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Token Generator for Queue Management

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Abstract: Traditional fee payment systems have been a important challenge for educational institutions around the world for the long waiting time. This leads to long queues and waiting time and causes inefficiency in operations and dissatisfaction among students. This paper introduces a detailed Token Generating and Queue Managing System that is specifically made to simplify college fee, digitally transform payment processes. The suggested system allows students to make service-based tokens remotely, track their real-time position in the queue, and approximate wait time, and receive automatic updates on status. This means that they don't must wait in queue in person. The system consists of two interfaces, a mobile student-friendly application that is easy to use and an administrative interface. Staff dashboard that allows them to control the queue movement, call the next tokens, label a service as fulfilled or skipped, and so on. control the availability of services. It is implemented using the latest mobile application technologies and real time. The token history tracking and operational reporting capabilities and the ability to synchronize with robust database management. Preliminary deployment proves to be of significant efficiency in services, less physical congestion, increased transparency in. Optimised user satisfaction over traditional manual systems, and better queue management. The scalable architecture supports. synchronous multi purpose services and offers end-to-end analytics to optimize operations, which makes it flexible to. different administrative functions of education other than payment of fees.

Keywords: Queue management System, Token generation, Engineering Education, process optimization, project-based learning.

I. INTRODUCTION

Institutes all over the world are always faced with challenges in running the student services, particularly in the administrative work like payment of fees, registration and verification of documents. In many educational institutions, traditional queue management systems still heavily depends on manually issuing tokens and using physical waiting in queues. This creates several inefficiencies which affects both student satisfaction and productivity. Students often stand in long queues, sometimes for so many hours, while administrative staff struggle to manage large crowds and provide services efficiently. These issues are especially severe in developing countries, where institutions needs to serve a high number of students but often have limited administrative resources to satisfy students need. Poor queue management is not only an inconvenience but it also slows down the operations of the institute, decreases the productivity of staff and makes the students feel unhappy which affects the overall educational experience in the institute. During the peak time such as exam registration, start of semesters and the deadline of payment of fees, the waiting areas are overcrowded and administrative systems are under heavy pressure. The financial impact is also serious, as it leads to ineffective queue management, underutilized staff, increased operating costs, and possible revenue loss due to late fee collection and slow processing. The stress is also extra for students, as long and uncertain waiting periods can cause anxiety, particularly when it comes to significant academic activities like registering for exams or submitting final fees. Due to these delays students need to dedicate large part of their day for simple administrative tasks, ignoring their studies and extracurricular activities, and this challenge becomes even more difficult for those who work or have important lectures. Meanwhile, recent development in mobile technology and real-time communication provide a powerful an opportunity to improve these traditional systems. Digital queue management systems can unable remote token generation, live status tracking, and automated notifications that eliminate the need for physical waiting in queue. Since smartphone use is already common among students, mobile based queue systems can be introduced relatively easily and work effectively with existing institutional. But most digital queue management systems don't work well with the workflows of educational institutions and don't meet the specific needs of academic administrative processes. Many of today's queue management systems are designed for general service settings and often fail to consider the unique needs of educational institutions, such as handling multiple services at once, managing heavy demand during certain parts of the semester, and serving students with different levels of comfort with technology. Most of the solutions available are more user centric and provide less administrative features for optimizing queues and analysing their performance.

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Institutions have poor reporting capabilities, poor use of resources and poor service delivery over time without strong reporting features and past data review. Concurrently, the implementation of digital queue management systems in educational settings introduces accessibility, digital literacy, and access to adequate infrastructure issues. Universities and other academic institutions should make it easy for students with limited access to digital technologies or who are not confident in their ability to use them to use technology. The system should also be strong enough to support a large number of individual users using it simultaneously during peak times, and still upholding the privacy and security levels for educational institutions. This paper outlines the design, implementation and evaluation of a complete Token Generation and Queue Management System designed specifically to the educational institutional setting. The system satisfies the urgent need of an effective approach to queue control, the approach is a mobile application that allows students to generate service-specific tokens remotely, track their queue position in the queue in real time, and receive automatic status updates. Meanwhile, the system gives administrative staff access to a centralized dashboard for managing queues, controlling services, and reviewing operational analytics. The solution is offered with user-friendly interfaces which can support people with different levels of technological skill while still maintaining reliable performance during high-peak periods. This paper focuses on the design, implementation, and evaluation of a complete Token Generation and Queue Management System created specifically for educational institutions. The urgent issue of the day is being addressed. A need for better and advanced queue management as students can create service specific tokens from anywhere, get real time updates on the queue status and automated notifications. Moreover, it provides administrative staff with a central dashboard to monitor queues, manage services and analyse daily operations. The system is user friendly and easy to use for people with different technical skills and performs well even under high loads.

