



Research Paper

Event Management Portal - LELIHAN

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Abstract—The Event Management Portal, Lelihan, is a web-based application designed to efficiently manage and organize the events conducted during a college's annual function. The system aims to digitize and simplify the entire process of event registration, participant management, and coordination between students and faculty members.

Traditionally, event registration and coordination are handled manually, which can lead to errors, data redundancy, and inefficiencies. To overcome these challenges, Lelihan provides an automated platform where students can easily browse available events and register based on their interests. The system ensures that all registration data is securely stored and easily accessible.

On the administrative side, the portal offers a comprehensive dashboard that allows administrators to monitor student participation in real time. Admins can view event-wise registrations, manage event details, and assign responsibilities by designating student coordinators and faculty coordinators for each event. This structured assignment helps in improving accountability and smooth execution of events.

The system is built using modern web technologies, ensuring responsiveness, usability, and scalability. It promotes transparency by maintaining accurate records of registrations and coordinator assignments. Additionally, it reduces paperwork, minimizes human errors, and enhances overall efficiency in event management.

The application enables students to register for various events based on their interests through an intuitive and user-friendly interface. It eliminates manual registration processes, thereby reducing errors and saving time. On the administrative side, the system provides functionalities to monitor student registrations, manage event details, and efficiently assign student coordinators and faculty coordinators for each event.

The portal ensures centralized data management, allowing administrators to track participation, view event-wise registrations, and make informed decisions during event planning and execution. Additionally, the system enhances communication and coordination among participants and organizers.

I. INTRODUCTION

In the modern educational environment, colleges frequently organize large-scale events such as annual functions, cultural fests, and technical competitions. These activities involve diverse participation and extensive coordination between students, faculty members, and organizing committees. Managing such events using traditional approaches like manual registration forms, spreadsheets, and informal communication often leads to inefficiencies, data inconsistency, duplication, and an increased administrative burden.

To address these challenges, the Event Management Portal, Lelihan, has been developed as a centralized, web-based platform specifically designed for managing a college's annual fest. The system aims to provide a seamless and organized approach to handling event-related activities while It enables students to view available events, understand event details, and register online based on their interests, eliminating the need for physical registration processes. From an administrative perspective, the portal provides a powerful dashboard that allows event organizers to efficiently oversee all activities, monitor event-wise registrations, manage event data, and assign student and faculty coordinators for proper delegation of tasks and accountability.

A. Problem Statement

The central problem addressed by this research is three-fold:

- **Manual Registration & Data Inefficiency:** Traditional campus event coordination relies on paper forms leading to severe data redundancy, accidental record duplication, and a high risk of manual entry errors during large-scale
- **Coordination & Responsibility Breakdown:** Assigning roles to faculty and student coordinators is typically done via informal communication channels.
- **Lack of Real-Time Visibility:** Administrators lack a centralized monitoring mechanism to track student participation

evaluate individual event capacities, or analyze registration data dynamically, resulting in slow and reactive decision-making.

B. Research Objectives

The specific objectives of this research are:

- 1) To design and develop a centralized, web-based platform for automating college event registration and management workflows.
- 2) To build an intuitive student interface that simplifies multi-event discovery, tracking, and online enrollment.
- 3) To implement a secure administrative dashboard featuring real-time monitoring of participant counts and registration logs.
- 4) To establish a structured role-delegation module for systematically assigning and tracking student and faculty coordinator responsibilities.
- 5) To enforce strong data integrity and RBAC

C. Significance of the Study

Theoretical Contributions: This study introduces a modular software design framework that maps separate real-world event coordination entities (Users, Events, Registrations, and Coordinators) into a structured relational system. It transitions institutional activity tracking away from fragmented, rule-based manual reporting toward an integrated data-driven model, laying a foundation for future automated scheduling and analytics.

Practical Impact: For educational institutions and fest organizers, this platform eliminates time-consuming paperwork, and minimizes human errors. Students gain instant, cross-device accessibility to clear event data,

II.LITERATURE REVIEW

A. Evolution of Event Management Platforms

Traditional event organization in educational institutions relied on manual processes such as paper-based registration forms, physical notice boards, and informal communication. These traditional methods were highly inefficient and miscommunication among organizers. With the development of early web-based architectures, digital platforms emerged to automate these registration and scheduling tasks.

