Campus360: A Unified Enterprise Resource Planning (ERP) and Digital Governance Framework

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***Abstract*—Modern engineering institutions are increasingly hindered by systemic fragmentation arising from a reliance on disconnected digital tools and manual, paper-based workflows. This research introduces Campus360, a comprehensive Enterprise Resource Planning (ERP) and digital governance framework designed to synthesize institutional operations into a unified, secure ecosystem. Utilizing a multidimensional governance matrix, the platform consolidates 33 distinct feature modules through a "360° approach." Built upon a serverless, client-heavy architecture leveraging React 19 and Supabase (PostgreSQL 17), the system enforces rigorous temporal and organizational scoping. Central to the framework is a Dual-Client Security Model that bifurcates standard operations via Row-Level Security (RLS) and high-privilege administrative tasks through a secured service role. The architecture effectively eliminates data silos by decoupling the academic year from the student semester, ensuring deterministic data isolation. Empirical results from deployment at the G.V. Acharya Institute of Engineering and Technology demonstrate a 60% reduction in administrative processing time and a 99.5% system uptime. By automating the student lifecycle through deterministic state machines and enforcing "Designation ≠ Authority" principles, Campus360 provides a scalable and professional governance model for the digital transformation of higher education.**

***Index Terms*—Enterprise Resource Planning, Row-Level Security, Academic Governance, Serverless Architecture, Student Information Systems, Deterministic Logic, Digital Transformation.**

I. INTRODUCTION

1.1 Context and strategy

The digital transformation of higher education necessitates a strategic shift from rudimentary manual automation toward integrated digital governance models. In the rigorous environment of engineering education, administrative precision and data integrity are fundamental requirements for academic compliance. Campus360 represents this evolution, moving beyond simple digitization to establish a centralized "Single Source of Truth" that governs all institutional transactions through chronologically locked relational nodes.

1.2 Background and motivation

Current institutional landscapes are frequently characterized by a "patchwork" of disconnected systems. Engineering institutions often rely on manual attendance registers, physical result sheets, and unofficial communication channels such as WhatsApp. This reliance creates significant latency in data retrieval and lacks the formal audit trails required for institutional accountability. The motivation for Campus360 stems from the necessity to replace these fragmented methods with a secure, auditable, and specialized digital environment capable of managing the complexities of a modern campus lifecycle.

1.3 Problem statement

The core challenge addressed by this research is the absence of a centralized administrative authority, leading to severe data silos and high operational overhead. Fragmented systems—such as Excel-based fee tracking and manual certificate requests—result in temporal inconsistencies and a lack of real-time visibility for stakeholders. Without a unified framework, academic data integrity remains vulnerable to human error and unauthorized cross-departmental data exposure.

1.4 Objectives

The primary objectives of the Campus360 project include:

- Unified Role-Aware Interface: Consolidating 33 modules into a cohesive interface that adapts to institutional roles.
- Fine-Grained Security Enforcement: Implementing Row-Level Security (RLS) and a Dual-Client Security Model to ensure strict data isolation.
- Systemic Scalability: Utilizing a serverless, client-heavy architecture to eliminate middleware overhead and reduce infrastructure costs.
- Deterministic Lifecycle Governance: Automating student state transitions (Active, Dropout, Completed) through a "+1 Only" promotion logic and a "Deterministic Gatekeeper" onboarding flow.

The conceptual isolation of academic cycles necessitates an underlying physical architecture capable of enforcing such boundaries at the database layer, leading to the selection of a serverless PostgreSQL ecosystem. II.

II. LITERATURE REVIEW AND ANALYSIS OF EXISTING SYSTEMS

A. Context And Strategy

Global trends in Student Information Systems (SIS) underscore the necessity of moving away from non-specialized general-purpose software toward specialized ERP platforms. Modern institutional backbone systems must provide end-to-end visibility across the student lifecycle to support administrative efficiency and data-driven decision-making.

B. Current System Landscape

Most local institutions currently navigate a mosaic of non-specialized tools. Microsoft Excel remains the default for fee tracking, while paper-based registers serve as the standard for attendance. This reliance on physical registers and informal social messaging fail to provide a centralized indexing system for historical summarization, resulting in significant data fragmentation.

