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TECHNOLOGICAL INCUBATION CENTER INFORMATION MANAGEMENT SYSTEM AND DATA VISUALIZATION USING ONTOLOGY AND DATA INTEGRATION

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Abstract

Technological Incubation Centers (TICs) are vital institutions for fostering entrepreneurship, innovation, and economic development, particularly in emerging economies. In Nigeria, however, the lack of an efficient, integrated information management system (IMS) has hindered the full potential of these centers. This study develops a comprehensive Information Management System (IMS) for TICs that utilizes ontology-based data integration and data visualization techniques to enhance the management, monitoring, and reporting processes. The proposed system integrates decentralized data from various TICs across Nigeria, enabling seamless access to real-time information, better resource allocation, and improved decision-making. Through the use of ontologyand data integration, the system standardizes data representation and improves the accuracy and accessibility of reports, allowing for more effective monitoring of projects and financial resources. Additionally, data visualization tools help administrators and government stakeholders to visualize trends, performance metrics, and project outcomes, fostering transparency and accountability. The system was developed and tested using modern web technologies such as PHP, MySQL, and JavaScript**,** and its effectiveness was validated through real-world testing, demonstrating a robust, secure, and user-friendly platform. The research concludes that this IMS can significantly improve the operational efficiency of TICs in Nigeria, contributing to the development of an entrepreneurial ecosystem and supporting the sustainable growth of small businesses.

Keywords: Information management system; data integration; data visualization; ontologies; technological incubation centers; decision support system

1. INTRODUCTION

Technological Incubation Centers (TICs) have become increasingly important as a strategy for fostering entrepreneurship, innovation, and regional economic development. These centers, often government-backed, provide crucial support to technology-based startups by offering resources

such as mentoring, funding, and business development services. Since their inception in the 1980s, TICs have become a key component of economic policy in many countries, aimed at nurturing high-growth ventures and addressing market failures that hinder the success of small and early-stage businesses. However, despite their growth, there are significant challenges in managing and analyzing the vast amounts of data generated by TICs, especially in developing countries like Nigeria.

The performance and effectiveness of TICs in Nigeria have often been hampered by fragmented data systems, outdated infrastructures, and lack of integrated platforms to monitor and evaluate business activities under incubation. This issue is further compounded by the challenge of integrating heterogeneous data from different sources, which makes it difficult for stakeholders to derive meaningful insights and make informed decisions. While TICs collect large volumes of data from diverse sources, ranging from financial records to business progress reports that there is no unified system for managing and analyzing this data in real time.

In response to these challenges, this study proposes a comprehensive Information Management System (IMS) for Technological Incubation Centers in Nigeria, utilizing ontology-based data integration and data visualization techniques. The goal of the system is to streamline the process of data collection, analysis, and reporting by linking disparate data sets, enabling more effective decision-making and improving the overall management of TICs. By using semantic data integration and data visualization tools, the system will help decision-makers quickly identify trends, monitor business performance, and optimize resource allocation.

Previous research has shown that data integration and management in business incubators are crucial to improving their effectiveness. Phan et al. (2018) noted that incubators can address market failures by overcoming the uncertainty and high risks associated with supporting high-tech start-ups. However, the process of data integration in business incubators has always faced significant challenges due to issues with data syntax, schema, and semantics. To address this, this study adopts an ontology-based approach to data integration, which can bridge these heterogeneities by providing a common conceptual framework for organizing and interpreting data. This approach helps resolve challenges in connecting different data sources and ensures consistency and better decision-making across diverse systems (Hussler et al., 2020).

Additionally, the study integrates Natural Language Processing (NLP) and Deep Learning (DL) techniques to analyze unstructured data. This can help identify valuable patterns from business

reports, which often contain large amounts of unstructured textual data. The importance of such technologies in modern data management is highlighted by Kuan et al. (2019), who emphasize that data visualization and integration are essential tools for organizations to manage the complexity of big data and support informed decision-making in incubators.

This paper presents a case study of the Technological Incubation Center Information Management System developed using PHP, MySQL, and JavaScript, integrated with data visualization tools. The system is designed to improve the management of business records, enhance decision-making capabilities, and enable real-time monitoring and reporting. Through this approach, the study aims to bridge the gap between traditional information systems and the evolving needs of TICs, thereby enhancing their capacity to support innovation, drive economic development, and create sustainable jobs.

2. REVIEW OF RELATE WORKS

Table 1: **Summary of Related Literature**

Author	**Techniques**	**Work done**	**Limitations**
Binggui, *et. al* (2022)	Natural Language Processing (NLP)	They were able to show the strength and possibility of NLP for delivering smart healthcare	Lacks understanding various human languages
Awais (2019)	machine learning	Development of Machine Learning (ML) toolset for clinical decision support	Requires improvement in user authentication and security of data
Marut, 2016	Ontology-based	and clinical reminder system that link clinical guideline knowledge with patient registries	Lacks analytics, data visualization, monitoring and reporting functionalities
Bostjan, 2014	ontology based	bridges the gap between ontology based integration and service oriented architecture by enabling dynamic and transparent integration of information which is provided by services	The problem of splitting the query into static and dynamic query was not addressed fully.

