King Saud University
College of Computer and Information Sciences

SWE321:Software Design & Architecture

Smart Hospital

1.Definition

This section provides a project description of Smart Hospital System (SHS), Objectives, a list of abbreviations and definitions is provided. Additionally, a brief document overview.

1.1. Project description

        Patient safety and care in a healthcare practice is a top concern that doctors, nurses and administrators aim to improve every day. However, even the

most skilled, veteran practitioners are not immune to the occasional human error. Over the past few decades, there have been incredible advancements in patient safety, due in part to better technology. One technology that has had a tremendous impact is the barcode.

The Primary objective of this software is to increased patient safety , privacy , and ease of identification, this technology offers many other benefits, including improved operational efficiencies seamless adoption and ease of use .

1.2. Objectives

- To reduce paper use and preserve the environment .
- To reduce the amount of wasted time taken in order to search and bring patient file.
- To provide a convenient and innovative way for the hospital .

1.3. Definitions, acronyms and abbreviation

Definitions of all the acronyms and abbreviations used throughout this document

Term	Definition
Barcode	A barcode is a square or rectangular image consisting of a series of parallel black lines and white spaces of varying widths that can be read by a scanner .
Barcode reader technology	is an optical scanner that can read printed barcodes, decode the data contained in the barcode and send the data to an embedded device .
Embedded devices	is an object that contains a special-purpose computing system. The system, which is completely enclosed by the object, may or may not be able to connect to the Internet such as (mobile – tablet).
Medical history	the patient's past and present which may contain relevant information bearing on their health past, present, and future.
Prescription	A physician's order for the preparation and administration of a drug for a patient.

Patient file	The patient file is the principal repository for information concerning a patient's health care
2D barcode	Two-dimensional (2D) barcodes look like squares or rectangles that contain many small, individual dots.A single 2D barcode can hold a significant amount of information and may remain legible even when printed at a small size or etched onto a product. 2D barcodes are used in a wide range of industries, from manufacturing and warehousing to logistics and healthcare
RFID EPC Gen 2 UHF chip	FID (or Radio-Frequency Identification) leverages radio waves to transmit data from RFID chips to the readers.You can scan multiple tags at once, which results in fast reading. Because RFID allows you to identify each individual item, you will avoid scanning twice the same item, which is a recurring issue with barcode.Barcode encoding (e.g. GTIN) and RFID encoding (EPC) both follow the same standard by GS1, so the transition is smooth, and compatibility is guaranteed.
IV bags	An ongoing shortage of fluids used to deliver medicine and treat dehydrated patients has hospital workers scrambling during a nasty flu season and supplies from factories in storm-ravaged Puerto Rico have been slow to rebound.
EHR	Electronic health record (EHR) is a digital version of a patient's paper chart. EHRs are real-time, patient-centered records that make information available instantly and securely to authorized users.
QR code	Quick Response code (QR code) is one of the most popular types of two-dimensional barcode; it has a strong error correcting capability.

1.4. Overview

The remaining of the document includes six topics. The second topic introduces different types of stakeholders, the domain of the system, purpose, and problem solution. The third one provides some details about the system context view. The fourth topic specifies the systems functionality, in terms of nonfunctional and functional requirements also mention the system constraints. The fifth topic introduces challenges that we faced. The sixth topic introduces the Projection of the project.

2. Problem Domain Analysis

2.1.domain and stakeholders

2.1.1 Stakeholders

1. Doctors
2. Patient
3. Nurse
4. Pharmacist
5. Admin
6. reception employee

2.2. Purpose

Barcodes are used in every aspect of the healthcare industry. From the moment a patient walks into the door to the moment they pick up their medication at the pharmacy, barcodes are helping healthcare professionals track the procedures , medicine, and even the patients themselves.
When a healthcare professional scans the bracelet, he can make sure that he is treating the correct patient with the correct procedure. A mobile point-of-care solution not only lowers costs, it also increases efficiency and patient safety. Nurses and staff can collect information from a patient's identification bracelet, include the ability to electronically access his or her medical charts. Healthcare professionals can also update a patient's medical records, which will transfer to the hospital's database system.

There are many reasons why we chose this software. but the most important one is to help improve patient healthcare by making it easy for the doctors and nurses to treat them .

2.3. problems and solutions

2.3.1. Domain

• Hospital Environment .

2.3.2 Problem domain and solution

Barcode technology associated with embedded devices for Hospital System will solve many issues. Nowadays, manual search process for patient's file take few minutes depending on the speed of the network and the quality of computer device. when they use Barcode technology the system will display patient's file in few seconds only on device's screen.it will increase the speed for any process and facilitate the process of following up with the patient. Also, there is no chance to lose the data because everything is recorded electronically and backed up in different storages in database therefore less percentage of paper because data is stored electronic .In addition, the system becomes more secure, precise, allocate the right medicine for each patient and keep their privacy.

The system will generate special barcode for each patients and drug. so the doctor and nurse scan the barcode for patients and pharmacist scan the barcode for drugs and prescription.

3. The System Context View

3.1. Scenario 1 Write a prescription

Scenario 1	
Application: : Smart hospital .	
Scenario title: Write a prescription .	
Primary actor: Doctor .	**Secondary actor:** None.
Pre-Conditions: 1. The doctor should scan the barcode of the patient .	

1. **Input:** prescription .
2. **Output:**
   1- successful message .
   2- the prescription will be written in the patient's medical history .
   3- the name of the medicine will be written under medicine currently being taken .

Scenario Description:. : After scanning the patient barcode , the doctor needs to write a prescription for the patient . After write , the prescription will be in the patient's medical history and under the medicines that are currently being taken .

Scenario Steps:

Actor: The doctor	The system
1- In the patient file the doctor selects "write prescription ". 3- The doctor fills the form . 4- The doctor selects "ok".	2-The system displays a form to write the name of the medicine and duration . 5- The system displays successful message .

Post-Conditions:
1. Success condition : The prescription is written successfully.
2. Failure condition : The prescription is not written .

3.2. Scenario 2 add new drug .

Scenario 2	
Application: Smart hospital .	
Scenario title: add new drug.	
Primary actor: pharmacist.	**Secondary actor:** None.
Pre-Conditions: 1.The pharmacist must be logged in successfully .	

3. **Input:** drug information.
4. **Output:**
   1- a successful message when a drug is added successfully to the system.
   2- a warning message when a drug is not added successfully to the system.

Scenario Description: After scanning the new drug barcode for patient information , the pharmacist needs to write drug information. After writing the information, the system will check if the information format matches the system format standards if the format correct system will display a successful message if not the system will display warning message.	
Scenario Steps:	
Actor: The pharmacist	The system
1- The pharmacist scans the barcode of the new drug. 4-The pharmacist fills the following form: ▪ drug composition ▪ alternatives ▪ appropriate age ▪ dose ▪ conflict drugs ▪ location ▪ side effect ▪ number of items then press "add drug".	2-The system check if the drug has been added or not. 3-The system display "add new drug form" for the pharmacist. 5-the system display successful message.

Post-Conditions:
3. Success condition: The drug is added successfully to the system.
4. Failure condition: No drug is added to the system.

4. Requirements

In this section requirement specifications are provided. Both functional and nonfunctional requirements .

4.1. Functional Requirements

ID	Requirements
-----------	**Related to the system**
FR1	After scan barcode of the registered patient the system shall be able to recognize the patient by display Patient file watch continue the following information: - Patient name - Patient birth date - Patient register date

	- Patient sex - Patient address
FR2	After the scanned barcode of the registered patient, the system shall be able to give permits for the opening the patient rooms that has access write.
FR3	The system shall be able to generate new barcode for the new patient.
FR4	The system shall be able to generate new barcode for the new drug.
-----------	**Related to the admin**
FR5	The admin shall be able to login into the system.
FR6	The admin shall be able to create an account for doctor.
FR7	The admin shall be able to create an account for nurse.
FR8	The admin shall be able to create an account for pharmacist.
FR9	The admin shall be able to view the numbers of patients, doctors , nurse and pharmacists .
FR10	The admin shall be able to create a survey to ask the patient about the hospital services .
-----------	**Related to the doctor**
FR11	The doctor shall be able to login into the system.
FR12	The doctor shall be able to view the patient medical history .
FR13	The doctor shall be able to write a prescription .
FR14	The doctor shall be able to view the medicines that the patient is currently being taken .
FR15	The doctor shall be able to update the state of the patient (stable , deteriorated , improved).
FR16	The doctor shall be able to communicate with other doctors who are in charge of the same patient .
-----------	**Related to the nurse**
FR17	The nurse shall be able to login into the system.
FR18	The nurse shall be able to change patient status(discharged from hospital, TRANSFERRED to another hospital, HOSPICE).
FR19	The nurse shall be able to view information about the doctors in charge of the patient.
FR20	The nurse shall be able to change patient's medicine state when the patient took his/her medicine.
FR21	The nurse shall be able to view patient medical history .
FR22	The nurse shall be able to give the patient access to specific rooms in the hospital for a specific date and time only.
-----------	**Related to the pharmacist**
FR23	The pharmacist shall be able to login into the system.
FR24	The pharmacist shall be able to view the patient prescription ,when he scans the patient barcode .

FR25	The pharmacist shall be able to update the patient prescription state (checked/Unchecked).
FR26	The pharmacist shall be able to add a drug into drug set by filling drug information form(drug composition , alternatives , appropriate age , dose , conflict drugs , location , side effect , number of item)
FR27	The pharmacist shall be able to view the drug information (drug composition , alternatives , appropriate age , dose , conflict drugs , location , side effect , number of item) when he scans the drug barcode .
FR28	The pharmacist shall be able to update the drug information .
-----------	**Related to the reception employee**
FR29	The reception employee shall be able to login into the system.
FR30	The reception employee shall be able to view the patient barcode.
FR31	The reception employee shall be able to print the patient barcode.
FR32	The reception employee shall be able to generate barcode for the patient.
FR33	The reception employee shall be able to add new patient in "smart hospital" database.

4.2. Non-functional Requirements

ID	Requirements
-----------	**Usability**
NR1	The average time for the doctor to learn how to use the system shall be less than 2 hours.
NR2	The average time for the nurse to learn how to use the system shall be less than 2 hours.
NR3	The average time for the pharmacist to learn how to use the system shall be less than 2 hours.
NR4	The time taken for the admin to learn how to use the system shall be is less than 4 hours.
-----------	**Flexibility**
NR5	The system shall be able to accommodate any extended change and to the latest technological integrations.
-----------	**Maintainability**
NR6	The maintenance group shall be able to fix any problem occur suddenly at least 20 minutes varying on the cause of the failure.
NR7	The system shall be closed for 30 minute per week for maintenance and elaboration.
-----------	**Integrity**
NR8	The system shall secure secure by using implantable medical devices (IMDs) the information stored in database that are used for patient recognition.
NR9	The system will only be available to authorized users of the hospital.
NR10	Only the administrator shall authorize the rights to create a new account for the users and provide them with password.

-----------	Interoperability
NR11	The system shall be connected with the hospital database.

-----------	Expandability
NR12	The System shall be designed in such a way that allows for at least 10 additional features in the future.
NR13	The System shall accommodate any scalability changes for additional patient or doctor or nurse or pharmacist.

5. challenges

There are several challenges that we may encounter during developing this project, the main challenge is since we are using barcode technology in hospital system is very sensitive it should be safe and secure to ensure patient safety , having to guaranty that by using barcode system is most challenging for us . Some of the additional challenge is reading previous researches, documents and viewing existing systems rea in barcode technology in hospital , to help team members to better understand how this technology could be used to improve hospital system and its services .

Other group work-related challenges:
1. Other projects may slow down our work on this project.
2. Group meetings, figuring out a free time for all of us might be a bit challenging.
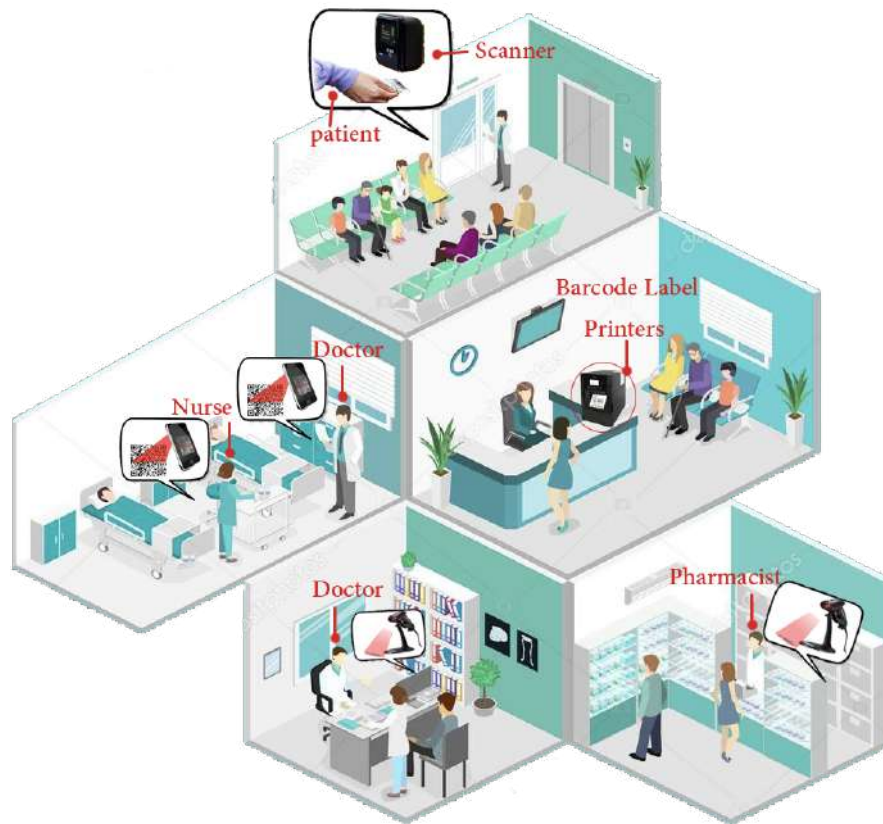3. Choosing the appropriate architecture .

