A Case Study on Hospital Management System

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A Case Study on

Hospital Management System

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Abstract

Nowadays, the IT system has made many changes in the medical field. Managing a multi-speciality hospital is a challenging task in this fast-paced world of medicine. Therefore, the need for a management type of organization is especially obvious in this field, especially in health services. Accordingly, the interactions between the hospital organization structure's systems and staff are analysed in an effort to enhance their management. The hospital management system (HMS) is a comprehensive web application that addresses various directions of clinical workflows. It manages the smooth performance of health care and administrative, medical, legal and financial tracking. This is would be considered as a backbone of the health facilities ' successful operation. The intended goal of this case study is to analyse the HMS system critically in terms of software engineering. This case study covers the main phases in the Software Development LifeCycle (SDLC), including the Requirement Gathering, Design, Verification and Testing, as well as software management. In requirement gathering, the user, system and domain requirements of the HMS system including the requirements elicitation and validation techniques required is determined. Then, in design, suitable user interfaces are specified with regard to the system functionality. Later, in the verification and testing, the applicable tools for verification and testing types are identified. At last, the cost estimation of the HMS system, the risk analysis and the quality assurance are analysed in details. As can be seen, a discussion is carried out in this case study in order to analyse the HMS system thoroughly.

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Aim

To study the principles of software engineering and to link knowledge to a real-world application of an online Hospital Management System (HMS).

Objective

- Understand the system functionality and describe the main functions of the HMS system.
- To propose an appropriate Software Development LifeCycle (SDLC) for the HMS System.
- Collect and analyse the HMS system requirements.
- To determine the suitable user interface types for the HMS system.
- To define and analyze the applicable tools to verify, validate and test the HMS system.
- To identify the software management activities and tools that are applicable to the HMS system.

Introduction

Nowadays, the IT system has made many changes in the medical field. Managing a multi-speciality hospital is a challenging task in this fast-paced world of medicine. The fundamental changes in the way of solving organizational problems are the replacement of the traditional analytical approach with the systematic type assessment, according to a management type criterion, which examines the relationships and interaction between various organization components. Therefore, the need for a management type of organization is especially obvious in this field, especially in health services. Accordingly, the interactions between the hospital organization structure's systems and staff are analysed in an effort to enhance their management.

This case study focuses on analysing a web-based Hospital Management Application Software. Web application manages the storage and retrieval of information through a combination of server-side scripts and client-side (JavaScript and HTML) scripts to provide information to users. HMS is used to control the hospital services and either a mobile or a computer browser can access the HMS application. HMS application consists of ten main modules that include all details regarding doctors, patients, nurses, hospital administrative, etc. into one software.

HMS allows the patients to register via a registration module (form), which gathers and stores all required patient's data. Patients can view available appointments to book an appointment. Once the patient visits the hospital, the receptionist will issue a clinic number for him. when the patient's turn came, the patient explains his condition to the consulting nurse, so that the nurse performs the pre-assessment examinations to diagnose the problem and then redirect him to the concerned doctor. Then, the concerned doctor will diagnose the patient, and then enter the prescription needed for the patient. If the patient needs further examination, then the doctor will redirect him to the nurse or lab assistant based on their responsibilities. Then, the doctor keeps track of the examination to recommend further actions if required, as

well as enters a new prescription for the patient. Once the prescription is ready, the pharmacist will prepare the medicines for the patient and enters the dose and guidelines of each medicine into the system. Finally, the patient will need to go to the cashier to pay for his/her visit.

HMS system can handle many tasks depending on the functions of the hospital management system. It supports policy-making, guarantees communication and coordination between staff, automates routine tasks, designs patient-focused workflows, advertisers, manages human and financial resources and delivers an uninterrupted supply chain.

Chapter 1: System Description

The Hospital Management System (HMS) is a web application, which used for the control of hospital services. The HMS web application can be accessed by either mobile or computer browser. The HMS application combines all details regarding doctors, patients, nurses, hospital administrative, etc. into one software. It has parts that make up a hospital with various professions. This chapter has three main subtitles in order to illustrate the working principle of the HMS system clearly. Firstly, the main modules of the system will be mentioned with its purposes. Then, the main users of the system with regard to their roles and privileges. And Finally, the complete working flow of the system will be explained.

1.1 The Main Modules of HMS System

The whole project consists of ten main modules, which are:

- **Login Module**

  This module allows users to log into the HMS with regard to their roles and privileges. After the user logs into the system, he can access the functions/features of it.

- **Registration Module**

  This module provides the ability to register new patients. Using this module, Receptionist can create accounts for new patients and therefore, patients can access their profiles.

- **Administration Module**

  This module controls the whole HMS system. Moreover, the manipulation of users' details is done using this module.

- **Patient Management Module**

  This module controls the patient flow. It is used to register the patients, to get health status data, to view treatment and to monitor medical histories and reports. In addition, this module contains all information about the patient such as his name, address, contact details and date of birth.

- **Doctor Management Module**

  This module comprises the doctors' list including their schedules or appointments. It also includes a list of drugs available for specific diseases so that the doctor can quickly check for an alternative whenever needed. An appointment may be made to the patient with reference to the doctor's schedule. By this way, HMS facilitates and hassles-free the coordination between doctors and the patients.

- **Nurse Management Module**

  This module includes the assignment of nurses to doctors. It also includes alerts and reminders of the tasks to be performed on the patient.

- **Appointment Management Module**

  This module shall arrange a doctor's schedule corresponding to the patient's application. It helps to coordinate the availability of doctors at any convenient time. It sets out the appointment for a new patient by assigning the doctor, time, date, department that is available at the time. An appointment is made to the patient with regard to the doctor's schedule. In addition, it enables the functionality of cancelling an appointment of a particular patient.

- **Laboratory and Test Management Module**

  This module displays the test results of a specific patient. When the doctor recommends a specific list of examinations, the same would be updated in the HMS, and then obtained by the laboratory (Lab Assistant). The lab assistant uses this module to analyse and record all the details of the tests carried out. The laboratory results can be accessed by the staff at the hospital, as well as provided for patient reports.

- **Pharmacy and Stock Management Module**

  This module manages the stocks and dates of expiry of inventories properly. It enables HMS Staff to keep track of stocks of medicine and to report to concerned HMS staff if stocks are running out of items.

- **Billing Management Module**

  This module aims to list all patient's costs at once and to generate a complete bill at the end of the consolation (visit). The cashier is the only user who can access this module to generate patient bills. This module helps to save time and effort, as the hospital departments will not need to generate separate bills.

1.2 The Main Users of HMS System

The main users of the **HMS "**As shown in **Fig3.2- The HMS Use Case Diagram**" is the following:

1. **Admin**

   Admin has the full system control, which ensures he can handle any process-related activity. Admin is the most authorized user with all system privileges. He can make any changes, such as adding new doctors, or any HMS staff members. As well as, he can edit all HMS users' profiles.

   Key functions:

   - Manage HMS Staff accounts.
   - Register HMS staff.
   - Allocate resources
   - Monitor transaction reports of patient payment
   - Observe medicine status of hospital stock
   - Monitor diagnosis report

2. **Patient**

   Key functions:

   - Book an appointment
   - View prescription details
   - View doctors list
   - View Reports and results
   - Watch payment history
   - Submit feedback
   - Manage own profile

3. **Receptionist**

   A receptionist is the first one who meets patients. He is responsible to register patients if they are new and updating their profiles if needed. They have access to the doctor appointment list to book an appointment as patient requests.