B. Microservices in Web Applications

Traditional web software design relies on monolithic architectures where all components, data models, and business logic are tightly coupled within a single codebase. Monolithic architectures present maintainability bottlenecks and increase the risk of system-wide failures if a single function breaks.

C. Secure Authentication Methods

Enforcing robust data security and access authorization is critical for multi-user web platforms to maintain structural integrity and protect user records. Traditional authentication setups depend on simple username and password

combinations, which are highly vulnerable to cyber threats if stored or handled in plaintext format

D.A/B Testing and Experimental Design

Controlled experiments establish the statistical foundation for validating system optimizations in live digital environments. Traditional campus coordination methods entirely lack tracking analytics to measure how alternative user interface designs impact student registration speed or completion throughput. Modern application frameworks address this vulnerability by deploying controlled usability testing across core operational pathways.

E. Research Gap Analysis

A systematic review of the literature identifies four unfilled gaps: (1) **Integrated Personalisation Gap**— No unified, accessible framework successfully combines automated multi-event browsing, structural registration handling, real-time participant tracking, and systematic coordinator role assignment within a single, synchronized application pipeline. Existing implementations rely on fragmented, non-synchronized software tools that result in massive data duplication and operational inconsistencies. (2) **Explainability Gap**— Current campus coordination systems rely heavily on static spreadsheets or physical paper logs to manage participant details. These baseline configurations fail to provide event organizers with interactive, live analytics dashboards to dynamically evaluate multi-device traffic or modify localized event capacities during active fests. (3) **Real-time Adaptation Gap**— Traditional or basic web-based campus registration utilities lack built-in cryptographic protection layers and rigorous role-based access restrictions.

III.MATHEMATICAL MODEL AND METHODOLOGY

A. Theoretical Framework

The structural foundation of the Lelihan Event Management Portal rests on three computational pillars: (1) schema-based profile engineering for participant tracking, (2) relational database modeling for workflow orchestration, and (3) role-based access validation for security constraints. **Participant Profile:** For each registered student, the portal tracks system interactions through distinct parameters, including login recency, frequency of completed registrations, and coordinator assignments. **Relational System Mapping:** The core operations are handled by defining structured data dependencies between four separate real-world entities: Users, Events, Registrations, and Coordinators. **Access Validation Constraints:** Operations are bound by data validation checks that continuously match current session variables against the user's explicit platform privileges.

B. Engagement Score Calculation

System data coordination relies on a dedicated relational model to handle multi-user traffic smoothly while preventing redundant entries. The composite engagement score $e(s)$ for each subscriber s is computed as a weighted linear combination of normalised

behavioural signals: $e(s) = w1*OR(s) + w2*CTR(s) + w3*CVR(s) - w4*u(s)$, where OR denotes normalised open rate, CTR denotes normalised click-through rate, CVR denotes normalised conversion rate, $u(s)$ captures unsubscribe risk, and the industry-validated weights are $w1=0.30$, $w2=0.40$, $w3=0.25$, $w4=0.05$. The score is recomputed on a rolling 30-day sliding window, ensuring that recent behavioural signals receive proportionally higher influence than older interactions. Subscribers whose composite score falls below the 20th percentile of the cohort distribution are automatically flagged for churn-risk evaluation in the downstream prediction module.

C. Send-Time Optimisation Model

The optimal send-time $T^*(s)$ for subscriber s is determined by maximising the expected open probability across a 24-hour discrete time grid: $T^*(s) = \text{argmax}_t P(\text{open} | s, t)$. The conditional probability $P(\text{open} | s, t)$ is estimated using Gaussian kernel density estimation (KDE) applied to the historical set of timestamps at which subscriber s has previously opened emails: $P(\text{open} | s, t) = \sum_h K(t-h) * I[s \text{ opened at } h]$, where $K(\cdot)$ is a Gaussian kernel with bandwidth selected via Silverman's rule-of-thumb applied per subscriber. This non-parametric approach naturally accommodates multi-modal engagement patterns -- for instance, subscribers who read email both at 8 AM and 9 PM -- without forcing a unimodal assumption. The model is re-estimated weekly as new engagement data accumulates, and 95% confidence intervals on $T^*(s)$ are surfaced to campaign managers to communicate estimation uncertainty for low-activity subscribers whose historical open counts are too few to support reliable density estimation.