6.Projection

Through working on this project, we will gain many skills such as:

1. Time management .
2. Decision making .
3. Problem solving .

7. Methodology

(this picture explains how we imagine our system will work, hospital 3d picture reference)

After some of our best Analysts meet with hospital management they take hospital management requirements and understand it very well then come with of this senior to give a quick description of how the system should work and what is the different kind of users we have and what they should be able to do:

-- senior --

Smart Hospital is a system that requires minimal user interaction by using different kinds of embedded device and the Smart Hospital application to provides a specific functionality, Smart Hospital used a barcode technology and its embedded

devices(printer, scanner) to do critical and important hospital jobs that we would like to separate them from hospital public application that most of the employee could access it like update patient file, write a prescription and other function that provide in 'functional requirements' topic. these functionalities can be seen and access by using Smart Hospital application that could be download in a phone device or pc for only authorized users to protect hospital security.

when a new patient comes to the hospital for the first time a new barcode must be generated and attached to the patient file, if the patient not new then 'reception employee' can easily retrieve the barcode from the Smart Hospital application that is downloaded in reception pc using the patient Identity number/ residence number, and by using "barcode label printer" the 'reception employee' give the patient his/her barcode.

once the patient gives his/her barcode to the doctor or nurse they should be able to access/edit all the patient information that they authorized to by scanning the barcode using their phone with barcode scanner(Captuvo™ SL42h scanner) and then all the related information to this barcode will display in the Smart Hospital application that is downloaded in their pc or phones since they work need to move a lot.

The nurse has the access right to give the patient access to specific rooms in the hospital (for a specific date and time only) the nurse able to give this access by using Smart Hospital application, and the patient can access rooms (the rooms that patient have access right to) by scanning his/her barcode using a scanner that is hang outside the room.

The pharmacist can scan the patient barcode by using the barcode scanner and then all the related information to this barcode will display in the Smart Hospital application that is downloaded in the pharmacy pc (pharmacist can't use the application in his/her phone for security purpose and the pharmacist work does not need move unlike nurse and doctor). after scan barcode, the pharmacist can read the patient prescription in Smart Hospital application and update the patient prescription state to "checked/Unchecked", "checked" means that the patient take medicine secsuffly and prescription is expired now and "Unchecked" if the patient did not take medicine secsuffly and prescription is not expired yet.

to help the process of writing a prescription by a doctor and give it by pharmacist, every drug in hospital pharmacy has a barcode.the pharmacist shall be able to view the drug information (drug composition, alternatives, appropriate age, dose, conflict drugs, location, side effect, number of the item) when pharmacist scans the drug

barcode he/she able to update the drug information so it becomes clear to the doctor(who should be able to see what drug is available and what is not) to write prescription easily. the pharmacist read the prescription in a faster way by scanning drug barcode since the drug barcode displays in prescription and tells a pharmacist where the drug is located in the pharmacy store.

All these different kinds of user account (reception employee, doctor, nurse, pharmacist) are created and managed by the admin account.

"ADMINs" are employees of the administrative and they took an order from hospital management to create an account.

---The end of senior -------------------------------------

The Analyst's team also suggests that the best development methodology is <u>waterfall</u> since the hospital management gives the freedom of the deadline of the project, but they insist it not take more than one year and a half. another reason was 'smart hospital' it's system clearly a hospital system which means a critical system and it's the first time for our company to work in a project like this.

Since it was not clear for our Analyst's team when the project actually will start, they wrote the project schedule in terms of weeks rather than specific dates, so a year and a half are 78 weeks (the maximum time that is given by hospital management for deadline).

This the project schedule that the analyst's team came with:

number of weeks	name of phase	responsible team	Comments (if any)
11	Requirements	Analysts team	At the end of this phase requirements document is completed it is reviewed by the SMEs&Business users.[1]

12	Design	Designers team	The main purpose if this stage is to create a blueprint that will satisfy all documented requirements, then to identify all inputs, processes and outputs needed and also to help avoid misunderstandings by involving the stakeholders such as managers and users.[2]
35	implementation	Development team	This phase is concerned with the physical construction of the software as set out in the design stage.[3]
15	Verification	Testing team	At this waterfall phase the project is tested to check whether it meets the requirements of the customer.[4]
5	Maintenance	maintenance team	The customer is using the application eventually. During this phase, the modifications that may occur due to changes in requirements, are implemented.[5]

Our testing team decided to use the <u>"STRESS TESTING"</u> method to test the system they think it's the best choice since our system is a hospital system, so we need to make sure that we have strong stability & reliability witch the stress testing known for it.
"Stress Testing is done to make sure that the system would not crash under crunch situations. It even tests beyond the normal operating point and evaluates how the system works under those extreme conditions." [6]

8. System Architecture

8.1. Design decisions

-Database: given the fact that the system relies heavily on data and data analysis, it became a must to optimize the data access and speed up the database operations, thus it was chosen to separate the database writing and reading operations into different and physically separated databases. This was based on the fact that Writing operations are usually consuming huge resources compared to reading operations.

- Implementation: The System has to be implemented in dot net framework, .NET is a developer platform made up of tools, programming languages, and libraries for building many different types of applications..

-Storage: The System's databases must be stored on a Server-based service.

-Database SQL:

I.) Familiarity with technology.

2.) High technical suppers.

- Application:

I.) as an application with desktop (Mac and Windows).
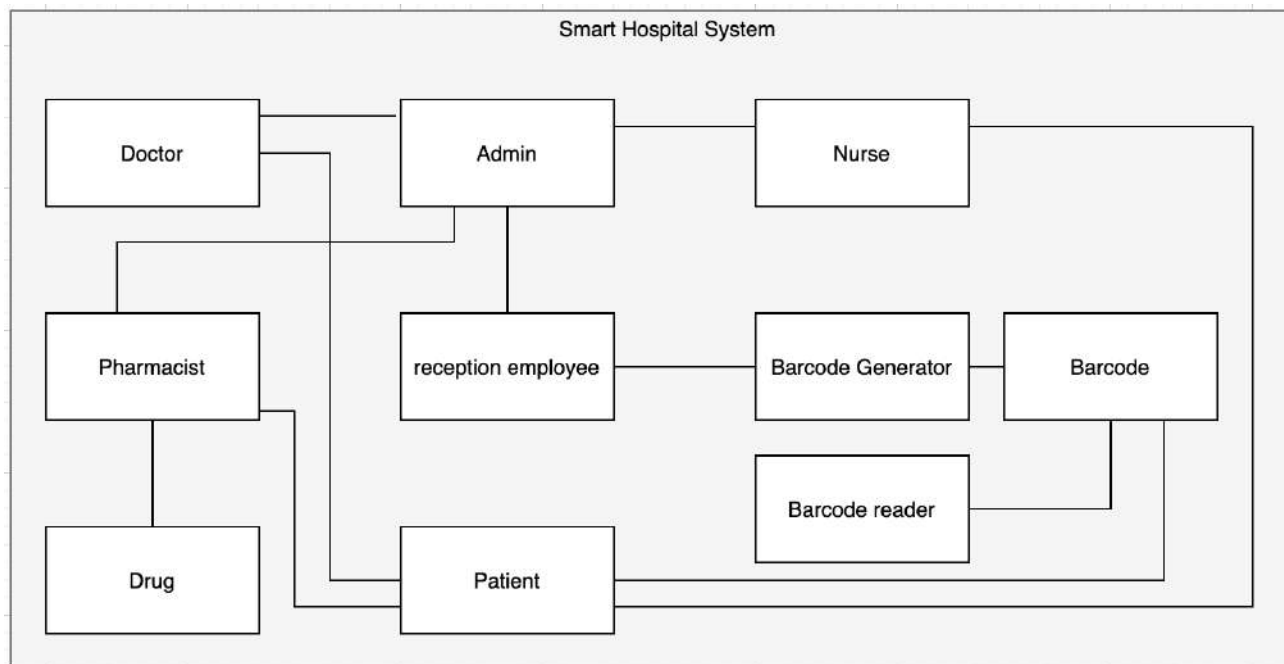
2.) as an application in mobile (iOS and Android).

8.2. Domain model

List of the concepts :
1. Doctor .
2. Nurse .
3. Patient .

4. Pharmacist.
5. Reception employee .
6. Barcode Generator.
7. Barcode.
8. Barcode reader.
9. Drug.
10. Admin.

(Box and Line diagram)

8.3. Architectural Style

The architectural style of the system is 'Three tier' which is type of distributed software architecture , it consist of 3 tiers : front-end tire is user interface , middle tire manages business logic and back-end tire handles database   .

this architecture has many advantage such as :

1- Enhancement of scalability , so the system has an ability to easily scale resources to meet the increasing workload , this is very important feature to a hospital system it must be able to accommodate the large increase in the number of patients and health practitioners .

2- Easy to maintain and modification , the developer can replace specific part of the system without affecting the other part therefore the maintenance will be easy and that what we need it in a critical system like a hospital   .

3- Hidden Database Structure , this added more security to the system and will make us sure that patients and health practitioners' data are safe .[7]

8.3.1. Our second choice for an architectural style

Layered is applicable when we have a number of classes that are closely related so they can be grouped into packages to provides a service to each other also each layer is independent .

 many of advantage such as :

1-the layers are independent so we can reuse the layer again .

2- each layer may hide private information from other layers.

but because of the low performance and the propagation of errors (since each layer takes a service from the layers below) which we do not want it in a hospital system , also layered architecture works with local systems (not distributed) and thats why can not be considered as a second choice .

8.4. Structural model

8.4.1. **The components and the initial diagram**

This section is about Identifying the components and the initial diagram based on tier Architectural style.

The System Architecture consists of three tiers which are, Front-end, Middle and Backend tier:

-   **Front-end tier:**

This tier contains a user interface , the user can generate new barcodes and can view information about existing patients, doctors , nurses , receptionists and

pharmacists. The user interface component is connected to the controller component as well as request business rules component to provide services from the application. Before the user logs in, the controller propagates to the authentication component in order to verify the authenticity of the user. The Barcode Scanner Captuvo component is an embedded system which scans a barcode and sends the scanned barcode digital information to the controller to display it to the user by using a service provided by the business rule.

- **Middle tier:**

In this tier where all the processing is done. the business rules component it provides the systems functional services. The business rule component provides services to the UI component and the controller that will propagate some services such as the update of the database or add new patients; this will be done using some additional services from the barcode generating component. This barcode generator is connected directly to the hospital's database so the barcode serial number must be reserved for each patient in the database and with no replication , the same thing applies to generating barcodes for drugs etc. the barcode generator will provide new barcode to the controller whenever it requested from the user and with based on the new barcode provided from the generator and the business rule service will update the hospital database.

- **Back-end tier**

The Back-end tier consists of the database component. The hospital database is a centralized database which is constructed using OLTP. For example, every scanned barcode digital information received from Captuvo scanner will be compared with

the barcode serial number in the database, if it exists then the information of that serial number will be retrieved from the database and will be displayed to the user. The hospital database administrator provides the necessary information to the hospital databases such as information about nurses , doctors, pharmacists, reception employees , drugs and their id. The authentication component will authenticate the user by requesting additional information from the hospital database such as verifying that the user login information is correct.

