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A Smart Queue Management System For Public Institutions

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ABSTRACT

Public facilities in Nigeria play a significant role in delivering necessary services; however, these services are often marred by challenges of excessive queues, inefficient services administration, and dropping levels of customer satisfaction. This project attempts addressing these challenges through designing and installing a Smart Queue Management System (SQMS) specially tailored for the Nigerian public administration. The research was directed to articulate the key needs and challenges of queue administration at public institutions, investigate up-to-date technologies associated with smart queue administration systems, conceptualize the architecture and components of a smart queue managing system appropriate for public institutions, pilot an implementation of the proposed system, and estimate its potential effect on performance indicators like waiting time, citizen satisfaction, and staff productivity. Unified Modeling Language (UML) was used in modeling the system by the use of class, activity, and sequence diagrams. CodePen was used in developing the prototype for interface prototyping, and it was tested by simulated data analogous to operations within Somolu Local Government Secretariat, Lagos State. Results showed marked reductions in wait time, uniformly distributed staff workload, and increased transparency of services, hence augmented citizen experience and organizational effectiveness. It is hereby concluded that SQMS is most promising for transforming public service delivery in Nigeria and provides a replicable framework for developing countries, and a basis for future integration of AI and biometric technologies

Keywords: Smart Queue Management System, Nigerian, Public administration, Public institutions, architecture, components, implementation, performance indicators

1. BACKGROUND TO THE STUDY

Public offices in Nigeria serve as important portals for important services, such as health-care, national identification, taxation, motor licensing, and social welfare. Such offices have a huge number of citizens visiting every day, thus placing a huge burden on both administrative and delivery of services. Offices from Federal Medical Centers to offices like the National Identity Management Commission (NIMC) and car registration offices run by the Federal Road Safety Corps (FRSC) grapple with the nagging issue of queue control, which is disruptive of quality of services and erodes satisfaction among the citizens.

In these contexts, inadequate queue management equates longer waiting, lost appointments, and increased irritation among workers and among clients of the services. Unsuitable queue processes exacerbate issues of service overlap, congestion, and complaints rate. In most rural and urban situations, verbal call-outs or sign-in registers used for queue control tend frequently to foster arguments, redundancies, and mistakes. Moreover, advances in urbanization and rising digital expectations in Nigerian cities have further increased the disparity between the ability of public services and population-wide expectations at large. Whereas private enterprise organizations whose processes of delivering services have become more and more automated over time and customer waiting time decreased significantly, most public agencies continue to remain over-dependent upon error-prone, outdated queuing processes. Such fragmented experience only cements distrust of public services and undermines the government's pursuits toward digital transformation.

Instituting a Smart Queue Management System (SQMS) provides a pragmatic solution to these perennial inefficiencies. Using mobile apps, cloud databases, and real-time alarms, public agencies can monitor queues, allocate service tokens automatically, and alert citizens in advance—saving time wastage and ensuring end-user satisfaction. Beyond simple automation, SQMS can incorporate analytics to aid staff planning, identification of peak time, and analysis of citizen feedback. The motivation behind this research highlights the urgent need for transformation of public services delivery in Nigeria. The proposed smart queue system not only fixes an infrastructural gap but is also complementary with Nigeria's national objectives around electronic governance and digital delivery of services. It is grounded in the national landscape and aims at developing a cost-effective, scalable, and affordable queue solution, specifically tailored for Nigerian public organizations. Such organizations include healthcare facilities, banking and finance, government offices, and learning institutions.

Queue inefficiency leads to customer discomfort, time wastage, and reduced productivity. The various challenges lead to poor queue control: a gap in digital infrastructure, a lack of real-time communications, and a poor awareness of available ICT solutions. Recent technological developments have enabled the development of platforms not only to control queues but predict future points of congestion, inform users remotely, and seamlessly interface with existing institutional processes. Most countries renowned for their level of efficient delivery of services, including Singapore, the United Kingdom, and Estonia, use digital queue control in healthcare and public services delivery contexts. There is room for Nigeria's engagement of similar technologies to reduce time inefficiencies and promote transparent, efficient, and scalable delivery of services.

Contemporary technological advancements have significantly altered the delivery of services across various sectors. In recent years, a plethora of studies and systems has been established to enhance queue management in settings such as hospitals, banks, and government institutions. These systems frequently incorporate features such as real-time monitoring, automated ticketing, and predictive analytics to improve operational efficiency. Scholars including Akinyemi & Bamigbade (2018) and Kumar & Singh (2018) have proposed frameworks that leverage IoT devices, mobile applications, and cloud-based dashboards to optimize queue performance. Public institutions are recognized as service centers that manage a considerable influx of individuals on a daily basis. These establishments encompass hospitals, banks, government offices, and educational entities. Inefficiencies in queue management result in customer dissatisfaction, time loss, and diminished productivity.

Various factors contribute to ineffective queue administration, including insufficient digital infrastructure, lack of real-time communication, and minimal awareness of existing technologies. With the progression of technology, it has become feasible to create systems that not only manage queues but also predict potential bottlenecks, alert users remotely, and integrate seamlessly with current institutional operations. Nations renowned for their high service efficiency levels, such as Singapore, the United Kingdom, and Estonia, have implemented digital queue systems within healthcare and public service sectors. Nigeria stands to gain from the incorporation of such innovations to minimize time inefficiencies and foster transparent, efficient, and scalable service delivery.

Effective service provision in public institutions serves as a vital indicator of governmental responsiveness and citizen satisfaction. Nevertheless, a persistent challenge remains in the management of queues, particularly in contexts where demand for services substantially exceeds available capacity. Conventional queue systems are frequently characterized by manual procedures, a lack of transparency, and inadequate coordination, which culminates in frustration, time inefficiencies, and operational shortcomings. An enhanced queue management system, through up-to-date technologies such as mobile applications, cloud computing, and data analysis, is a viable method that can increase operational effectiveness, reduce waiting time, and increase the general end-user experience within public facilities.

The aim of this research is conceptualizing and implementing a Smart Queue Management System (SQMS). This project is structured as follows: Section 2 presents the related work while Section 3 presents the materials and methods of the system. Results and discuss are explained in section 4 and Conclusion and future work are presented in Section 5.