   Key functions:

   - View appointment list
   - View status with Nurses (View nurses schedules)
   - Book an appointment
   - Register and Update Patient accounts
   - Issue clinic number
   - Manage own profile

4. **Doctor**

   Key functions:

   - Updating patient account
   - Diagnose patient
   - View his/her Schedule
   - View status with Nurses (View nurses' schedule)
   - View status with lab assistant (View lab assistants' schedule)
   - Create (Enter) prescription for a patient
   - Recommend examinations to lab assistants
   - Keep track of examination results
   - Generate reports
   - Manage own profile

5. **Nurse**

   Key functions:

   - Updating patient account
   - Perform pre-assessment examinations
   - View doctors' status (schedule)
   - View his/her Schedule
   - Allot patients for concerned doctors

- Keep a record of patient operation
- collect specimens
- Manage own profile

6. **Lab Assistant** specimens

   Key functions:

   - Updating patient Details
   - Perform examinations
   - Process specimens
   - Generate test reports like CT scan, X-Ray images, MRI reports
   - Enter Examinations costs
   - Manage own profile

7. **Pharmacist**

   Key functions:

   - Watch the patient's prescription
   - Give medication based on the patient's prescription
   - Enter medicines costs
   - Update medicine status of hospital stock
   - Manage own profile

8. **Cashier**

   Key functions:

   - Creating an invoice to pay
   - Order invoice for payment to the patient
   - Receive cash payment
   - See the history of payment for patients
   - Manage own profile

1.3 The Working Flow of HMS System

HMS System allows the patients to register via a registration module (form), which gathers and stores all required patient's data such as name, e-mail, gender, etc. Registered patients can skip this step and login directly using their username and password through the login module. Nevertheless, unregistered users can only take advantage of major system features such as viewing the hospital timings. After the patient creates an account and register, he can access the allowed system features/functionalities for patients. Patients can view available appointments, book an appointment and manage his/her own profile. After the patient book an appointment, he can visit the hospital according to his appointment.

Once the patient reaches the hospital, the receptionist will issue a clinic number for him since the receptionist has access to the system to view the appointments list and status with nurses and doctors. The HMS system also allows the receptionist to create patient accounts and book an appointment, referring to the doctors' schedule, for unregistered patients.

Once patient's turn came, the patient can explain his condition to the consulting nurse, so that the nurse performs the pre-assessment examinations to diagnose the problem and then redirect him to the concerned doctor/clinic. The HMS system enables the nurse to allot patients for the concerned doctors, to view doctors' status and to update patients' account.

Then, the concerned doctor will diagnose the patient, and then enter the prescription needed for the patient. If the doctor sees that the patient needs any further examinations like collecting and processing specimens, the system allows the doctor to redirect the patient to the Nurse again. After the nurse collects the specimens, the specimens will be sent to the laboratory so that the lab assistant can process, analyse the specimens, and then generate and enter the test results into the system. Furthermore, the doctor can redirect the patient to the lab assistant if there is a need to perform examinations such as X-Ray images, CT scan, MRI. The lab assistant can access the system and generate test reports regarding the examinations or test performed.

On the other hand, the doctor keeps track of the examination results entered by the lab assistant and then recommend further actions to be taken if required, as well as enters a new prescription for the patient.

The system also allows the patient to access his account to see prescription details and view his reports along with doctor advice. This feature is very useful since test reports usually take a long time to be generated, so that the patient may leave the hospital and view the results along with doctor's advice through his account without the need of going to the hospital again.

Once the prescription is ready, the pharmacist will prepare the medicines for the patient and enters the dose and guidelines of each medicine into the system. When the patient goes to the pharmacy of the hospital, he/she will find the medicines ready so that he/she can pick and go easily. The patient has two options to know the dose and guidelines of each medicine, either by asking the pharmacist directly or by accessing his/her account to see it. This will help the patient be aware of the medicines' dose if he/she forgets it.

Finally, the patient will need to go to the cashier to pay for his/her visit. The system allows the cashier to create and order invoice for payment through the billing module. In addition, the cashier can watch the payment history of the patients.

Chapter 2: Software Development Model

The Software Development Lifecycle (SDLC) that will be used for the development of the HMS web application is **the Agile SDLC Model**. This model has been chosen **because of many reasons** including:

- It minimizes the risks by creating software in the form of minor boxes (iterations).
- It allows for recurrent alterations.
- It improves the quality since defects are found and fixed early. (Existek, 2017)
- It enables the customer to see the result to check if he is satisfied or not. In other words, it helps to release the first product version fast.
- It does not treat the development steps as large sequential steps. It makes them all ongoing processes instead.
- It tends to work well in small projects where flexibility and speed are essential. (Jamsheer K., 2018)

Besides, according to research that has been conducted by the Standish Group, the Agile model has achieved a high rate of success that surpasses the Waterfall model success rate "As shown in **Fig3.2".** (Kukhnavets P., 2016)

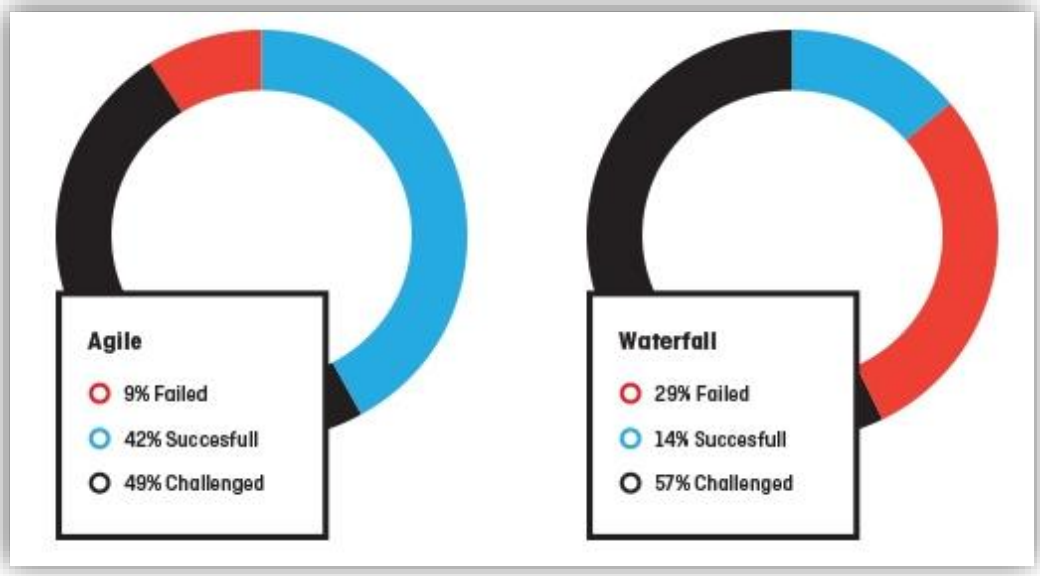


Figure2.1: A comparison between Agile and Waterfall models.

(Kukhnavets P., 2016)

On the other hand, it has some limitations like:

- The new requirements might clash with the existing system architecture.
- Changes in the system may be led to exceed the expected time in some cases. (Existek, 2017)

In conclusion, agile is the best for the HMS web application since it allows for more flexibility and incremental iteration, consequently, more features (adjustment of requirements) can be done. The Figure below **"Fig3.3"** shows the agile model's process of development.

