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Hospital-Pharmacy Management System: A UAE Case Study

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***Abstract*—**Large patients' queues at pharmacies and hospitals are a problem that faces the supposedly smooth and healthy environment in United Arab Emirates. As this sometimes leads to dissatisfaction from visiting patients, we tried to solve this problem with additional beneficial functions by developing the Hospital-Pharmacy Management System. The primary purpose of this research is to develop a system that joins the databases of a hospital and a pharmacy together for a better integrated system that provides a better coherent working environment. Three methods are used to design the system. These methods are detailed literature review, an extensive feasibility study and surveys for doctors, hospital IT managers and End-users. Interviews and surveys with related stakeholders were done to depict system's requirements; design and prototype. The prototype illustrates system's features and its client and server architecture. The system has a mobile application for visiting patients to, mainly, keep track of their prescriptions and access to their personal information. The server side allows doctors to submit the prescriptions online to pharmacists who will process them. This system is expected to reduce the long waiting queues of patients and increase their satisfaction while also reducing doctors and pharmacists' stress and facilitating their work. It will be deployed to users of Android devices only. This limitation will be resolved, as one of main future enhancements, once the system finds acceptance from hospitals and pharmacies in United Arab Emirates.

***Keywords*—**Hospital, Information System, Integration, Pharmacy.

I. Introduction

CURRENTLY, patients' queues are a major issue in many hospitals in United Arab Emirates (UAE). Most of the times, especially during the busy working hours, patients are crowded in front of the pharmacy waiting for turn in the queue to take their prescription. This could lead to patients' dissatisfaction and a stressful work environment for the pharmacists. In order to overcome these problems, this system will provide functions and modules to result in a better comfortable experience for the visitors. Also, it will allow the pharmacists to work in a relaxed environment away from the long demanding queues of patients. The concept of hospital pharmacy is widely spread in UAE. It is a pharmacy that is usually found within the location of its associated hospital. They are mostly concerned with providing medications for patients visiting the hospital. With its hospital, they form an integrated hospital-pharmacy system. The purpose of an integrated system is to enable the whole organization to operate under a cohesive structure and to deliver high quality healthcare services to the community. Hospital-Pharmacy Management System (HPMS) is a system that connects the databases of a hospital and a pharmacy together for a better flow of work. It is to be used by hospitals and their pharmacies to improve the working environment and patients' satisfaction in the future. This system is designed for hospitals that have an attached pharmacy as a whole organization.

This paper is organized as follows. Section II describes methods used to depict functional and non-functional requirements of HPMS, as well as, its design. Section III combines the results from the HPMS requirements' analysis and design to determine HPMS features and prototype. Section IV then discusses the tangible and intangibles benefits of HPMS and the authors' contributions in a summary table. Finally, Section V presents our conclusion.

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II. Methods Used for Project Usefulness

The three methods below are used to determine the project usefulness:

- Conduct detailed literature review
- Achieve an extensive feasibility study
- Run surveys for doctors, hospital IT managers and End-users

A. Literature Review

After searching throughout the internet and visiting several hospitals, the following projects have similar functions to HPMS:

i. Pharmacy Module-Medinous Hospital Management System: This site for the mentioned company stated that they are specialized in the pharmacy management automation as well as the bar coding facility. What HPMS has in common is that they both provide billing information (for the patients) when the doctor issues the prescription [1].

ii. Hospital in Abu Dhabi, UAE (name kept anonymous for privacy of organization): This hospital system has a link between the databases of the hospital with the databases of the pharmacy resulting in an interconnected system between the two databases. In addition, doctors can check medicines' availability in the stock.

iii. Hospital in Abu Dhabi, UAE (name kept anonymous for privacy of organization): This system has a feature that allows the doctors to check the availability of

medicines in the stock. However, they have problems in this facility, where the number of medicines in the stock does not always reflect the real quantity.

iv. Project's differences: As stated above, this project has similarities with other systems in the hospital-pharmacy database links, and checking availability in stock. However, HPMS has additional features that other systems lack, such as, a mobile application that allows users to check their recent or old prescriptions and other information needed. In addition, it permits the doctors to submit their prescription directly to the pharmacy from which order starts processing by the pharmacists.

B. Feasibility Study

Making a feasibility study uncovers the strengths and the weaknesses of the business project proposed from all of its possible aspects including financial, organizational, economic, social and business aspects [2]-[4]. Here, we will discuss technical, schedule, operational and economic feasibility studies of this project. The discussion will be concise in order to keep the paper's length acceptable.

