IJRSSET

Afya App – The Mobile Personal Health Management Platform

Mabusi Erick

Faculty of Information Technology,
Strathmore University, Nairobi, Kenya
emabusi@gmail.com

Bernard Shibwabo Kasamani

Faculty of Information Technology
Strathmore University, Nairobi, Kenya
bshibwabo@strathmore.edu

Abstract: *The provision of Health services in developing countries is hampered by various challenges. One area that has not been fully ventured into is formulating a holistic way to help improve health of people by enabling use of mobile technologies to get health services on the go. In general, Patients using current information systems face the problem of not accessing medical services outside the hospital premises. These problems can be solved by using a mobile application that is linked with current and any possible future hospital information system. The solution consists of an application that allows patients to first record their health records and keep track of their general health changes in real-time, enabling patients to get medical assistance by having direct communication with their respective doctor(s) and accessing public health and emergency data on the go. This way, health problems are solved fast, efficiently and at any time of the day.*

Keywords: *mHealth, m-Health, Patient records, Afya, Personal Health Recording*

1. INTRODUCTION

A hospital is an institution for caring for sick people usually maintained by a private endowment, public funds or both [1]. Typically hospitals in Kenya use either electronic information management system or non-electronic information management system to manage the patients' health records and store their medical history.

Generally, in a hospital using non-electronic information management, patient records are stored in numbered files that are arranged and placed in shelves in a chronological manner. Furthermore, some hospitals implementing an electronic information management system do not fully use this system to manage all patient records, usually they only use the system to track in and out patient records, know the corresponding file number to a certain patient name and for the hospital finance management process [2].

The problem in current health information systems in Kenyan hospitals is first they do not allow patients to access their medical records remotely while they are outside hospital premises. The systems do not predict what a patient might be suffering or how best to treat the patient based on his specific body condition or as per patients' medical history and treatment patterns.

Mobile health (mHealth) is a term used for the practice of medicine and public health supported by using mobile communication devices, such as mobile phones, tablet computers and PDAs, for health services and information [3]. Mobile health has been developing as a result of limitation of healthcare systems of developing nations like Kenya [4, 5] and the recent rapid rise in mobile phone penetration in developing countries like Kenya [6].

Currently, mHealth concept is like "SMS for Life" is an innovative public-private partnership that harnesses everyday technology to improve access to essential malaria medicines in rural areas. It uses a combination of mobile phones, SMS messages and electronic mapping technology to track weekly stock levels at public health facilities in order to eliminate stock-outs, increase access to essential medicine and reduce the number of deaths from malaria.

"SMS for Life" was initially piloted across three districts in the United Republic of Tanzania, covering 129 health facilities and 226 villages, representing 1.2 million people. When launched in 2009, 26% of all health facilities did not have any ACTs in stock, but by the end, 99% had at least one ACT dosage form in stock. In addition, 888,000 people in the three pilot districts had access to all malaria treatments at the close of the pilot, versus 264,000 people at the start, which helped to reduce

the number of deaths from malaria. Figure 1 shows a clinic where "SMS for Life" is being implemented.

Fig1. *Malaria Clinic helped by SMS for Life program that uses cell phones to efficiently deliver malaria vaccine*

According to the analyst firm Berg Insight, around 2.8 million patients worldwide were using a home monitoring service based on equipment with integrated connectivity at the end of 2012. Patients are not able to get medical services outside hospital premises and the information systems used in hospitals are limited to interpreting patterns in medical records of patients. There is need to enable patients to record and access their hospital health records from anywhere there are. Also there needs to be a way to notify patients early on health patterns that may lead to serious health problem(s) or death before the problem occurs.

This project set out to develop a mobile personal health management application. The application supports patients and general individuals track and manage their health and health related issues outside hospital premises which can also link with both existing and new hospital systems. Moreover, the mobile application supports individuals maintain good health hence improve their productivity in all aspects of their livelihood.

2. REVIEW OF RELATED LITERATURE

2.1. The Kenya Health Sector Situation

2.1.1. General Situation Analysis

Life expectancy (LE) at birth in Kenya reduced to a low of 45.2 years during the 1994-2010 policy period, but was estimated to have risen up to 60 years by 2009 - a tendency that was reflected across all age groups [4,5].

About 52 per cent of Kenya's population have access to basic health services within 5 km, Access to basic Primary Health Care (PHC) and referral services however, still remains a significant challenge. Significant disparities in service availability exist between rural and urban areas and in hard to reach areas [4, 5].

Mortality rates remains high. The main causes of deaths include: HIV/AIDS (29.3%), perinatal conditions (9.0%), lower respiratory infections (8.1%), Tuberculosis (TB) (6.3%), diarrhoea (6.0%) and malaria at (5.8%) among others. The other causes of death include cerebrovascular diseases, ischaemic heart disease, road traffic accidents and violence [4, 5].

