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## Design and Implementation of Secured Personal Data Servers of Patient Medical Records in Nigeria: A Case Study of Island Maternity Lagos

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### Abstract:

*This research is based on the design and implementation of Secured Personal Data Server of Patient Medical Records in Nigeria. It is built upon the emergence of portable data server (PDS) with well secured devices that combines the security of smart cards with embedded software devices and storage capacity of NAND Flash Chips which is a novel model that is in compliance with healthcare standards in relation to data and service user-friendliness. 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in order to allow users pass on their rights of access to other users, permission given for right of access can be withdrawn based on the stipulated restrictions that have been defined in the program.*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 problem of inadequate healthcare facilities in producing sustainable development in Nigeria, breaches of security, delivery, confidentiality, ethical risk issues and privacy risks incurred by centralization due to privacy violations that arise from negligence, abusive use, internal and external attacks. The PDS with current server-based approach, cryptography-based and server-side secured hardware is capable of dismissing the semajor problems. The researchs peficific objectives are to provide the main functionalities of a database engine that will be interoperable with existing data sources and allow secured data sharing protocols by establishing control of how users personal data are shared with others and creating a way of harmonising patient's data from other hospitals in the country as well as beyond and also allow interoperability of clinical systems. This study adopts authentication and authorization method at inter / intra organizational levels for the security and delivery of patients' clinical data. A stratified database with indexing and hashing techniques that can change strata without incurring a dramatic number of alterations where precomputed, relational context and Queries are executed in a pure pipeline fashion. The system will cut down substantially the cost of travelling abroad for medical consultations, which runs into billions of U.S. dollars or Naira (the Nigerian currency), especially given the poverty and related economic difficulties that Nigeria and other developing world countries face. The PDS devices are expected to assist doctors and clinicians in reviewing patients' medical history and status prior to a consult or in reaching a diagnosis. It is also expected to provide support regarding timely referrals to and location of healthcare facilities for parallel care as needed.*

**Keywords:** Accessibility, authentication, authorization, confidentiality, electronic records, interoperability

### 1. Introduction

Healthcare accessibility has been identified as one of the major cherished indicators of a country, whether developing or developed. Nigeria ranks among developing nations and healthcare accessibility is a strong marker for development in Nigeria, particularly the country's healthcare system. Therefore, the importance of the availability of adequate healthcare facilities in providing sustainable development cannot be over-emphasized. Every country appreciates the importance of good, affordable and accountable healthcare delivery and researchers like Navarro& Bennet, et al., (2011), Kazemzadeh and K, Sartipi (2010). In addition, the persistent low-quality of health services in Nigeria's public healthcare facilities is also inadequate, making the private sector an alternative choice for healthcare consumers in Nigeria. As a result, there is urgent need for serious intervention by the Nigerian government in providing healthcare facilities and services. That urgent need makes governmental involvement critical; one of the factors to look for in assessing the rate of development in a country is the availability and accessibility of healthcare to people Sarumi, J.A, et. al., (2013). The introduction of patient medical records on secured personal data servers will create a way of harmonising patient's data from other hospitals in the country as well as beyond and also allow interoperability of clinical systems Verhanneman, T (2003).

The breaches of security, delivery, confidentiality and ethical risk issues have been an age-long problem with an increased amount of personal data that is automatically gathered and stored on hospitals database and whose benefits must be weighed against privacy risks incurred by centralization. Asabe, S. A., et.al., (2013), Anderson, R. J (1996) and Aldrawiesh and F. Sieweet et. al., (2011). This research will strongly address these deficiencies by contributing to already existing electronic patient medical record keeping systems. Therefore, data servers must be able to interoperate with

external servers and must provide traditional database services like durability, availability, query facilities, and transactions.

This research adopts a personal data servers approach, identifies the main technical challenges associated with it and produces a solution based on design and implementation of secured personal data servers of patient's medical records that positively affect and increase the efficiency of treatments received by patients, positive data control, full knowledge of patients diagnostic history and eventually, adequately secured personal data servers of medical records in Nigeria. In view of the above facts, if the Ministry of Health decides to compute statistics or to build an anonymized dataset from a cohort of patients, the targeted PDSs will perform the processing and deliver the final result while preventing any leakage of sensitive data or identifying information.

### 1.1. Statement of the Problem

Problem of inadequate healthcare facilities in producing sustainable development in Nigeria. Healthcare accessibility is a strong marker for development in Nigeria, particularly the country's healthcare system. As a result, there is urgent need for serious intervention by the Nigerian government in providing healthcare facilities and services.