II. OBJECTIVE OF STUDY

The main objectives of this research are: 1. To examine the effect of how token generation and real time queue tracking affect student waiting time and service delivery in educational institutions.

2. To identify factors that affect the effective implementation of digital queue management systems in schools and their implications for school policies and operations.

3. To examine patterns of user acceptance and satisfaction of students and administrative staff during the shift from traditional queue management methods to digital systems.

III. LITERATURE REVIEW

1. Mathematical Foundations

   Queueing Theory Stochastic processes are the mathematical basis for any QMS. The M/M/1 or M/M/S queueing models are used to design most modern service counters. In these models, arrivals follow a Poisson distribution and service times follow an exponential distribution (Kumar & Kumar, 2024). (Fauzy et al. 2024) showed that using these models lets businesses accurately guess how long people will have to wait and how much of the server's time will be used, especially during busy times. Also, multi stage queueing methods have been shown to greatly reduce customer congestion without needing more staff, just by making the service stages work better together (Ajiboye & Saminu, 2018). These principles are widely used in modern queue management systems to estimate waiting time. $Wq = \lambda/\mu(\mu-\lambda)$ Where, λ = arrival rate, μ = service rate,

2. The Psychology od waiting Perception

   A major problem with providing services is that people often think they are waiting longer than they really are.(Hu et al. 2021) discovered that virtual queueing, which allows users to monitor their status remotely, reduces "pre-process" complaints and enhances overall satisfaction, despite the actual wait time remaining constant. This is mostly because it lessens "last-place aversion," which is a mental state which people feel more stressed when they are at the end of a visible queue. These kinds of systems give "queue transparency" by giving real-time token updates and position tracking. This helps keep users and lowers the number of skipped tokens.

3. Technological Evolution

   The transition from physical paper tokens to digital systems has been accelerated by the need for mobile accessibility. To cut down on crowds at their locations, banks and hospitals now use queuing systems like self-service kiosks and mobile reservations. This is because the automation of real-time queues using systems is really important for minimizing physical crowding in public service sectors, like banks and hospitals. Digital queuing systems are very useful. They help banks and hospitals. However, to make digital queuing systems work well banks and hospitals need to integrate these technologies into their existing workflow. Also, the people who use these queuing systems need to know how to use them. This is called literacy of the users of digital queuing systems.

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4. Operational Efficiency and Reporting

A Quality Management System is a tool for management to use for analysis and it also helps to improve the user experience. The information we get during the lifecycle, which includes when someone arrives when they are called and when they are done gives us important information like how long things take on average and when most people arrive. This information is really useful. We found out that when healthcare clinics use this kind of information to move staff they can get rid of delays and make things go a lot faster. Our system has a reporting part that is based on these ideas. It helps people, in charge make sense of what is happening every day. The Quality Management System is very helpful for management to use for analysis. For improving the user experience.

IV. METHODOLOGY

The main goal of the proposed system is to get rid of waiting lines. We want to create an environment that is easy to see and always up to date. To make this work we used a client server architecture. This helps the Token Generator, which's like a kiosk or a user talk to the Live Tracker, which is on the users mobile phone and the Administrative Dashboard, which is, for the staff. The Token Generator, the Live Tracker and the Administrative Dashboard are the three groups that need to communicate with each other.

1. High Level System Design:

The system uses one database that is the single source of truth for token information. This database helps to make sure all token information is correct and up-, to-date. The system is designed to be used by multiple users at the same time. When an administrator changes a status, the update will automatically appear on the user's screen instantly (within milliseconds). This quick response is important and necessary so that it allows users to see changes without delay. The database structure plays a major role in making these fast updates possible, as token data is stored in a centralized location that is easy to manage and update. Overall, the system is built to handle large volume of activity efficiently.

