

Title

**SMART PASSPORT PRE-APPLICATION AND APPOINTMENT SCHEDULING SYSTEM: A
DIGITAL ACCESS APPROACH FOR PASSPORT SERVICES IN MALAWI**

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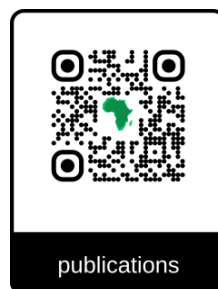
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Issued October 2026 Certificate

AR20267IM2WI



ABSTRACT

Passport application processes that rely on physical visits and manual, first-come-first-served procedures can result in long queues, repeated visits, and difficulties managing daily demand. This paper presents the design and development of a Smart Passport Pre-Application and Appointment Scheduling System intended to improve access to passport services in Malawi. The system integrates a web platform, a mobile application, and a USSD channel to accommodate applicants with different levels of internet access. It supports preliminary applications for new passports, renewals, and lost or damaged passport replacements, together with application status tracking and notifications. Applications are assigned to the nearest appropriate immigration office, where authorized administrators use office-specific dashboards to review and manage applications assigned to their respective offices. An appointment date is automatically allocated after an application is approved, based on the office's available appointment slots and daily capacity. The system also incorporates administrative reporting, applicant record management, and role-based access control. The reported technology stack includes React, React Native, Node.js, Express, and MySQL, while Africa's Talking sandbox services support USSD and SMS testing. Initial testing documented six test cases covering registration, application submission, administrator approval, USSD simulation, SMS notification, and database connectivity, all recorded as passed. However, further testing is required to evaluate the expanded functionality, mobile application performance, security, usability, and operational effectiveness. The proposed system demonstrates how integrated digital channels and capacity-based scheduling can support more organized and accessible passport application management in Malawi.

KEYWORDS: Passport services, e-government, appointment scheduling, USSD, digital public services, Malawi, web application, service accessibility

INTRODUCTION

Background of Study

Public service delivery is a critical component of national development, and efficient systems are essential to ensure that citizens receive timely and effective services. In many developing countries, including Malawi, government departments responsible for issuing passports face significant operational challenges due to reliance on manual and first-come-first-served processes. At the Malawi Immigration Department, passport application services often involve long queues, overcrowding, and extended waiting times. Citizens are required to physically visit immigration offices to initiate the application process, which leads to inefficiencies such as time wastage, congestion, and in some cases, failure to be served within a single day due to limited processing capacity. The absence of a structured appointment scheduling system contributes significantly to these challenges, as there is no mechanism to regulate the daily number of applicants. Furthermore, access to digital services remains uneven, with some citizens lacking internet connectivity, making it necessary to consider inclusive technological solutions. Advancements in information and communication technology provide an opportunity to address these issues through the development of digital systems that enhance service delivery. This study proposes the design and implementation of a Smart Passport PreApplication and Appointment Scheduling System that allows citizens to book appointments in advance through both web-based platforms and USSD technology. The system aims to reduce overcrowding, improve efficiency, and ensure equitable access to passport services.

RESEARCH OBJECTIVE

Objectives General

- To design and implement a Smart Passport Pre-Application and Appointment Scheduling System that improves service delivery by reducing queues and enhancing efficiency in passport application processes.

Specific Objectives

- To develop a web-based platform that allows citizens to submit preliminary passport application details.
- To design a USSD-based interface for users without internet access.
- To implement an automated appointment scheduling system based on daily capacity limits.
- To develop an administrative dashboard for managing appointments and monitoring applicants.
- To implement a notification system for informing applicants of their scheduled appointment dates.

LITERATURE REVIEW

Falah et al. (2025) investigated the implementation of online queue management systems in immigration offices with the aim of improving public service efficiency. The study focused on replacing traditional manual queuing systems with digital platforms that allow users to obtain queue numbers remotely. Using system analysis and user feedback, the researchers found that online queue systems significantly reduce congestion, waiting time, and overcrowding in service centers. The system also improved customer satisfaction by providing a more organized service structure. However, the study revealed that the system mainly focuses on queue management after users have already initiated the service process and does not support pre-application or appointment scheduling features. Additionally, it does not provide alternative access methods for users without internet connectivity. This highlights the need for a more comprehensive system that integrates pre-application, scheduling, and inclusive access methods such as USSD, as proposed in this study.

Ramesh et al. (2026) developed a smart appointment scheduling system integrated with queue management and waiting time prediction. The system utilizes real-time data and machine learning techniques to optimize appointment allocation and reduce overcrowding in service environments. The study demonstrated that integrating appointment scheduling with queue monitoring improves operational efficiency and reduces waiting time significantly. Furthermore, the system enhances decision-making by predicting peak hours and adjusting scheduling accordingly. Despite these advantages, the study is primarily focused on healthcare systems and relies heavily on advanced technologies such as machine learning, which may not be practical in low-resource environments. Additionally, the system does not consider accessibility challenges for users without internet access. This creates a gap for simpler, more inclusive systems that can be applied in public service sectors such as passport application.

Rodríguez (2026) explored intelligent queue

management systems that integrate appointment scheduling with predictive analytics to enhance service delivery. The study emphasized the importance of using data-driven approaches to manage customer flow and reduce waiting times. The findings indicated that such systems improve resource utilization, reduce congestion, and enhance overall efficiency in high-demand service environments. However, the study also noted that implementing such intelligent systems requires advanced infrastructure, technical expertise, and reliable internet connectivity. This makes them less suitable for developing countries where access to technology may be limited. Moreover, the study does not address the needs of users without internet access, highlighting the importance of incorporating simpler technologies such as USSD to ensure inclusivity.

Siddiqui et al. (2025) examined advanced queuing models in smart service systems, focusing on improving system efficiency through the use of modern technologies such as blockchain and data analytics. The study demonstrated that digital queue systems can enhance transparency, reliability, and efficiency in service delivery. By automating queue processes and integrating advanced technologies, the system minimizes delays and improves user experience. However, the study is highly technical and complex, making it difficult to implement in real-world public service environments, especially in developing countries. Additionally, it does not consider user accessibility challenges, particularly for individuals without access to internet-enabled devices. This suggests the need for simpler and more practical solutions that can be easily implemented and accessed by a wider population.

Baballe (2022) analyzed the shortcomings of traditional queue management systems in public institutions. The study highlighted that many organizations still rely on manual processes, which lead to inefficiencies such as long waiting times, overcrowding, and poor service delivery. The research emphasized that the absence of digital systems limits the ability to manage customer flow effectively and results in dissatisfaction among users. Furthermore, the study identified the lack of appointment scheduling mechanisms as a major contributor to congestion in service centers. However, the study did not propose a comprehensive digital solution that integrates queue management with pre-application and scheduling features. This gap supports the need for a modern system that combines these functionalities to improve service delivery.

METHODOLOGY

The system was developed using the Agile software development methodology, which emphasizes iterative development, continuous testing, and flexibility. This approach

allowed the system to be developed in stages, starting with core functionalities such as user registration and login, followed by more advanced features like appointment scheduling and notifications. Each stage of development involved planning, implementation, testing, and evaluation. This ensured that errors were identified and corrected early, leading to a more stable and reliable system. The use of Agile methodology also made it easier to adapt to changes and improvements during the development process.

SYSTEM DESIGN

This chapter presents the design of the Smart Passport Pre-Application and Appointment Scheduling System. It explains how the system is structured, how different components interact, and how data flows within the system. The design phase translates the system requirements identified in the previous chapter into a blueprint that guides the development process. Various design tools such as system architecture, use case diagrams, data flow diagrams, and class diagrams are used to provide a clear understanding of the system.

SYSTEM ARCHITECTURE

The system adopts a client-server architecture consisting of three main components: the user interface, the application server, and the database. The user interface includes both a web application and a USSD interface, allowing users to interact with the system either through the internet or via mobile networks. The application server, developed using Node.js and Express, processes user requests and contains modules such as authentication, application processing, appointment scheduling, notification handling, and reporting. The database, implemented using MySQL, stores user information, application details, appointment records, and system logs.

USE CASE DIAGRAM

The use case diagram illustrates the interaction between the system and its main actors, namely the applicant and the administrator. The

applicant interacts with the system by registering an account, logging in, submitting a pre-application, requesting an appointment, and receiving notifications. On the other hand, the administrator is responsible for managing appointments, controlling daily capacity, monitoring attendance, and managing users.

DATA FLOW DIAGRAM

The data flow diagram represents how data moves within the system. Applicants provide registration details, application information, and appointment requests to the system. This data is processed by the system and stored in the database. The system retrieves relevant information when needed and generates outputs such as appointment confirmations and notifications.

CLASS DIAGRAM

The class diagram describes the structure of the system in terms of classes and their relationships. Key classes in the system include User, Application, Appointment, Notification, and Admin. The User class stores personal details and authentication information, while the Application class contains pre-application data submitted by users. The Appointment class manages scheduling details, including assigned dates and status. The Notification class handles communication with users, and the Admin class represents administrative operations such as managing users and appointments. Relationships between these classes ensure proper data organization and system functionality.

INPUT DESIGN

Input design focuses on how data is entered into the system. The system provides userfriendly forms for registration, login, and application submission. These forms are designed to be simple and intuitive, ensuring that users can easily provide the required information. Validation mechanisms are implemented to ensure data accuracy and completeness. For example, users must enter valid phone numbers and all required fields must be filled before submission. This reduces errors and improves the quality of data stored in the system.

OUTPUT DESIGN

Output design defines how information is presented to users. The system provides clear and concise outputs such as registration confirmations, login responses, appointment details, and notifications. These outputs are displayed through the web interface and can also be sent via SMS for users accessing the

system through USSD. The design ensures that users receive timely and understandable feedback, improving their overall experience with the system.

TABLE DESIGN

The table design defines the structure of the database used in the system. The main tables include users, applications, appointments, and notifications. The users table stores user details such as name, national ID, phone number, and password. The applications table stores pre-application data, while the appointments table records scheduled dates and status. Relationships between these tables are established using primary and foreign keys to ensure data integrity. This design supports efficient data storage, retrieval, and management within the system.

SYSTEM DEVELOPMENT

Functional Modules

The system is divided into several functional modules, each responsible for a specific task within the application. These modules work together to ensure smooth system operation.

Authentication Module

The authentication module is responsible for managing user access to the system. It allows new users to register by providing personal details such as name, national ID, phone number, and password. It also enables existing users to log into the system using their credentials. This module ensures that only authorized users can access system functionalities and protects user data through secure login mechanisms.

Application Submission Module

The application submission module allows users to submit their passport pre-application details. It collects necessary user information and ensures that all required fields are completed before submission. The module also checks for duplicate applications using identifiers such as

national ID and phone number. Once validated, the application is stored in the database with a pending status.

Appointment Scheduling Module

The appointment scheduling module is the core component of the system. It is responsible for assigning appointment dates to users automatically. The system does not allow users to select dates; instead, it allocates appointments based on availability and system capacity. This helps in preventing overcrowding and ensures fair distribution of appointment slots.

Admin Management Module

The admin management module provides administrators with tools to manage the system. It allows them to view applications, approve or reject requests, and monitor system performance. Administrators can also control system settings such as daily appointment capacity, which influences how appointments are scheduled.

Notification Module

The notification module is responsible for sending messages to users regarding their application status. It informs users when their application is submitted, when an appointment is scheduled, and when there are updates such as approval or rejection. It also sends reminders before the appointment date to ensure users do not miss their scheduled time.

User Dashboard Module

The user dashboard module provides users with a personalized interface where they can view their application status, appointment details, and notifications. It allows users to track their progress and stay informed about updates related to their application.

Theme Management Module

The theme management module enhances the user experience by allowing users to switch between different display modes such as light and dark themes. It ensures consistency in the user interface and stores user preferences for future sessions.

Database Module

The database module is responsible for storing and managing all system data. It maintains user information, application records, appointment details, notifications, and system settings. The database ensures data integrity and supports efficient retrieval and storage operations.

Algorithms Used in the System

The system uses several algorithms to ensure efficient processing, security, and fair scheduling of appointments.

- **Password Hashing Algorithm**

The system uses the bcrypt hashing algorithm to secure user passwords. During registration, the password provided by the user is converted into a hashed format using a salt value. This ensures that the original password is not stored in the database. During login, the system compares the entered password with the stored hash to verify user identity.

- **Sequential Algorithm**

A sequential algorithm is used in processes that follow a fixed step-by-step flow, such as user registration and application submission. In these processes, data is collected, validated, processed, and stored in a logical sequence without any branching or repetition.

- **Selection Algorithm**

A selection algorithm is used in decision-making processes such as user login and application validation. The system checks conditions such as whether a user exists or whether the password is correct. Based on these conditions, the system determines the appropriate response, such as granting access or displaying an error message.

- **Iterative Algorithm**

An iterative algorithm is used in the appointment scheduling process. The system repeatedly checks available dates against the daily capacity limit. If a date is fully booked, the system moves to the next date and continues the process until an available slot is found. This ensures that appointments are allocated efficiently without exceeding capacity.

- **Queue-Based Scheduling Algorithm**

The system also implements a queue-based scheduling algorithm to ensure fairness in

appointment allocation. Applications are processed in the order they are received. The system calculates the position of each application in the queue and assigns an appointment date based on the number of applications already in the system and the daily capacity limit.

SYSTEM TESTING

System testing is performed to verify that the complete Smart Passport System functions correctly as an integrated system. This phase evaluates the interaction between the frontend, backend, database, and Africa's Talking USSD/SMS services. The purpose of testing is to ensure that all modules work together properly and that the system satisfies the specified requirements. The testing process also confirms that the system behaves correctly during real user operations such as user registration, passport application submission, application approval or rejection, automatic appointment scheduling, report generation, and SMS/USSD notifications.

The system testing process was conducted to assess the functionality, integration, security, performance, usability, acceptance, compatibility, user acceptance, and regression capabilities of the Smart Passport System.

Functional testing was intended to verify that all system functionalities met the specified requirements. Test cases covered user registration, passport application, data verification, and profile updates. The expected result was that create, read, update, and delete operations would work correctly and that the system would process data without errors. The USSD simulator was also tested to determine whether commands executed properly and returned appropriate responses. In addition, the notification system was assessed to verify that alerts were delivered successfully to users' notification inboxes. The recorded results were marked as passed.

Integration testing focused on the interaction and data flow between different system components. Tests examined communication between the frontend and backend to ensure that data moved accurately between the presentation layer and business logic. Database connectivity and data persistence were also assessed by storing and retrieving information from the MySQL database. API endpoints were tested to verify that they returned the expected status codes and data formats. Furthermore, the integration between the notification system and the main application was examined to ensure that notifications were triggered when relevant events occurred. The recorded results were marked as passed.

Security testing aimed to determine whether the system could protect user information and prevent unauthorized access. Invalid

login attempts using incorrect credentials were tested to confirm that access was rejected. SQL injection test inputs were intended to assess whether the system handled potentially harmful inputs safely. Authentication tokens and session management were examined to verify that expired tokens and unauthorized requests were rejected. Role-based access control was also tested by attempting to access data without the required permissions. The recorded results were marked as passed.

Performance testing was intended to assess the system's efficiency under normal and heavy workloads. One test scenario involved evaluating response times with 50 concurrent users, with an expected response time below two seconds while maintaining system stability. Load testing of critical API endpoints was intended to identify bottlenecks and determine how well the system handled increased workloads. Database query performance was also considered to assess whether queries completed within acceptable time limits. The recorded results were marked as passed.

Usability testing focused on determining whether the system was easy to use, particularly for people with limited technical knowledge. Navigation tests were designed to establish whether users could complete tasks without confusion. Form validation was assessed by submitting invalid information and checking whether clear error messages guided users towards correcting their inputs. Responsive design testing was also intended to verify that the interface displayed appropriately on mobile phones, tablets, and desktop computers. The recorded results were marked as passed.

Acceptance testing was intended to determine whether the system met its business and user requirements. The proposed test involved inviting ESCOM end-users to evaluate the system under realistic conditions and confirm whether the requirements were satisfied. A feature-completeness test compared the implemented functions against the system requirements checklist. Real-world workflow testing focused on passport application and application-status tracking to determine whether users could complete these processes successfully. The recorded results were marked

as passed.

Compatibility testing was designed to assess whether the system operated consistently across different software and network environments. Browser compatibility tests covered Google Chrome, Mozilla Firefox, Safari, and Microsoft Edge. Operating-system compatibility testing considered Windows, macOS, and Linux, particularly for backend API functionality. USSD network compatibility testing was also intended to assess operation across MTN, Airtel, and Vodafone networks. The recorded results were marked as passed.

User acceptance testing (UAT) focused on validating the system against stakeholder expectations. Test scenarios were designed for government officials and citizens to assess whether the system met their requirements. End-to-end workflow testing examined whether citizens could complete the passport application and status-tracking processes. The recorded results were marked as passed.

Regression testing was intended to ensure that software updates and bug fixes did not introduce new problems. Functional tests were to be repeated after code changes to determine whether previously working features remained operational. Additional tests were designed to verify that bug fixes did not negatively affect existing functionality. The recorded results were marked as passed.

FEEDBACK FROM USERS

Feedback was collected from users during the testing and demonstration of the Smart Passport System. Users reported that the system was easy to use, responsive, and effective in simplifying passport application processes. The online application process reduced manual paperwork and improved accessibility for applicants. Administrators appreciated the automated appointment scheduling feature, report generation module, and backup management system because these functionalities improved efficiency in managing applications. Users also found the USSD service useful for accessing passport services without internet connectivity. The feedback received indicated that the Smart Passport System successfully achieved its objectives of improving passport application management, reducing processing delays, and providing accessible digital services for both online and offline users.

CONCLUSION

The Smart Passport System was successfully developed as a

digital platform for managing passport applications and appointment scheduling. The system was designed to improve the traditional manual passport application process by introducing online services, automated scheduling, and efficient communication between applicants and immigration offices. Through the system, applicants can submit passport applications online or through USSD services, making the platform accessible to both internet and non-internet users. The project successfully implemented important functionalities such as user registration, online passport application, application approval and rejection, automatic appointment scheduling, report generation, backup management, and SMS/USSD communication. The integration of Africa's Talking sandbox also enabled testing of SMS notifications and USSD services for offline accessibility. The admin dashboard provides immigration officers with tools for managing applications, monitoring appointments, generating reports, and maintaining system records efficiently. The Smart Passport System improves service delivery by reducing paperwork, minimizing delays, and improving transparency in the passport application process. Applicants are able to track their application status and receive appointment notifications automatically. The system also improves operational efficiency within immigration offices by automating repetitive processes such as appointment scheduling and notifications. Overall, the project achieved its main objective of developing a smart, reliable, and accessible digital passport management system. The system demonstrates how modern web technologies and communication services can be used to improve government services and support digital transformation in Malawi.

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