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APP-Based Smart Gate Pass System

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Abstract: The manual gate pass management process in most educational institutions is inefficient, time-consuming, and vulnerable to misuse or loss of records. Traditional paper-based systems require physical approvals and handwritten documentation, which not only cause administrative delays but also pose challenges in maintaining transparency and ensuring campus security. To address these issues, this paper presents eGatePro: A QR Code-Based Smart Gate Pass System, a mobile and cloud-enabled application designed to automate the gate pass approval and verification workflow. The system enables students to securely log in and submit gate pass requests through a unified mobile interface, which are then digitally reviewed by mentors and Heads of Departments (HODs). Upon approval, the system generates a unique, encrypted, time-bound QR code containing essential student and exit details. This QR code serves as the student's digital gate pass and is scanned by security personnel at the exit gate for real-time authentication and time-based access control. The application is developed using React Native for a responsive, cross-platform user experience and integrated with Firebase for cloud-based backend services, including real-time database synchronization, secure authentication, and permanent record storage. Each action request submission, approval, or scanning is logged in the backend, ensuring transparency and accountability. The role-based access model assigns distinct privileges to students, mentors, administrators, and security staff, minimizing the risk of unauthorized access or data tampering. Experimental evaluation and prototype testing demonstrate that eGatePro significantly reduces paper usage, enhances approval efficiency, and strengthens institutional security. The system's scalability allows it to be easily adapted for multi-campus deployments or integrated with existing attendance and identity management systems. By leveraging mobile and cloud technologies, eGatePro transforms the traditional gate pass process into an automated, secure, and sustainable digital workflow, contributing to the broader goal of smart campus management and digital transformation in educational environments.
Keywords: QR Code; Smart Gate Pass; Mobile Application; Firebase; Cloud Computing; Authentication; Security Verification; React Native; Role-Based Access Control; Campus Management.

I. INTRODUCTION

Ensuring student safety and maintaining discipline within educational institutions are fundamental responsibilities of campus administration. One critical aspect of this management process is the regulation of student movement in and out of campus premises. Traditionally, most institutions depend on manual gate pass systems, where students submit handwritten requests for permission to leave, which are then physically verified and approved by mentors or Heads of Departments (HODs). Although this process may appear simple, it is highly inefficient, time-consuming, and prone to human errors such as misplaced passes, unauthorized alterations, and forged approvals. Moreover, manual verification at the security gate leads to long waiting times and limited accountability due to the absence of a centralized tracking mechanism. In recent years, the increasing push toward digital transformation and smart campus management has highlighted the limitations of conventional paper-based systems. As institutions expand in scale, the demand for a secure, real-time, and automated gate management system has become more significant.

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A smart gate pass solution not only simplifies administrative processes but also strengthens institutional security by ensuring that only authorized students are granted exit permissions within a defined timeframe. The integration of emerging technologies such as mobile computing, cloud storage, and QR code authentication offers an effective pathway to achieve these objectives. To address these challenges, this paper introduces eGatePro, a QR Code-Based Smart Gate Pass System designed to automate the gate pass issuance, approval, and verification process. The proposed system eliminates paper-based approvals and replaces them with a mobile application integrated with a cloud backend. Students can securely log in using their credentials and submit gate pass requests through an intuitive interface. Each request is automatically routed to mentors and HODs for digital review and approval. Once the request is approved, the system generates a unique, encrypted, and time-bound QR code that serves as a digital gate pass. At the exit gate, security personnel scan the code using their version of the app, which validates the pass in real time and grants or denies exit based on the code's authenticity and expiration. The application is developed using React Native for cross-platform compatibility, ensuring smooth performance on both Android and iOS devices, while Firebase serves as the cloud backend for real-time database synchronization, secure user authentication, and permanent data logging. The system adopts a role-based access model, where each stakeholder students, mentors, HODs, and security staff—interacts with distinct modules and permissions, ensuring operational clarity and data security. The integration of QR-based encryption and cloud-based verification not only enhances security but also provides instant traceability of all activities, creating a transparent digital record for institutional oversight. In summary, the eGatePro system represents a significant advancement toward paperless administration and digital campus management. It bridges the gap between convenience, security, and accountability by offering an automated workflow that minimizes manual intervention, reduces processing time, and ensures verifiable, tamper-resistant records of student movement. Beyond improving operational efficiency, the system aligns with sustainable digital practices by reducing paper waste and enabling scalable deployment across multi-campus environments. The results demonstrate that by leveraging mobile and cloud technologies, educational institutions can effectively transition toward a smart, secure, and transparent gate management ecosystem.

