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Online Issuance of Certifications Using Real-time Monitoring

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***Abstract*—The Revenue Department has experienced many delays and inefficiencies when it comes to processing requests for castes and any other type of certification for an extended period of time. To provide a solution for these issues, this web application proposes a method of automating the processing of the applications and allow them to be both verified and tracked by using real-time data. With this method of automating the processing of applications, citizens will have a very user-friendly interface to complete and submit their application. They will also be able to track the status of their application at any time. The same dashboard that allows them to view the status and track the progress of their application will enable the Revenue Department to monitor the status and track each application in real-time. Because the data from all applicants is accessible via a centralised database, this method of automating the processing of applications means that the time to validate an application is minimised, and applicants will be informed of the status of their application by either email or SMS. Therefore, this solution is designed to provide enhancement to the efficiency, accountability, and transparency of the Revenue Department with the ultimate goal of creating a service delivery model focused on citizens.**

***Keywords*—Certificate Issuance, Real-Time Monitoring, E-Governance, Workflow Automation, Alert, Tracking**

I. INTRODUCTION

As a developing country, in India and many other countries, various types of documents are produced to provide a basis for services that people receive from Government welfare programs, education related benefits, employment reservations and scholarships. They are used to establish a form of identification for individuals. Issuing social justice related certificates will help to promote inclusive and transparent governance. The failure or delays in issuing these documents can create significant adverse effects on the social and economic aspects of marginalised communities. Creating a fast and easy process for obtaining these documents will allow for the growth of marginalised communities toward inclusive and transparent governance.

Traditionally, certificates were issued using large amounts of paper and required many hours of work from Local Government to produce. Applicants had to bring their applications into a Local Government office so that they could be confirmed. This often resulted in long wait times, missing documents, or a considerable amount of time spent wondering if and when they would receive their Certificates. Furthermore, in many instances, Local Governments did not offer Citizens an easy way to complete the entire process of obtaining a Certificate in one location, requiring applicants to return to Local Government offices multiple times for different parts of the process.

Some governments have looked into delivering features like online application submission or downloaded fillable forms as partial answers to this issue in recent years. Nevertheless, the full electronic submission, processing, and issue of certifications are not supported by these kinds of systems.Additionally, applicants still need to provide physical documentation and go through the same lengthy verification process that has historically taken place in person, but now with additional complications such as lack of real-time tracking ability. There continues to be significant challenges associated with ongoing issues related to duplicate data entry; delay in receiving verification; lack of coordination; and limited as well as inconsistent access to real-time monitoring of all application processing from initial submission to final issuance.

In order to address the aforementioned challenges, this project plans to establish a comprehensive web-based application process that integrates application submission, document uploads, verification and approval, issuance of certificates and allows users to monitor their applications via a personal dashboard.

The application process is conducted entirely online and does not require physical visits or any face-to-face contact with government officials. The system will let you create an account, upload documents in a secure way, and keep track

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Vol. 14 Issue 12 , December - 2025

of how far along your application is through your personal dashboard.

Automated progress updates, notification via e-mail and SMS, and audit trail of all actions taken by the system enable users to track their applications through the different stages of verification (clerks), validation (staff), and approval (the sub-divisional officer).Digital signing of certificates upon completion of an application will provide a secure download of the certificate from the e-Government web site.

The automation of the administrative burden associated with providing certificates to the citizenry provides a significantly more rapid and efficient method for processing applications as well as a more transparent environment in which potential corruption may be minimized. Automation also provides a much greater level of confidence for citizens in the services provided by our governmental entities.The automation solution complements the overall vision for e-Government and supports the development of efficient, citizen-centric service delivery and digitized government reform.

II. LITERATURE SURVEY

Digitising both Governance and Academic Services at an accelerated pace in conjunction with the rapid increase in digital distribution has created higher demands for secure and greater capacity to issue and verify Academic Certificates as well as other types of certificates. The disadvantages of traditional paper-based methods include excessive manual processing time, potential loss or damage to records due to physical handling, difficulties in counterfeiting, increased administration costs, and so on. Current research and developments by many organizations have attempted to use web technology or QR codes or blockchain technology to help alleviate many of these issues.