1) Schedule Feasibility

Schedule feasibility is the likelihood of a project to be completed within its scheduled time frame. Based on the answers of the IT managers of hospitals that are interviewed, it would take about two to three years to develop the whole system from scratch.

2) Operational Feasibility

Operational feasibility is a measure of how well a proposed system solves the problems, and takes advantage of the opportunities identified during scope definition and how it satisfies the requirements identified in the requirements analysis phase of system development [5]. The major problem that is identified is the long queues of patients waiting at the hospital's pharmacy for their turn to take their prescribed medication and their dissatisfaction as a result of too much waiting. Another problem was the stress placed on the pharmacists that have to prepare a large number of prescriptions for long queues of displeased patients as fast as possible. When managers and related stakeholders were interviewed and surveyed, most of them agreed that it is a problem faced in hospitals and their attached pharmacies. When HPMS is proposed to solve that problem, it got mostly positive and welcoming attitudes encouraging to develop it. The "PIECES" framework is useful for identifying operational problems to be solved [6], and their urgency: **P**erformance, **I**nformation, **E**conomy, **C**ontrol, **E**fficiency and **S**ervices. Here is the summary of PIECES in the context of HPMS.

- Economy: Are services provided by the current system cost-effective? Could there be a reduction in costs and/or an increase in benefits? Services provided by the system are cost effective. Costs used to develop the system will be compensated with increased customer satisfaction and more frequent visits to the hospital and its pharmacy thus leading to more people buying medications from the hospital's pharmacy. This will lead to an increase in benefits.
- Control: Are there effective controls to protect against fraud and to guarantee information accuracy and security? Since the system will connect the databases of the hospital and the pharmacy together, all users' activities would need to be recorded. This could be done by implementing a "log file" feature in the system that records all the users' activities attached with the date and the time the activity was performed. Besides, the access' privileges to the system could be done as per the user's role.
- Efficiency: Does current system make good use of resources: people, time, flow of forms? The system makes good use of the people resources associated with the system. For example, the system needs the pharmacists to check the submitted prescriptions in the system to start processing them to fulfill the point of fast processing of prescriptions. Also, for the system to work effectively, it requires the doctors to submit the prescriptions from their computer to the pharmacy so the pharmacists can start preparing them. Moreover, the patients need to check their prescriptions from the mobile application to know all the information related to their prescriptions.
- Solutions for dealing with resistance (if any): Does management support the project? The three hospitals interviewed so far agree that the project is beneficial for them.

How do the end users feel about their role in the new system? Mostly, end users are satisfied with their role in the system. Patients are supportive of having a mobile application that tells them all what they need about their prescriptions, billing information and when to pick-up medication from the pharmacy. Patients interviewed and surveyed mostly agreed that this is a really useful system that will save their time so that won't have to wait again in pharmacy queues. Also, pharmacists stated that this would decrease their stress and help them work in a better relaxed environment while trying to serve the customers better and faster. Moreover, doctors liked the ability to be able to check the availability of the medicine in the pharmacy stock before prescribing it or having to call the already-busy pharmacists to check if the medication is available or not. However, some doctors pointed that filling the prescription and submitting it to the pharmacy can take time if they are busy having many patients. This can be solved by assigning an assistant/nurse for each doctor during those busy times to fill in the prescription on the system while the doctor examines the patient (The doctor will dictate the prescription so the nurse would simply just write the mediation into the system, and will not write anything on their own).

Overall, the stakeholders involved have a positive attitude about their roles in the system. Which users or managers may resist the system? People who are more used to the old systems (e.g. Manual written system) may find the new system uncomfortable to use in the beginning as it is something new that they haven't used before. However, this can be easily solved by making training sessions for all end users involved

on how to use the system effectively.

3) Economic Feasibility

There are many cost/benefit analysis that help in assisting the costs and benefits related to a project. In this economic feasibility, break-even point and return on investment are applied.

a) Break-Even Point

Break-even point is the point where the cost value of the project equals its benefit value. The purpose of this analysis is to estimate how long (in years) will it take for an institution, in our project hospital, to redeem and return back the costs [7].