Block diagram:
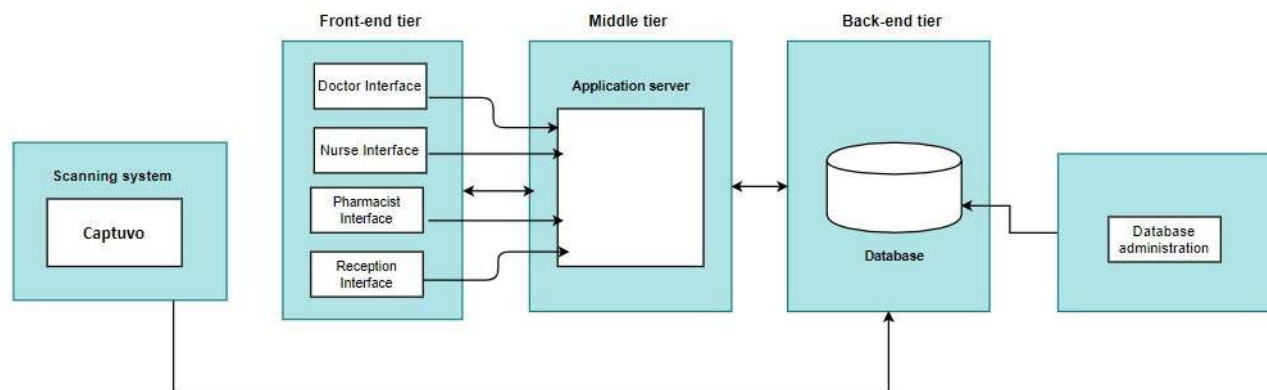
Class diagram :
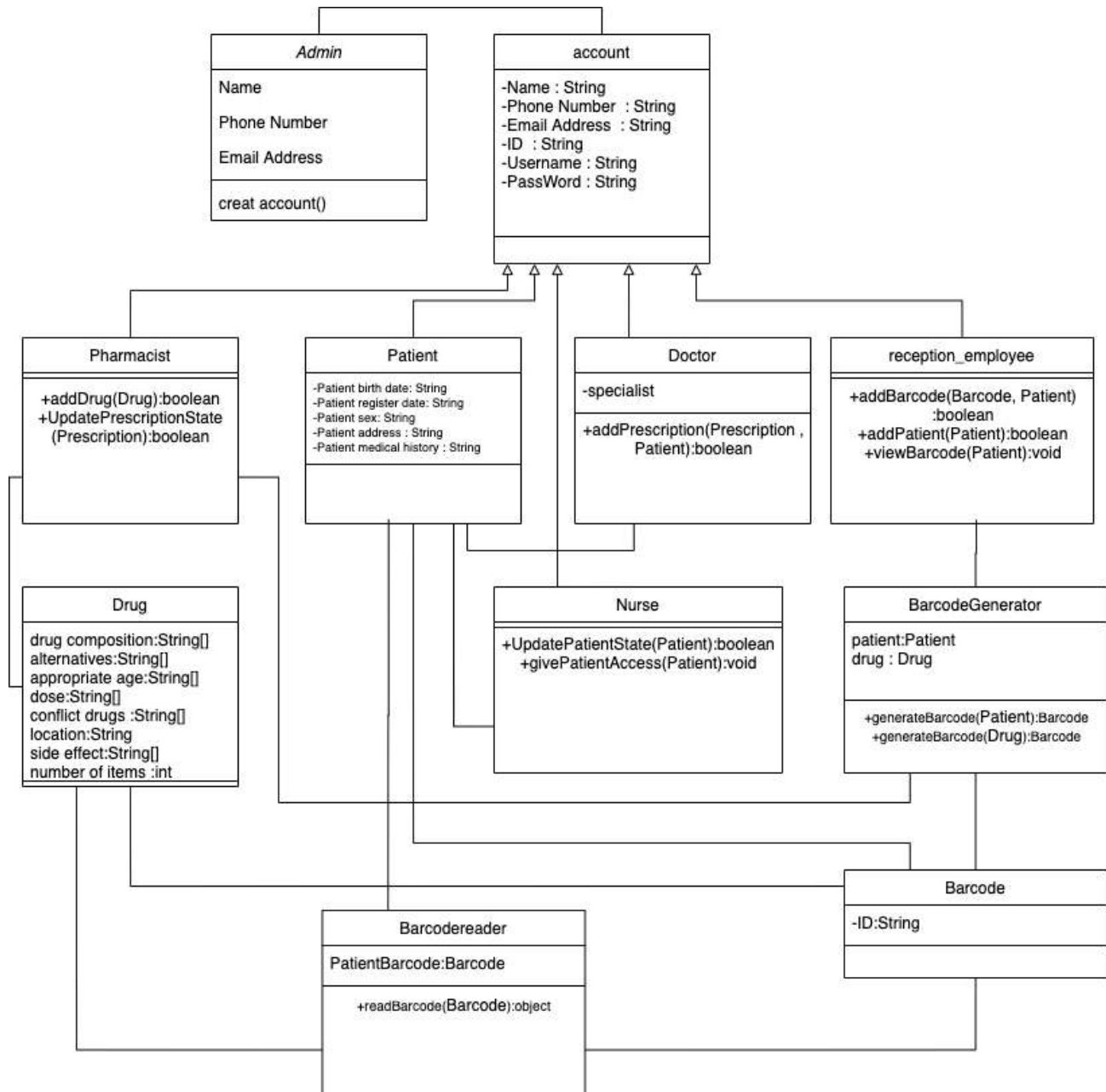
8.4.2. Third party components and database

This section is identifying the third party components used in our system and the database:

Captuvo™ SL42h scanner :

The third party component is Captuvo, it's a barcode scanner that is attached to a mobile phone , tablet or any type of device . it's important feature is fast and accurate reading of linear and 2D barcodes. The **Captuvo** has been specifically enhanced to rapidly capture even the most challenging healthcare barcodes such as clear IV bags and micro-2D barcodes found on medications, saving time and improving patient safety. Captuvo will be used as an external system that integrates with our healthcare system .For example if a doctor logs in to the smart hospital system and once the doctor scans the patient's barcode it will directly list information about the patient . [9][11][12]

Database:

OLTP database:

Our system has a centralized database with all the details of patient , doctor and nurse. The database is constructed using OLTP (online transaction processing) database. The main strength of an OLTP database is that it allows for quick, real-time transactional processing. It is built for speed and delivers sub-second response times. For example, when a patient presents at the front desk, you search for her name in the EHR and instantly see a result.[10]

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8.4.3. use case diagram:
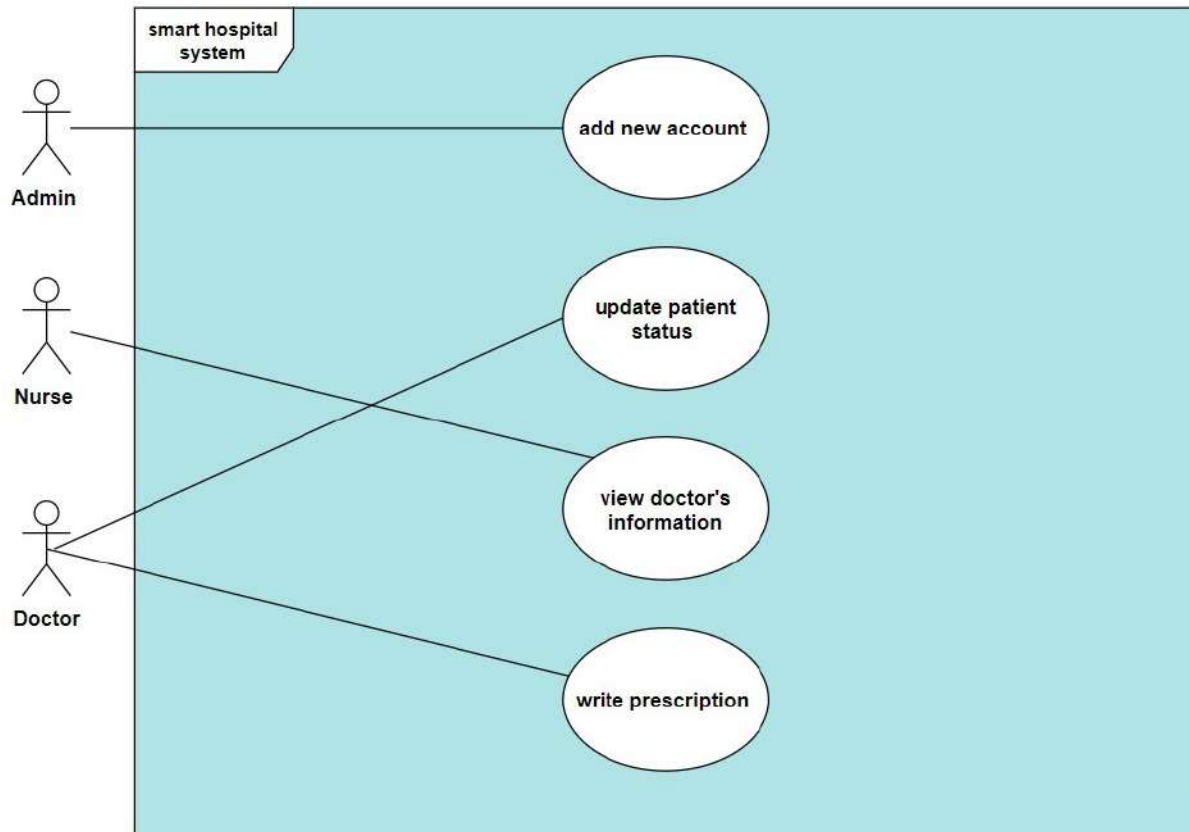
8.4.4. use case description and sequence diagrams .

use case description (Create a doctor account):

Use Case Description
System: Smart hospital .
Use Case name: Create a doctor account .

Primary actor: Admin.	Secondary actor(s): None.

Description: This use case describes how an admin can create a doctor account in the system .

Relationships: Includes None. **Extends:** None.

Pre-conditions: 1- The admin must be logged in successfully .

Steps:

Admin	System
1-This use case begins when the admin selects : "Create a doctor account " 3-The admin fills the form information : · Doctor's name · Doctor's ID · Doctor's Email · Password · Specialty 4- The admin selects" create "option .	2-System displays a Form . 5 - System displays a message "Account created successfully ". 6 –System return back to the home page .

Alternative and exceptional flows:

1-admin quits: If at step 4 the customer selects cancel:

1-   The use case ends with a failure condition .

2- Incomplete information

If the admin did not fill the information in step 3 then he selects "create" a warning message will display and step 5 , 6 will not execute .

Post-conditions:

Successful condition : The system created the account successfully .

Failure condition : The system did not create the account   .

Create a doctor account (Sequence diagram)
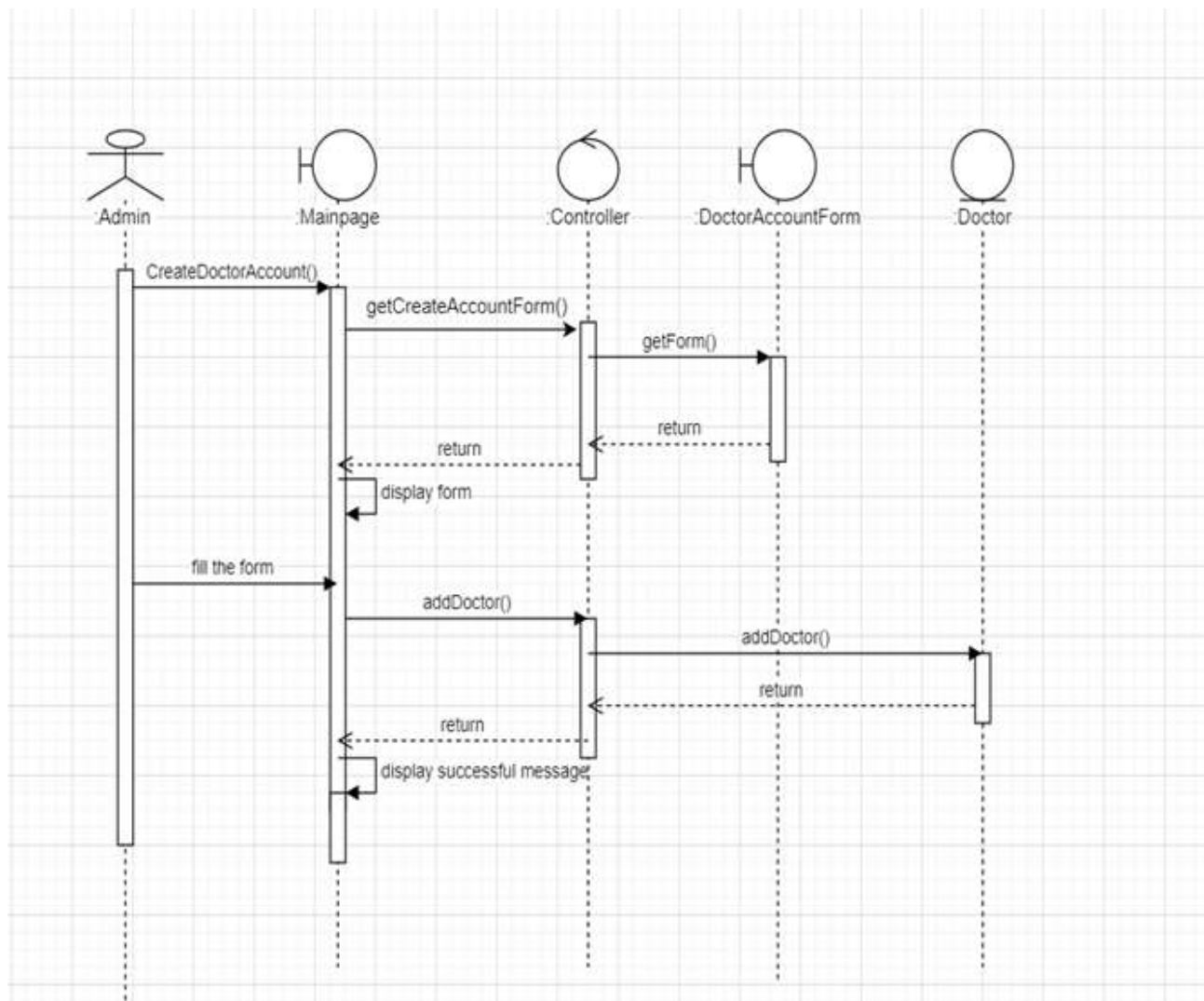
Create a doctor account (State machine diagram phase 3)
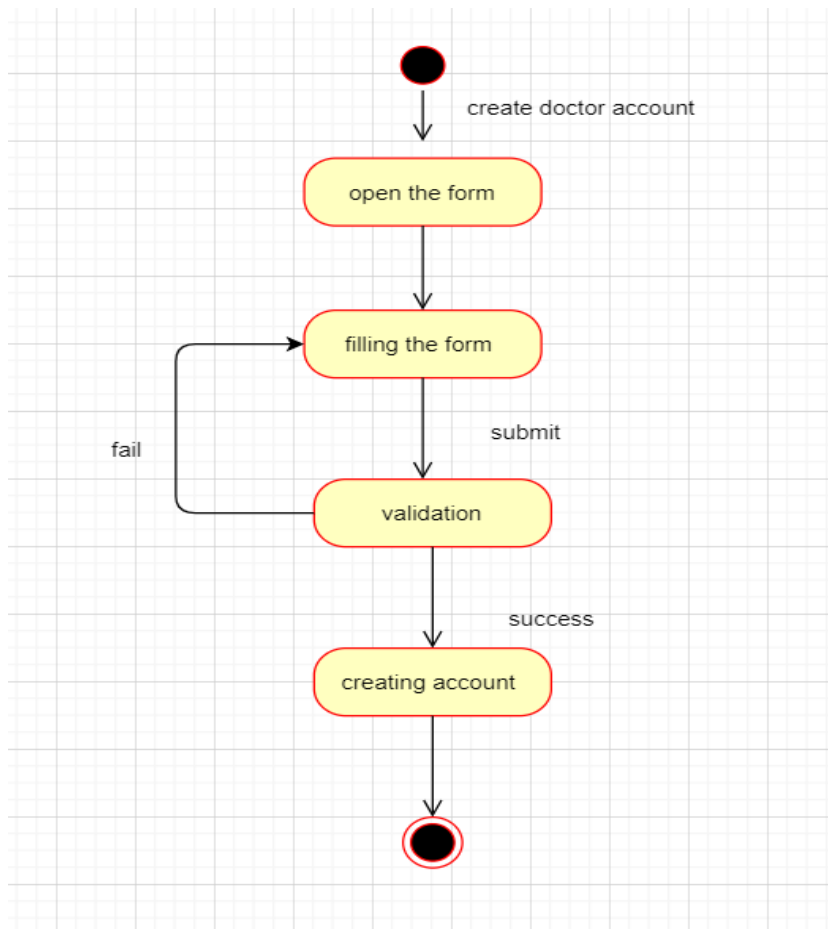
use case description (write prescription):

Use Case Description
System: Smart hospital
Use Case name: write prescription
Primary actor: Doctor   **Secondary actor(s):** None
Description: This use case describes how a doctor can write a prescription in the system.
Relationships ▪Includes: None ▪ Extends: None
Pre-conditions: 1- the doctor logged in successfully. 2- the doctor views patient information.

