# IMPLEMENTING OPERATIONS SUPPORT SYSTEMS IN E-HEALTH BASED SYSTEMS

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#### **ABSTRACT**

Information and communication technologies have been introduced in different dimensions of the health care. e-Health is the use of advanced communications technologies such as the Internet, portable, wireless and other sophisticated devices to support health care delivery and education. It has the potentials of improving the efficiency of health care delivery globally.

With the increasing demand for information at the point of care, health care providers could explore the advances provided by mobile technologies and the increasing capabilities, compactness and pervasiveness of computing devices to adopt operations supports systems (OSS) in e-Health based systems in order to provide efficient services and enhance their performances.

In this paper, we present, the development and implementation of operations supports in e-Health based systems. The system promises to deliver greater productivity for health care practitioners.

Keywords: Architecture, e-Health, globally, portable, productivity and wireless devices

# 1.0 INTRODUCTION

Over the last decade, the need to develop and organize new ways of providing efficient health care services has resulted in a dramatic increase in the use of Information and Communications Technology (ICT) based solutions in health care delivery, generally known as e-Health.

This entails a fundamental redesign of health care processes based on the use and integration of electronic communication at all levels. A benefit of e-Health is that patients in one country can seek treatment and other services from other countries with their patient records moving with them electronically. A patient with his medical information moving electronically via wireless technology is empowered to play active role in the decision making process during his treatment. Treatment processes in care centres are facilitated with the introduction of operations support systems (OSS).

e-Health based OSS are essentially designed to automate manual health care processes, making the operations of health care practitioners and the network infrastructure more error-free and efficient. OSS solutions for e-Health takes advantage of state-of-the-art information technology to address health care enterprise-wide needs and requirements to reduce costs, provide reliable, flexible, mobile, timely, secure health care delivery to patients by health care providers, centres or practitioners

Research efforts and the use of communications technologies (fixed and mobile) to extend the reach, range and manoeuvrability of health care application and contents are covered in [1, 2, 3, 4]. It is not uncommon in recent times, to have a number of personalized applications for prescription, research, reference, patient education, and other applications for accessing daily schedules being bundled with hand-held devices to provide supports for physicians [5, 6, 7]. However, research on applications based on wireless LAN to improve health care services in the hospitals are becoming more popular [1, 3, 8] because of the increased demand for real time access to medical information by medical and support personnel, the maturation of 802.11 standards, and the proliferation of 802.11-enabled devices. Simple wireless devices such as PDAs from literatures [9, 10, 11] are reported to be more flexible and portable for use by physicians than some more computational desktop computers.

The use of mobile technology devices such as PDAs, cell phones, laptops, etc for health care (mobile health care) [12] delivery promises a revolution to modern health care as physicians stand to make more current and accurate prescribing decisions, thereby reducing harmful drug interactions. In addition to enhancing quality of patient care, e-Health technology, through the elimination of redundant paperwork, also facilitates more efficient and effective delivery of patient care.

The remaining part of this paper is discussed as follows; In Section 2, we present a design of the system, in Section 3, we present the implementation technologies and a discussion of users' interactions with the system in Section 4. We conclude in section 5.

### 2.0 SYSTEMS DESIGN

Prior to our design and implementation, we accomplished our requirements engineering processes by interacting with the various medical practitioners at the Covenant University Health Centre to gather the requirements for the system. We were able to identify some supports services which are represented architecturally in the following sections:

# 2.1 Operations Support Services in e-Health Systems The supports services and their main features are discussed as follows;

## • Patient Medical Record Support Service (PMRSS)

This is the core support service in e-Health based systems [13]. It is one of the components in the application layer of the software architecture and interacts closely with the laboratory test support service(s), and the pharmacy and billing support service(s). It communicates with other support services in the application layer to capture the required data which are committed to the data layer for more permanent storage. It solves many of the logistic problems of archiving, retrieving, tracing and finding out paper based medical records. It provides functionality that maximizes the usage of the patients' medical information by serving as central sources of information for communications between health care providers, covering the patients' history, observations, diagnosis and therapeutic conclusions.

With PMRSS in place, reports such as laboratory test, medication, doctor-patients appointment, billing information, patient and staff data are easily generated.

• Laboratory Test Support Service (LTSS)

This support system aims at improving patient safety and efficiency in care delivery. A doctor who wants to confirm the presence or absence of diseases may request that a patient undergoes a laboratory test. After the test is performed, the result is given to the patient or captured and committed directly to the system via a mobile device for a later use by the referring physician.