TABLE I
BREAK-EVEN POINT

Year	0	1	2	3	4	5
Yearly Net Present Value	1,000,000	446,500	398,500	356,000	318,000	283,500
Overall Net Present Value	1,000,000	-553,500	-155,000	201,000	519,000	802,500

To shorten the paper, the authors avoided providing details about the table's values calculations. As we can notice from the table above, the transmission from the negative value of the overall Net Present Value (NPV) to its positive value is between year two and three. Therefore, the project break-even point occurs around year 2. And to be more accurate, we should calculate the break-even ratio to give us a specific number of the break-even point. The equation of the break-even ratio is:

$$Break\ even\ ratio = \frac{|\ beginningYear\ amount\ |}{endYear\ amount + |\ beginningYear\ amount\ |} = \frac{|-155{,}000|}{201{,}000+|-155{,}000|} = 0.43 \quad (1)$$

Therefore, the accurate break-even point is at 2.43 years. In the break-even analysis diagram, the blue line represents the NPV of all the benefits of the project, while the red one represents the NPV of all the costs. The break-even point occurs between the second and third year, approximately 2.43 years.

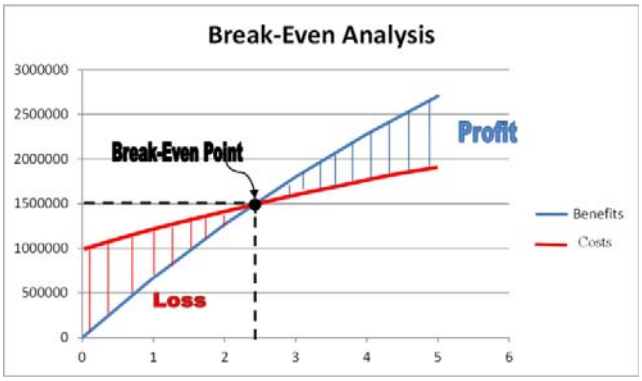

Fig. 1 Break-Even Analysis

The years before the break-even point experience loss in the revenue, since the costs of the project exceed its benefits. Whereas years after the break-even point experience rise in revenue (profit), due to the fact that benefits exceed costs.

b) Return on investment (ROI)

Return on Investment (ROI) is a type of cost/benefit analysis and a performance measure that helps in assessing the efficiency of an investment or comparing the efficiency of several investments [8]. The ROI is important, since it can give us an overall view of whether the investment should be overtaken or not. Due to the fact that there is only one investment in this project, the ROI will be only calculated on it. The equation for calculating the ROI is:

$$ROI = \frac{EstimatedLiftimeBenefits - EstimatedLiftimeCosts}{EstimatedLiftimeCosts} \quad (2)$$

In this project, the estimated lifetime benefits equal 2,703,750 DHs and the estimated lifetime costs equal 1,901,250 DHs, therefore:

$$ROI = \frac{2{,}703{,}750 - 1{,}901{,}250}{1{,}901{,}250} = 42.2\% \quad (3)$$

Since the ROI is larger than 0 and the payback period (break-even point) is in 2.43 years, then the investment can be proceed and overtaken. During the development of this system, authors collected surveys and conducted interviews that helped in assessing the specifications of the system. Surveys were collected from 40 people. Where 14 out of 40 were doctors, pharmacists and nurses, 6 out of 40 were IT managers and employees and 20 out of 40 were regular users or patients. Moreover, interviews were conducted from three different hospitals in Abu Dhabi, UAE. In the following section, the interview summary is presented.

C. Interview Summary

1) Doctors Interviews

Doctors in the first hospital prefer the new system due to the fact that it saves time and makes prescribing medicines quicker and more efficient. These are the same arguments doctors from the second hospital agree with, but with the emphasis on having teams of nurses that are qualified in helping and assisting the doctors. Doctors from the third hospital found that using the option of checking the availability of medicine is very helpful while working, and thought that facilitates the prescription process. In contrast, they agreed that letting the patients order medicines from their apps, even with prescription, is an invalid move and cannot be applied.

2) Pharmacists Interviews

Pharmacists in all the three hospitals that we visited agreed that this system is going to make the general atmosphere in the pharmacy calmer and enhance the level of comfort for the pharmacists. Pharmacists in the first and third hospitals assured that checking the availability in the stock by the

doctors will save them time, while pharmacists from the second hospital did not think that this will have significant impact on their, as they already do not get so many calls from the doctors. Moreover, they all liked the idea of the mobile application and its functions, but all agreed that users cannot order medicines from their mobile application.

3) IT Department Interviews

Both the first and second hospitals do not have links between the databases of the hospital and the pharmacy, while the third hospital already has these links. All the IT managers welcomed the idea and confirmed its success, as one of the hospitals has this system implemented. All of them were happy with the idea of having a mobile application for the users, but excluding the feature where the users order their prescription.