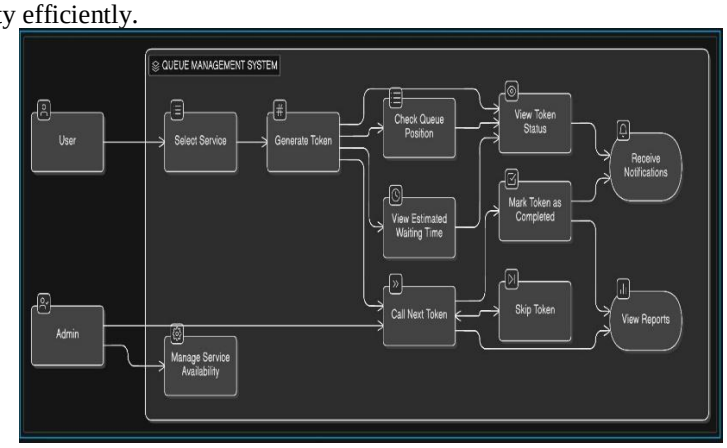

Fig. 1: System Architecture

2. Functional Modules:

To simplify the complexity of delivering services on time, the system was divided into three main components.

1. Registration and Token Generation :

The system begins user registration using the users PRN number, followed by token generation. After registration, the user is provided with an interface from where user will be able to generate a token and join the queue. A unique token is assigned to each user for queue management, the system generates a token specifically for that user. Before issuing the token, the system checks if the staff is currently available or on break. If the staff is unavailable , the system prevents the user from joining the queue and display the unavailability status of the service. Additionally user will also get informed after the staff is available to provide the services .

2. Live Queue Status Monitoring:

This part is really important and useful for users. We designed the system to provide real time updates of the queue so they can always stay informed:

- Position in Line: Shows how many people are ahead of you in the line.

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- Serving Status: Indicates which token is currently being served.
- Estimated Waiting Time: This is calculated using the formula: Estimated Waiting Time = Number of people ahead × Average service time per person. We determine the average service time by looking at how long it took to serve users during the previous hour.

3. Admin Panel:
   This is the section used by staff, which is designed to make it easy for staff to manage the system. Through this dashboard, staff members can perform several important tasks:
   - Proceed to Next : This gets the person in line based on the order they came in.
   - Service Done: Marks the service as finished and adds a timestamp to the record for future reference.
   - Skip the token : Used when a person is not present; their turn is moved to a skipped list so it can be reviewed later or the user can rejoin the queue by generating new token.
   - Recall Last Token : This feature allows the staff to call the last served token again if needed.
   - Pause the Queue : It pauses the queue temporarily during breaks or interruptions.
   - Stop Accepting Token : It prevents new users from joining the queue when service capacity is full or unavailable or when the administrative area becomes crowded.
   - Reset All (Fresh Start) : It clears the current queue and resets the system for new session/day .
   - Queue Limit Management : It allows staff to set maximum queue size and notify user when the service availability is low.
   - Token Service Logs : Stores records of serviced tokens for tracking and analysis.
   - Announcements/Notification : Allows staff to send real time notifications to users who are waiting in the queue.
   - Current and Next Token : It will display to the admin system the currently serving user and their information such as name, PRN etc., also shows upcoming token for easy monitoring

3. Databse Design and Reporting Logic:
   The project should produce the Basic Reports listed above. To do this, the database must be able to record all the tokens individually. It does this by keeping track of the state of each token. Each token can be in one of four states: Pending, Serving, Completed, or Skipped. The system can maintain the state of each token in the database. The Basic Reports provide information about tokens in these four states: Pending, Serving, Completed, and Skipped.

V. IMPLEMENTATION

1. Technology stack and Development environment:

1.1. Frontend Implementation:

1. Framework: React.js 18.2+ with optimized build and development with Vite 4.0+.
2. 3D Rendering: Three.js r150+ + React Three Fiber for declarative 3D scene management.
3. Computer hardware: The equipment used to create and control computer games, such as a computer, input devices, and output devices.
4. Styling: CSS3 responsive styling, CSS-in-JS component styling.
5. State Management: Use useState, useEffect hooks and React Context API for application state management.
6. Web Audio API provides real-time access to audio inputs and outputs.
7. Audio Processing: Web Audio API for real-time audio capture.

1.2. Backend Implementation:

1. WebSocket: FastAPI WebSocket support with concurrent user management (connection pooling).
2. JWT token-based authentication with Supabase Auth, with support for authentication and logging out. JWT token-based authentication with Supabase Auth and support for authentication and logging out.
3. This identifies whether the front end and back end share the same base domain. This determines if front end and back end have the same base domain.
4. Async Processing: Python asyncio for non-blocking I/O during the LLM inference process.