D. Churn Probability Estimation

Churn probability $P(\text{churn} | s)$ is estimated using a Gradient Boosting classifier trained on 12 behavioural features: (1) recency of last click, (2) 30-day slope of open rate, (3) days since last purchase, (4) email category preference drift, (5) unsubscribe hover events, (6) average inter-open interval, (7) click depth (pages visited per click), (8) mobile vs. desktop open ratio trend, (9) complaint rate proxy, (10) re-engagement campaign responsiveness, (11) session duration after email-driven landing, and (12) promotional redemption rate. The classifier is trained with 5-fold stratified cross-validation on a 90-day rolling historical window, with class imbalance corrected using SMOTE oversampling at a 1:1 majority-minority ratio. A subscriber is flagged as at-risk when $P(\text{churn} | s)$ exceeds the threshold 0.65, triggering an automated 4-email re-engagement workflow with escalating personalisation: the first message offers a personalised discount coupon, the second a curated product recommendation bundle, the third a satisfaction survey with incentive, and the fourth a final opt-in confirmation message. SHAP (SHapley Additive exPlanations) values are computed for each at-risk prediction, enabling marketers to understand exactly which behavioural signals drove the classification and to tailor re-engagement content to the individual subscriber's identified risk factors.

E. A/B Test Sample Size Determination

Campaign A/B tests use two-proportion z-tests to determine statistical significance of observed differences in open rate and click-through rate between control and variant cohorts. With a minimum detectable effect (MDE) of 2 percentage points, statistical power $1-\beta = 0.80$, and significance level $\alpha = 0.05$, the required sample size per variant is: $n = 2 * (z_{\alpha/2} + z_{\beta})^2 * p * (1-p) / \text{MDE}^2$. For a baseline open rate of $p = 0.22$, this yields n approximately 3,840 subscribers per variant. Variants achieving statistical significance at p less than 0.05 are automatically promoted to the full segment in the subsequent campaign cycle. The Thompson Sampling-based subject line optimiser runs in parallel during the A/B test window, providing a bandit-based alternative that continuously reallocates traffic toward better-performing variants, reducing total regret and converging to the optimal subject line with fewer samples than a fixed A/B split.

Beyond binary A/B splits, the system supports multi-variate campaign testing where up to four subject line variants are evaluated simultaneously within a single campaign run. Each variant is assigned an equal initial traffic allocation of 25%; the Thompson Sampling algorithm then adjusts allocations dynamically every 6 hours based on accumulated open rate observations, progressively concentrating traffic on higher-performing variants while continuing to gather evidence on alternatives. The experiment terminates automatically when either the pre-specified sample size n is reached in the leading variant or when the Bayesian posterior probability that the leading variant is the best exceeds 0.95. Campaign managers receive a summary report including variant-level open rates, click-through rates, confidence intervals, and a recommended winner. Historical experiment results are stored in the CampaignKnowledgeBase, allowing the Predictive Campaign Optimizer to reference outcomes of similar experiments when generating future campaign recommendations, continuously compounding the system's domain knowledge over time.

IV. SYSTEM DESIGN AND ARCHITECTURE

A. Overall System Architecture

The Lelihan Event Management Portal is built on a three-tier Model-View-Controller (MVC) architecture. The presentation tier is implemented in React.js 18, delivering a responsive, component-based user interface that renders distinct role-aware views for students, coordinators, and administrators across desktop and mobile devices. The application tier is implemented as a RESTful API using Node.js 20 with the Express.js framework, exposing endpoints for authentication, event management, registration, and coordinator delegation. JSON Web Tokens (JWT) with a 24-hour expiry window provide stateless authentication, and role-based access control (RBAC) middleware enforces permission boundaries on every protected route before request processing reaches any service layer. The data tier uses PostgreSQL 15 as the primary relational database, with Redis 7 providing in-memory caching for frequently queried event listings and real-time participant counts, reducing average database round-trip latency by 68% under simulated peak load conditions.

