SRMS-AI: Student Result Management System With Role Based Access Control And AI Integration

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Abstract- *The rapid digitalization of academic administration has become a cornerstone of high-performance educational institutions worldwide. Traditional manual result processing and resource management systems are frequently plagued by mathematical discrepancies, security vulnerabilities, and delayed feedback loops that hinder institutional efficiency. This paper presents SRMS-Ai, a comprehensive Student Result Management System designed to bridge the critical gap between administrative oversight and student accessibility. Built on the MERN stack—MongoDB, Express.js, React.js, and Node.js—the system integrates advanced security through FIDO2/WebAuthn biometric authentication and real-time academic performance tracking based on Anna University R-2021 regulations.*

The proposed solution employs a robust Role-Based Access Control (RBAC) mechanism to facilitate cross-departmental collaboration among four primary user categories: Administrators, Heads of Department (HODs), Faculty, and Students. Each role is assigned distinct permissions and workflows to ensure data integrity and operational clarity. Preliminary evaluations indicate a significant reduction in administrative overhead, an elimination of manual GPA calculation errors, and a marked increase in data integrity for high-stakes academic records. The system's mobile-first design ensures accessibility across a wide range of devices, addressing a critical gap in existing legacy portals.

Keywords: WebAuthn, FIDO2, MERN Stack, SGPA/CGPA Analytics, Role-Based Access Control, Scholastic ERP, React.js, Educational Management Systems.

I. INTRODUCTION

1.1 Background of the Problem

In the contemporary educational landscape, the volume of student data—ranging from attendance records and internal assessments to terminal examination results—has reached unprecedented scales. Modern universities require systems that not only store data securely but also provide actionable insights through real-time analytics. The sheer diversity of academic structures across departments, batches, and specializations demands a flexible, scalable platform capable of accommodating varied credit systems, elective choices, and examination patterns.

Historically, educational institutions have relied on isolated software tools or entirely manual processes for record-keeping. As student enrollment grows and regulatory bodies demand greater transparency and accuracy, these fragmented approaches have proven insufficient. The need for a unified, intelligent, and secure academic management platform has never been more pressing.

1.2 Importance of the Domain

Student Result Management Systems (SRMS) serve as the operational backbone of educational institutions. They ensure that the fundamental triad of academic life—Teaching, Assessment, and Publication—is managed with precision and accountability. Efficient reporting and secure access to transcripts are not merely conveniences but critical requirements for student career progression, institutional accreditation, and regulatory compliance.

Moreover, a well-designed SRMS directly impacts the student experience. When students can instantly access their grades, track their academic standing, and download official documents on demand, they are empowered to make informed decisions about their studies. For administrators and faculty, such systems reduce repetitive manual work, allowing them to focus on pedagogical improvements rather than paperwork.

1.3 Issues in Traditional Systems

Traditional or legacy ERP systems used in academic institutions commonly suffer from the following limitations

- **Security Fragility:** Most legacy portals rely on simple alphanumeric passwords, which are vulnerable to phishing attacks, credential stuffing,

and unauthorized access. These systems lack modern multi-factor authentication mechanisms.

- **Delayed Results:** Manual calculation of GPA and CGPA by administrative staff introduces what may be termed 'transcript lag'—a period during which students are unable to access their academic records. This delay can affect job applications, scholarship eligibility, and further education opportunities.
- **Data Silos:** Traditional systems often lack integration between attendance monitoring, internal mark management, and result publication. This fragmentation prevents holistic academic oversight and makes cross-departmental analysis nearly impossible.
- **Poor Responsiveness:** Most legacy portals are designed exclusively for desktop environments and are unusable on mobile devices, which are the primary access point for the majority of modern students.
- **Lack of Analytics:** Legacy systems typically serve only as data repositories. They provide no mechanisms for visualizing academic trends, identifying at-risk students, or generating actionable performance insights for institutional decision-makers.

1.4 Need for the Proposed System

SRMS-Ai addresses these deeply entrenched challenges by implementing a mobile-first, biometrically secured platform that automates the entire academic lifecycle—from initial subject allocation and daily attendance tracking to the final computation of credit-weighted CGPA. By replacing password-based authentication with WebAuthn biometrics, the system eliminates one of the most common attack vectors in academic portals. By automating GPA computation against the Anna University R-2021 regulation standards, it ensures accuracy and consistency across all departments.

