American Journal of Engineering Research (AJER) ***2016***
American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-5, Issue-6, pp-285-292
www.ajer.org
Research Paper Open Access

A Constraint-Based Access Control Model for Information Distribution in Nigeria's Healthcare Systems

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ABSTRACT : *Sharing clinical data within the domain of Nigeria's healthcare system through an Information Technology central platform appears to be a major challenge, perhaps due to low technological development of the country. This deficiency constantly exposes the supposedly private data of patients to the wrong hands through the current hand-to-hand transfer of such data within the healthcare domain. The manual transfer, as observed is appalling; and has subjected the healthcare information distribution system to breaches of security, delivery, confidentiality and ethical risk issues. This research addresses these deficiency with 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. It provides an electronic hand-shake using an access control model that can store clinical data of all patients and share the same data among the concerned healthcare professionals in the healthcare domain. The specific objectives of this research are to develop a constraint based framework for access control in an information distribution system that will generate a pattern of misuse and also provide a central information platform for the control of access related activities. The distributed system is a cloud server where information of the patients' are stored and can be easily accessible by the NHMS personnel or doctors remotely. Achieving this objective compels the study to adopt authentication and authorization method at inter / intra organizational level for the security and delivery of patients' clinical data. The use of role based access control tools were used to regulate individual access rights to the network resources based on security policies and rules defined in the program. The developing platform is Windows OS and the web server is Apache. The system was designed to securely manage and coordinate patient's clinical profiles, dynamically identify levels of data to be accessed, grant authorized access to clinicians/doctors, and privileges to online information transfer / delivery. In order to access a resource, users must meet the regulatory conditions of the policy class which is in conformity with organizational standards as stipulated by the Federal Ministry of Health in Nigeria that regularize healthcare policies. The system was designed to be flexible and adaptive in order to allow users pass on their rights of access to other users, permission given for right of access can be withdrawn based on the stipulated restrictions that have been defined in the program. The research is a novel model that is in compliance with healthcare standards in relation to data and service user-friendliness. The designed framework facilitates flexibility to any deployed environment.*

Keywords: *Accessibility, access control, electronic hand shake, authentication, authorization, confidentiality and cloud server.*

I. INTRODUCTION

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 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)

Therefore, this thesis presents an Information Distribution for NationalHealthcare 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, cliniciansand 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.

II. REVIEW OF RELATED WORKS

Chandramouli, (2001) recognizes the emergency access requirement and proposes a logic driven role based dynamic model supporting context constraints. He introduces a concept called `domain' to group objects. The researcher uses emergency and logic driven concept as a tool to group related data but the information cannot be access remotely. This new concept of

context based approach will enable us group objects in cloud server instead of the domain as expressed by Chandramouli, (2001). Hence, the information can be secured and easily accessible from any network resources remotely.
Verhanneman, (2003) supports practice of fine-grained and dynamic policies in the healthcare domain. They focus on a reconfigurable implementation and identify a number of shortcomings of current technologies for aiding their implementation. Standard data representation formatsand ontologies are used to make the model compatible with different health care systems but in this newly developed system, a client server approach was used. The doctors, patient and clinicians are the client while the admin is the server. The two tears will be integrated together with the concept of middleware technology; hence, this enable a health policy compliances between the two tiers.
Blobel, (2004) Information technology is expected to become an essential tool in providing reliable information for supporting the delivery of health care services. Nevertheless, incorporating such technologies to support the provision of health care raises concerns over the protection of patient's information. The technological, social and legal implications regarding the access and release of medical data have to be considered carefully during the implementation of interconnected health information systems. Secure an effective data exchange along with the protection of patients confidentiality are two issues that electronic health records need to address to make them reliable and secured in a shared healthcare environments. This newly developed health care system looked into these constraints by developing a web based system for effective data exchange and encryption of the database to keep patients information secure.