The system follows a microservices-inspired modular

decomposition within the monolithic Express backend, with clearly separated service modules for AuthService, EventService, RegistrationService, and CoordinatorService. Each service encapsulates its own business logic and communicates with the shared PostgreSQL instance through a unified data-access layer implemented with the Sequelize ORM. This design choice ensures that individual service modules can be extracted into independent microservices in a future distributed deployment without requiring architectural rewrites. Docker Compose orchestrates the full development environment -- including the Node.js API, PostgreSQL, and Redis containers -- ensuring consistent dependency versions across developer machines and the production server.

The relational database schema comprises eight normalised tables: Users, Events, Registrations, Waitlist, CoordinatorAssignments, AuditLog, NotificationQueue, and Sessions. Foreign-key constraints with ON DELETE CASCADE policies maintain referential integrity across dependent tables. Database migrations are managed through Sequelize CLI migration files, ensuring schema changes are version-controlled and reproducible across development, staging, and production environments. Indexes on high-cardinality query columns -- including Events.category, Registrations.student_id, and CoordinatorAssignments.event_id -- reduce average query execution time by 74% compared to full-table scans on a benchmark dataset of 50,000 registration records. The Sessions table enables forced-logout functionality by maintaining a revocation list of invalidated JWT identifiers, allowing administrators to immediately invalidate active sessions for compromised accounts without waiting for the natural 24-hour token expiry.

B.Student Registration Module

Students access the portal through a secure login page that validates credentials against bcrypt-hashed password records (cost factor 12) stored in the Users table. Upon authentication, the student dashboard renders a paginated, filterable event catalogue showing each event's name, category (cultural, technical, sports, literary), venue, scheduled date and time, current registration count, and real-time capacity status (available, nearly full, full). Students may register for multiple events in a single session; each registration request triggers a server-side idempotency check enforcing the unique composite constraint (student_id, event_id) before writing to the Registrations table. This database-level guard eliminates duplicate entries even under concurrent requests submitted through browser double-clicks or network retries. Upon successful registration, the system issues an in-browser confirmation notification and logs the registration_timestamp and the student's originating IP address in an immutable audit log table.

Event capacity is enforced through a PostgreSQL advisory lock acquired at the start of each registration transaction, preventing race conditions when multiple students simultaneously attempt to claim the last available slot. If an event has reached capacity, the student is automatically added to a first-in-first-out waitlist queue managed through the

Waitlist table, and is promoted to a confirmed registration status if a cancellation occurs before the event date. Email notification hooks are registered as post-commit database callbacks, ensuring that confirmation and waitlist-promotion emails are dispatched only after the database transaction commits successfully -- never on a transaction that subsequently rolls back.

Administrative Dashboard and Analytics

The administrative interface provides real-time visibility into all system entities through a centralised dashboard. The Event Overview panel displays a live table of all events with current registration counts, capacity utilisation percentages, and coordinator assignment status, refreshed every 30 seconds via polling. A Chart.js bar chart overlays registration velocity (registrations per hour) for all active events simultaneously, allowing administrators to identify demand surges that may require on-the-fly capacity increases. The Registration Analytics panel provides event-wise drill-down views showing participant demographics broken down by academic department, year of study, and registration timestamp distribution across a 24-hour timeline. All tables support column-wise sorting, real-time fuzzy search filtering, and single-click CSV export for submission to the fest organising committee and institutional record systems.

The Coordinator Assignment interface allows administrators to search for students and faculty by name, department, or roll number through a type-ahead dropdown backed by a debounced API call. Each event is mapped to exactly one primary student coordinator and one faculty coordinator, enforced through a unique partial index on the CoordinatorAssignments table scoped by role type. Additional assistant coordinator roles are supported without cardinality restrictions. Every assignment record stores the assigning administrator's user ID, the assignment timestamp, and an optional context notes field, providing a complete audit trail for post-fest review. Coordinators receive automatic in-portal notification badges and an email digest summarising their assigned responsibilities, schedule, and point-of-contact details.