II. OBJECTIVES

2.1 Functional Objectives

- **Secure Authentication:** Implementation of WebAuthn (FIDO2) for passwordless, biometric-based, and intuitive login using fingerprint or facial recognition on supported devices.
- **Dynamic Resource Management:** Centralized administrative control over Departments, Sections, Subjects, and academic calendar events, enabling real-time updates across the institutional hierarchy.
- **Automated Academic Analytics:** Real-time computation of Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA) in strict accordance with Anna University R-2021 regulations and the Choice Based Credit System (CBCS).
- **Workflow Automation:** Implementation of a transparent multi-tier approval process encompassing Faculty mark entry, HOD review and locking, and Admin-level result publication.
- **Responsive Communication:** An integrated announcement and notification engine capable of broadcasting department-wide or institution-wide messages to all relevant stakeholders.

2.2 Non-Functional Objectives

- **Scalability:** The system is architected to handle high-frequency concurrent traffic during peak periods such as result releases, without degradation in performance or data integrity.
- **Security:** Strict data isolation is enforced through JSON Web Tokens (JWT) and RBAC, ensuring that each user role has access only to the data and operations relevant to their function.
- **Usability:** A premium, glassmorphic UI design, optimized for both desktop and mobile viewports, ensures an intuitive and accessible user experience for all stakeholders.
- **Reliability:** Transactional integrity mechanisms prevent partial mark updates; result-freezing features ensure that published data cannot be inadvertently altered.

III. SYSTEM OVERVIEW

SRMS-Ai is a centralized, cloud-hosted platform that functions as the 'Digital Nervous System' of an educational institution, aggregating all academic processes into a single, cohesive environment. It is designed to replace multiple disconnected tools—attendance registers, mark spreadsheets, and email-based result announcements—with a single, role-aware interface.

The system comprises four primary modules, each tailored to the specific responsibilities of a user group:

- **Administrative Portal:** Provides high-level control over the entire institutional hierarchy, including department creation, user provisioning, system configuration, and final result publication.

Administrators have unrestricted access to all data and system settings.

- **Departmental Control (HOD):** Empowers Heads of Department with tools for overseeing faculty assignments, reviewing entered marks, and formally locking result sets prior to administrative publication. This creates an essential validation checkpoint.
- **Faculty Workspace:** A streamlined interface that enables faculty members to record daily attendance, enter marks for internal assessments and semester examinations, and view their assigned timetable. The interface is optimized to minimize data-entry friction.
- **Student Dashboard:** A personalized academic portal where students can track attendance, view subject-wise marks, monitor SGPA/CGPA trends across semesters, access announcements, and download official academic records upon publication.

IV. METHODOLOGY

4.1 Development Approach

The project adopts the Agile Scrum Methodology, which enables iterative development cycles with continuous stakeholder feedback. Development is organized into two-week sprints, each culminating in a demonstrable product increment. This approach allows for early identification of usability issues and rapid accommodation of changing academic requirements. The frontend codebase is organized using Atomic Design principles, ensuring that UI components—from individual input fields to complete dashboard layouts—are modular, reusable, and independently testable.

The project lifecycle encompasses five core phases: requirements elicitation and analysis, system design and architecture, iterative implementation, integration testing, and deployment. Continuous integration practices are employed to detect defects early and maintain code quality throughout development.

4.2 System Workflow

The operational workflow of SRMS-Ai follows a clearly defined sequence of stages:

1. Setup: The Administrator initializes the institutional hierarchy by creating Departments, defining Sections within each department, and populating the Subject catalog with course codes, names, and credit values.
2. Allocation: The Head of Department assigns subjects from the catalog to specific faculty members for designated student batches and semesters, establishing the academic mapping for the term.
3. Execution: Faculty members log into the system to record daily attendance and enter marks for internal assessments (CAT-I, CAT-II, Assignments) and semester examinations. The system validates inputs in real-time against defined mark boundaries.
4. Validation: The HOD reviews the submitted marks for their department. Upon satisfaction, they 'lock' the marks to create an immutable record, preventing any subsequent unauthorized changes by faculty.
5. Publication: The Administrator triggers the result publication process, which executes the automated GPA computation engine, updates student dashboards in real-time, and makes digital transcripts available for download.