Steps:	
Doctor	**System**
1- The doctor selects "add prescription". 3- The doctor writes a prescription. 4- the doctor selects "submit". 6- The doctor selects "confirm".	2- The system displays a prescription list. 5- The system displays prescription with a confirmation message 7- The system displays message "prescription added successfully"

Alternative and exceptional flows:

1-<u>In Step 4:</u> **doctor selects cancel :** If before or at step 4 doctor, select cancel . the system will re- direct to the main page and the use case will end with failure condition.

2-<u>In step 6:</u> **doctor selects cancel:** the system will re- direct to the main page and the use case will end with failure condition.
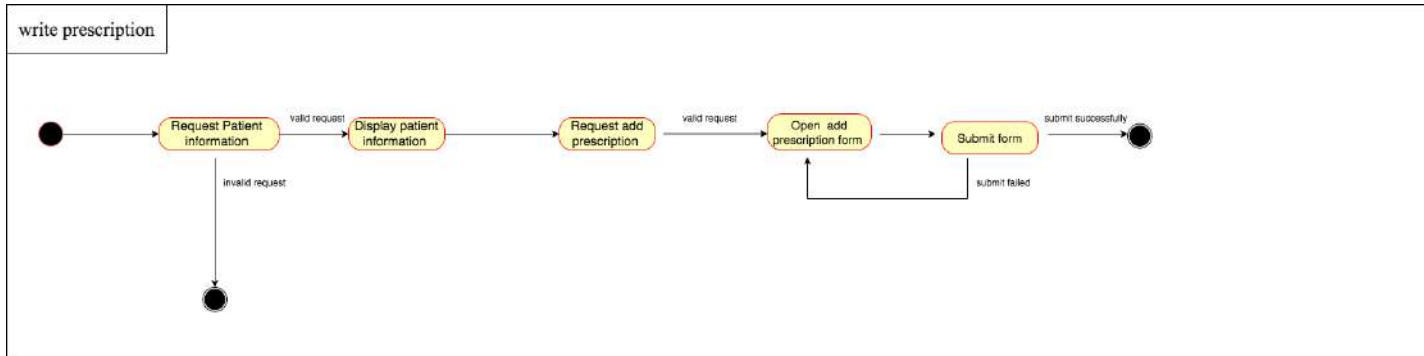
Post-conditions:

Successful condition : The system adds a prescription successfully. **Failure condition:** The system fails to add prescriptions.

write prescription (Sequence diagram):
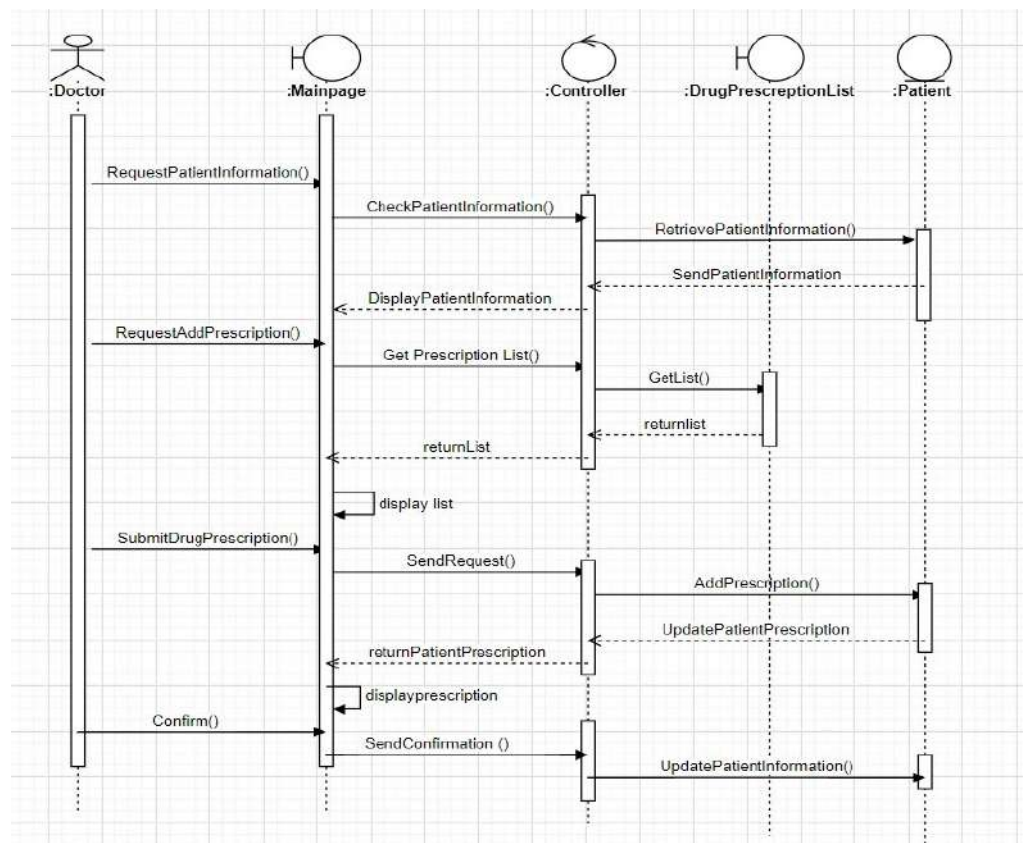
write prescription (State machine diagram phase 3):

use case description (update patient status).

Use Case Description
System: Smart hospital.
Use Case name: update patient status

Primary actor: Doctor	**Secondary actor(s):** none

Description: the doctor updates patient status .
Relationships ▪ **Includes:** none ▪ **Extends:** none
Pre-conditions: the doctor must be logged in successfully.

Steps:	
Primary Actor (mention name)	**System**

1- Doctor scans the patient's barcode .	2- System display patient profile.
3- doctor presses patient "status" button.	4-system displays three options (stable, deteriorated, improved).
5- Doctor choose the desired option.	
6- doctor choose "save" button.	

Alternative and exceptional flows:

In step 6: If the doctor clicks the save button without choosing a status a warning message "you didn't choose a status" will appear.

In step 6: If the doctor selects to cancel the use case ends with a failure condition.

Post-conditions: the patient status will be updated successfully.

update patient status (State machine diagram):
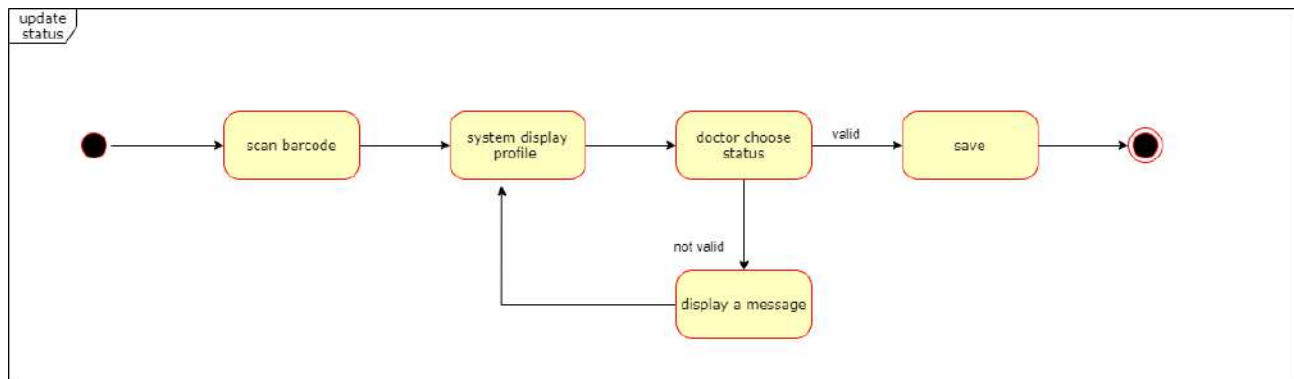
update patient status (sequence diagram):
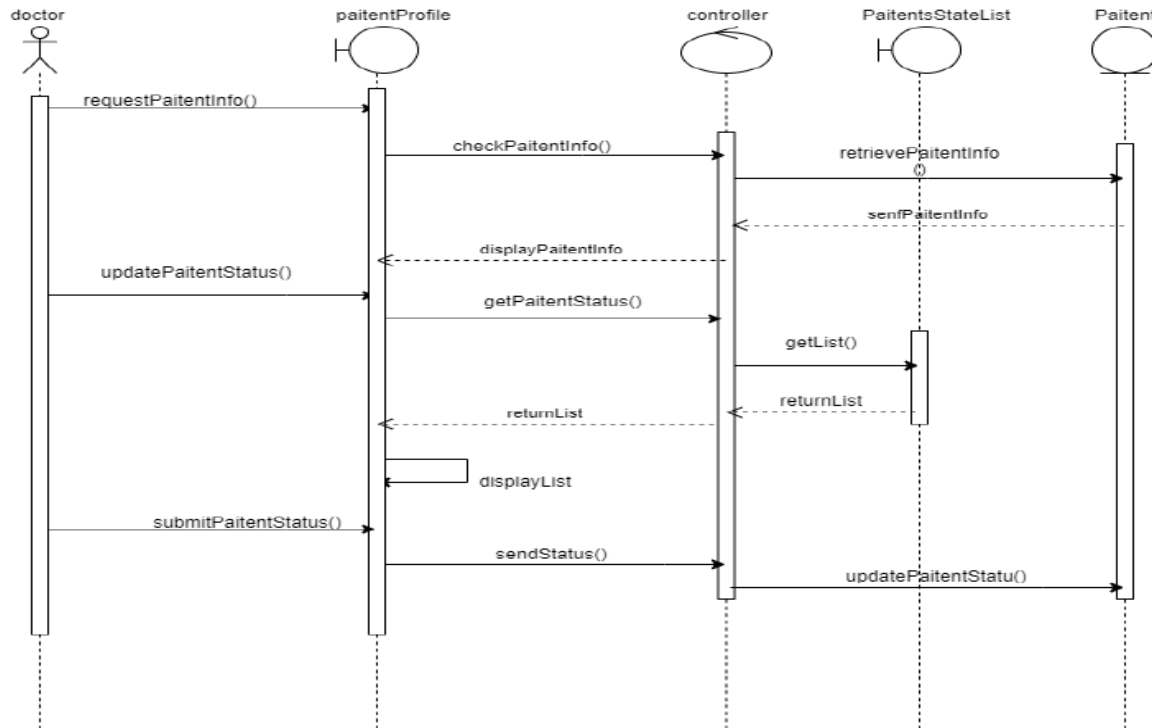
use case description (view information about in charged doctors).

| Use Case Description |
| --- |
| System: Smart Hospital. |
| Use Case name: view information about in charged doctors . |
| Primary actor:
Nurse. | Secondary actor(s):
None. |
| Description: this use case describes how a Nurse can view an information about the doctors in charge of the patient. |

Relationships
▪ Includes: none. ▪ Extends: none.

Pre-conditions:
The Nurse logged in successfully.
The Nurse had scanned the patient barcode .

Steps:

Primary Actor (Service Provider)	System	Secondary Actor(s) (none)
1. This use case starts when the Nurse select "view in charged doctors " 3 . The Nurse select any doctor in the list that displayed . 5. The Nurse select close .	2. The System will display a list of the doctors in charge of the patient . 4. The System will display the information about that doctor including his name , specialist , age , id .	

Alternative and exceptional flows:
1. Nurse quits
If at any step before step 3 the Nurse selects cancel.
1.The use case ends without completing the condition.