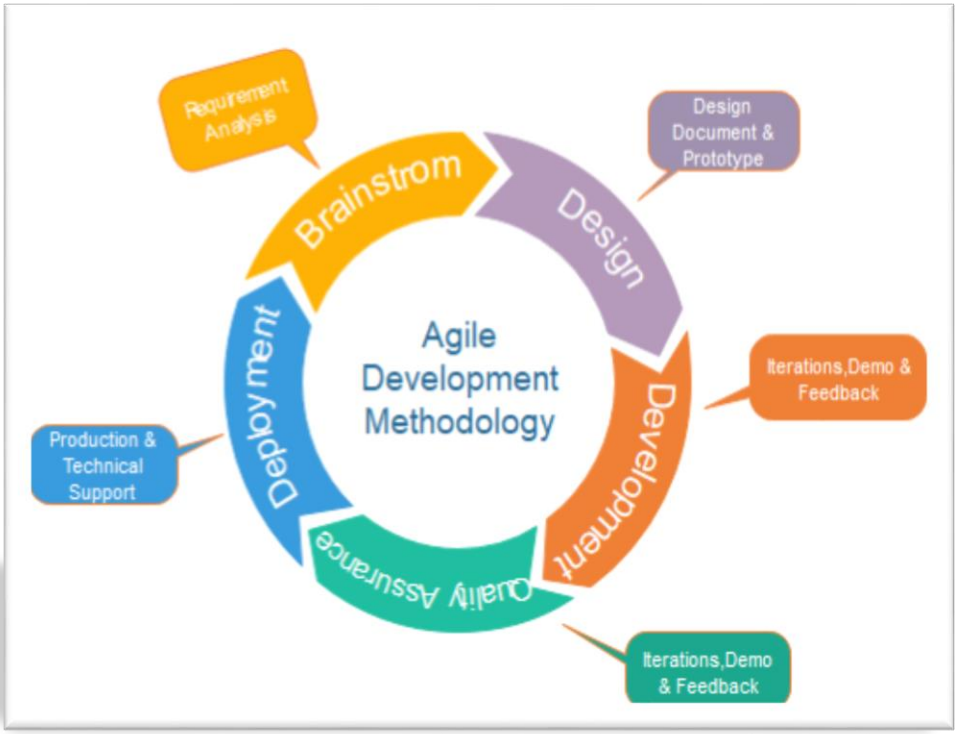


Figure2.2: The process of development in the agile model.

(Javatpoint, 2019)

Chapter 3: Requirements Gathering

3.1 User requirements

The user requirements specify what the HMS system must be capable of doing to solve the problems of the set of potential users of HMS. The system owners and end-users write them with information from Quality Assurance. The user requirements are identified using natural language, along with diagrams for a broader understanding. The specifications listed in this section will be checked and tested in the Quality Qualification or User Acceptance Testing. User Requirements Specifications are not meant to be a technical document because it should be understandable by readers with basic knowledge of the system. (encyclopedia, 2019)

The user requirements can be categorized into two major categories, which are:

3.1.1 Functional requirements

Functional requirements define the function of the device, explaining the actions taken by the HMS system clearly and quantitatively. These requirements define the capabilities of the HMS system, as well as its process or workflow. It also determines the form of input and output desired. Some of the functional requirements of the HMs system are:

- **Registration**

  The admin is the only user who can register doctors, nurses, receptions, lab assistants, cashiers and pharmacists. The patient can register through the registration module. In addition, the system should allow a receptionist to register new patients into the system.

- **Authentication**

  The user (patients) should be able to create an account in the HMS system through the registration module (form). The following details should be entered in the registration module:

  - Full Name
  - Username (ID)
  - E-mail
  - Gender
  - Phone Number

- Date of Birth
- Password
- Confirm Password

- **Login**

  The system must enable registered users including all categories of users to log in through the login module, by entering the username and password.

- **Manage Account**

  Users of the HMS system should have the ability to manage their account including changing their password, email or phone number.

- **Input validation**

  The system should validate all inputs entered by the user to ensure that the user does not leave any blank required fields. This is also important to ensure that the inputs are entered in the correct format and does not exceed the size specifies.

- **Unique Username (ID)**

  The username of each user in the HMS system should be unique. Equally important, the system should verify that the username, which is entered in the registration form, is not already used by another user in the system.

- **Issuing clinic numbers**

  The receptions should have the ability to view nurses' schedule to use the system for issuing a clinic number for patients.

- **Allot patients for doctors**

  The system shall enable nurses to view doctors' status (Schedule) to allot patients successfully for the concerned doctors in terms of their problem.

- **Appointment List**

  The receptionist shall be able to view the full appointment list.

- **Booking an appointment**

  The system shall provide the available appointment to receptionist and patients in order to book a new appointment.

- **Updating Schedules**

  The system shall update the schedules of users automatically whenever a new appointment is booked or a patient is redirected.

- **Inform (Notify) Users**

  The system shall inform doctors, nurses, lab assistants, pharmacist whenever an action has to be taken by them.

- **Creating Prescription**

  The doctor shall user the system to create/enter a prescription for the patient. On the other hand, the patient also should have access to view the prescription through his/her account.

- **Redirecting Patients**

  The system shall enable doctors to redirect the patient to nurses and lab assistants.

- **Generating Reports**

  The system shall enable lab assistants to generate test reports like X-Ray images, CT scan, MRI reports.

- **View Reports by patient**

  The patients shall use the system to view their test results reports as well as doctors' advice and prescription.

- **View Reports by doctor**

  The system shall allow doctors to view the patients' reports and enter required advice for the patient, as well as new prescriptions if needed.

- **Dose of Medicines**

  The system shall allow the pharmacist to enter the dose and guidelines of each medicine for patients.

- **Examination and Medicine Costs**

  The system shall allow lab assistants and pharmacist to enter the costs of the examinations and medicines.

- **Check Out (Payment)**

  The system shall allow the cashier to create and order invoice for payment through the billing module. The cashier shall watch the payment history of the patients.

3.1.2 Non-Functional Requirements

The non-functional requirement defines the operational requirements off the system, as well as the constraints to be followed in order to improve the system's functionality. The following are some of the non-functional requirement that needs to be considered in the HMS system:

- **Availability**

  The system must be available 24/7.

- **Capacity**

  The system must support a load of 3000 users at a time.

- **Performance**
  - **Response Time**: The system must respond within 2 seconds after verifying the details and other data of the patient. In other words, the time to load a web page over a 56Kbps modem connection should not exceed 2 seconds.
  - **User Interface**: User interface display shall response within 5 seconds.
  - **Conformity**: The system should be in accordance with Windows Accessibility.
  - **Virus Protection**: Devices in the hospital that use the system must have firewalls enabled and an Active Anti-Virus in usage.

- **Durability**

  In case of failure, the system should be recovered by itself within 10 seconds, and the server must receive a comprehensive crash report stating the problem occurred.

- **Adaptability**

  The system (web application) must be adaptive and responsive to support devices of all types.

- **Security**
    - **Modification**: Changes in the system like (insert, erase, and update) is coordinated and performed by the Admin only.
    - **User Rights**: users' activity of the system should be controlled so that each user can access the allowable activities only.
    - **Data**: the transaction data should be transmitted in an encrypted form.
    - **Database Protection**: the database should be protected by a strong password.
- **Safety and Maintainability**

  A backup of the database should be performed every week, so that the system can be recovered in case of any database damage, which may be occurred due to a catastrophic failure, such as a disk crash.
- **Accessibility**

  The system can be accessed by the Admin and many other users but the access level is controlled of each user as per their scope of work.

3.2 System Requirements

System requirements define the specifications required to use the system. The following are some of the System requirements that need to be considered for the HMS system:

- The system needs to run seamlessly with at least 300 MB of Internal Memory and 700MB of Random Access Memory (RAM).
- The system needs a minimum Internet speed of 500 kbps to successfully refresh and load pages/modules.
- The system (webApp) needs internet connectivity to work to access (SharpenedProductions, 2019)

3.3 Domain requirements

Domain requirements specify the environment where the system shall operate successfully. These requirements are essential, as they often represent the basics of the system domain. Such requirements are explicitly written for developers, so that it may contain technical terms or calculations. (Sommerville, 2008) The following are some of the domain requirements that need to be considered for the HMS system:

- The HMS system must be compatible with any device since it is a web application.
- The data transfer of the system must be assured according to the Fast Healthcare Interoperability Resources (FHIR), the Health Level Seven (HL7) and the Digital Imaging and Communications in Medicine (DICOM) Standards. (Barkova, 2017b)
- The system with complying with Accountability Act (HIPAA) and Health Insurance Portability compliance testing, which specifies the technical safeguards applicable to a hospital web application. (Barkova, 2017a)