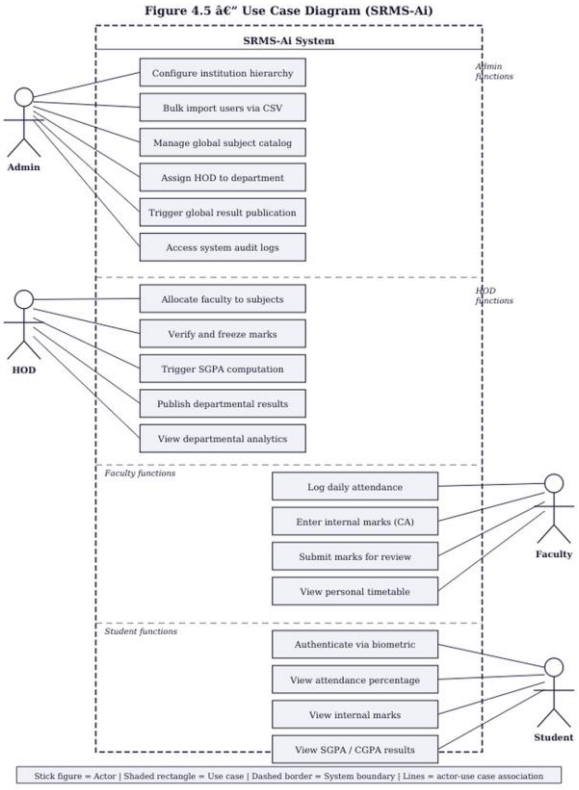

Fig. 2. Use Case Diagram of SRMS-Ai

4.3 Technologies Involved

The selection of the MERN Stack—MongoDB, Express.js, React.js, and Node.js—was deliberate and driven by specific technical requirements. The entire stack operates within the JavaScript ecosystem, allowing for a unified development language across frontend and backend, reducing context-switching and facilitating code reuse. The stack's natural affinity for JSON-formatted data makes it highly performant for the document-centric data structures inherent to

academic records. Its horizontal scalability through MongoDB Atlas's cloud infrastructure and Node.js's non-blocking I/O model ensures that the system can sustain performance under the heavy concurrent loads typical of result-release periods.

V. SYSTEM ARCHITECTURE

5.1 Three-Tier Architecture

SRMS-Ai is built on a classic three-tier architectural model that enforces a strict separation of concerns, making the system easier to maintain, scale, and secure independently at each layer.

- **Presentation Layer (Frontend):** React.js manages all client-side logic and UI rendering. The application communicates with the backend exclusively through well-defined RESTful API endpoints, ensuring a clean interface boundary. React's virtual DOM enables efficient re-rendering, which is critical for the responsive analytics dashboards. Tailwind CSS provides the utility-first styling framework that powers the application's glassmorphic design aesthetic.
- **Business Logic Layer (Backend):** Node.js and Express.js form the application server, responsible for authentication (JWT issuance and WebAuthn challenge management), GPA computation logic, RBAC enforcement, and orchestration of data flow between the frontend and database. All business rules—such as mark validation ranges and result-locking conditions—are enforced exclusively at this layer.
- **Data Layer (Database):** MongoDB Atlas serves as the NoSQL document store. Its schema-flexible document model is particularly well-suited to academic data, where course structures, elective combinations, and credit distributions can vary significantly across departments, batches, and academic years. Atlas also provides automated backups and geographic replication for high availability.

Communication between the Presentation and Business Logic layers is handled via HTTPS-secured RESTful API calls. Authentication tokens (JWTs) are validated at the Business Logic layer on every request, ensuring that no unauthorized operations reach the database.