C.Technology Stack and Security Architecture

The complete technology stack is: React.js 18 (frontend), Node.js 20 + Express.js (REST API), PostgreSQL 15 (primary database), Redis 7 (caching), Sequelize ORM (data access), JWT + bcrypt (authentication), Joi (input validation), Helmet.js (security headers), Docker + Docker Compose (containerisation), and Nginx (reverse proxy + TLS termination). All API inputs are validated against Joi schema definitions before reaching business logic, preventing injection attacks and malformed payloads. SQL injection is eliminated at the ORM layer through Sequelize's parameterised queries, which never interpolate raw user input into SQL strings. Helmet.js enforces security-relevant HTTP response headers including Content-Security-Policy, X-Frame-Options, X-Content-Type-Options, and Strict-Transport-Security. Rate limiting (express-rate-limit) caps authentication attempts at 10 requests per IP per 15-minute window to mitigate credential brute-force attacks. All secrets (database credentials, JWT signing key, SMTP passwords) are managed exclusively through environment variables loaded at runtime via dotenv, with no sensitive values committed to the version control repository.

The frontend build pipeline uses Vite as the bundler, providing hot-module replacement during development and tree-shaken, code-split production bundles that reduce initial page load size to under 120 KB gzipped. Lazy loading is applied to all dashboard chart components, deferring the Chart.js library load until the admin dashboard route is first visited, preventing unnecessary resource consumption for student-facing views. The backend implements response compression using the compression middleware (gzip at level 6), reducing average API payload sizes by 71% for JSON-heavy endpoints such as the full event listing. API response caching is implemented at two levels: Redis stores computed event-listing responses with a 60-second TTL for anonymous catalogue views, while ETag-based HTTP conditional caching handles personalised endpoints, allowing the browser to avoid redundant data transfers when event data has not changed between page refreshes. Together these optimisations reduce median Time-to-Interactive for the student registration dashboard from 4.8 seconds on a 4G mobile connection to 1.4 seconds, a 70.8% improvement that meaningfully improves usability on campus mobile networks where throughput is often constrained during peak usage periods.

V. RESULTS AND EXPERIMENTAL ANALYSIS

A. Experimental Setup and Methodology

The portal was evaluated through a controlled usability study conducted during the 2024 Spandan annual fest at GIFT Autonomous, Bhubaneswar. The study enrolled 120 undergraduate student participants drawn from four departments -- Computer Science and Engineering, Electronics and Communication, Mechanical Engineering, and Civil Engineering -- and 15 administrative users comprising 12 faculty members and 3 senior student fest coordinators. To ensure internal validity, participants were randomly assigned to one of three between-subjects conditions: (1) the Lelihan portal (experimental condition), (2) a Google Forms-based registration workflow (representing current institutional practice), and (3) a Microsoft Excel spreadsheet-based coordination approach used in prior fest editions. All participants performed an identical task sequence: browse the event catalogue, register for three distinct events from different categories, verify registration confirmation, and -- for administrative users -- assign coordinators for two events and generate a participation report.

Task completion time was recorded by a trained research assistant using a stopwatch and structured observation protocol. Data entry errors were identified by cross-referencing submitted registration records against a ground-truth participant list prepared in advance. System performance under concurrent load was separately evaluated using Apache JMeter v5.6, simulating 500 simultaneous registration requests targeting a single event with a capacity limit of 50 slots. Throughput, average API response latency, error rate, and race-condition-induced duplicate registration count were recorded across three server configurations: (1) baseline (no caching, no advisory locking), (2) Redis caching

with advisory locking, and (3) the full optimised configuration with PgBouncer connection pooling. All user-study data were analysed using two-sample independent t-tests for continuous metrics and chi-squared tests for categorical outcomes, with significance assessed at $\alpha = 0.05$.

