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Implementation of an efficient digital health care delivery system in Nigeria

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Abstract
Health care accessibility has been identified as one of the major indicators of development in Nigeria Health care system. The importance of the availability of adequate health care facilities in providing sustainable development can therefore not be over-emphasized. Contrary to some opinions, it has been agreed that lack of basic health care facilities have led to inefficiency in production, declining productivity, reduced life expectance and increased infant mortality rate.

This study addresses the major challenges facing the development of an access control model and produces an access control framework, targeting these challenges that will permit access control for information distribution in *Nigeria's* healthcare systems. The problems confronting Nigeria's Healthcare Systems are inability to produce a centralized NHMS record keeping system, share or exchange patients clinical data online, securely manage / coordinate patient clinical profiles dynamically and abolish manual hand-to-hand data transfer that has exposes the patients' Information to myriad of attacks.

The model is designed with the capabilities of handling homogeneous and heterogeneous systems that uses variety of schema, operating systems and database applications at any location of the healthcare system so that users are able to read but not able to update the data at another location for security reasons.

Keywords: NHMS, Healthcare Systems, Digital Health Care, Nigeria

Introduction
Healthcare industry is evolving rapidly, increasing the capability of delivering a high quality of service to the public. The rapid development of information technology (IT) has introduced many valuable directions to medical and healthcare sectors. The emergence of high-speed network communication, mobile technology and digital storage has led to a more accessible and convenient way to obtain medical facilities. It is clear that the involvement of IT in the medical sector will provide many more advantages in the development of the medical sector itself. This paper describes a technological approach to deliver health services online by using a distributed system.

To make keeping health records paperless and processing them systematically, the system manages Electronic Health Records (EHR) and provides access for them to a wide variety of users such as patients, doctors, medical officers, researchers and students. The accessibility is achieved by implementing various client technologies such as web, mobile and PC to access the system. Since the EHRs are processed by system components implemented in various environments, standardization of health records is implemented along with a standard communication protocol to communicate between system components. Hence, we have introduced a novel approach to healthcare management in IT, and it is intended to contribute as much as possible to the community who are dedicated to IT in healthcare

Review of Related Works
Health care accessibility has been identified as one of the major indicators of development in Nigeria Health care system. The importance of the availability of adequate health care facilities in providing sustainable development can therefore not be over-emphasized. Contrary to some opinions, it has been agreed that lack of basic health care facilities have led to inefficiency in production, declining productivity, reduced life expectance and increased infant mortality rate. The health care industry in Nigeria is presently still growing unlike what is obtained in developed countries in Europe and America. This reported growth (high death rate, increased mortality rate and reduce life span) is obvious in the unavailability of

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good health care facilities in Nigeria and the health care system is insufficient when available because of lack of accessibility to facility (Perry,2000) and (Olutola et al, 2009)

In addition, the persistent low quality of health services that is provided in the available public health care facilities are also inadequate which has made the private sector an alternative choice for health care consumers in Nigeria. As a result, there is urgent need for serious intervention on the part of government in the provision of health care facilities. Government involvement is very important because to determine the rate of development in a country, one of the factors to look at is the availability of health care to people. As government intervenes, their focus should be to step up the equitable distribution and accessibility of health care facilities. The argument therefore is that before government or even the private sector can intervene, there must be relevant and adequate information base that is up-to-date. This information base would serve batter if it is about hospitals' locations, their concentration and specializations. This is where the use of relevant and modern Information and communication technologies (ICTs) comes in. For instance, the growth of ICTs; more particularly the Internet, has improved the ease of retrieving relevant information (about almost anything) on all aspects of life. Interestingly, this retrieval ability can occur from computer systems across the globe, such that distance is not a barrier. Likewise, it has also further broadened the already wide margins that exist between those that search for information and those that do not. The principle behind the rapid growth of information technology is that it reduces redundancy; allows more greater and accurate access to data as well as provide greater understanding of how the same data could be used in different ways.

Therefore, this thesis presents an Information Distribution for National Healthcare Management Scheme (NHMS) that uses a web-based spatial approach, authentication and authorization method and role based access control tools to regulate individual access rights to the network resources to aid the distribution of health care facilities in Nigeria. This system is expected to assist doctors and clinicians in identifying patients' profiles and medical status. It is also expected to provide support with respect to rightly locating health care facilities at real time; especially to areas where serious attention is inevitable. With this system, patients, doctors, clinicians and stakeholders would be able to visualize the distribution of hospitals in Nigeria. Government would therefore benefit since the system would assist her in communicating effectively to the general public concerning the demand for more health care facilities

As a result of this, the purpose of this thesis is to alleviate the problems confronting Nigeria Health care system which are inability to produce a centralized NHMS record keeping systems, share of exchange patients clinical data, securely manage/coordinate patient clinical profiles dynamically and abolish manual hand-to-hand data transfer that has exposes the patients' information to myriads of attacks