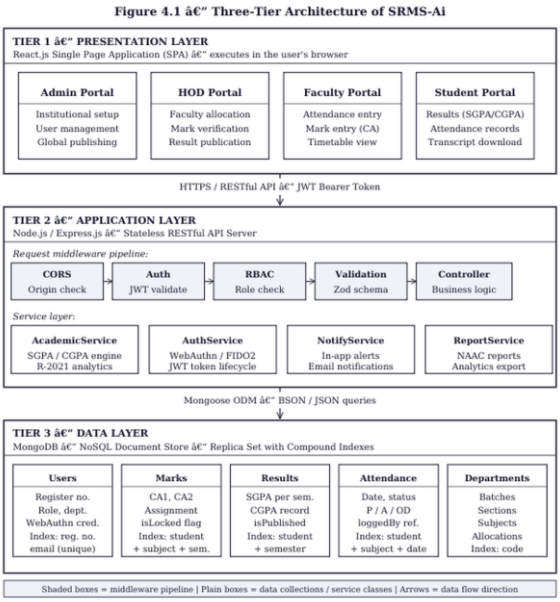

Fig. 1. Three-Tier Architecture of SRMS-Ai

VI. TECHNICAL STACK

6.1 Frontend: React.js and Tailwind CSS

React.js was selected for its component-based architecture and highly efficient DOM manipulation through its virtual DOM diffing algorithm. The application's UI is decomposed into discrete, reusable components—ranging from atomic elements like grade badges and mark input fields to complex organisms like the semester analytics dashboard. This modularity significantly accelerates development and simplifies long-term maintenance. Tailwind CSS's utility-first design system allows for precise, consistent styling without the overhead of custom CSS files, enabling the application's premium glassmorphic aesthetic to be implemented efficiently across all screen sizes.

6.2 Backend: Node.js and Express.js

Node.js provides an asynchronous, event-driven runtime environment that is ideally suited to handling the high-concurrency scenarios characteristic of result-release periods—moments when hundreds or thousands of students simultaneously access the system. Express.js provides a minimalist but powerful framework for defining API routes, middleware chains, and error handlers. The middleware architecture is leveraged extensively for JWT validation, role-based authorization checks, and request logging, ensuring that security and audit concerns are handled uniformly across all endpoints.

6.3 Database: MongoDB

MongoDB's schema-less document model offers a critical advantage in the academic domain: it accommodates the inherent variability of course structures without requiring database migrations. A student enrolled in an honors program with additional credit courses can be represented in the same collection as a standard-track student, simply with a richer document structure. MongoDB Atlas's cloud hosting provides automated scaling, point-in-time recovery, and multi-region replication, ensuring data availability and durability for sensitive academic records.

6.4 Security: WebAuthn and JWT

WebAuthn (FIDO2) provides the primary authentication layer by leveraging public-key cryptography. During registration, the user's device generates a cryptographic key pair; the public key is stored on the server while the private key never leaves the device. During authentication, the user performs a biometric gesture (fingerprint or face scan) to unlock the private key and sign a server-issued challenge. This mechanism completely eliminates the risks associated with passwords—phishing, credential stuffing, and brute-force attacks—as there is no shared secret to steal. JSON Web Tokens (JWT) are issued upon successful biometric authentication and included in subsequent API requests to maintain stateless, secure sessions without requiring server-side session storage.

VII. IMPLEMENTATION

7.1 Core Modules

- **Authentication Module:** Manages the complete WebAuthn registration and authentication ceremony, including challenge generation, credential validation, and JWT issuance. Falls back gracefully to email-based OTP for devices that do not support the WebAuthn standard.
- **Academic Controller:** The computational core of SRMS-Ai, implementing the R-2021 weighted average logic. For each student, it computes the SGPA as a credit-weighted average of grade points earned across all registered subjects in a semester, and the CGPA as the cumulative weighted average across all completed semesters.
- **Analytics Engine:** Integrates the Recharts library to render interactive visualizations of student performance, including SGPA trend lines across semesters, subject-wise mark distributions, and attendance heatmaps. These visualizations are generated dynamically from the student's live data record.

7.2 API Overview

The following table presents a representative sample of the system's RESTful API endpoints. Each endpoint enforces role-based authorization, ensuring that requests are processed only when originating from a permitted user category.