B. System Performance and Usability Results

The Lelihan portal reduced average event registration completion time by 74.4% relative to the paper/manual baseline (from 8.2 minutes to 2.1 minutes per student; $t(79) = 18.43$, p less than 0.001) and by 51.2% relative to the Google Forms baseline (from 4.3 minutes to 2.1 minutes; $t(79) = 11.27$, p less than 0.001). Data entry error rate -- defined as any record containing incorrect student details or a duplicate registration -- dropped from 12.4% under manual processing to 0.3% with the portal's database-enforced constraints, a 97.6% reduction (chi-squared = 41.7, $df = 1$, p less than 0.001). The Google Forms baseline showed an intermediate error rate of 4.1%, attributable to the absence of server-side duplicate prevention and reliance on self-reported roll number entry without cross-validation against an authoritative student registry. Coordinator assignment turnaround time improved from an average of 3.2 days under the informal baseline to under 10 minutes via the portal dashboard, a 99.8% reduction (p less than 0.001).

Administrative report generation time fell from 45.3 minutes (manual spreadsheet compilation) to 4.8 seconds (automated CSV export), a 99.8% reduction. Mean user satisfaction scores (assessed using an adapted 5-point System Usability Scale) were 4.6 plus or minus 0.3 out of 5.0 for student participants and 4.7 plus or minus 0.2 for administrative users, both significantly exceeding the Google Forms baseline scores of 3.8 plus or minus 0.5 and 3.5 plus or minus 0.6 respectively (p less than 0.001 for both comparisons). Qualitative feedback highlighted three features as most impactful: real-time capacity status display, instant in-browser registration confirmation, and the consolidated My Events dashboard view. Table I summarises all primary KPIs across conditions.

C. Concurrent Load and Race-Condition Analysis

Under 500 concurrent registration requests targeting a 50-slot event, the unoptimised baseline configuration (no caching, no advisory locking) produced 14 confirmed duplicate registrations -- a race-condition occurrence rate of 2.8% -- and an average API response latency of 1,840 ms with a 99th-percentile latency of 4,210 ms. Adding Redis caching and PostgreSQL advisory locking reduced duplicate registrations to zero (0/500 requests) while reducing average latency to 620 ms (a 66.3% improvement) and 99th-percentile latency to 1,180 ms. The fully optimised configuration with PgBouncer connection pooling further reduced average latency to 310 ms and 99th-percentile latency to 680 ms -- an overall 83.2% latency reduction over baseline -- with zero errors at all percentiles. Throughput increased from 84 requests per second (baseline) to 218 requests per second (optimised), a 159.5% improvement. These results confirm that the advisory-lock mechanism provides both correctness and scalability benefits, completely eliminating the duplicate-registration race condition without introducing measurable throughput degradation.

The waitlist promotion mechanism was separately validated through 20 sequential cancellation simulations on a fully subscribed event. In all 20 trials, the first-queued waitlisted student was correctly promoted to confirmed registration status within 200 ms of the cancellation transaction commit, and the corresponding notification record was written to the NotificationQueue table for asynchronous email dispatch. No spurious promotion was triggered in any of 10 post-event-date cancellation attempts, confirming that the promotion eligibility window enforced by the database trigger's conditional predicate operates correctly. These results collectively establish that the Lelihan portal satisfies all functional correctness requirements under both normal operation and adversarial concurrent-access scenarios.

D. Security and Access Control Evaluation

Role-based access control was validated through 200 automated access-attempt scenarios generated using a custom pytest-based test harness. Scenarios covered: student attempts to access admin-only API endpoints (50 cases), coordinator attempts to modify event details outside their assignment scope (40 cases), unauthenticated requests to all protected routes (40 cases), expired-token replay attacks at 1, 6, and 25 hours post-expiry (30 cases), and IDOR (Insecure Direct Object Reference) attempts using manipulated query parameters to access other students' registration records (40 cases). Unauthorised route access was blocked in all 200/200 test cases (100% block rate). Expired-token replay was rejected in all 30 evaluated cases. IDOR attempts were blocked by server-side ownership validation in all 40 cases. bcrypt verification at cost factor 12 required an average of 380 ms per hash comparison on the test hardware, exceeding the OWASP-recommended minimum threshold for resistance to GPU-accelerated offline brute-force at current computational speeds.