Ali et al., 2018	Virtual Data Integration	They developed a Virtual – Data Integration Framework (V-DIF) that meets most of the users' expectations	concentrate mainly on data integration process and avoid or ignore the other two processes (inconsistency detection and resolution)
Ali, 2018	Mapping Approach	Provides a linkage between the fundamental components required to provide accurate and unambiguous answers to the users' queries from the integration system	Cannot use the sources of the data to resolve the duplicate through source preferences.
Vinoth, 2019	Ontology based	By using Internet of Things will help us to cure the patient in a short period of time	The paper focused only on the security of the system
Richter and Weber 2016	case based reasoning	Medical dataset	Existence of many problems without solutions
Jagannathan, 2009	KNN	The performance of CBR applications was enhanced	The missing data values of some attributes have been handled while others are not treated

3. RESEARCH METHODS

3.1 Data Sources

Data was collected from Technological Incubation Centers in Nigeria, focusing on the records of businesses under incubation, funding status, and project execution details. The data was obtained through document review, where existing records on information management practices at the incubation centers were analyzed to understand the system and identify any gaps. Observation of the infrastructure and network systems at the centers was carried out to assess the feasibility of implementing an electronic data management solution. Interviews were conducted with key stakeholders, including administrators and staff, to gather insights into the challenges and needs for a more integrated information management system. The data collected from these sources were integrated into a relational database (i.e., MySQL) to form the foundation for developing the new Technological Incubation Center Information Management System.