Health care is a rapidly changing industry, which faces constantly changing conditions that has brought about an ever-increasing demand for healthcare services. It has estimated that in each year, NHMS records account for a cost of about $37.6 billion and $17 billion of that relates to preventable errors as suggested by Adlassnig K.P &

Information E. F (2009). In addition, with the increasing density of the human population, the issues are getting worse and at the end of the day these population increase come at a great cost to the healthcare industry and forces them to offer improved healthcare services to the patients. Emergence of Information Technology and its associated parts in the National Health Management Scheme (NHMS) sector will introduce many more benefits in the development of the NHMS sector and more in the future with advanced and powerful applications, people who conduct NHMS research's with electronic NHMS records will be more productive and unveil valuable findings easily. Through electronic medical records, clinical staff can gather patient data and automated tests conveyed for NHMS sensitivity interactions and prescriptions. The importance of having electronic medical records reflected by the project done by the National Health Service (NHS) in the United Kingdom, have accomplished one of the major projects to have a national electronic medical record. The main target of NHS project is to have 60,000,000 patients for accumulated electronic NHMS record by 2010 that came into light lime (Aldrawiesh, et al., 2011). Information technology (IT) have contributed a lot towards the healthcare sector by improving the quality of the service as well as the safety and efficiency and accuracy in information gathering. Generally, the complexity of implementation and unbearable cost are main barriers of Information Technology applications in the NHMS sector as suggested (Al-Muhtadi, J 2003). The need to be in good health and relish the good things of life has been a necessity to humanity from time immemorial. Every country appreciates the importance of good, affordable and accountable healthcare delivery. Therefore, researchers like Navarro & Lancet (2010) and Bennet, et al., (2011) had focused on standards, security policy integration and conflict reconciliation within the healthcare organizations and with a global view in the World Health Organization security and policy specifications. The concern of this study is because the researchers referenced did not consider the sensitive medical records of patient data in information distribution systems that has led to security, privacy and ethical issues that support dynamic constraint rules that is important to achieving confidentiality and integrity in policy integration process that are of paramount importance in healthcare innovation systems.

Methodology

Every country appreciates the importance of good, affordable and accountable healthcare delivery. The manual hand-to-hand transfer of data as observed, which has subjected the healthcare information distribution system to breaches of security, delivery, confidentiality and ethical risk issues; has been implemented in the database system of NHMS by the integration of encryption into the developed system, also the contextual framework in figure 3.4 explicitly encapsulate the constraints based access control model. This study has a unique contribution to already existing electronic NHMS record keeping systems, by designing and developing a framework with a proof of concept for centralization of patient clinical data for Nigeria healthcare delivery. The distributed system is a cloud server where information of the patients is stored and can be easily accessible by the NHMS personnel or doctors remotely. The system is securely designed, manage and

coordinated with records of patient's clinical profiles, dynamically identify levels of data that should be accessed, grant authorized access to clinicians / doctors, and privileges to online information transfer / delivery.

Therefore, this study is a novel constraint-based access control model that complies with National or Global distribution of healthcare standards, developed based on a framework built for data and service accessibility within the Nigeria's healthcare systems. The model is designed with the capabilities of handling homogeneous and heterogeneous systems that uses variety of schema, operating systems and database applications at any location of the healthcare system so that users are able to read but not able to update the data at another location for security reasons.

NHMS Client Applications
NHMS is designed to cater for various types of users from various locations with the help of modern communication technologies like ADSL, HSDPA, GPRS, WAP and Wi-Fi. The most important feature of NHMS is its ability to cater for users having any of these technologies.

Desktop Client
Desktop client is a software program installed on a PC, which provides users with an interactive user friendly interface to consume NHMS services. It is intended to be used by users at home or in the office. For hospitals, offices and other NHMS institutes, it is recommended that they use desktop clients.

Web Client
Web client is simply a website which allows the user to obtain NHMS services from anywhere. Users who do not use any permanent PC or use more than one PC from time to time, are recommended to use the web Client.

Mobile Client
Mobile Client is a software program that runs on small devices like mobile phones, PDAs or portable PCs and is useful for users on the move. They can use NHMS service via a mobile phone while they are traveling. One of the important components of the NHMS is the web service. All the NHMS services are implemented in the web service and all end user interfaces are connecting to the web service to request services. The main component attached to the web service is the database. Interoperability and extensibility are the key features of a healthcare system and they are enforced by the web service. SOAP is the communication standard of the web service and it allows users in different client technologies to get the service of NHMS. Security is another major concern in the development of NHMS because NHMS records are considered to contain highly sensitive information. Another aspect is the privacy of the users who are reluctant to disclose their private information. Moreover, intruders may try to access the system to get NHMS records with malicious intentions and may try to threaten someone's life.