The breaches of security, delivery, confidentiality and ethical risk issues have been an age-long problem with an increased amount of personal data that is automatically gathered and stored on hospitals database and whose benefits must be weighed against privacy risks incurred by centralization. Therefore, data servers must be able to interoperate with external servers and must provide traditional database services like durability, availability, query facilities, and transactions processing.

The level of trust which can be put in the Personal Data Servers Security (PDSS) cannot be found in the Traditional Servers. Supporting Servers are assumed to correctly provide services that are expected from them (typically serve, store, retrieve, and delete data requests) but they may try to breach confidentiality of any data that is stored locally which constitutes a problem solvable by this research work.

### 1.2. Objective of the Study

The aim of the research is to design and implement a software that will "Secure Personal Data Servers of Patient Medical Records in Nigeria".

The specific objectives of this research are: -

- To provide the main functionalities of a database engine (data description and structuring, access control, query facilities and transactions) to help in developing user-centric application. Embedding the database engine in the secure portable tokens to ensure that only authorized data are delivered to the querier's terminal.
- To be interoperable with existing data sources, allow the acquisition and rendering of personal data, and to allow secure data sharing protocols among them.
- To re-establish the control of the user on how her personal data is shared with others (what data? With whom? For how long? and for which purpose?). In other words, pds must give the ability to enforce privacy principles (e.g. Consent, limited collection, limited retention, audit for all data it stores and for all data it accesses from other pds).
- To inherit the portability and tamper-resistance of the device embedding it, thereby providing disconnected facilities and an enforcement of security rules stronger, yet more flexible, than those of a traditional server.

## 2. Literature Review

Technology in our time has continued to make huge difference in enhancing and promoting government and business operations. The pace of change will continue to grow and the effect will be amazing because Information Technology is driving the change. However, requisite knowledge and skills in the application of IT are required since Nigeria needs continuous and effective adoption of emerging technologies to enhance all areas of development. Consequently, there is the need for Nigeria to benefit from this trend and transformed itself through technology. Bass, D (2010) and Bennet, et. al., (2011).

In the Nigeria healthcare industry, technology has been assessed to be slow in playing vital role in order to enhance medical information globally (Frenk, J (2010) for the improvement of personal health and diagnosis in the interest of the individual and the country at large.

### 2.1. Review of Existing Related Works

According to Ende (2008), health issues have generated heightened concern globally due to a preponderance of increasingly life-threatening ailments, some of which have defied all curative measures. Osain (2011) posits that the nature of health problems related to health delivery system in Nigeria has made it expedient that the system be studied, using various approaches. Access to health services in developing countries is very uneven. Despite Nigeria's strategic position in the continent, the country is greatly underserved in the healthcare sphere.

Okuboyejo (2013) identified wide regional disparities in the health sector in terms of health status, mode of health service delivery, resources availability and workforce which is of concern to this study. Earlier, in a 2006 report, assessed that health facilities are inadequate in Nigeria, especially in rural areas. Beside the inadequacy of facilities, the country is also facing deficiency of certified and/or licensed allied health workers. The few that are available are unevenly distributed with most of them concentrated in urban areas. Even in urban areas where health facilities and personnel are

concentrated, access to a minimal level of healthcare for large segments of the urban population continues to be a pressing public health policy concern (Fosu, 1989). Consequently, rural communities, where many Nigerians reside, find it difficult to have access to quality healthcare on top of the existing inadequate access to basic amenities, such as education, good roads, potable water, and electricity. Nigerian masses travel long distances to get these resources, where they exist at all.

The lack of standard, workable, infrastructure has inhibited the timely delivery of quality healthcare service (Okuboyejo, 2013). The fact is that optimal performance of the Nigerian health delivery system is constrained by poor institutional arrangements, defective functional relationships, and management mechanisms. The rapid population growth in the country has overstretched extant social resources. This has made healthcare planning unrealistic and resulted in the inadequacy of facilities for Nigerian citizens who need quality healthcare services (Odusote, 2010).

Lule, Ramana, Epp, Huntington and Rosen (2005) have observed that dysfunctional health systems in developing countries are failing to save lives and meet the health needs of the people, and these inadequate systems are slowing progress in economic development. Lule, et. al. (2005) identified shortage in human resources, especially in remote areas, poorly trained providers, poor quality of care, lack of drugs and equipment, and ineffective referral systems as factors impeding the provision of basic health services in Nigeria.