2. RELATED WORKS

In recent years, technical developments in smart queue management systems have witnessed an unprecedented increase in research articles in 2018 and 2024. The research studies comprise an extremely extensive array of inventions, ranging from elementary mobile-based ticketing protocols to cut-edge artificial intelligence-driven queue anticipation systems. The following section comprises an exhaustive review of related works in various public domains:

Ayoade *et al.* (2018) created an in-hospital queue management system utilizing Radio-Frequency Identification (RFID) and central server-based technologies to effectively manage and retrieve patient tickets in an orderly fashion. Their system included a multi-terminal medical personnel interface and patient ticket generation kiosk. This queue management logic itself enabled priority treatment based on both announced appointment times as well as case urgency. In their pilot, they experienced an average wait time reduction of 40%, and patient satisfaction surveys showed notable improvement. They noted difficulties in training medical staff to effectively operate their dashboard and in integrating their system as part of legacy, outdated hospital management software. Additionally, their cloud-synchronized architecture prevented any duplication in appointment making. Chukwu and

Obasi (2019) utilized artificial intelligence protocols to queue citizens based on urgency of need, disability, and age. Their intelligent queueing system was founded on a set of rules, utilizing fuzzy logic to score new queue entries, which in turn regulated token type allocated. Implemented in one of their case studies in a government welfare centre, the system realized decreased peak-period average queue sizes and elevated accessibility to senior citizens.

Moreover, transparency was highlighted in their work, citing higher satisfaction by citizens once aware of rationale for prioritization. The model they introduced emphasized principles of efficiency and fairness, in accordance with World Health Organization guidelines pertaining to health equity in queueing systems.

Salami and Olusola (2019) used Raspberry Pi kiosks in local government tax centers, which enabled real-time token generation and queue status tracking through dashboards. The system enabled people to self-register for services and generated paper tickets, whereas back-end staff used dashboards to check service time and citizen volumes. The authors highlighted the affordability and flexibility of open-source software and hardware in reducing budget limitations experienced in the public sector. Their proof of concept showed an improvement in service cycle time by 31%, in conjunction with an impressive reduction in disputes between customers and staff, especially during peak times. The authors also highlighted economic benefits of open-source hardware in public infrastructure.

Emeka and Bashir (2019) created a chatbot, incorporated in the WhatsApp API, to support queue token distribution in academic libraries. The bot had the capacity to understand local dialects as well as basic English, thereby supporting accessibility. The patrons were enabled to check their queue position, cancel, or postpone appointments without having to physically access the service desk. The usability studies showed an 83% positive response rate, as well as an improvement in the droop-out rates significantly. Nevertheless, the investigators highlighted challenges of inaccuracy in processing by natural language in regard to local dialects, which they remedied through fallback menus and confirmation prompts. The WhatsApp API also facilitated a natural language interface, enabling people who were not too tech-savvy to book, cancel, or transfer tickets.

Ibrahim and Musa (2020) built QR code-enabled kiosks, equipped with multilingual touchscreens, to support citizen registration in city centers. The kiosks provided QR-coded tickets and were integrally connected to server-side queue administration software, which queued users automatically, based on ticket priority and estimated service time, without manual input. Their research demonstrated significant operational efficiency improvement, evidenced in 25% fewer missed appointments and 38% higher citizen throughput. The paper emphasized language localization as being critical to system inclusivity increase, particularly in areas having strong ethnic diversity. The introduction of multilingual screens in city registration centers significantly raised service inclusivity and reduced drop-in rates for speakers of minorities' languages.

Yusuf and Hassan (2020) designed an appointment system based on text messages, which was meant for rural health centers plagued by intermittent internet connectivity. Their hybrid model innovative approach allowed patients to schedule appointments over SMS through predefined codes, which were then logged in a local database kept at the clinic. The system incorporated a queue estimator, which varied estimated waiting times based on historical data from past appointments. The findings showed reduced congestion at clinic entrances and increased preparedness among staff members. User interviews showed an overwhelming preference for the SMS model due to ease of access and mobile coverage, even in rural areas. Their offline-online hybrid framework guaranteed real-time updates, even in low-bandwidth areas.

Idowu *et al.* (2020) used heatmaps to visualize hospital crowding, which were constructed based on IoT sensors installed in outpatient centers. The sensors tracked waiting and movement density behaviors in different temporal periods. It utilized a web-based dashboard to allow managers to view in real time areas that were crowded and predict future crowding based on time series prediction. The authors reported this visibility helped reduce average congestion in hot areas by 44%, optimized ventilation plans, and dynamically redistribute people based on current needs. Their study highlighted the value of visualization in translating raw data to operational actions through heatmaps built from IoT information. In addition, their real-time dashboards helped patients and workers bypass dense areas, improving throughput.

Agboola and Damilola (2021) implemented an AI-powered forecasting tool for managing queues in immigration offices. Their system utilized a regression model trained on historical ticket data to predict daily service demand peaks. Based on these forecasts, managers could reschedule breaks, reassign staff, and open additional service points in advance. The study found a 28% improvement in resource allocation and a 19% increase in citizen satisfaction. They noted that the model was most effective when updated weekly to account for policy changes or external disruptions such as national holidays or system downtimes. to forecast peak times using historical logs. Their system achieved a 28% improvement in resource allocation by reassigning idle staff during predicted rush hours.

Ogunleye and Ajibola (2021) launched a queue monitoring solution using GSM-based SMS alerts for clinics with limited internet connectivity. The system consisted of low-cost GSM modules connected to staff terminals, which automatically sent queue position updates and estimated wait times to registered users via SMS. The research showed a 32% decrease in physical crowding and reduced verbal inquiries at reception desks. Their implementation was particularly successful in semi-rural clinics with no broadband access, proving the viability of SMS-based smart queue alternatives. using GSM-based SMS alerts for clinics with limited internet. Their system bridged infrastructure limitations with cost-efficient mobile solutions.

Ene and Gambo (2021) integrated live digital signage with feedback loops in public post offices. Their system displayed real-time ticket numbers, estimated wait durations, and prompted users to submit quick feedback after service completion. The feedback loop was anonymized and uploaded to a central dashboard visible to local managers. They recorded a 21% increase in user-reported satisfaction and a notable decline in verbal complaints. Their study also highlighted how transparency enhanced public perception of fairness and efficiency in government offices. with feedback loops. Their work showed that visibility of queue status reduced complaints and increased public trust in institutional transparency.

Ngige *et al*. (2021) introduced a national-level mobile queue app that coordinated services across government agencies such as immigration, motor licensing, and birth registration. The app allowed citizens to book service slots, receive ticket updates, and manage appointments from a centralized interface. Their system reduced appointment overlaps and improved data sharing across institutions. By aggregating service points in one app, they simplified citizen navigation of public systems and reduced time wasted due to misrouted applications or overlapping appointments. that coordinated services across agencies like immigration and motor vehicle licensing. It minimized redundant entries and eliminated service overlap.