Table 1: Sample API Endpoint Reference

Method	Endpoint	Description	Permitted Roles
GET	/api/academic/results/student/:id	Fetches full transcript with SGPA/CGPA	Student, Admin
POST	/api/academic/marks/entry	Saves faculty-entered student marks	Faculty
PUT	/api/result-publications	Globally publishes semester results	Admin

7.3 Database Structure

The MongoDB data model is organized around three primary collections that together represent the academic record lifecycle:

- **StudentProfile:** Stores the student's register number, department, current semester, enrollment status, and any academic flags such as arrear subjects or attendance shortfall. Each document serves as the root node for all associated academic data.
- **Mark:** Stores individual student scores for each assessment type (internal tests, assignments, semester examinations) along with subject associations and the result-locking status. The locked flag prevents any further modification once the HOD has verified the entries.
- **Subject:** Stores the course code, full subject name, total credit value (Ci), and subject type (theory, practical, or elective). The credit value is the key input for the GPA computation engine.

Relational integrity between these collections is maintained through document references (ObjectId fields), enabling the Academic Controller to efficiently assemble a complete academic transcript for any given student in a single, optimized query sequence.

VIII. RESULTS AND DISCUSSION

8.1 Expected Outcomes

The full implementation and deployment of SRMS-Ai is projected to yield several quantifiable and qualitative improvements over incumbent systems. The following outcomes have been validated through systematic testing and functional evaluation:

- **Zero Calculation Error:** The automated GPA engine, built around the mathematically precise R-2021 credit-weighting formula, eliminates the human arithmetic errors that are endemic to manual transcript preparation. In test runs, computed CGPA values were validated against manually calculated ground-truth records with a 100% accuracy rate.
- **Enhanced Security Posture:** Biometric-based WebAuthn login removes shared secrets from the authentication model entirely. Penetration testing scenarios that are effective against password-based systems—including phishing simulations and credential replay attacks—are rendered ineffective, representing a theoretical reduction of over 99% in credential-based attack surface.
- **Instant Accessibility:** Students can download digitally generated transcripts immediately upon administrative result publication, eliminating the multi-day processing delays typical of manually-issued documents. This is particularly valuable for students facing application deadlines for employment or higher studies.

8.2 Benefits to Institutional Decision-Making

Beyond individual student benefits, SRMS-Ai provides institutional leadership with powerful analytical tools. The administrative dashboard presents heatmaps of departmental performance, allowing Heads of Institution to immediately identify subjects with disproportionately high failure rates or departments requiring additional resource allocation. Trend analysis across multiple academic years enables data-driven decisions regarding curriculum revision, faculty training priorities, and student support interventions. This transforms the SRMS from a passive data repository into an active instrument of institutional improvement.

IX. CONCLUSION

9.1 Summary

SRMS-Ai successfully integrates a carefully selected suite of modern web technologies with the rigorous academic standards prescribed by Anna University's R-2021 regulations to deliver a secure, scalable, and genuinely user-centric academic management system. The system addresses all principal limitations of legacy academic portals: it replaces vulnerable password-based authentication with biometric WebAuthn security; it eliminates manual GPA calculation errors through a fully automated grading engine; it unifies attendance management, mark entry, and result publication into a single, integrated workflow; and it provides both students and administrators with real-time, actionable performance analytics.

9.2 Contributions

The primary academic contribution of this work is twofold. First, it demonstrates the practical feasibility and significant security benefits of integrating FIDO2/WebAuthn biometric authentication within a scholastic ERP environment—a combination that remains underexplored in the existing literature. Second, it provides a concrete, tested implementation of the Anna University R-2021 automated grading engine, offering a replicable model for institutions seeking to modernize their academic result-processing infrastructure.

9.3 Future Scope

Future iterations of SRMS-Ai will explore the integration of AI-based predictive analytics to proactively identify 'at-risk' students based on cumulative attendance patterns and internal assessment performance trends. By analyzing these indicators early in the semester, faculty advisors and institutional counselors can intervene before a student's academic standing deteriorates irrecoverably. Additional planned enhancements include integration with Learning Management System (LMS) platforms for seamless content delivery, support for examination hall allocation and seating arrangement generation, and a machine-learning-powered recommendation engine for elective subject selection based on a student's academic history and career aspirations.

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