# • Pharmacy and Billing Support Service (PBSS)

This module is patient-centred. Its functionalities include checks for drugs interactions, billing and allergic drug alert. The module helps to minimize medication errors and adverse drug effect on patients by allowing physicians send prescription information directly to the pharmacist after reviewing patient's allergic medication list real-time via handheld devices. It incorporates a knowledge driven risk management support to enhance clinical decision support from the point of care. The system automatically generates the bills and forwards prescription information to the central server for review and dispersal by the pharmacist in due course.

# Documentation Support Service (DSS)

These support services enable authorised users especially physician to record complaints, diagnoses, allergies, medications, referral information and other data electronically. As patient visits to a care centre, the nurse or medical record personnel calls up his details from the e-Health system in readiness to provide appropriate services. Where his record does not exist, a new record is created with the patient demographic information, vital statistics etc. The patient registration process and other encounters or interactions with medical personnel are equally captured with standard interfaces.

# • Data Access and Update Support Service (DAUSS)

These support services provide an interface for authorised users to easily retrieve and modify information. Each patient record is assigned a unique identity number. Patient identification and verification is required to maintain data integrity of the system. This is achieved by keeping a unique patient's t Identity across the entire patient's records. At the point of care, the physician is able to search for a patient's record in relation to a service earlier received by providing the identity number. The system equally provides support for the modification or update of records where necessary.

## • Security and Authentication Support Service (SASS)

In a hospital setting, several users access the patient's records to improve services to patients. These users include, doctors, nurses, laboratory personnel, pharmacists amongst others. A common way to give access right to hospital personnel is according to their functional and structural role which relates to their profession or specialty [13]. Based on the level of authorization, each personnel is allowed to view and modify only those information he is authorized to have access to.

# • View and Report Support Service (VRSS)

Electronic view capability is vital for e-Health bases systems. At various points in a patient care, it may be necessary to review or visit a patient's medical information. To view a patient's record, an authorised user after been authenticated by the system, is allowed to search for patient's record by providing the patient's identity. The reason for a view may include a review of doctor's diagnosis, past medications, laboratory result or test, bill information. An update is allowed where wrong information was earlier captured or entered.

The process of treating a patient requires some mobility of the patient or the medical personnel while the patient record moves electronically. The cooperation between the different personnel is captured in the collaboration diagram in Figure 2.1.

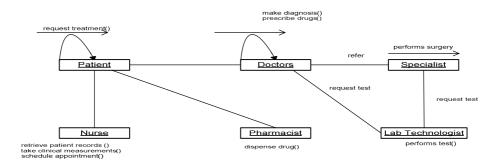


Figure 1: Collaboration Diagram

### 2.2 Architectures

Health care delivery in a hospital environment is inherently mobile combined with the tremendous need to have timely and accurate access to patients' information at all times. Thus the architecture proposed must allow easy capture, search, retrieval, and update of patient information from the point of care within the hospital setting. We used a client-server multi-tier based architecture for the hardware (physical) and a 3-tier client / server architecture for the logical software (logical) implementation and deployment. The two architectures are depicted in Figure 2 and Figure .3 respectively.

### 2.2.1 The Hardware Architecture

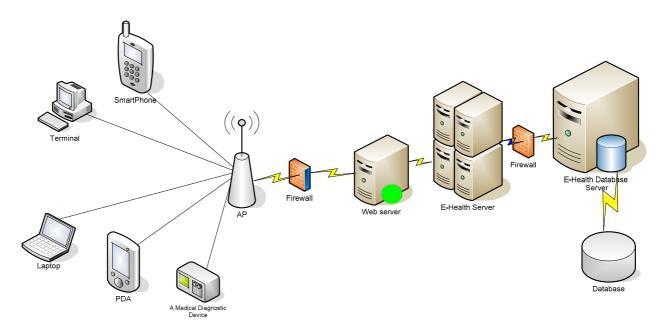


Figure 2: Hardware Architecture for e-Health Based System

This architecture consists of a complete range of robust performance client and server platforms with integrated enterprise application and data extendable to care providers at the point of care.

The client systems include PDA, cell phone and smart phone and other handheld medical devices that combine real time access to enterprise systems and data with processing power for local analysis. The client devices have features to connect to enterprise resources and application over wired LAN, 802.11 based wirelesses LAN or high speed wireless wide area network with viewing surface ideal for recording, searching, analysing and reviewing patients' information.

The servers are used to maintain connectivity to enterprise resources for the mobile health care providers that include the doctors, nurses, laboratory technologists and other support staff. Load on the application server tier is balanced by using multiple application servers.

Firewalls are set up to filter all network traffic moving in and out of the e-health system. The hardware architecture is highly secure and utilizes multiple layers of firewall protection to create several region of trust. The robust servers provides, real-time access to point of care database originating from systems across the enterprise system within the mobile environment to facilitate timely and accurate care delivery and practice management.