3.4 Requirements Elicitation

The requirements elicitation is one of the most error-prone and difficult steps in the phase of requirements gathering. The purpose of elicitation is to understand and explore the requirements of consumers. Elicitation is performed to evaluate the collected requirements in details, before the analysis stage. There are various techniques of requirements elicitation including brainstorming, interviews, prototyping, observation, and many other techniques. (Corporate, 2018)

However, the best two techniques that may suit the HMS system are:

- **Observation**

  Observation allows the analysts to analyse and gather valuable information, which is already available. This technique is essential as all business analysts will report what they see in other forms such as business procedure prototypes and diagramming along with the defined use cases. (Masters, 2012)

- **Interviews**

  Interviews allow working through the knowledge base of the system's users so that developers can understand how users think. This technique plays a big role in writing strong requirements. It also helps to gather a large amount of data quickly. (Corporate, 2018)

However, both of the techniques work well in gathering the requirements of the HMS system, even though observation would be more effective for the HMS system since the system has various user categories. Observation enables the analyst to provide his/her opinion of understanding the work so that ensuring that no confusion exists. (Masters, 2012)

3.5 Requirement Validation

Requirements validation is mainly used to ensure that the defined requirements match the desires of the users. It is involved with finding the issues or problems related to the requirements. Validation of Requirements is a very essential step as issues related to requirements may lead to extreme modification when perceived later in the development process. There are various techniques of requirements validation including test case generation, requirements Reviews, prototyping, walk-through and automated consistency analysis. The best two techniques that may suit the HMS system are:

- **Test Case Generation**

  This technique involves performing a number of test cases, in order to reveal the issues related to the requirements. If the test case is difficult or impossible to be designed, it is widely believed that the implementation of the system will be also difficult, so that the requirements must be reconsidered.

- **Requirements Reviews**

  This technique involves reading and reviewing the Software Requirements Specification (SRS) document by a group of people including those who interact with the customer and system developers, in order to analyse the SRS document in details to check inconsistency, errors and ambiguity.

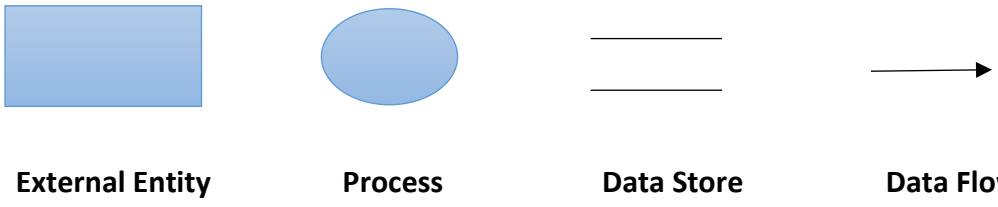
However, both of the techniques work well invalidating the requirements of the HMS system, even though **Requirements Reviews** would be more effective for the HMS system. Using Requirements Reviews will enable to initiate negotiations with the customer, in order to find a solution if a problem or error was found. (Algabry, 2016)

3.6 Diagrams

This section describes four types of diagrams, which used in the requirements gathering stage.

3.6.1 Overall behaviour – Data Flow Diagram (DFD)

The DFD diagram – Context Level is used to describe the overall behaviour of the HMS system "As shown in **Fig3.1**". The main symbols used in DFD diagrams:



External Entity **Process** **Data Store** **Data Flow**

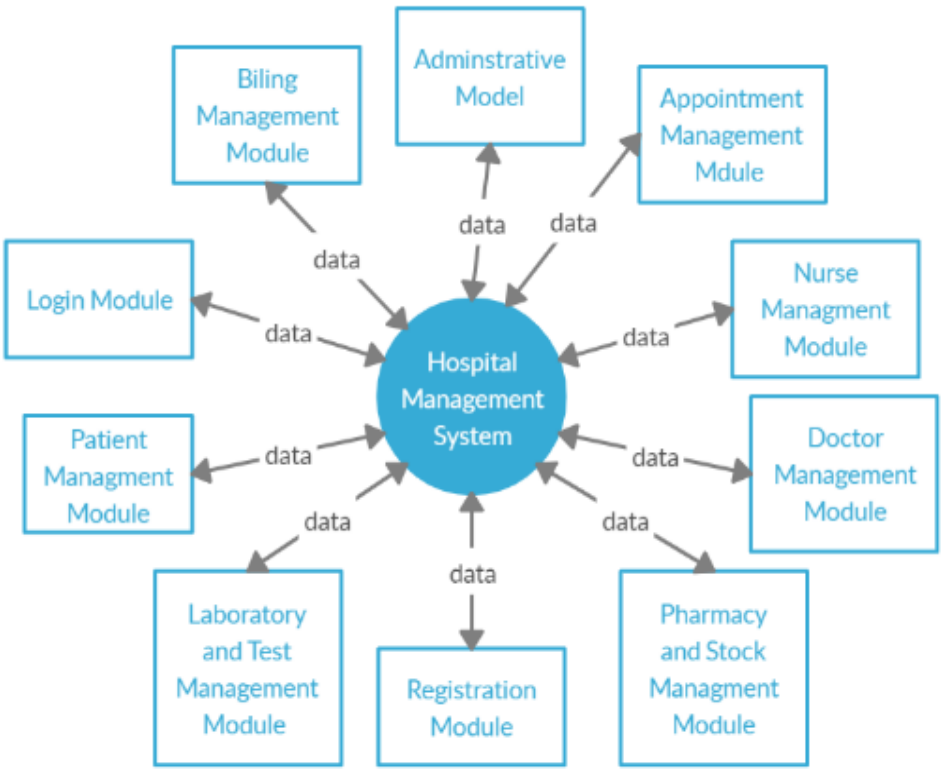


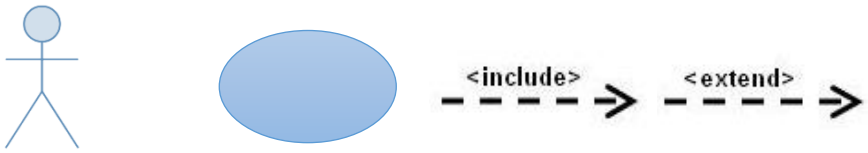
Figure3.1: Dataflow Diagram of the HMS system.

(Creately, 2019)

3.6.2 User interaction - Use Case Diagram

The Use Case Diagram is used to simplify and analyse the requirements of the HMS system "As shown in **Fig3.2**". This type of diagram consists of four main components, which are the boundary of the system, the actors, the use cases and the relationships between the use cases and actors. The use cases help to determine the expected behaviour of the system but not the exact method to make it happen. The key concept of a use case diagram is to design the system from the perspective of the end-use. (Rouse, 2015)

Symbols of use case diagrams:



Actor (user) **Use Case** **Include** **Extend**

3.6.3 Objects and relationship - Object model

The Object Model is used to describe the HMS system corresponding to classes and objects "As shown in **Fig3.3**". It helps to identify the interaction between different models, so that describes the static structure of the system. It also helps to reduce the complexity of the system and make it easy to be understood. (Techopedia, 2019)

3.6.4 Sequence of Object Interactions- Sequence Diagrams

A sequence diagram simply shows the sequential order of the communication between the objects of HMS system "As shown in **Fig3.4**". This type of diagram is mainly used to visualise and design the thought process of a specific function. (GeeksForGeeks, 2019)

Symbols of sequence diagrams:

Object **Use Case** **Activation Box (Time Period)** **Lifeline (Timeline)** **Activity** **Reply**