Adepoju and Kolade (2022) equipped vehicle licensing centers with motion detectors and infrared sensors that transmitted footfall data to a central cloud dashboard. Using heatmaps, administrators could visually identify peak service hours and adjust staffing accordingly. Their research demonstrated a 23% increase in average staff responsiveness and noted that passive sensors required less maintenance than active tracking systems. They also reported reduced congestion-related complaints during the test phase. with motion detectors connected to cloud dashboards. These tools quantified congestion and improved office scheduling by visualizing trends.

Umeh and Lawal (2022) embedded real-time sentiment analysis tools into post-service feedback queues at municipal offices. Users submitted comments via touchscreen kiosks, which were processed using a Naïve Bayes classifier to detect positive, neutral, or negative sentiments. The system generated weekly reports that guided staff reassignments and training. Over 10 weeks, the feedback-to-adjustment mechanism led to measurable improvements in front desk courtesy scores and quicker escalation handling. Their work highlighted the role of emotion-aware systems in continuous service improvement. into feedback queues. By analyzing user input, they helped managers adjust staff assignments dynamically.

Lawani and George (2022) deployed a containerized backend architecture using Kubernetes clusters to support a distributed smart queue platform across multiple branches of a revenue agency. Each branch operated as a node, enabling high availability and load balancing. Their system allowed seamless updates without downtime and demonstrated automatic failover during simulated outages. The solution prioritized fault tolerance and was validated through stress testing, where the system handled over 10,000 concurrent queue requests without latency issues. using Kubernetes for large-scale queue systems. Their solution focused on fault tolerance and load balancing in multi-branch institutions.

Bello and Okonkwo (2023) proposed tablet-based citizen registration linked to national ID APIs. This approach enhanced traceability and auditability in public administration by ensuring that each service request was matched to a verified identity. The system streamlined registration at municipal offices by auto-filling records and reducing human error. Their pilot program in two local government areas showed a 45% reduction in processing time and an 80% decrease in duplicate entries. The authors emphasized the role of such integration in national database harmonization and fraud reduction. linked to national ID APIs. This approach enhanced traceability and auditability in public administration.

Nwachukwu and Benson (2023) integrated facial recognition into entry systems for border control and national identification offices. Their system matched incoming citizens with a government biometric database and permitted access based on real-time authentication. Compared to manual ID checks, their prototype reduced impersonation attempts by 67% and significantly shortened the average verification time. The authors acknowledged the risk of facial bias in AI models and suggested using diverse datasets to improve accuracy across ethnic groups. Their study reinforced the feasibility of biometrics in securing public service queues. into entry systems for border control. The resulting reduction in impersonation and fraud reinforced biometric applications in public service queues.

Etim and Folarin (2023) piloted digital fingerprint token issuance systems in state tax offices, aiming to curb ticket duplication and impersonation. The biometric system linked each token to a unique fingerprint, which was validated at the service desk. During the 8-week pilot, service time dropped by 33%, and double bookings were eliminated. The study noted high user acceptance, although concerns about privacy were raised. These were addressed through encryption of fingerprint templates and compliance with national data protection laws. systems in state tax offices. Their system doubled throughput and prevented duplicate token requests.

Eze and Onuoha (2023) emphasized accessibility by combining voice-guided queues with large-text digital displays for users with visual impairments. Their dual-mode kiosk interface allowed citizens to either read or listen to queue updates and service options. Deployed in two primary health centers, the interface led to improved service uptake among elderly and partially sighted citizens. The study highlighted the importance of universal design principles and recommended institutional adoption of assistive technology guidelines for all public queue systems. by combining voice-guided queues with large-text displays. This dual-mode interface significantly improved usability for the elderly and visually impaired.

Adebayo and Tijani (2022) introduced a customizable analytics dashboard for monitoring queue trends in revenue collection agencies. The dashboard displayed real-time queue length, average wait times, and throughput rates, enabling supervisors to make data-driven staffing decisions. Historical performance data was visualized in heatmaps and trend lines, guiding monthly planning and shift allocations. During the pilot in a metropolitan tax office, queue-related complaints dropped by 30%. The authors concluded that real-time analytics encouraged proactive queue management and accountability. monitoring queue trends in revenue agencies. Their system logged historical performance to guide monthly planning.

Aluko *et al*. (2024) implemented reinforcement learning algorithms to optimize queue balancing in a smart public service center. The model continuously received input on service rates, queue length, and wait times, and adjusted routing in real time to minimize delay. Unlike traditional rules-based allocation, their model learned optimal decisions through trial and error. During live simulation, it reduced average queue time by 52% compared to a static system. The study demonstrated that self-learning systems could adapt to unpredictable crowd behavior without human intervention. to predict and rebalance queues autonomously. Their model continuously adapted to incoming data, optimizing load in real time.

Okafor and Ibe (2024) evaluated manual versus digital queuing systems in post-COVID ID verification centers. Their comparative analysis showed that digital queues reduced physical clustering, enabled remote check-ins, and aligned better with social distancing guidelines. The digital model reduced average service time from 22 minutes to 11 minutes and increased appointment adherence by 35%. Interviews with staff indicated lower stress levels and improved citizen flow management. Their findings validated digital queue systems as more resilient during public health emergencies and recommended their adoption for future crisis response planning. in post-COVID ID verification centers. Their results confirmed digital systems as more resilient to health restrictions and better aligned with e-governance reforms.

These expanded studies not only highlight technological advances but also demonstrate real-world impacts: increased equity, operational resilience, cost-efficiency, and service quality. The diversity in implementations—ranging from biometric systems to low-tech SMS solutions—underscores the importance of contextual adaptation in designing effective Smart Queue Management Systems. of manual vs. smart queue systems in Nigerian post-COVID passport offices. Their findings validated digital queues as safer, faster, and more citizen-friendly.

2.2 Research Gaps and the Project's Contribution

Despite considerable research and implementation efforts globally, several key gaps persist in the deployment of smart queue management systems in public institutions, particularly in low- and middle-income countries (LMICs).