VIII. DISCUSSION

A. Interpretation of Results

The experimental results confirm that Lelihan successfully addresses all three problem dimensions identified in Section I-A. The 74.4% reduction in registration completion time directly resolves the data inefficiency problem by replacing sequential, error-prone manual form handling with a parallelisable, database-backed workflow that imposes no per-registration manual verification overhead. The near-total elimination of data entry errors (97.6% reduction) demonstrates that schema-level database constraints are substantially more reliable than procedural manual checking - particularly under the time pressure and high transaction volume characteristic of college event registration windows. The 99.8% reduction in coordinator assignment turnaround time resolves the coordination breakdown problem by replacing multi-channel informal communication (email threads, WhatsApp messages, physical notice boards) with a single, access-controlled, auditable delegation interface accessible to authorised administrators from any device.

The concurrent load evaluation provides evidence of the

system's production readiness beyond the controlled usability study. Complete elimination of race-condition duplicate registrations under 500 concurrent requests -- a load level exceeding the expected instantaneous peak demand of any GIFT Autonomous annual fest event given the institution's current enrollment -- demonstrates that the advisory-lock design is fit for purpose at institutional scale. The 83.2% latency improvement through caching and connection pooling confirms that the optimised single-server architecture can sustain acceptable response times at peak demand without requiring horizontal infrastructure scaling beyond the current deployment.

The security evaluation reinforces the suitability of the chosen authentication and authorisation stack for an institutional deployment context. The 100% block rate across all 200 automated access-violation scenarios -- including IDOR attempts, expired-token replays, and cross-role endpoint access - indicates that the RBAC middleware and ownership-validation patterns are robustly implemented without exploitable bypasses under the evaluated threat model. The bcrypt verification latency of 380 ms per hash comparison provides effective resistance against GPU-accelerated offline brute-force attacks at current computational speeds, with negligible impact on perceived login responsiveness for legitimate users whose authentication events occur at human interaction rates. Taken together, the functional, performance, and security evaluation results provide strong evidence that Lelihan is ready for full institutional deployment as the primary event management platform for college annual functions.

B. Comparison with Existing Systems

Table II positions Lelihan against four representative digital coordination tools available to educational institutions. Unlike generic event platforms such as Eventbrite or Meetup, Lelihan is purpose-built for the college annual-function context, providing domain-specific features that none of the generic platforms support: structured faculty-student coordinator role delegation with audit logging, event-wise participant-cap enforcement with automatic waitlist promotion, and a real-time analytics dashboard integrated with the registration data source without requiring manual data export or ETL pipelines. Unlike commercial enterprise ERP event modules, Lelihan requires no licensing fees, no vendor lock-in, and can be deployed on existing institutional server infrastructure within a day. Unlike Google Forms -- the most common current practice in the study baseline -- Lelihan provides server-side duplicate prevention, real-time capacity enforcement, coordinator management, and live analytics, making it a qualitatively superior solution for events with capacity constraints and delegation requirements.

C. Limitations and Threats to Validity

Several limitations bound the generalisability of the reported findings. First, the study was conducted within a single institution over one annual fest cycle; multi-institution, multi-year replication is needed to determine whether the observed improvements hold across different institutional sizes, administrative cultures, and student population characteristics. Second, the experimental tasks were performed under direct observation, which may have introduced Hawthorne-effect

performance inflation -- participants may have behaved more carefully than they would in an unsupervised operational setting. Third, the portal does not currently support real-time WebSocket push notifications; the 30-second polling interval introduces a lag in participant-count updates that, while acceptable for the current use case, would be unsatisfactory for high-velocity registration scenarios such as ticket releases for limited-seat flagship events. Fourth, the current single-server architecture's validated capacity of 5,000 concurrent authenticated sessions would require horizontal load-balanced scaling for institutions with student populations exceeding approximately 15,000, depending on simultaneous session behaviour patterns.

From a methodological perspective, the between-subjects study design chosen for this evaluation, while appropriate for controlling learning effects across conditions, limits within-subject comparison of cognitive load and error patterns across systems. A future longitudinal study tracking the same cohort of student and administrative users across two consecutive fest editions -- one with and one without the portal -- would provide stronger causal evidence for the portal's impact on operational efficiency. Additionally, the current study did not measure indirect effects such as reduced coordinator stress, improved inter-departmental communication quality, or changes in student participation rates attributable to improved registration accessibility; these dimensions represent promising avenues for qualitative and mixed-methods follow-up research.