Agbala (2013), Odusote (2010), and Osain (2011) converged on the view that improvements in healthcare delivery in many parts of the developed world have continued to point to the fact that communication technology is central. The recent development of information and communication technology (ICT) now brings about rapid changes to people's everyday lives. Daily lifestyle is now ICT-driven and over the next few years, it seems daily existence and experiences will be further defined and refined by the role of ICTs in the society. Health is closely related to people's everyday activities, such as working, eating, commuting, shopping, leisure-time activities, and sleeping.

### 3. Methodology

The researcher's goal is to allow the development of a powerful, user-centric applications and to serve data requests from existing server-based applications, managing personal data, requiring a well-organized, structured, and consistent query representation of these documents. This study adopts authentication and authorization method at inter / intra organizational level for the security and delivery of patients' clinical data. (Lees, C. E, Chronaki, E. N, et, al., (2014)

This study adopts a stratified database with indexing and hashing techniques that can change strata without incurring a dramatic number of alterations, organizes the index sequentially and speeds-up lookups. Indexed Model, Relational context, and Queries where all key joins are precomputed can be executed in a pure pipeline fashion without consuming RAM or producing intermediate results.

This research is expected to assist doctors and clinicians in reviewing patients' medical history and status prior to a consult or in reaching a diagnosis. It is also expected to provide support regarding timely referrals to and location of healthcare facilities for parallel care as needed. Microsoft Operating System, Database Management System, and MySQL were tools used during the development for achieving the desired objectives.

#### 3.1. Results (Expected Outputs / Results)

This research expected output will be to: -

- Enable on-demand access to computing and large storage facilities which are not provided in the present electronic healthcare environments
- Supports big data sets for electronic health records (EHR), radiology images and genomic data offloading, a burdensome task, from hospital IT departments.
- Facilitates the sharing of EHRs among authorized physicians and hospitals in various geographic areas, providing more timely access to life-saving information and reducing the need for duplicate testing/diagnosis, and
- Improves the ability to analyse and track information (with the proper information governance) so that data on treatments, costs, performance, and effectiveness studies can be analysed and acted upon promptly.

The PDS software will inherit the tamper resistance of the Secure Portable Tokens making hardware and side-channel attacks highly difficult, Aldrawiesh & Sieve, (2011). Provide the user with intuitive tools and underlying mechanisms helping him or her to control how his or her personal data is shared.

The basic software (operating system, database engine and PDS generic tools), called the PDS core, will be certified according to the Common Criteria, making software attacks also highly difficult by revisiting the main database techniques to make the PDS core compliant with the secure portable tokens (SPT) hardware constraints.

The PDS core will be made auto-administered in contrast to its traditional multi-user server counterpart, hence, DBA attacks are also precluded. Therefore, re-establish the traditional functions of a central server (durability, availability, global queries) in a secure way using Honest but Curious Supporting Servers. The PDS holder cannot directly access the data stored locally but he/she can only get the data according to privileges after authentication (e.g. by a pin code)

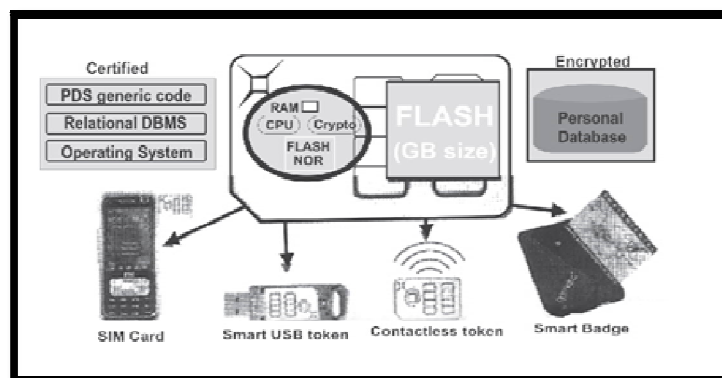


Figure 1: Secure Portable Token and Embedded PDS (Adaptive)