4) Users Interviews

Patients supported the new system, and liked how it will save their time. They all agreed that they hate waiting for a long time in pharmacy queues and that they will prefer this system. Users thought that the mobile application will be a nice addition to the system, as it lets them know when to pick-up their medicine. They also wanted to have an extra feature that permits them to order medicine directly from the mobile application. Although users would like to have this feature, we cannot implement it for them. All doctors, pharmacists, and IT managers agreed that this is an invalid step in order to maintain patients' health and security and to save both the pharmacists and patients' time. The three methods above allowed us to depict the functional and non-functional requirements of the system. These functional and non-functional requirements, as well as, the system design are presented in the results section below.

III. Results

The requirements' definition below is the result of detailed literature review, extensive feasibility study and surveys for doctors, hospital IT managers and End-users.

A. Requirements Analysis

The analysis of requirements has determined HPMS functional and non-functional requirements. The functional requirements are declarations that define services, reactions and behaviors of the system [9]. Below are HPMS functional requirements:

TABLE II
HPMS Functional Requirements

Doctor's and Nurse's functions	User's functions	Pharmacist's functions
Log in	Log in	Log in
Write prescription	Cancel order	Check patient's file
Submit prescription	Check prescriptions	View prescriptions
Write patient's information		Change prescriptions

The non-functional requirements used to judge the operation of a system, rather than specific behaviors [9]. The non-functional requirements are:

- Reliability requirements: are concerned about the failures a system can have. HPMS needs to provide a continuous and ongoing performance, with as minor faults as possible, to be considered reliable by its users. For instance, when end users request services from the HPMS, the last one has to be always available to answer their requests, and has to provide the least amount of faults and errors to rise to users' expectations.
- Usability requirements: are concerned with simplifying the system to be both understandable and readable in addition to representing it in the best and easiest way. Users of the Hospital-Pharmacy Management System will probably be from different educational backgrounds and computer expertise. Thus, the system needs to provide users with a simple and easy interface to be adequate for all people.
- Privacy and security requirements: are concerned with keeping the information private and confidential. The Hospital-Pharmacy Management System needs to provide for all the communication sessions conducted between two parties or more the complete and ultimate privacy, away from the interference of outsiders. Only the supervisor of these parties or peers can access their transactions. The data and information exchanged between any two peers or more in the HPMS are considered highly private, and some of the information is inaccessible, even for the supervisor, to look at them. Moreover, the system should only permit the parties or peers that their usernames and passwords match the ones saved in the database from logging into the system. Unauthorized peers cannot log in or access the system, as this step is called the authentication.

B. System Design

The design phase helps in technically modeling the functional and non-functional requirements of the HPMS converting them into readable and understandable diagrams. In addition, the interface prototype screens show the user interface of the system. The mobile application user interface is shown with a description on each screen and the functions offered by the application in that screen. Moreover, the system interface for doctors is portrayed and demonstrated for various functions and screens. The Fig. 2 below displays the Use Case diagram for the Hospital-Pharmacy Management System. Use Case diagram provides a simplified and graphical representation of what the system must actually do [10]. The main actors of the system are doctors, nurses, pharmacists, and users (patients).

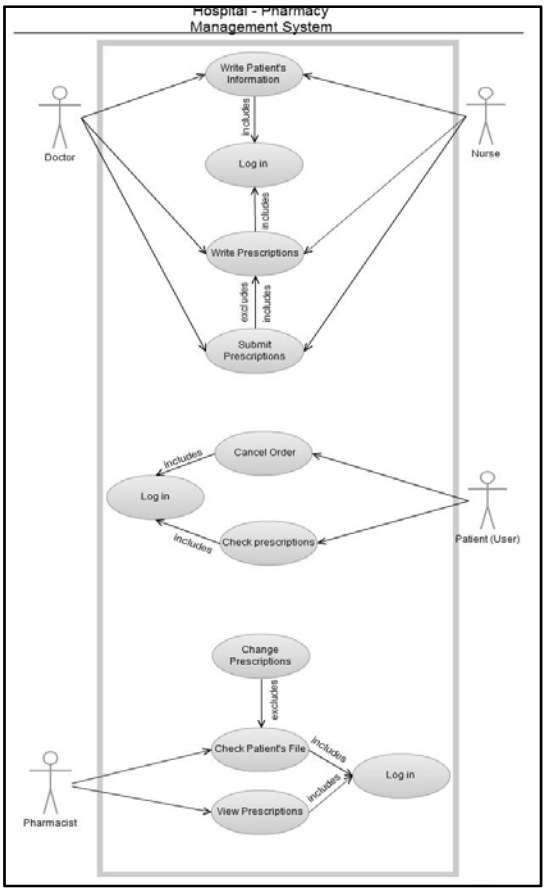

Fig. 2 HPMS Use Case Diagram

The Fig. 3 below presents the sequence diagram for "write prescription" function that is for doctors when writing the patients' prescriptions. A sequence diagram focuses on messages interchange between a number of objects in the system [11]. The Fig. 4 below shows the HPMS class diagram. In the diagram, classes are represented with boxes which contain three parts: upper part holds the name of the class, middle part contains the attributes and bottom part gives the methods or operations [12].