To solve the rising issue of counterfeit diplomas, Gangwar and Chaurasia have developed a DApp based on blockchain technology, which provides an electronic platform for both the issuance and verification of academic certification. They have integrated the Ethereum blockchain, Smart Contracts, IPFS Storage, and QR Codes into their system, which allows for immutability, transparency, and quick verification. Their research points out that utilising a decentralised system significantly diminishes verification costs and does away with reliance on central servers; therefore, their concept is able to utilise the full scale of Blockchain technology in an unbreakable fashion[1].

Albar and Perdana concentrated their research on the development of an online web-based system to create and generate digital certificates for training and events. Their intent was to reduce the amount of time spent generating certificates via manual processes and printing certificates, through automated generation and distribution of digital certificates. In addition to showing how the use of QR codes on digital certificates makes it easier to verify authenticity and increases accessibility for an end user, the research does not offer detailed information on more sophisticated security threats (e.g. data tampering)[2].

A number of studies have focused on the role of online birth registration and certification systems in supporting government and citizen service delivery. The study conducted by Lande et al. illustrates how online birth certificate systems have the potential to replace the current manual registration processes with a system that provides improved accessibility, supports faster processing of registrations, and allows for centralised storage of records[3]. Chaudhari's research provides an example of the development of a web-based birth registration and tracking system, which offers online availability of data on registered births and supports the planning of population growth. The findings of these studies indicate that while online systems improve overall efficiency, however, they continue to rely upon centralised databases, which are at risk for compromise to both the security of the database and the integrity of the data contained within[4].

A large scale assessment of the Indian Birth Registration System was carried out by N. Kumari, who explored the socio-economic & demographic factors that affect the levels of birth registration in the country. She has found that the factors influencing rates of registration include the degree of knowledge people have about the system, the level of parental education, and living in an urban area. Although Kumari identified systemic weaknesses in the registration system, the study does not put forth any proposed technical solutions for dealing with the issues of fraudulent registrations or verifications[5].

Darshan and Mohan Kumar's paper describes the creation of an Internet-based caste certificate verification service utilizing QR codes and Triple DES encryption as means of providing quicker verification and renewal of certificates with less manual effort needed to perform these tasks. Further, this research shows that QR Codes and Cryptographic Techniques both add an additional layer of security, but ultimately still rely heavily upon a centralised authority for operation[6].

Research has demonstrated that digital or online certificates have improved efficiencies, access to services, and service delivery by utilizing blockchain technology for decentralization, immutable nature and trust-less verification. However there remains a significant gap in current solutions where many remain centralized and vulnerable to data manipulations and single points-of-failures; this paper addresses that gap. In this study, we will propose an innovative, secure and scalable framework for the electronic receipt of certificates and their subsequent verifications, thereby increasing the likelihood of minimizing fraud and administrative burden while at the same time enhancing public confidence in the certificate.i.e. a new model for the receipt of certificates. To accomplish this, we will build on some of the key benefits and characteristics of blockchain technology.

III. SYSTEM ARCHITECTURE

This new system is built on a Client-Server Architecture that can be easily scaled up or down based on demand with little to no loss in performance.

International Journal of Engineering Research & Technology (IJERT)
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Vol. 14 Issue 12 , December - 2025

A. Architectural Components

Presentation Layer (User Interface): The Frontend uses React.js and Tailwind CSS for creating a Mobile Responsive Design that is accessible via Smartphones to users in Rural Areas.

Application Logic Layer: For maintaining business logic, executing business logic and creating a means by which to route APIs, Node.js and Express.js are used.

Data Persistence Layer: MongoDB (NoSQL) was selected for storing all types of Application Structures like Income Forms and Cast Forms together, which is why it is known as a Flexible schema.

Notification Service: A notification service integrated with the Twilio SMS Gateway and SendGird Email Gateway acts as an alert system whenever there is a change in state.

B. RBAC (Role Based Access Control)

Controlled access to sensitive information using a clearly defined:

- App Applicants can file for applications, upload supporting documents and monitor their application progress
- Clerks only have Read and Verify abilities when they perform preliminary document checks
- Staff can Verify the information against existing records and may ask the applicant for additional documents
- The SDO is the only person who has Approval and Digital Signature Authorisation to produce the Final Certificate

C. System Modeling

UML diagrams are used to accurately define the functional specifications of a System from the System Requirements.

1) Use Case Diagram: The Use Case Diagrams show how the System will functionally interact with each of the four actors that interact with it: Applicants, Clerks, Staff, and SDO. They provide a visual representation of the overall System's operations, listing the high-level actions of each of the four actors.

This section describes the four parties involved in the application process and gives a summary of it.

- **Applicant** - The applicant is the individual or individual(s) that will register and apply for all caste, income and domicile certificates along with the applicant's ability to track the progress of the application.
- **Clerk** - The clerk is the first level of the personnel hierarchy to review and inspect the documents attached to the application for completeness and legibility.
- **Staff** - Personnel doing deep verification; may verify using physical records and/or other databases.
- **SDO** - Highest level in the verification process, all verification done by the clerks/staff is reviewed by the SDO. If he/she is satisfied with the application and verification then legal documents are digitally signed by him/her and produced.

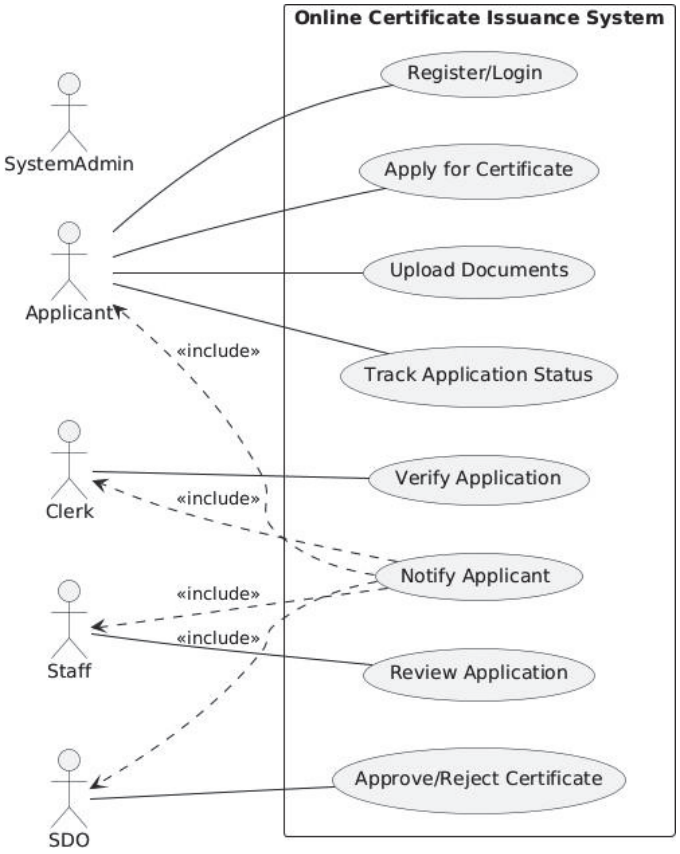

Fig. 1: Use Case Diagram

2) Class Diagram: The Class diagram represents the static structure of the system, defining the objects, their attributes, and the relationships between them. This serves as the blueprint for the database schema and object-oriented programming implementation.

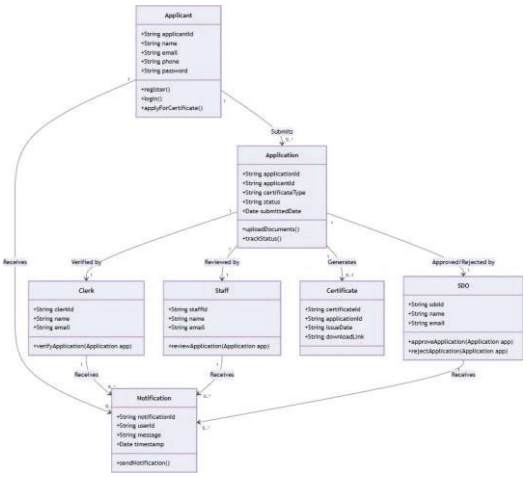

Fig. 2: Class Diagram

The description of the Using this Partner Service definitions

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 12 , December - 2025

includes the following:

- **User Class** - a base class that provides common authentication attributes.
- **Application** - an object which contains the state of the client's request and references one or more Document objects.
- **Inheritance** - three classes (Applicant, Official, and SDO) extend from the User base class which provides a common authentication mechanism with a different permission set.
- **Certificate Class** - A Certificate is generated upon successful completion of an applicant's application. The Certificate have a digital signature to provide proof of the certificate's authenticity.

IV. METHODOLOGY

Constructive Research is a methodology that will be used to address a specific local administrative issue by developing a solution through its five components: Requirements Elicitation, Development of a System, Algorithm Creation, System Architecture Building, and Testing & Validation.

A. Elicit Requirements and Collect Data

To identify if the new Digital Certificate Issuance System will provide a viable approach to real-time operational difficulties, qualitative and analytical data have been collected using the following methods:

1) **Observation of the existing process**
The research team performed a direct observation of the local Tehsil office to determine what caused the key bottleneck in processing. The major bottleneck was found to be the slow transfer of physical documentation from the Clerk to the Sub Divisional Officer (SDO), not the delay caused from entering data into a computer.
2) **Interviews with stakeholders**
Semi-structured interviews were conducted with three primary groups of stakeholders:
   - Applicants - They reported difficulty tracking their applications' current progress and needing to visit multiple offices.
   - Administrative Staff - Most of the administrative staff were aware that, because of their handwritten applications containing many errors, many of their applications were rejected.
   - IT Administrators - They expressed concern about the inability for the new system to work with legacy hardware and infrastructure.
3) **Review of Documents**
The Government of Pakistan's Standard Operating Procedures (SOPs), Guidelines for Issuing Digital Certificates, and the Rules for Validating Digital Certificates were reviewed to ensure compliance with all statutory and administrative requirements concerning the implementation of a digital issuance process and forms.

B. Software Development Lifecycle(SDLC)

The Agile Scrum Methodology was applied to develop the system as such methodologies provide a flexible and rapid response mechanism for providing feedback from users.

The sprints were set for 2 weeks and were organized around user registration and authentication at the beginning, with subsequent sprints producing the verification workflow, automation modules, and official certificates.

All code changes were tracked using Git, which provided for cooperative development, a controlled means of tracking code versions, and the facility for safe roll-back of code.

C. Algorithmic Framework

The system relies on algorithms that operate in the backend to minimize human intervention, decrease the chances for bias, and ensure the secure creation of official certificates; therefore, both its effectiveness and transparency depend on algorithmic-based methodologies.

1) FIFO Queue Management: Earlier, in traditional manual workflows, where applications could be processed in a random manner, subjectivity was removed from the process by the use of a rigorous FIFO (First-In-First-Out) system.

$$\text{Priority}(A) = \frac{1}{\text{Timestamp}(A)}$$

Where, A = Application

Thus, although older applications received higher priorities by default, overrides could only be granted with the approval of a senior level.

2) Hash-Based Certificate Verification: Each certificate generated will contain unique cryptographic hashing code to verify integrity of the document without needing a stamp or handwritten signature.

Verification Workflow:

- Data Extraction: Key data fields (Name, Certificate ID, Issue Date) are combined into a single string.
- Hash Generation: The string is processed using the SHA-256 algorithm to produce a secure hash.
- Embedding: This hashcode is printed directly on the certificate.
- Verification: When users enter the hashcode on the verification portal, the system recalculates the hash from stored data.
- If Hash(Stored Data) = Hash(Input Code) → the certificate is authentic.

Using this approach we can ensures security and tamper detection without using QR codes or physical seals.

D. System Architecture Implementation

This system follows a three-tiered architecture that clearly separates the different functions of each layer and allows for the scalability and maintenance of the overall system.

1) **Client Tier:** The client layer of the system consists of a single page application created using React.js. This allows for a responsive design and provides access to

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Vol. 14 Issue 12 , December - 2025

users in areas where they do not have good internet connections (e.g., users in rural areas).

2) **Server Tier:** The server layer of the system is developed on Node.js and Express.js and has multiple responsibilities, including:
   - Handling API requests,
   - Processing the application's workflow,
   - Enforcing Role-Based Access Control (RBAC)
   - Creating and verifying cryptographic hash codes.
3) **Database Tier:** The database tier of the system uses MongoDB as its backend database. MongoDB has flexible schemas, which allow for the easy addition of new fields or approach to provide certificate/form updates without affecting existing records in the database.

E. Testing and Validation Protocol

The testing approach consists of a multiple-level testing framework for performance, accuracy, and system integrity.

Unit Testing involves the testing of individual parts such as date validation and hash generation with multiple edge case scenarios to ensure they perform as expected.

Integration Testing ensures the systems can communicate properly with one another including all aspects of the backend and database including file uploads and status updates.

User Acceptance Testing (UAT) piloted with fifty application samples to determine average "Time-to-Issue" for all fifty applications, which is then compared with the average time using manual processes and shows that significant improvements can be made to efficiency.

V. Results and Discussion

A. Improvements to Performance

The simulation of a load test demonstrates an impressive reduction in Turnaround Time (TAT) for the Digital Workflow.

- Manual Process - 15 to 21 days due to the movement of files and the order in which they are processed (queuing).
- Digital Workflow - 2 to 5 days. This is possible because files no longer need to be moved physically, so we have reduced the risk of losing or missing files. The Digital Workflow ensures that batches of files are processed in the order they were submitted.

B. User Experience (UI/UX)

The "Faceless" nature of the system was successfully confirmed.

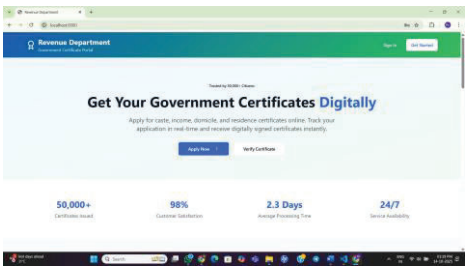

Fig. 3: Landing Page

Description: The Landing Page of the system is the primary entry point for the system users and gives an overview of the services offered and methods of working with the applicants and officials (login or register).

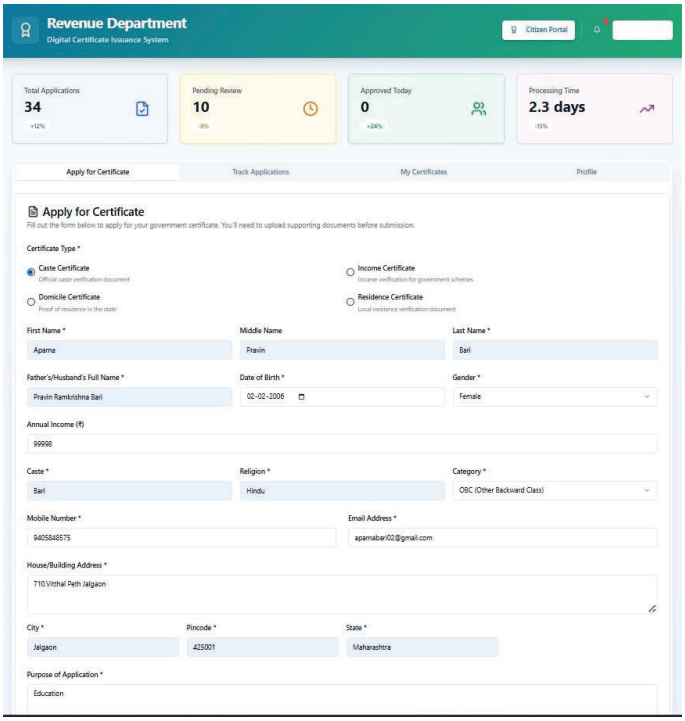

Fig. 4: Apply to Certificate

Description: Applicants are able to fill out an application for a variety of certificate types (Birth,Income,Caste, and Domicile). The application form requires the entry of personal information and to upload requested documents. Once the application is submitted, an application identifier is assigned for tracking the application.

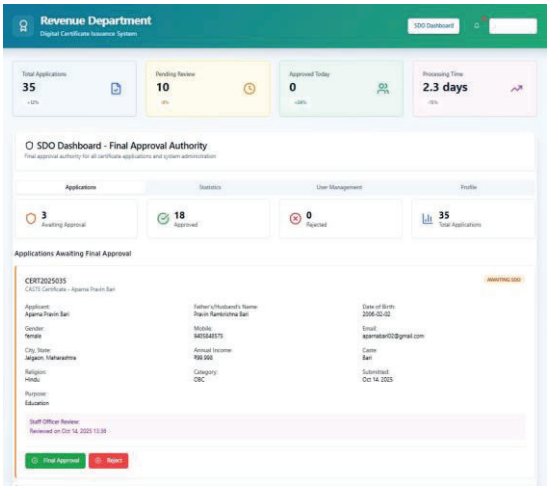

Fig. 5: SDO Dashboard

Description: The SDO Officer Dashboard allows SDOs to review all applications submitted to the SDO, including

International Journal of Engineering Research & Technology (IJERT)
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Vol. 14 Issue 12 , December - 2025

those pending and approved/verified applications. The SDO can review application detail, approve or reject applications and track what is happening with the system.

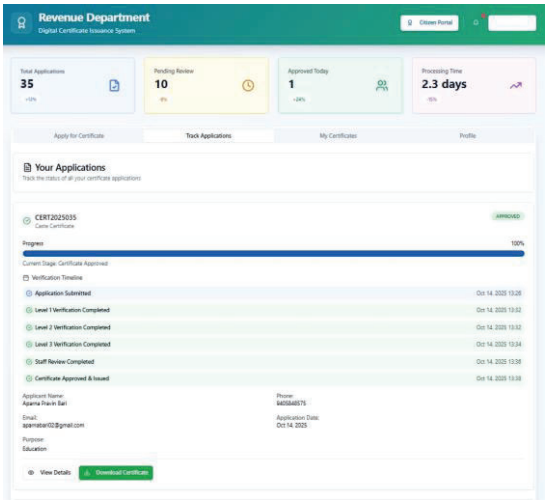

Fig. 6: Track Application

Description: Applicants can use the Track Application Interface to see what stage has been reached in the processing of their applications for certificates at any point in time. This interface shows the day that each exists filed for an applicant's request, the type of certificate being issued (e.g., Clerk, Staff, SDO), and whether the final decision was approved or rejected.

Fig. 7: Sample Certificate

Description: The Certificate View page allows users to view or download a copy of the certificate when it has been issued. The certificate contains a QR code or link that allows the user to verify that it is authentic.

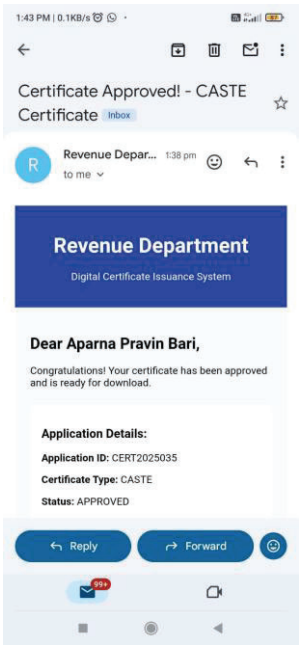

Fig. 8: Email Notification

Description: Every time a major event occurs in the course of an application (i.e., application received, verification complete, application approved or rejected), an email notification is sent automatically. This keeps the user informed on what is happening with their application.

C. Transparency and Accountability

Unalterable audit logs help to eliminate the "black-box" type of governance. A record of all administrative actions provides a deterrent against unethical acts. If an application is rejected, the officer has to select a reason from a set of pre-defined reasons through a drop-down box that is sent to the applicant to provide transparency.

VI. CONCLUSION

By utilizing a digital platform to provide citizens with the ability to apply for development and submit materials as well as to receive real-time updates about their application(s) development, the creation of a Web-Based Certificate Issuing System illustrates how digital solutions would eliminate the inconsistent delays that frequently occur within administrative processes.

This new system allows for significantly quicker and clearer processing through the use of multiple digital tools including the automated verification of documentation, the management of application submissions via structured queues, and the validation of certificate issuance via cryptographic hash techniques. Furthermore, because there are layers of architecture designed into the user interface, back-end logic and database, this layered architecture allows for easy updates to the system

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 12 , December - 2025

as well as to develop for continued scalability of the services provided to departments of governments.

Overall results show that there has been a drastic improvement in both the speed of processing application(s) completion as well as a clearer communication method for both citizens submitting applications as well as department personnel who have administered/processed the applications. Increased transparency and decreased administrative burden allow for improved ability to hold departments accountable, reduces redundancy in administrative workflows as well as blends with current e-Governance objectives through the creation of a more responsive and citizen/customer-centric model for the delivery of services.

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