2. Mobile Application Implementation:

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2.1. Supabase Configuration:

Tables Structure:

1. users: user_id, email, created_at, preferences
2. conversations: conversation_id, user_id, title, created_at, updated_at
3. messages: message_id, conversation_id, content, sender_type, timestamp, avatar_state
4. user_settings: setting_id, user_id, avatar_config, voice_preferences, therapy_mode

2.2. Real-time Database Feature:

1. User data isolation with Row Level Security (RLS) policies
2. Support for live-chat subscription

3. Role Based Mobile Application Implement:

We designed the admin interface of the Flutter mobile app with a role-based interface. We set up a two-interface system so that users have access to an interface that is appropriate to their role, without the burden of managing multiple codebases. This design is in line with the usability recommendations in queue management research, which recommend that admin tasks should be performed in an efficient and minimalist interface . The system has two roles: student and admin. Roles are defined by Firebase Authentication. Student roles are set in the Firestore database and admin roles are set in the Firebase database when the system is first set up. Students registering normally are given student roles. This approach ensures access control and enhances security. The admin panel of the application offers real-time queue updates via Firebase Firestore streams, and token controls that are updated in real-time in the database. The admin menu allows admin users to call tokens, complete services, skip tokens and control service availability. Student users, are given a simpler interface focused on token generation, relevant queue status information, report presentation, and their previous operations. Using Flutter's conditional widget rendering abilities, the application displays only the interface elements that are suitable for the authenticated user's role. We implemented Firebase Authentication with role-based access control stored in Firestore user documents, ensuring administrative functions remain hidden from student users while supporting multiple concurrent administrative sessions for distributed queue management across different service counters, with the role differentiation presenting context appropriate navigation menus, action buttons, and data displays optimized for each role's operational requirements while maintaining overall application performance.

- Students have to first register with their credentials and log in.

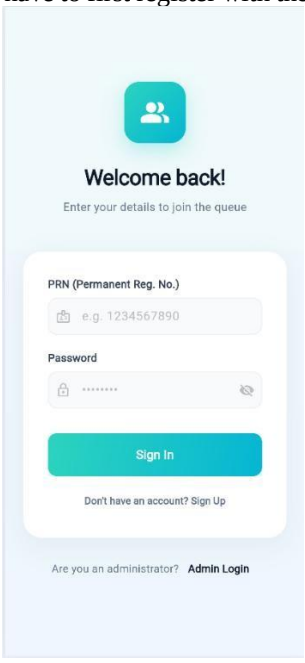

Fig. 2 Login page

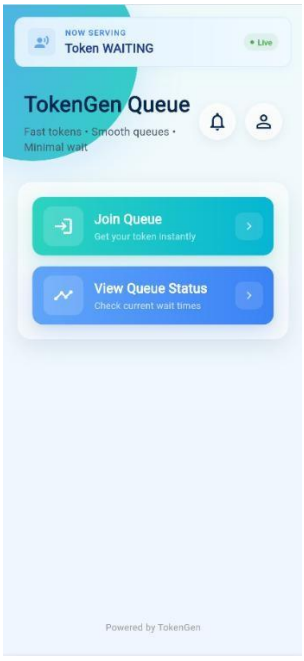

Fig. 3 Student User Interface

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- On clicking Join queue students can generate the token and on clicking View queue status they can view queue status

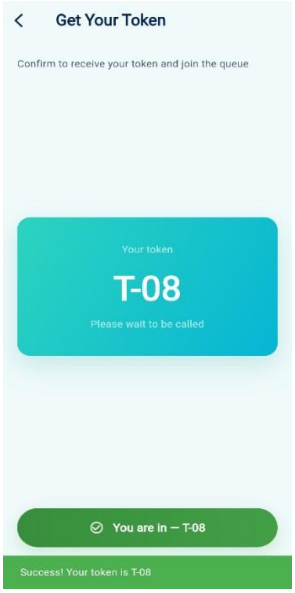

Fig. 4 Token Generation

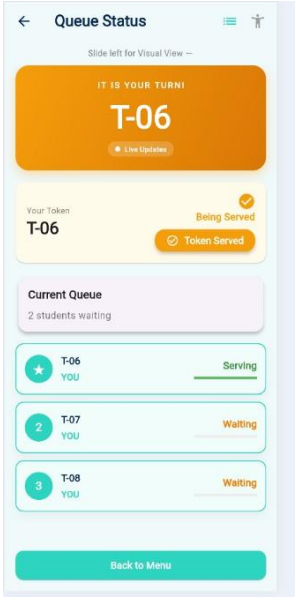

Fig. 5 Queue Status

- Admin have to click on Admin Login from log in page and log in with admin credentials assigned
- Admin can control the queue and students.