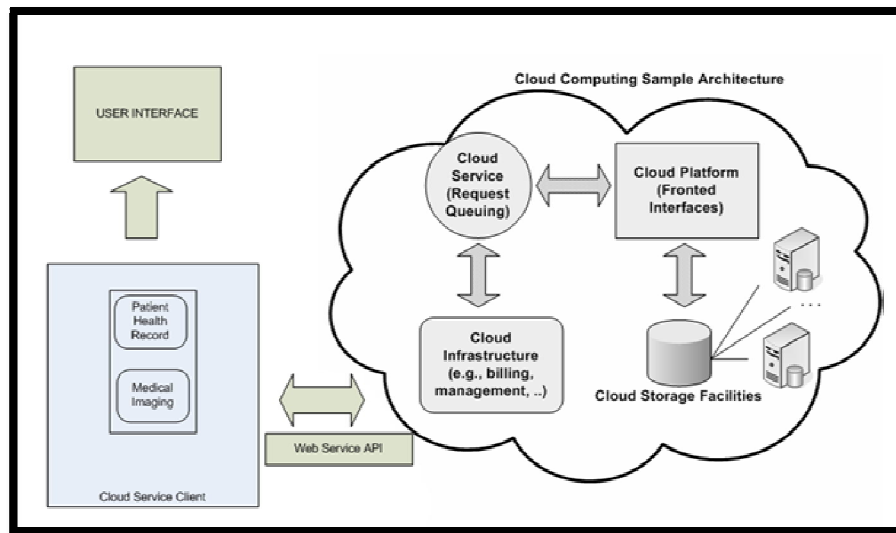


Figure 2: Architectural Frameworks for Distributive Healthcare System  
Source: Fernaz, N., Nazmun, N., 2012

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 developed program.

#### 4. Contribution to Knowledge

The main purpose of this research is to design and implement a system that will enhance / improve the Nigeria healthcare sector with the use of new technologies. The limitation of both centralized and distributed databases was taken into consideration at the design and implementation phases. Security measures are taken at several levels to protect the database from unauthorized access, malicious destruction or alteration and accidental introduction based on secured personal data servers of patient medical records in Nigeria. This study has a unique contribution to already existing electronic record keeping systems, by designing and developing a framework with a proof of concept for centralization and distribution of patient clinical data for Nigeria healthcare delivery built upon the emergence of portable data server (PDS) that combines the security of smart cards with embedded software devices and storage capability of NAND flash chips, was a novel contribution to the developed system.

The system would reflect a novel concept that all patients, clinicians, doctors and researchers can benefit from its distributive tendencies which will provide a comprehensive range of health services. The patients can consult their doctors with easy and make appointments online, patient diagnosis can be read online by virtue of user privileged permissions. The paper elaborate on all those findings and knowledge gained in this research that will contribute to the community present researches and those that will be conducting research in the future. The system 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 healthcare system so that users are able to read but not able to update the data at another location for security reasons.

#### 4.1. Recommendation

The study recommends that:

- A fully distributed database system is recommended where execution of global transactions requires communication among the sites which include sharing of data, reliability and availability, and speedup of query processing – the ability to share and access data in a reliable and efficient manner where a global database administrator is responsible for the entire system but part of these responsibilities is delegated to the local database administrator for each site with local autonomy that is often a major advantage of distributed database.
- A unified Regulatory Agency for Healthcare Informatics should be established for each state where patients' clinical information for Nigerian healthcare systems are collated and centralized for easy accessibility that will eventually regulate standards for healthcare industry in Nigeria.
- The development of a central database in a country that can be globally accessed when required by an authorized clinician / doctor from any part of the world will be an acceptable recommendation for global accessibility.
- An electronic clinician health record solution such as the Secured Personal Server (PDS) that will enable physical and other healthcare providers to securely access healthcare information collated from any number of trusted sources relating to an individual patient in a structured and easily accessible way.
- A healthcare informatics platform will allow for homogeneous and heterogeneous system activities that will allow for healthcare data to be stored and accessed via electronic patient health record solution.
- Development of Neuro-Fuzzy system that will be able to make intelligent decision.

#### 5. Conclusion

This research adopts a personal data servers approach, identifies the main technical challenges associated with it and produces a solution based on design and implementation of secured personal data servers of patient's medical records that positively affect and increase the efficiency of treatments received by patients, positive data control, full knowledge of patients diagnostic history and eventually, adequately secured personal data servers of medical records in Nigeria. The research is driven by the ability to compare policy laws in relation to healthcare, existing laws supporting the research in the areas of recommendations and laws amended to make our ideas feasible.

In view of the above facts, if the Ministry of Health decides to compute statistics or to build an anonymized dataset from a cohort of patients, the targeted PDSs will perform the processing and deliver the final result while preventing any leakage of sensitive data or identifying information.

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