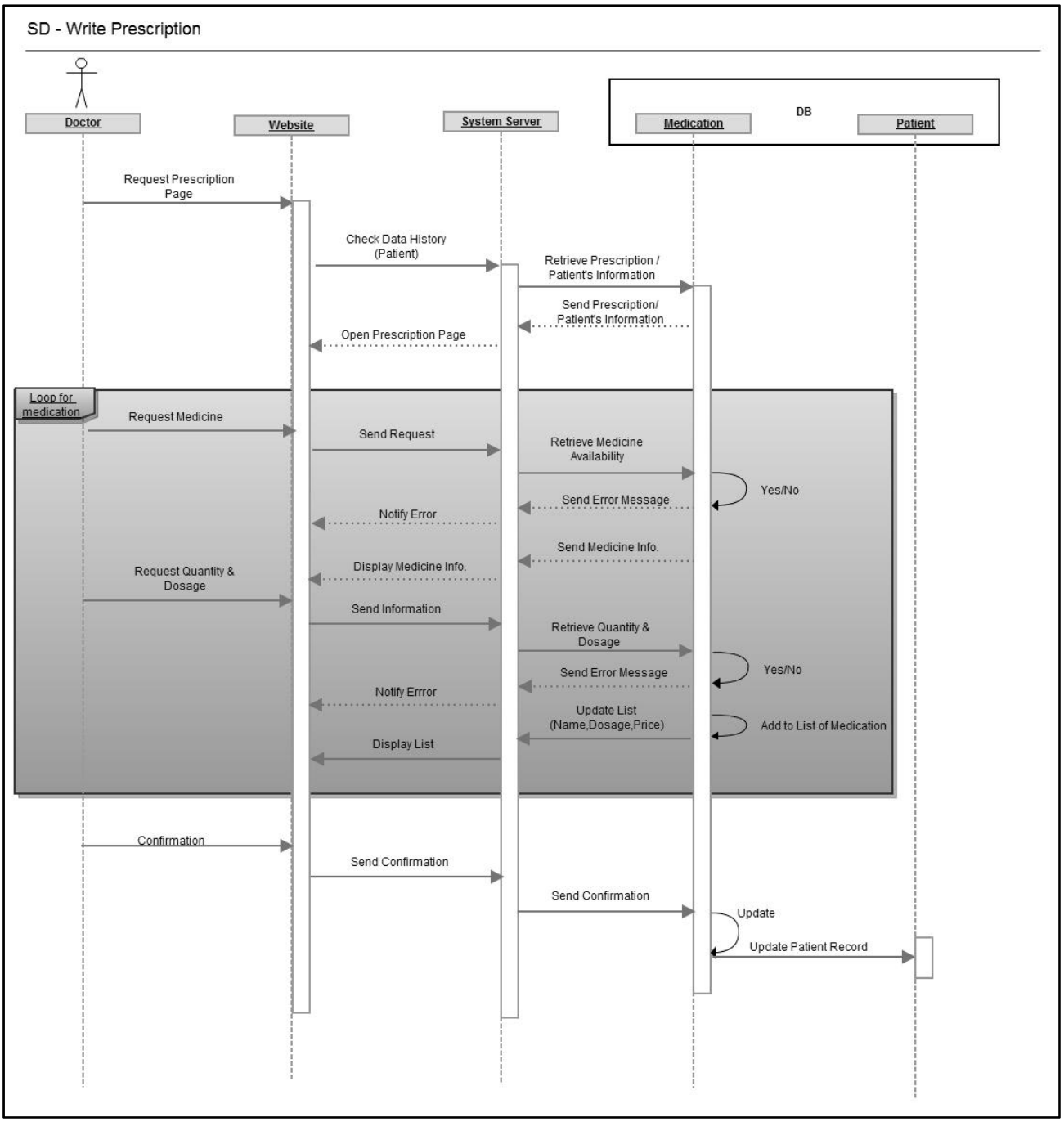

Fig. 3 Sequence Diagram for Write Prescription

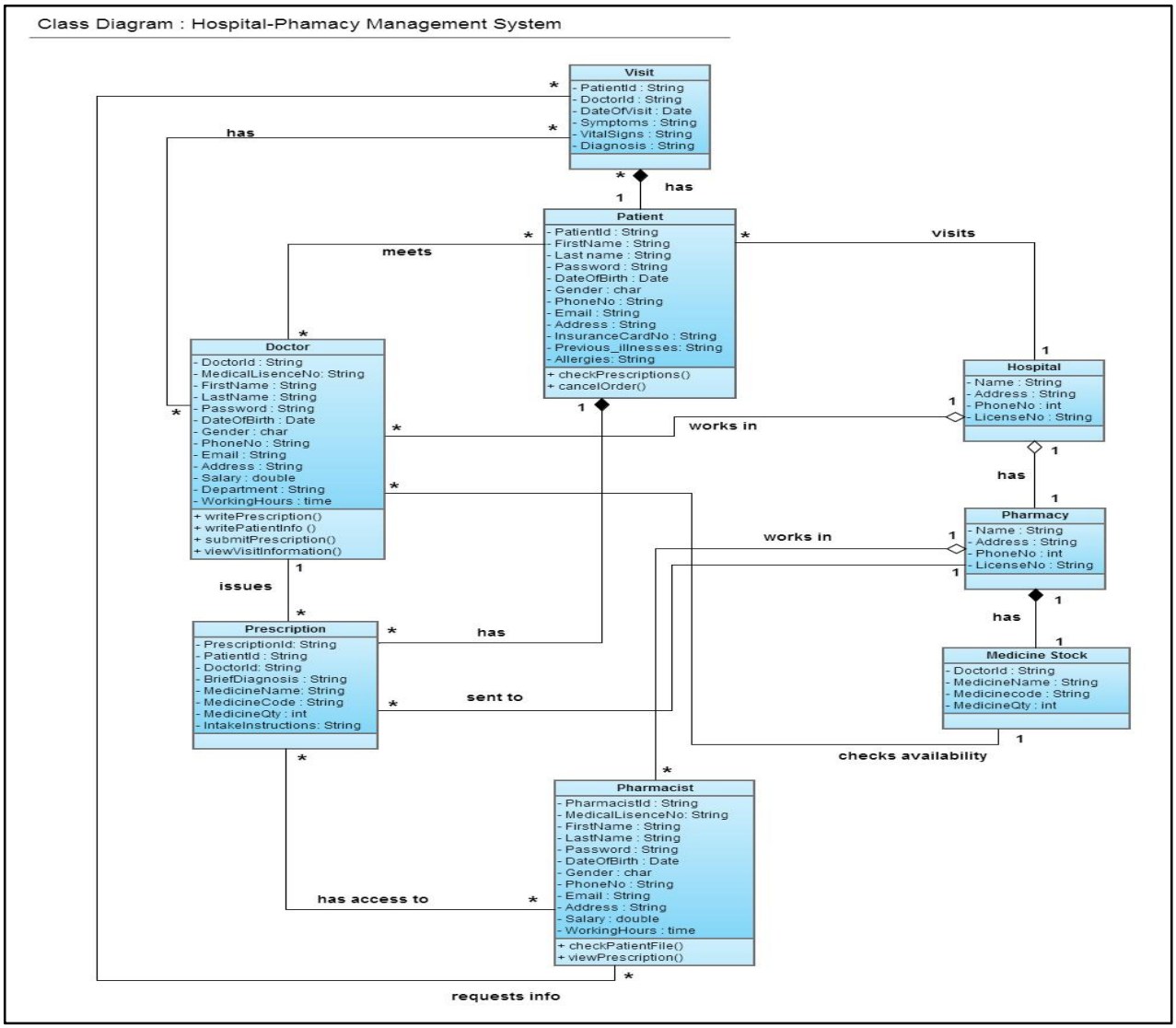

Fig. 4 HPMS Class Diagram

C. System Prototype

For demonstration purposes, here are few screens of HPMS prototype for the client side (the mobile application), as well as, the server side (the portal). The prototype screens below serve to provide specifications for a real, working system rather than a theoretical one. Fig. 5 below shows the mobile screen that appears to the user right after he logs in to the application. The screen shows the list of prescriptions containing the categories from which the user can choose from. There are three categories available to choose from, which are Ordered Prescriptions, Un-ordered Prescriptions and Cancelled Prescriptions. The Fig. 6 below displays the mobile screen that is shown when the user clicks on the Ordered Prescriptions link from the previous screen. The Status column displays the status of the prescription's processing in the pharmacy. A checked checkbox indicates that the prescription is ready, while an empty checkbox indicates that the prescription is not ready yet and it is still in the pharmacy processing phase. The Fig. 7 below presents the mobile screen that appears when the user clicks on the first prescription for instance from the table shown in Fig. 5.