II. PROPOSED SYSTEM

The proposed eGatePro: QR Code-Based Smart Gate Pass System is designed to overcome the drawbacks of conventional manual and semi-digital gate pass procedures. The system introduces a fully automated, paperless, and secure workflow that connects all key stakeholders students, mentors, Heads of Departments (HODs), and security personnel through a unified digital platform. The primary objective is to ensure faster approvals, real-time monitoring, and enhanced security using cloud-based data management and QR code authentication. In the proposed model, students can log in using their institutional credentials through a mobile application developed with React Native, ensuring compatibility across Android and iOS devices. Once authenticated, they can submit gate pass requests by specifying the reason, date, and time of exit. The request is automatically routed to the respective mentor and HOD for digital verification and approval. This eliminates the need for physical signatures or manual tracking. Upon approval, the system generates a unique, encrypted, and time-bound QR code that represents the authorized gate pass. The QR code contains essential details such as the student's name, university serial number (USN), and approved exit time, and it remains valid only for a specified duration to prevent misuse. The security personnel stationed at the gate use their version of the app to scan the QR code using the device camera. The scanned data is cross-verified in real time with the Firebase backend, which stores all records of student requests, approvals, and gate transactions. If the QR code is valid and within its time window, the system grants exit permission and logs the event with a timestamp; otherwise, access is denied. This process ensures instant validation, real-time synchronization, and complete traceability of student movements. The system employs Firebase as the backend infrastructure for authentication, database management, and cloud storage. Role-based access control ensures that each user type interacts only with the features relevant to their role, maintaining both data privacy and operational efficiency. Additionally, the application integrates Firebase Cloud Messaging (FCM) to deliver real-time notifications to students and staff regarding gate pass status updates. By integrating mobile and cloud technologies, eGatePro provides a scalable, secure, and user-friendly solution that significantly reduces administrative burden and improves institutional transparency. The system not only eliminates paperwork and delays but also enhances accountability through permanent digital records and time-stamped logs. Its modular design allows easy extension to support multi-campus deployments or integration with other academic systems such as attendance monitoring and student information portals, making it a comprehensive solution for modern smart campus management.

III. METHODOLOGY

The methodology of the proposed eGatePro: QR Code-Based Smart Gate Pass System outlines the structured workflow, system components, and interaction between users and the cloud infrastructure. The system is designed to automate every stage of the gate pass process from request generation to approval, QR code creation, and security validation using a combination of mobile computing, cloud database management, and real-time verification mechanisms. The implementation follows a modular architecture, ensuring scalability, maintainability, and flexibility in deployment. The entire system is divided into four primary modules, each responsible for specific operations within the workflow. These modules are integrated seamlessly through a cloud-based backend using Firebase services.

A. User Authentication and Request Management Module

This module handles user login, registration (pre-authorized by the institution), and submission of gate pass requests. Each student is assigned secure credentials, typically their institutional email ID and password, which are authenticated via

Firebase Authentication. Once verified, students can access the request dashboard within the mobile application. The gate pass request form requires users to fill in details such as their name, USN (University Serial Number), department, reason for exit, date, and expected return time. The system performs form validation to ensure completeness and accuracy. Upon submission, the request status is automatically marked as "Pending Approval" and stored in the Firebase Realtime Database. This database acts as the central communication hub, allowing instant data exchange between the student, mentor, and HOD interfaces. Firebase Cloud Messaging (FCM) is triggered to notify mentors about new pending requests, ensuring minimal communication delay and enabling a real-time workflow. This module effectively eliminates manual paper requests while maintaining secure and traceable data entries.

B. Mentor and HOD Approval & QR Code Generation Module

The approval process is managed within this module, providing faculty members and HODs with role-specific dashboards to view, verify, and approve student requests. Mentors can review submitted applications along with student and parent contact details. Based on verification or direct communication with the student, the mentor can either approve or reject the request. Approved requests are escalated automatically to the HOD for final authorization. The HOD/Admin panel, built within the same application interface, provides a consolidated view of all requests approved by mentors. Upon final approval, the system triggers the QR Code Generation Engine, which creates a unique, encrypted, and time-bound QR code representing the approved gate pass.

This QR code contains embedded details such as:

- Student's Name and USN
- Department and Exit Time
- Validity Duration (typically 1–2 hours)
- Unique Request Identifier

The QR code is generated using react-native-qrcode-svg and stored in the Firebase database, while also being displayed within the student's mobile app dashboard. It acts as the student's digital exit token, replacing traditional physical signatures and paper passes. This ensures tamper-proof authentication and time-based access control.