Post-conditions: The Nurse had a view in charged doctors information successfully .

view information about in charged doctors (Sequence diagram):
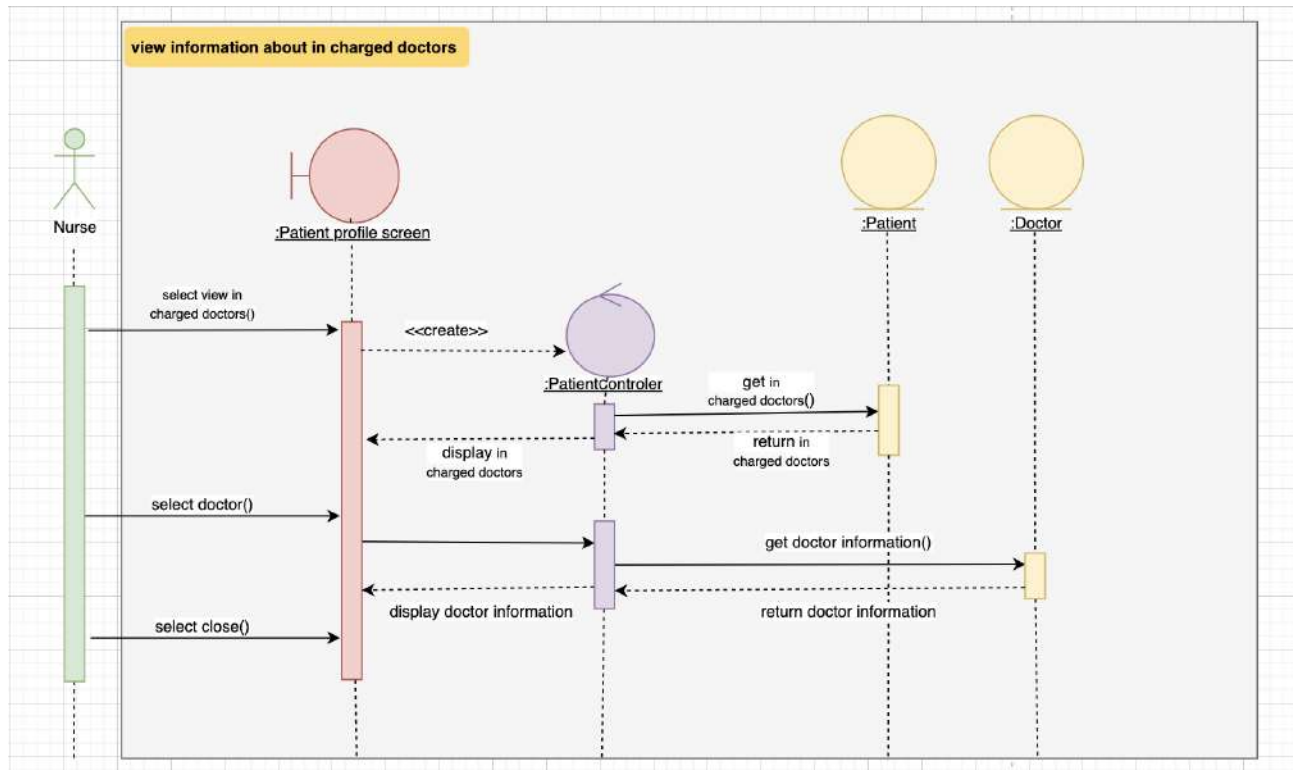
view information about in charged doctors(State machine diagram phase 3):
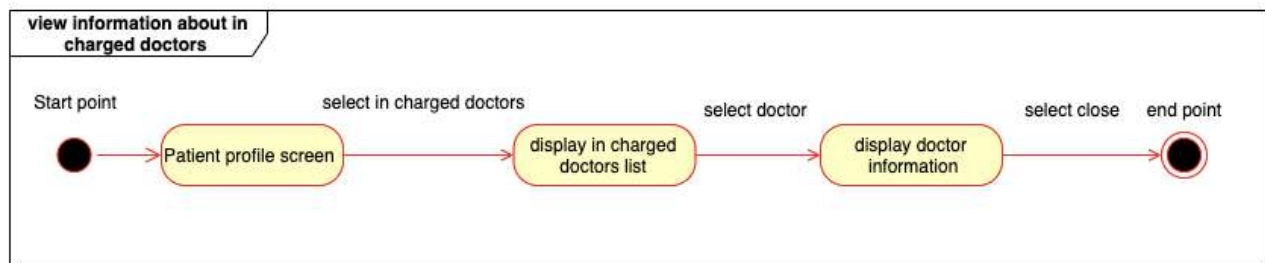
8.5. User interface

A barcode is a device allowing medical staff to detect and track the state of the patient (see figure 8.5.1). The interface is designed to confirm design principles. Bearing in mind good interface design principles, we ensured that barcode technology which is associated with embedded systems can be

used by a wide range of users from different backgrounds specially doctors and nurses who have little technological experience. For the reasons above, the interface is simple and straightforward.

The functionality of the application is well-placed and explicit and that achieves a high degree of visibility. After each operation that has been made E.g. scan patient barcode (see figure 8.5.2), the system will display a processing icon with a loading circle (see figure 8.5.3). This will assure users that the action that has been taken is accomplished (see figure 8.5.4). Additionally, the application obtains the graphical icons that are designed according to the principle of affordance. It is also both aesthetically and functionally consistent.

The interface of barcode technology affords high usability and it includes Learnability, Efficiency, Satisfaction for its users. Learnability is met in this system by having straightforward user interface designs that are predictable in layout and navigation. Moreover elements such as buttons are repeated in a rhythmic pattern which makes the learning process easy for the users. Such an example is resetting all filled fields to empty fields can be done easily by pressing the reset button of that process.
Affordance of barcode technology associated with embedded systems is provided by having simply a device that reads the barcode. Each button associated with a clear text that indicates understandable meanings, these clear text will give users a clue on how to perform the tasks. It's clearly known for users that the 1st button is for scanning the barcode.
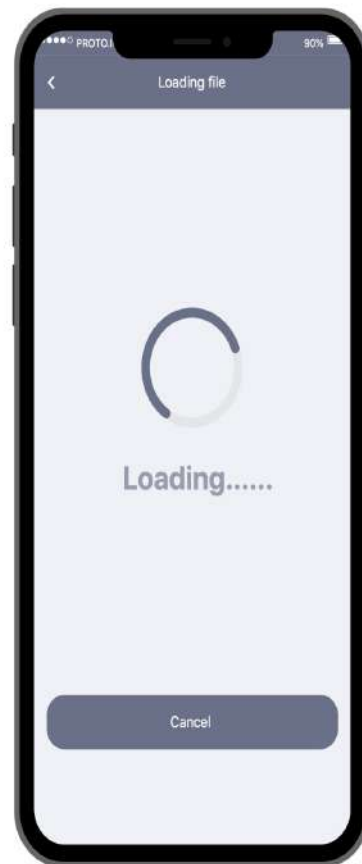Efficiency is also improved since each interface is familiar and not complicated, new users will learn how to perform tasks such as scanning barcodes immediately, thus users who have no experience about patient information will still be able to trace and follow up their state of patient easily. Aesthetic backgrounds and round shapes with modern fonts increase the satisfaction and enjoyment of users when using the system.for scan barcode process which shows the high usability of barcode technology.
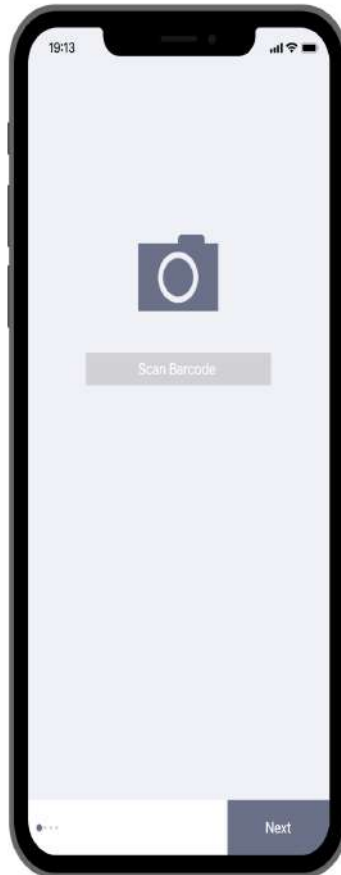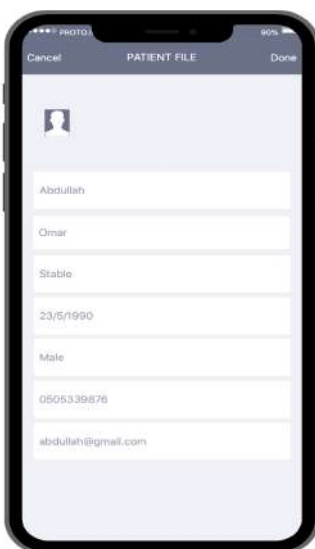
(figure 8.5.1)   (figure 8.5.2)   (figure 8.5.3)

(figure 8.5.4)

9. Non-Functional Properties

This section provides a description of the non-functional requirements that are supported by the proposed architectural style and the reason why they are important and their constraints:

Quality Attributes

1. Usability:

It defines how difficult it will be for a user to learn and operate the system.The usability of the interface is critical because our goal is to minimize the wasted time in the scanning or barcode generating process , also the users of the system may be from different ages and technical backgrounds. In result, an easy interface required for fast barcode scanning and fast handling with patient's information.

2. Integrity:

Integrity is the process of insuring that the data is authentic, accurate and protected from any unauthorized users such that it guarantees to an acceptable level that the data of the users will not be used for any malicious purposes by unauthorized users. This is beneficial for the system because it deals with patient's , doctor's , nurse's sensitive data such as their Ids or patients health record that must not be accessed or manipulated by any unauthorized parties . Integrity Is an important attribute so to be able to cope with malicious attacks from outside or inside of the system, and to keep the access to the system to only the authorized users such as doctors, admins , nurses , receptionists , pharmacists. administrator and other users can access the system but the access level is controlled for each user according to their work scope, to prevent any unauthorized access or manipulation.

3. Maintainability:

It is the ability of the system to go through changes with a fair degree of effortlessness. It affects the time needed to restore the system after a failure. Excessive dependencies between components have a very negative effect on maintainability. changes in the system tier and database tier don't affect the application tier, as well as they do not affect hardware and subsystems.

4. Flexibility:

It refers to the ease of modification of a system to cater for different environments or problems for which the system is originally not designed. the system needs to have the ability to integrate with the latest technology and the integrations must be done without affecting the system's subsystem. such as new scanner technology .

Constraints:

- **Hardware constraint:**

The scanner technology must be available to access any information via barcode.

- **Software constraint:**

Algorithms that are used to generate barcodes should generate barcodes without any duplication and must be attached to the correct patient's file in the database .Any failure in any of those will Cause a problem in the process.

- **Timing constraint:**

The time it takes for the system to respond to the external system is less than 20 seconds . such that the response of the system after scanning the barcode and retrieving patient's information should not exceed 20 seconds.

- **Reliability constraints:**

Reliability is ability to perform the expected service dependably and accurately, the Reliability in this system depends on the barcode generator any failure such as duplicate or false barcode generating or any mismatch in database information, will cause a huge problem in diagnosing patient's problems , Maintaining accurate and neat records of the patient's medical history, Prescription of efficient, reliable and affordable medicines.[13]

- **Size constraint:**

 The size constraint is limited to the passable numbers of patients , doctors , nurse, pharmacist, receptionist in the hospital . The system can accommodate any number of patients ,the system supports expandiplity therefore an additional database can be added to the system to accommodate the additional users.

- **other constraint:**

- System is only accessible within the hospital premises only.
- Only the administrator can access the whole system.
- Each user should have an individual ID and password.

10. Quality Assurance

10.1. reviews :

Based on our project we will use database design **DBSR** review monthly at every 15th of April , and also weekly test plan review **TPR** during the implementation phase every Wednesday.

10.2. Verification :

To ensure that the system is building right we have decided to choose Dynamic Verification Which means verify the execution of every component in the system . In general the goal of "Verification" demonstrates the consistency, completeness, and correctness of the software during each stage of the software development life cycle . To assure that, the developers built what was specified in the design we made pre-test cases by using Junit for every function in the component or class so no function the developers forget and no function that works unexpectedly . To ensure that the developers followed standards and regulation we will make a chick list to every developer that contains the standard that the developer must follow . [8]

10.3. Validation:

1. We will give the hospital a demo version before 2 weeks of the final version is released along with some of our team members to train hospital employees to use the system.
2. In the first month after releasing the final version, every day one of our maintenance team should be working at the hospital since its critical system and related to saving people's lives, we need to deal with problems in a faster way.
3. the system is expandable so we can welcome any suggestions from the hospital after releasing the final version.
4. the system has met the requirements.
5. the system is secure.

11. Future Considerations

Our system can accommodate future changes since it has the flexibility to add new functionalities like merging many hospitals together .And our architecture supports these changes since we just need to add this change on the back-end tire. The key parts on our system are the middle tire which is our functionality to get every user the access to the parts available and hide the other. Also, the back-end tire which is our DB we should keep it available 99.9% . The back-end tire is riskier than the other tiers since the availability of the DB is very important to get the information of the patient at the moment that requested it .So we fix this problem by adding a back-up DB to our system .

12.component diagram
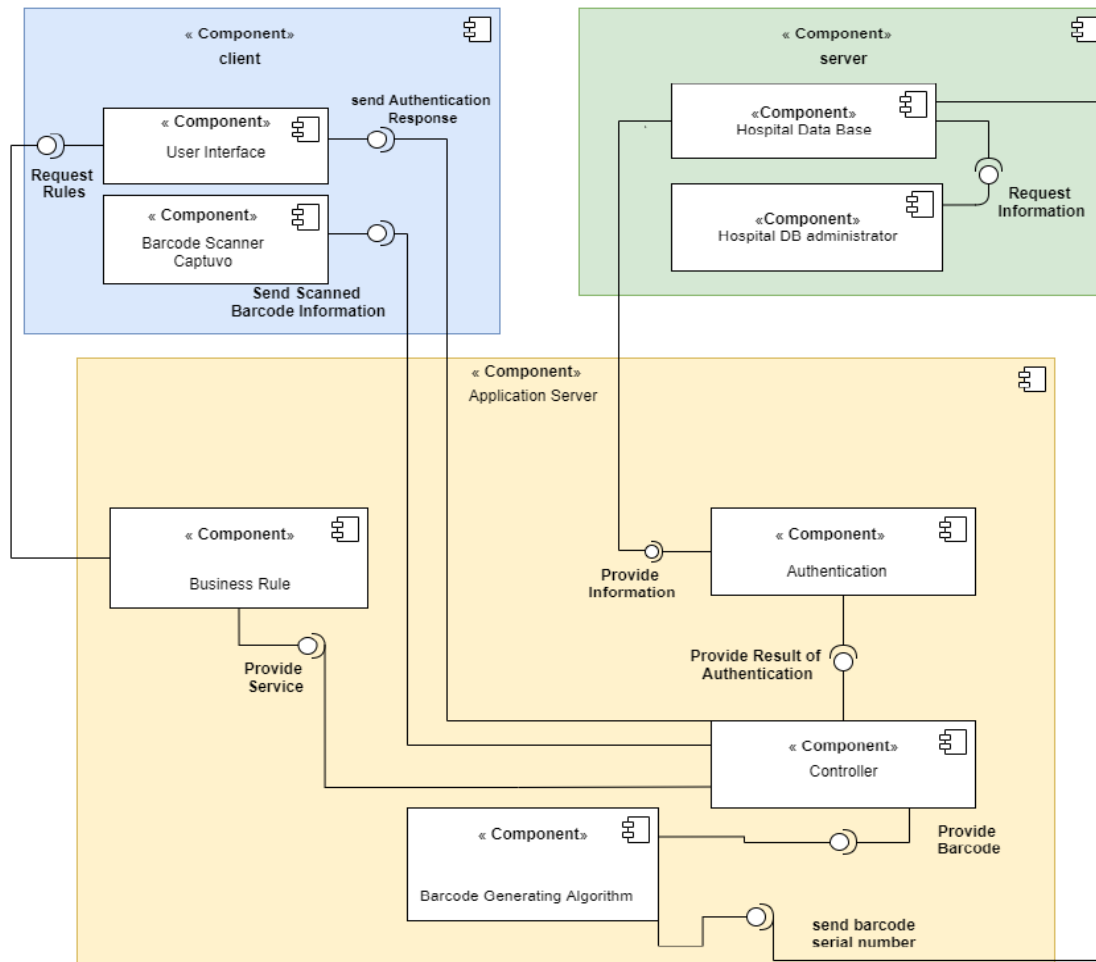
SYSTEM DATABASE:

1. Description

The database component is a centralized database system which consists of patients , nurses , doctors , pharmacists , drugs , reception employees and their information provided by the Registration administrator.