To overcome these issues, the system has a security implementation which helps to keep the system integrity up. Only the registered users are allowed to use the system, in spite of the interface they are using, they are authenticated each time they are using the NHMS system by providing a username and password. Web services always use encryption methodologies to communicate to the client software. The use case diagram is drawn to illustrate all users and the interaction of them within the system.

In order to grant or deny access to the health information system, the user access history was retrieved using the MySQL database management system that helps update the access history after every new transaction and after the retrieval of the access history, the relevant parameters in the database were used and the user transaction will be carefully combined to generate constraints that will subsequently be used to grant or deny access to users. After the constraints are generated, the satisfaction of the constraints by a user will determine whether such user will be allowed access to the healthcare information system or will be denied access to the system.

Structured Query Language (SQL):
The patterns of misuse by users will be generated by querying the audit trail section of the database using the Structured Query Language (SQL) to extract all records in the audit trail that represent compromised transactions in which users tried to gain access to the healthcare information system illegally. These generated patterns of misuse will be used in conjunction with the constraints in the healthcare information system to easily cipher genuine requests for access by users from requests that are from users that wish to compromise the access mechanism of the healthcare information system. The developed model will determine what user activities will be granted permission by the system and what level of access a user gets.

An important feature of clinical decision making is the ongoing relationship between the physician and patient. The knowledge a physician gains in caring for the patient for a long period of time can provide greater insight into the likelihood that a given disease was present.

Role Based Access Control Tools
Methodology Design of RBAC in NHMS
In an organization with a heterogeneous IT infrastructure and requirements that span dozens or hundreds of systems and applications, using RBAC to manage sufficient roles and assign adequate role memberships becomes extremely complex without hierarchical creation of roles and privilege assignments. Within an organization, roles are created for various job functions. The permissions to perform certain operations are assigned to specific roles. Members or staff (or other system users) are assigned particular roles, and through those role assignments acquire the computer permissions to perform particular computer-system functions. Since users are not assigned permissions directly, but only acquire them through their role (or roles), management of individual user rights becomes a matter of simply assigning appropriate roles to the user's account; this simplifies common operations, such as adding a user, or changing a user's department.

Three primary rules are defined for NHMS RBAC:
i.   Role assignment: A subject can exercise permission only if the subject as selected or been assigned a role.
ii.   Role authorization: A subject's active role must be authorized for the subject. With rule 1 above, this rule ensures that users can take on the only roles for which they are authorized.

iii.   Permission authorization: A subject can exercise permission only if the permission is authorized for the subject's active role. With rules 1 and 2, this rule ensures that users can exercise only permissions for which they are authorized.

Additional constraints may be applied as well, and roles can be combined in a hierarchy where higher-level roles include permissions owned by sub-roles. With the concepts of role hierarchy and constraints, one can control RBAC to create or simulate lattice-based access control (LBAC). Thus RBAC can be considered to be a superset of LBAC.

When defining an RBAC model, the following conventions are useful:

S = Subject = A person or automated agent
R = Role = Job function or title which defines an authority level
P = Permissions = An approval of a mode of access to a resource
SE = Session = A mapping involving S, R and/or P
SA = Subject Assignment
PA = Permission Assignment
RH = Partially ordered Role Hierarchy. RH can also be written: ≥ (The notation: x ≥ y means that x inherits the permissions of y.)
A subject can have multiple roles.
A role can have multiple subjects.
A role can have many permissions

Permission can be assigned to many roles
An operation can be assigned many permissions
Permission can be assigned to many operations
A constraint places a restrictive rule on the potential inheritance of permissions from opposing roles, thus it can be used to achieve appropriate separation of duties. For example, the same person should not be allowed to both create a login account and to authorize the account creatio Thus, using set theory notation:

$$PA \subseteq PXR$$

a many to many permission to role assignment relation.

$$SA \subseteq S \times R$$

a many to many subject to role assignment relation.

$$RH \subseteq R \times R$$

A subject may have multiple simultaneous sessions with different permissions.