In 2012, there was 105, 369 registered medical personnel with a ratio of 259 per 100,000 persons. However, distribution of human resource for health remains skewed. The ASALs remain the most disadvantaged in the provision of health services especially, the distribution of health facilities and availability of health personnel. Throughout the country, some categories of health workers are more concentrated in urban and private sector services [4, 5].

The country spends approximately 5.4 per cent of GDP on health accounting for 4.6 per cent of government expenditures. This however remains below the Abuja target of 15 per cent. The private sector remains an important stakeholder for health and the government is increasingly promoting Public Private Partnership (PPP). Private sector financing accounts for 37 per cent of total health spending in the country. 80 per cent of the population remains largely uninsured. The total membership for National Health Insurance Fund (NHIF) is currently 3.33 million with the formal sector having 2.45 million and the informal sector 0.88 million [4, 5].

Table 1 shows the leading causes of deaths, and disabilities in Kenya [4, 5]. There are different types of games of many variations that come into play. Examples include: Puzzles, mazes, fantasy/adventure and simulation games. Some games require physical skill and strategy, while others are games of chance. Some are board or adventure game, while others involve simulation involving real events or fantasy. However, no evidence supports a greater therapeutic or educational effect in either situation.

Table1. *Leading causes of death disabilities in Kenya*

Rank	Disease or injury	Percentage of total deaths
1	HIV	29.3
2	Conditions arising during prenatal period	9.0
3	Lower respiratory infections	8.1
4	Tuberculosis	6.3
5	Diarrheal diseases	6.0
6	Malaria	5.8
7	Cerebrovascular disease	3.3
8	Ischemic heart disease	2.8
9	Road traffic accidents	1.9
10	Violence	1.6

2.1.2. Challenges

Some of the main challenges facing Kenya health sector that are targeted for MTP by [4, 5] include the following

- Inadequate requisite infrastructure for comprehensive basic health care (model health facilities) and level 4 health facilities

- Shortage of essential medicines and medical supplies

- Low doctor to population and nurse to population

- Inadequate emergency transportation

- Emergence of drug resistant TB strains

- Prevalence of HIV/AIDS, TB and Malaria

- Increased morbidity and mortality associated with HIV/AIDS

- Rise of cancer; hypertension, heart diseases and diabetes

- Rise in road traffic accidents causing injuries and death

- Micronutrient deficiency disorders for children and under-fives

- Lack or inadequacy of a rapid referral system

- Insufficient facilities to handle immediate maternal cases

- Inadequate rapid and effective maternity services

- Understaffed public health facilities

- Inequitable distribution of the available human resource coupled with shortages of skill mix

- High cost of health care and financing

- Low coverage of health insurance

- Provision of health services under devolved system

- To show to perform first aid and solutions to other emergency or urgent health (or life) critical situation.

2.1.3. Kenya Health Policy and National Development Agenda

Kenya has over the years taken important steps aimed at laying a firm foundation to overcome the development obstacles and improve socio-economic status of her citizens including health. The development of Kenya Health Policy Framework (KHPF 1994-2010), launching of Vision 2030, enactment of the Constitution 2010, and fast tracking of actions to achieve the Millennium Development Goals (MDGs) by 2015 are some of the steps [4, 5].

The implementation of KHPF 1994-2010 has led to significant improvement of health indicators such as infectious diseases and child health. The emerging trend of non-communicable diseases is however a threat to the gains made so far. This new health Policy provides the long term intent of government towards attaining its health goals. The Policy aims at consolidating the gains attained so far, while guiding achievement of further health gains in an equitable, responsive and efficient manner. It is envisioned that the ongoing government reforms, together with anticipated sustained economic growth, will facilitate the achievement of the health goals [4, 5].

2.1.4. Kenya Health Policy and National Development Agenda

Kenya has over the years taken important steps aimed at laying a firm foundation to overcome the development obstacles and improve socio-economic status of her citizens including health. The development of Kenya Health Policy Framework (KHPF 1994-2010), launching of Vision 2030, enactment of the Constitution 2010, and fast tracking of actions to achieve the Millennium Development Goals (MDGs) by 2015 are some of the steps [4, 5].

The Constitution introduces a devolved system of government which would enhance access to services by all Kenyans, especially those in rural and hard to reach areas. The Constitution also singles out health care for specific groups such as children and persons living with disabilities. The underlying determinants of the right to health, such as adequate housing, food, clean safe water, social security and education, are also guaranteed in the Constitution [4, 5].

2.2. Mobile Technology and Service Provisioning

2.2.1. Mobile Technology Growth In Kenya

There has been a rapid growth of mobile phone users in Kenya since the year 2000. Mobile-cellular telephone subscriber increased from 127,404 in the end of the year 2000 to 30,731,754 in the end of the year 2012 [6].

2.2.2. Kenya Mobile Internet Usage

In Kenya, 99 percent of Internet connections can be traced from mobile devices. There are 6.5 million Internet subscriptions in total and 6.4 million of those are from mobile devices. It should be noted that this isn't just access via mobile phones, but also Personal Computers via 3G modems. Mobile Web subscriptions are growing at 69 percent year-on-year. In a country where mobile phone subscriptions outnumber fixed lines 107:1, there can be little doubt that the future of web in Kenya is mobile [7].