Jahnke, (2005) provide a context-aware information service for healthcare systems. They introduce an ontology-based context management system that allows a user to define contexts employing terms from the NHMS field. Their context ontology is composed of domain independent (e.g. time and location) and domain dependent (following Health Level 7 Reference Information Model) parts. Agility is a distinctive aspect of the health care profession. Clinicians operate in a fast changing environment with needs to access different pieces of information in different situations. On the surface it would appear that clinicians would benefit tremendously from the use of modern mobile technology. In reality, however, the health care sector has been hesitant to embrace electronic clinical information systems in general and mobile technologies in particular. In this developed system, we introduce an ontology-based Context Management System that allows the user to define contexts using terms from the medical fieldto improve the adoption of healthcareinformation..
Toninelli, (2006) presents a secure collaboration mechanism. They used Context-aware information service and semantic modeling technologies to provide a semantic Context Aware Access Control (CAAC) framework. Semantic technologies are used for context/policy specification to allow high-level description and reasoning as employed in this study.
Hung, (2007) provides an extended RBAC model that focuses on privacy. He investigates the privacy requirements identified by the Health Insurance Portability and Accountability Act (HIPAA). He determines the major privacy concerns as the:

i. Acquisition, storage, and processing of data,
ii Consent for processing and disclosure of data,
iii Rights of subjects to access and modify their data sets.

Regarding confidentiality, integrity and availability requirements of patient data, a major concern is to avoid disclosure of these data to unqualified users. Access by unauthorized users to patient data may result in misdiagnosis, delays in treatment, or mistreatment. Other consequences may include financial problems such as denial of insurance coverage and loss of job opportunities (Hung, 2007).
Hung, (2007) discusses issues in developing a privacy access control model for supporting mobile and ad hoc healthcare applications. They developed their model, considering privacy rules for Protected Health Informatics (i.e. limitation on collection, disclosure, use, and retention) and mobility. They used a policy specification language such as Ponder and Rei to implement their model. However, their method did not bridge the gaps that exist within heterogeneous and homogeneous systems that is addressed / embraced by this study which the developed system covers

Hafner, (2008) identify a number of use cases in the healthcare domain such as dynamic access control, delegation, break glass, 4-eyes-principle, and usage control. They used specialized SELECT-Framework for model driven security for the healthcare domain based on UCON (a security policy model for usage control). They use unified modeling language (UML) and object constraint language (OCL) to express constraints and relations.

III. SYSTEM DESIGN

The constraint based access control system model for information distribution in Nigeria's healthcare systems as designed, NHMS needs to be implemented to satisfy all the requirements mentioned in the above section as well as future needs as demanded. One of the major design principles based for the system is the extendibility. NHMS is expected to cater for all present market requirements while having the flexibility to face changing requirements as it is being used because the healthcare sector is a rapidly evolving industry which introduces new things to the world day by day. Initially the main inputs and outputs are analyzed because manipulating inputs and producing the required output is the fundamental of any system. For NHMS, there are a widerange of inputs both identified as well as unidentified. As mentioned above, the system should have the ability to manipulate unidentified inputs as well as in the future since extendibility is enforced. Identified inputs are shown in Table 3.1

Table 3.1: Defining the Inputs Methods

Input	Type
Patient basic information	Text
Patient Records	Documents
Audio	Audio files / binary streams
Video	Video file/ binary streams
Imaging Inputs	Image files
Medications	Text
News	Text

3.1Database Design

Database can be identified as the heart of the system since it is the main asset for the system and should keep all data related to NHMS. The database should be able to store all the data formats discussed and it is designed for efficient data storing and retrieving functionality to cater for large number of users. Concurrent processing of data is required as the NHMS information can be manipulated from anywhere simultaneously. Since the system is from remote locations via the web service, stored procedures are used to cater for the large traffic of usage expected.

3.2 Class Diagram

A **class diagram** in the Unified Modeling Language (UML) is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, and the relationships between the classes as shown in fig 3.2. The class diagram is the main building block in object oriented modeling. The classes in a class diagram represent both the main objects and or interactions in the application and the objects to be programmed. The main classes that are identified in our system NHMS design are as follows: Assessment, Assessment Result, Categories, Patient, NHMS field, Personal Detail, and Users.