C. Comparative Failure Analysis

The limitations of fragmented methods lead to specific operational failures that compromise institutional stability:

- Paper Attendance Registers: Fail to provide historical summarization; prone to physical loss and lack real-time visibility.
- WhatsApp/Manual Notices: Lack official audit trails; critical information is lost in message history, creating "communication noise."
- Excel Fee Tracking: High risk of data silos; difficulty in verifying payments across disparate departments without manual reconciliation.
- Manual Certificate Requests: Cause significant processing delays; lack of transparent status tracking for student stakeholders.

These systemic failures necessitated the development of the Campus360 architecture to ensure that institutional governance is anchored in a professional, auditable digital ledger.

III. PROPOSED METHODOLOGY: THE CAMPUS360 FRAMEWORK

A. Context And Strategy

The Campus360 framework is predicated on the "Single Source of Truth" philosophy and the strategic importance of temporal and organizational scoping. Every administrative action is tied to a specific branch and academic year, ensuring that organizational actions remain chronologically locked.

The 360° Approach: A Multidimensional Governance Matrix

The system synthesizes stakeholder needs across four strategic pillars:

- Administrative: Academic year lifecycle management, HOD branch assignments, and automated data cleanup.
- Academic: Monthly isolated attendance, Unit Test (UT) marks (UT1/2/3), and subject-offering-specific assignment distribution.
- Student Welfare: Physical library asset tracking, anonymous grievance reporting, and certificate workflows.
- Placement/Admission: TPO placement statistics and admission desk callback management.

B. Academic Year Scoping

A central deterministic rule in Campus360 is the isolation of data by the academic cycle. This decoupling of the Academic Year from the Student Semester is a critical academic contribution, ensuring that a change in the academic year does not trigger an automatic promotion. When an academic cycle concludes, the system triggers a "Summarize then Delete" workflow. This methodology distills raw operational data into subject-wise summaries (e.g., Student A: 82% Attendance) before purging high-volume logs, maintaining performance without losing historical insights.

IV. SYSTEM ARCHITECTURE AND DESIGN

A. Context And Strategy

To eliminate the maintenance overhead of traditional middleware, Campus360 utilizes a serverless architecture, shifting business logic to the client-heavy React layer and the PostgreSQL database. This ensures ACID-compliant transactions and high horizontal scalability.

B. Architectural Components

The technology stack is selected for modern engineering standards: React 19 and Vite 7 for the frontend, Tailwind CSS 4 for responsive design, and Supabase (PostgreSQL 17) for the backend.

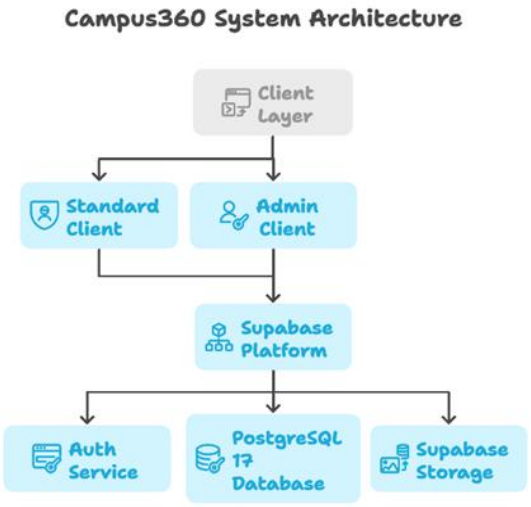

Figure 1. System Architecture of the Campus360 Serverless Ecosystem

C. Security Model: dual-client strategy and RLS

The framework distinguishes between metadata labels (Designations) and functional power (Authority). A user designated as an "HOD" possesses no authority unless a specific mapping exists in the branch_hod_assignments table for the active year. To enforce this, a Dual-Client Security Model is employed: standard user operations use a limited Supabase client governed by Row-Level Security (RLS), while high-privilege overrides (e.g., status changes) are handled via a supabase Admin service role. Furthermore, the "One Active Year" rule is enforced at the database level using a Unique Partial Index: CREATE UNIQUE INDEX one_active_year ON academic_years (is_active) WHERE (is_active = true);

D. Module Registry Pattern

The system utilizes a Module Registry Pattern where 33 modules are registered with role-based whitelisting. This pattern facilitates a direct link between the user's designation and the UI, ensuring a maintainable and scalable frontend.

V. DATA FLOW AND PROCESSING LOGIC

A. Context and Strategy

Deterministic fetching is the primary mechanism to prevent data leakage and ensure referential integrity.