2. Behavior/functionality

The functionalities of this component are update, delete and save patients , nurses , doctors , pharmacists , drugs , reception employees and their information provided by the Registration administrator.
The required attributes are:
o Patients
o Nurses
o doctors
o pharmacists
o drugs
o reception employees

3. connectors and interfaces :

Connect to the data retrieved from the administration registration and authentication .

Hospital database administration registration:

1. Description

o The hospital database administration registration component receives the data from the doctors , pharmacists , nurses and reception employees themselves and registers it in our database .

2. Behavior/functionality

o The functionality of this component is that **database administration** can add , update, delete and save information of reception employees, nurses , doctors , pharmacists , drugs and in the database .
The required attributes are:
For the Doctor :
o Doctor's ID
o Doctor's name
o Doctor's Email
o Password
o Specialty

For the nurse:
o Nurse's name
o Nurse's ID
o Nurse's Email
o Password

For the drug :
o drug composition
o alternatives
o appropriate age
o dose
o conflict drugs
o location
o side effect
o number of items

reception employees
o Employee's ID
o Employee's Email
o Password

3. connectors

Connect to the data retrieved from reception employees ,nurses, doctors and pharmacists and database
.

Business Rule component:

Description:

Business Rule components contain Business Rules which are constraints on particular data values .
These constraints need to be true, regardless of any particular processing requirements. Analysts
define these constraints during the data design stage, rather than during application design .

Behavior/functionality:
The functionality of this component uses Business Rules that is part of the system. The main
functionality of this component is to provide Business Rules services to limit the data that was entered
by the user, and try to check the data to be following our system rules.

Connectors and Interfaces:

The Business Rule component is directly connected to the controller to provide some services and connected to the user interface to provide the rules that we used in our system .

Barcode generating algorithm component :

Description:

Barcode generating algorithm is a some algorithms to provide a unique barcode to the patients and the drugs depending on their information . In our system Barcode generating algorithms are defined as a main functionality in our system.

Behavior/functionality:

After filling the information about the patients or the drugs we are able to use the Barcode generating algorithm to generate a barcode depending on the information of a specific patient or drug .The barcode will be unique and we will deal with the barcode like primary ID in our system.

Connectors and Interfaces:

The Barcode generating algorithm component is directly connected to the hospital database to provide the barcode serial number after generating it and putting it in the database.Also, it is directly connected to the controller to provide the barcode.

Authentication component:

Description:

The authentication component will authenticate the user by requesting additional information from the system's database in order to verify that the user login information is correct as well as verify whether if the user that is logged in is a doctor, nurse, pharmacist or register employee and it also verify the barcode belongs to which patient/drug if the barcode serial number registered and if not registered it will tell that there is no data for this barcode.

Behavior/functionality:

The Authentication component receives the scanned barcode and requires from (doctor, nurse, pharmacist or register employee) to write there password to make sure that the data will be seen by authorized user and display what only he/she can access. It receives the user input password/ the

scanned barcode from the controller and compares it with the data received from the Hospital database.

Connectors and Interfaces:

The Authentication component is directly connected to the Hospital database in order to request data related to the Patient, drug and (doctor, nurse, pharmacist or register employee). It is also directly connected to the controller to receive the data related to the the Patient, drug and (doctor, nurse, pharmacist or register employee).

Controller component:

Description:

The controller acts as a mediator by communicates the data between: User interface component and the Authentication component and the Business rule component and barcode scanner captuvo and Barcode generating algorithm component.

Behavior/functionality:

It propagates the user input password to the Authentication component and returns the Boolean result back to the User interface. Additionally, it requires data
from business rules and the User interface and barcode scanner captuvo. also, it requires from Barcode generating algorithm component to generate barcode.

Connectors and Interfaces:

It is directly connected to the User interface component, barcode scanner captuvo and Business rule component to request data related to the Patient, drug and (doctor, nurse, pharmacist or register employee) and the scanned barcode. it also connected to Barcode generating algorithm component to ask the generate barcode.
also, it directly connected Authentication component in order to send the required data.

· User interface (UI)

· Description

This component describes the user interface , it is different from one user to another according to the role (doctor , nurse , pharmacist , admin , reception employee) , it makes the user interact with the system .

· **Behavior**

The user interface component only :

1-displays appropriate interface to the user .

2-takes the inputs from the user .

3-display messages to the user .

· **Connectors and interface**

User interface connects with business rule to request rules and constraints that must be true on the data for example : the name should be characters and not contain a number .

User interface connects with the controller to provides the user input to it .

· **Barcode Scanner captuvo**

· **Description**

This component is a device for reading printed barcodes .

· **Behavior**

This component reads the barcodes and sends digital information to the controller.

· **Connectors and interface**

It connects with the controller to send scanned barcode information to it .

13.Deployment diagram
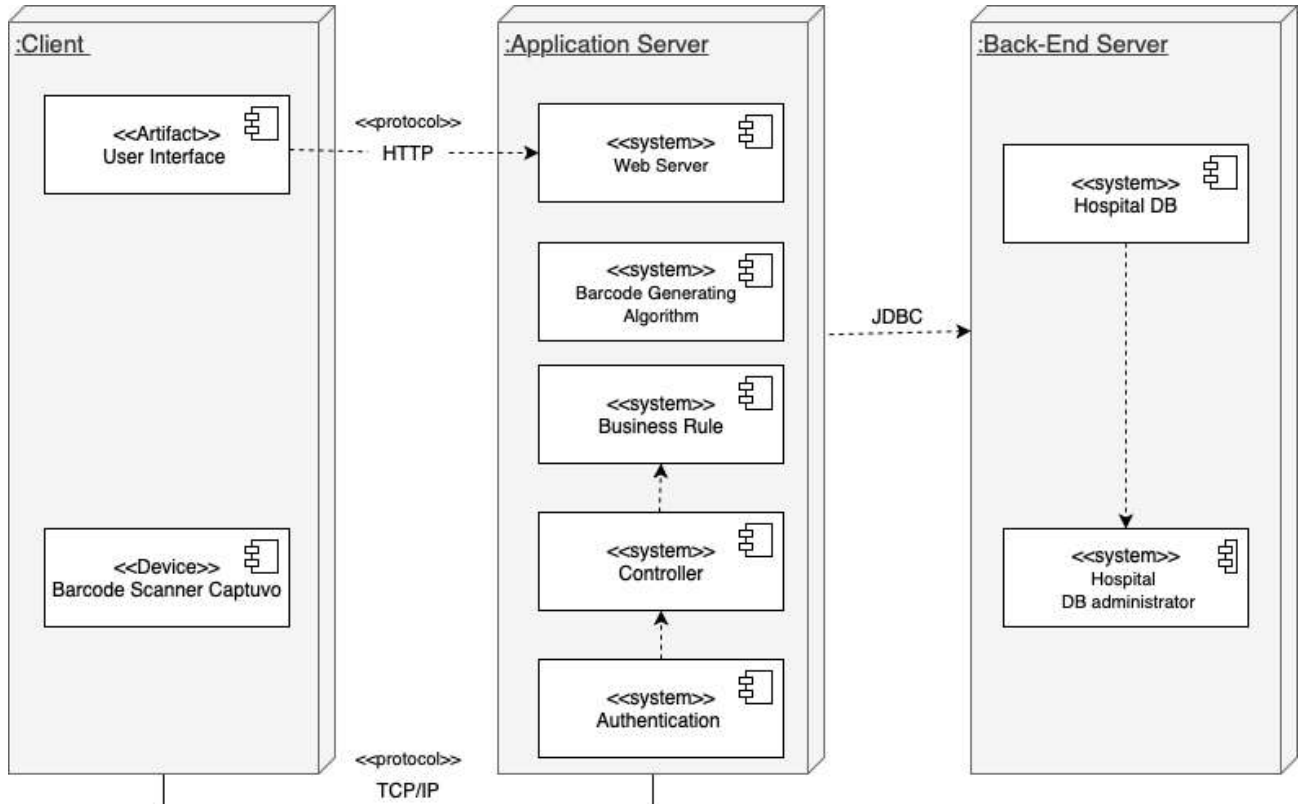
14.Dynamic model:

● **Doctor activity Diagram:**
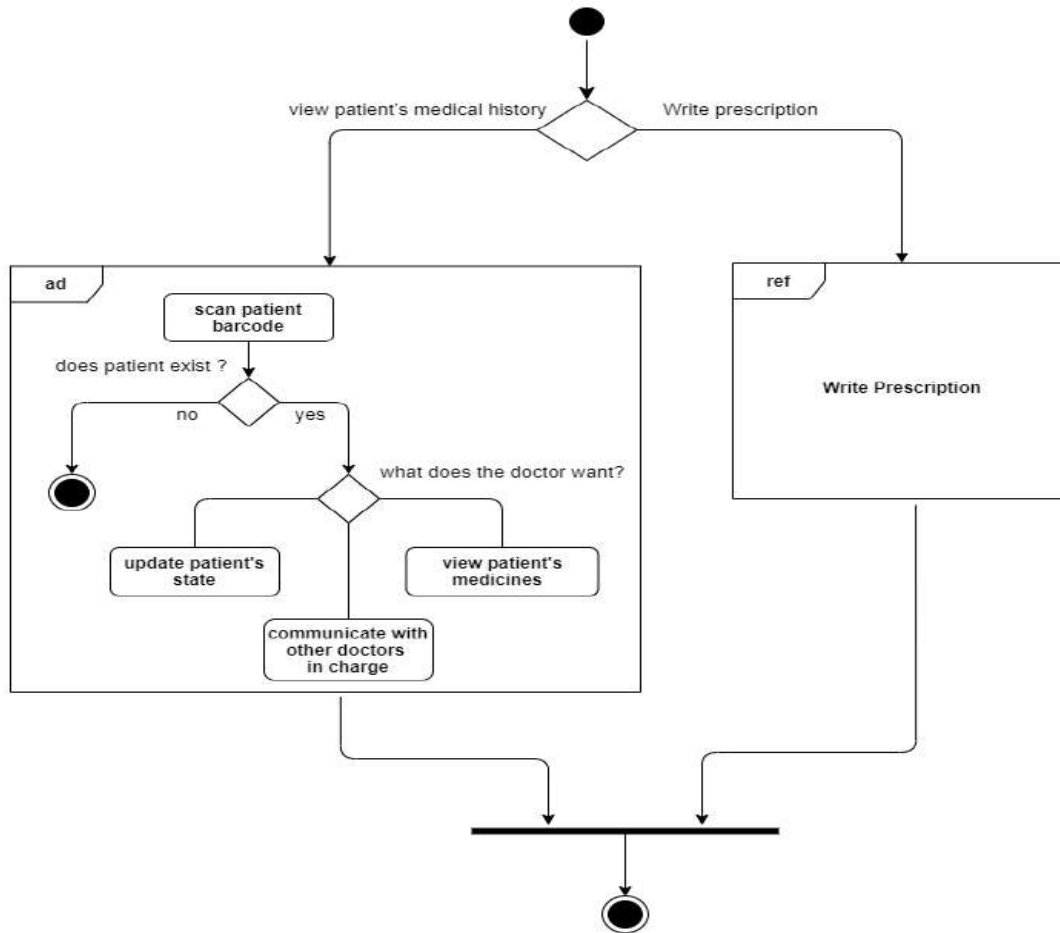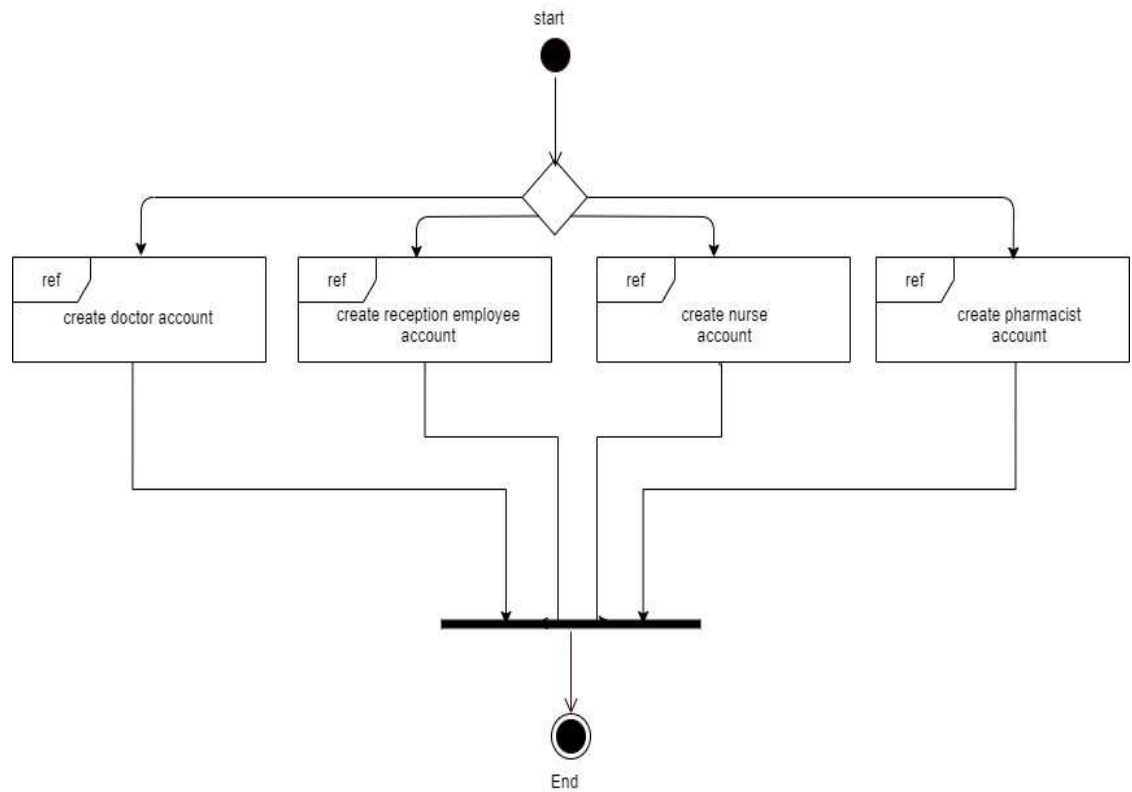
● **Nurse Activity Diagram:**
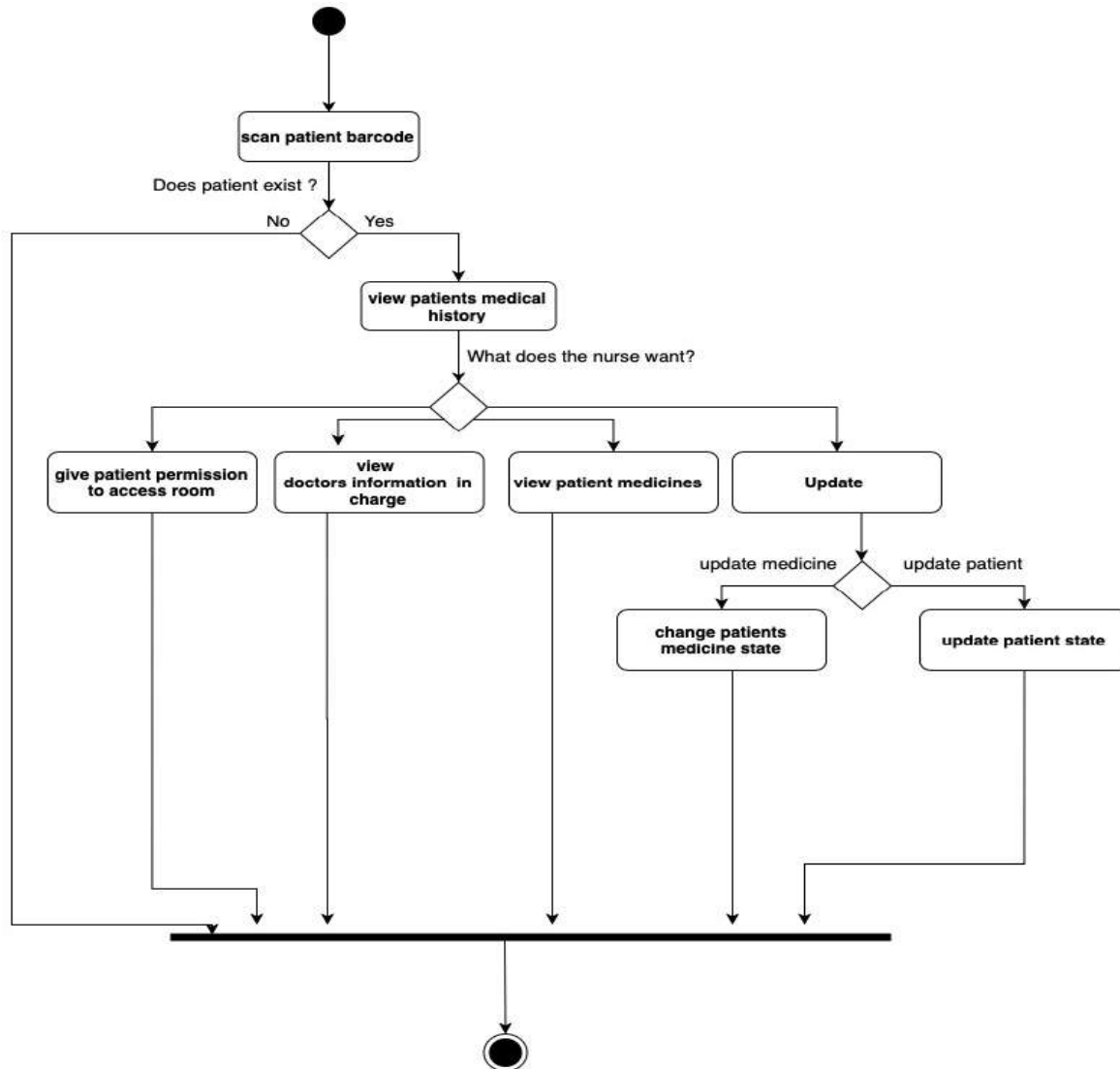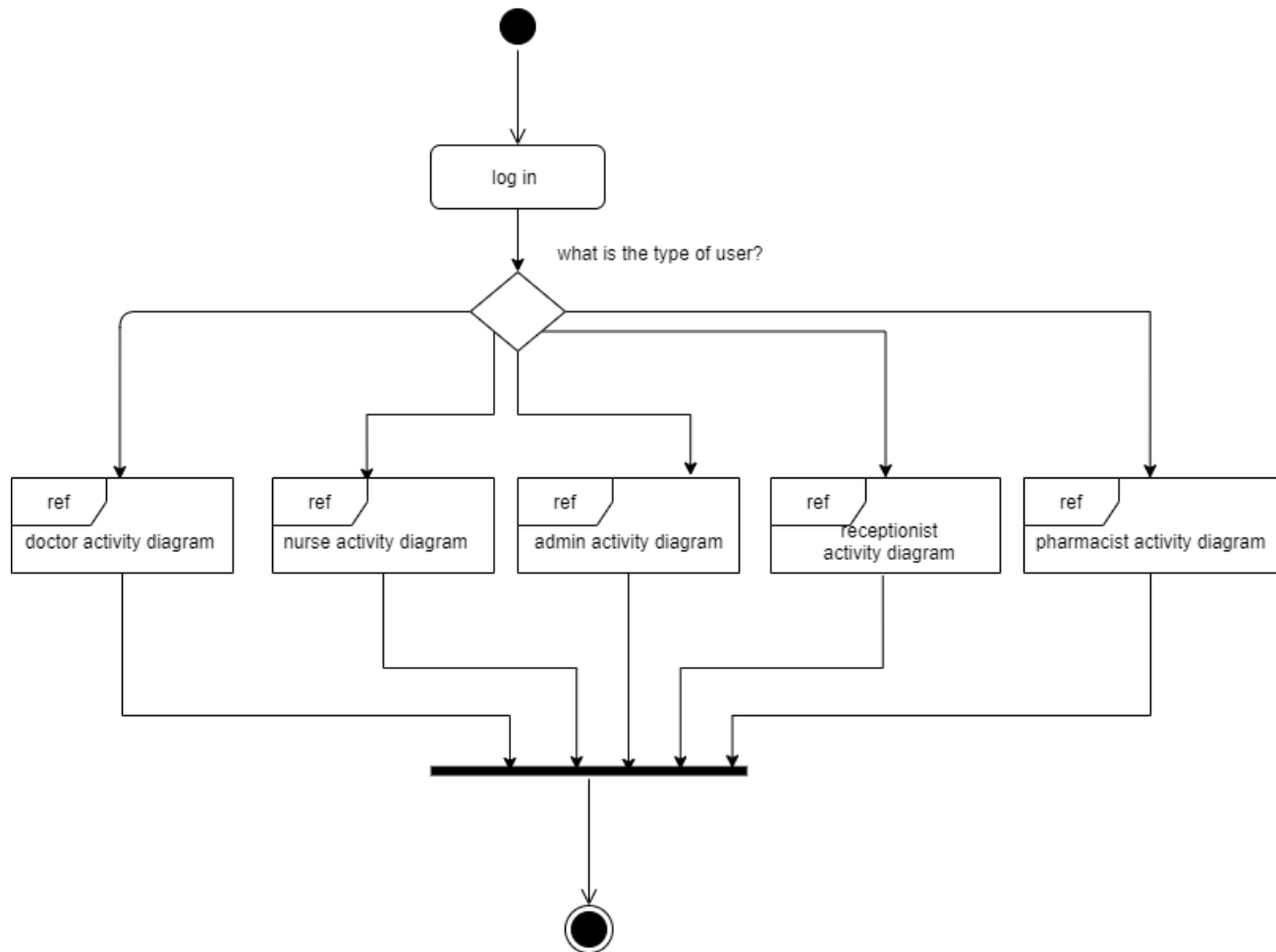