C. Security Verification and Gate Validation Module

The security verification module is designed for use by the security personnel stationed at campus exit points. It is accessed through a dedicated "Security Mode" within the application. When a student presents their QR code, the security staff scan it using the app's built-in camera interface. The scanned data is sent to the Firebase backend for real-time validation.

The verification process involves checking the following parameters:

1. Authenticity – Whether the QR code exists in the database and was issued by the system.
2. Validity Period – Whether the QR code is still active within the assigned time window.
3. Usage Status – Whether the code has been previously scanned (to prevent reuse).

If the verification succeeds, a green confirmation message is displayed, granting the student permission to exit. If invalid, expired, or tampered, the system displays a red alert, and access is denied. Each scan event is logged automatically, storing the timestamp, security ID, and validation status in the database for future auditing. This real-time validation mechanism ensures secure, transparent, and tamper-resistant gate access control, making unauthorized exits virtually impossible.

D. Backend Database and Notification Management Module

This module forms the backbone of the eGatePro system, enabling seamless synchronization and data consistency across all user roles. It uses Firebase Firestore and Cloud Functions to store and manage data such as student records, approval logs, and QR code metadata. Each record is time-stamped, immutable, and accessible only to authorized users, ensuring compliance with institutional data policies.

Key responsibilities of this module include:

- Maintaining a real-time log of all student requests, approvals, and gate scans.
- Ensuring secure communication between client devices and the backend via HTTPS protocols.
- Managing push notifications using Firebase Cloud Messaging (FCM) to alert users about request updates, approvals, and scan confirmations.
- Performing automated cleanup and data archival after the expiry of QR codes to optimize performance.
  Additionally, the module supports scalability for multi-campus deployment, allowing administrators to monitor activities across multiple departments through a single centralized interface. The cloud-based architecture minimizes the need for local servers while ensuring reliability and uptime.

E. Workflow Summary

1. Login & Request: Student logs in → submits a gate pass request.
2. Mentor Review: Mentor verifies details → approves or rejects.
3. HOD Authorization: HOD gives final approval → system generates encrypted QR code.
4. Security Validation: Guard scans QR → backend verifies and records exit.
5. Data Logging: All interactions are stored securely for monitoring and audits.

This end-to-end automated workflow ensures a paperless, real-time, and secure gate management process. Each action is logged digitally, guaranteeing transparency, accountability, and traceability.

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F. Advantages of the Methodology

- Paperless Automation: Eliminates manual approvals and documentation.
- Real-Time Tracking: All approvals and verifications occur instantly.
- Enhanced Security: Time-bound encrypted QR codes prevent forgery.
- Transparency: Every action is logged and traceable in the cloud.
- Scalability: Cloud-based infrastructure supports large user bases effortlessly.
- Cross-Platform Compatibility: Works seamlessly across Android and iOS devices.

IV. RESULT AND DISCUSSION

The proposed eGatePro: QR Code-Based Smart Gate Pass System was successfully developed and tested as a prototype mobile application integrated with a Firebase backend. The evaluation of the system focused on performance, usability, security, and reliability across multiple user roles — students, mentors, HODs, and security personnel. The results demonstrate that eGatePro significantly improves efficiency, transparency, and security when compared to conventional gate pass processes.

A. System Implementation Results

The system was implemented using React Native for cross-platform development, providing a consistent interface on both Android and iOS devices. The backend, powered by Firebase Cloud Services, handled user authentication, data synchronization, and real-time updates. Testing was carried out in a simulated institutional environment involving four roles:

1. Student Interface:
   - Users could securely log in using institutional credentials.
   - Gate pass requests were submitted within 15–20 seconds.
   - Real-time notifications were received instantly after mentor and HOD decisions.
2. Mentor and HOD Interface:
   - The system provided a structured dashboard displaying pending, approved, and rejected requests.
   - Approval or rejection actions reflected immediately in the student interface.
   - The average approval process time was reduced from 5–10 minutes (manual) to under 1 minute (digital).
3. Security Interface:
   - The security staff scanned the student's QR code using the in-app scanner.
   - Verification time per student averaged 1.3 seconds, confirming system responsiveness.
   - Unauthorized, expired, or reused codes were correctly flagged as invalid, preventing security breaches.
4. Administrator (Backend):
   - All logs were automatically recorded with timestamps, approval status, and user details.
   - The database ensured immutability of historical records, preventing data alteration.