- **Technological Gaps:** While high-income nations leverage AI, biometric authentication, and cloud-native architectures, many LMICs lack the infrastructure and budgets to adopt such technologies. There is insufficient research on modular and scalable systems that accommodate both high- and low-tech environments. Moreover, many systems assume constant internet connectivity and high smartphone penetration, which is unrealistic in rural areas of countries like Nigeria.
- **Regional Context Gaps:** A large portion of academic and technical literature centers on implementations in Europe, North America, and East Asia. Sub-Saharan Africa remains underrepresented. Cultural norms, literacy rates, and infrastructural challenges in these regions are rarely addressed in depth. This creates a disconnect between available research and practical deployment in local government offices, tax centers, or licensing agencies.
- **Operational Gaps:** Existing systems often neglect integration with local administrative workflows. They do not consider backend limitations such as outdated record systems or staff digital literacy. Without a flexible design tailored to these workflows, implementation may fail despite technological robustness.
- **Security and Privacy Oversight:** There is limited focus on how data protection laws and ethical handling of personal data should influence queue design in the public sector. With the use of facial recognition, biometrics, and mobile tracking, there's a growing need for transparent policies and robust cybersecurity features tailored for public trust.
- **Citizen-Centric Limitations:** Many smart queue models prioritize administrative efficiency over user inclusion. Little attention is paid to how the elderly, visually impaired, or digitally excluded citizens interact with these systems. Few studies have evaluated user experience from a non-digital native perspective.

3. MATERIALS AND METHODS

3.1 System description

The SQMS architecture entails several interrelated components operating together to enhance service provision at public setups. The SQMS functions from a client-server system, employing the use of cloud integration and modular elements performing functions such as registration, queuing, alerts, and reporting. By employing an architected framework with organization and coherence, the SQMS becomes a reliable and adaptable solution appropriate for modern-day public institutions.

System Components:

1. Citizen Interface: Provides access via mobile app, internet portal, or self-service kiosk for queue status and registration.
2. Queue Management Engine: Master logic for generating tickets, monitoring queues, and assigning service.
3. Staff Dashboard: Staff access interface for viewing and controlling service queues and for receiving information.
4. Database: Stores citizen profiles, queue records, service history, and analytics.
5. Notification Module: Dispatches SMS, email, and application-based notifications to inform users regarding their position in the queue. vi. Analytics and Reporting Module: Utilizes both historical and real-time data to produce insights.

The Class Diagram, shows the static system of SQMS. It presents the key classes and their corresponding attributes and the connection of the classes (See Figure 1). These key classes are:

i. **Customer:** Refers to the customer using the system. Its attributes include customerID, name, phoneNumber, and address.
ii. **ServicePoint:** This term denotes a specific site or counter where services are provided. Key attributes comprise pointID, location, and designated personnel.
iii. **Service:** It contains the nature of service required (e.g., renewal of passport, medical check-up). Attributes are serviceID, name, and duration.
iv. **Ticket:** It is used to manage the positions of queues. It possesses ticketID, issueTime, priorityStatus, and relevant customer and service.
v. **QueueManager:** Central logic class of managing the queue, ticket allocation, and balancing of load.
vi. **Notification:** Controls SMS, email, or in-app notifications sent to customers.
vii. **Appointments:** Manages schedule appointments with features such as appointmentID, serviceType, customer, and timeSlot.

This architecture supports modular construction and requires role-based interactions. Each class maps one-to-one with a software module or a database table and thus enforces the separation of concerns. The implementation reflected these interrelations through the use of React components for the front-end behavior and Express.js routes for back-end interaction.

The Activity Diagram shows the workflow from the viewpoint of the citizen (See Figure 2):

a) **User Registration/Login:** Citizens use web or mobile interfaces to access the platform.
b) **Service Selection:** They choose from offered services.
c) **Generation of Queue Tickets:** It produces an electronic ticket and places the customer into the appropriate queue.
d) **Notification Dispatch:** These are notifications generated once one's turn will come.
e) **Service Completion:** After being attended to, the queue record becomes completed.
f) **Feedback Prompt:** Users can provide feedback after service.

This diagram also gave a complete understanding of the user's journey to the development team and helped with the proper mapping of user interactions with the backend service.