● **pharmacist activity diagram**
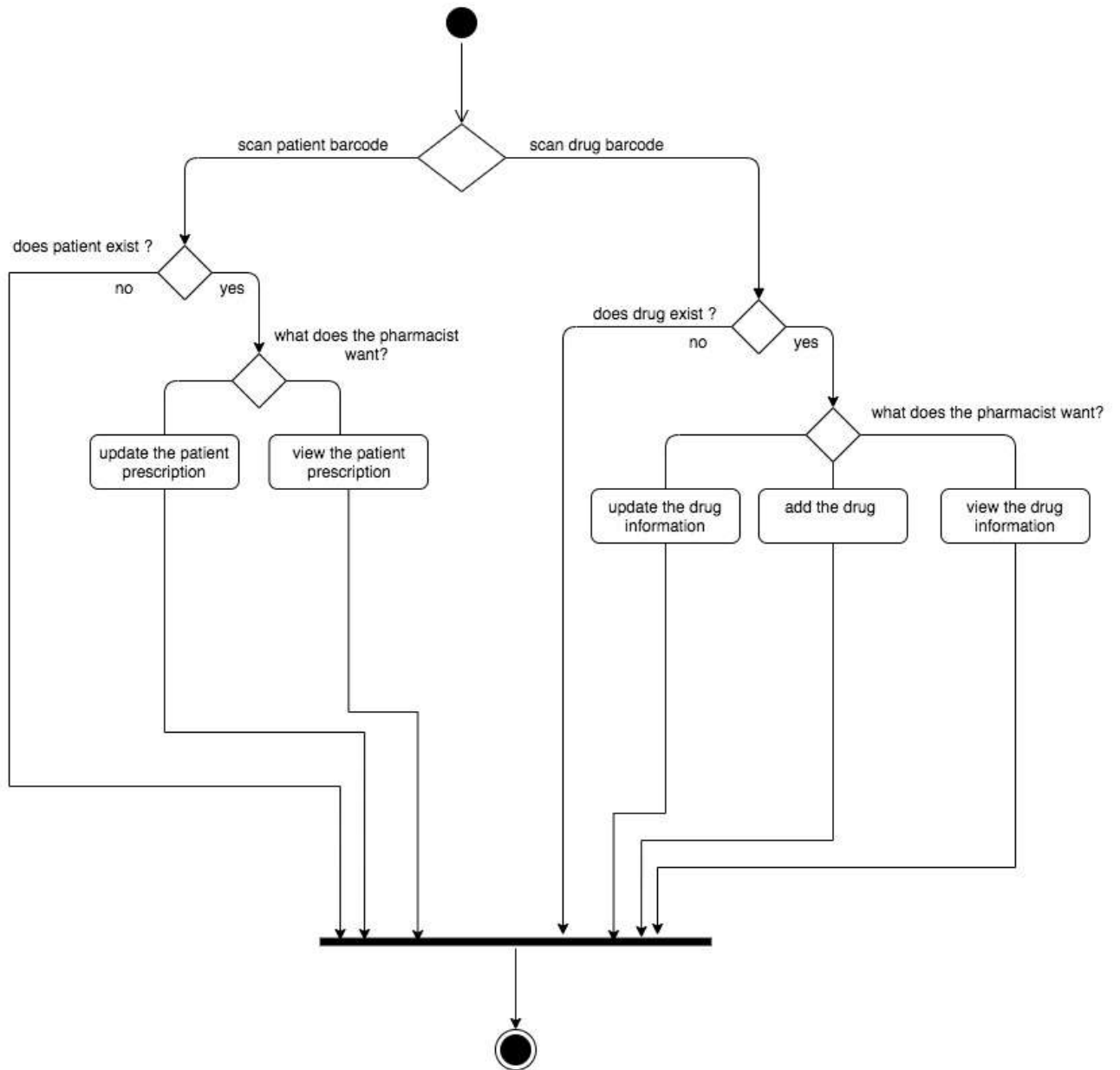
- **reception employee activity diagram**
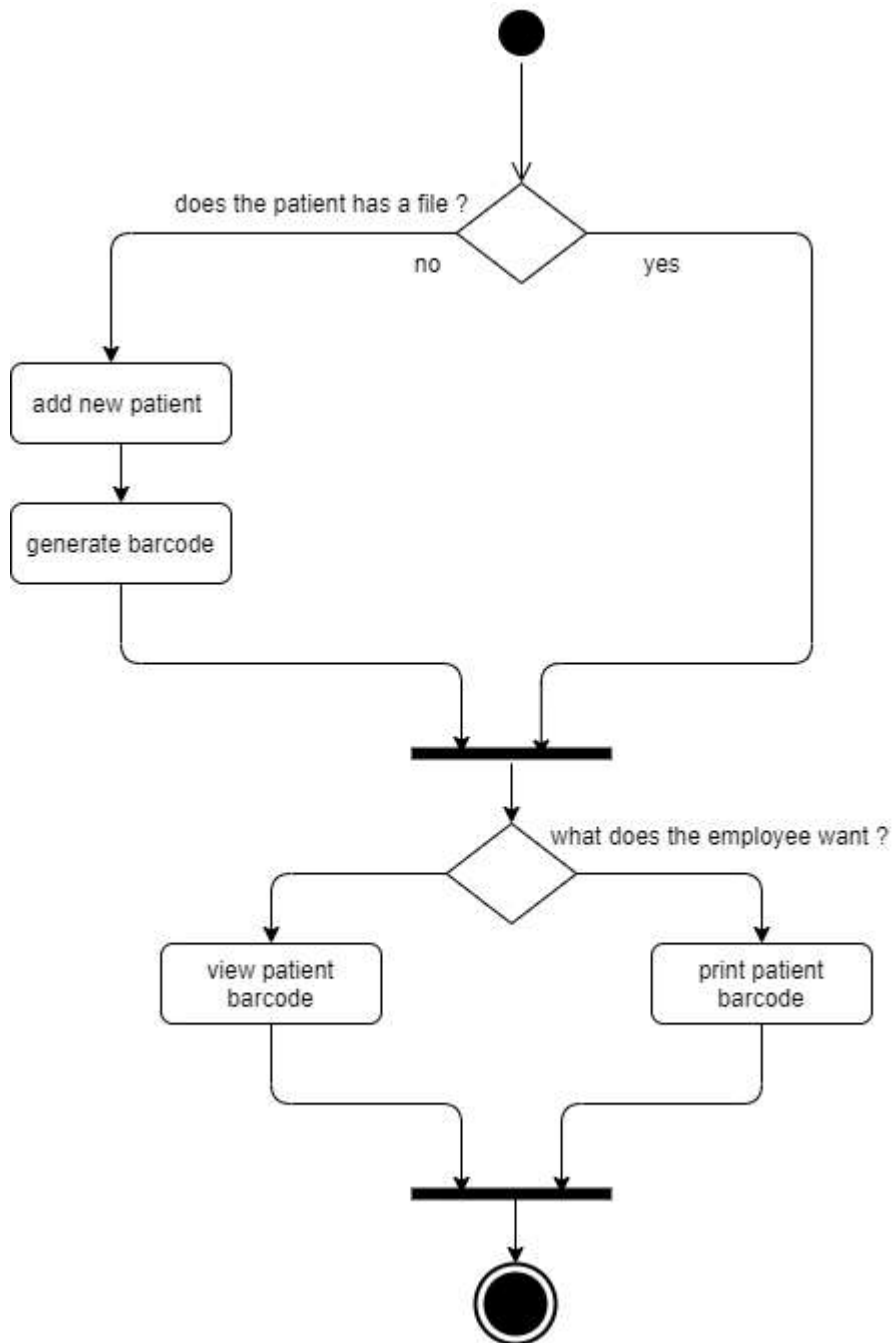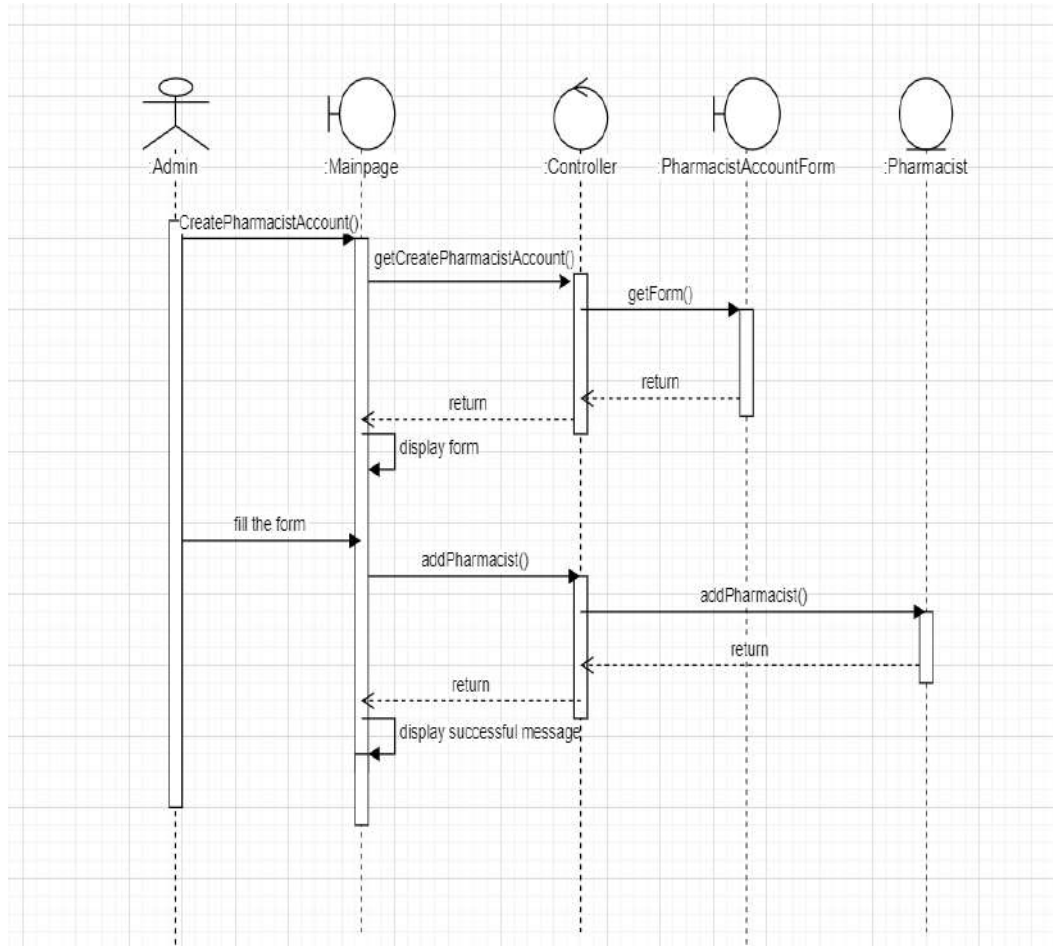
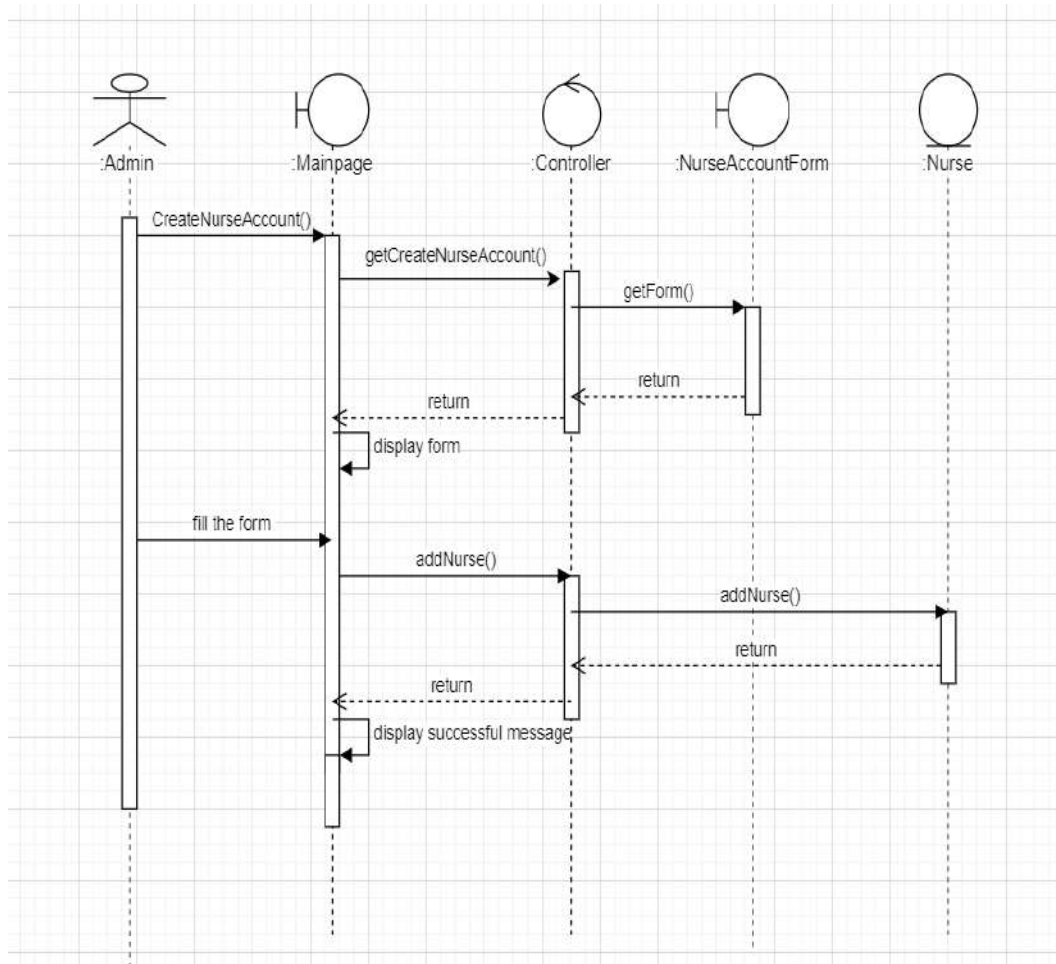- **admin activity diagram**

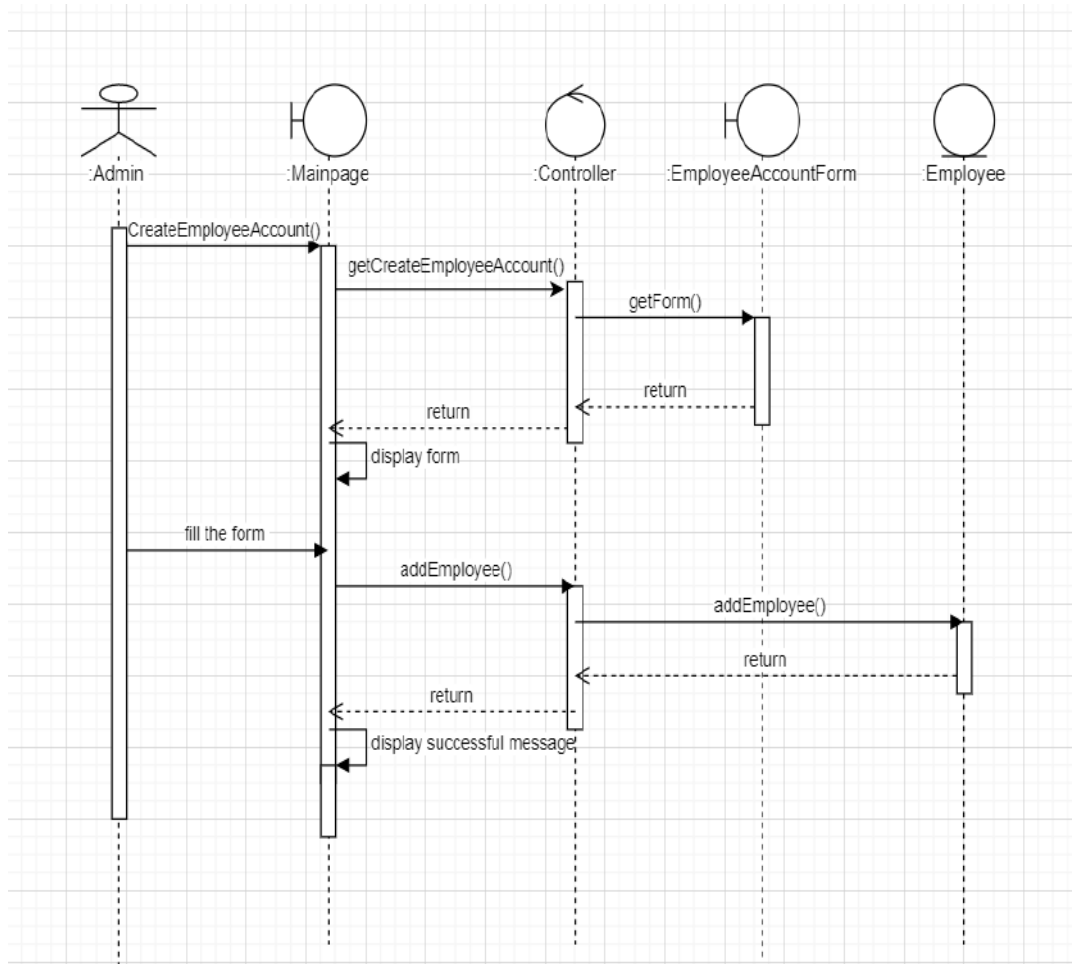● **System interaction diagram**

15.Other sequence diagrams :

Create pharmacist account (Sequence diagram)

Create nurse account (Sequence diagram)

Create reception employee account (Sequence diagram)

16. References :

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[14]:Mathematical Methods Applied to Digital Image Processing by Jeng-An Lin [online] Available at:https://www.hindawi.com/journals/mpe/2013/848276/[12 Dec 2013]

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