2.2.3. Windows Phone Usage

Windows Phone (WP) is an operating system for smart mobile devices like phone and tablets created by Microsoft Inc. a company incorporated in United States of America. As of February 2013 windows phone had 2.6% market share and sold 6.0 Million units [2] including Kenya.

2.2.4. Windows App Usage

[8] Estimates that 1.2 billion people worldwide were using mobile apps at the end of 2012. This is forecast to grow at a 29.8 percent each year, to reach 4.4 billion users by the end of 2017. Furthermore 13% of mobile app users come from Africa and Middle East.

2.3. Health Information Systems

2.3.1. Health Information System in Kenya

In 2001 under the APHIA Financing and Sustainability Project team a hospital management information system was built locally and deployed at Chogoria hospital and in part at coast provincial general hospital and Thika district hospital [9]. With better management information and tighter controls, there was more money for better patient care. Moreover, the system was developed by a Kenyan, in Kenya, so is less expensive than anything available internationally.

Another commercially available hospital management system is that developed by Pinnacle systems designed to integrate the different information systems existing in hospitals into one single efficient system solves the problems inherent in a network of multiple programs that are non-compatible with each other. It can integrate almost any type of services, systems, departments, clinic, processes, data and communication that exist in a hospital. Its design can even handle non-medical services or functions like security and maintenance [10].

2.3.2. Challenges and limitations of Health Information Systems

Some challenges and limitation to implementing of a hospital information system include technical problems like having poorly developed software, poorly implemented of maintained software and private vendor having the source code [11].

Cost for the hardware running information system and cost for service contract are expensive resulting to slow funds availability leading to frequent break down the information system and end user frustrations [11].

Other challenges in implementing of health information system are those related to human resource like frequent replacement of staff in hospitals and having insufficient number of trained staff to perform various tasks [11].

2.3.3. Personal Health Recording (PHR)

The advancements in healthcare practice, the limitations of the traditional healthcare processes and the need for flexible access to health information, create a continuing demand for electronic health systems (e-health systems) everywhere. In this direction, personal health record (PHR) systems are a new, innovative and constantly evolving area that empowers patients to take more active role in their own health and make informed decisions [12].

According to [13], Personal Health Record (PHR) is a specified re-cord which is implemented in clinical practices and de-signed for a consumer. PHR usually includes data collected from different sources such as from health care providers, pharmacies, insures and the consumer. A typical PHR would provide summarized information about the patient. A PHR typically includes information about medications, allergies, vaccinations, illnesses, laboratory and other test results and surgeries and other procedures.

3. THE PROPOSED HEALTH MANAGEMENT PLATFORM

3.1. The Way Forward

In order to develop Afya App to a high quality object oriented application object-oriented analysis and design methodology was used develop Afya App. In an object oriented analysis and design complex software system can be broken down into various objects, combining the data and the functions that operate on the data into a single unit, the object. This form of object decomposition provides a natural way of breaking the problem down into isolated, manageable parts. In many cases, the development

effort shifts from writing a new code, to assembling existing objects in new and innovative ways to solve a problem. Thus, object-oriented analysis and design methodology cuts down development time and costs, leading to faster time to market and significant competitive advantage, and enables producing more flexible, modifiable, easily maintainable object-oriented systems [14].

The life cycle of development of object oriented systems development involves three phases which are analysis phase, design phase and implementation phase. Analysis phase is when model of a real world application is developed showing its properties and functional behaviors. Design phase when an analysis model is refines and adopted to the system environment and implementation phase when the design model is implemented using programming language or database management system [14].

3.2. Analysis and Design

3.2.1. Functional Requirements

- To analyze the symptoms of a patient and select the probable disease which the patient is suffering from.

- To schedule notifications for the medication, surgeries appointment and an appointment with a specialist doctor.

- To store and show the medical records, patient specific issues (like allergies and past surgeries) and medical history of the user (patient).

- To show the patients the nearest medical institution and show the details of the services being offered in the institution.

- To identify and calculate charges in different hospitals and services including information of medical insurance supported in the medical institution.

- To identify and suggest insurance services convenient to a specific patient needs.

- To list emergency contacts both public and private to help patients get fast medical support in case of emergency.

- To schedule notifications on daily health tips to the user.

- To show the chemical elements of common food substance and medication, furthermore notify the user if a substance he or she is allergic to is contained inside.

- User to schedule appointment(s) with a doctor or specialist

- Close friends and family members of an admitted patient to be able to know how well the friend of family member is doing respectively.

3.2.2. Non-Functional Requirements

- Availability of internet connection to update saved data from time to time and give relevant data to the user.

- Accurate and speedy working of mobile phone.

- Accurate saving and retrieving of data especially the medical record.

