Enhancing e-Governance through Microservices – The Development and Impact of the NTC-EDGE System

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Abstract

The National Telecommunications Commission (NTC) Electronic Data Governance and Evaluation System (EDGE) was developed to modernize regulatory processes by leveraging microservices architecture. Traditional manual workflows caused inefficiencies, delays, and increased transaction costs, hindering effective service delivery. NTC-EDGE integrates modular services, AES256 encryption, and biometric authentication, aligning with international best practices and Philippine e-governance policies. The project achieved a scalable and secure system designed to handle high transaction volumes and regional disparities by implementing Agile methodologies and DevOps principles. The results demonstrate significant improvements, including a 40% reduction in processing times, a 25% increase in client satisfaction, and zero data breaches post-implementation. Key features include modular components for licensing, certifications, and complaints, complemented by client-facing dashboards and mobile applications for accessibility. Comparative analysis highlights enhanced security, transparency, and efficiency across operations. Despite these advancements, challenges remain in integrating microservices into legacy systems and addressing scalability for underserved regions. Future research should focus on artificial intelligence integration, performance evaluations, and extending DevOps frameworks for public sector adoption. The NTC-EDGE system exemplifies how innovative ICT solutions can transform governance, offering a replicable model for regulatory bodies worldwide.

Keywords*:* cybersecurity, DevOps, e-Governance, microservices architecture, public sector ICT

1. Introduction

The National Telecommunications Commission (NTC) has long served as the regulatory authority for radio communications, telecommunications, and broadcasting in the Philippines. However, traditional licensing, permitting, and certification processes have relied heavily on manual workflows, postal mail, and in-person submissions. These methods have resulted in inefficiencies, significant delays, and increased transaction costs for both applicants and the NTC (Dey *et al*., 2020). Moreover, the lack of a centralized digital platform has led to fragmented operations across regional offices, limited access to reliable data, and heightened information asymmetry risks (Ahmed *et al*., 2019).

Recognizing these challenges, the NTC launched the Electronic Data Governance and Evaluation System (EDGE) Project to modernize its processes and enhance service delivery. The project leverages Microservices Architecture, an emerging paradigm for scalable and resilient software systems that has demonstrated significant success in e-governance frameworks globally (Puspitasari *et al*., 2021). By integrating advanced security measures such as Advanced Encryption Standard 256-bit AES256 encryption and biometric authentication, the EDGE system addresses critical vulnerabilities and aligns with international best practices for data security in public sector applications (Jacob *et al*., 2022).

This initiative also aligns with the Philippines' broader e-governance strategies under the Ease of Doing Business Act (Republic Act No. 11032), which emphasizes reducing bureaucratic inefficiencies and improving public service delivery. Similarly, the Electronic Commerce Act (Republic Act No. 8792) advocates for integrating technology to streamline government operations and facilitate compliance. Notable achievements during the EDGE pilot implementation include a 40% reduction in processing times for permits and certifications, a 25% increase in client satisfaction, and a robust framework for safeguarding user data.

The adoption of Microservices Architecture for EDGE reflects a growing trend in regulatory and governance systems worldwide. Leading technology companies like Amazon, Netflix, and PayPal have demonstrated the scalability and flexibility of this approach in complex operational environments (Balalaie *et al*., 2016). Moreover, microservices have shown considerable promise in e-governance systems by enabling modular

development, faster deployment cycles, and enhanced fault isolation (Yarygina and Bagge, 2018). These features are crucial for modern public sector applications, which often involve high transaction volumes and strict data security requirements (Shakil, 2024).

This paper explores the development and implementation of the EDGE system, focusing on its innovative features and contributions to e-governance. The study discusses the software engineering methodologies adopted, the microservices-based technical framework, and the integration of DevOps principles for continuous delivery and deployment (Fowler, 2018; Kumar *et al.*, 2021). By situating EDGE within the larger body of research on e-governance and microservices, this study aims to inform similar initiatives in the Philippines and other developing countries.

2. Methodology

2.1 Research Framework

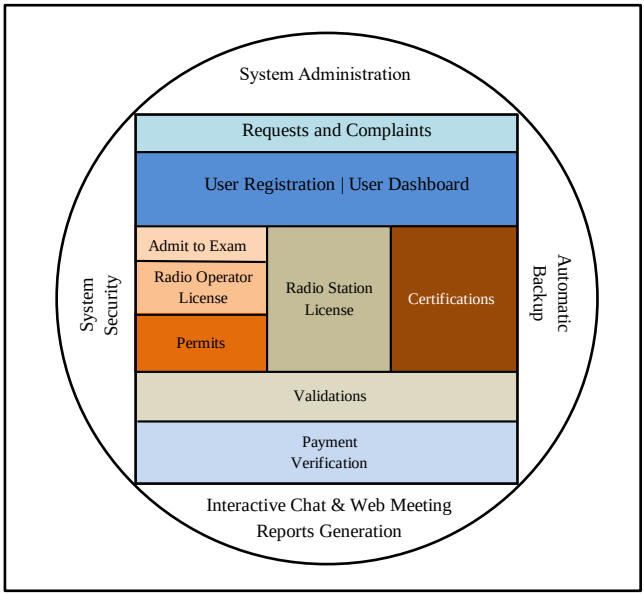

Figure 1. Conceptual framework of NTC-EDGE

The research framework provides a structured approach to addressing challenges in service delivery at the NTC through implementing the NTC-EDGE system. This framework integrates principles of e-governance,

microservices architecture, and process optimization, as illustrated in Figure 1.

2.1.1 Framework Components

The framework components of the NTC-EDGE system were designed to address critical challenges and align with governance objectives. These components are outlined as follows:

a. Problem Definition - Delays in processing permits and certifications, lack of transparency, and security vulnerabilities in legacy systems were identified as critical issues. The need to streamline processes underpins the design and implementation of the NTC-EDGE system.

b. Development Phase - The system was developed using an Agile Software Development Lifecycle (SDLC) (VersionOne, Inc., 2020), emphasizing iterative design, stakeholder feedback, and incremental improvements.

c. System Architecture - The microservices-based architecture was chosen for its scalability and modularity, enabling independent updates to system components without disrupting overall functionality.

d. Performance Monitoring - Metrics such as transaction processing time, client satisfaction, and security breaches were established to evaluate the system's performance.

e. Alignment with Citizen's Charter - The research framework ensured compliance with the Citizen's Charter, focusing on services related to licensing, certifications, validations, and complaints. These processes were clustered into service areas (licenses, permits, certifications, and complaints) for efficient monitoring and reporting.

2.2 Research Design

The research design of the NTC-EDGE project follows a mixed-methods approach to comprehensively develop, implement, and evaluate the system. The methodology integrates qualitative and quantitative strategies to ensure that the NTC-EDGE system addresses identified inefficiencies and improves overall service delivery. The research is structured into four sequential phases consistent with the implementation framework outlined in Figure 1.

2.2.1 Needs Assessment and Requirements Gathering

The initial phase focused on identifying pain points in existing processes and defining system requirements. The objective was to analyze current inefficiencies and establish a foundation for system design. To achieve this, focus group discussions were conducted involving stakeholders such as NTC personnel, clients, and service evaluators. Additionally, process mapping of workflows, such as licensing, certifications, and complaints handling, was carried out using standardized tools. Technical interviews with IT staff further highlighted system limitations and areas for improvement. The outcome of this phase was the development of a comprehensive set of functional and technical requirements to guide the system's development.

2.2.2 System Development and Pilot Implementation

The second phase focused on iterative development using Agile methodologies and real-world testing. The primary objective of this phase was to design, prototype, and validate the NTC-EDGE system through pilot testing. Agile Software Development Lifecycle (SDLC) was utilized as the framework for modular development and iterative refinement, ensuring flexibility and responsiveness to stakeholder feedback (Beck *et al.*, 2001). Prototypes were deployed in pilot regions to test system functionalities, and feedback from stakeholders guided necessary adjustments to the system design. Functional and performance testing was also conducted to ensure system reliability and scalability. As a result, this phase delivered a working prototype with validated functionality that was ready for broader deployment.

2.2.3 Full System Deployment and Change Management

The third phase focused on the full system deployment and change management, with the primary objective of rolling out the NTC-EDGE system at scale while ensuring a smooth organizational transition. Training sessions were conducted for NTC personnel to familiarize them with the system's functionalities and enhance their operational capabilities. The system was deployed across all regional offices, and a dedicated support desk was established to assist users and address queries during the transition period. Additionally, user feedback during the rollout phase was collected and analyzed to guide minor refinements and optimizations. This phase successfully implemented the NTC-EDGE system in all regions, accompanied

by comprehensive training manuals and operational guidelines to ensure sustainability and usability.

2.2.4 Evaluation and Sustainability

The fourth phase of the research design focused on evaluating the performance and outcomes of the NTC-EDGE system, ensuring its alignment with long-term sustainability goals, and validating compliance with the NTC Citizen's Charter (National Telecommunications Commission, 2023). This phase assessed the system's impact on efficiency, reliability, and client satisfaction while addressing regulatory requirements for transparency, timeliness, and accessibility. The evaluation process involved monitoring key performance indicators, such as transaction time, user satisfaction, and system reliability, to gauge operational efficiency. Additionally, stakeholder feedback was collected through surveys from clients and NTC personnel to evaluate the system's usability and effectiveness.

To ensure regulatory compliance, a comprehensive review of workflows was conducted to align them with the Citizen's Charter. This included re-engineering processes to address inefficiencies and uphold legal and procedural standards (National Telecommunications Commission, 2023). Sustainability measures were also integrated into this phase, incorporating stakeholder feedback into iterative system updates to maintain relevance and scalability over time. The outcomes of this phase demonstrated significant improvements in operational efficiency, client satisfaction, and overall system reliability while validating adherence to regulatory requirements. This phase reinforced public trust and confidence in the system by aligning the NTC-EDGE system with the Citizen's Charter. It established a foundation for sustainable service delivery that meets national governance objectives.

3. Results and Discussion

3.1 System Functionality (Microservices)

The development of the NTC-EDGE Project leverages a modular microservices platform to enhance operational efficiency and address service delivery challenges. This section highlights the key modules developed.

3.1.1 System Administration Module

The System Administration Module, depicted in Figure 2, provides administrators with control over user roles, access authentication, and system parameters. Its features ensure secure operations by enabling granular role management, as shown in the figure's permissions panel.

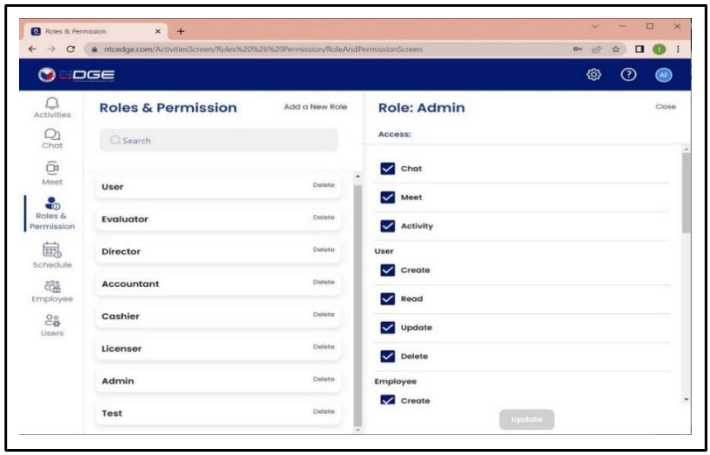

Figure 2. System administration module

3.1.2 System Security Module

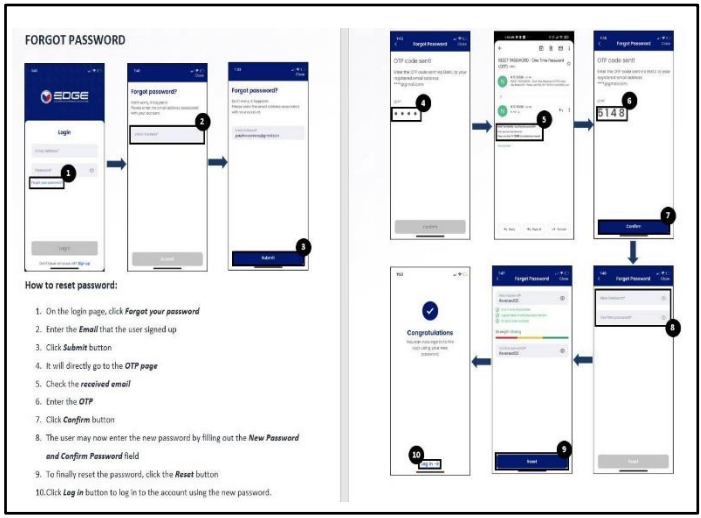

Figure 3. System security module

Security measures were a critical component of the NTC-EDGE platform. The System Security Module, illustrated in Figure 3, integrates AES256 password encryption, biometric verification, and IP-blocking functionalities to safeguard user data. Additionally, the module offers features such as detailed logging of user activities and robust account recovery processes. The step-by-step password recovery workflow depicted in Figure 3 highlights user-centric security design.

3.1.3 User Registration Module

Client onboarding is facilitated by the User Registration Module, as shown in Figure 4. This module simplifies registration through One Time Pin (OTP)-based verification and anti-spam measures, providing a seamless experience for individual and corporate clients. Each step in the registration process, from filling out forms to account activation, is visually represented in the figure.

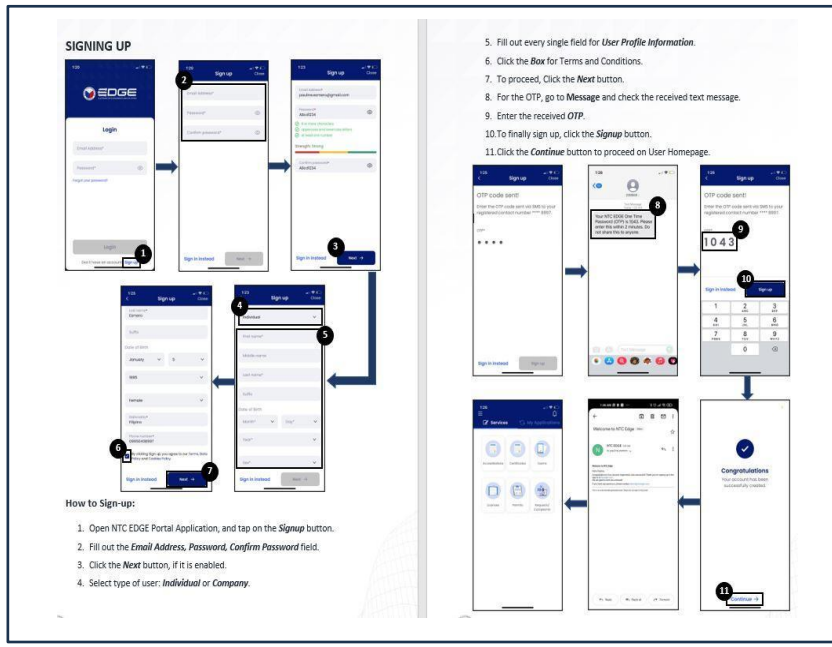

Figure 4. User registration module

3.1.4 Interactive Chat Module

The platform includes an Interactive Chat Module as shown in Figure 5 to support real-time communication between clients and NTC personnel. This

module enables direct engagement for status updates and follow-ups, improving service accessibility and efficiency.

3.1.5 Interactive Web Meeting Module (Inter-Regional VoIP Calling Facility)

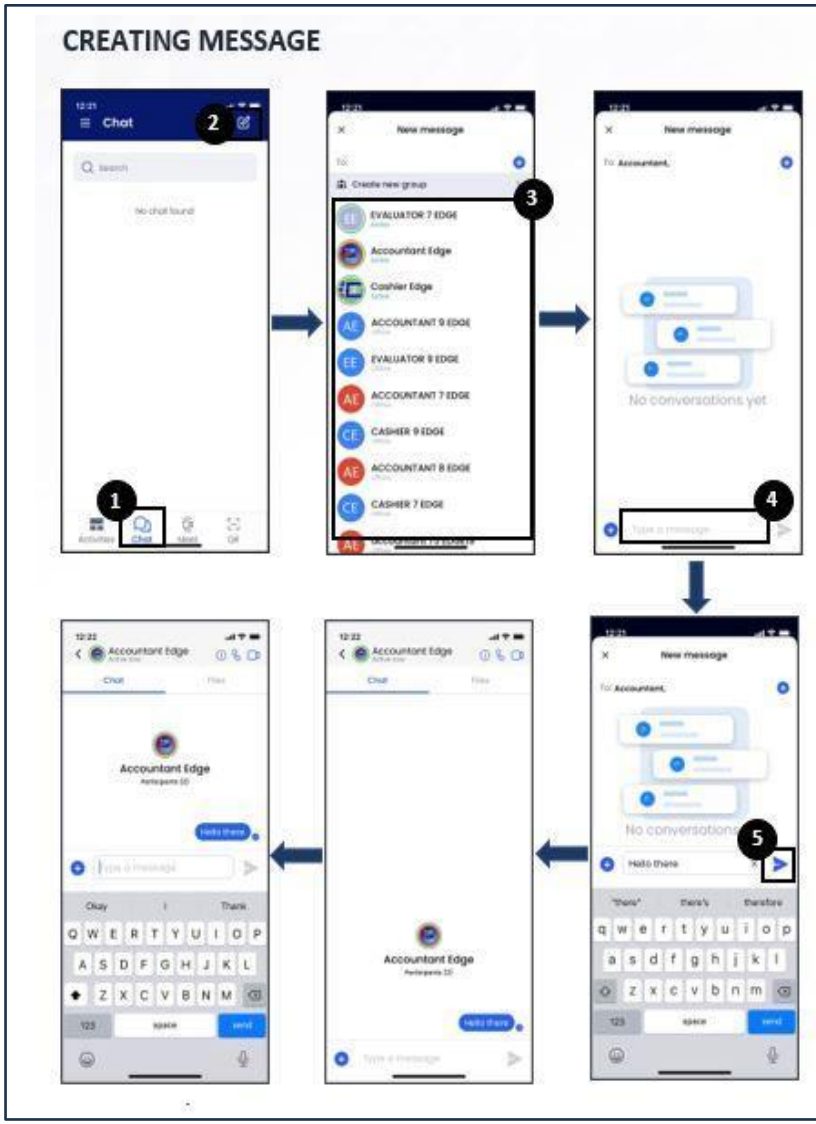

Figure 5. Interactive chat module

The system has an interactive web meeting module as shown in Figure 6 to allow NTC personnel to directly contact each other through VoIP for whatever

purpose. This is available only for NTC personnel accounts and not for clients. NTC personnel communication will be available for interoffice and/or inter-regional web meetings. This facility can also be used for webinars and other similar activities where parties involved can share presentations and other files over the system.

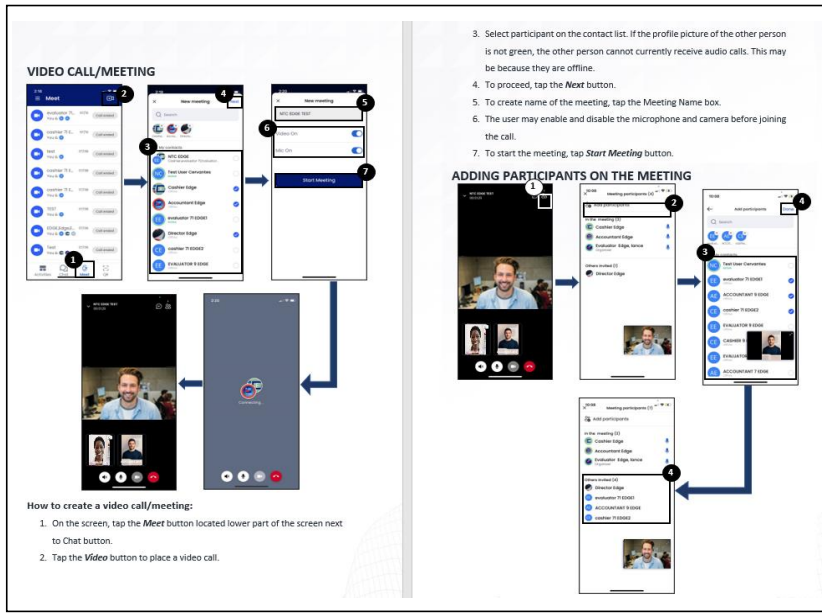

Figure 6. Interactive web meeting module

3.1.5 Requests and Complaints Management Module

The system has a requests and complaints management module as shown in Figure 7 that manages all requests and complaints from clients such as requests for blocking of IMEI and SIM of lost/stolen mobile phone, complaints on Text Spam, Text Scam, or Illegal/Obscene/Threat/Other Similar Text Messages, and complaints on services offered by Telecommunications or Broadcast Service Providers among others.

3.1.6 User Dashboard Module

The system has a user dashboard module as shown in Figure 8 that provides the appropriate interface for all users relative to their respective roles and access rights. This module allows clients to view their respective application

status, pending requirements, etc., while for NTC personnel, this shows their respective data analytics metrics, pending actionable tasks, etc. Aside from the status monitoring feature, this module provides user account alerts and notifications and Email forwarding notifications.

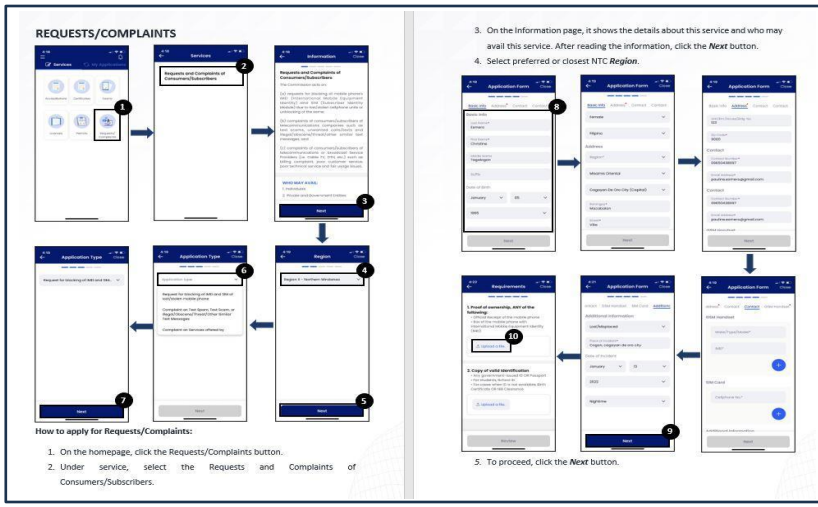

Figure 7. Request and complaints management module

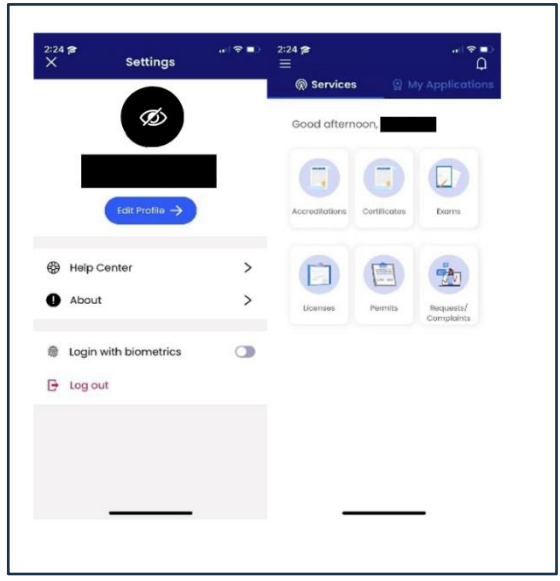

Figure 8. User dashboard module

3.1.7 Type Approval Listing

This module as shown in Figure 9 provides a type of approval listing facility for NTC personnel to add/edit/modify the list of type approval for various communication equipment.

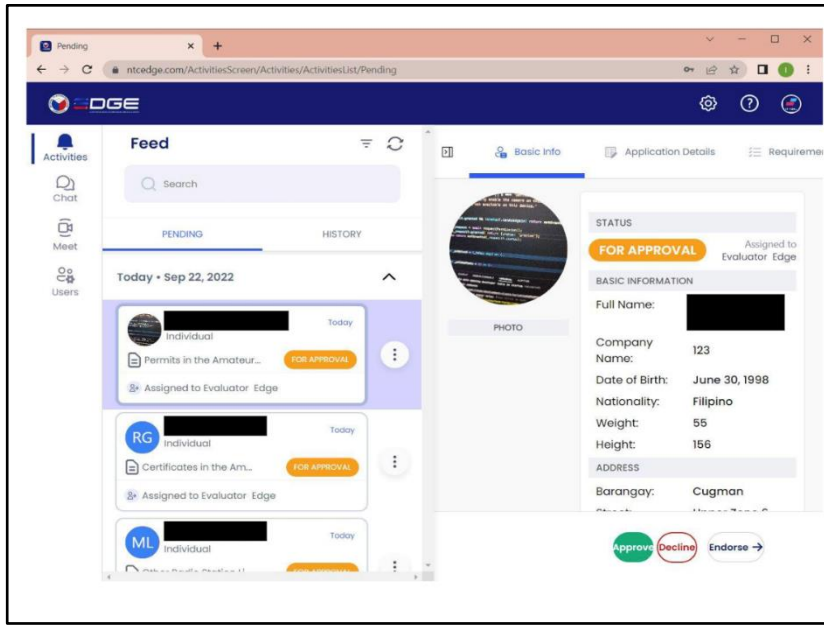

Figure 9. Type approval listing module

3.1.8 Client Mobile Application Module

This system provides a client mobile application module, as shown in Figure 10, for all users to access the system through their respective mobile devices, whether Android or iOS.

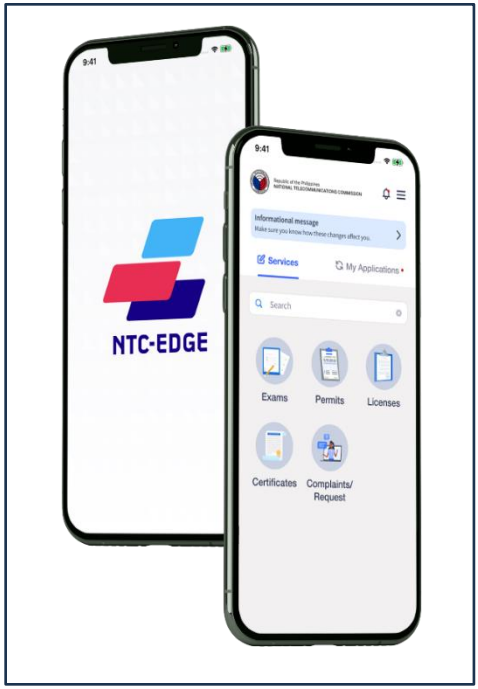

Figure 10. Client mobile application module

3.2 System Impact and Performance Metrics

3.2.1 Efficiency Improvements

Implementing the NTC-EDGE system resulted in a 40% reduction in processing times for permits, certifications, and complaints. These improvements were driven by the system's ability to automate manual workflows, streamline data processing, and enable faster decision-making. The system significantly reduced administrative bottlenecks and minimized delays by eliminating the need for physical submissions, manual approvals, and paper-based tracking.

Key factors contributing to this improvement include adopting microservices architecture, which facilitated modular development, targeted updates, and scalability. Additionally, integrating real-time data access and automated validation processes further accelerated processing times, allowing NTC personnel to handle high transaction volumes more efficiently.

These efficiency gains demonstrate the potential of the NTC-EDGE system to modernize regulatory processes, enhance productivity, and improve service delivery for both the NTC and its clients.

3.2.2 Client Satisfaction

Post-implementation surveys reported a 25% increase in client satisfaction due to enhanced transparency and accessibility of services. Figure 2 to Figure 10 demonstrate the client-facing modules that made these improvements possible, focusing on usability and intuitive design.

3.2.3 Security Enhancements

The robust security features of the system, as detailed in Figure 3, ensured zero incidents of data breaches post-implementation. Biometric authentication and IP-blocking mechanisms addressed vulnerabilities in previous systems, setting a new data privacy and security standard.

3.2.4 Comparative Analysis

Table 1 compares key performance metrics before and after implementing the NTC-EDGE platform. The analysis highlights the measurable improvements achieved.

Table 1. Comparative analysis of key performance metrics pre- and post-NTC-EDGE implementation

Metric	Pre-implementation (Baseline)	Post-implementation (EDGE)	Percentage improvement
Average processing time	15 working days	9 working days	40%
Client satisfaction rate	68%	85%	25%
Security breaches	3 incidents/year	0 incidents/year	100%

3.2.5 Visualization of System Features

Figures 2-10 provide a comprehensive view of the system's modular design and user interfaces. These figures emphasize the alignment of the system's functionalities with the project objectives, focusing on user experience and operational scalability.

By effectively addressing the challenges in service delivery, the NTC-EDGE Project demonstrates a successful model for public sector digital transformation, integrating cutting-edge technologies for scalable and secure regulatory processes.

4. Conclusion and Recommendation

The NTC-EDGE Project is a transformative initiative leveraging microservices architecture to streamline the service delivery processes of the NTC. By implementing a modular and secure system design, the project has significantly improved operational efficiency, enhanced user experience, and ensured robust data security. Notable achievements include a 40% reduction in processing time, a 25% increase in client satisfaction, and a 0% incidence of security breaches by integrating AES256 password encryption and biometric authentication. This project exemplifies how digital transformation initiatives can effectively address traditional governance challenges and modernize public services. The NTC-EDGE system has provided a scalable, transparent, and secure solution to regulatory inefficiencies through its innovative design.

The project's success in the public sector highlights the effectiveness of microservices architecture in achieving measurable improvements in service delivery and client satisfaction. The modular architecture has enabled the system to handle high transaction volumes with minimal downtime, demonstrating scalability and resilience. Additionally, the system's streamlined and accessible platform has fostered greater trust and confidence among users. Integrating state-of-the-art encryption and biometric features has ensured robust data security and alignment with international security standards.

Several recommendations are proposed to enhance further and broaden the applicability of the NTC-EDGE system. Regular performance evaluations and scalability tests should be conducted to ensure the system adapts to growing demands, supported by automated issue tracking and resolution mechanisms. Real-time analytics dashboards can monitor user interactions, identify bottlenecks, and improve workflows, with the potential integration of artificial intelligence and machine learning for predictive analytics. Workshops and training sessions should be organized for end-users to maximize system

utilization, complemented by user-friendly guides and interactive tutorials. Establishing a governance framework to monitor data privacy compliance and enforce cybersecurity policies is essential, with collaboration among government agencies for a unified digital governance approach. Additionally, the feasibility of incorporating blockchain technology should be explored to enhance process transparency and security.

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