Data Flow Diagram (DFD) of the Existing System

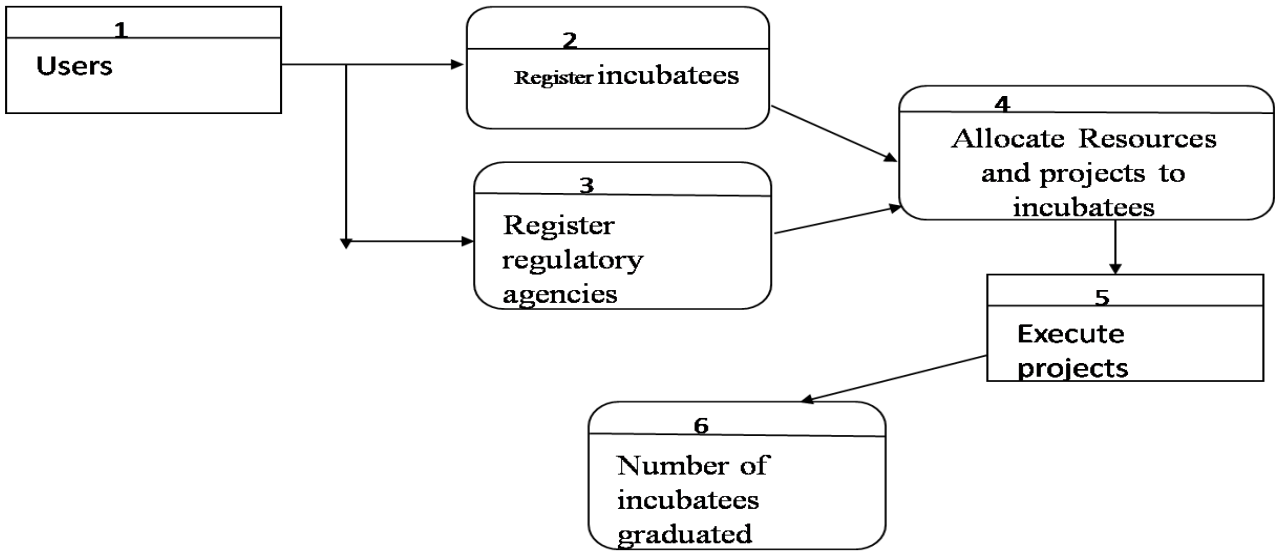

Fig 2.1: Data Flow Diagram of the existing system

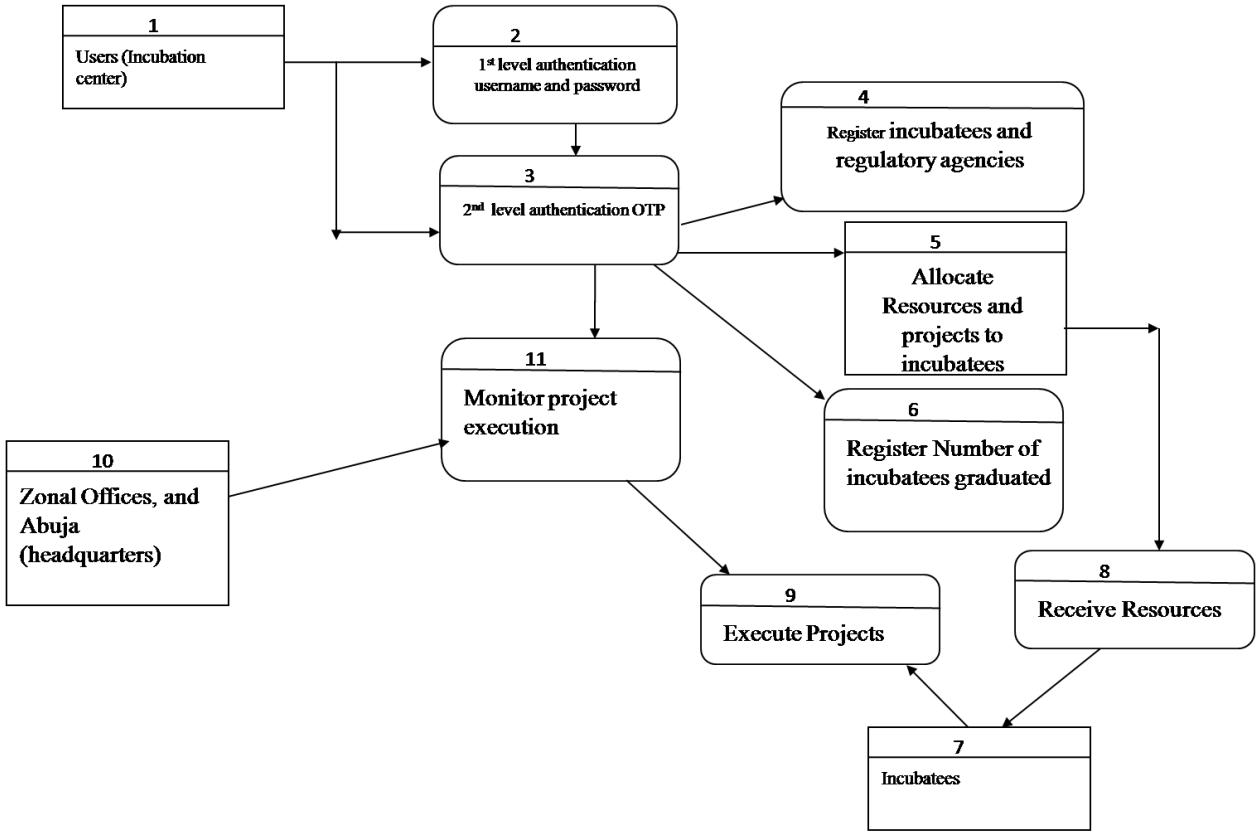

Fig 3.1: Data Flow Diagram of the proposedsystem

3.2 The Process of Information Management for the Technological Incubation Center

The Technological Incubation Center Information Management System (TIC-IMS) is designed to improve the operational efficiency of incubation centers by centralizing information management, automating processes, and offering real-time analytics to support decision-making. The system integrates data from various sources and ensures smooth communication between key stakeholders such as incubatees, administrators, and zonal offices.

TIC-IMS is built with a modular structure that addresses different functions including incubatee registration, project setup, resource requests, and administrative tasks. Each module is tailored to the specific needs of its users. The Incubatee Sub-System manages registration, project setup, and resource requests, while the Admin Sub-System oversees user management, resource allocation, and system maintenance. The Zonal Office Sub-System provides performance metrics and data visualization tools to track the success of incubation activities.

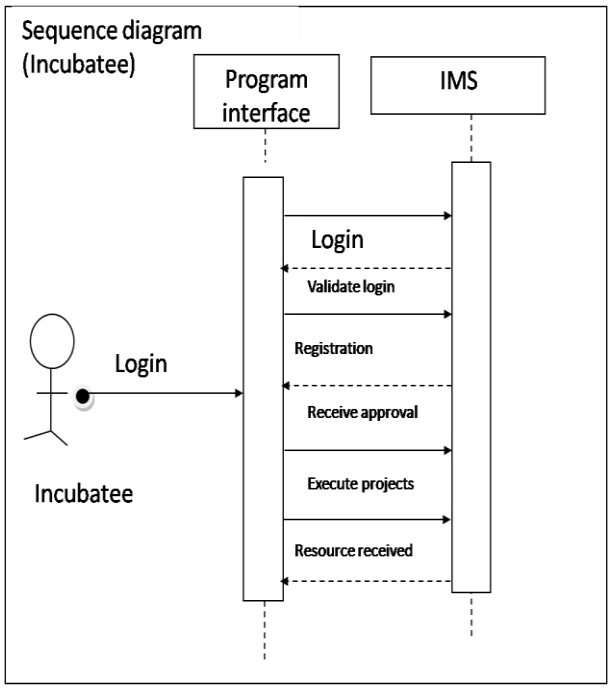

Fig. 3.2: Sequence Diagram (Incubatee)

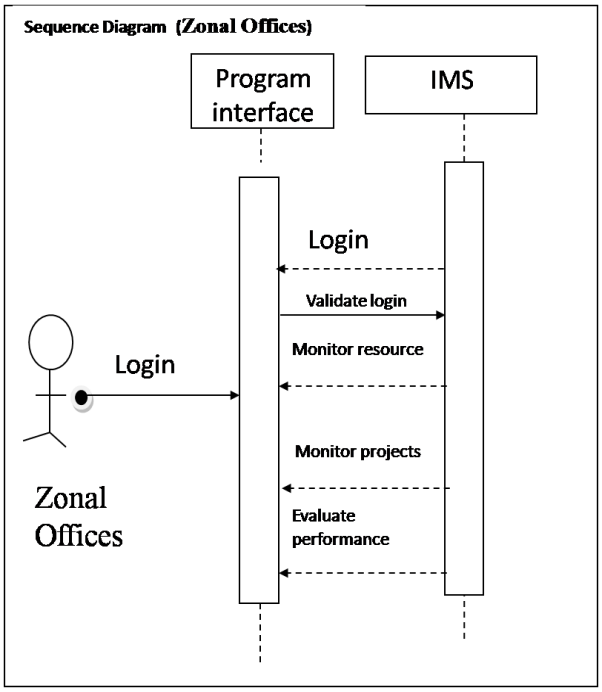

Fig. 3.3: Sequence Diagram (Zonal Offices)

A key feature of the system is its data integration and virtualization capabilities. Data from decentralized databases are processed and unified through backend SQL queries, and presented to users in a structured format. This data is then used to generate reports and visual analytics on incubatee performance, resource usage, and project progress. Virtual data integration allows the

system to create dynamic reports and visualizations in real-time, providing stakeholders with up-to-date information on key metrics.

The user interface is designed to be intuitive, with a centralized menu that gives access to the various modules based on user roles. Incubatees can register, set up projects, request resources, and upload business plans or proposals. Admin users can manage user accounts, approve registrations, allocate resources, and track the progress of projects and performance metrics. Zonal offices, meanwhile, can access detailed performance reports, monitor key performance indicators, and assess the overall effectiveness of the incubation center, including resource allocation and project completion rates.

3.3 Implementation of the Technological Incubation Center Information Management System

The Technological Incubation Center Information Management System (TIC-IMS) utilizes a combination of frontend and backend technologies to ensure a responsive, scalable, and user-friendly platform. The system is designed to handle a variety of tasks including incubatee registration, project management, resource allocation, and real-time performance reporting.

The frontend is developed using HTML, CSS, and JavaScript to create a responsive user interface, while PHP is employed for server-side scripting and dynamic page generation. The backend relies on MySQL as the relational database for storing critical data such as incubatees, projects, resources, and user roles. During development, the system is hosted on a local server using WAMP, with SQLyog used for managing the MySQL database. JavaScript libraries like jQuery and Chart.js are integrated into the system to handle dynamic data visualization and reporting functions.

The database is structured with several key tables that store user and project-related data. These include the Users Table, which stores login credentials and user roles; the Incubatee Table, which contains incubatee profiles and project details; the Resource Table, which tracks resource requests and allocations; the Project Table, which monitors project statuses and milestones; and the Notification Table, which stores communication between admins and incubatees. The relationships between these tables allow the system to run complex queries to generate detailed reports on project progress, resource usage, and incubatee performance.

The TIC-IMS is divided into multiple functional modules, each serving a distinct purpose. The Login Module ensures secure user authentication with role-based access control. The Sign-Up/Registration Module allows incubatees to register, submit project details, and upload necessary

documents. The Resource Allocation Module helps the admin manage resource requests and allocations. The Approval Module enables admins to approve or reject incubatee applications. The Notification Module facilitates communication between the admin and incubatees, while the Graduate Module marks incubatees as graduated based on completed projects. The View Project Module allows admins to track the progress and status of incubatee projects.

The system employs a data integration pipeline that consolidates information from various subsystems to generate reports and visual analytics. The pipeline begins with data extraction from various tables using SQL queries, followed by data transformation to a suitable format for reporting. Finally, the processed data is presented through the system's reporting and dashboard interface, where users can generate real-time or on-demand reports.For optimal performance, the system requires specific hardware and software specifications. The hardware includes a 2.4 GHz processor, 4 GB of RAM, and a 500 GB hard drive. The software requirements include Windows 10, WAMP Server for local development, Microsoft Dreamweaver 8, and PHP/MySQL for web development.The TIC-IMS tracks several performance metrics to assess the effectiveness of the incubation process. These include incubatee progress, resource utilization, and project completion rates. Admin users and zonal offices can access reports based on these key performance indicators (KPIs) to evaluate system performance and make informed decisions about resource allocation and project management.

4. SYSTEM DESIGN AND IMPLEMENTATION

The Technological Incubation Center Information Management System (TIC-IMS) is built using modern web technologies, including HTML, CSS, PHP, JavaScript, and MySQL, offering a modular structure that supports efficient interaction among incubates, administrators, and zonal offices. This system is designed to streamline operations, enabling seamless management and sharing of information across different user roles within the incubation center.

The core objectives of TIC-IMS are to provide a centralized platform for managing information, facilitate the integration of decentralized records, and enable real-time data analytics and visualization. These functionalities support decision-making, performance tracking, and resource management, allowing users to monitor key performance indicators (KPIs) and evaluate the success of incubation activities.

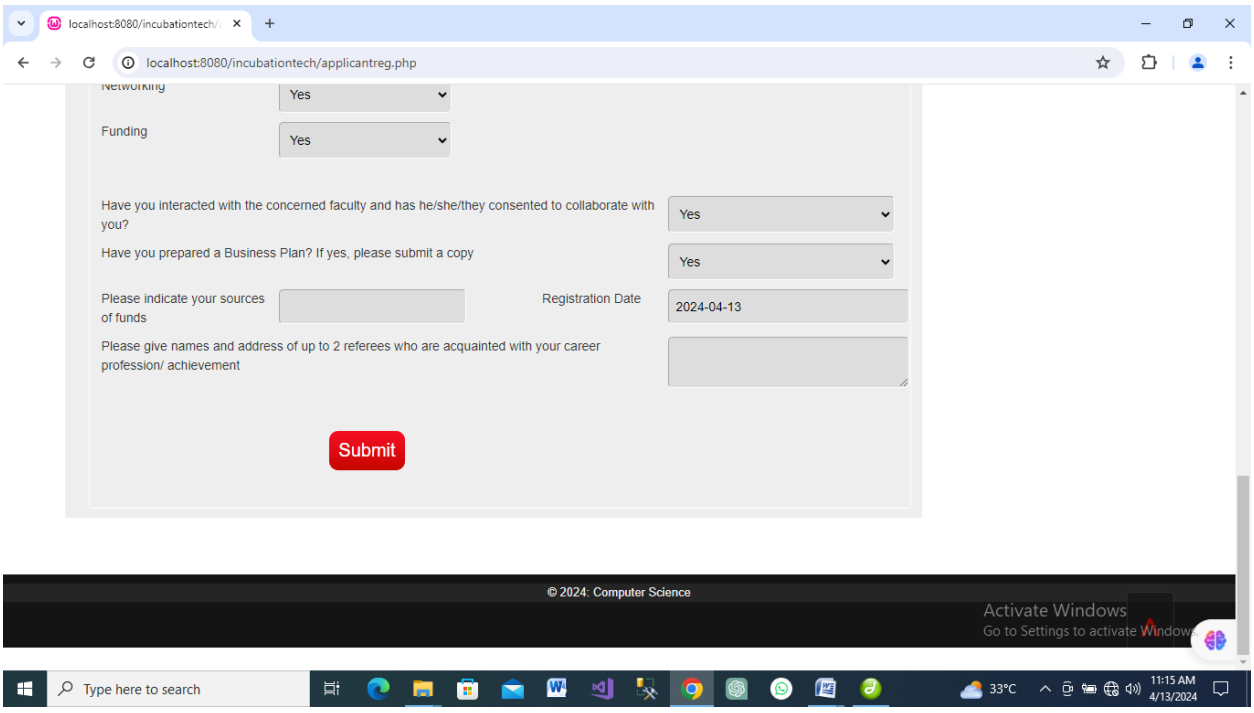

Fig. 4.1: Incubatee Application Form

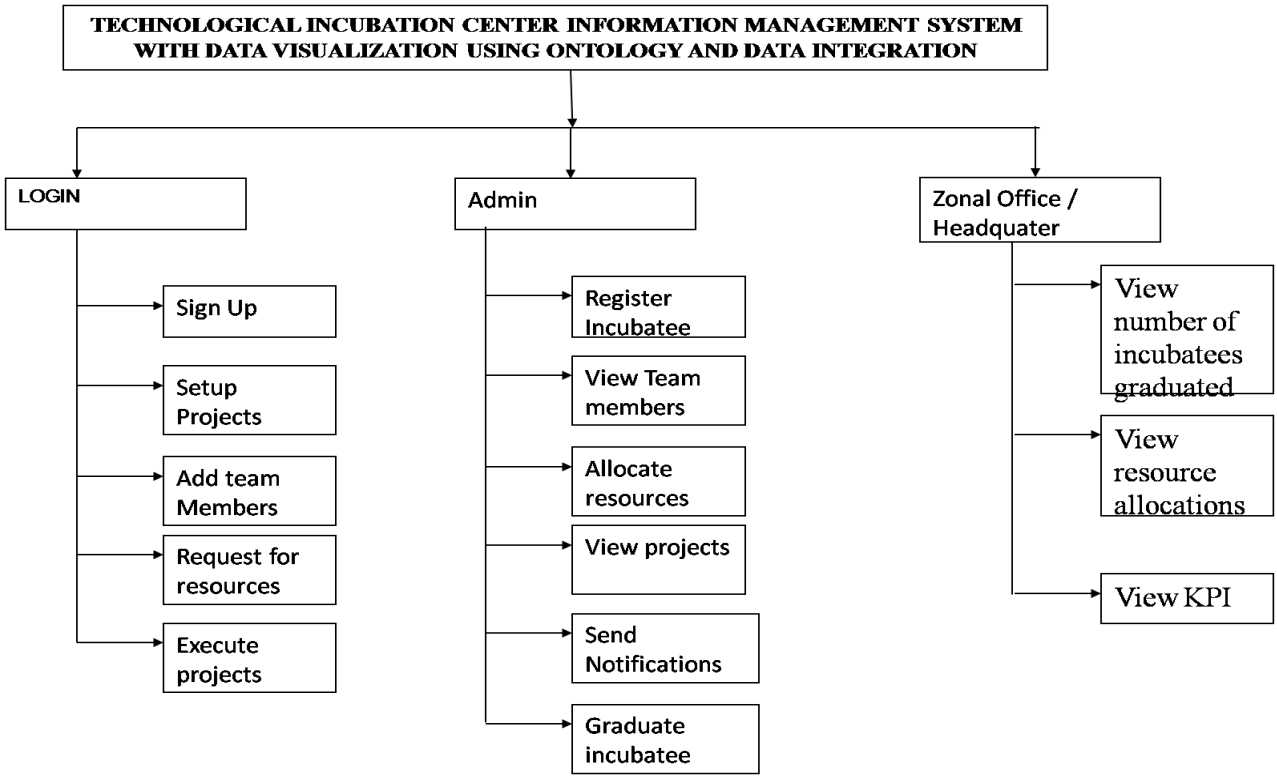

Fig 4.2: High Level Model of the Proposed System

TIC-IMS consists of three main modules tailored to specific user roles: the Incubatee Sub-System, Admin Sub-System, and Zonal Office Sub-System. The Incubatee Sub-System allows incubatees

to register, manage projects, upload business plans, request resources, and track progress. The Admin Sub-System facilitates user registration, project approval, resource allocation, and database maintenance, along with monitoring project progress and sending notifications. The Zonal Office Sub-System provides access to performance metrics and KPIs, supporting decision-making at the zonal level.

The backend of the system is powered by a MySQL database, which is managed through WAMP Server for local development and testing. The database structure includes essential tables such as the Users Table, Incubatee Table, Resource Table, and Notification Table. This structure ensures the integrity and accessibility of data, enabling efficient integration and management of records across various subsystems.

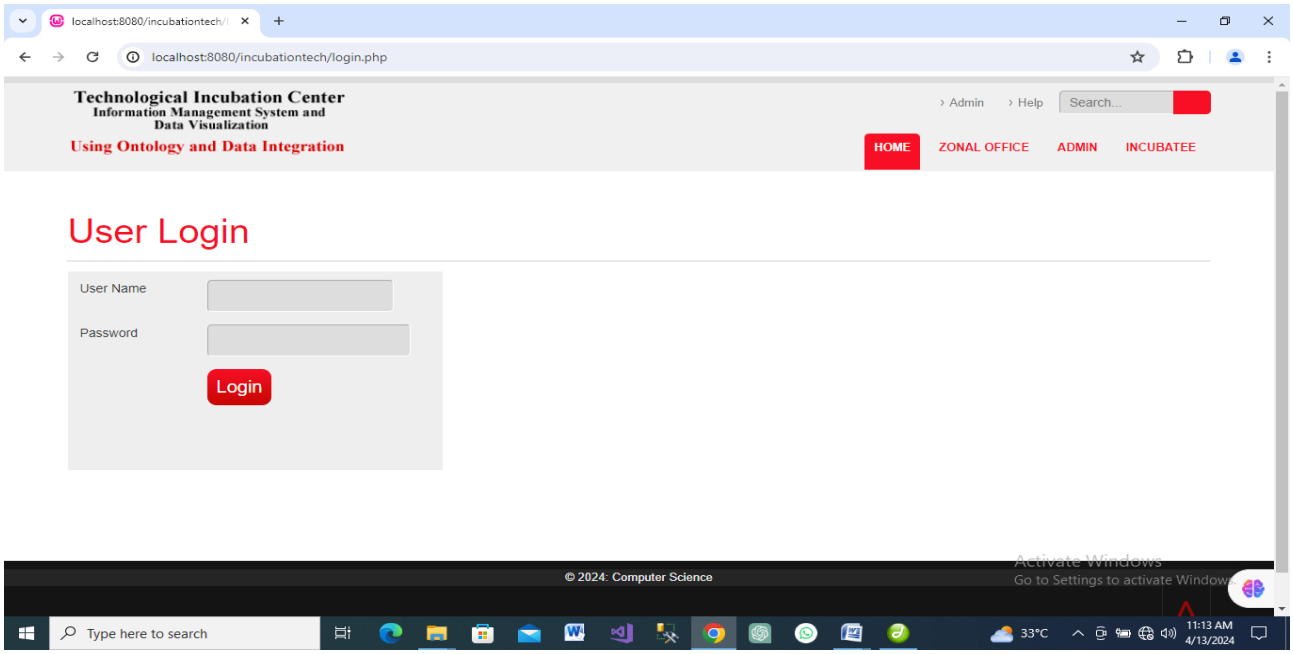

Fig. 4.3: Login Form

Key modules within the system include the Login Module, which provides secure access based on user credentials; the Registration and Setup Modules, which allow incubatees to sign up and set up their projects; the Resource Allocation Module, which enables admins to manage resource requests and allocations; and the Notification and Reporting Modules, which allow admins to send notifications and generate dynamic reports on project status, resource usage, and KPI performance.

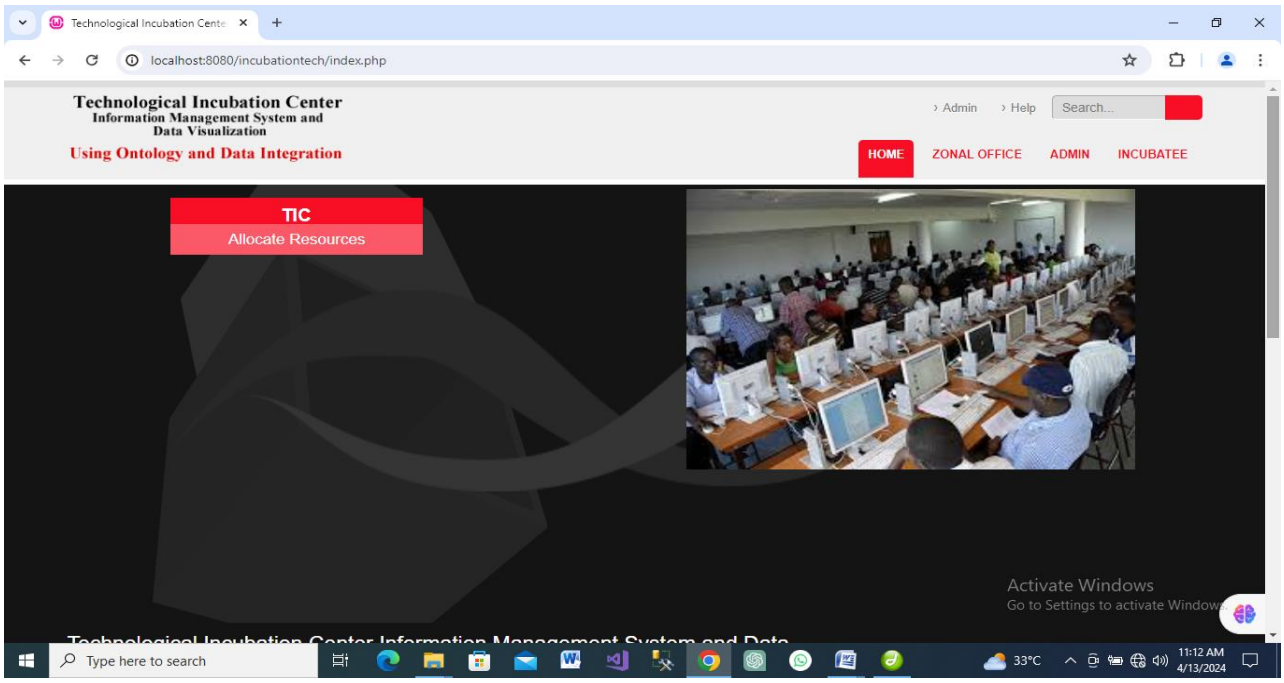

Fig. 4.4: Home Page

Real-time data analytics and reporting features are integral to TIC-IMS, offering dynamic visualizations of KPIs such as the number of incubatees graduated, resource allocations, and project completion rates. These reports help both admins and zonal offices assess the performance of the incubation program and make informed decisions.

The technology stack used for the implementation of TIC-IMS includes HTML, CSS, JavaScript for the frontend, and PHP and MySQL for the backend. WAMP Server provides the development environment for local testing. This combination of technologies was chosen for its flexibility, scalability, and ease of use, ensuring that the system can efficiently handle the needs of the incubation center while providing a user-friendly and responsive interface.

5. SYSTEM TESTING, INTEGRATION, AND DEPLOYMENT

System testing is essential for identifying errors and ensuring that the software functions correctly under different conditions. The chapter emphasizes the importance of performing early and frequent tests, integrating development and testing cycles, and formalizing a testing methodology to achieve consistent results. The testing strategy follows a structured approach: unit testing, integration testing, and system testing. It incorporates both functional (e.g., unit, system, and

acceptance testing) and non-functional (e.g., performance, security, and usability testing) tests to evaluate the software's reliability and performance.

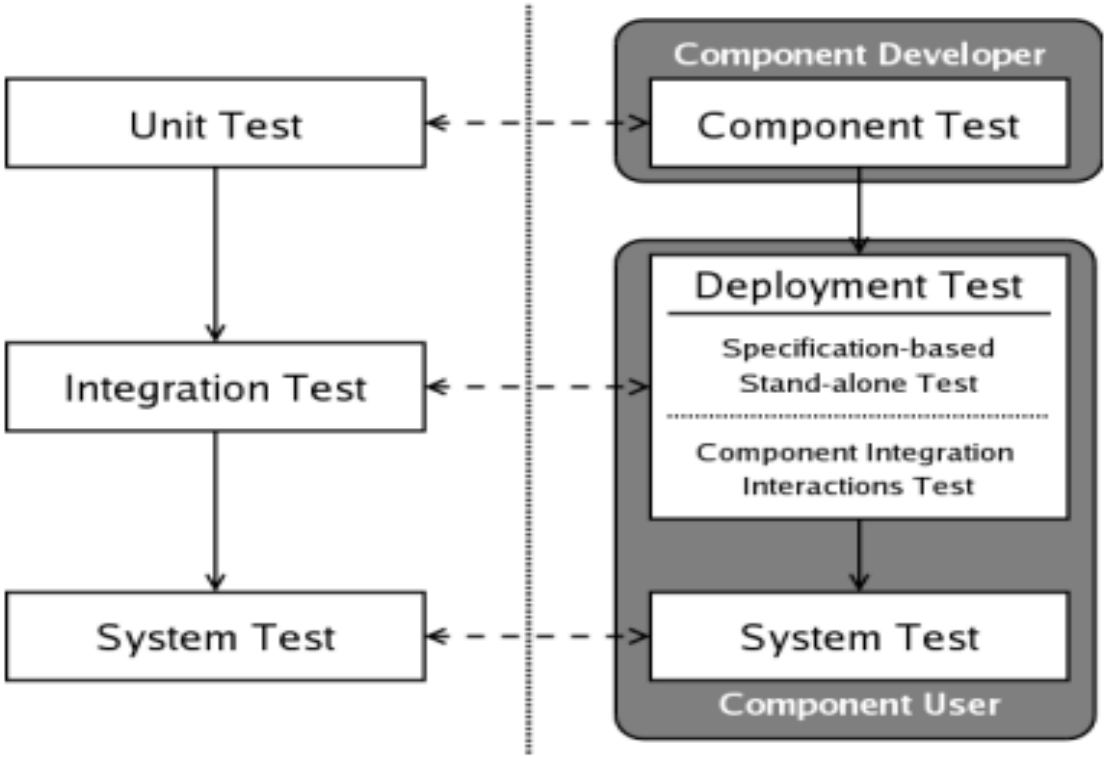

Fig. 5.1: System testing stages

5.1 Testing Phases and Results

The software undergoes comprehensive tests to ensure it meets business and technical requirements. Functional tests verify that the system performs as expected, while non-functional tests assess attributes such as load handling, security, and user-friendliness. Automated testing is used to reduce repetitive manual tests and improve efficiency. The system was subjected to integration testing, which ensures the interaction of software components, and system testing, which checks the software's functionality across different environments (e.g., Windows 10 and Google Chrome).

Table 5.2: **Performance Assessment**

Assessment Tool	**Score (%)**
Reliability	82
User Friendly	92
Flexibility	75
Random Generator OTP	95

Security	98

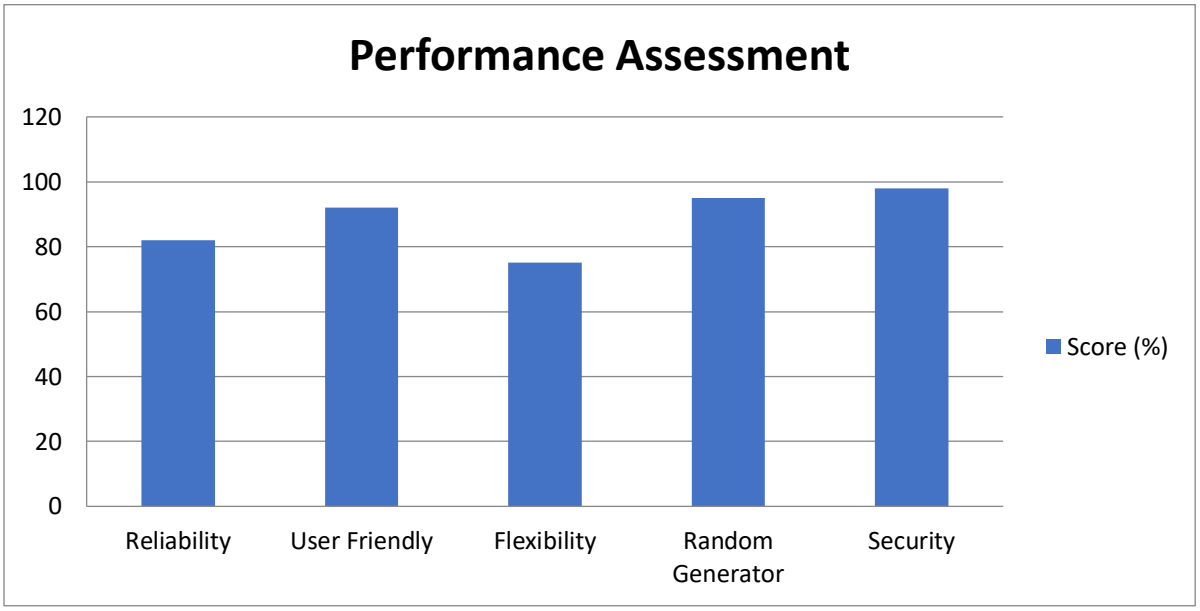

Fig. 5.2: Performance assessment

5.2 Deployment and Changeover

Different methods of system changeoverparallel, direct, phase, and pilot changeover—are considered, with parallel changeover recommended to mitigate risks by allowing both systems to run concurrently until the new system proves stable. The deployment strategy ensures minimal disruption to daily operations and offers fallback options if issues arise with the new system.

5.3 Training and System Conversion

Effective deployment also requires comprehensive training for staff to ensure they can operate the system efficiently. Staff members are trained on data entry, system management, and security practices. Additionally, the process of system conversion from manual records to a computerized format is described, with an emphasis on ensuring data accuracy and integrity.

6. CONCLUSION

The study concludes that Technological Incubation Centers play a vital role in fostering entrepreneurship and innovation, particularly in developing countries. The automation of information management within these centers is crucial for improving transparency, operational efficiency, and resource allocation. The IMS developed in this research provides a scalable and

secure solution for managing TICs across Nigeria, offering real-time data monitoring and project tracking capabilities.

The system facilitates the integration of data across multiple TICs, making it easier for the national headquarters to monitor and assess the performance of incubation centers. This data-driven approach contributes to informed decision-making and ensures the effective utilization of resources.

This research contributes to the field by providing a practical solution for the management of Technological Incubation Centers using a web-based platform. The study showcases the use of ontology and data integration in a real-world context, enhancing the management of incubation projects, resources, and data across multiple centers. Additionally, the research highlights the importance of system testing methodologies and their role in ensuring the reliability and security of software applications in organizational settings.

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