Methodology Procedures for 'NHMS System' Requirements

- Controlling user access to applications and the data within them
- Identify each user
- Grant them permissions to work with applications and data
- Test for that, when they use the application
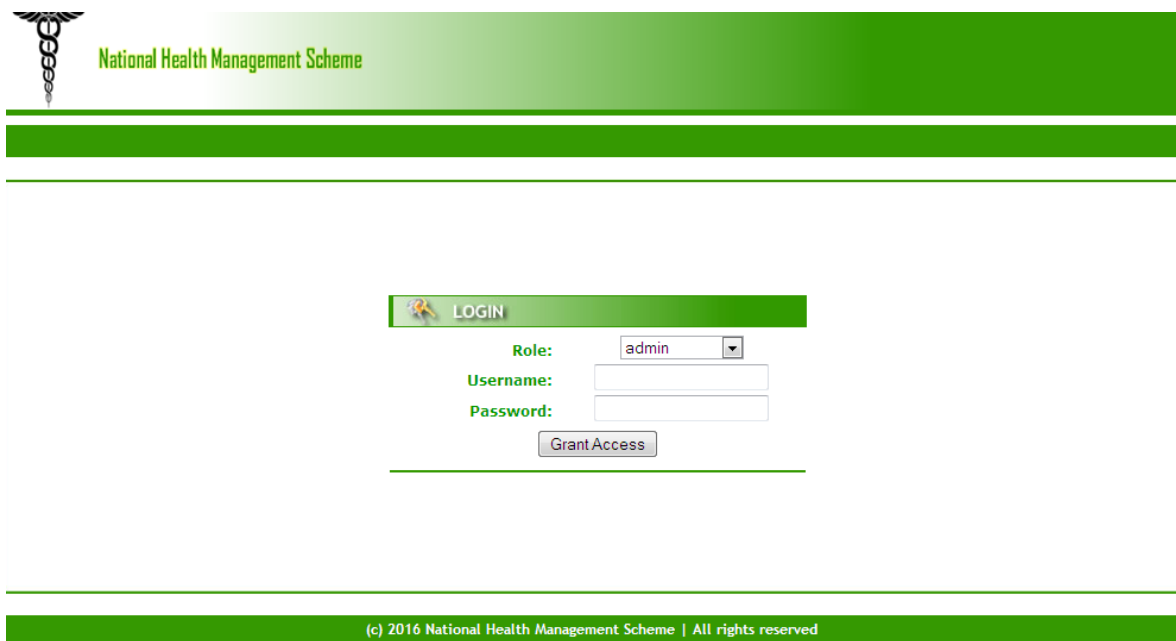
Fig 3.1: NHMS Information System (www.NHMS4sarumi.com)

With the NHMS web platform, any of the actors in the Diagnosis (Administrator, Doctor, and Patient) can register if he or she is authenticated and authorized to the administration. Then he or she can view the details of the patients and can send and receive the information about his/her patients from the front-end or web interface.

The whole communication between the doctor and the patient is secured through RBAC to manage user privileges. Network permissions are through the wamp server. You can now register a new user by accessing the /users/localhost/NHMS.php or login through the NHMS domain, *'www.NHMS4sarumi.com'* and login with the

newly created credentials as shown in fig:3.1. The login action calls the $this->Auth->login () function in the Validate.php class, and it works without any further configuration because we are following conventions been used. That is, having a User model with a username and a password column, and use a form posted to a controller with the user data. This function returns whether the login was successful or not, and in the case it succeeds, then we redirect the user to the configured redirection URL that we used when adding the Validate.php to our application.

The user function provided by the component returns any column from the currently logged in user. We used this

method to add the data into the request info that is saved. Let's secure our app to prevent some authors from editing or deleting the others' posts. Basic rules for our app are that admin users can access every URL, while normal users (the author role) can only access the permitted actions.

System Implementation
The health care sector is a large industry which is an aggregation of both government and private bodies including the general public. It implies NHMS should have the capability to cater for all these parties with the relevant requirements. Implementation of NHMS is considered to be conducted in several phases because it is not practical to implement such a large system at one time. From a technical point of view, high end equipment is required for the successful implementation of NHMS and the infrastructure first needs to be set in place to implement NHMS. Initially, the servers should be installed in a relevant location which has some sort of physical security. The servers required are a database server and Web server. For the database server MS
SQL server is used and IIS server is used as the Web server. Advanced security features are applied for these servers to protect them from access by unauthorized users with malicious intentions

Technologies Used: The whole system is developed using Microsoft .Net framework which provides powerful features to the system to develop it easily in minimum time duration. Visual Studio 2008 is the Integrated Development Environment (IDE) used to develop this entire system and MS SQL server is the database server used. Basically NHMS was developed as 5 individual components as follows:
i. Windows desktop application
ii. Web application
iii. Mobile Application
iv. Web Service
v. Database

Conclusion
The system would reflect a novel concept that all patients, doctors and NHMS researchers can benefit from its distributive tendencies which will provide a comprehensive range of NHMS services. The patients can consult their doctors with the use of NHMS system by making appointments online, diagnose patients, and read and send their NHMS records online. The paper elaborates on all those findings and knowledge gained in this research that will contribute to the community who are conducting researches at present and those that will be conducting researches in the future.
The model is designed with the capabilities of handling homogeneous and heterogeneous systems that uses variety of schema, operating systems and database applications at any location of the healthcare system so that users are able to read but not able to update the data at another location for security reasons.

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