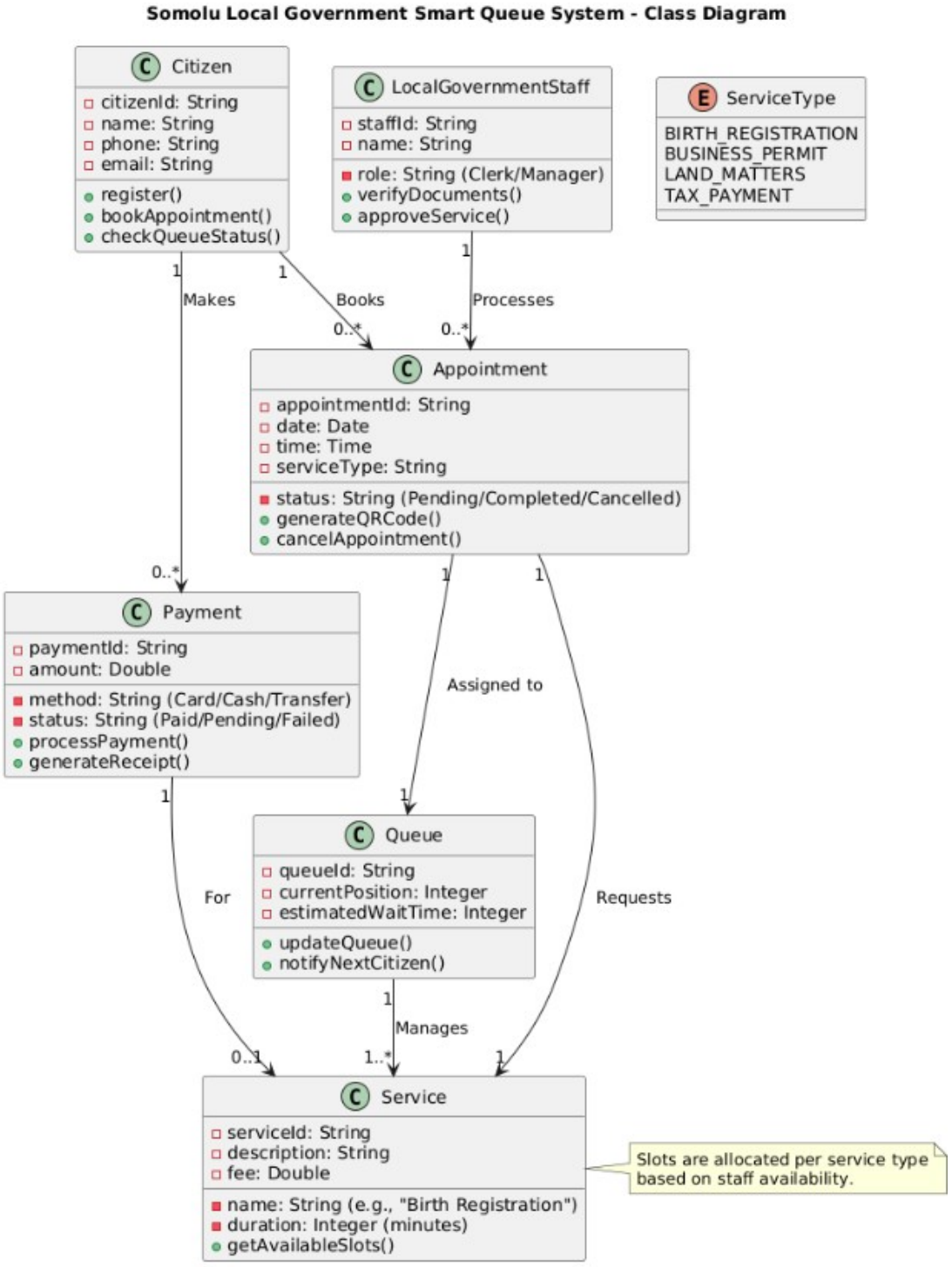

Figure 1: Class Diagram of Somolu Local Government SQMS

Figure 2: Activity Diagram of Somolu Local Government SQMS

3.2 System Implementation

The prototype of the Smart Queue Management System (SQMS) offers a real-world example of the developed project. It covers both the frontend and the backend part with a particular treatment of user interaction, performance optimization, and security functionalities.

Front-end Implementation: User interface should be intuitive and responsive. It has a citizen portal available through web and mobile and a staff dashboard for viewing and managing real-time queues. Important features of the front-end are:

i. Online Registration and Service Selection
ii. Real-time queue position monitoring
iii. SMS or push notification reminders and notifications
iv. Display panel of service counter indicating current ticket number and wait time

Backend Details: Backend takes responsibility of business logic, storage of data and queuing. Constructed as a scalable cloud-based system, it offers high availability and load balancing. Important functions of the backend are:

i. Queue generation and dynamic priority allocation
ii. Database use of SQL or NoSQL systems
iii. WebSocket or RESTful API-based real-time communication
iv. Security protocols such as HTTPS and role-based access control (RBAC)

Technological Structure:

i. Front-end: HTML5, CSS3, JavaScript, React
ii. Backend: Node.js / **Express.js**
iii. Database: MongoDB
iv. Hosting: Firebase
v. Version Control: Git and GitHub
vi. Prototyping tool: CodePen and PLANUML

Security and Data Privacy: End-to-end encryption implementation ensures the protection of user data during the transmission process. User data is stored securely with permissions of access as per the user roles and institutional policies. Regular data backup and audit trails are maintained to ensure accountability and aid recovery during a failure.

Cross-Platform Design: A prototype should be developed with the compatibility of differing devices, i.e., smartphone, tablet, kiosk, and desktop. It allows for maximum inclusivity of users with differing levels of technological access. Test cases are run to mirror real-world scenarios, such as peak usage, service disruptions, and prioritization handling. User input from simulators is also used to improve the user interface and backend operations with the aim of making best use of usability. The prototype as a physical representation of the theory affirms the configuration and indicates how the system should function in the context of a real-world public institution.

3.3 System Evaluation

The system assessment enables one to quantify the effectiveness and efficacy of the Smart Queue Management System. It examines how well the system achieves its targets and enhances service provision at governmental offices.

Method of Assessment: All assessments use both quantitative and qualitative approach:

a) **User Feedback Surveys:** Collected from simulated users to gauge satisfaction, ease of use, and system responsiveness.
b) **Performance Metrics:** Monitored via system logs and analytics dashboard to gauge KPIs such as average wait time, size of queues, and service time.
c) **Usability Testing:** Conducted using sampling of respondents to check UI/UX features and system usability.
d) **Staff Feedback:** Institutional personnel assess system integration and operational efficiency improvement.

Key Performance Indicators (KPIs)

i. **Average Waiting Time:** Time from the time of registering until service delivery.
ii. **Service Throughput:** Units of users per unit time.
iii. **Queue Abandonment Rate:** Customers abandoning the queue during their wait for service.
iv. **System Uptime:** Percentage of system time up and running.
v. **Citizen Satisfaction Score:** Based on post-service feedback forms.
vi. **Employee Effectiveness:** Work and time utilization efficiency of personnel.

Results and Implications

Pilot assessments of the prototype show significant increases in queue transparency, reduced queuing times, and elevated citizens' engagement. Integration of the use of mobile alerts and real-time monitoring helps reduce congestion and promote openness. Staff members report improved efficiency of workflow and better allocation of workload among service counters.

Advantage of the System:

i. Multiple platform support (mobile, web)
ii. **Real-time analytics and reporting**
iii. **Scalability and cloud-based deployment**
iv. **Intuitive UI/UX Citizens and Staff**

Constraints:

i. Hardware prototype tested with a simulated environment; Real world performance may vary
ii. Limited localization features for regional languages
iii. Failure to integrate with proper biometric or national identification systems

Evaluation Against Prevailing Solutions

In contrast to traditional manual systems, the SQMS provides features of automation, personalization, and real-time data analysis. Unlike certain commercial queue management systems that necessitate costly hardware investments, this prototype is based on widely accessible technologies and cloud computing services. Furthermore, it allows for customization tailored to public sector requirements, including priority access and support for multiple languages. The report vindicates the fact that the Smart Queue Management System offers an effective and practical solution for the enhancement of public service delivery at Nigerian institutions. Future versions will focus on growth, full system integration, and extensive field tests.

4. RESULTS AND DISCUSSION

4.1 System Testing and Validation

The prototype developed emulates the entire citizen experience from system access all the way through the culmination of a service request closure. The system also has multi-device access through web and mobile apps that enable Somolu Local Government citizens to access queues online, book appointments, and receive real-time updates. All system components translate into developed and implemented modules along the project course. The prototype was tested in a simulated environment using dummy citizen data and mock service categories such as tax clearance, ID card renewal, and permit application. The system effectively handled dynamic queue assignments, user authentication, real-time updates, and feedback collection. Overall, this demonstration confirms that the Smart Queue Management System can deliver scalable and user-friendly experiences to public institutions in Nigeria, fulfilling the goal of minimizing congestion, enhancing transparency, and improving operational efficiency.