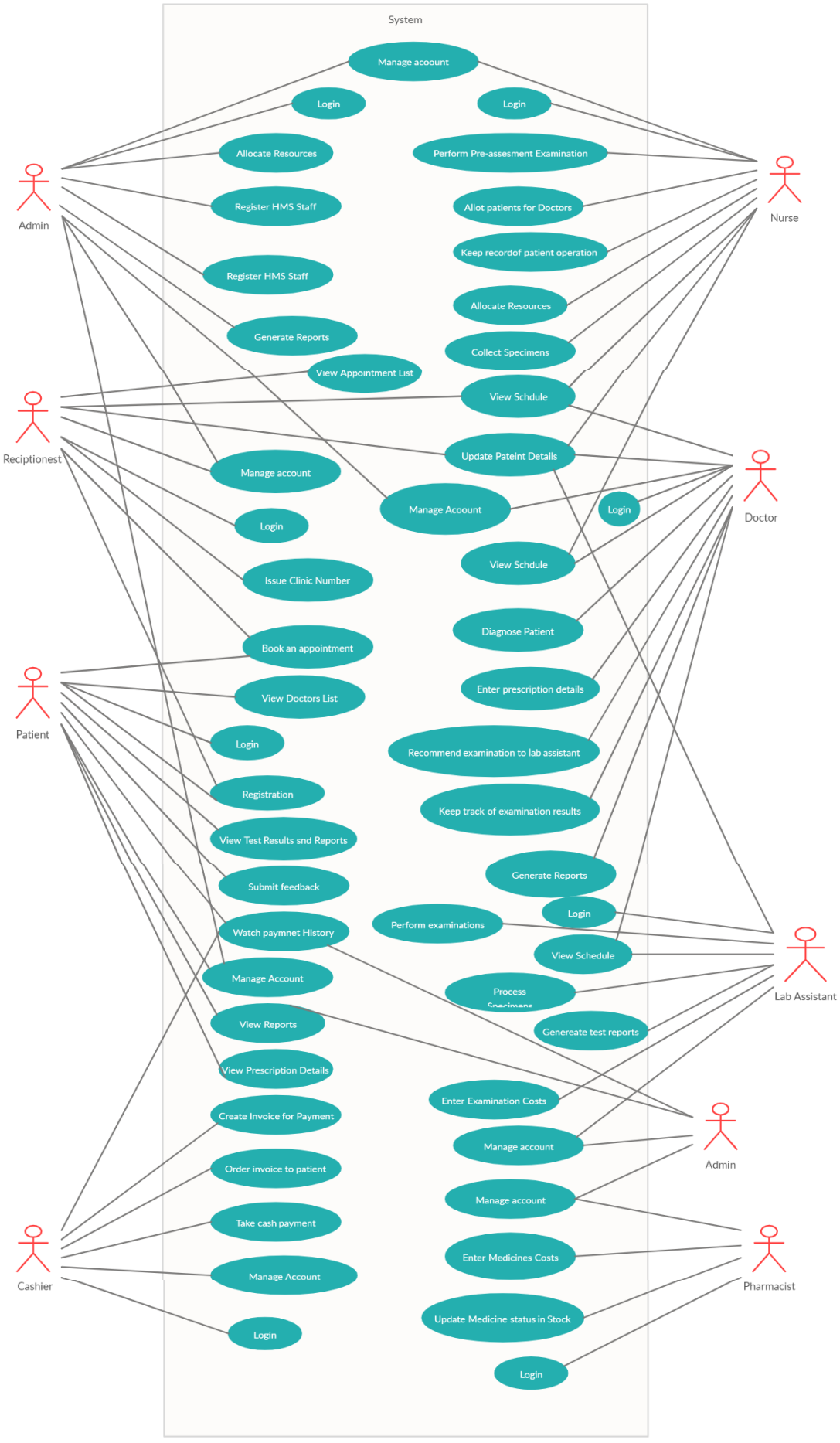


Figure3.2: Use Case Diagram of the HMS system.

(Creately, 2019)

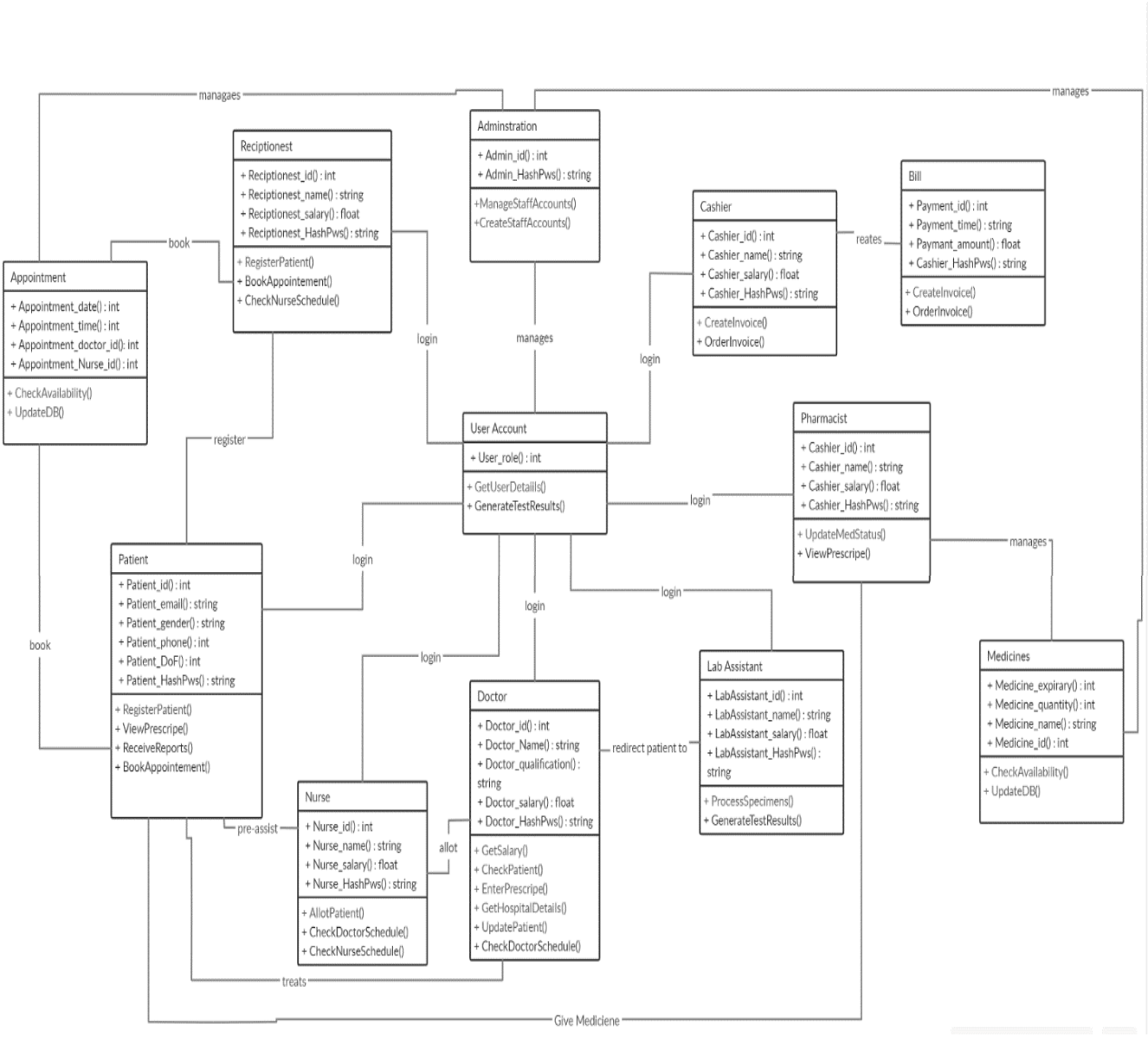


Figure3.3: Object model of the HMS system.