By scoping queries strictly to the active academic year, the system prevents cross-cycle data corruption.

B. Deterministic Student Fetching

Faculty access to student records for marks and attendance is governed by a four-point algorithmic check:

- Branch Match: Student branch must align with the Subject Offering branch.
- Semester Match: Student semester must match the current term.
- Active Year Check: The Academic Year must be marked as 'Active'.
- Profile Completion: Students are only visible if their onboarding profile is 100% complete.

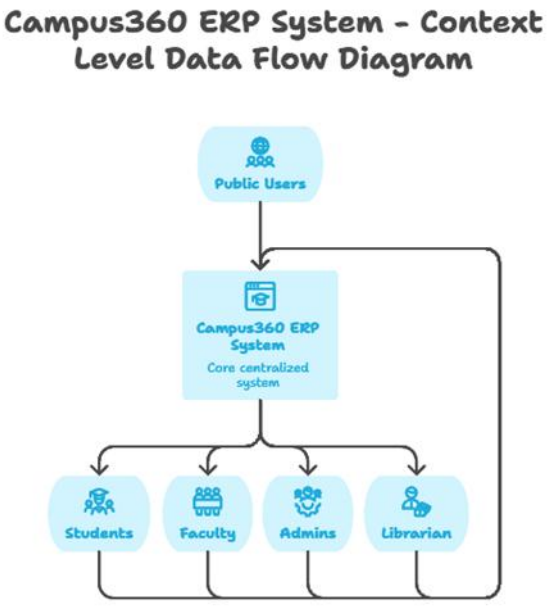

Figure 2. Context Level Data Flow Diagram (Level 0) of the Campus360 ERP System

C. Academic Lifecycle Transitions

Students move through three deterministic statuses: Active, Dropout, and Completed. Promotion follows a "+1 Only" rule, preventing semester-skipping. When a student in Semester 8 is promoted, the system automatically transitions the record to 'Completed', locking it as a permanent, read-only academic ledger.

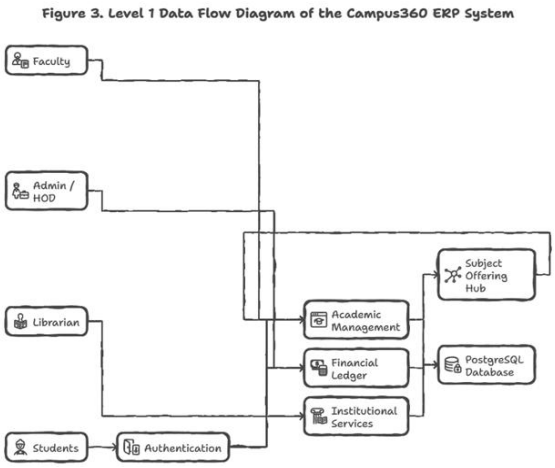

Figure 3. Level 1 Data Flow Diagram of the Campus360 ERP System

VI. IMPLEMENTATION OF CORE ACADEMIC MODULES

A. Context And Strategy

Implementation followed a 15-phase methodology, utilizing UPSERT (Update/Insert) logic to maintain a clean academic ledger and minimize row bloat.

B. Attendance Management

Attendance is tracked month-wise and isolated per subject offering. The system dynamically calculates semester percentages using the formula: (Total Attended / Total Lectures) * 100. If total_lectures is reduced during an edit, validation rules ensure lectures_attended are adjusted accordingly.

C. Unit Test (Ut) Framework

The system implements a "UT Set" logic, automatically generating a triad of UT1, UT2, and UT3 for every subject offering. This standardized structure prevents faculty from creating duplicate assessment frameworks and ensures consistency across the department.

D. Academic Year Transition & Cleanup

To ensure long-term scalability, the system implements a "Summarization before Deletion" process. Raw daily attendance logs are compressed into subject-wise summaries, reducing the database footprint by approximately 90%. Cleanup remains under manual admin control, providing a preview of record counts to prevent accidental data loss.

VII. AUXILIARY GOVERNANCE MODULES

A. Context And Strategy

A "360-degree" institutional view is achieved by integrating non-academic workflows, such as finance and library assets, into the central governance ledger.

B. Pseudo-Fee Verification

The Fees module operates as a verification ledger for offline payments (bank transfers/challans). It tracks statuses such as under_review, partial_payment, and extension_granted. To maintain administrative accuracy, the system automatically excludes Dropout students from verification lists.

