designing the project to meet the requirements. In addition, during the design process, system architecture, system characteristics, system integration, security information, and other related design requirements will be listed and explained (Langer, 2018).

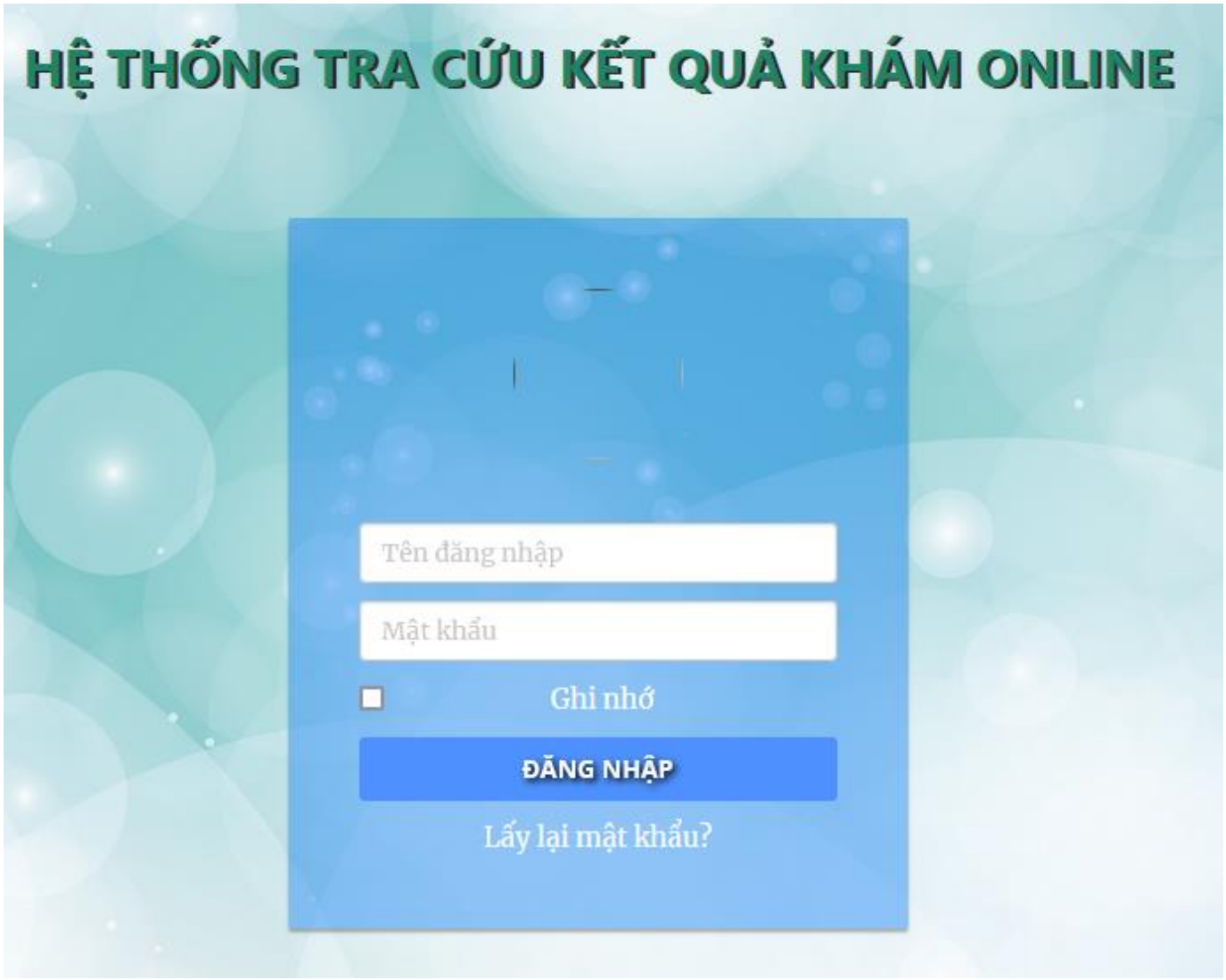
## *3.1 User Characteristics*

User characteristics are also related to the system characteristics and need to be considered when designed and implemented into the system. Since the system is designed based on the clinic operations and to solve the insurance problem, people are an operational key of the system. There are three types of user characteristics: unskilled user, partly skilled user, and highly skilled user. Below is general information about each type of user:

**Unskilled User – Walk-In Patients**

Kiosks are available at the hospital for patients to check in and view general information about their profile. It is assumed that these patients have no relevant prior skills or education about the system, other than basic abilities to operate an automated system. Therefore, this part of the system needs to be designed simply, like other automated public systems such as vending machines.

In addition, a patient portal on the clinic's website will be available for patients to get their diagnostic results, or any related documents, when needed. The information on the patient portal will be represented in a simple/easy way, so that even a patient with minimal knowledge of technology can understand. Below is a sample of the log-in screen for the patient portal on the clinic's website:



**Partly Skilled User – Associated Staff, Doctors, Nurses, Front Desk Clerks**

Associated staff members, including front desk workers, nurses, or doctors, should be able to use the HIS application features that pertain to their access permission. All the common actions like add, delete, edit, and save information should be performed promptly. There are some restrictions for all of these actions (add, delete, edit, save). For example, there are some types of information/data that can only be changed by IT administrators, the CEO, or personnel who has executive access level. Depending on the access level of the staff, some actions will not be available to their account like delete or edit. Moreover, the staff should be able to reset and restart the application on their computer, if needed. Certain doctors will be assigned as editors to manage some portions of the system, including information for their department. This class of user would be expected to have at least a high school degree in the case of staff members, an associate degree in the case of nurses, and a medical degree with some experience in the case of doctors.

**Highly Skilled Users – Management Team, C-suit, The Owner, IT Manager, and Specialty Consultants**

The management team, such as C-suite, the owner, IT manager, and specialty consultants, should be able to review, edit, and control the system related to their permission rights. The owner and IT manager should have the highest permission rights within the system. IT staff should be able to perform installation and configuration of hardware and the constituent HIS components (servers, mobile devices, network devices). IT staff should not be able to change patient data. The software should be easy to install and update with provided user documentations and related resources.

## *3.2 User Interface Requirements (UI)*

Like user characteristics, the user interface is one of the system characteristics that relates to how the system is being viewed and used by the users. The system needs to be designed as user friendly and must have an attractive interface.

Since the clinic is based in Vietnam, the interface of the application will be in Vietnamese. The hospital systems in Vietnam are only slightly different than from hospital systems in the U.S., so the HIS applications will be similar to other HIS applications found in the U.S.

**Non-remote device UI:**

The non-remote computer UI is the interface used by associated staff and patients (at the kiosk). It can be used by the manager, if needed. Located on the kiosks, the touchscreen interface is mainly used for interactions between patients and the machine. It allows patients to interact with the machine using their finger. Patients can use the kiosk to check in and view their profile information. A monitor feature will be added to the application to track patient's requests for assistance. The staff members can use either the physical keyboard or screen keyboard to assist patients. At the bottom of the virtual keyboard, an option box for using a physical keyboard will be provided. In addition, an assistance request option is provided within the application, so the staff could use it to request help from a manager. The touchscreen and keyboard will be cleaned and sanitized at the end of every day. An automatic hand sanitizer dispenser will be provided next to the kiosk for the patient's convenience.

In addition, specific computers are used by staff members for registering patients, checking information, managing transactions, ordering supplies, and more. It is a thick client, and all necessary applications are installed fully or partially on these computers. The patient application will be installed in these devices as well, but it will require authority credentials from associated staff members to open. It has a hardware and software capacity to handle a large number of transactions.

**Remote device UI:**

The remote device's UI is designed to run on a small, wireless-enabled touch screen tablet or iPad. A laptop could also be used as remote device. It is used by manager to view and manage the system process. Control and manage applications will be installed on these devices, and it will require credentials from an authorized IT manager to open. Privileged access will be given based on people's credentials.

**Online UI:**

The clinic website is the online UI. It is mainly used for patients, but not restricted to staff. On the website, patients have more options to make appointments, view their diagnostic results, update their profile information, and more. The interface is designed simply, so that users only have to point and select interface. It allows users to interact with the content of the application running on a remote server through a Web browser. The content of the Web page is downloaded from the clinic server and the user can interact with this content. Any input information from patients will be transferred back to the server after being optimized by the application

## *3.3 Performance*

### 3.3.1 Capacity

- 99% of the system shall be working properly regardless of the number of devices (remote and non-remote) or patients using the application at the same time.
- 99% of the system shall be working properly regardless of the number of simultaneous users to be supported.
- 98% of the transactions shall be processed in less than five second.
- 100% of the hardware devices (remote and non-remote) shall be able to run the applications as a standalone application, and not require installation of any customized embedded firmware.
- 90% of the hardware devices (remote and non-remote) shall be able to perform and run without charging for at least 6-8 hours.
- 99% of hospital servers shall be able to support no less than 500 concurrent connections from physical and online users.
- All the collected information will be “renewed” every 6 months to a year from hospital servers.

### 3.3.2 Availability

- Hours of operation: 24/7.
- Level of availability required: High.
- Coverage for geographic areas: Online platform – Globally.
- Impact of downtime on users and business operations: 90% of the system shall be able to recover in as quick as 10 seconds in the case of incidents.
- Impact of scheduled and unscheduled maintenance on uptime and maintenance communications procedures: 80% of the system shall be able to perform its functionalities.
- Reliability (e.g., acceptable mean time between failures (MTBF), or the maximum permitted number of failures per hour):
    - At least half of hardware devices should be available to managers and staff in case of hardware failure.
    - Redundant servers need to be used in case of failure, downtime, or excessive traffic at the primary server.

### 3.3.3 Latency

The maximum acceptable time (or average time) for a service request: 5 minutes.

## *3.4 Manageability/Maintainability*

### 3.4.1 Monitoring

Any requirements for product or service health monitoring, failure conditions, error detection, logging, and correction is provided below:

- The system shall be able to be monitored by authorized personnel of the clinic.
- The system shall be able to detect any errors during transactions.
- The system shall be able to log every state of changes and be able to recover from system failure.

### 3.4.2 Maintenance

- The system shall be able to restore itself to its previous state in the event of failure (power loss or system crash.)
- The system shall be able to keep the transactions between hardware devices with servers in 20 seconds to monitor the device's operation status.

### 3.4.3 Operations

Below are some normal and special operations that are required by the users:

- The system shall provide reasonable time for interactive operations.
- The server shall be able to operate unattended indefinitely; it will not require physical interaction except for upgrades and failure of hardware elements.
- The collected information shall be able to transfer to clinic servers without any interruption.
- The system shall provide support options for users and associated staffs (contact with administrators).
- The system shall backup its data weekly.
- The system shall be able to recover in the event of failure.
- The database management system (DBMS) shall be able to handle the backup and recovery process with the operating system, or external software running on a timed backup system.

# 4. Scope, Content, and Relationship of the System

The PIS contain various systems such as Patient Management System (PMS), Clinical Information System (CIS), and Clinical Support System (CSS). Below is the relationship diagram of the HIS (Salleh, 2021),

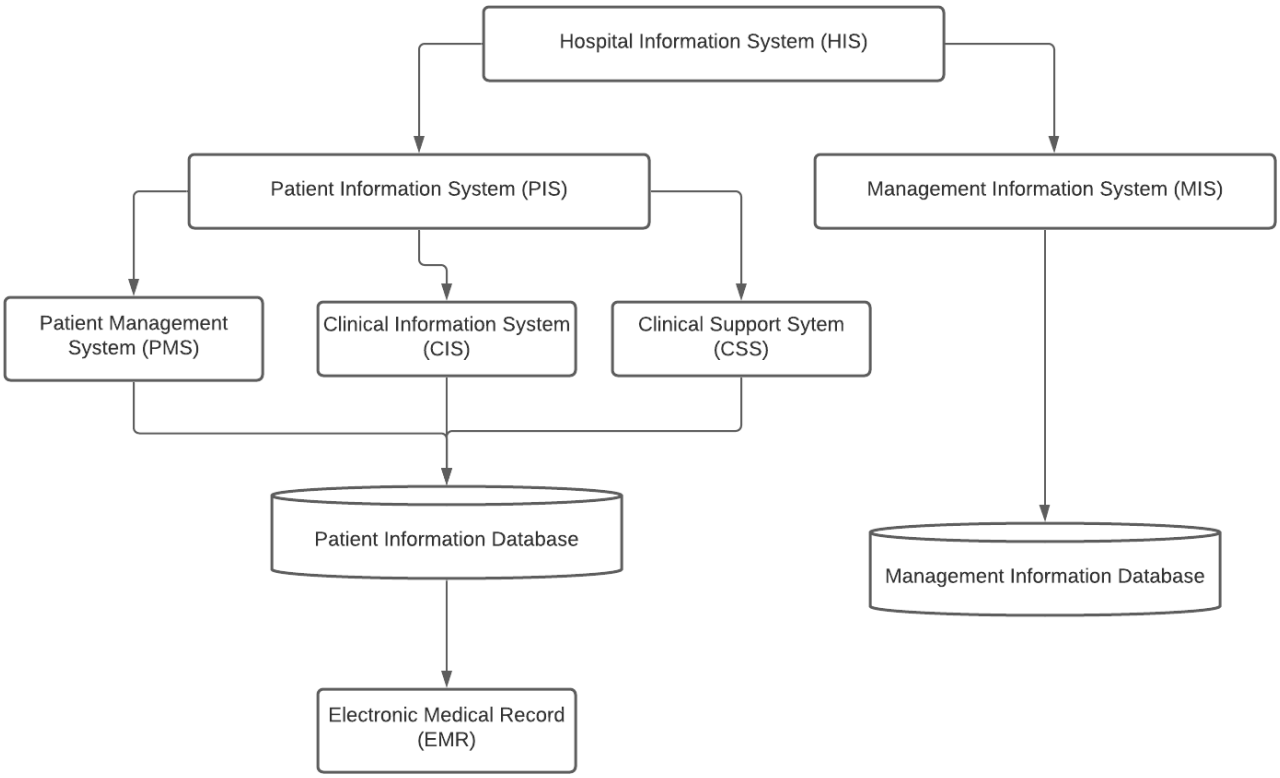



Figure 3. The sub-systems in HIS

The Clinical Information System is an Information System (IS) that is mainly used for patient care activities such as diagnostics, X-RAY, medication orders, Magnetic Resonance Imaging (MRI), etc. The system will be used by doctors, nurses, therapists, clinical pharmacists, optometrists, and many other types of doctors. The CIS will contain modules that will help the doctors and other clinicians perform their work better with higher quality. Some of these modules include:

- Patient care plans
- Clinical decision support
- Clinical data management
- Quality control
- Data storage
- Task execution/order entry

Below is the diagram of the CIS:

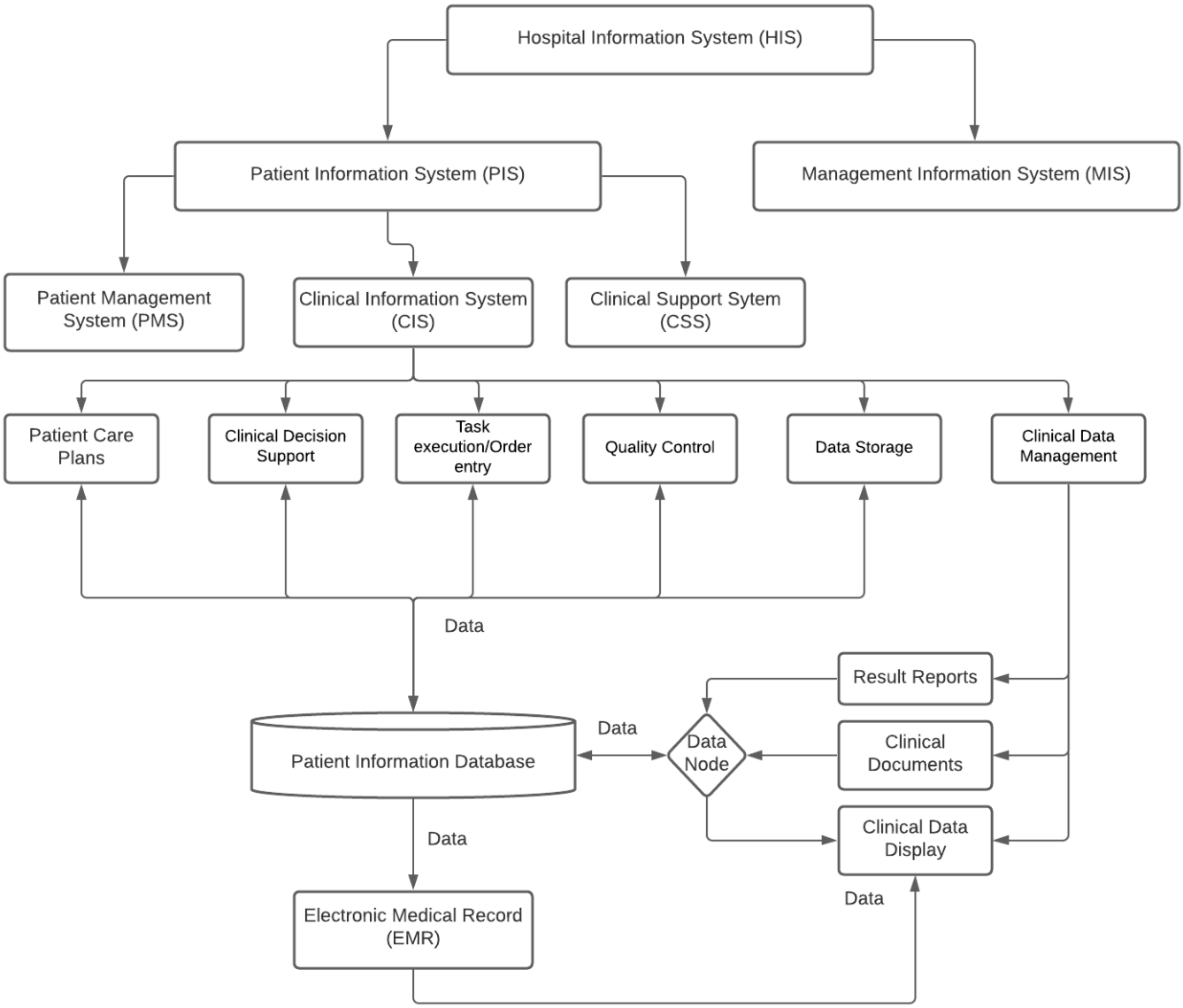



Figure 4. The diagram of CIS

All the information and data from the CIS will be transferred to each module based on its functionality. Then, these modules will send the data to the patient information database for storage and organization. Then, the data will be transferred to the EMR in order to display the necessary information for doctors and clinicians to view. The database will also respond to each modules' request and send necessary data to each module regarding to the functionality of these modules. In addition, in the CIS, the clinical data management module will not send the data directly to the patient information database, but it will provide the data for three sub-modules, including the result reports, clinical documents, and clinical data display. Then, these three sub-modules will send their data to a data

node. The database will send the data that is requested by clinical data display (requested by doctors on the computer) to the data node as well. At the data node, the data will be sorted out and sent to desired sub-modules or database. The clinical data display sub-module will only receive data from multiple sources like the database, EMR, and clinical data management to display necessary information for the doctors and clinicians (Salleh, 2021).

Moreover, the CSS will be used for performing tests and providing supplies. The direct care provider can request these services through the Order entry/Task execution module in the CIS. The test results will be transferred to the database when they are made available. Any doctors or departments can request supplies like drugs, blood products, sterile supplies, and food to be delivered to their location. The deliveries and receipts will be documented and sent to the database (Salleh, 2021).

# 5. Integration of Components in the PIS

The integration into the PIS is essential to make the whole PIS work properly. It depends on the proper linkages between sub-systems/modules within the system. The CIS, CSS, and PMS are built around the key modules such as order entry, common user interface, electronic medical record, and patient information database. Below is the integration diagram of PIS (Salleh, 2021):

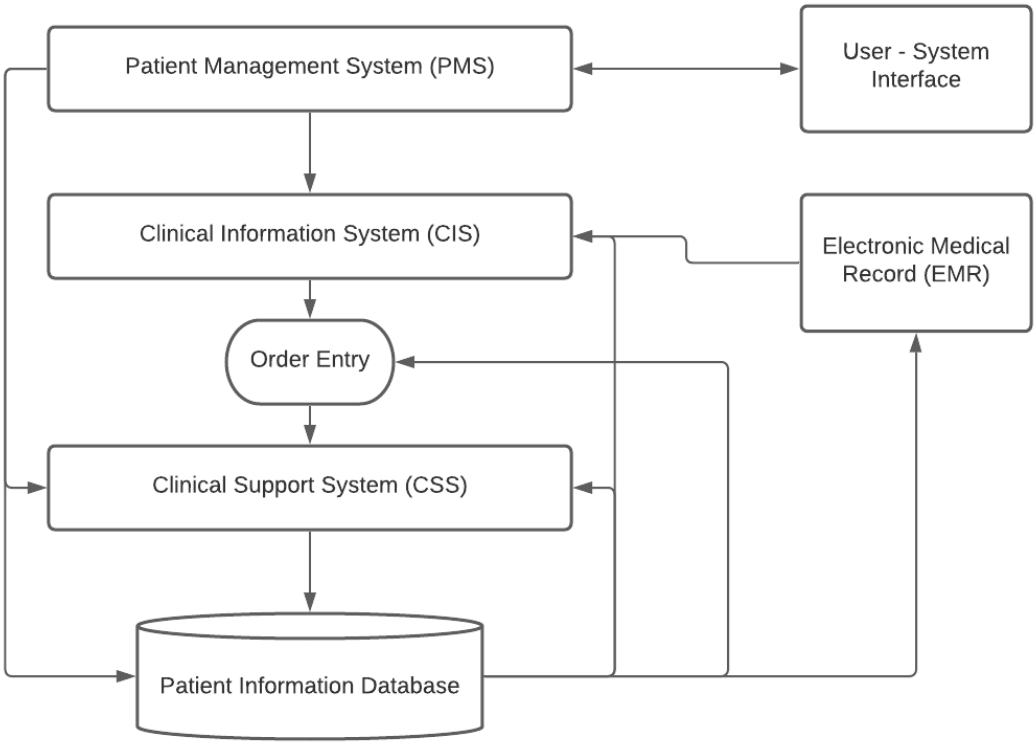



Figure 5. Integration diagram of PIS

According to the diagram, the order entry module is the bridge application between CIS and CSS. Similarly, the CIS, CSS, including the order entry module, is the bridge application between the PMS and patient information database. The systems like PMS, CIS, and CSS use modules like order entry, user-system interface, and EMR as their bride applications to communicate with each other and the database.

## *5.1 Role of Patient Management System (PMS)*

The PMS is used to manage and distribute the identification, patient information, and other static data like payment and insurance transactions to the patient information database. The data will then be used by other systems for various purposes. Thus, the PMS needs to be designed in a way to make sure that the data is normalized and can be obtained repeatedly. Below is the diagram of PMS:

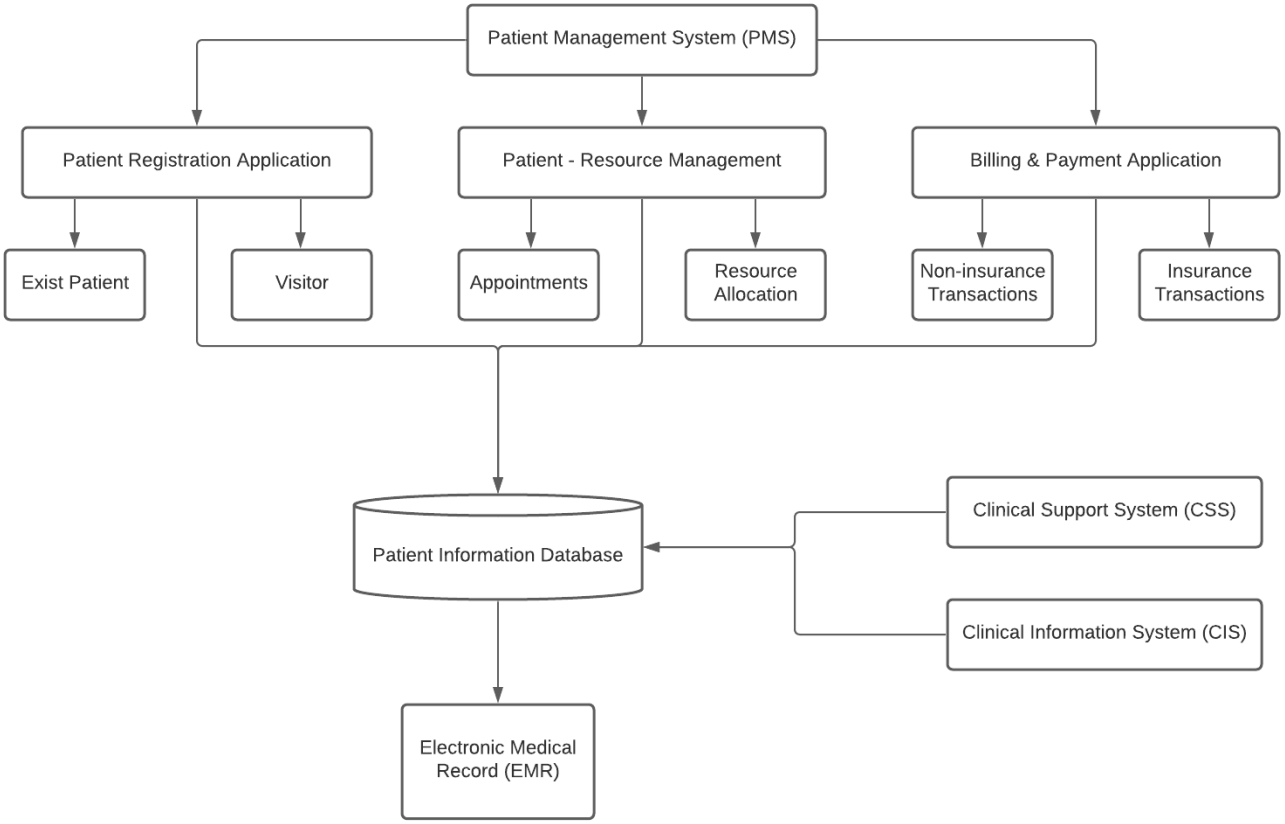



Figure 6. PMS diagram

Under the PMS, there are patient registration applications, patient resource management, and billing and payment application. Each of these applications will perform different tasks and focus on different areas. For example, the patient registration application is used to get information from patients. It will have a feature that identifies who is the existing patient and who is the visitor, then sorts the information into an appropriate table in the database. Similarly, the patient-resource management will manage information of appointments and resource allocation. The billing and payment application will collect and manage the non-insurance transactions which are used for patients/visitors who do not have insurance coverage, as well as for insurance transactions for patients who have insurance coverage. The billing and payment application will be designed as an automated application to reduce human errors when inputting variables into the system.

## *5.2 Role of Order Entry Module*

The order entry module acts as a liaison between the doctors/care providers and the application for planning, initiation, and execution of tasks. A transaction will be enabled at one module to go to another module and be executed. Below is the diagram of order entry processing,

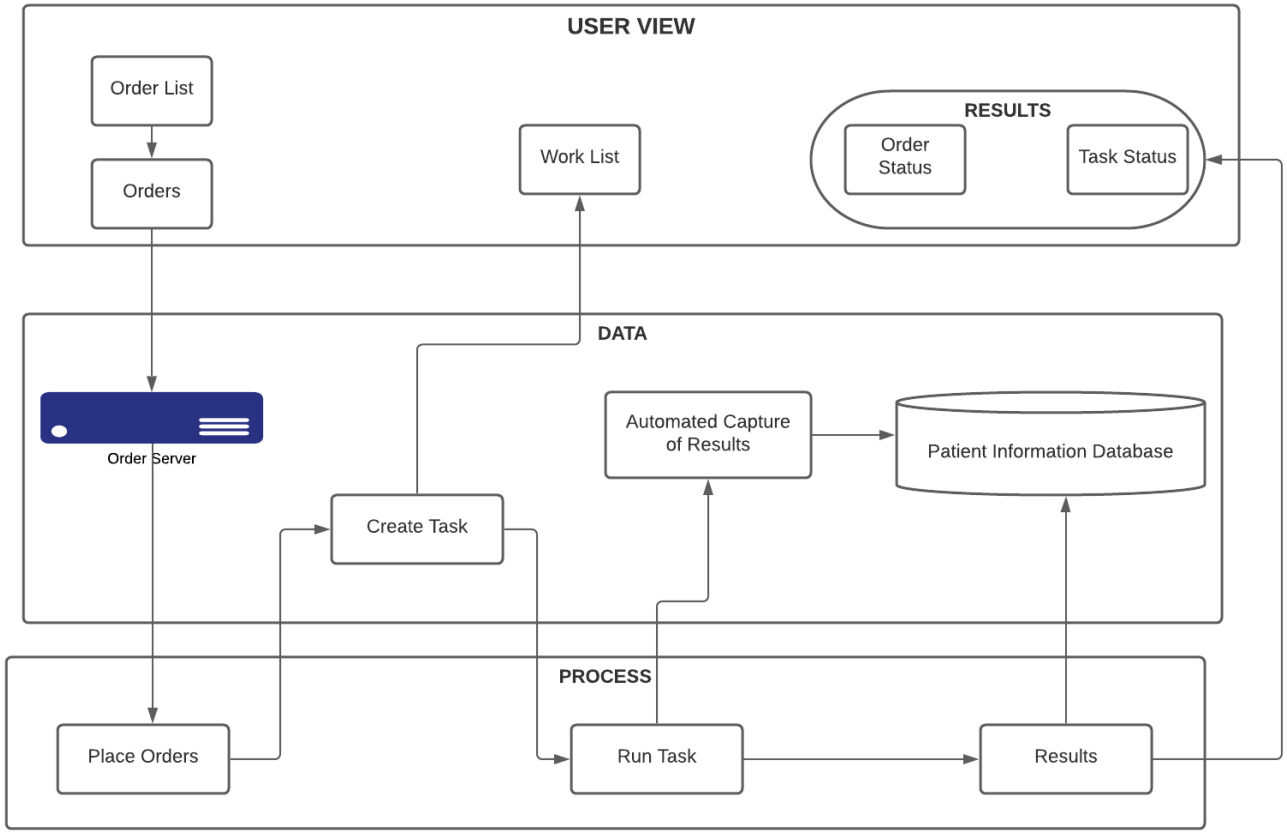



Figure 6. Order Entry Processing Diagram

When a user (doctor or care provider) places an order on their computer, the order list is created, and it will send the order data to order server, the data will be saved on the server, then proceed on placing order. After that, a task will be created and added to the work list where the user can see. Then, it will run the task to deliver the results. The results will be saved directly to the patient information database, then it will update the order status and task status for user to view. During the running task process, the results will also be captured automatically to the database before it moves to the results stage.

## *5.3 Role of Patient Information Database*

Patient Information Database (PID) is a crucial component of the integrated HIS as well as the PIS. It allows users to create and share data from one computer to another computer, or print label, documents, and more. It helps to monitor and improve the value of healthcare services. In addition, the data could be shared with other systems in the following case, sharing data with other hospitals or institutions for diagnosis purposes, or using data warehouse to integrate data and patient information and send it to the MIS for analysis, business, and research purposes. Below is the general diagram of PID and the data warehouse diagram,

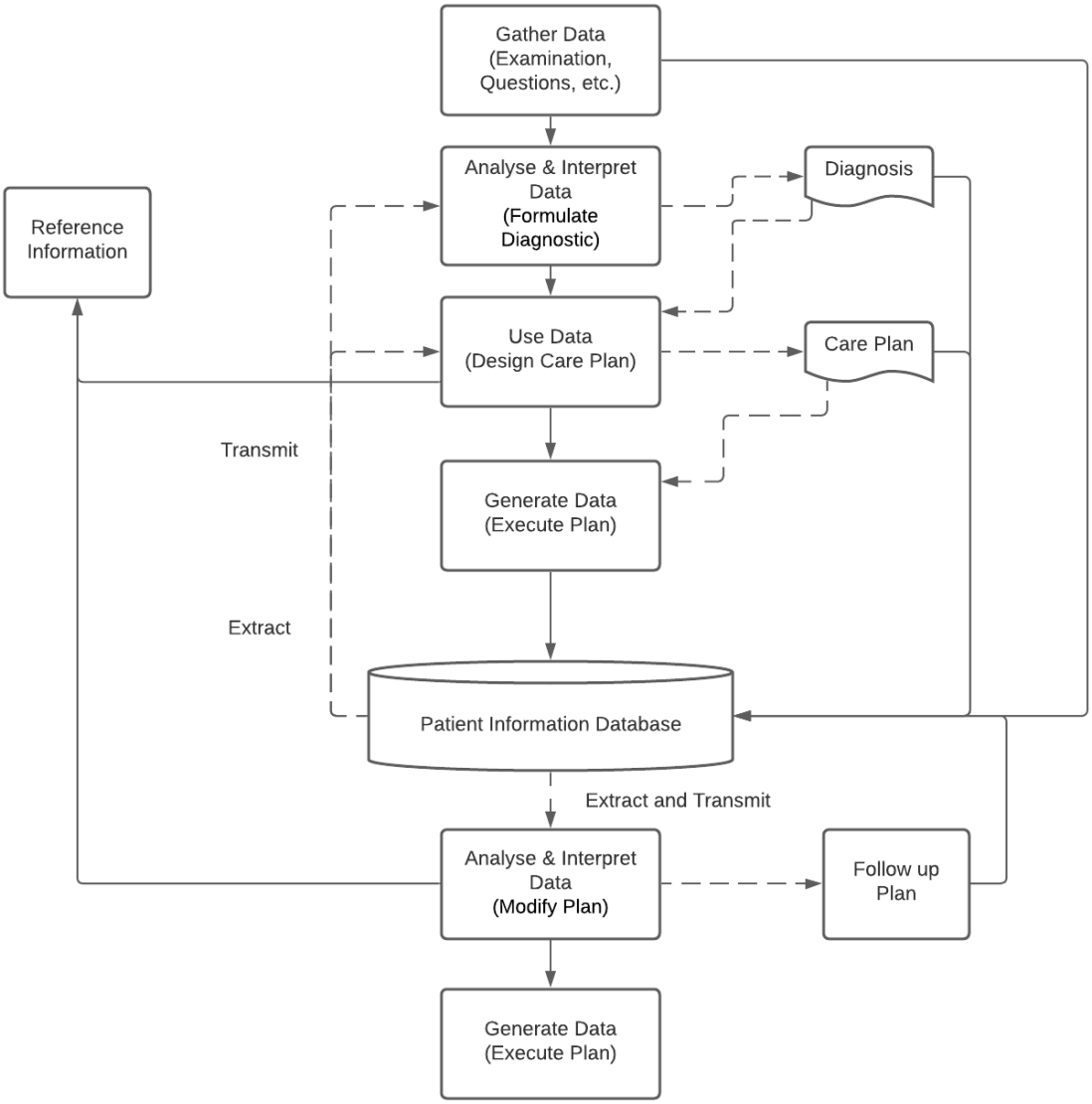



Figure 7. General Process of PID

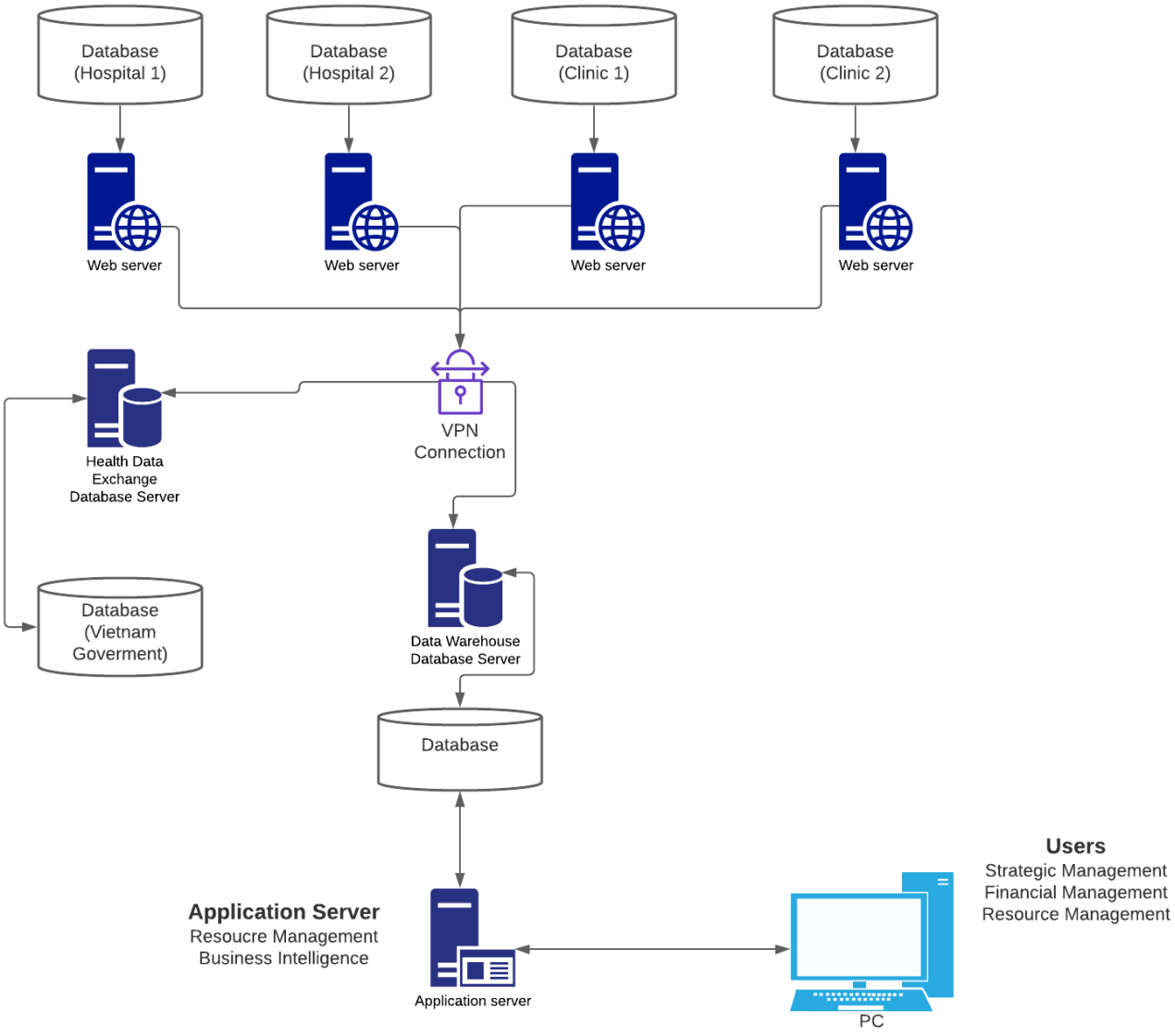



Figure 8. Data warehouse diagram

## *5.4 Role of Electrical Medical Record (EMR)*

The electrical medical record replaces the paper version of patient's medical information. It also includes more data, test results, and treatments. The EMR can be used to display some data from patient care applications and the PID. In addition, in some situations, the EMR can be printed and keep as physical paper records for business and insurance purposes.

## *5.5 Role of User - System Interface*

The requirements of user interface have been listed on section 3.2 of this document. There are some additional requirements such as,

- The screen viewed by users need to be the same for all instances of use of the system
- The set of applications or views required by a user should be made available to them, including logging in and logging out, based on the user's role
- Accessing to various applications at a same time should be minimized

## *5.6 The Clinic Process and Integration of PIS*

Below is the diagram of the clinic process together with the integration of PIS:

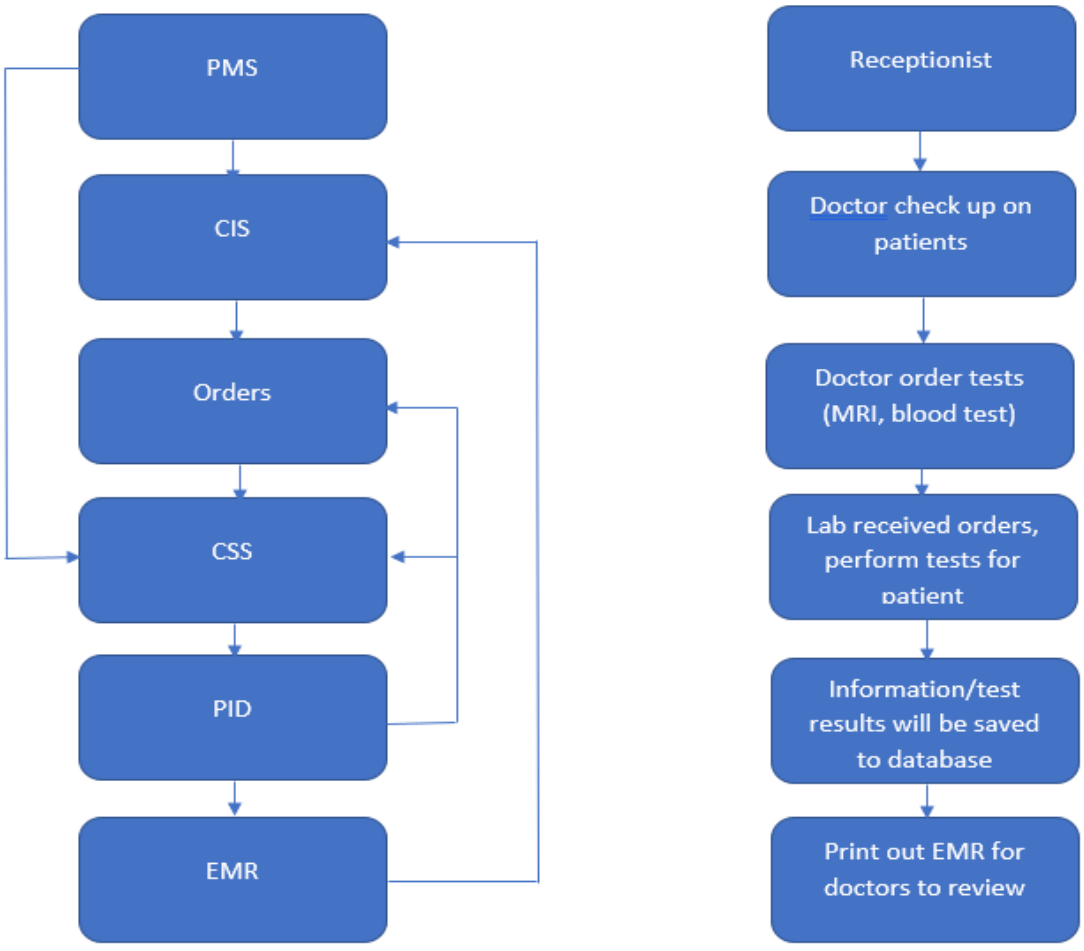



Figure 9. Clinic process and integration of PIS

Based on the clinic process, each patient will check in with the receptionist when they arrive at the clinic. After that, the receptionist will enter the patient information into PMS, and finally the information will be transferred to the CIS where it will be used by doctors. Next, the doctor will call the patient for diagnosis/checking up. The doctor will pull out patient information from the CIS at this time and enter diagnosis results and any additional comments about the patient's conditions into the CIS. After the diagnosis, the doctor will use the lab order application to order any necessary lab tests, such as blood test, MRI, X-RAY, etc. The doctor orders will be transferred to the CSS and processed by lab technicians. The lab test results will be saved to the PID and be reviewed by the lab technician to verify the accuracy of test results with patient information. At last, the lab test results, and other necessary information will be transmitted to EMR, which will be reviewed by doctors. After reviewing the EMR, the doctor will have a better understanding of their patient's conditions and be able to provide the best treatment plan for each patient.

# 6. System Integration

The integration of HIS with other systems such as Radiology Information System/Picture Archiving and Communication System (RIS), or Laboratory Information System (LIS) is very important for the patient care quality and hospital business. The integration could help to improve and support the activities of incident reporting, clinical epidemiology, disease surveillance, quality management, and more. The development of integration between HIS and other systems will be listed as future improvement for the system, due to the limit time of the course, and short of employees.

# 7. Management Information System (MIS)

The management information system is an information system that is related to the business set of sub-system and applications that assist managers to manage the hospital. There are some components of the MIS such as,

- Administration system
- Human Resources (HR) system

- Accounting information system
- Financial & budgetary system
- Material management system
- Hospitality services system
- Facility management system

All of the above sub-systems will interact with the Management Information Database (MID) and PID to use the collected data from these applications and databases for analyzing and making strategy decision. All the data from PID and MID, will be sent to an analytical database to be processed and analyzed in order to support the decision-making process. The data is also transferred to the data warehouse for making strategic management plans including planning of funding, resource planning, epidemiology, and more. The diagram of MIS is provided below,

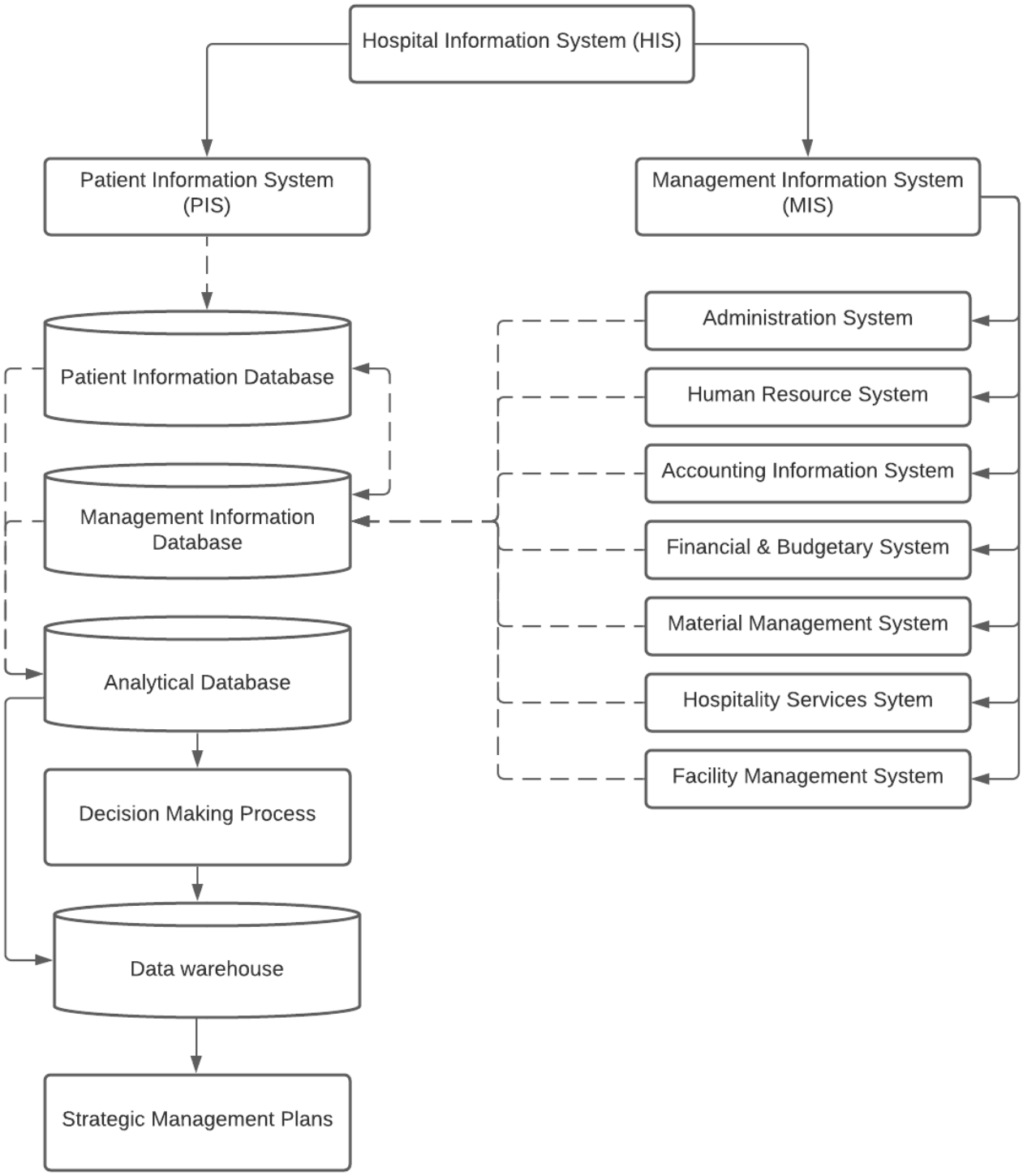



Figure 10. The MIS diagram

# 8. Insurance Transaction

## *8.1 Types of Insurance in Vietnam*

There are three types of insurance in Vietnam: Government insurance, province insurance and private insurance. Each insurance will have different regulations and policies. However, there are some common policies that is used by all insurances for their cover such as,