(Creately, 2019)

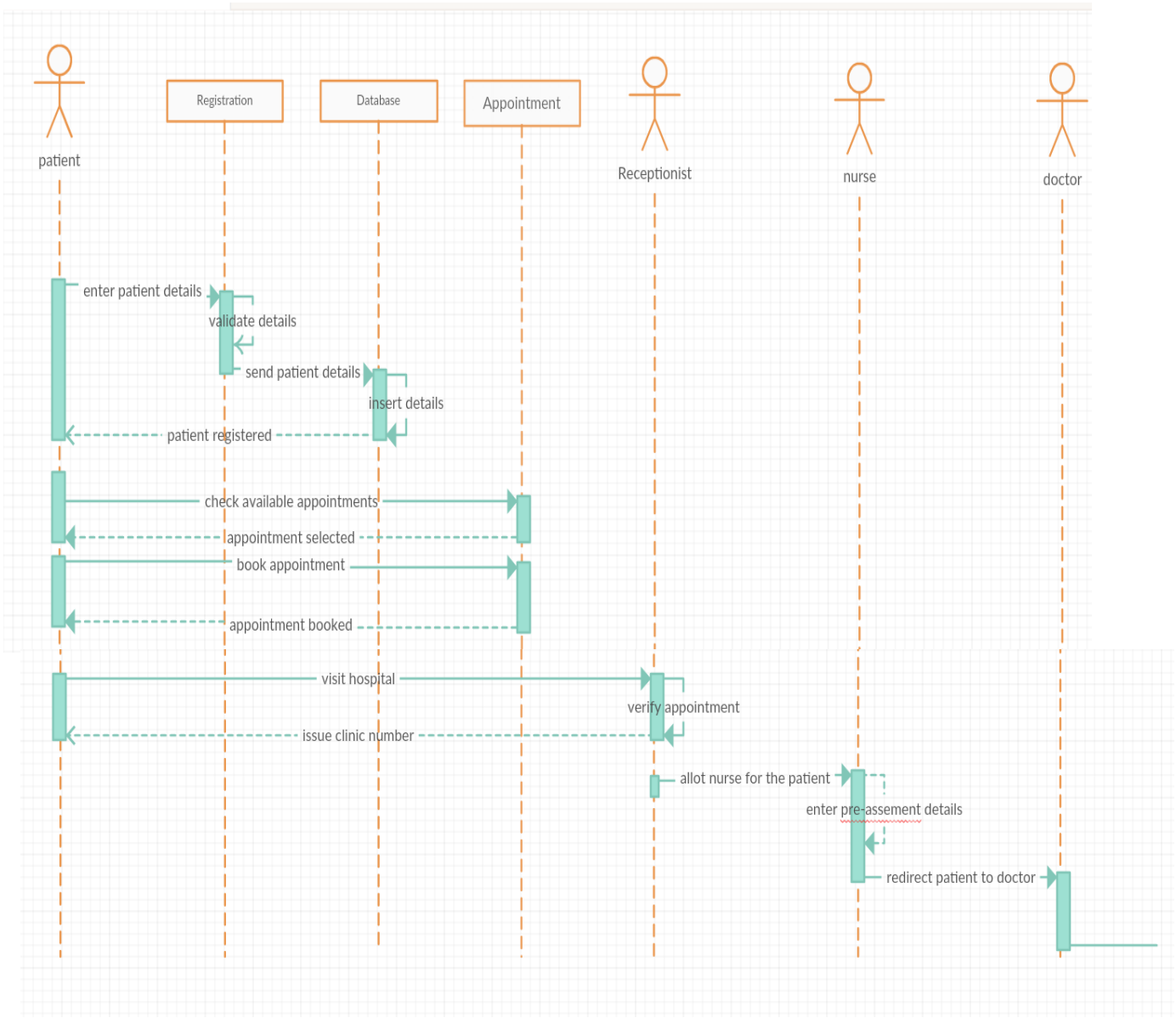


Figure3.4: Sequence Diagram for booking an appointment by an unregistered patient in the HMS system.

(Creately, 2019)

Chapter 4: User Interface

The interaction and communication between the users and the system are called the User Interface (UI). In other words, UI is the way through which a user communicates with the HMS system (web application). There are various types of user interfaces, which are:

1. Graphical User Interface (GUI).
2. Command Line Interface (CLI).
3. Form-based interface.
4. Menu-based (Menu-driven) interface.
5. Natural language interface. (TheTeacher, 2019)

For the HMS system (web application), the interfaces that are suitable to be used are:

- **Graphical User Interface**

  The HMS web application is mainly based on the GUI Interface. This interface is suitable to be used for showing results that require using graphical objects or icons in the web application "As shown in the example in **Fig4.1**". This type of interface allows the user to interact with the application/system. The major reasons (advantages) of using this type of interface are its attractiveness and ease of use. (Study.com, 2015)

Figure4.1: Example of GUI interface (View Test Results/ Using Graphics).

(Baskar, 2011)

- **Menu-based Interface**

  This interface is suitable to be used for the home page in the web application "As shown in the example in **Fig4.2**". It is a very simple interface, which makes the way of navigation easier. It is very famous to be used in web applications due to its simplicity and user-friendly properties. It gives the user the option to choose a single function (step), which further causes another step until the user reaches the desired page. The major reasons (advantages) of using this type of interface are its simplicity especially for new system's users "as mentioned earlier" and its self-explanatory menu options. (Study.com, 2015)

Figure4.2: Example of Menu-based interface (The home page).

(Baskar, 2011)

- **Form-based Interface**

  This interface is suitable to be used for entering patient details, reports, and other similar functions that require entering details in the web application "As shown in the example in **Fig4.3**". This type of interface is very common to be used whenever the application requires entering formulaic information. In the HMS system, the registration of the patient, booking an appointment and other similar activities might be done with the help of this interface. (TheTeacher, 2019)

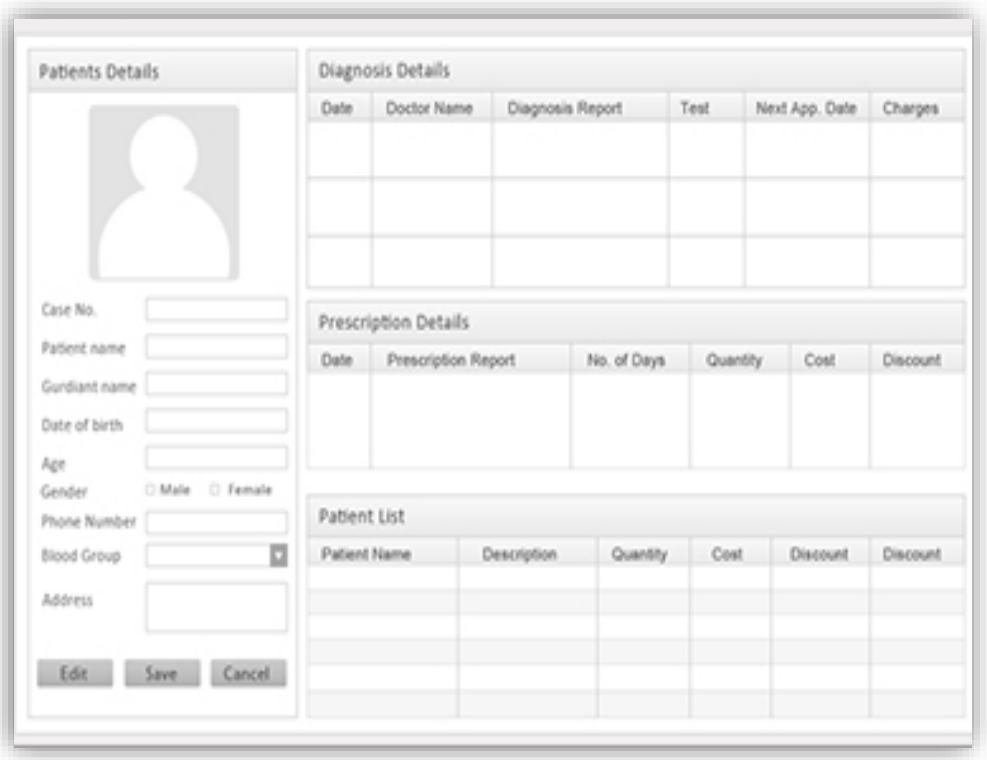


Figure4.3: Example of From-based interface (Entering Details).

