International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com
© 2026 IJERST. All Rights Reserved
Peer Reviewed, Referred & Indexed Journal

Research Paper

DESIGN OF A MULTI-TIER ROLE-BASED APPROVAL ROUTING ENGINE FOR ACADEMIC ADMINISTRATION PORTALS

Dr. M V NARAYANA [1], GOPATHI RAVI VARMA [2], KATKAM SHIVA KUMAR [3], ERAVELLY ASHWITHA RAO [4], SOMA ESHWAR [5]

[1]Professor, Dept. of CSE, Guru Nanak Institutions Technical Campus, Ibrahimpatnam, Telangana, India

[2, 3, 4, 5] B.Tech, Dept. of CSE, Guru Nanak Institutions Technical Campus, Ibrahimpatnam, Telangana, India

ABSTRACT— In contemporary academic and corporate institutions, the efficient administration of human resources, performance evaluations, and strategic decision-making relies heavily on automated, secure, and resilient digital infrastructure. This project proposes a comprehensive HR Portal Management system engineered to modernize, centralize, and streamline institutional workflows. The core system architecture is built upon five critical technical pillars: structured administrative Hierarchy, robust DevOps practices, secure One-Time Password (OTP) authentication, centralized HR Portal Management, and scalable Database Handling. First, the platform introduces a digital Hierarchy routing engine that enforces strict Role-Based Access Control (RBAC) across Head of Department (HOD), Dean, and Director dashboards, eliminating the bottlenecks associated with physical document processing. Second, to guarantee high availability and seamless scalable deployment, automated continuous integration and continuous deployment (CI/CD) pipelines have been integrated as standard DevOps practices to minimize downtime during high-traffic appraisal periods. Third, stringent security protocols are enforced via dynamic, time-sensitive OTP verification, safeguarding sensitive performance metrics, intellectual property,

and personal HR data from unauthorized credentials. Fourth, the unified HR Portal Management suite centralizes previously fragmented operations—such as Teaching Appraisals, Leave Quotas, and Research & Development (R&D) tracking—into synchronized, role-specific HOD, Dean, and Director dashboards. Finally, the underlying data tier leverages a highly indexed NoSQL Handling framework (MongoDB) capable of storing unstructured media proofs and executing rapid, cross-departmental queries to furnish leadership with real-time analytics. Ultimately, this integration of modern web technologies transitions the institution away from legacy, paper-based operations into a resilient, data-driven ecosystem.

Index Terms – Multi-Tier Approval Routing, Role-Based Access Control, Academic Administration, Workflow Automation, Approval Management, Educational Portals, Access Control, Business Process Management, Web-Based Systems, Information Systems.

I. INTRODUCTION

In modern academic institutions, administrative workflows serve as the foundational backbone governing all human resource decisions, faculty evaluations, resource allocations, research grants, and departmental policy enforcement. Traditionally, these processes rely on a structured institutional hierarchy to maintain operational standards, verify academic compliance, and ensure thorough quality control across diverse departments. Decisions and approvals must migrate sequentially through multiple administrative levels, typically starting with departmental verification at the grass-roots level, progressing to academic and resource evaluation at the school level, and concluding with final executive authorization at the directorate level. Historically, this hierarchy was managed through physical paper files, manual signatures, and inter-office routing envelopes. However, with the rapid evolution of web technologies, cloud databases, and secure authentication frameworks, there is a global shift toward digitizing administrative operations. Automating hierarchical routing through web-based portals and role-specific dashboards is no longer just a convenience, but an absolute necessity to eliminate operational bottlenecks, enforce strict data boundaries, and provide complete tracking transparency. By designing custom interfaces that mirror the natural administrative hierarchy of the organization, software developers can build workflows that are

highly efficient, secure, and user-friendly, paving the way for a paperless campus environment. To realize this digital transformation, this project presents the design and implementation of a comprehensive Institutional Management System. The system is built upon five interconnected technical pillars: structured administrative Hierarchy, robust DevOps practices, secure One-Time Password (OTP) authentication, centralized portal management, and scalable Database Handling. By combining these technologies, the system coordinates user requests (leaves, appraisals, research files) across three primary administrative dashboards—specifically, the Head of Department (HOD) Dashboard, the Academic Dean Dashboard, and the Executive Director Dashboard—ensuring requests are verified and authorized sequentially. Security and role enforcement are managed at the core session layer. When an administrator attempts to access the portal, a two-factor verification challenge is generated via a secure OTP gateway and dispatched to their registered email or phone line. Upon successful verification, the backend issues a cryptographically signed JSON Web Token (JWT). The React frontend SPA decodes this token to load the corresponding role-based dashboard, while backend Express.js route-guards validate the token signature on every API call. This configuration establishes strict data isolation, preventing HODs from accessing Dean-level data, or Deans from accessing Director-level overrides. The data tier is powered by a cloud-hosted MongoDB database and integrated with Cloudinary media buckets. MongoDB's document-oriented NoSQL architecture is uniquely suited for institutional management records because it stores varied request files, appraisal scores, and workflow audit logs as flexible BSON documents. It utilizes compound database indexes to return query results in milliseconds. At the same time, Cloudinary handles uploaded document proofs (PDFs, images), returning secure links that are saved in MongoDB, allowing dashboards to render proofs instantly and support realtime data analytics for institutional directors. Finally, the application is deployed and maintained using modern DevOps methodologies. Continuous integration and continuous deployment (CI/CD) pipelines are established using GitHub Actions. Whenever updates are pushed, the pipeline automatically runs linting checks and endpoint tests, compiles frontend assets using Vite, and deploys the application with zero service downtime. Continuous server

monitoring processes ensure high availability, making the system stable, secure, and scalable for institutional administration.

II. RELATED WORK

A. Role-Based Access Control (RBAC) in Academic Systems

Role-Based Access Control is widely used in academic administration portals to manage permissions based on user roles such as student, faculty member, department head, dean, and administrator. RBAC improves security by ensuring that users can access only the resources and approval stages relevant to their responsibilities. This approach reduces unauthorized access and simplifies permission management in large educational institutions.

B. Workflow Automation in Educational Institutions

Traditional paper-based approval processes often lead to delays, document loss, and lack of transparency. Workflow automation systems digitize these processes by automatically routing requests to the appropriate authorities based on predefined rules. Automated workflows improve operational efficiency, reduce processing time, and provide better tracking of approval status.

C. Multi-Tier Approval Mechanisms

Multi-tier approval systems involve multiple levels of authorization before a request is finalized. In academic environments, applications such as leave requests, project approvals, purchase requests, and examination approvals may require validation from several authorities. Multi-tier routing ensures accountability, transparency, and compliance with institutional policies.

D. Dynamic Routing Algorithms for Approval Processes

Modern approval routing engines use rule-based and dynamic routing algorithms to determine the next approver based on request type, department, priority, and organizational hierarchy. These intelligent routing mechanisms reduce manual intervention and optimize approval workflows for faster decision-making.

III. PROPOSED METHODOLOGY

The proposed system introduces an automated, web-based Institutional Management System designed to unify user authentication, data persistence, hierarchical routing, and software lifecycle operations.

The application is built using the MERN stack (MongoDB, Express.js, React.js, and Node.js) and operates on a digital state-transition model. When a user submits an application, the system uses custom backend middleware to evaluate their credentials, automatically placing the request into the HOD's pending queue. Once verified, the routing engine pushes the request to the Dean's dashboard, and subsequently to the Director's portal for final sign-off. Rejection pathways are also programmed, allowing reviewers to route documents backward with feedback comments.

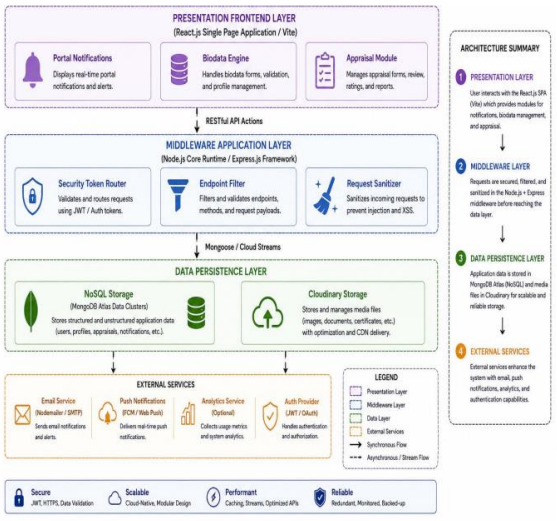


Fig. 1: System Overview

1. **Authentication and RBAC Module:**

This module manages user login, session security, and permission scoping. Upon receiving credentials, it verifies user details in the database and triggers the OTP verification challenge. Once the user submits the correct OTP, the module generates a JSON Web Token (JWT) containing the user's role (HOD, Dean, or Director). The client application reads this token to render the appropriate dashboard interface, while the backend middleware validates the token signature to authorize all subsequent API actions.

2. **HOD Department-Level Appraisal Verification Module:**

This module provides the entry-level evaluation interface. It queries the database for submitted faculty appraisal forms within the HOD's specific department. The HOD can view teaching records, publication certificates, and research documents. