Title

DIGITAL DRIVERS HUB: THE MALAWI ROAD TRAFFIC USER/CITIZEN INTERACTION SYSTEM

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ABSTRACT

Road traffic management in Malawi continues to face challenges associated with paper-based workflows, fragmented records, delayed processing, limited application visibility, fraud risks, and weak coordination of road-safety information. This paper presents Digital Drivers Hub, a citizen-interaction platform proposed to modernise driver licensing, vehicle registration, road-incident reporting, and traffic-fine management. The system brings citizen-facing services and administrative workflows into a central digital environment. Its design uses a React and Vite web frontend with Supabase services and a PostgreSQL database, including role-based access control and Row Level Security. Planned capabilities include online applications, supporting-document uploads, digital records, QR-code verification, incident reporting with location data, notifications, and administrative dashboards. The interface is designed for mobile use and low-bandwidth conditions relevant to Malawi. The project demonstrates a practical software approach to improving access, traceability, and operational oversight; however, any claims about national service improvements require further evaluation and authorised integration with government systems.

KEYWORDS: Digital government; road traffic management; Malawi; driver licensing; vehicle registration; citizen services; Supabase; PostgreSQL

INTRODUCTION

1.0 INTRODUCTION

Road traffic management is a vital government function that has a direct impact on public safety, economic productivity and the convenience of citizens in their daily lives. It is the Directorate of Road Traffic and Safety Services (DRTSS) in Malawi that performs important services such as driver licensing, vehicle registration and road safety enforcement. And whilst they are servicing a growing population of drivers and vehicles, these services still largely operate around manual paper-based processes.

In the traditional system, citizens had to visit physical offices to submit applications, show supporting documents, take photos and make payments. This approach has been working for decades but the pure increase in number of vehicles and licensed drivers has put a tremendous strain on the system. Long queues, delays in processing and sometimes even loss of documents have frustrated the public to a great extent.

But the manual system also creates systemic challenges, not just inconveniences. This includes an increased risk of fraud, inaccuracies in financial reporting and delays in the collection and sharing of critical road safety data. Such weaknesses undermine both the delivery of services and informed decision making at policy level.

Driver's Digital Hub was designed as a comprehensive solution to these challenges. It provides a centralized digital platform to manage the entire lifecycle of driver and vehicle related services from application submission and document verification to approvals and payments all in one integrated system. This platform digitizes the

processes that significantly improve the operational efficiency, transparency, and the real-time availability of information to the citizens and the government administrators.

The Driver's Digital Hub has been tailored for low bandwidth environments, in light of the specific context of Malawi, including limited and uneven internet connectivity throughout the country. The system boasts a clear, intuitive and structured user interface, built on the principle of Tactical Clarity, ensuring accessibility and ease of use for both the ordinary citizens and the DRTSS staff, regardless of their digital literacy level.

This initiative is a significant step in the digitalisation of Malawi road traffic management through the Driver's Digital Hub, providing faster, more reliable and more transparent services and laying a robust foundation for future digital governance.

BACKGROUND OF THE STUDY

1.1 BACKGROUND OF THE STUDY

Road traffic management is an essential government function that directly impacts safety, economic activity, and everyday convenience. In Malawi, these services such as driver licensing, vehicle registration, and road safety enforcement are handled by the Directorate of Road Traffic and Safety Services (DRTSS) and are still largely paper-based.

Traditionally, citizens must physically visit offices to submit applications, present documents, take photos, and make payments. While this approach has worked for years, increasing numbers of vehicles and drivers have put heavy pressure on the system. This has resulted in long queues, delays, and occasional loss of paperwork, which frustrates users.

The manual system also creates deeper issues, including opportunities for fraud, inaccurate financial reporting, and delays in sharing important road safety data. These weaknesses affect both service delivery and decision-making.

Driver's Digital Hub was developed to address these challenges by introducing a centralized digital platform for managing the full lifecycle of driver and vehicle services. It allows applications, verification's, approvals, and payments to be handled within one system, improving efficiency, transparency, and access to information in real time.

The system is designed with Malawi's conditions in mind, including limited and uneven internet access. It is optimized to work smoothly on low connectivity and uses a simple, structured interface approach ("Tactical Clarity") to ensure it remains easy to use for both citizens and government staff.

PROBLEM STATEMENT

1.2 PROBLEM STATEMENT

Despite ongoing attempts to improve Malawi's road traffic services, these services still have serious problems because they continue to depend on manual and semi-digital processes. These issues impact citizens, the performance of government and road safety outcomes.

For citizens, services such as driver's license applications and vehicle registration require multiple physical visits to offices. People must

submit hard copy documents, wait in long queues, and often experience delays of several weeks. Without an online system for tracking applications or receiving updates, the process becomes even more frustrating, especially for those living far from cities like Lilongwe or Blantyre, where travel adds extra cost and time.

Fraud is also a serious problem. The absence of a centralized verification system makes it easier for unqualified individuals to obtain licenses or for fake documents to circulate. This weakens road safety, as some drivers may not have been properly tested or certified. Vehicle records can also be manipulated, making it harder to trace stolen vehicles or enforce compliance.

Record keeping remains inefficient because paper-based files are easily lost, damaged, or difficult to retrieve. This limits enforcement, as traffic officers often have no quick way to confirm whether a license or vehicle registration is valid during roadside checks.

Incident reporting is another gap. Road accidents are recorded through manual police reports that are rarely compiled into a centralized database. As a result, authorities lack reliable data to identify accident hotspots or improve road safety planning.

Financial tracking is also weak. Traffic fines are often handled in cash or through manual deposits, which increases the risk of errors and makes it difficult to confirm whether all revenue reaches government accounts.

Finally, the absence of real-time dashboards means administrators cannot effectively monitor system performance or make timely decisions, relying instead on outdated periodic reports.

Driver's Digital Hub is designed to solve these challenges by centralizing data, automating processes, and providing real-time access to information across all road traffic operations.

RESEARCH OBJECTIVES

1.3 OBJECTIVES

The primary objective of this project was to develop a secure, scalable, and intelligent digital road management platform that modernizes driver and vehicle services while improving road safety and operational transparency in Malawi.

To achieve this primary objective, the following specific objectives were defined:

1.3.1 Digitize driver licensing workflows:

The system provides online application forms, document upload capabilities, and digital approval processes that eliminate the need for multiple physical visits.

1.3.2 Enable online vehicle registration:

Vehicle owners can register new vehicles, transfer ownership, and access digital registration certificates through the platform.

1.3.3 Implement secure biometric identity verification:

The system captures and verifies biometric data to ensure that license applicants are who they claim to be, reducing identity fraud.

1.3.4 Provide digital temporary registration certificates:

When permanent licenses or certificates are being processed, the system generates time-limited digital documents that serve as proof of registration.

1.3.5 Enable real-time road incident reporting:

Citizens and officers can report accidents, hazards, and other incidents directly through the platform with GPS location data and multimedia attachments.

1.3.6 Improve traffic fine management and payment processing:

Fines are issued digitally, and citizens can pay through integrated payment channels with automatic receipt generation.

1.3.7 Create centralized driver and vehicle databases:

All records are stored in a structured PostgreSQL database that supports fast searching, filtering, and reporting.

1.3.8 Support real-time administrative monitoring:

Administrators have access to dashboards showing application volumes, processing times, incident locations, and revenue collection statistics.

1.3.9 Reduce fraud and corruption:

Digital verification, audit trails, and transparent workflows make fraudulent activities more difficult and easier to detect.

1.3.10 Improve citizen accessibility:

The platform is mobile-responsive and designed to work on low-bandwidth connections, making services accessible to citizens across Malawi.

LITERATURE REVIEW

1.4 Literature Review

This section reviews existing studies and digital road management systems related to transport services and digital transformation in Malawi. The review helps to understand the challenges affecting current systems and how Driver's Digital Hub can provide a better solution.

Malawi's E-Government Context

Over the past few years, the Malawi government has been working toward improving digital public services. The National Digitalization Policy (Government of Malawi, 2023) was introduced to support the digitization of government operations and improve service delivery across different sectors. Despite this progress, several challenges still exist, especially in rural areas where internet access and digital infrastructure remain limited (Chawani & Mndolo, 2024).

According to the United Nations Development Programme (UNDP, 2026) Digital Readiness Assessment Report, Malawi still faces problems such as poor system integration, low digital skills, and limited interoperability between government platforms. This means many institutions still operate independently without sharing information effectively.

Research by the Centre for Policy and Research on Digital Society (CPRDS, 2024) also revealed that some digital systems in Malawi fail because too many processes still depend on manual intervention. Staff training, resistance to technological change, and inefficient workflows continue to slow down service delivery (Phiri & Banda, 2024). These findings influenced the design of Driver's Digital

Hub, which focuses on automation, centralized management, and user-friendly workflows.

The MalTIS Experience

The Malawi Traffic Information System (MalTIS) is one of the existing digital systems used by the Directorate of Road Traffic and Safety Services (DRTSS). The system handles services such as vehicle registration and driver licensing. However, several reports published between 2024 and 2025 showed that MalTIS experienced frequent network failures and system downtime (DRTSS, 2024; MalTIS Technical Audit Report, 2025).

In some situations, citizens failed to renew licenses or obtain documents because the system was offline for several days. Reports also showed that technical support depended heavily on foreign companies managing the system outside Malawi (Chikonde, 2025). This created delays whenever faults occurred because local authorities had limited control over the infrastructure.

These problems demonstrated the importance of building systems that are reliable, locally manageable, and scalable. Driver's Digital Hub addresses this issue by using modern open-source technologies such as Supabase and PostgreSQL, which allow better flexibility and local system management.

Road Safety Data and Incident Reporting

Road accident reporting in Malawi is still largely manual and poorly coordinated. Studies published in Injury Epidemiology (Manda et al., 2022) showed that Malawi lacks a centralized and real-time reporting system for road accidents and injuries. Because of this, authorities often struggle to collect accurate and timely information for planning and emergency response.

The Driver's Digital Hub project introduces a GPS-based incident reporting feature that allows users to report accidents in real time. This improves response coordination while also helping authorities collect reliable road safety data for analysis and decision-making (Kumwenda, 2025).

Digital Transformation Challenges in Malawi

Several studies have shown that Malawi's digital transformation journey still faces major challenges. The Open Government Partnership (OGP, 2025) noted that weak infrastructure, unstable internet connectivity, outdated systems, and limited smartphone access continue to affect the success of e-government services.

In addition, some researchers argue that many institutions are only converting paper systems into digital forms without fully redesigning how services operate (Mapemba & Chimwaza, 2024). This often results in digital systems that still inherit the same inefficiencies found in manual processes.

Driver's Digital Hub was designed with these challenges in mind. The system includes features such as biometric verification, QR-code validation, role-based access control, and real-time notifications to improve transparency and reduce fraud. The platform was also optimized for mobile devices and low-bandwidth environments to improve accessibility for users across Malawi.

Implications for Driver's Digital Hub

The literature reviewed shows that successful digital systems require more than just technology. Factors such as usability, automation, infrastructure control, accessibility, and proper system integration are equally important.

Driver's Digital Hub was therefore developed to provide a practical and modern digital road management platform capable of addressing many of the weaknesses identified in previous systems. By combining centralized services, real-time operations, and secure verification methods, the platform aims to support Malawi's broader digital transformation and road safety modernization efforts.

QR Code Verification

QR codes have gained acceptance as a low-cost verification method in government services. A study by Kato and Tan (2017) found that QR codes provide a balance between security and usability—easier to implement than Near Field Communication (NFC) or Radio Frequency Identification (RFID), but more secure than manual entry of reference numbers.

In Driver's Digital Hub, generated licenses include QR codes that encode the license number and a signed verification token. Traffic officers can scan these codes using any smartphone camera to verify license validity, even without dedicated hardware.

Database Security and Row Level Security

PostgreSQL's Row Level Security (RLS) feature has been recommended for multi-tenant applications where users should only access their own data (Supabase Documentation, 2023). RLS policies are defined as SQL expressions that filter query results based on user identity. For Driver's Digital Hub, RLS ensures that citizens see only their own applications; driving schools see only their enrolled students, and administrators have broader access for monitoring purposes.

Gaps in Existing Literature

While substantial research exists on e-government and digital identity systems, few studies focus specifically on road traffic management in low-income countries with limited internet infrastructure (Mkandawire & Chiumia, 2025). Most published case studies describe systems in middle-income or high-income countries where connectivity and digital literacy levels differ significantly from Malawi's context.

This project contributes to filling that gap by documenting a system designed specifically for local conditions such as being mobile-first, bandwidth-efficient, and built on open-source technologies that do not require expensive licensing fees.

SYSTEM ANALYSIS

2.0 INTRODUCTION

Before developing Driver's Digital Hub, I conducted an analysis of the current road traffic management processes in Malawi to understand how services are delivered and where the pain points exist.

The existing system is primarily manual. A citizen seeking a driver's license must first visit a road traffic office to obtain application forms. These forms are completed by hand and submitted along

with supporting documents such as a national ID, medical certificate, and driving school completion letter. The applicant then waits while a clerk checks the documents, after which payment is made at a separate cashier window.

For photo capture, applicants proceed to a designated photography area where an officer takes a physical photograph, prints it, and attaches it to the paper application. The completed application is then placed into a queue for review by a licensing officer. This review can take several days or weeks, depending on workload and staff availability.

Once approved, the license is printed on a card using a specialized printer, laminated, and made available for collection. The applicant must return to the office to pick it up, often waiting in another queue for final verification.

Vehicle registration follows a similar pattern. New vehicle owners submit purchase documents, customs clearance forms, and identification to a registration officer. A physical registration book (bluebook) is prepared by hand or using basic computer templates, stamped, and issued to the owner. Duplicate copies are filed in cabinets at the office.

Incident reporting occurs through police stations rather than road traffic offices. When an accident happens, involved parties visit the nearest police post to make a statement. Officers take down details on a form, which is then filed locally. There is no automatic process for sharing this data with road traffic authorities or for aggregating incident statistics nationally.

Fine collection operates on a separate track. Traffic officers issue physical fine slips to offenders, who must then visit a bank or road traffic office to make payment. The paid slip is returned to the traffic office to clear the record. This disconnected process creates opportunities for revenue leakage, as there is no direct verification that payments reach the correct accounts.

Data storage across these processes is fragmented. Some offices maintain digital spreadsheets, others rely entirely on paper ledgers. There is no central database linking driver records to vehicle registrations to incident reports. When an officer needs to check a driver's history, they must physically request files from multiple offices, a process that can take days.

2.1 Problems in Existing System

The analysis of the existing system revealed several specific problems that Driver's Digital Hub was designed to address.

2.1.1 Processing Delays: Because applications move physically between desks and offices, processing times are unpredictable. A straightforward license renewal that should take minutes can stretch to weeks if files are misplaced or staff are absent. During my observation, I noted that the average time from application submission to license collection was approximately fourteen working days.

2.1.2 Fraud Vulnerability: The manual verification process relies heavily on document appearance and clerk judgment. I found that it would be relatively easy for an individual to submit falsified driving school certificates or medical reports, as there is no

digital verification connecting these documents to their issuing institutions.

2.1.3 Poor Record Accessibility

Paper records stored in cabinets are searchable only by physically browsing files. This makes it impractical for officers to check a driver's history during roadside stops. It also means that when a driver loses their physical license, there is no way to obtain a replacement quickly without re-submitting full documentation.

2.1.4 No Incident Intelligence

Without a centralized incident database, road safety authorities cannot identify accident hotspots or analyze crash causes. This limits their ability to target interventions such as signage improvements or enforcement campaigns to locations where they are most needed.

2.1.5 Revenue Leakage

The separation between fine issuance and payment collection makes it difficult to ensure that all issued fines are eventually paid. I identified several scenarios where fine slips could be lost or destroyed, effectively canceling the penalty without having official records.

2.1.6 Limited Public Access

Citizens living outside major cities must travel long distances to access services. For a farmer in Nkhata Bay, spending a day traveling to Mzuzu for a license application means lost income and transport expenses that effectively increase the cost of the service.

2.1.7 No Transparency

Applicants have no way to check the status of their applications without visiting the office in person. This creates uncertainty and often leads to multiple unnecessary visits as applicants check whether their documents are ready.

2.1.8 Difficult Compliance Monitoring

The system does not provide administrators with easy visibility into which driving schools are producing successful candidates or which vehicle owners have expired licenses. Compliance monitoring therefore depends on manual audits, which are resource-intensive and infrequent.

FEASIBILITY AND PROPOSED SYSTEM

2.2 FEASIBILITY STUDY

Before committing to full development, I conducted a feasibility study examining technical, operational, economic, and legal aspects of Driver's Digital Hub.

2.2.1 Technical Feasibility

From a technical perspective, the project is feasible. The selected technology stack React with Vite for frontend; Supabase for backend is well documented and supported by active developer communities. I had prior experience with React and Supabase from previous coursework, which reduced the learning curve.

The system requirements are relatively modest. It can run on a standard web server for the frontend, while Supabase (or a self-hosted PostgreSQL setup) handles the backend services. On the user side, only a modern web browser and internet connection are required, which is increasingly accessible in Malawi through mobile data.

The main technical challenge is unreliable internet connectivity. To address this, the frontend was optimized to reduce unnecessary server requests and includes optimistic UI updates to maintain usability during brief connection drops. In future versions, offline functionality using local storage could further improve reliability in low connectivity areas.

2.2.2 Operational Feasibility

Operational feasibility looks at whether the system can realistically fit into existing government workflows and be used by the people involved.

In this case, the main challenge is not technology but the users and processes. Feedback from road traffic staff shows mixed reactions; younger officers are generally open to digital tools, while some senior staff are more cautious due to concerns about job security and adapting to new systems. This means successful implementation will require proper training and change management to help staff transition smoothly.

Another important factor is citizen access to technology. Since not everyone in Malawi has a smartphone or reliable internet, the system is designed to work on basic smartphones using mobile data. In future, it could also include USSD support so that even feature phone users can access key services.

2.2.3 Economic Feasibility

The project is economically feasible because it uses open-source technologies such as React, Supabase, and PostgreSQL, which reduces software costs. Supabase also offers a free tier suitable for initial deployment.

The main costs involve development, training, maintenance, and technical support. However, the system is expected to reduce paperwork, improve revenue collection, reduce fraud, and increase operational efficiency, making it cost-effective in the long term.

2.2.4 Legal Feasibility

Legal feasibility involves compliance with data protection and privacy regulations. Malawi has the Electronic Transactions and Cyber Security Act, which provides a framework for digital signatures and data protection. The system was designed with privacy principles in mind, storing only necessary personal data and implementing access controls to prevent unauthorized viewing.

Biometric data collection raises particular legal considerations. The system stores biometric templates rather than raw images where possible, and all biometric operations require explicit user consent.

2.3 PROPOSED SYSTEM

Driver's Digital Hub is proposed as a modern digital platform that will replace the manual and disconnected road traffic processes currently being used. Instead of handling services separately, the system brings citizens, driving schools, and administrators together into one centralized environment.

The main idea behind the proposed system is to make road traffic services easier, faster, and more transparent by allowing most processes to be completed online with minimal physical visits to offices.

For driver licensing, users can apply online, upload required documents, make payments digitally, and receive updates in real time. The system also supports biometric verification and QR-code validation to improve security and reduce fraud.

For vehicle registration, users can submit ownership details digitally and receive electronic bluebooks and registration records. This helps improve record management while reducing paperwork and processing delays.

The proposed system also introduces a real-time incident reporting module, which is not available in the current system. Citizens can report accidents or road hazards using their mobile devices, while GPS location and images can be attached automatically. This allows administrators to respond faster and monitor incidents more effectively.

Administrators will have access to dashboards that display important information such as pending applications, payment records, incident reports, and system activities in real time. This improves monitoring and decision-making compared to traditional paper-based reporting methods.

The system also uses Role-Based Access Control (RBAC), meaning each user only accesses information related to their responsibilities. Citizens manage their own records; driving schools manage student information, and administrators oversee the entire system.

In addition, real-time notifications help keep users updated throughout every process. Applicants receive updates whenever their applications are reviewed, approved, or rejected, reducing the need for physical follow ups and improving overall transparency.

SYSTEM DESIGN AND ARCHITECTURE

3.0 INTRODUCTION

This chapter presents the design of the proposed system, It translates the requirements identified in into a structured system blueprint. The design focuses on how the system components interact, how data flows across modules, and how users interact with the platform.

The system design ensures scalability, security, usability, and interoperability. Various design tools such as system architecture, use case diagrams, data flow diagrams, and class diagrams are used to visually represent the system structure.

3.1 SYSTEM ARCHITECTURE

Driver's Digital Hub is designed on a modern client-server architecture and has a well defined separation of concerns between the frontend and backend. This design choice was made to improve maintainability, scalability and security.

The frontend is a single-page application built with React 18 and Vite. When a user accesses the system, the browser downloads a bundle of JavaScript, CSS, and HTML files. All subsequent interactions happen through API calls to the backend, with page updates handled client-side rather than through full page reloads. This approach reduces bandwidth usage and provides a smoother user experience.

The backend is provided by Supabase, which is a platform built on top of PostgreSQL. Supabase handles authentication, database storage, file storage, and real-time subscriptions. I chose Supabase over

building a custom backend because it provides these features out of the box, significantly reducing development time while maintaining security.

Communication between frontend and backend happens through HTTPS requests. For standard data operations (create, read, update, delete), the frontend uses Supabase's client library, which automatically handles authentication headers and response parsing. For real-time features, the frontend opens a WebSocket connection that stays open while the user is active, allowing the backend to push updates instantly.

The database layer is PostgreSQL with Row Level Security policies. Each table has associated policies that determine which users can perform which operations. For example, the licenses table has a policy that allows citizens to read their own licenses but not those of others, while administrators can read all licenses.

File storage (photographs, uploaded documents, incident images) is handled by Supabase Storage. Each file is stored in a bucket with its own access policies. License photos, for instance, are stored in a private bucket accessible only to the individual and administrators, while incident images may be stored in a bucket with different access rules.

The system does not include a dedicated caching layer at this stage, as expected user volumes are moderate. If the system scales significantly in the future, Redis or a similar cache could be added between the frontend and database.

Figure 3.2 System Architecture Diagram

METHODOLOGY AND DEVELOPMENT

4.0 INTRODUCTION

This chapter presents the actual development process of the DDH. It provides a detailed description of the system modules, the technologies used in their implementation, key algorithms applied, and how the various components work together to achieve the project objectives.

4.1 METHODOLOGY

I used an Agile development methodology for this project, specifically a simplified version of Scrum adapted for a single developer working within a limited timeframe.

The decision to use Agile rather than Waterfall was based on the project's complexity and uncertainty. While I had a clear vision of the final system, many details are exactly how the biometric capture should work, what information administrators need on dashboards, and how the real-time notifications should behave emerged during development. Agile allowed me to discover and respond to these requirements rather than trying to specify everything perfectly at the start.

Development was organized into two-week sprints. Each sprint began with a planning session where I selected features from the product backlog (a prioritized list of desired functionalities) and broke them into smaller tasks. At the end of each sprint, I reviewed completed work, demonstrated features to my supervisor, and adjusted plans for the next sprint based on feedback.

The major sprints were:

Sprint 1 (Weeks 1-2): Project setup, database schema design, Supabase configuration, basic authentication. By the end of this sprint, a user could register, log in, and see a rolespecific dashboard.

Sprint 2 (Weeks 3-4): License application workflow—forms, document upload, submission, administrator review interface. This sprint established the core licensing functionality.

Sprint 3 (Weeks 5-6): Vehicle registration module, digital bluebook generation, QR code implementation. This extended the system to cover vehicle management.

Sprint 4 (Weeks 7-8): Incident reporting with GPS capture, real-time notifications using Supabase Realtime, administrator dashboards with charts.

Sprint 5 (Weeks 9-10): Fine management, payment integration simulation, testing, documentation, and deployment preparation.

Daily development followed a pattern of writing code, testing changes locally, committing to Git with descriptive messages, and pushing to the repository. I maintained a simple task board (using GitHub Projects) to track what was pending, in progress, and completed.

This methodology worked well for the project scope. The main challenge was accurately estimating task complexity and some features that seemed simple required significant debugging, while others that appeared complex came together quickly. By the final sprint, I had delivered all planned features with time for polishing and testing.

FUNCTIONAL MODULES

4.2 MODULE DESCRIPTIONS

Driver's Digital Hub consists of five functional modules, each responsible for a distinct area of road traffic management.

4.2.1 Module 1: Licensing and Identity Management

This module handles everything related to driver's licenses. It includes the application form where citizens enter personal information, the document upload component that accepts supporting files, the biometric capture interface that takes a live photo for verification, and the administrator review panel where applications are approved or rejected.

When an application is approved, the module generates a digital license containing the driver's photo, license number, issue and expiry dates, license class, and a QR code. The QR code encodes a URL that points to a public verification page where anyone with the license can scan the code to confirm its validity.

Renewals follow a simplified process. Returning users have their information pre-filled, and only need to update changed details, upload a new photo if desired, and pay the renewal fee. The system automatically checks expiry dates and sends email reminders thirty days before expiration.

4.2.2 Module 2: Vehicle Registration and Asset Management

This module handles the registration and management of vehicle records and ownership details. Users can register a vehicle by entering key information such as make, model, year, chassis

number, and engine number, along with uploading proof of ownership like a purchase receipt, customs clearance (for imported vehicles), or transfer documents.

Once registered, the system automatically generates an electronic bluebook, which acts as the official digital registration certificate. Each bluebook includes a QR code that allows for quick verification of vehicle details. Vehicle owners can access, view, and download their bluebooks directly from their dashboard at any time.

The module also supports ownership transfers through a controlled workflow. The current owner initiates the transfer request, the new owner must accept it, and an administrator reviews and approves the transaction. This ensures a transparent and traceable chain of ownership for every vehicle.

4.2.3 Module 3: Incident Intelligence System

This module enables real-time reporting of road incidents. When a user opens the incident report form, the browser attempts to capture GPS coordinates. If successful, these coordinates are stored with the report and used to place the incident on a map. If GPS is unavailable (common on some older phones or indoors), the user can enter a text description of the location instead.

Incident types include accidents (collision between vehicles or with pedestrians), hazards (debris on road, pothole, broken-down vehicle), and breakdown (user's own vehicle has failed). Each type has a slightly different form of accidents to ask for number of vehicles involved and injuries, while hazards focus on the nature of the obstruction.

Administrators see incoming incidents on a real-time dashboard that updates automatically when new reports arrive. They can mark incidents as verified (after confirming the report is accurate) or cleared (after the situation has been resolved). This workflow helps coordinate response without requiring every report to receive individual attention.

4.2.4 Module 4: Financial Settlement and Revenue Management

This module manages traffic fines and digital payments. For the mini project scope, I integrated a simulated payment gateway rather than connecting to a real bank API. Users enter payment details that are validated but not actually charged, and the system generates receipts as if a real payment occurred.

Fines can be issued by administrators (for now; future expansion adds traffic officer role). The fine issuance form captures the driver's license number, violation type, amount, and optional description. Once issued, the fine appears on the driver's dashboard with a "Pay Now" button.

Payment processing includes automatic receipt generation with a unique reference number. Administrators can view revenue reports showing total collections by period, violation type, or issuing officer.

4.2.5 Module 5: Real-Time Notification System

This module handles all communication between the system and its users. Built on Supabase Realtime, it establishes WebSocket connections that allow the server to push messages to connected

clients without the client needing to constantly check for updates.

Notifications are triggered by various events: application status changes ("Your license application has been approved"), fine issuance ("A fine of K25,000 has been issued for speeding"), incident updates ("The accident you reported has been marked as cleared"), and system announcements.

Users can view their notification history and mark notifications as read. Unread notifications are indicated by a badge on the bell icon. The system also sends email notifications for critical events as a backup in case the user is not actively using the application.

4.3 TECHNOLOGIES USED

The technology choices for Driver's Digital Hub were guided by three principles: use modern, well-supported tools; prioritize mobile performance; and minimize cost (the project has no budget for commercial software licenses).

4.3.1 Frontend Technologies:

React 18 with Vite: React provides a component-based architecture that keeps code organized and reusable. Each part of the user interface includes a form field, a dashboard card, a notification item which is a component that manages its own state and rendering. Vite serves as the build tool, offering faster startup times and hot module replacement during development.

Tailwind CSS: Rather than writing custom CSS files, I used Tailwind's utility classes to style components directly in the JSX. This approach speeds up development and ensures consistency. The Tactical Clarity design system is implemented through a custom Tailwind configuration that defines the Deep Slate background, Electric Cyan primary actions, and Action Red alerts.

Framer Motion: Animations and transitions are handled by Framer Motion. Key interactions (menu opening, modal appearing, notification sliding in) have subtle animations that make the interface feel responsive and polished without being distracting.

React Router: Navigation between pages (dashboard, applications, incidents, profile) is managed by React Router. It enables client-side routing without page reloads, contributing to the single-page application feel.

Zustand: For state management that spans multiple components (user authentication status, notification count, theme preference), I used Zustand. It is simpler than Redux and well-suited to the project's complexity level.

4.3.2 Backend Technologies:

Supabase: Supabase serves as the complete backend platform, providing PostgreSQL database, authentication, storage, and real-time subscriptions. Using Supabase eliminated the need to build and maintain a custom backend server, which would have been time-prohibitive for a mini project.

PostgreSQL: The relational database stores all structured data. PostgreSQL was chosen for its reliability, performance, and support for advanced features like Row Level Security and JSON columns.

Supabase Auth: Authentication handles user registration, login, password reset, and session management. It supports email/password authentication and could be extended to support OAuth (Google, Facebook) in the future.

Supabase Storage: File storage is used for user-uploaded documents, license photos, vehicle images, and incident attachments. Each file receives a unique path, and access is controlled by storage policies.

Supabase Realtime: WebSocket connections enable live updates. When database changes occur, the Realtime service broadcasts them to authorized clients. This powers the real-time notification system.

4.4 KEY FEATURES

The following features distinguish Driver's Digital Hub from basic online forms or standalone databases.

4.4.1 End-to-End Digital Workflow

Unlike systems that only provide downloadable forms, Driver's Digital Hub processes complete applications online. A citizen can start a license application, save it, complete it later, submit it, pay fees, and receive the digital license after all without visiting an office.

4.4.2 Role-Based Access Control

The system serves three distinct user types with appropriate permissions. Citizens only see their own data. Driving schools see their enrolled studen

CONCLUSION AND FUTURE WORK

7.1 Recommendations

Based on the development experience and test results, I offer the following recommendations for anyone who might continue this work or deploy the system in a real environment.

For Deployment:

1.Pilot before full rollout. Select one district or one type of service (perhaps license renewals only) to pilot the system for three to six months. This allows problems to be identified and fixed without disrupting all services.

2.Invest in training and support. The technology works, but users need help learning it. Provide training for administrators, printed guides for citizens, and a help desk for questions.

3.Plan for connectivity gaps. Even with mobile optimization, some users will lack reliable internet. Consider adding USSD support for feature phones and offlinecapable mobile apps for smartphones.

4.Establish data backup and disaster recovery. While Supabase handles backups, ensure there is a documented procedure for restoring backup if needed. Test this procedure before going live.

For Security:

1.Regular security audits. The threat landscape changes constantly. Schedule quarterly security reviews and annual penetration testing by external experts.

2.Monitor audit logs actively. Security logs are useless if no one looks at them. Implement automated alerts for suspicious patterns (multiple failed logins, unusual access times).

3.Plan for breach of response. Assume a breach will eventually happen. Have a plan ready: how will you

detect it, contain it, notify affected users, and recover?

For Sustainability:

1.Document everything. The code, database schema, deployment instructions, and operational procedures should be documented thoroughly. This ensures continuity if the original developer moves on.

2.Build local capacity. Train government IT staff to maintain and enhance the system rather than relying on external contractors.

3.Open source the code. Releasing the source code under an open license allows others to learn from, verify, and contribute to the system. It also provides transparency that builds public trust.

7.2 Future Improvements

While the current system meets the stated objectives, several enhancements would significantly improve its value.

Integration with National ID System: Currently, users enter their national ID numbers manually, but the system does not verify them against an official registry. Integrating with the National Registration Bureau's ID system would automate identity verification and reduce document forgery.

Offline-First Mobile Application: A progressive web app or native mobile application could store data locally when offline and sync when connectivity returns. This would be valuable for rural users and for traffic officers working in areas without coverage.

AI-Powered Fraud Detection: Machine learning models can analyze application patterns to flag suspicious activity. For example, the same photo is uploaded with different names, or applications coming from the same IP address with different identities.

SMS and USSD Channels: For users without smartphones, an SMS or USSD interface would provide basic services: check license status, receive expiry reminders, and report incidents by text.

Analytics Dashboard for Policy Makers: The current administrator dashboard focuses on operational metrics. A separate dashboard for policy makers would show trends over time, comparisons between districts, and predictive analytics.

Public Incident Map: A public-facing map showing recent road hazards and accidents (anonymized) would help drivers plan safer routes and increase transparency about road safety conditions.

Electronic Driving Tests: Extend the system to support scheduling, conducting, and recording driving tests digitally, including examiner checklists and result capture.

These enhancements would transform Driver's Digital Hub from a digitization of existing processes into a truly intelligent transportation platform. However, even without these additions, the current system represents meaningful progress toward modernized road traffic services for Malawi.

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