(Baskar, 2011)

Chapter 5: Verification and Testing

5.1 Verification

It is very important to ensure that the HMS system performs what it is expected to do before the system is delivered to the users. Verification is the process of determining if the system fits the defined criteria and meets the requirements of the customer or not. There are various types of verification, which are used to ensure the quality of the system, such as demonstration, inspection and analysis. (Catherine, 2018) Some of the verification techniques that may suit the HMS system are the following:

- **Inspection**

  It is the process of checking the software word-by-word for the purpose of tracking defects, validating relevant requirements' traceability and ensuring consistency. This technique comprises five main roles, which are the moderator, the recorder, the author, the reader and the inspector. It may involve checking the source code of the system and the syntax error. This technique helps in identifying the errors and defects in the code by the inspection team. (CareerRide, 2016)

- **Demonstration**

  It is the process of handling the product in order to achieve the expected performance of it. It mainly concentrates on checking the main functionalities of the system. (Catherine, 2018)

- **Walkthroughs**

  It is the process of defining defects and errors by the developer so that the development team and the other participants can come out with observations and suggestions for improvements, in order to take the right action. (CareerRide, 2016)

5.2 Testing

The software testing is the process of Verifying and Validation (V&V) that the system is working successfully in terms of its defined requirements. (Gupta, 2017) For ensuring this process in the HMS web application, the following types of testing should be performed:

- **Functionality Testing:**

  This type of testing involves verifying that the system meets the defined functional requirements in the SRS document. I also involve testing all web pages' links, forms, cookies and Search Engine Optimisation (SEO). The forms of the web application should be working as expected, followed by its validation controls to ensure that the mandatory fields are not left empty and to validate the entry type in each text field. Equally important, the data entered by the user in the forms should be transmitted successfully.

- **Usability Testing:**

  This type of testing involves verifying/testing the navigation to and from each web page in the HMS web application, as well testing the content of it to ensure that it is free of spelling or grammatical errors. Usability testing is an essential part of the development of any web application.

- **Interface Testing:**

  This type of testing involves testing the three main parts of the HMS system, which are the application, the database server and the webserver. It is important since it verifying that the connection between these three layers is established successfully. In addition, developers should take into account to display corresponding errors to users whenever an error occurred.

- **Database Testing:**

  This type of testing is vital since it ensures the integrity of data in the database, the time is taken to response for queries and the accuracy of data retrieved from the database.

- **Compatibility Testing:**

  This type of testing ensures that the HMS web application is working in all browsers and operating systems in a correct manner.

- **Performance Testing:**

  This type of testing ensures that the HMS web application is working efficiently under all loads including peak loads.

- **Security Testing:**

  This type of testing involves maintaining the security of the web application including unauthorized access prevention, expiry of session times and using SSL certificates. (Guru99, 2019)

Chapter 6: Software Management

This chapter discusses the three main criteria for the management of HMS system, which are risk management, cost estimation and quality management or assurance.

6.1 Risk Assessment

In this section, a risk analysis of the HMS system is carried out in order to identify the possible risks, damages and harms that may affect the behaviour of the HMS system. This analysis is crucial for the HMS system since the system related to the healthcare field so that human lives are involved. Therefore, the HMS system should take into account all the aspects of building a functional operations management system. The risk analysis is illustrated in the form of a table to provide the simplest technique of risk projection, as follows:

Table6.1: RMMM Risk Assessment Table for HMS system. (Spark, 2018)

	Risk Summary	Risk Category	Probability	Impact (1-4)	RMMM
1	The HMS system does not meet the specifications/ requirements/expectations	Project Risk	15% - 20% As a misunderstanding between the customer and the developer may involve. Each person has a different way of thinking and the natural language used is well known for its ambiguity	3 marginal, as the system may not perform the main operations it has to do. It is not critical since it could be solved before development.	**M1:** Meetings should be conducted with the customer regularly in order to prevent such a risk (problem). As well as, making use of prototyping to collect the feedback if changes are required. **M2:** Validation and Verification (V&V) process must be taken into account to ensure that the system works as expected. As well as, the understanding between the developing team and the customer must be verified. **M3:** Investigate the possible reasons that may lead to such a problem. Meetings could also be conducted to discuss the problem and decide what actions should be taken.

2	Late Delivery of the project	Schedule Risk	35% - 45%	3	**M1:** Proper steps and plan have to be set earlier before the implementation of the project to ensure timely delivery by evaluating the project scope on the basis of the production deadline. **M2:** monitoring the schedule of the project to ensure that each team is working at a planned rate. The project managers or developers can check this. **M3**: Investigate the possible reasons that may lead to such a problem like changing of requirements. In worst cases, an extension to the deadline may be asked to form the customer.
3	Computer Crash	Technical Risk	5% - 10%	1	**M1:** Performing regular data backup on the project as well as associated documentation in multiple locations. Hosting the project on GitHub or Azure may also help in avoiding data loss. **M2:** The staff members should always be aware of the reliability and stability of the computers, which they work on. Any adjustments in the environment's stability should be noted and taken seriously. **M3:** Investigate the problem to find the causes of it and ensure that it is not a flake. Checking for backups and then recovery should be done in case of such a problem occurred.
4	Unsuccessful management of	Financial /Budget Risk	30-40%	3	**M1:** use effective cost estimation techniques, along with the use of historical data. A buffer amount of money should be maintained for extra costs.

	project budget				**M2:** Track expenses and make budget decisions to keep up with changes during the project. **M3:** Investigate the possible reasons that may lead to over-budgeting and or discover appropriate ways to reduce costs without affecting the performance or the quality of the system.

Table Keys:

Impact (1-4): 1 – Catastrophic, 2 – Critical, 3 – Marginal, 4 – Negligible

RMMM: M1 – Mitigation, **M2** – Monitoring, **M3** – Management

On the other hand, there are some other techniques for analysing the possible risks of the HMS system. These techniques are considered as the latest techniques used by the project managers. Two of these techniques are listed below:

- **Risk Assessment Template for IT**

  This technique is developed especially for IT projects including the HMS system. It involves numbering, ordering the risks in a provided space. This process makes it easy later to track any upcoming risking in reality faster.

- **Risk Register**

  This technique is similar to Risk Assessment Template for IT technique; however, it enables the risk manager to prioritize the risks, as well as assigning the responsible person/ employee to resolve it. It also helps to identify and describe the list. It will then provide space for illustrating the potential impact on the project and what the expected solution is to mitigate the risk if any. (Westland, 2019)

6.2 Cost Estimation

In this section, a set of techniques and methods used for the estimation of the HMS system's costs is discussed. The process of the estimation of costs usually utilizes a set of techniques. These techniques compute the output, which is expressed in the form of efforts and duration, from the given set of inputs, which is expressed in the form of cost drivers. (ProfissionalQA.com, 2016)

As mentioned before, the HMS system is a web application that aids in converting the existing manual process in hospitals into an easier online process for the management of the hospital. In this section, the Function Point Analysis (FPA) technique is used to estimate the size of the application, followed by the COCOMO Model technique to estimate the effort required for the project. According to (shodhGanga, 2014) , FPA and COCOMO Model techniques are used by most of the IT companies due to their accuracy. The following are the steps involved in estimating the cost of the HMS system:

- **Size Estimation using FPA**
    1. Calculate the Unadjusted Function Point (**UFP**)

       Considering that, the HMS system has:
        - 40 High External Inputs (EI)
        - 7 Average External Outputs (EO)
        - 5 Low External Inquiries (EQ)
        - 50 Average Internal Logical Files (ILF)
        - 10 Average External Interface Files (EIF)

Table6.2: Standard Conversion table for Function Point Analysis.

