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Architectural Framework for An Integrated E-Demographic System Based on Browser-Server Structure: The Case of Nigeria

Zia-Ul-Rahman Muhammad Abubakar

Department of Mathematical Sciences, Faculty of Science, Bauchi State University Gadau, Nigeria
Email: usmanwaziri@basug.edu.ng

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Abstract

The advent of digital and information technologies has revolutionized demographic data collection, storage, and analysis processes, enabling more efficient and accurate information management systems. Globally, demographic data plays a crucial role in policy formulation, resource allocation, and health/socio-economic planning for national development. However, in Nigeria, the lack of synergies among the relevance agencies and the existing manual system of demographic data collection and processing presents numerous challenges, including inefficiencies, inaccuracies, security vulnerabilities and delays. This research paper proposes architectural framework for an integrated e-demographic system (IEDS) based on browser-server (B/S) structure to improve data accessibility, availability, security, and scalability. The system is designed to streamline demographic data collection, management, and analysis by utilizing a centralized server accessible via standard web browsers. This architecture doesn't require any specialized software, is a user-friendly interface that allowing users to access the system from any device at any time with just an internet connectivity. The browser-server model ensures real-time data synchronization and facilitating up-to-date demographic analysis.

Keyword:
Architecture, e-demographic, browser-server, population, IEDS

Correspondence:
Author: Zia-Ul-Rahman Muhammad Abubakar
Email: usmanwaziri@basug.edu.ng

I. Introduction

Demographic data is vital for understanding population dynamics and making informed decisions in various sectors, including healthcare, education, and economic development. In Nigeria, the collection and processing of demographic data have traditionally been conducted through manual means, resulting in significant inefficiencies and inaccuracies. The need for a more efficient system has become increasingly apparent, especially in the digital age, where technology can significantly enhance data collection, storage, and analysis. Another trending issue facing the country is lack of synergies among the national agencies such as National Population Commission (NPC), National Identity Management Commission (NIMC), Independent National Electoral Commission (INEC), Minister of Budget and Economic Planning, Nigerian Immigration Services, and National bureau of statistics (NBS) to mention but few, presents numerous challenges, including inefficiencies, inaccuracies and security vulnerabilities [1, 2, 3, 4, 5, 6].

An e-demographic system refers digital platforms designed to accept, manipulate and analyze demographic data using electronic or digital means. The e-demographic information system would pertain to demographic data collected, stored, and managed electronically within Nigeria. This system would likely use a browser-server model, meaning that the data can be accessed and managed via web browsers interacting with servers where the data is stored and processed

An e-demographic system architecture based on a browser-server model involves a structured setup that allows authorized users to interact with and access demographic

data using web technologies.

The browser-server model, also known as the client-server model, is a foundational concept in web architecture that describes how the system's client (browser) and server components interact to deliver the e-demographic services.

The key components and purposes of such a proposed system include the collection of demographic information through electronic means such as online surveys, government databases, or mobile apps. The collected data is then securely stored on central servers, facilitating data processing by analyzing and organizing the information to extract useful insights. The system excels in providing data accessibility and security, allowing authorized users to access and manage the data through a web interface while ensuring the protection of sensitive demographic information from unauthorized access.

A. Statement of the Problem

The existing manual system for collecting and processing demographic data in Nigeria is fraught with challenges. These include time-consuming processes, human errors, data inconsistencies, and limited accessibility to real-time information. Such issues hinder the effective use of demographic data for policy-making and planning. There is a pressing need for a modern, integrated system that can streamline these processes and provide accurate, timely, and accessible data.

B. Significance of Study

The study aims to address the limitations of the current manual system by proposing a digital solution that use a browser-server structure. The significance of this study lies in its potential to revolutionize how demographic data is collected, processed, and utilized in Nigeria. By providing a more efficient and reliable system, this research can contribute to better decision-making, resource allocation, and overall socio-economic development.

C. Aim and Objectives of the Study

The aim of this study is to develop an integrated e-demographic system architecture that improves the quality and accessibility of demographic data in Nigeria. The objectives of this study include:

i. To design a system architecture based on a browser-server model and develop a database architecture that supports efficient data storage and retrieval in order to synergize the national agencies with unified database.

ii. To implement an integrated e-demographic system architecture.

II. Related Literature Review

Demographic data in Nigeria are produced through censuses, surveys and administrative records. National Population Commission (NPC) has the statutory responsibility for the production of demographic and vital statistics in Nigeria and is therefore, the main source of data. However, according to the chairman NPC in 2013, has admitted that it does not have accurate figures on Nigeria's population because the various estimates that have been presented by the commission in the past have been mired in controversy [6]. The collection and management of demographic data have evolved from manual methods to sophisticated electronic systems. According to [7, 8, 9], traditional methods of demographic data collection, such as paper surveys and manual entries, are prone to errors, delays, and data loss. The transition to digital systems has addressed many of these issues, offering automated data collection, real-time data entry, and improved data integrity.

Reference [7] studied highlights the challenges in the accuracy and reliability of demographic data in Nigeria, such as age misreporting and preference for certain digits. He emphasizes the need for improved data collection methods, including the adoption of electronic systems, to enhance data quality and support effective policy-making. [8], considered an online integrated information system for demography in Nigeria based on browser-server structure, this paper explores the design and implementation of a web-based system for demographic data management. The authors discuss the benefits of a browser-server architecture, which include real-time data updates, easy access for users, and enhanced data security. The system's architecture is designed to address the fragmentation of demographic data and to provide a unified platform for data analysis. While [9], concentrated more on automating the import of health and demographic surveillance system data, this study focuses on automating the collection and processing of demographic and health data using electronic systems. The authors argue that the shift from paper-based methods to electronic systems can significantly reduce data entry errors and improve the efficiency of data management processes.

According to [10], studied a trustworthy architectural framework for the administration of e-voting, (the case of Ghana). The authors seek to optimize the voting processes and governance of the Electoral Commission of Ghana by proposing a trustable e-voting theoretical framework which dwells on biometric data of various candidates as the basis for encryption of ballot, dedicated channel for transmission of counted ballots and, connecting and disconnecting the database server before and after voting.

In contrast of [11, 12, 13, 14, 15, 16] in their research work focuses design and implementation on digital census with difference approaches. For example, [11] implement a secure online internet-based application user friendly to everyone who lives in Canada can complete their 2006 census questionnaire online, [12] used PDA: personal digital assistant for Design and Implementation of Census Data Collection System, while [15] used browser server structure to upgrading and integrating the efficiency of census data collection management system in Nigeria.

Reference [17], discussed on the design and evaluation of the integrated national database in the Nigeria with a aiming at exploring the end user perception of the countries decades of citizens' data collection and the technical view of the

developed system. Reference [18] study designed a college English online learning system, which uses Browser/Server (B/S) as the architecture, JSP technology as the programing language, and MySQL database technology as the data storage and management database. Reference [19] consider designed and implementation of browser/server environment-based hospital information search system (BS-HISS), he presents an algorithm between browser, server and construct the databases for accessibility and data accuracy.

Reference [20] developed a web-based population monitoring information system (web-based-PMIS) that provides inputs and outputs information support to admin/users in order to update their demographic information. In his paper, the object oriented analysis and design methodology (OOADM) was adopted. The high level model of the proposed system was also designed and displayed in a format easily understandable to the user. Ref. [21] UID designed based online census system for electronic governance applications, such as online data capturing, integrating census system with Aadhar database, census data monitoring and utilization of online census database for various e-Governance application. Unlike [22] were they used unique identification (UID) number based online census system under e-Governance initiatives. The designed includes the design of online data collection forms with relevant user interface, user authentication based on one time password and integration of census data with UID database for fetching existing citizen information.

Therefore, the present research work proposes a web-based platform of an architectural framework for integrated e-demographic system based on browser server structure aims to improve data accuracy, reduce administrative burdens and time consuming, and support informed policy-making for inclusive governance and national development.

A. Framework of Existing Manual System

In Nigeria, the current demographic data collection and management system is predominantly manual, characterized by paper-based processes, physical forms, and decentralized data storage. The manual system is employed across various governmental agencies responsible for population and demographic statistics, such as the National Population Commission (NPC), local government offices, and other related institutions [1, 22].

B. Key Characteristics of the Existing Manual System

i. Data Collection

Data collection is carried out through surveys, censuses, and fieldwork. Enumerators or field officers manually fill out physical forms during interviews or on-site observations. The forms typically include details such as age, gender, occupation, marital status, educational background, and other relevant demographic information [1, 6].

ii. Data Storage:

Collected data is stored in physical archives, often organized in filing cabinets or storage rooms within local government offices or the headquarters of the NPC. And the storage of these records is prone to issues such as data loss, damage from environmental factors (e.g., fire, water damage), and difficulty in retrieval.

iii. Data Processing:

Processing of the data involves manual entry of the collected information into spreadsheets or simple databases. This task is time-consuming and prone to human error. The analysis of demographic trends and statistics is often delayed due to the slow pace of data processing, and the lack of automation further complicates the synthesis of large datasets.

iv. Data Sharing and Reporting:

Reports and summaries of demographic data are generated manually, often requiring extensive time to compile and verify accuracy. The sharing of data between different governmental agencies or departments is also manual, involving the physical transfer of documents or the use of email for digital copies, which raises concerns about data security and integrity.

C. Predominant Challenges of the Existing Manual System

i. Inaccuracy:

Human errors during data collection, entry, and processing often result in inaccurate or incomplete data.

ii. Inefficiency:

The manual nature of the system slows down the overall process, from data collection to reporting, making it difficult to respond quickly to emerging demographic trends or crises.

iii. Security:

The manual system is vulnerable to unauthorized access, data theft, or loss, as physical records are less secure and harder to protect.

iv. Data Integration:

With demographic data scattered across various offices and agencies, integrating and reconciling this information is challenging, leading to inconsistencies and discrepancies in national statistics.

III. Methodology

A. Browser Server Structure Overview

Browser-Server is internet access to the server and can be either open to all or limited access to those with passwords and privileges (such as a company server) etc. This could be a private server but with internet based access rather than LAN (Local Area Network) access. The server has a three-step response to a client. First, it accepts the connection, and then it reads and processes the client's request. Finally, it sends a reply to the client. For some client-server relationships, like a database server, there may be multiple requests and replies.

Since database requests may take a long time to process, the server must be multi-threaded in order to handle concurrent requests. In the case of HTTP, a single request will lead to multiple replies [23, 19].

B. Advantages of Browser Server Structure

The adoption of a browser-server architecture for an integrated e-demographic system offers several advantages that address the limitations of the existing manual and decentralized approaches. These include but are not limited to:

i. Centralized Data Management:

The browser-server structure allows for centralized storage and management of demographic data on a secure server. This centralization ensures that all data is consistent, up-to-date, and easily accessible to authorized users across the country and reduces data redundancy and the risks of discrepancies that are common in decentralized systems.

ii. Accessibility:

One of the key advantages of the browser-server structure is that it enables users to access the system from anywhere with an internet connection, using a standard web browser. This is particularly beneficial in a country like Nigeria, where geographic diversity and infrastructure challenges can make data access difficult. Also, all agencies can retrieve and input data in real-time, regardless of their location, improving the responsiveness and timeliness of demographic analyses and decisions.

iii. User-Friendly Interface:

The use of a web browser as the interface for the e-demographic system ensures a user-friendly experience. Most users are already familiar with navigating web browsers, reducing the learning curve and promoting wider adoption of the system.

iv. Interoperability:

A browser-server architecture facilitates integration with other government systems and databases, enabling seamless data exchange and interoperability. This is crucial for creating a holistic view of the population and ensuring that demographic data can be easily cross-referenced with health, education, and economic data.

C. Browser Server Structure Architecture

The architecture of the integrated e-demographic system in Nigeria, based on the browser-server model, is designed to be robust, scalable, and secure. This architecture comprises three main components: the presentation layer, application layer, and data layer. The data access in the B / S model starts from the presentation layer to the application layer and then to the data layer as shown in **Fig 1**.

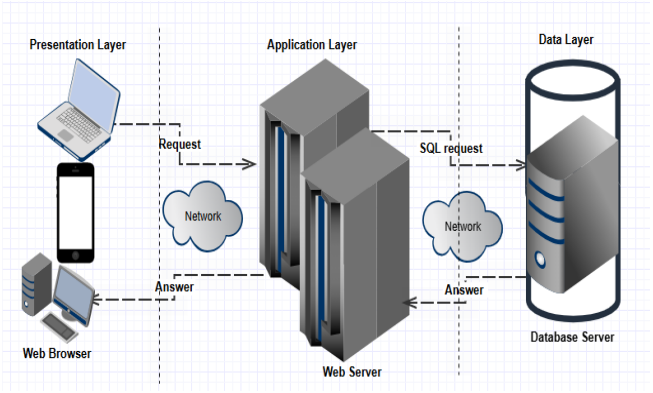

Fig 1. Browser Server System Architecture.

i. Presentation Layer:

Also known as the client-side of the architecture consists of web browsers, which are the primary interfaces for users to interact with the e-Demographic system. Users access the system through standard web browsers (e.g., Chrome, Firefox, Safari), making the system accessible from various devices, including desktops, laptops, tablets, and smartphones.

ii. Application Layer:

The application server hosts the core logic of the e-Demographic system. It handles tasks such as data validation, processing business rules, and managing sessions. The application server interacts with the database server to store and retrieve data based on user requests. Also, application server implements security protocols to protect sensitive demographic data. This includes encryption of data in transit, user authentication, and access control mechanisms.

iii. Data Layer:

The database server is responsible for storing all demographic data in a structured format. It uses a relational database management system (RDBMS) such as MySQL or PostgreSQL to manage the data efficiently. The database schema is designed to optimize data retrieval and ensure data integrity. The server processes SQL queries generated by the application server, retrieving or updating data as needed. It is designed to handle large volumes of data and support complex queries to meet the system's demands.

IV. The Proposed Integrated E-demographic System (IEDS) Architecture

The IEDS consists of the browser server, application server, and database server, which are designed to synergize and integrate demographic data across various governmental agencies. The architecture primarily involves key components such as the National Population Server, Civil Registration Server, Immigration Server, and Other Agencies Server. Each server component has specific functions and is connected to the Integrated E-demographic Central Server as diagrammatically below

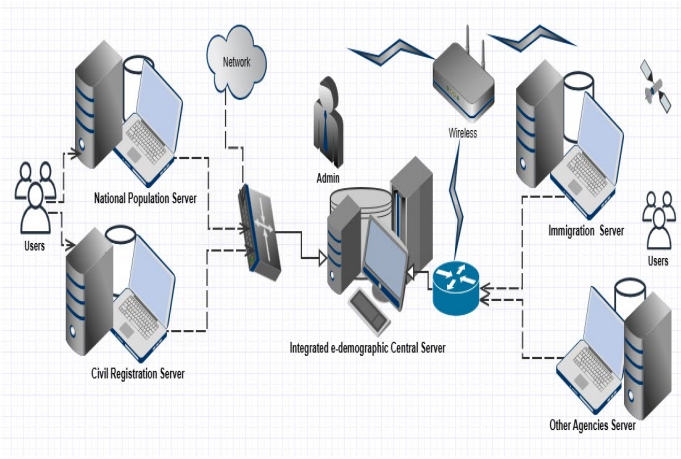

Fig 2. IEDS Architecture.

- **The Integrated e-demographic Central Server:**
  i. At the heart of the IEDS architecture is the Integrated e-demographic Central Server. This server acts as the central processing unit, coordinating the data flow between all other servers. It is managed by an administrative unit (Admin) that ensures the system's integrity and security.
  ii. The central server receives and processes data from the National Population Server, Civil Registration Server, Immigration Server, and Other Agencies Server, ensuring that all information is synchronized and accessible when needed.
- **Network and Communication:**
  i. Data flow between these servers is facilitated by a network infrastructure, which may include both wired and wireless connections. The network ensures that data is transferred securely and efficiently across the different servers.
  ii. A satellite connection could be used for remote or difficult-to-reach areas, ensuring that the system remains robust and accessible nationwide.
- **Data Access and Users:**
  i. **Users:** Both internal (governmental staff) and external users (citizens) can access specific data through the servers. The type of access granted will depend on the user's role and the type of data they need.
  ii. **Admin:** The admin is responsible for managing the central server, ensuring that data is consistently accurate and up-to-date, and handling any necessary maintenance or updates to the system.

A. The Proposed Integrated E-Demographic System (Ieds) Database

MySQL is a widely used open-source relational database management system (RDBMS). It is based on Structured Query Language (SQL), which is a standardized language for managing and manipulating databases ([25] and [26]). The Integrated E-demographic System (IEDS) Database is a comprehensive framework designed to centralize and manage demographic data from various governmental agencies. This architecture ensures that demographic data is efficiently processed, stored, and made available for different analytical purposes. The authorized agencies can retrieve up-to-date demographic information from anywhere at any time. By centralizing data from various sources, inconsistencies and errors are reduced, as described below

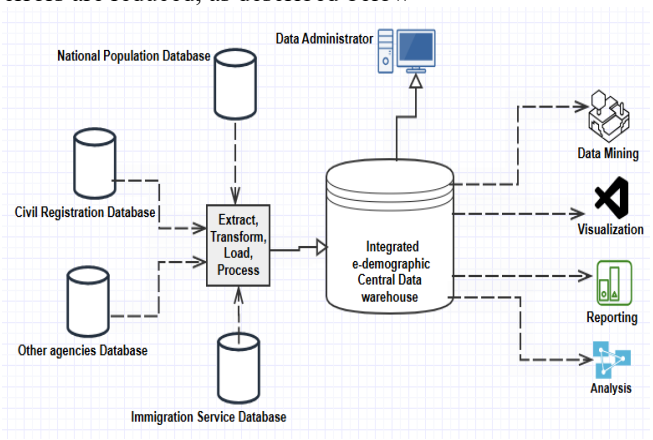

Fig 3. IEDS Database.

The key components and processes within this IEDS are as follows:

- **Source Databases:**
  i. **National Population Database:** This database stores population data, including national identification and voter cards records of individuals across the nation.
  ii. **Civil Registration Database:** It contains vital records such as birth, death, marriage, residence and other civil status information.
  iii. **Immigration Service Database:** This database handles data related to immigration, including visas, residency permits, exit, e-passport and other immigration-related documentation.
  iv. **Other Agencies Database:** This includes data from other governmental bodies, such as health, education, and social services, which contribute to a holistic demographic profile.

- **ETL Process (Extract, Transform, Load):**
  i. Data from the various source databases is extracted, transformed, and loaded (ETL) into the central data warehouse. This process ensures that the data is cleaned, standardized, and integrated, making it suitable for further analysis.
  ii. The ETL process is crucial for maintaining data consistency and accuracy across the different

databases, enabling the central warehouse to function as a unified repository of demographic information.

- **Integrated E-demographic Central Data Warehouse:**
  i. The central data warehouse is the core of the IEDS, where all processed data from the source databases is stored. This centralized repository allows for efficient data management and retrieval.
  ii. The warehouse is designed to support high-performance data operations, making it capable of handling large volumes of demographic data.

- **Data Administrator:**
  i. The Data Administrator plays a critical role in managing the central data warehouse. This role includes overseeing the ETL process, ensuring data integrity, and maintaining the overall health of the database system.
  ii. The administrator also facilitates access to the data for authorized users and ensures that the system complies with security and privacy regulations.

- **Data Utilization:**
  i. **Data Mining:** The system supports advanced data mining techniques, allowing for the extraction of valuable insights from the stored demographic data.
  ii. **Visualization:** Data can be visualized using various tools, helping users to understand trends, patterns, and relationships within the data.
  iii. **Reporting:** The system generates comprehensive reports based on the data stored in the warehouse, which can be used for policy-making, planning, and decision-making.
  iv. **Analysis:** Detailed analysis can be conducted on the integrated data, enabling deep dives into specific demographic aspects, helping researchers and governmental initiatives for national development.

B. The Proposed High-Level Decomposition of Web-based IEDS

The Web-based Integrated Electronic Data System (IEDS) is designed to manage and streamline various governmental services, with separate modules for users and administrators. (See figure 4 below)

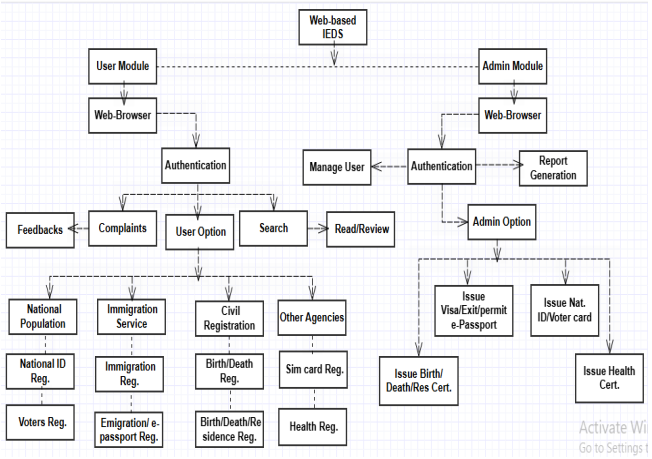

Fig 4. IEDS Decomposition.

The dashed lines indicate the flow of information and control between the different components. For example, after authentication, users and admins can perform various actions as discussed below.

- **User/Applicant Module:** This is the interface that end-users use to interact with the IEDS. Users access the system via a web browser, where they must first authenticate themselves. Once authenticated, they can perform various tasks such as searching for information, submitting complaints, providing feedback, and interacting with different governmental agencies for services. These services include national population registration, such as national identification (NI) and voter card (VC); immigration registration, such as immigration (IR), emigration (ER), e-passport (eP), visa (VR) residence permit (RP), and exit (EX); and civil registration, including birth (BR), death (DR), marriage (MR), residence (RR), and other agency registrations, such as health (HR), education, and SIM card registration (SM).
- **Admin Module:** This is the interface used by administrators to manage the system. Like the user module, the admin module is accessed via a web browser, is use for administrators who manage the system and user accounts. Administrators must authenticate themselves to gain access to the system's management tools. They can manage user accounts, issue documents like IR/ER/eP/EX/VR, VR/NI cards, BR/DR/MR/HR certificates, and generate reports based on system data for monitoring and decision-making.

C. Proposed an integrated e-demographic System (IEDS) Flowchart

The Integrated E-Demographic System (IEDS) is designed to efficiently manage and streamline the processing of demographic-related services and documentation. The system flowchart comprises two main components: the System Administrator Page and the User/Applicant Page. Each page

has specific functions and responsibilities that contribute to the system's overall efficiency and effectiveness as shown below

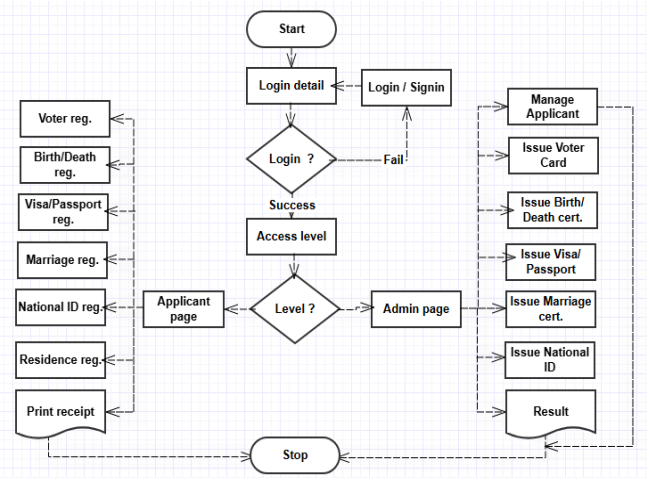

Fig 5. IEDS Flowchart.

The System **Administrator Page** serves as the central control hub, overseeing all aspects of the IEDS. Administrators have privileged access to manage and process various demographic services and applications. Their responsibilities include handling user/applicant data from submission to approval, as well as issuing certificates and identification documents.

In contrast, the **User/Applicant Page** is the interface through which citizens can access and apply for various demographic services. This page offers a streamlined process for individuals to submit applications, upload required documents, and track the status of their requests. Application submission and document upload are key responsibilities of the users/applicants.

D. Algorithm of Integrated e-demographic System (IEDS)

This mathematical algorithm outlines the step-by-step processes in the Admin and User/Applicant modules of the IEDS, detailing how input data is transformed into the desired outputs.

Algorithm 1 Process Flow of the Integrated E-Demographic System

Start
Input: Login details L_d
Verify L_d
if Login is Valid **then**
    Access Level Determination
    Retrieve Access Level ℓ
    if ℓ = Applicant Level **then**
        Direct to User/Applicant Page
        User selects service S_p
        if S_p = VR/NI **then**
            Proceed with VR/NI
        else if S_p = BR/DR/MR/RR **then**
            Proceed with BR/DR/MR/RR
        else if S_p =IR/ER/eP/EX/VR **then**
            Proceed with IR/ER/eP/EX/VR
        else if S_p = Print Receipt **then**
            Proceed with Print Receipt
        end if
    else if ℓ = Admin Level **then**
        Direct to Admin Page
        Admin selects action A_k
        if A_k = Manage Applicant **then**
            Proceed with Managing Applicant
        else if A_k =Issue VR/NI Card **then**
            Proceed with VR/NI Card
        else if A_k = Issue BR/DR/MR/HR Cert. **then**
            Proceed with BR/DR/MR/HR Cert.
        else if A_k = Issue IR/ER/eP/EX/VR **then**
            Proceed with IR/ER/eP/EX/VR
        else if A_k = View/Print Results **then**
            Proceed with View/Print Results
        end if
    end if
else
    Display "Login/Signin Failed"
    Return to Input L_d
end if
Stop

E. Ensure Security of Ieds Based on Browser Server Structure

To ensure the security of the IEDS based on browser-server structure, several key measures must be implemented:

- **Data Encryption and Access Control:**
  i. All sensitive data transmitted between the browser and server must be encrypted using robust encryption protocols like TLS (Transport Layer Security) to prevent unauthorized access during transmission.
  ii. Ensure that data at rest, especially demographic information, is encrypted using AES (Advanced Encryption Standard) or similar strong encryption algorithms.
  iii. Implement role-based access control (RBAC) to restrict access to different parts of the system based on user roles. Ensure that only authorized personnel can access sensitive data and system configurations.
  iv. Enforce strong password policies and two-factor authentication (2FA) for all users accessing the system.

- **Server and Data Storage Security:**
  i. Harden the server by disabling unnecessary services and ensuring that all software, including the operating system, is up to date with the latest security patches.
  ii. Implement firewall rules to restrict access to the server to only necessary ports and IP addresses.

iii. Store demographic data in a secure database with regular backups to a secure location. Ensure that access to the database is limited and monitored.
iv. Implement database encryption to protect data from unauthorized access, even if the database is compromised.

- **Monitoring, Logging and User Training:**

i. Implement comprehensive logging of all activities within the system, including login attempts, data access, and changes to system configurations. Logs should be stored securely and reviewed regularly for suspicious activities.
ii. Set up intrusion detection systems (IDS) and intrusion prevention systems (IPS) to monitor network traffic and detect potential security threats in real-time.
iii. Provide regular security training for all users to ensure they understand the importance of security practices, including recognizing phishing attempts and the proper handling of sensitive information.
iv. Develop and implement an incident response plan to quickly address and mitigate the impact of any security breaches or incidents. Ensure that all stakeholders are aware of the plan and their roles in the event of a security incident.

- **Applications for the Advanced Encryption Standard (AES) Algorithm in the Proposed IEDS**

In the Integrated E-Demographic System (IEDS) for Nigeria, the Advanced Encryption Standard (AES) algorithm is applied to ensure the security and confidentiality of sensitive demographic data such as birth and death records, national IDs, and other personal information. The system uses a browser-server architecture, which requires robust encryption mechanisms to safeguard data during transmission and storage. Key applications of AES in the proposed system are:

i. **Data Encryption in Transit:** AES is used in conjunction with **SSL/TLS protocols** to encrypt data exchanged between users (applicants and administrators) and the server. This prevents interception of sensitive information as it moves across the network. Furthermore, AES is integrated within the SSL/TLS protocol to protect any sensitive information such as: user registration details, identification documents (e.g., National ID, Voter ID, passports) and personal applications for demographic services. AES encrypts the data before it leaves the browser and decrypts it upon reaching the server.
ii. **Data Encryption at Rest:** The demographic data stored in the MySQL database is encrypted using AES. This ensures that even if the database is breached or accessed by unauthorized parties, the encrypted data remains unreadable without the decryption key. In addition, AES uses a symmetric encryption approach, meaning the same key is used for both encryption and decryption. The system ensures that only authorized users and services have access to the key required to decrypt the data.
iii. **Secure Authentication and Session Management:** AES is applied to encrypt user credentials and session tokens, ensuring that login processes and user sessions are protected from hijacking or unauthorized access. Moreover, user passwords are hashed and encrypted using AES before being stored in the database. This ensures that, even in the event of a data breach, user passwords remain protected from decryption and misuse.
iv. **Key Management and Role-Based Access Control:** The system employs a Key Management System (KMS) to securely manage and store encryption keys. This ensures that only authorized personnel can access the keys necessary to decrypt sensitive data, enforcing role-based access control within the system. Also, secure KMS is integrated into the IEDS, responsible for generating, distributing, and storing encryption keys. The KMS ensures that: only system administrators with appropriate clearance can access the keys required to decrypt stored data and user-specific keys may be generated, ensuring that applicants' private data remains secure even in shared storage environments.
v. **vi. Encrypted Backups for Disaster Recovery:** All system backups are encrypted using AES to protect demographic data during backup operations, ensuring data security even in off-site storage or cloud environments. More so, the system backups, whether stored locally or in the cloud, are encrypted using AES. This ensures that, even in the event of a physical breach (such as theft of storage media), the demographic data remains secure.

- **Important Uses of AES in IEDS:**

i. **High-Level Security:** AES provides 128-bit, 192-bit, or 256-bit encryption, offering robust protection against modern cryptographic attacks.
ii. **Performance Efficiency:** AES is efficient, making it suitable for real-time data encryption and decryption without significantly impacting system performance.
iii. **Compliance:** AES encryption ensures compliance with local and international data protection regulations, such as the Nigeria Data Protection Regulation (NDPR) and GDPR, which mandate the secure handling of personal data.

F. Comparative Table: Proposed IEDS verses Previous Studies

The table below compares the proposed **IEDS** with previous demographic systems in terms of accuracy and time consumption. **Table 1**.

Table 1. Proposed IEDS verses Previous Studies.

Criteria	Proposed IEDS (Browser-Server Structure)	Previous Systems (Manual or Legacy Systems)
Accuracy in Data Handling	**High**: Automated data validation, reduced manual errors, encryption for data integrity.	**Low to Moderate**: High occurrence of human errors in data entry, potential for inaccurate records due to manual processing.
Real-Time Data Processing	**Real-Time**: Instant processing and updates to demographic data (births, deaths, ID registrations, etc.).	**Delayed**: Manual data processing leads to delays in updating demographic records, leading to data inconsistencies.
Time Consumption for Service Delivery	**Low**: Automated application submission, status tracking, and certificate issuance; significantly reduced processing time.	**High**: Lengthy manual processes for verifying documents, processing applications, and issuing certificates.
Data Consistency and Synchronization	**Consistent**: Data consistency is maintained across different regions and departments through a centralized server.	**Inconsistent**: Manual systems may lead to discrepancies across different regions and departments.
User Accessibility	**High**: Web-based access, allowing users to apply for services from any location with internet connectivity.	**Low**: Limited to in-person applications and processing, leading to geographic and logistical barriers.

i.

V. Integrated E-Demographic System (IEDS) for Population Projection

IEDS is a comprehensive digital platform that manages and processes demographic-related services this include but are not limited to birth registration, death registration, immigration, and emigration. Beyond its primary functions, the IEDS can play a crucial role in estimating population projections by leveraging data from these key modules; birth/death reg. modules and immigration/emigration reg. modules.

A. Estimating Population Projections

By integrating data from these modules, the IEDS can provide real-time and accurate estimates of the population. The process involves:

i. **Data Collection:** The system continuously collects and updates data on births, deaths, immigration, and emigration.

ii. **Population Projection Formula:** The system can apply a basic population projection formula:

$$P(t) = P_0 + (B - D) + (I - E), \qquad (1)$$

where P(t) is the projected population at time t; P_0 is the current population; B is the number of births; D is the number of deaths; I is the number of immigrants; E is the number of emigrants.

B. Algorithm of Population Projections

Algorithm 2 Population Projection Estimate

Input: Input: P_0, number of births: B, number of deaths: D, number of immigrants: I, number of emigrants: E.

Output: Population projection $P(t)$ at time t.

Step1: **Start**

Step2: **initialize:** P_0; B; D; I; E

Step3: **Compute:**

Natural change: $B - D$

Net migration: $I - E$

Step4: **Calculate:** $P(t)$ at time t

$P(t) = P_0$+ Natural change+ Net migration

Step5: **Display**: $P(t)$

Step6: **Stop.**

C. Real-Life Example of Estimating Population Projections Using IEDS

Let's consider a real-life example to illustrate how an Integrated E-Demographic System (IEDS) can estimate population projections using data on births, deaths, immigration, and emigration.

i. **Scenario:** Assume a country, let's call it "Country X," is using an IEDS to manage its demographic data. At the beginning of the year 2024, the current population (P0) of Country X is 10,000,000. Throughout the year, the IEDS collects the following data: Number of Births (B): 200,000; Number of Deaths (D): 100,000; Number of Immigrants (I): 50,000; Number of Emigrants (E): 20,000

ii. **Population Projection Calculation:** Using the population projection formula of equation (1) above, where: $P(t)$ is the projected population at the end of the year 2024; Po=10,000,000 Po = 10,000,000; B =200,000 B =200,000; D =100,000 D =100,000; I =50,000 I = 50,000; E =20,000 E= 20,000.

Therefore, from equation (1) above, we have

$$\begin{aligned} P(2024) &= 10{,}000{,}000 + (200{,}000 - 100{,}00) \\ &\quad + (50{,}000 - 20{,}000) \\ &= 10{,}000{,}000 + (100{,}00) + (30{,}000). \end{aligned}$$

This implies $P(2024) = 10{,}130{,}000$

iii. **Interpretation:** At the end of the year 2024, the projected population of Country X is estimated to be 10,130,000. This projection accounts for Natural Increase (A net gain of 100,000 people due to births exceeding deaths) and Net Migration (An additional 30,000 people due to more immigrants arriving than emigrants leaving).

VI. Conclusion

The development of an Architectural Framework for an Integrated E-Demographic System based on a browser-server structure presents a robust solution for managing and processing demographic data in Nigeria. This system offers a streamlined, efficient, and secure method for handling critical demographic functions, including registration of births, deaths, marriages, residence and the issuance of identification documents such as national IDs e-passport and voter cards.

By adopting modern web technologies and centralized data management, the proposed framework enhances accessibility, reduces processing time, and improves the accuracy of demographic records. The browser-server architecture ensures that the system is scalable and capable of accommodating Nigeria's large and diverse population. It also supports real-time updates and data integration, facilitating better decision-making and policy formulation at the national level.

Furthermore, the Integrated E-Demographic System's ability to synergize various agencies and not only streamlines the management of demographic data but also serves as a powerful tool for estimating population projections. By analyzing data from births, deaths, immigration, and emigration modules, the system can generate accurate forecasts that are vital for effective policy planning and resource allocation.

VII. Future Research work

As we continue to expand the Architectural Framework for an Integrated E-Demographic System Based on Browser-Server Structure: The Case of Nigeria, several key areas for future research emerge. For example, we have proposed MyEclipse as the Integrated Development Environment (IDE), JSP (JavaServer Pages) or python as the programming language, and MySQL as the relational database technology for the development and implementation of the IEDS-system.

Also, future research should explore the potential of alternative or complementary technologies. Investigating the latest advancements in web development frameworks, database management systems, and IDEs could reveal more efficient or scalable solutions tailored to the unique requirements of Nigeria's demographic landscape.

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