- Patient must have insurance card that includes
    - Patient ID number
    - Picture of patient
    - Name of patient
    - Data of Birth (DOB)
    - Gender
    - Place where the patient first used of the insurance card
    - Type of insurance cover
    - Place where the insurance card is issued/replace
    - Expiration date
    - QR code
- There are different types of insurance cover, and it will display on the insurance card
- Not all the tests including diagnostic tests, lab tests, etc. are covered by the insurance company
- The patient who has insurance will have their medicines covered by the insurance company
- Patients have an option to buy medicines that is not covered by the insurance (out of pocket)
- Depend on the type of insurance cover, patients will be covered from 80% - 100% patient care fee.
- All the patient insurance information, tests, used medicines and transactions need to be stored and sent to the insurance company quarterly for reviewing and reimbursement
- Physical copy of transactions including patents insurance information, used medicines, patient care services, tests, etc. may be required by the insurance company for references

According to these policies from the insurance company to hospitals and clinics, the clinic must have a system that host insurance application which can store the patient insurance information, transactions and other related information in order to claim the reimbursement for the clinic. However, the current system does not have these applications and is not designed for insurance transactions or integration with other systems, sub-systems, or applications.

## *8.2 Benefits of Insurance Coverage to the Clinic*

Almost 60% of the clinic's profits come from insurance reimbursement. A full patient care package that includes blood tests, lab tests, general diagnostics, blood pressure tests, etc., cost around $5 million – $10 million VND (or around $220 USD - $440 USD). With insurance coverage, the patient will usually pay around $2 million VND (which is $88 USD). They will have an option to buy the necessary medications after the tests, and these will cost around $25 USD, if it is covered by the insurance, or $50 USD, if it is not covered by the insurance.

Thai Hoa clinic is located in Ninh Thuan province, so most of the patients are famers or working middle class. Thus, 98% of the patients have insurance and use it when they go to the clinic. The clinic usually has 500 – 800 patients per day, so the profits from insurance reimbursement are great. In addition, since the clinic is located at Ninh Thuan province, it accepts province insurance and government insurance. The clinic will accept private insurance when it becomes a hospital.

## *8.3 Problem with Insurance Transactions*

Since the current system does not have applications that is designed to use for insurance transactions. Many of the transactions is still processing with physical paper records. It is wasting time, money and resources of the clinic. Another risk to the process is losing the paper records. If the clinic lost the transactions records or patient insurance information record, it is really hard or impossible to claim the reimbursement from insurance company.

### *8.4 Solution*

With the current design of the HIS on this project. The problem will be solved. In the current design, the PIS will handle all the insurance transactions including medicine used, diagnostic tests, lab test, etc. then it will store the data in the PID, send specific data to insurance companies by request. In addition, the MIS will also use the patient insurance information to improve the business process and strategies to make a better profit for the clinic.

In addition, doctors and health care providers could use CIS applications such as patient care plans, decision support, lab orders, and more, to improve patient care. In fact, doctors and health care providers will likely use all of these applications on a daily basis. Patient care plans are designed to manage, provide, or proposed treatment plans for patients based on their condition. Decision support will be used to collect information like available treatment, diseases, patient condition, and previous and similar treatment cases. This information will then be made available to doctors or health care providers when needed. Lab order applications will be used to take orders from doctors for some lab tests, such as blood test, MRI, X-RAY, etc.

## 9. Conclusion

The purpose of this project is to design a hospital information system for Thai Hoa Clinic as it converts into a hospital. The system needs to be fully designed within its scope. The system will also be used to solve insurance problems, which is important because the clinic makes its profits from insurance.

In this project, all the knowledge and information from different aspects of an information system has been used to design the HIS, such as strategy management system, cyber security, database management, enterprise system, etc. This project is a comprehensive project, and all the knowledge about management and information systems has been covered properly.

Moreover, there are some potential ways to improve the system, such as integration with LIS and RIS, using cloud technology for database and applications, or the ability to expand the system based on business requests.

# 10. APPENDIX

## Appendix A. Definitions, Acronyms, and Abbreviations

HIS: Hospital Information System

PIS: Patient Information System

MIS: Management Information System

PID: Patient Information Database

MID: Management Information Database

LAN: Local Area Network

OS: Operating System

IDE: Integrated Development Environment

ID: Identity Document

IT: Information Technology

CEO: Chief Executive Officer

RAM: Ready Access Memory

CPU: Central Processing Unit

EMR: Electronic Medical Record

VPN: Virtual Private Network

DBMS: Database Management System

DC: Domain Controller

PC: Personal Computer

GUI: Graphic User Interface

API: Application Programming Interface

SDLC: Software Development Life Cycle

SRS: Software Requirement Specification

C-suite: The executive-level managers within a company

- Chief Executive Officer (CEO), Chief Financial Officer (CFO), Chief Operating Officer (COO), and Chief Information Officer (CIO)

UI: User Interface

IS: Information System

PMS: Patient Management System

MRI: Magnetic Resonance Imaging

RIS: Radiology Information System/Picture Archiving and Communication System

LIS: Laboratory Information System

DOB: Data of Birth

USD: U.S dollar

VND: Vietnamese Dong

QR code: Quick Response code

BR_G_#: Business Requirement_General_#

BR_P_#: Business Requirement_Patient_#

BR_AS_#: Business Requirement_Associted Staff_#

BR_M_#: Business Requirement_Manager_#

N/A: Not Applicable

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# Appendix C. Questionnaire – Gathering Tool

Below is the summary of design objects based on collected information. These information are provided by the clinic owner – Dr. Thai, and it acts as a formal information – gathering tool.

| **Design Objects** | **Given Information** |
|---|---|
| Purpose of Application | To improve working process, and solve the insurance problem |
| Use of collected information | To improve patient care quality and process. It is also used for business purposes |
| Content of Applications | Systems, sub-systems, applications, module, sub-modules |
| Deployment of Application | On computer and online |
| Budget and Deadline | $1M. It is a continue project – 4 months for the course |

# Appendix D. Requirements

## *Functional Requirements*

In the table below, the requirement numbering has a scheme - BR_X_0## (BR: Business Requirement, G: General, P: Patient, AS: Associated Staff, M: Manager).