Fig. 5 HPMS mobile application main screen

Fig. 6 Ordered Prescriptions

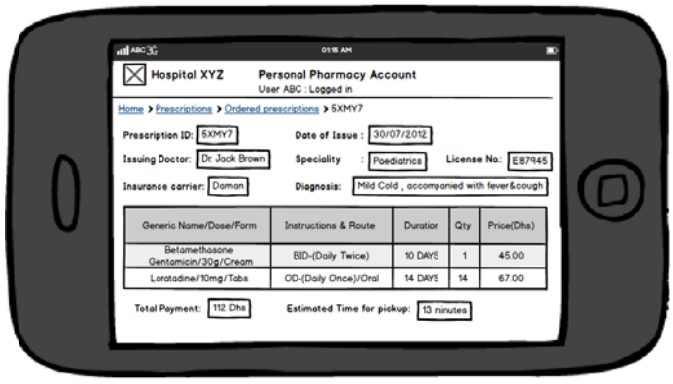

Fig. 7 Prescription details

The few screenshot below illustrate the HPMS portal. Fig. 8 below shows the "Personal Profile" tab of the doctor's portal.

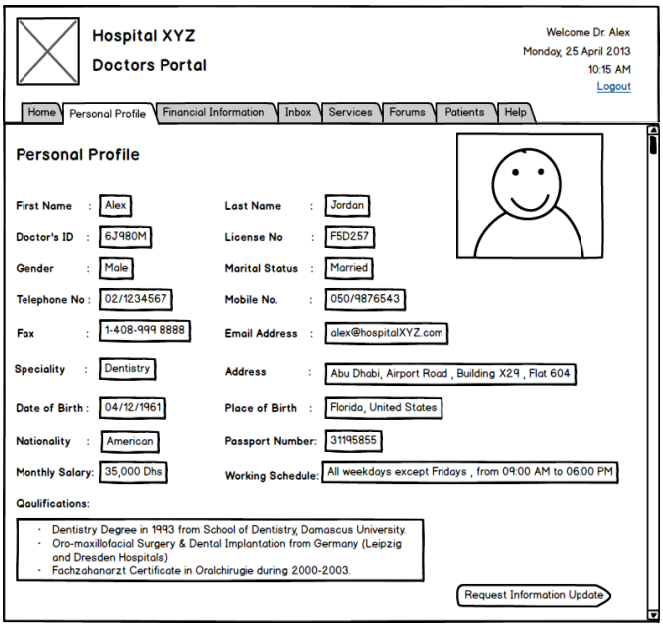

Fig. 8 Doctor's Portal: Personal Profile Tab

The Fig. 9 below presents the Write Prescription page after choosing the write prescription option from the Patient tab. The Instructions & Route column explains how the medication is administered. The second availability column tells if the requested quantity is available or not.

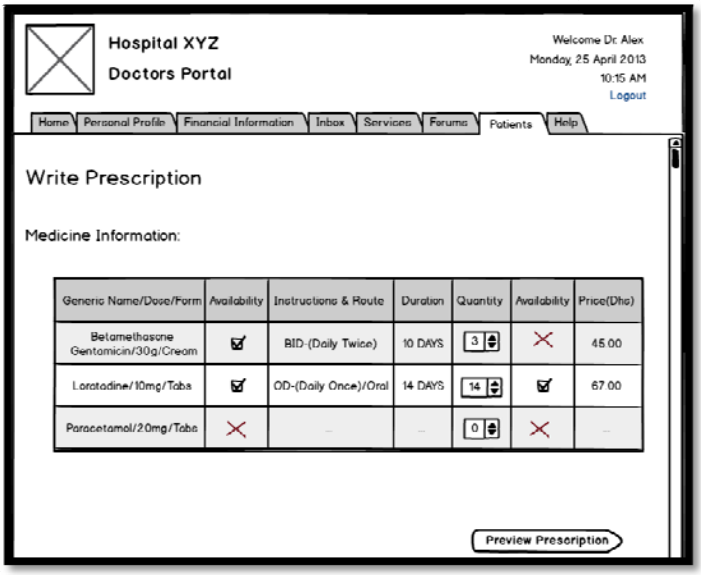

Fig. 9 Write Prescription-Medicine Information

IV. Discussion

There are many benefits could result from the Hospital-Pharmacy Management System. These benefits are classified as tangible and intangible benefits. Tangible benefits: Tangible benefits are the benefits that can be easily and readily quantified as money value. In appropriate deployment environment, HPMS can exhibit the following tangible benefits such as:

Increase patients visits: The Hospital-Pharmacy Management System will save time for doctors, nurses and pharmacists while they are dealing with patients. In addition, it will provide peaceful working environment without stress and anxiety. Therefore, these personnel will be more comfortable in the work site, which will reflect positively in dealing with the patients. So, more patients will probably come and visit this hospital, and this will potentially have a significant effect on the profit of the hospital.

Cost/error reductions: The Hospital-Pharmacy Management System, as stated earlier, saves time and offers comfort for its users. Therefore, more profit and revenue will be received by the hospital, and as a result, less cost will face the hospital. Moreover, the system is well designed to obtain high quality performance for its users and it is constructed to cover potential errors and mistakes that the users will probably do. As a result, both cost and errors will be decreased. Increase throughput/efficiency: Providing for the doctors, nurses, and pharmacists the comfortable and distressful working place will increase the quality and efficiency of their work, particularly in dealing with the patients. Improvements in work quality lead to better satisfaction of patients, which will increase their chances of coming back to the hospital, resulting in increment of profit and revenue.

Intangible benefits: Intangible benefits are benefits that cannot be quantified as money values; they are interested in the quality side of the benefits rather than the quantity side.

Increase flexibility of operations: The Hospital-Pharmacy Management System makes the job of the doctors, nurses, and pharmacists easier since it functions with several operations automatically and without the need of personnel's effort. In addition, it saves for these personnel a large amount of time due to the same reason stated above. Moreover, users get their fair share of operations flexibility. The mobile application will allow users to view and cancel prescriptions from any place they are. This is an advantage for the users as they can easily check-up any notifications or updates through their mobile phones as well as the opportunity to cancel prescriptions.

Higher quality services: The system will improve the quality of the personnel work and will raise the efficiency of their job outcomes. Since the Hospital-Pharmacy Management System will, as stated before, provide advantages not only for the comfort of the employees but also for their time-management. Higher quality services lead to higher users' satisfaction, which results to better relations with customers.

Better customer relations: Any company, institution or association that is well known for its good quality services and products usually has decent relationship with its customers. The Hospital-Pharmacy Management System will provide good services for the hospital's patients, due to the usable and efficient functions of the system. Therefore, patients will be comfortable while dealing with the hospital and will feel pleased about the general environment and faculty members of the hospital. As a result, the relations between the patients and the hospital will improve significantly.

The summary table below highlights the authors' contributions.

TABLE III
AUTHORS' CONTRIBUTIONS

What was already known on the topic	What this study added to our knowledge
Yearly Net Present Value	1,000,000
Overall Net Present Value	1,000,000

V. CONCLUSION

Large patients' queues at pharmacies and hospitals are a problem that faces the supposedly smooth and healthy environment. As this sometimes leads to dissatisfaction from visiting patients, HPMS has been developed to resolve this concern in UAE health sector. Through a thorough literature review, an extensive feasibility study and surveys for doctors, hospital IT managers and End-users, the authors highlighted the system's usefulness. The requirements analysis and system design phases provided a functional prototype for HPMS. The prototype illustrated the tangible and intangible benefits of HPMS. The Hospital-Pharmacy Management System will save time for doctors, nurses and pharmacists while they are dealing with patients. In addition, it will provide peaceful working environment without stress and anxiety. Improvements in work quality lead to better satisfaction of patients, which will increase their chances of coming back to the hospital, resulting in increment of profit and revenue. Moreover, users get their fair share of operations flexibility. The mobile application will allow users to view and cancel prescriptions from any place they are. HPMS will be deployed to users of Android devices. This limitation will be resolved, as one of main future enhancements, once the system finds acceptance from hospitals and pharmacies in UAE.

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Dr Khelifi has held impressive past careers, most recently working as a lecturer for the Engineering School of Technology in Canada and previously working for United Nations MSF in Canada, Ministry of Relations with Citizen and Immigration in Canada and Ministry of Finances in Tunisia. As a Canadian ISO member in Software Engineering, Dr Khelifi is contributing in developing software measurement standards.