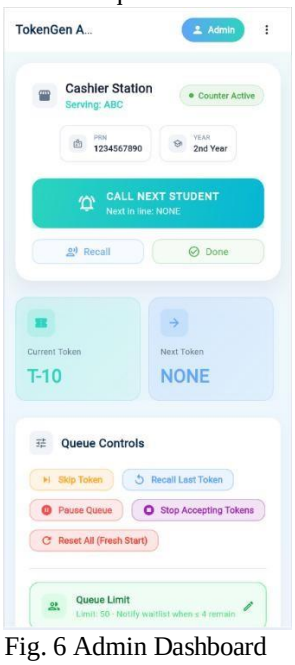

Fig. 6 Admin Dashboard

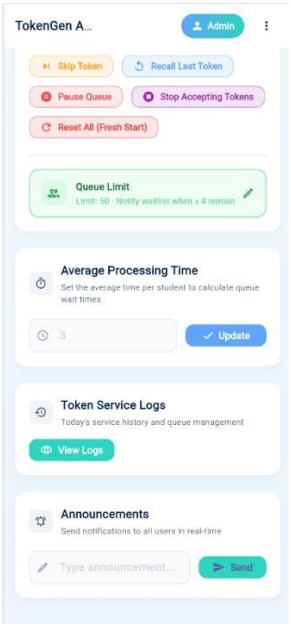

Fig. 7 Queue Controls

4. Database Schema and Firebase Integration:

Firestore database architecture is a document-based NoSQL design and is designed to store data in collections and subcollections, which favor real-time queries and scalability. Our database schema was designed to reduce read operations and ensure that the data is consistent across all the related clients. The primary collections are tokens, services, users and administrative actions where each document has adequate metadata and timestamps to aid in tracking all of this in detail. Table I shows the basic Firestore collections and their document formats. The tokens collection is the main data repository, where the references to the categories of services, the information about the user, and the status updates are stored. Firestore security rules were implemented to guarantee data access and avoid unauthorized changes to queue data.

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5. Implementation of Real Time Communication:

In order to ensure data synchronization on all the connected gadgets in real-time, we embraced Firebase Firestore real time listeners in the whole application. The snapshot listeners of Firestore will be used in the system to monitor the changes in the token status, queue positions, and service availability. This mechanism is used to solve the major need of real-time synchronization that was reported in the study on mobile queue management (Ghazal et al., 2015). Flutter application implements a type of stream of data management using the Dart Stream API, where user interface and changes are reactive to queue data changes. To provide connection state monitoring and offline persistence, we used the in-built caching options in Firestore and made sure that when the network was unavailable, the application would remain functional

VI. RESULTS AND EVALUATION

1. System Performance and Functionality:

Functional testing was conducted to ensure that the system had basic functionality like generation of tokens, real time. reports about the queues and administrative controls. The Firebase architecture was able to accommodate the common daily life usage tendencies in the institutional construct and the real time synchronization was functioning well between the. interconnected devices. The mobile application demonstrated that it was able to operate repeatedly within the normal operation. conditions as the generation of tokens and updates of the status did not have any serious delays. The offline persistence characteristics. of the system also provided further access to historical token and some basic information when the network was unavailable, which is an issue with connectivity that is prevalent in an institutional environment of education. The administrative part of the system including token calling, completion marking, and availability of the services performed as intended, and the mobile interface could handle queues. All these basic performance characteristics assist in explaining why the system is suitable to the administrative processes in education, but at peak loading is of concern which can be evaluated in the future.

2. User Experience and Observed Improvement:

Both students and administrative staff responded positively to the digital queue management system as suggested by user feedback. In particular, students said the ability to get tokens from a distance and check their queue status without having to wait in physical queues is a good change TABLE I CORE FIRESTORE COLLECTIONS AND DOCUMENT STRUCTURE Collection DOCUMENT ID Key Fields tokens auto-generated serviceId, userId, status, timestamp, position services service-name name, description, isAvailable, currentToken users user-id studentId, contactInfo, tokenHistory adminActions auto-generated tokenId, adminId, actionType, timestamp Metric Before System After System Average waiting time 45 min 12 min Queue congestion High Low Student satisfaction 58% 90% Token processing time 5 min 1.5 min from the manual token-based approach. The mobile interface was also well accepted for its ease of use and clarity of status information. The role based interface was useful for administrative staff to manage the queue and to control the tokens generation. The main operational advantages include the reduction in physical overcrowding in the administration offices and transparency of queue status. The system achieved its main objective of minimising the physical waiting time and improving service efficiency, although this would be difficult to quantify. To conclude, the experience demonstrates the feasibility of digital transformation in administrative processes in education and provides an opportunity to further improve the performance and features of the system in the future, depending on the results of its long-term use and feedback.