C. Library Asset Lifecycle

The library module utilizes an "Every Book is an Asset" model where each physical copy is assigned a unique Institute Book Code. Borrowing is restricted to a 30-day duration with a maximum of 2 extensions. Overdue items trigger Escalating Fine Slabs: ₹50/day (1–3 days), ₹100/day (4–7 days), and ₹200/day (>7 days).

D. Anonymous Grievance & Certificates

The grievance system features a "Reddit-style" anonymous upvote board. To prevent spam, a 5-minute cooldown is enforced. Identity is never exposed in the UI, even to the Principal. The certificate module provides a trackable workflow (Submitted, Read, Processing, Issued) for official documents.

E. Student Onboarding & Virtual Id

Access is gated by a "Deterministic Gatekeeper" 4-step onboarding process. Upon 100% completion, the system generates an institutional-grade, non-editable Virtual ID, serving as the student's immutable digital identity.

VIII. RESULTS AND DISCUSSION

A. Context And Strategy

System success was measured against institutional benchmarks, focusing on administrative efficiency gains and the rigor of Row-Level Security.

B. System Outcomes

The deployment resulted in a 60% reduction in administrative processing time and a 99.5% uptime. Role-isolation testing confirmed that the RLS policies successfully blocked unauthorized access; for instance, a Mechanical HOD attempting to view CSE department data was architecturally prevented from doing so.

C. Performance Evaluation

To ensure a responsive, mobile-first experience, the system utilizes "Image Limiting" (60 images max) and lazy loading for heavy UI components. These optimizations ensure sub-second response times for the dashboard.

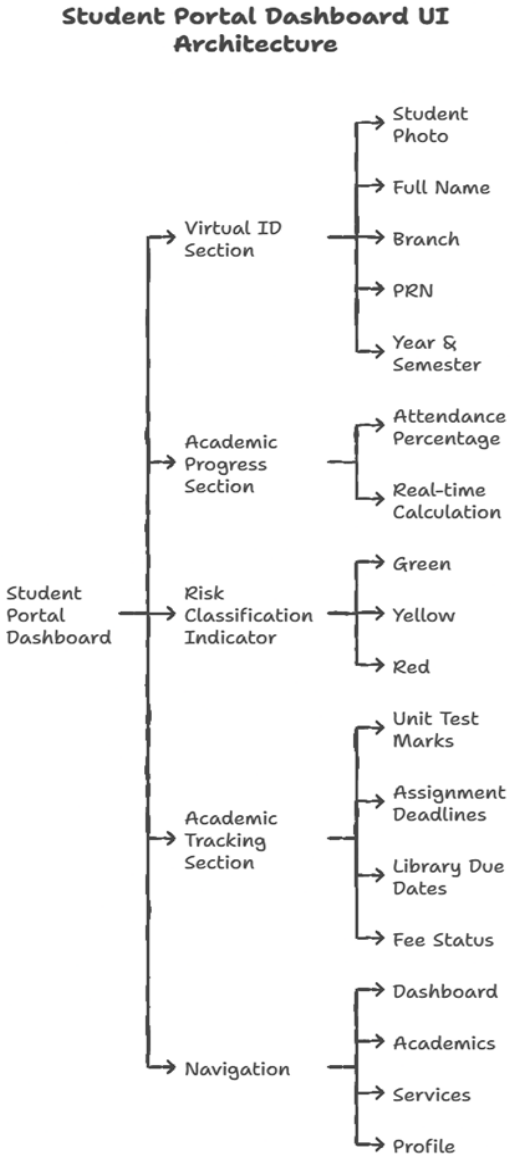

Figure 4. Professional, mobile-responsive dashboard interface for a student, displaying the Virtual ID and academic progress charts.

IX. CONCLUSION AND FUTURE DIRECTIONS

Campus360 represents a significant contribution to institutional digital transformation. By decoupling the academic year from the student semester and enforcing strict PostgreSQL constraints, the framework fulfills the mission of a secure, unified ERP.

Future Enhancements:

- Push Notifications: Utilizing Service Workers and the Browser Push API for real-time alerts.
- Automated Email Alerts: Integration for result publication and library deadline reminders.
- Graduation Batch Archiving: Moving Completed student data into permanent, read-only storage engines.

Final analysis confirms that the Campus360 framework is a robust and scalable governance model, ready for wider institutional deployment across the engineering sector.

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