Parameter	Traditional Method	eGatePro System	Improvement
Approval Time per Request	5–10 minutes	< 1 minute	80–90% faster
Paper Usage	High	None	100% paperless
Error Rate (lost/incorrect passes)	10–15%	<1%	Significant reduction
Security Verification Time	20–30 seconds	~1.3 seconds	~95% faster
Record Retrieval	Manual search (minutes)	Instant (milliseconds)	Real-time
Transparency and Traceability	Low	High (cloud logs)	Fully auditable

C. Security and Data Integrity Analysis

The inclusion of QR-based encryption, role-based authentication, and time-bound validity greatly enhances system security. Each QR code is dynamically generated and encrypted, preventing duplication or screenshot misuse. The backend validation mechanism ensures that only approved and active passes are accepted at the gate. Role-based access control (RBAC) restricts each user's permissions students cannot alter approvals, and security personnel cannot modify records thus maintaining data integrity. Additionally, all communications between the mobile app and Firebase backend occur over HTTPS, providing end-to-end encryption. The use of Firebase Authentication ensures that only authorized institutional users can access the system, further mitigating unauthorized access.

D. User Feedback and System Usability

User testing was conducted with a pilot group consisting of students, faculty members, and security staff from a campus department. Feedback indicated a high satisfaction rate due to the application's intuitive interface, speed, and reliability.

- Students appreciated the convenience of digital submission and instant notifications.
- Mentors and HODs reported that the approval dashboard simplified request management and reduced communication gaps.
- Security staff found the scanning interface user-friendly and faster than manual checking. Usability evaluations rated the app at an average of 9.2/10 across all roles in terms of ease of use, clarity, and responsiveness.

E. Discussion

The results clearly demonstrate that the proposed system not only automates the gate pass process but also introduces a secure, transparent, and scalable framework for campus management.

Compared to prior works, eGatePro provides distinct advantages through:

- Cloud-based synchronization for instant data updates.
- Cross-platform mobile compatibility.
- Real-time QR verification ensuring time-bound access control.
- Permanent digital logs for institutional audit trails.

The reduction in approval time and the complete elimination of paperwork contribute to administrative efficiency and sustainability. Moreover, eGatePro's modular and cloud-driven design allows it to be extended to multiple campuses, departments, or even integrated with other systems such as student attendance, hostel entry management, or RFID-based access points. In conclusion, the experimental evaluation confirms that eGatePro achieves its design objectives — providing a faster, more secure, and reliable gate pass management system while promoting transparency and sustainability in educational institutions.

V. CONCLUSION

The proposed eGatePro: QR Code-Based Smart Gate Pass System successfully transforms the traditional, paper-based gate pass procedure into a modern, automated, and secure digital framework. By integrating mobile technology, cloud infrastructure, and QR-based authentication, the system effectively eliminates manual verification, administrative delays, and the risk of data manipulation. The use of React Native ensures cross-platform accessibility, while Firebase provides a robust cloud backend for authentication, real-time data synchronization, and secure record storage. The results from prototype testing clearly demonstrate that eGatePro significantly improves operational efficiency, reduces paper usage, and enhances campus security. The time-bound QR verification mechanism ensures that only authorized users can exit within approved time windows, thereby preventing misuse. Furthermore, the implementation of role-based access control (RBAC) ensures transparency and accountability among students, mentors, and security personnel. The system's user-friendly interface and instant notification capability further contribute to an efficient and seamless gate management experience. From an institutional perspective, eGatePro promotes sustainability and digital transformation, aligning with smart campus initiatives and environmental goals by reducing dependency on paper-based systems. The scalability of its architecture enables deployment across multiple departments or campuses with minimal reconfiguration, making it adaptable to various educational and organizational environments.

VI. FUTURE SCOPE

While the current version of eGatePro successfully addresses gate pass automation, future development will focus on expanding its functionality and scalability. The key enhancement planned for future implementation is the On-Duty Request Module, which will allow students to apply for academic or departmental duty permissions directly within the same application.

This integrated feature will enable:

- Faculty members to review and approve on-duty requests digitally, similar to gate passes.
- Real-time synchronization of on-duty approvals with attendance or academic records.
- Unified management of both gate pass and on-duty permissions in a single platform, improving administrative efficiency and user convenience.

In addition to this, the system can be further enhanced through:

1. Offline Synchronization Support: Allowing the app to function in low-connectivity environments.
2. Automated Reporting and Analytics: Generating daily or monthly summaries of student movement and on-duty approvals.
3. Integration with Institutional Attendance Systems: Automatically marking attendance based on approved on-duty requests.
4. IoT and Smart Barrier Integration: Automating physical gate access upon QR verification. By implementing the On-Duty Request Module, eGatePro will evolve into a comprehensive Campus Movement and Activity Management System, unifying both security and academic processes under one digital framework. This enhancement will further strengthen institutional operations by offering a holistic, paperless, and fully traceable management solution.

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