Afya App uses the Windows. Storage namespace and the System. Linq namespace to store and retrieve medical records and other Afya App data inside the users' phone, in the local isolated storage space for Afya App and therefore there is no formal or structured database or database management system used. This is because Afya app uses the model view view-model (MVVM) architecture suggested in [15] to organize and structure data and the views inside the app.

A user downloads Afya App from Windows Phone Store either directly from a windows phone operating system device or from http://www.windowsphone.com/en-US/store.

On the first opening of the app, the user should be prompted to enter login credentials, sign up for an Afya App account or enter to Afya App patient default mode. Generally there are 2 types of users in Afya App a patient and a doctor.

Users can have more than one login session by using a different account type, therefore allowing doctors to perform their official duties and manage their health using Afya App.

In order for a user to login he or she should have an internet connection. After successful login performing of specific functions may or may not require internet connection depending on the task or settings set by the user. Furthermore on receiving data online, the data is stored locally so that the user can access the data offline when there is no internet connection.

Users may opt to logoff (and leave their data saved or delete), add another user login session or pin lock the app when starting a new session so as to protect their private data. Figure 2 summarizes the operations on a Use case diagram. Figure 3 presents the class diagram for the Afya App application.
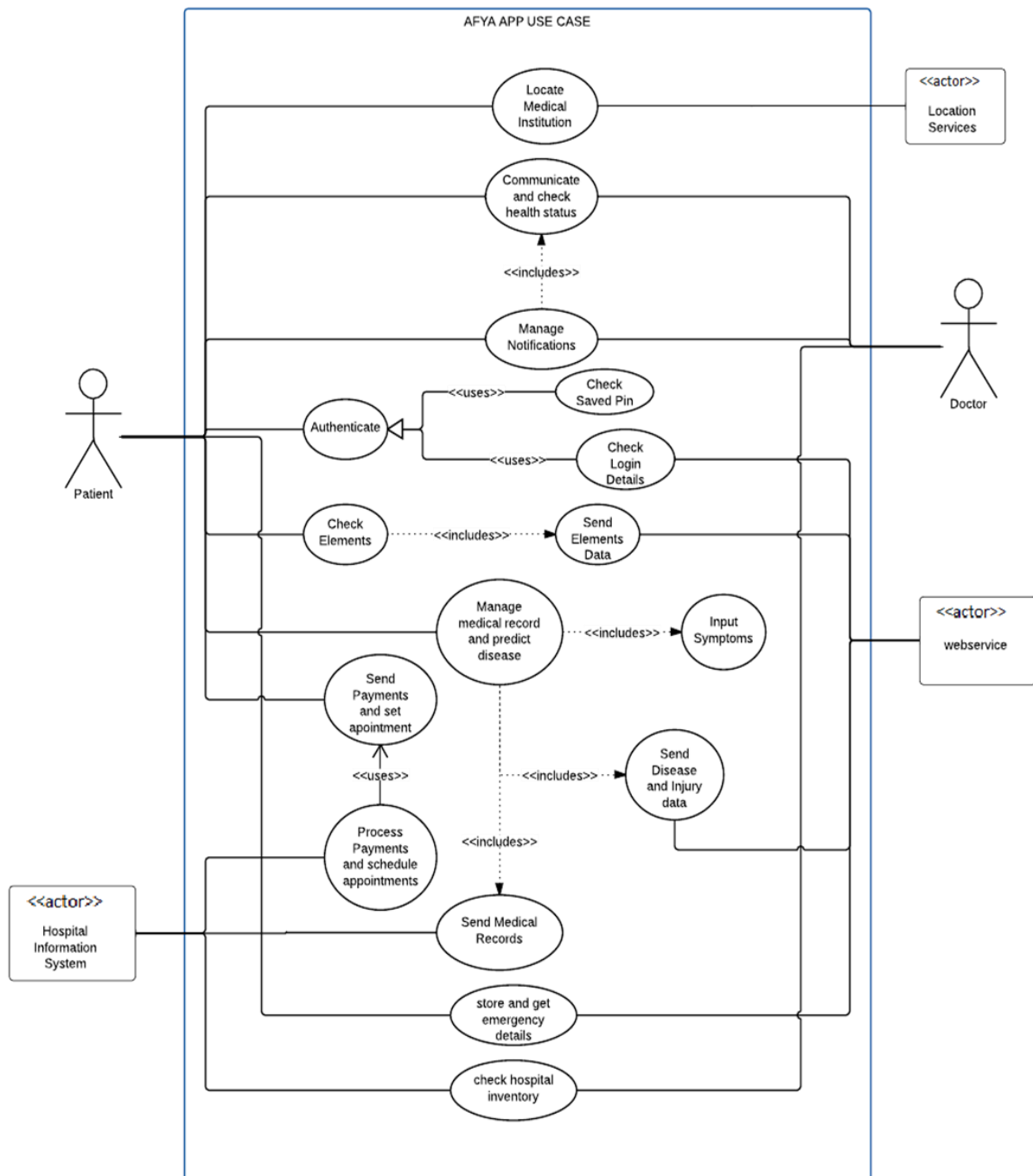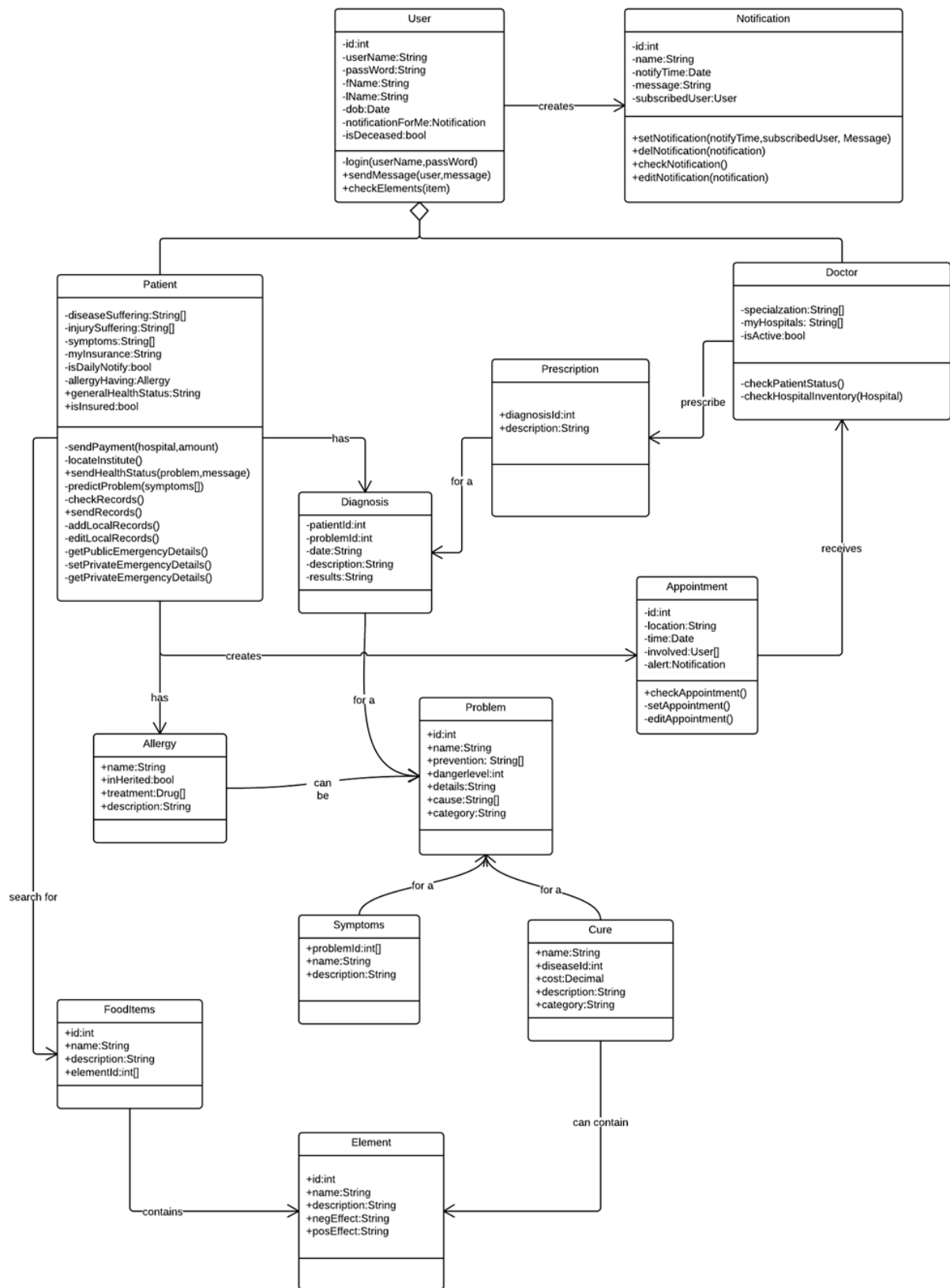

Fig2. *Afya App Main Use Case Diagram*

Fig3. *Afya App Class Diagram*

Afya app has an online database which is used to store and retrieve users' and general health data. A similar physical database is also stored locally on the users' phone. The local database stores user data when there is internet connection and update the online database when there is internet connection.

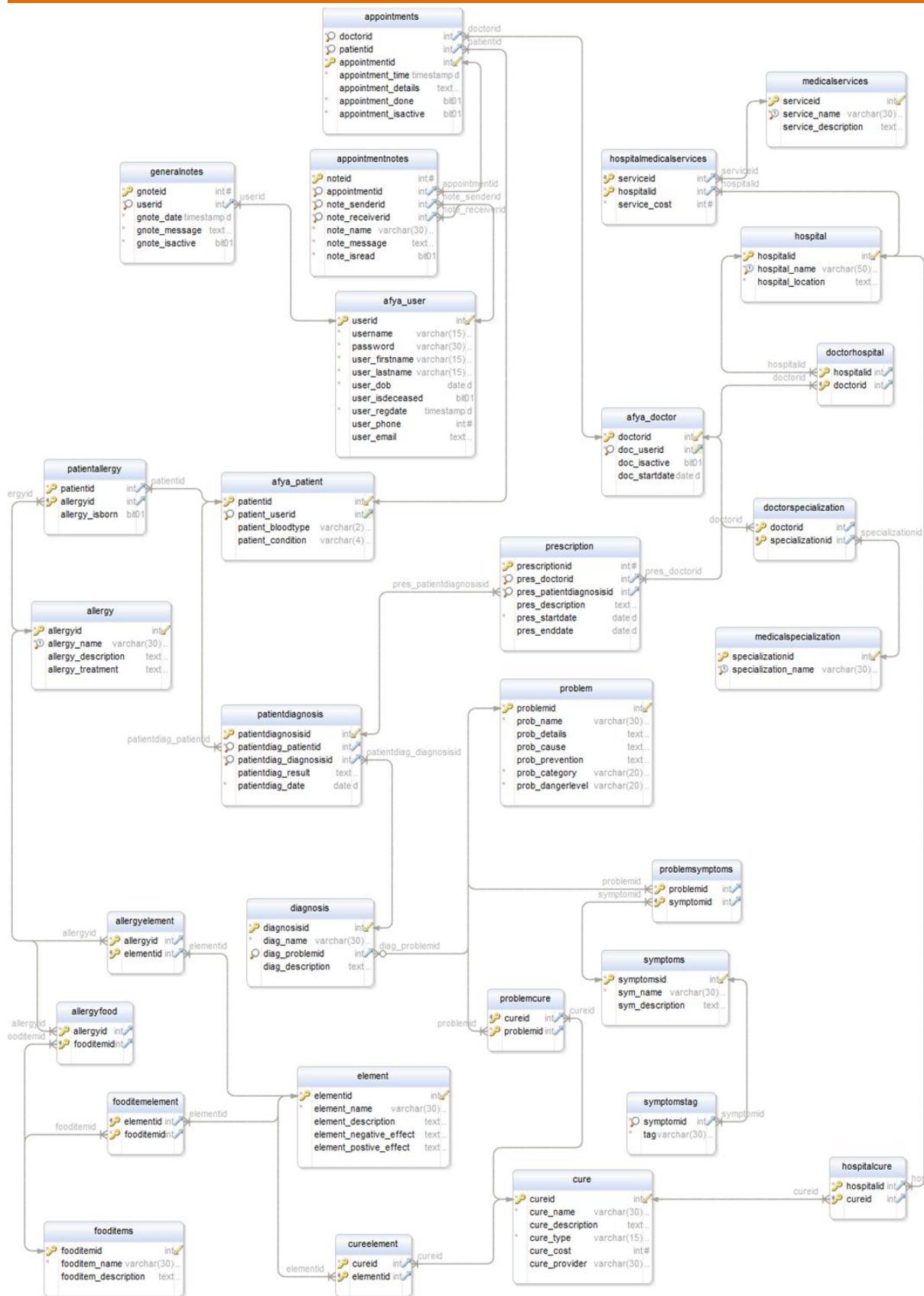Afya App online database can be illustrated using the schema diagram presented in Figure 4 Afya App Database Schema.

Fig4. *Afya App Database Schema*

3.3. Implementation and Testing

In Afya App has been implemented and tested an windows phone emulator on personal computer running Windows 8.1, on the developer windows phone device and other 2 devices for testing and given to two test users. Figure 5 shows Afya App in testing.
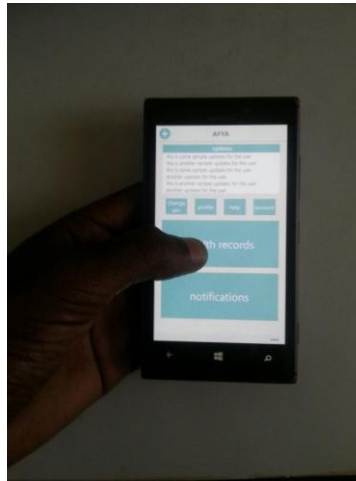
Fig5. *Developer Testing Afya*

3.3.1. Installation Testing

Afya App has been tested in different devices namely Nokia Lumia 820, Nokia Lumia 920 and Huawei Ascend W1 to assure it can be installed correctly and work on any user device. After testing it was vivid that Afya App can be installed correctly on different windows phone devices.

Figure 6 shows Afya App running on a Lumia 925 device and Figure 7 shows Afya App running on Lumia 820 device. Both devices show the user on the navigating on Afya App dashboard page.