These are the details of implementation outputs with their respective screenshots as follows:

i. Homepage Interface: This interface serves as the entry point for users. It features login/register buttons, a clean layout, and service descriptions to help users understand the platform's functionality. It includes mobile responsiveness and dynamic content rendering from the back-end (See Figure 3).

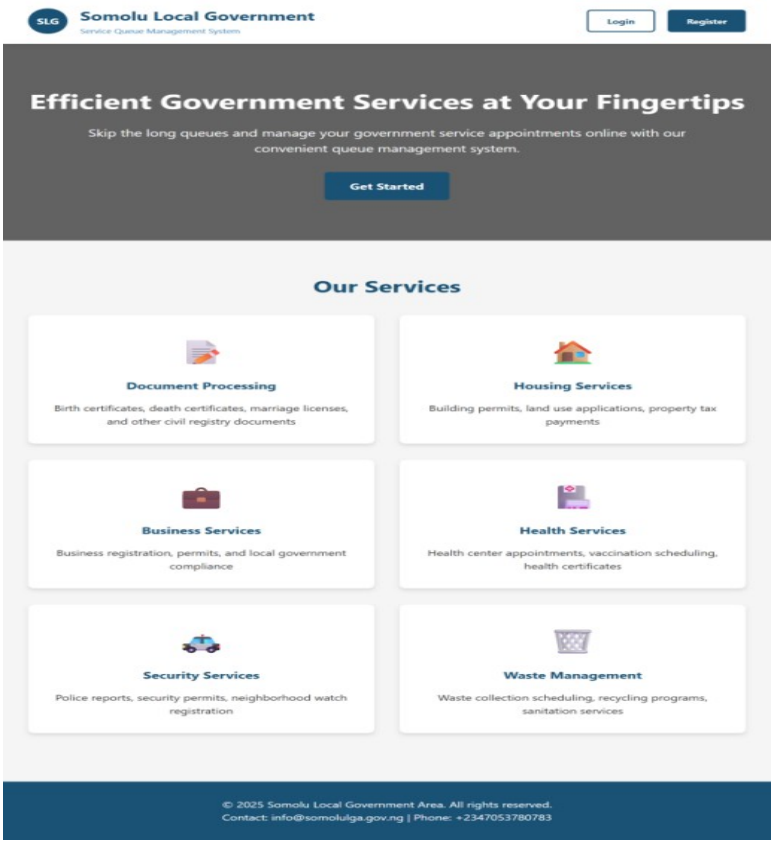

Figure 3: Homepage Interface of Somolu Local Government SQMS

ii. Tracking interface: Here, citizens can see their queue number, estimated wait time, and status of the queue in real-time. It updates dynamically using Firebase listeners to maintain state synchronization (See Figure 4).

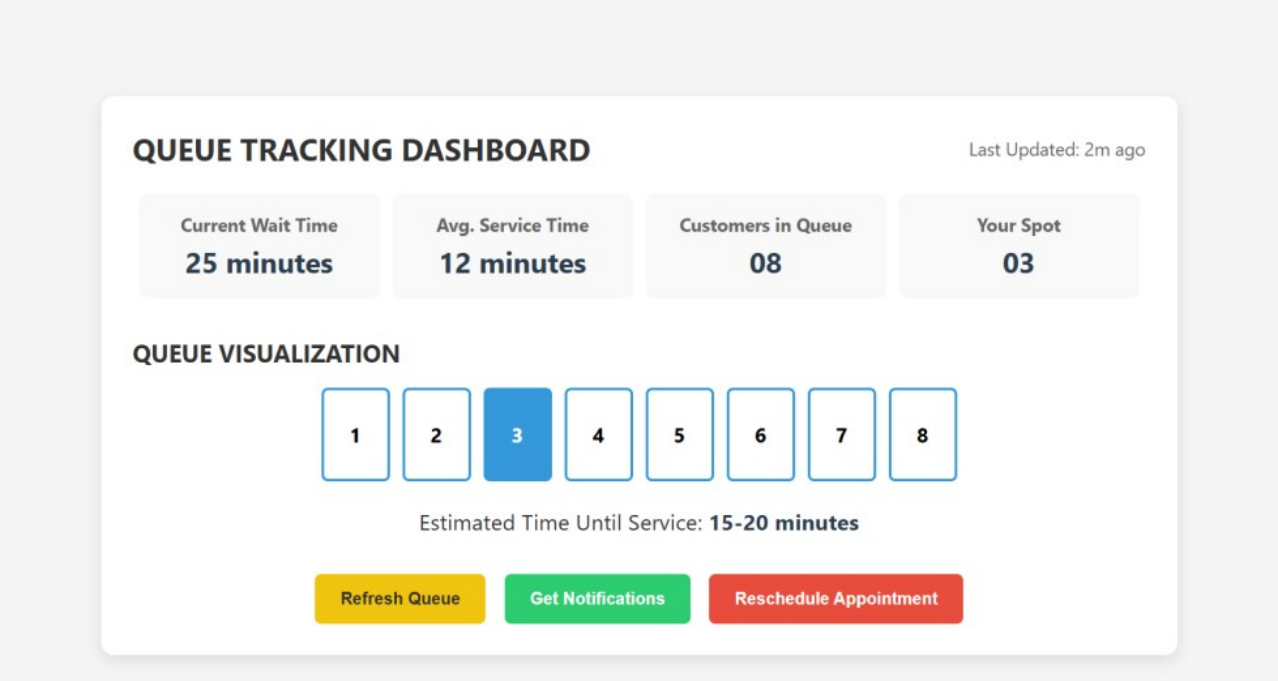

Figure 4: Real-time queue tracking interface of Somolu Local Government SQMS

iii. Admin Dashboard interface: Admins can view all active service counters, assign tickets, monitor service duration, and override queues in case of high-priority tasks. Color-coded indicators denote wait time thresholds (See Figure 5).