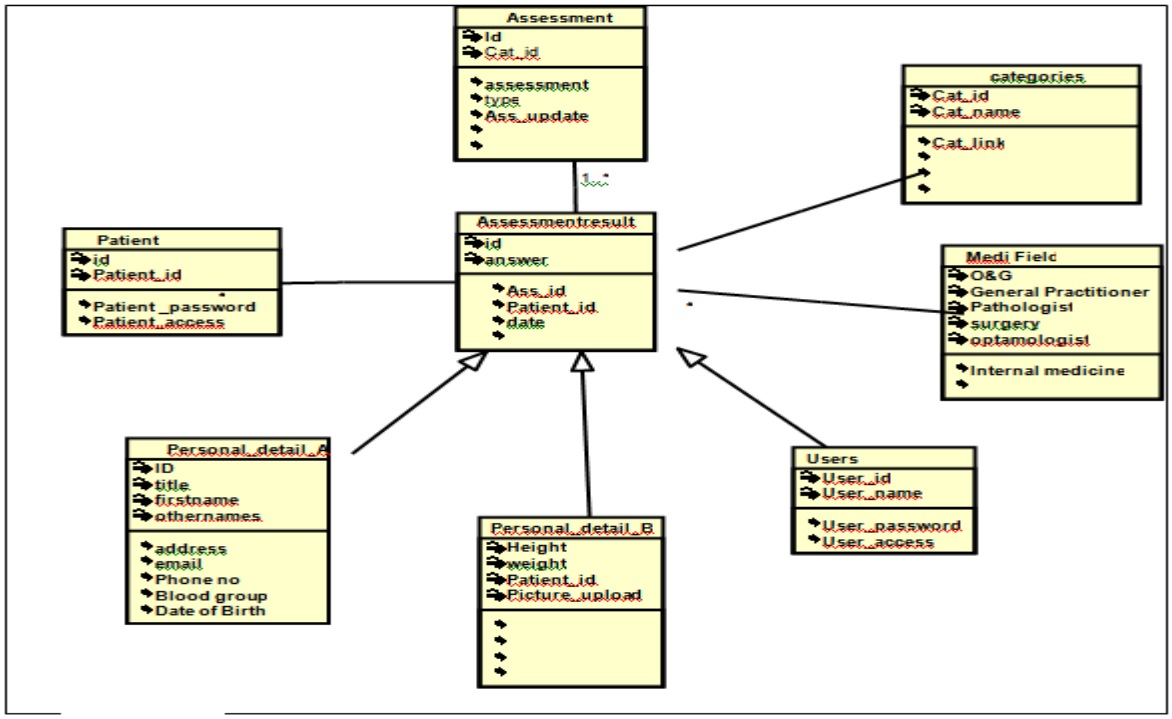


Fig 3.2: Entity Relationship Diagram (Source: Adaptive)

IV. RESULT AND IMPLEMENTATION

4.1 Role Algorithm in PHP

```
<?php
classRole
{
     protected$permissions;

     protectedfunction__construct() {
          $this->permissions = array();
     }
     // return a role object with associated
permissions
     publicstaticfunctiongetRolePerms($role_id) {
          $role= newRole();
          $sql= "SELECT t2.perm_desc FROM role_perm
ast1
                    JOIN permissions ast2 ON t1.perm_id
= t2.perm_id
                    WHERE t1.role_id = :role_id";
          $sth= $GLOBALS["DB"]->prepare($sql);
          $sth->execute(array(":role_id"=>
```

Fig: 4.1 Role Algorithm PhP (Source: Adaptive)

```
<?php
classPrivilegedUserextendsUser
{
    private$roles;

    publicfunction__construct() {
        parent::__construct();
    }

    // override User method
    publicstaticfunctiongetByUsername($username) {
        $sql= "SELECT * FROM users WHERE username = :username";
        $sth= $GLOBALS["DB"]->prepare($sql);
        $sth->execute(array(":username"=> $username));
        $result= $sth->fetchAll();

        if(!empty($result)) {
            $privUser= newPrivilegedUser();
            $privUser->user_id = $result[0]["user_id"];
            $privUser->username = $username;
            $privUser->password = $result[0]["password"];
            $privUser->email_addr = $result[0]["email_addr"];
            $privUser->initRoles();
            return$privUser;
        } else{
            returnfalse;
        }
```

By creating a new class in the 'NHMS' Database that extends your existing user class, you can reuse your existing code logic for managing users and then add some additional methods on top of those which are geared specifically towards working with privileges as shown in fig 4.3