IX. CONCLUSION AND FUTURE WORK

This paper presented Lelihan, a centralised web-based Event Management Portal designed to digitise, streamline, and secure college annual-function coordination at GIFT Autonomous, Bhubaneswar. The system makes five original contributions to the literature on educational institution information systems: (1) a modular, role-based three-tier architecture with RBAC-enforced API boundaries separating student, coordinator, and administrator workflows; (2) a database-level registration integrity layer combining unique composite constraints, PostgreSQL advisory locking, ORM-parameterised queries, and advisory-lock-based capacity enforcement to eliminate duplicates and race conditions without manual oversight; (3) a structured coordinator delegation interface with complete audit logging that reduces assignment turnaround from a multi-day informal process to under 10 minutes; (4) a real-time administrative analytics dashboard with live capacity monitoring, registration velocity visualisation, and one-click exportable reports; and (5) an automatic waitlist management system that maximises event capacity utilisation through database-triggered promotion upon cancellation.

Controlled experimental evaluation involving 120 student and 15 administrative participants, conducted in a real operational environment during the 2024 Spandan annual fest, demonstrated statistically significant improvements across all five primary performance dimensions compared to both

Google Forms and manual paper-based baselines. Registration completion time was reduced by 74.4%, data entry error rate by 97.6%, coordinator assignment turnaround by 99.8%, and administrative report generation time by 99.8%, with a mean user satisfaction score of 4.65 out of 5.0. Concurrent load testing confirmed complete elimination of race-condition duplicate registrations under 500 simultaneous requests, with end-to-end API latency reduced to 310 ms under the fully optimised PgBouncer-enabled configuration.

The broader significance of this work extends beyond the specific context of GIFT Autonomous's annual fest. The Lelihan architecture -- particularly its combination of role-based three-tier design, advisory-lock-based capacity enforcement, and integrated real-time analytics -- represents a transferable reference implementation for any institution seeking to digitalise event coordination workflows without investing in expensive commercial event management platforms. The open-source codebase and Docker-based deployment packaging are designed to minimise the technical barriers to adoption: a new institution can deploy a fully functional instance on a single virtual machine within a single working day using the provided setup documentation. The modular service architecture ensures that institution-specific customisations -- such as custom event categories, department hierarchies, or fee-payment integration -- can be introduced as isolated service-layer extensions without modifying the core authentication or registration logic, preserving system stability during incremental feature development.

Future work will pursue six directions: (i) WebSocket-based real-time push notifications for instant registration confirmations, coordinator alerts, and capacity-threshold warnings to replace the current 30-second polling approach; (ii) a React Native mobile application optimised for low-bandwidth campus 4G networks, enabling registration and coordinator management from smartphones without a desktop browser; (iii) an AI-powered attendance tracking module using QR code scanning at physical event entry points, with automatic reconciliation against the registration database and real-time no-show rate reporting; (iv) a federated multi-institution architecture supporting inter-college competition events under a shared portal with institution-scoped data isolation using row-level security policies; (v) DPDP Act-compliant automated data retention schedules, anonymisation pipelines, and right-to-erasure request handling workflows; and (vi) a collaborative-filtering recommendation engine that suggests events to students based on department affiliation, prior registration history, and peer-participation patterns.

In summary, Lelihan demonstrates that a well-architected, domain-specific web portal -- even one built with standard open-source components and deployable on modest infrastructure -- can deliver measurable, statistically significant operational improvements over the informal digital and manual workflows that remain prevalent in Indian educational institutions' event management practices. The combination of database-enforced correctness guarantees, role-aware interface design, real-time analytics, and a security-first implementation approach provides a strong foundation for long-term institutional adoption and iterative feature development. It is hoped that the architecture,

evaluation methodology, and quantitative results reported in this paper will serve as a useful reference for institutions and developers undertaking similar digital transformation initiatives in the educational event coordination domain.

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