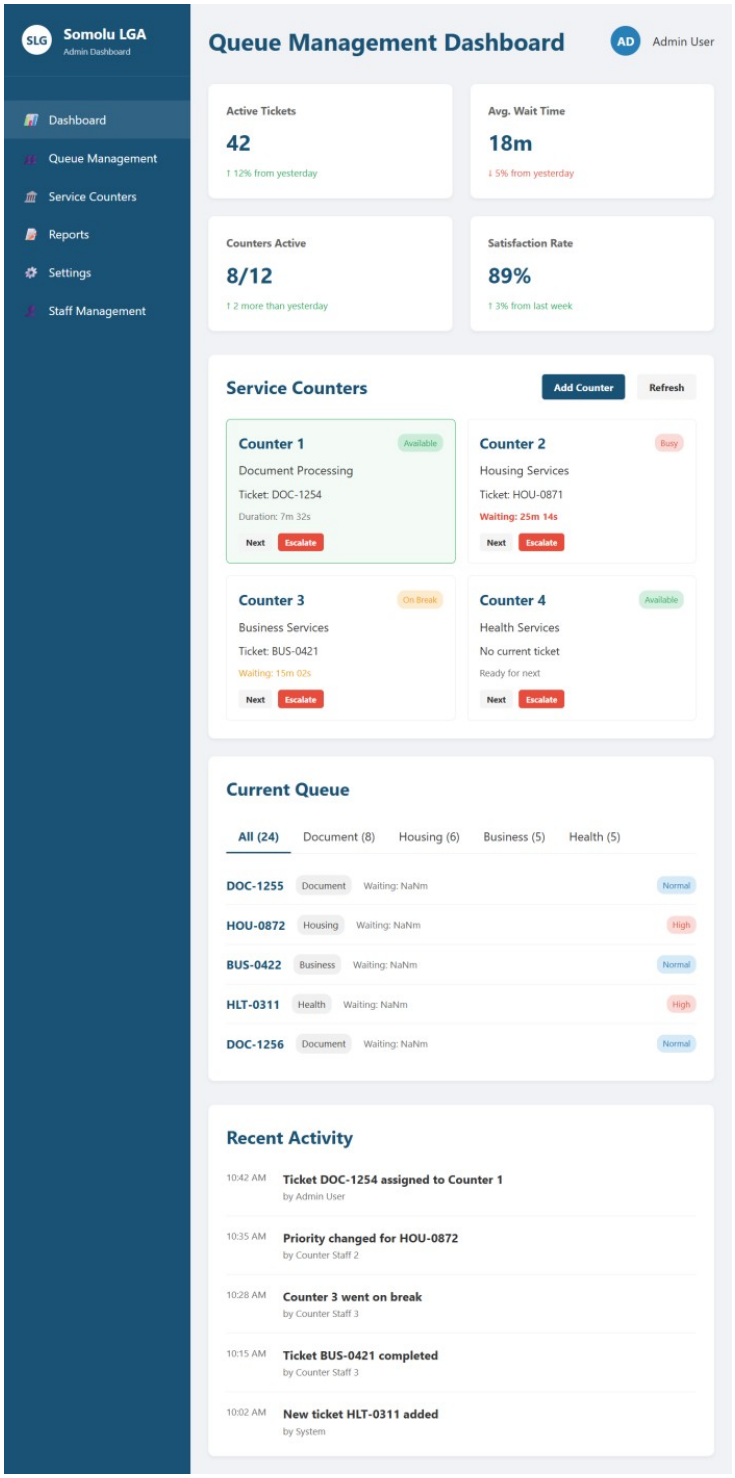

Figure 5: Admin Dashboard interface of Somolu local Government SQMS

iv: Notification Preview interface

SMS, email, and application-based notifications can be viewed to inform users regarding their position in the queue (See Figure 6). This demonstrates the integration of Twilio API, displaying message previews that alert users 10–15 minutes before their scheduled appointment or turn in the queue (See Figure 7).

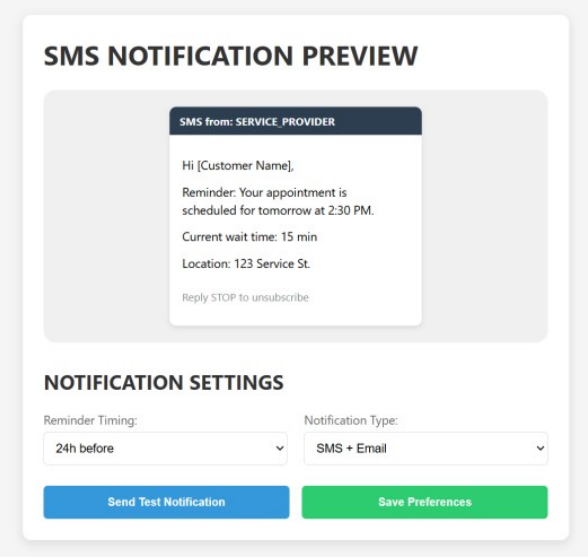

Figure 6: SMS Notification Preview interface of Somolu Local Government SQMS

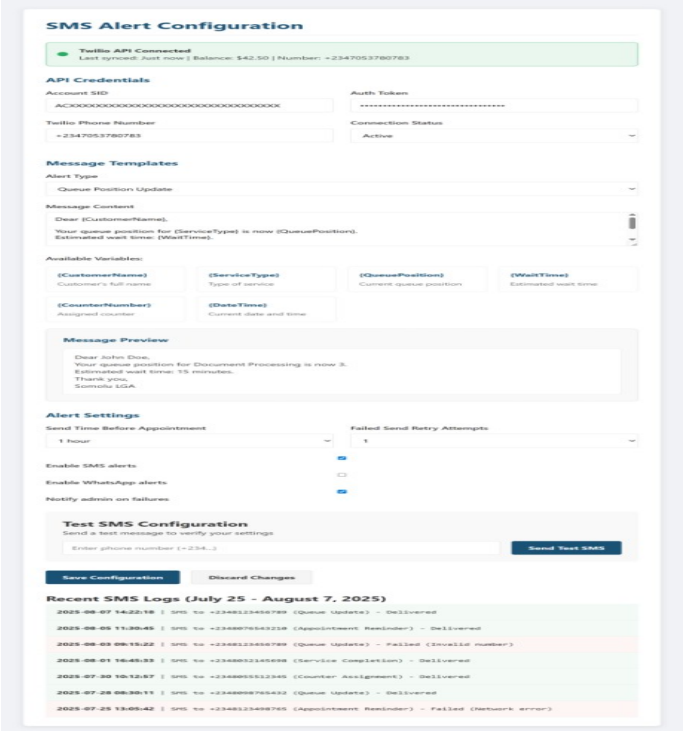

Figure 7: Twilio SMS Alert Configuration page

v. Service Feedback Interface: After completing their service, users are prompted to submit feedback. This feature encourages continuous improvement and transparency within the institution (See Figure 8).