#### 2 2 2 The Software Architecture

Figure 3 gives an overall logical (software) view of the architecture of the e-Health system. The architecture shows the locations of the each of the supports service in the system. It is

a 3-tiered client-server which consists of the client interface, middleware and database repository. The database is separated from the client through the middleware. The middleware concept helps to solve scalability, load balancing, transactional processing and interoperability issues by providing a means that allows different hardware and software from different manufactures to share common Patient medical records.

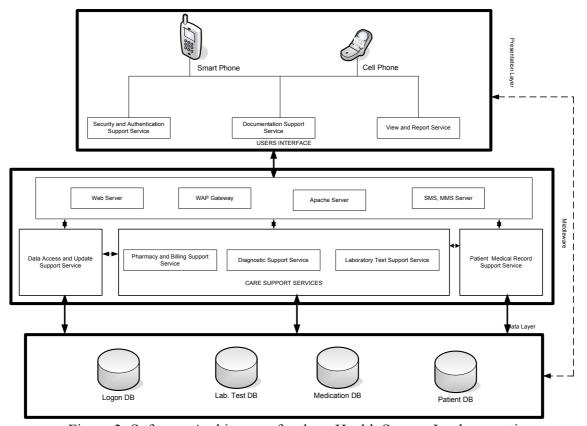


Figure 3: Software Architecture for the e-Health System Implementation

The mobile clients have a zero application code layer on it, that is, it is a thin client. The client has as its components the Security and Authentication Support Service (SASS), Documentation Support Service (DSS) and the View and Report Service (VRS). These support services do not store or process any form of data. They only provide an interface for middle layer and the data layer.

#### 3.0 IMPLEMENTATION TECHNOLOGIES

The prototype application was implemented and tested on a client-server architecture separated by a mobile network. The server application developed in Java was deployed on an Apache Server running on a Windows Operating System. Java was used for the application development to ensure it portable across various platforms. The client application accessed the server application via a windows CE micro browser on a PDA.

The design of WML decks required special considerations due to the resource constraint associated mobile devices. The application starts with WML cards that introduce the user to the support services in the application. After a deck has been downloaded a copy of it is cached in the mobile device for some time depending on the system's configuration. Java Server Pages were used in addition to WML to add dynamic functionalities to the static WML pages by providing access to an MS Access database through ODBC-JDBC Bridge.

Openwave V7 Simulator provided a cost effective platform for testing the application at the development stage as it is free on the Internet. At the implementation and testing stages the application was deployed on an O<sub>2</sub> Xda Mini S PDA running Windows Mobile 5.0 Operating System. The WAP platform facilitated the delivery of contents from the Server to the mobile device via a WAP gateway. The WAP content compiled at the gateway are sent to the device as binary content.

### 4.0 DISCUSSION

The following screen shots show the interactions of the users with the application.

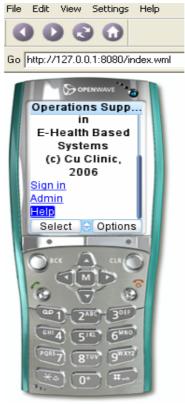


Figure 4: Welcome Page

The application is launched with a welcome message and the hyperlinks to some of the functionalities within the application. To facilitate the efficient and effective mobile health care, it is essential to provide the functionalities which directly support the user in their preferred way of performing their task. For example, the interface provided in the doctor's module allows him to capture each of the variables in a usable pattern. Figure 5 shows a medical doctor's interaction with the system.

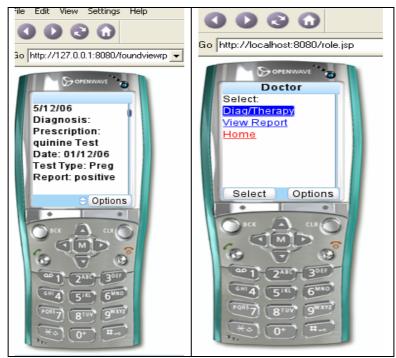


Figure 5: Doctor's Interaction

#### **CONCLUSION**

In this paper, we are able to demonstrate the implementation of an application for mobile devices such as mobile phones and PDA in enhancing the effectiveness of health care professionals in the delivery of services to patients. The various supports services were adequately depicted in robust architectures for easy implementation.

The deployment and adoption of this application will improve medical services which are presently cumbersome with so much of paper work in most health care centres in the country. Furthermore, it will help many countries to meet their national health care policies and the millennium development goal 3, goal 4, and goal 5 which bother on health care.

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