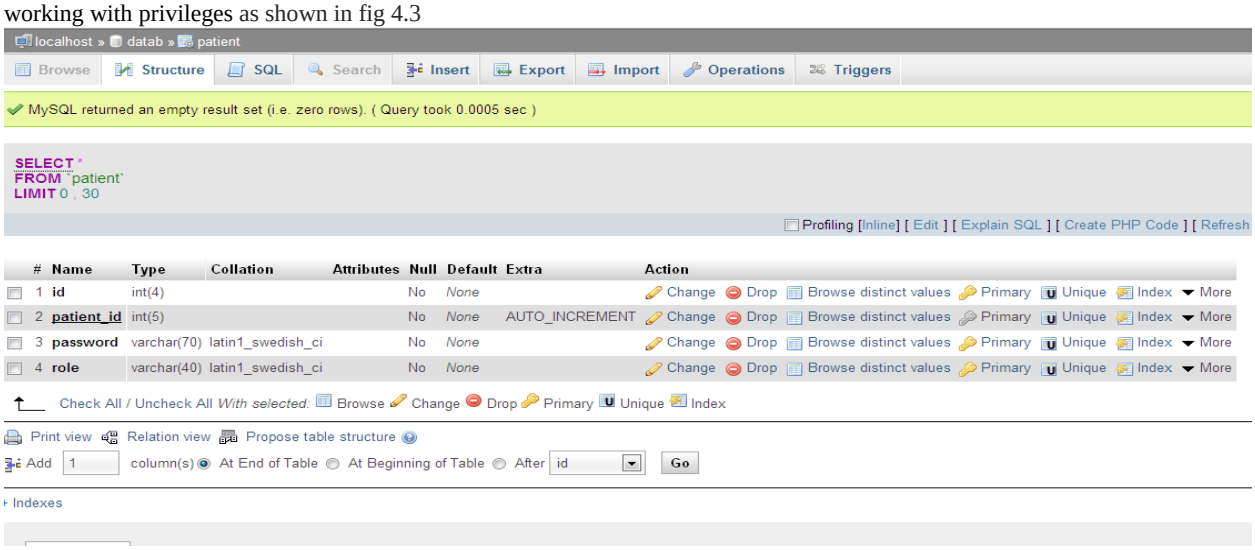
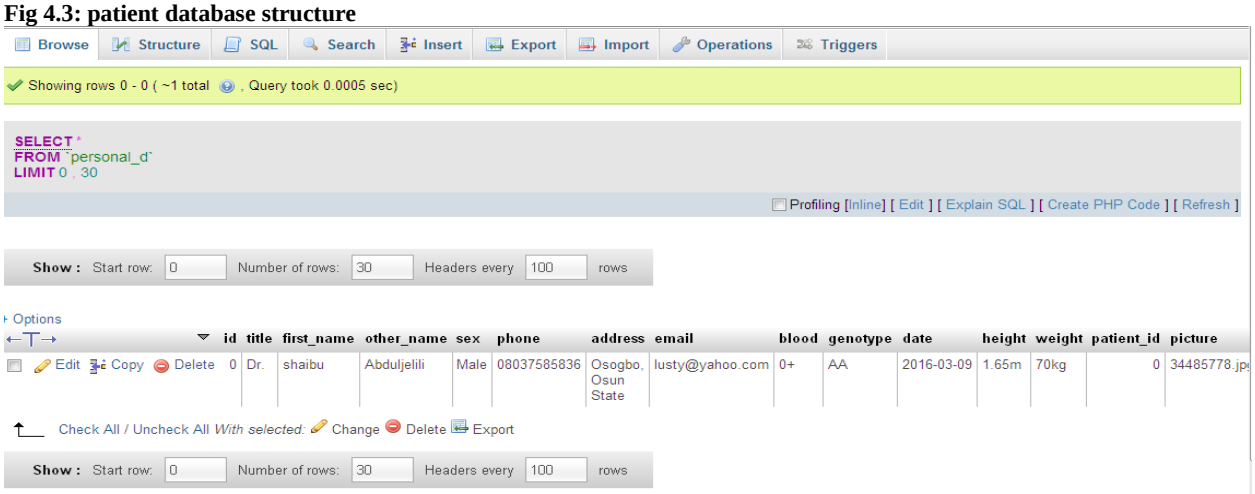


Fig 4.3: patient database structure



Login Details

Step 1-Type http://localhost/hospital/staff_info.php
Step 2-Login as Admin (Username: aliyat, Password: mummy1)
Step 3-Click on Access to login doctors' profile
Step 4-Fill in information as required
Step 5-Click Insert to save information
Seedetails in figures 4.8 to 4.15:

Fig 4.8: Administrator Login

Fig4.8 Admin profile

Fig 4.8 above is the login screen for doctors, patient and admin. Login username and password will be created by the admin

so that they have access to edit their profiles and gained access rights toindividual dashboard(interface).