| **Req#** | **Requirement** | **Priority** | **Date Reviewed** | **SME Reviewed / Approved** |
|---|---|---|---|---|
| BR_G_1 | Clinic server shall host the HIS and provide system data processing and storage capability. | High | 10/31/2021 | Tony |

| Req# | Requirement | Priority | Date Reviewed | SME Reviewed / Approved |
|---|---|---|---|---|
| BR_G_2 | The application shall provide patients with designed functionalities (for kiosk and website). | High | 10/31/2021 | Tony |
| BR_G_3 | A remote and non-remote device shall provide associated staff/administrators with designed functionalities (for associated staff/administrator). | High | 10/31/2021 | Tony |
| BR_G_4 | All functionalities shall be accessible through the HIS application. | High | 10/31/2021 | Tony |
| BR_G_5 | The system shall be user friendly. | Medium | 10/31/2021 | Tony |
| BR_G_6 | The system shall be easy to manage and control. | Medium | 10/31/2021 | Tony |
| BR_P_1 | A patient shall be able to find their diagnostic information on the clinic website. | High | 10/31/2021 | Tony |
| BR_P_2 | A patient shall be able to request appointment or change schedule on the clinic website. | Medium | 10/31/2021 | Tony |
| BR_P_3 | A patient shall be able to give a review about the clinic on their website. | Medium | 10/31/2021 | Tony |

| Req# | Requirement | Priority | Date Reviewed | SME Reviewed / Approved |
|---|---|---|---|---|
| BR_P_4 | A patient shall be able to leave comments and/or contact information for related issues with the clinic. | High | 10/31/2021 | Tony |
| BR_P_5 | A patient shall be able to call associated staff for help through the application. | High | 10/31/2021 | Tony |
| BR_P_6 | A patient shall be able to view and rate other reviews of the clinic | Medium | 10/31/2021 | Tony |
| BR_P_7 | A patient shall be able to send a direct message to the management team. | Low | 10/31/2021 | Tony |
| BR_AS_1 | An associated staff shall be able to log into their work devices using their assigned username and password. | High | 10/31/2021 | Tony |
| BR_AS_2 | An associated staff shall be able to log out of their device. | High | 10/31/2021 | Tony |
| BR_AS_3 | An associated staff shall be able to activate hardware devices (remote and non-remote) and open the associated account on the non-remote device. | High | 10/31/2021 | Tony |
| BR_AS_4 | An associated staff shall be able to create, edit, delete, and give permission to user account. | High | 10/31/2021 | Tony |

| Req# | Requirement | Priority | Date Reviewed | SME Reviewed / Approved |
|---|---|---|---|---|
| BR_AS_5 | An associated staff shall be assigned a specific non-remote device with associated account. | High | 10/31/2021 | Tony |
| BR_AS_6 | An associated staff shall be able to use additional features to assist customers (physical and online) when needed. | High | 10/31/2021 | Tony |
| BR_AS_7 | An associated staff shall be able to report any errors in the application to the management team. | High | 10/31/2021 | Tony |
| BR_AS_8 | An associated staff shall be able to manage patient registration forms for the following actions: add, search, create new record, edit, and print out of the patient information form. | High | 10/31/2021 | Tony |
| BR_AS_9 | An associated staff (mostly doctors) shall be able to sort patients based on department, date, view patient information, including history of treatment, and transfer patient to appropriate department. | High | 10/31/2021 | Tony |

| Req# | Requirement | Priority | Date Reviewed | SME Reviewed / Approved |
|---|---|---|---|---|
| BR_AS_10 | An associated staff shall be able to receive patient information from different departments along with their treatment to proceed payments. | High | 10/31/2021 | Tony |
| BR_AS_11 | An associated staff shall be able to receive patient information from departments to perform appropriate treatments for the patient and send the results back to the patient's doctor. | High | 10/31/2021 | Tony |
| BR_AS_12 | An associated staff shall be able to manage the clinic supply with desired actions. | High | 10/31/2021 | Tony |
| BR_AS_13 | An associated staff shall be able to manage patient insurance information based on regulations and policies of the insurance company. | High | 10/31/2021 | Tony |
| BR_AS_14 | An associated staff shall be able to approve the insurance request based on regulations and policy of the insurance company. | High | 10/31/2021 | Tony |
| BR_AS_15 | An associated staff shall be able to create the deposit money based on the coverage of the insurance company. | High | 10/31/2021 | Tony |

| Req# | Requirement | Priority | Date Reviewed | SME Reviewed / Approved |
|---|---|---|---|---|
| BR_AS_16 | An associated staff shall be able to export the insurance file that contains all the information about patient insurance coverage, treatments, medicines, etc. to the insurance company quarterly. | High | 10/31/2021 | Tony |
| BR_AS_17 | An associated staff shall be able to export the weekly reports of financial, supply, working performance, patient, medicines, and doctor bonuses. | High | 10/31/2021 | Tony |
| BR_AS_18 | An associated staff shall be able to export any actions on the system including doctor decisions, failed log in, errors, etc. | High | 10/31/2021 | Tony |
| BR_M_1 | A manager shall be able to do everything an associated staff member can do. | High | 10/31/2021 | Tony |
| BR_M_2 | A manager shall be able to control and manage the system with designed features. | High | 10/31/2021 | Tony |
| BR_M_3 | A manager shall be able to control the associated staff account. | High | 10/31/2021 | Tony |

| Req# | Requirement | Priority | Date Reviewed | SME Reviewed / Approved |
|---|---|---|---|---|
| BR_M_4 | A manager shall be able to contact the provider (third party software, hardware) with any technical issues. | High | 10/31/2021 | Tony |

## *Non- Functional Requirements*

| Req# | Requirement | Priority | Date Reviewed | SME Reviewed / Approved |
|---|---|---|---|---|
| BR_G_7 | The system shall be able to recognize the patient's identity when they are using different devices to log in. | High | 10/31/2021 | Tony |
| BR_G_8 | Any users who make use of the system need to hold a Login ID and password. | High | 10/31/2021 | Tony |
| BR_G_9 | Any modifications like insert, delete, update, etc. for the database can be synchronized | High | 10/31/2021 | Tony |

| | | | | |
|---|---|---|---|---|
| | quickly and executed only by the ward administrator. | | | |
| BR_G_10 | The system shall be able to provide acknowledgment in just one second once the patient's information is checked. | High | 10/31/2021 | Tony |
| BR_G_11 | The system shall be able to support at least 90% of employees in the clinic. | High | 10/31/2021 | Tony |
| BR_G_12 | The user interface shall be able to acknowledge within five seconds. | High | 10/31/2021 | Tony |
| BR_G_13 | The system needs to be easy to use and can run on various operation system (OS). | High | 10/31/2021 | Tony |

| | | | | |
|---|---|---|---|---|
| BR_G_14 | The system shall be able to offer the efficiency for data backup. | High | 10/31/2021 | Tony |
| BR_G_15 | The system shall be able to track every mistake as well as keep a log of it. | High | 10/31/2021 | Tony |
| BR_G_16 | A system log shall be generated for every activity on the system. | High | 10/31/2021 | Tony |
| BR_G_17 | The system shall be available all the time. | High | 10/31/2021 | Tony |
| BR_G_18 | Associated staff, including doctors, nurses, and front desk staff need to have appropriate user rights. | High | 10/31/2021 | Tony |

# Appendix E. Project Plan

**Execution Approval:**

The completion of all planning activities including approval of functional requirements, project design and project funding.

**Acquire Project team:**

The project manager/CIO follows necessary steps to obtain the human resources needed to complete the project. All the resources and schedule are provided and designed based on the negotiation between involved business units and managers.

**Develop Project Team:**

The project manager/CIO evaluate each team members based on their skill sets, then assign different part of the project to them based on their skill. The schedule/deadline and workload are also provided for the team members.

**Executing the Project Management Plan:**

The project manager/CIO perform the plan activities such as communication plan, risk management plan, distribution plan, etc.

**Conducting Status Review Meetings:**

The review meeting will be conducted in order for all relevant parties including project manager and team members to keep track with the project process.

**Update Project Schedule and Management plans:**

The schedule and any changes of the project will be updated promptly to relevant parties.

**Quality Assurance (Testing):**

Quality tests are performed throughout the duration of the project to ensure the project meet standard requirements, and the application working properly.

**Acceptance of Deliverables:**

The clinic owner accepts the final product in advance an agreed upon standard of performance or capability. The owner must authenticate acceptance of each deliverable and satisfy with the functionality and quality of the product.

**Complete Execution Phase Review:**

After the product is delivered, stakeholders are invited to review and comment on the project. All the related information like lessons learned and strategies will be documented for future projects.

An estimate for the execution of the project is provided below,

**Tentative Schedule:**

A separate excel file of tentative schedule is include on the submission.

**Budget:**

| **Cost** | **Amount** |
|---|---|
| Internal Labor | $ 500,000.00 |
| External Labor | $ 100,000.00 |
| Non-Labor | |
| Hardware/Software | $ 400,000.00 |
| **Total Budget** | $ 1000,000.00 |

The project is completed successfully within the given budget ($1M) and timeline (109 days). The HIS meet the client's expectations throughout all its stages.