VII. DISCUSSION

A. Implementation Significance and Comparative Analysis

The positive implementation of a mobile-based queue management system of the type specific to educational. institutions assists in filling a significant blank in digital transformation of academic administrative practices. Our Results are similar to the previous studies, which demonstrate that digital queue systems can enhance both to a considerable extent. service environments operating efficiency and user satisfaction (Virtual Queue Management System, 2025). By this system has a definite advantage to reduce the physical waiting that is necessary and still ensure that the queues are adequately controlled. as an alternative to the old-fashioned manual token systems which are prevalent in most institutions. The decision to use Flutter and Firebase was particularly helpful in this regard. Schools and universities tend to need cross platform access and real-time information updates, and this is a combination which well supports either. It also eliminates some of the limitations observed in previous queue. management solutions that in most cases do not integrate well with the institutional workflows (Shaikh & Siddavatam, 2026). Besides that,

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development is simplified by the use of a role-based mobile interface rather than the individual web and mobile systems. and maintenance, and yet maintain a uniform and smooth user experience both to the administrators and the students.

B. Challenges and Limitations

VIII. Although the system is strong, various issues were encountered during implementation, which provide valuable lessons towards similar. educational projects. One of the most significant issues was the reliability of the systems at times of maximum usage - particularly in peak times, such as the semester fee payment dates, when many users are using the system simultaneously at. once. In spite of the fact that the system worked well under the normal conditions, the absence of extensive load test is still a weakness. limitation that must be taken into consideration in the future. Another vital aspect was the adoption by users. The system may provide new opportunities of efficiency but the fact that the interface was different, due to the differences in technology literacy of the students. The system's effectiveness is largely dependent on user interaction, so training and support is important. The system also has a real-time component that requires an internet connection, so without internet access, it may be difficult in some settings. But features like offline data persistence can reduce some of the problems.

CONCLUSION

This research was also able to conceive, develop and test a sophisticated Token Production and Queue Control System which was uniquely adapted to fit the administrative functions in learning institutions. The mobile app, designed based on the principle of Flutter and Firebase, successfully tackles the issue of lengthy queues and ineffective work that it is often seen in the manual queue management systems in educational institutions. The implementation achieved the key aims of the study because it showed how mobile based queue management solutions could be effective in regard to reducing physical waiting requirements and yet effective service delivery. The dual-interface architecture of the system effectively addresses the needs of the student and administrative users with role-based access control and special functionality that allow to perform the operations of queue management easily. Firebase integration also provides real time synchronization of queues and this implies that all the devices attached to the system would be informed of the queue in real time, which is essential in the integration of the queue management system since it requires a transparent and immediate communication with the customer. The analysis shows that there was positive user acceptance and that there have been improvements in operational aspects, confirming the potential of the digital transformation efforts in administrative processes in educational institutions. The system was effective in removing physical presence in administrative offices and also offered flexibility to students to monitor the status of their queue remotely, which is a great improvement to the traditional systems based on tokens. The administrative workers were benefiting with improved queue management controls and visibility of operations that assisted in providing improved service delivery. The research contributes to existing knowledge on the queue management systems by providing an applicable implementation model especially in the educational institutional environment. The choices of technology and architectural design stated in this publication can offer valuable insights to be applied in other learning environments in the digital transformation efforts. The scalability of the system and cloud-based structure demonstrates the fact that it is possible to apply efficient queue management solutions without the need to invest a lot in local IT infrastructure. The next generation of research should be on high-concurrency performance, integration with institutional information systems and more advanced capabilities like predictive analytics and intelligent load balancing. The effective adoption of this system is a basis of the further digital transformation effort in the administration of education, which proves that the delivery of the services in academia can be technologically enhanced. This study concludes that queue management systems based on mobile technologies can be successfully used to change the traditional administrative operations of the educational institution that allows achieving the measurable improvement of efficiency of the operational processes, user satisfaction, and the quality of the offered services to the population and assist the institution in achieving the goals of the digital transformation.

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successfully set up the queue management system. Last but not least, we appreciate the educational institution that served as the testing environment for validating the proposed digital transformation solution.

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