Fig 4.8.1: Output

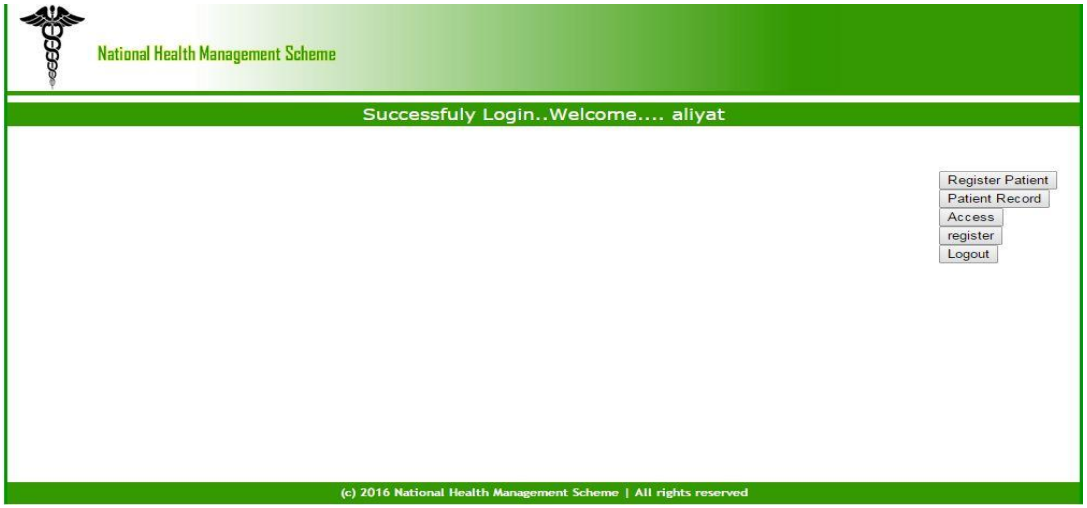


Fig 4.8.1 display the welcome page for the administrator. This interface allow the administrator to create an access role for the patient and the doctors. The interface also help the admin to register patients and retrieval of patients, nurses and doctors records.

Fig 4.9: Doctors details

Figure 4.9 above helps to create the doctors profile and inserting it into the database for remote access. It includes the doctor registration number, name, username, password, email and the doctors phone number

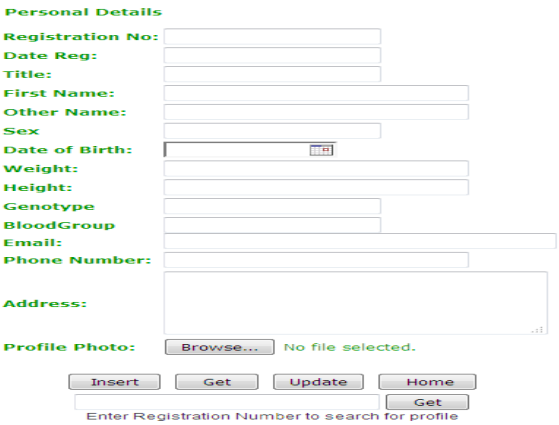


Fig 4.10 Add doctor menu;

The form was used to add the doctor's full identity like genotype, weight, date of birth, blood group, address, profile photo. It will automatically be storedand archived so that it will be access remotely by other resident doctors when required.

DOCTORS PROFILE

Fig 4.11: First Doctor

The form above display the profile of the first doctor. The doctor's profile can be retrieved from the archived after querying the database. This display the summary of the doctor biography and profile for other doctors to view/access in case of emergency

CONCLUSION

Constraint based access control model for information distribution in Nigeria's healthcare system is a novel innovation that will ensure security, confidentiality and ethical risk issues in the healthcare domain as well as improve the quality, efficiency and effectiveness of healthcare delivery by allowing healthcare professionals to share information about their patients across the globe. This model will hugely cut the cost of travelling for NHMS consultations, which runs into billions of dollars / Naira especially from developing world in the face of poverty and dwindling economies of these nations.With the rapid development of technology in the healthcare sector, collaboration and integration of healthcare systemsare required to help management in administrative activities; provide information in healthcare services and also, reveals that the majority of patients are willing to use newtechnologies to deal with healthcare services.

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