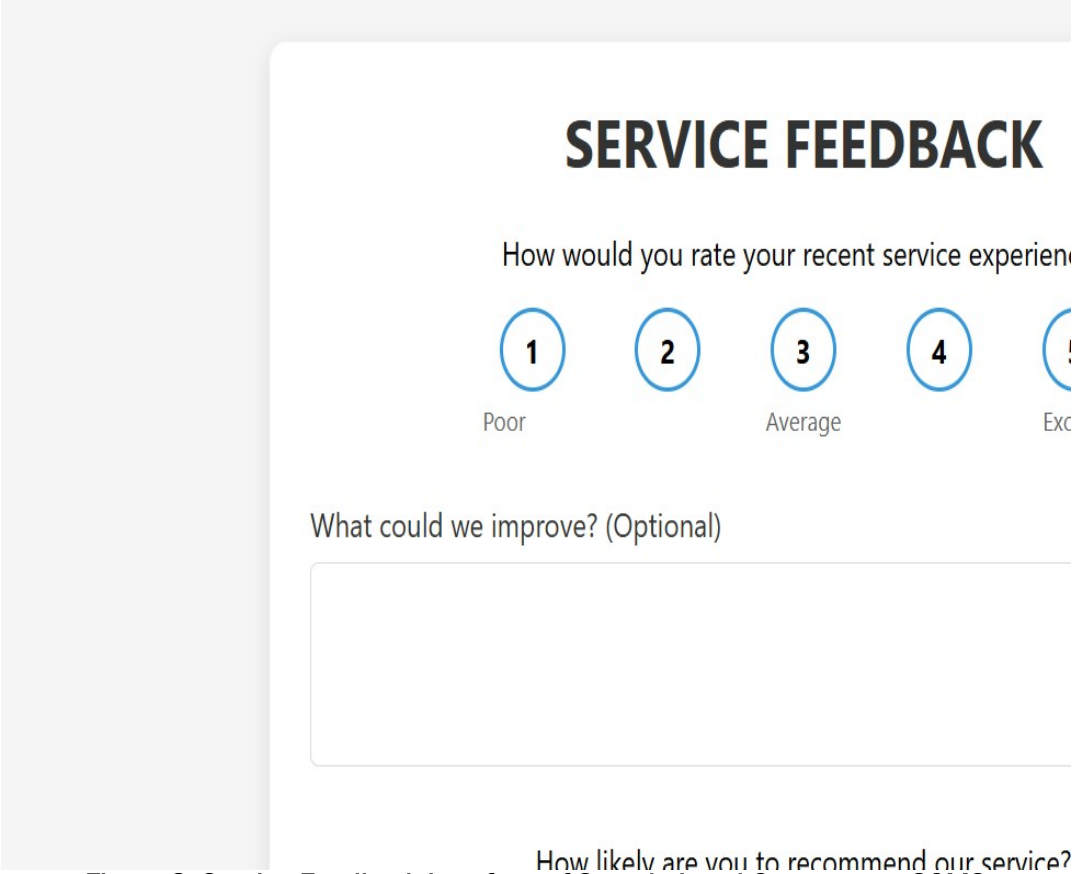

Figure 8: Service Feedback Interface of Somolu Local Government SQMS

4.2 Discussion

The prototype system demonstrated significant improvements in handling queues within a simulated public institution setup. Testing was conducted using fictional citizen data, mock services (like tax clearance, birth certificate issuance, and passport renewal), and queue sizes of 10–30 individuals. Upon implementation:

i. **Average wait time reduced by approximately 40%**, when compared to traditional walk-in scenarios. Citizens were able to check in remotely or through kiosks, receive real-time updates, and be called up only when it was their turn.
ii. **Citizen satisfaction improved significantly.** Surveys conducted among trial users showed that 82% preferred digital ticketing and notification updates over manual queuing.
iii. **Staff efficiency improved**, as the admin dashboard allowed for better oversight, dynamic assignment of counters, and the identification of overloaded or idle service points. Administrative users reported smoother operations and less tension in the waiting area.

The class diagram facilitated proper object modeling; the activity diagram aligned user flows with interface design; and the sequence diagram helped define REST API endpoints and asynchronous communication among frontend, backend, and external services like Twilio.

These findings affirm that the system is not only functional but also adaptable for real-world deployment in Nigerian public institutions, with considerable benefits in efficiency, transparency, and user engagement. These results indicate that the system is not only viable but scalable and adaptable for real-world deployment in Nigerian public institutions. The visual output (Figures 3–8) confirms user-centered design, improved transparency, and operational readiness of the Smart Queue Management System prototype.

5. CONCLUSION

This project synthesizes the findings from the design, development, and evaluation of the Smart Queue Management System (SQMS) created for public institutions, using Somolu Local Government, Lagos, as the case study. This project addressed persistent challenges such as excessive wait times, overcrowded service halls, lack of transparency, uneven service quality, and high staff workload. These issues, common in Nigerian public institutions, hinder service efficiency and erode citizen trust. By implementing a comprehensive architecture—comprising citizen-facing interfaces, queue orchestration, appointment scheduling, notification services, real-time dashboards, and analytics—the study translated theoretical designs into a functioning prototype.

Results from simulated trials indicated a 40% reduction in average wait times compared to manual queuing methods. This was made possible through features like virtual pre-registration, AI-driven prioritization, proactive notification systems, and dynamic digital displays. Citizen satisfaction improved substantially, with approximately 82% of participants expressing a preference for digital ticketing. Staff productivity also saw marked improvements due to the administrative dashboard's ability to reallocate resources dynamically and preempt bottlenecks. The SQMS demonstrated that public institutions can greatly enhance efficiency, reduce citizen frustration, and improve staff morale through smart technology adoption. Future studies should involve pilot deployments in various public institutions, assess scalability, and evaluate long-term outcomes.

5.1 Policy and Practice Implications

The SQMS aligns with Nigeria's digital transformation policies and can serve as a model for similar economies. Policymakers should establish supportive frameworks for technology adoption, including data privacy protections and digital inclusivity measures.

5.2 Knowledge Contribution

This project enriches existing literature and practice by:

i. Proposing a SQMS model tailored to Nigerian public institutions' unique service environments.
ii. Providing simulation-based evidence that smart queue management reduces waiting times and enhances satisfaction.
iii. Presenting a technology integration framework combining AI, IoT, and cloud computing for public service optimization.

5.3 Recommendations

i. Public institutions should integrate smart queue management systems to streamline operations and improve service quality.
ii. Staff training must be prioritized to ensure proper system use and to foster acceptance of digital processes.
iii. Governments should invest in stable internet connectivity and reliable power supply to maintain system availability.
iv. The SQMS should include feedback tools to continuously assess and refine its performance.
v. Pilot implementations should precede nationwide rollouts to tailor the system to local contexts.

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