(TutorialsPoint, 2019)

Rating	Values				
	EO	EQ	EI	ILF	ELF
Low	4	3	3	7	5
Average	5	4	4	10	7
High	6	5	6	15	10

According to **Table6.3,** the UFP value can be calculated as follows:

Table6.3: Obtaining the value of UFP for HMS system.

Type of components	Complexity * Value	Total
EI	40 * 6	240
EO	7 * 5	35
EQ	5 * 3	15
ILF	50 * 10	500
EIF	10 * 7	70
Total UFP		860

Hence, **UFP = 860**

2. Calculate the Technical Complexity Factor (**TCF**)

   Considering that, the HMS system requires:

   - Average (3) Performance
   - Moderate (2) Data Communication
   - Significant (4) On-Line Update
   - Incidental (1) Reusability

   Total = 10

   TCF = (0.65 + 0.01 * 10) = 0.75

   Hence, **TCF = 0.75**

3. Calculate the Function Point Count

   FP Count = UFP * TCF

   = 860 * 0.75

   = **645**

   Hence **FP Count (Size) = 645 FP** (shodhGanga, 2014)

- **Effort Estimation using COCOMO Model**

  Assuming: **A = 3**, Sum of Weight of Scale Factors = 13

  1. Calculate B

     B = (0.91 + 0.01 (Sum of Weight of Scale Factors))

     = (0.91 + 0.01 (13)) = **1.04**

  Considering that HMS developed using Visual Basic (VB), Hence **LOC/FP for=32**

  2. Calculate Size

     Size = 645 * 32 = 20640 SLOC ~ **20 KSLOC**

  Assuming: **EAF = 0.2** based on the project cost drivers

  - Calculate Effort

    Effort = A * EAF * $(Size)^B$

    Effort (Nominal) = A * $(Size)^B$

    = 3 * $(20)^{1.04}$

    = 67.638 Persons/Months

    ~ **68 Persons/Months**

    Effort (Maintenance) = A * EAF * $(Size)^B$

    = 3 * 0.2 * $(20)^{1.04}$

    = 13.528 Persons/Months

    ~ **14 Persons/Months**

  - Calculate SE

    SE = 0.28 + 0.2 (B – 0.91)

    = 0.28 + 0.2 (1.04 – 0.91)

    = **0.306**

  - Calculate Duration

    Duration = 3.67 × $(\text{Effort (Maintenance)})^{SE}$

    = 3.67 × $(14)^{0.306}$

    = **8.23 Months**

  - Calculate Actual Staff

    Actual Staff = (Effort (Maintenance) / Duration)

    = (14 / 8.32)

    = 1.68 Persons ~ **2 Persons** (shodhGanga, 2014)

On the other hand, there are some other techniques for estimating the cost of the HMS system. These techniques are considered as the latest techniques used by the project managers. Two of these techniques are listed below:

- **Analogous Estimating**

  This technique is used when the available project information is limited. It involves comparing the cost of the project with other previous similar projects' costs, in order to estimate the cost of the proposed project. It is also called top-down estimating technique. This technique may suit the HMS system if it needs to choose the fastest technique that can also be used when the project details are limited. However, it has the disadvantage of unreliability sometimes since it mostly relies on the developer's judgment for estimating the cost. (Usmani, 2019)

- **Parametric Estimating**

  This technique calculates the cost of the project based on the historical data or parameters of other previous similar projects' costs. It relies on using the statistical relationship between the variables and the historical data. It has the advantages of accuracy and it is considered to be more accurate than all other cost estimation to techniques including the analogous estimating technique. (Usmani, 2019)

6.3 Quality Management

In this section, the quality management activities that are carried out for the development of HMS system will be discussed. First, let's clarify the meaning of "Quality", which literally implies that a product must fulfil its requirements. The importance of Quality management for HMS system relies on ensuring the following:

- Saving time and money.
- Producing a stable and successful web application (product).
- Maintaining the security and effectiveness of the web application.
- Meeting users and customer expectations / satisfy users.
- Adding useful features suggested by the Quality Assurance (QA) team. (Baghdasaryan, 2018)

The QA team are responsible for monitoring each and every stage of the Software Development LifeCycle (SDLC), in order to ensure that the system is working as expected without any errors. As well as, suggesting solutions to problems and collecting the quality data. (Baghdasaryan, 2018)

The four main activities involved in the quality management process are:

1. **Quality Assurance**: the establishment of quality standards and organisational procedures.
2. **Quality Planning**: the selection and modification of standards and suitable procedures.
3. **Quality Control**: the guarantee of following the standards and procedures by the development team.
4. **Software measurement and metrics**: the guarantee of having the required quantitative analysis of quality attributes and software processes. (MymgTeam, 2011)

One of the most recommended standards of quality management, which can help maintain the quality attributes essential for the HMS system, is the ISO 9000. ISO 9000 is a set of international quality management and quality assurance standards, which have been set up to assist companies to document the elements of quality systems necessary for a successful quality system. ISO 9000 standard is categorized into three

main categories in terms of the type of industry for the organization. These categories are ISO 9001, ISO 9002 and ISO 9003. For the HMS system, ISO 9001 is the most applicable standard as it is involved with organizations includes development, design, servicing goods as well as production. The main advantages of using these standards for the HMS system is to:

- Preventing from repeating the same mistakes again.
- Providing continuity as anyone who understands the standards can understand the organisation as well.
- It focuses on inward processes.
- ISO 9000 standards are accepted by most of the countries around the world. (ASQ, 2019)

On the other hand, there are some other quality tools that can be applicable to the HMS system. Two of these tools are listed below:

- **Pareto Diagram**

  This special vertical graph is separated into categorizes representing all possibilities or events that may arise. These categories vary from the high frequency on the left to the low-frequency scale on the right side of each group "As shown in **Fig6.1"**. This diagram mainly relies on the rule of 80/20. (KnowledgeHut, 2019)

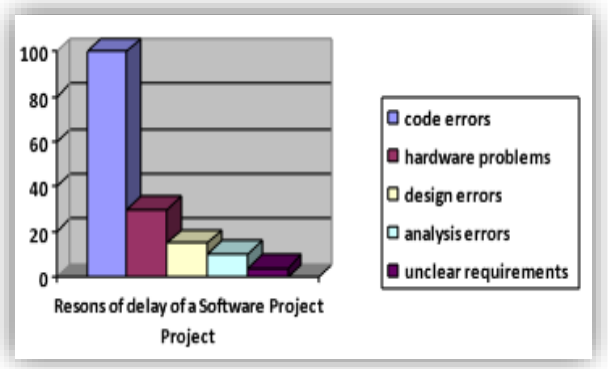


Figure6.1: Pareto Diagram.

(KnowledgeHut, 2019)

- **Check Sheets**

  The check sheet includes inspections and tests, as well as the characteristics that can result from each test. The approval conditions for each sample test shall be specified on the sheet to decide whether a sample product is inspected. This tool has the advantage of simplicity and reusability, as the test sheets obtained at different times or places can be stored for later use. (KnowledgeHut, 2019)

Chapter 7: Conclusion

In conclusion, this report discusses a case study of an online web-based Hospital Management System (HMS). The aim, objectives, background and problem statement of the project, followed by, the system description, its main actors and modules are clearly stated. In addition, a suitable Software Development LifeCycle (SDLC) was outlined properly, along with its advantages and disadvantages. Furthermore, the user, system and domain requirements of the HMS system including the requirements elicitation and validation techniques required were determined. The UML and behavioural diagrams described the system and illustrated the relationship between objects, and the processes flow of the HMS system, which helps to better understand the system. The discussed design of the interfaces provides good user experience and offers accessibility features for users of the system. Through the identified verification tools, the HMS system was ensured to work as per the expectations. Followed by, the applicable types of testing web applications/HMS system. In the end, the development costs, potential major risks and how they can be addressed, quality assurance principles as well as standards are to be followed through software management, were successfully determined in order to make the HMS system market successful.

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