Fig6. *Afya running on Lumia 925*
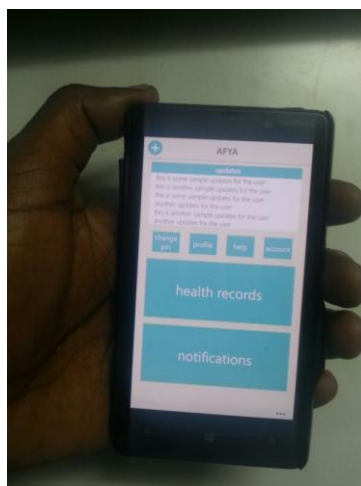
Fig7. *Afya running on Lumia 820*

3.3.2. Functional and Non-Functional Testing

Afya functional and non-functional requirements have been tested to make sure that all the required functionality are delivered to the user by verifyingspecific action performed on Afya App when a user is using Afya App.

Some tests done include checking if a user can store and show the medical records, patient specific issues, checking if a user can set notification and alarm, checking if multiple users can use Afya app and checking if user can get public emergency contacts.

From the functional and non-functional testing done, it was conclude that all functional and non-functional requirements have been archived.

3.3.3. Destructive Testing

Tests to attempts to make Afya App to fail to verify that Afya App functions properly even when invalid or unexpected inputs are entered by the user, therefore ensuring Afya App has robustness of input validation and error-management.

One of input fields tested are fields which input the users' PIN. PIN fields in Afya App, that on the PIN check page and the ones on the change PIN change have first been set to an input scope of numbers only therefore as seen on Figure 8user can only input number values, also since number input scope of number have the point sign "." for decimal if the user uses it on the any fields he will get the error message "Please input a number" as seen on Figure 8.
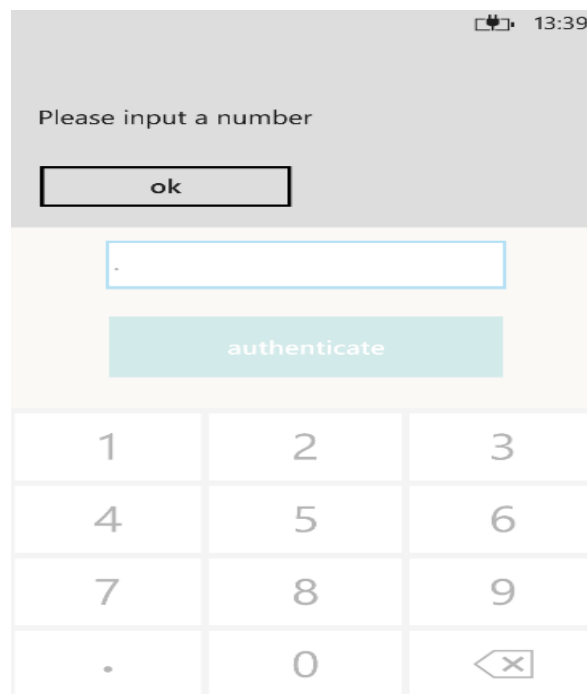
Fig8. *Message box notifying the user of an invalid PIN input*

3.3.4. Performance Testing

Test to determine how Afya App performs in terms of responsiveness and stability under a large workload was done.

Testing on how long to takes for Afya App to be loaded was done using visual studio 2013 ultimate edition windows phone application analysis and was determined to be 0.89 seconds.

Visual studio 2013 ultimate edition windows phone application analysis also checks how much an app is responsive, battery consumption and the phone memory used. Figure 9 Screenshot showing windows phone application analysis report shows Afya Apps' full windows phone application analysis report.

Fig9. *Screenshot showing windows phone application analysis report*

From the results shown on Figure 9, it was concluded that Afya App has high performance rate.

3.3.5. Usability Testing

Testing to check if Afya apps' user interface is easy to use and understand was done, and based on test users reviews Afya app interface is easy to use and understand.

Afya App has was debugged to a phone and given to 5 test users as shown on Table 2 to be tested for a minimum of 15 minutes and a maximum of as hours. After use of Afya App the test user comments and/or experience where recorded, Table 2 show the experience which the test users had while using Afya App.

**Table2.** *Test user experiences on use of Afya App*

Person	Gender	Education	Role/Occupation	Experience
A	Male	Undergraduate	Student	Very easy to use
B	Male	Undergraduate	Student	Navigation and content arrangement is superb
C	Male	Undergraduate	Student	Very easy to understand and getting way through on first use
D	Female	Undergraduate	Student	Nice performance on my phone
E	Female	Undergraduate	Student	Simple, excellent and east to use interface

From the experiences of test users of Afya App show on Table 2, it was concluded that Afya App has a high usability.

3.3.6. Security Testing

Testing of how confidential health data is protected from hackers and another authorized access was done.

Based on the security tests done it was concluded personal health data of each user is well protected, and most essentially by checking PIN every time a use re-opens Afya App further descriptions of this testing is presented in Figure 10.
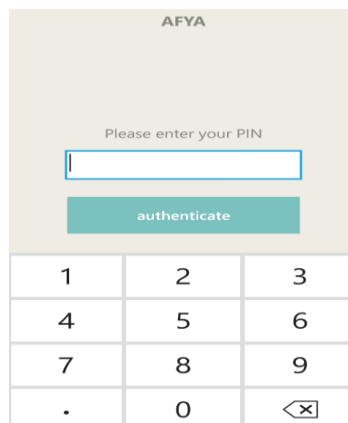
Fig10. *Screenshot showing PIN checking on reactivating of the Afya App*

4. CONCLUSION

The digitization of medical records is important so as to provide a way that individuals are able to track and monitor their health records stored in different hospitals (or medical institution). This also serves the purpose of allowing doctors to monitor their patients' closely hence patients getting medical services on the go and little by little helping to save life. Current hospital information systems should have Application Programming Interfaces (APIs) to allow other systems to integrate with them to share data that will help patients (and other users) so as to improve provision of health services globally.

Afya App enables users to create and retrieve medical services outside health institutions and schedule notification to help people improve their health. This has been found to be necessary to help saving life of a patient. With Afya App users can track and manage their health and health related issues outside hospital premises hence maintaining a good health while improve their productivity in all aspects of their livelihood.

REFERENCES

[1] Columbia University Press, "hospital" 2014. [Online]. Available: http://www.reference.com/browse/hospital

[2] International Data Corporation, "Press Release". 2013. [Online]. Available: http://www.idc.com/getdoc.jsp?containerId=prUS23946013#.UTCOPjd4DlY

[3] P. Germanakos, C. Mourlas, and G. Samaras, A Mobile Agent Approach for Ubiquitous and Personalized. 10th International Conference on User Modeling (UM'05), 2005, (pp. 67–70). Edinburgh.

[4] Kenya Ministry of Health, "Second Medium Term Plan, 2013-2017". 2013. [Online]. Available: http://www.health.go.ke/img/Second-Medium-Term-Plan-2013-2017-Transforming-Kenya-Pathway-to-Devolution-Socio-Economic-Development-Equity-and-National-Unity.pdf

[5] Kenya Ministry of Health, "Kenya Health Policy 2012-2030". 2013. [Online]. Available: Ministry of Health: http://www.health.go.ke/img/Kenya-Health-Policy-2012-2030.pdf

[6] International Telecommunication Union, "Statistics". 2013. [Online]. Available: http://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2013/Mobile_cellular_2000-2012.xls

[7] Communications Commission of Kenya, "Mobile subscribers in the country inch towards 30million". 2013. [Online]. Available: http://www.cck.go.ke/ news/2012/ Mobile_Sub scribers.html

[8] Portio Research, "Fast growth of apps user base in booming Asia Pacific market." 2013. [Online]. Available: http://www.portioresearch.com/en/blog/2013/fast-growth-of-apps-user-base-in-booming-asia-pacific-market.aspx

[9] United States Agency for International Development, "The Kenya Hospital Management Information System". 2013. [Online]. Available: http://pdf.usaid.gov/pdf_docs/PNADE397.pdf

[10] Pinnacle Systems, "Hospital Information Systems", 2014. [Online]. Available:: http://www.pinnaclesystemskenya.net/hisman.htm?compid=404837&formid=8&h=809ba0f53bfff380df07

[11] H. Khan,."Challenges of setting up hospital management information system". 2013. [Online]. Available:: http://www.docstoc.com/docs/49834557/Challenges-of-setting-up-hospital-management-information-system-%28HMIS

[12] I. Genitsaridi, H. Kondylakis, L. Koumakis, K. Marias and M. Tsiknakis, Towards Intelligent Personal Health Record Systems: review, criteria and extensions. Procedia Computer Science, 2013, 327-334. doi:10.1016/j.procs.2013.09.043

[13] R. Alawneh, E. A. Sheikh, and R. Kanaan (2011). Development of Embedded Personal Health Care Record System. iBusiness, 178-183. doi:10.4236/ib.2011.32024

[14] H. El-Ghareeb, Object Oriented Analysis and Design. 2014. [Online]. Available: http://www.slideshare.net/helghareeb/object-oriented-analysis-and-design-12164752

[15] Microsoft. "MVVM". 2013. [Online]. Available: http://msdn.microsoft.com/en-us/ library/ gg430869%28v=PandP.40%29.aspx

AUTHORS' BIOGRAPHY

Erick Mabusi is pursuing Bachelors of Business and Information Technology at Strathmore University. He has been honoured in recognition of academic excellence during academic year 2012/2013 and 2013/2014 at Strathmore University. Erick served as a Leader of computer Youth entrepreneurship scheme of Youth for Africa club. He is a passionate Windows phone apps developer. He is also an active web programmer and can program in a variety of programming languages. He is responsible for giving the overall idea of the system.

Dr. Bernard Shibwabo Kasamani, PhD is currently working as a Lecturer in the Faculty of Information Technology at Strathmore University. He holds a Bachelor's Degree in Business and Information Technology and a Master of Science in Information Technology from Strathmore University. He holds a doctorate in Information Technology from Strathmore University. He is a member of the steering committee for the Annual Strathmore ICT conference. He has also been a customer service agent, lead developer, shotokan coach and Mentor. His research interests include Systems Integration, Dataspaces, Data mining, business intelligence and applications.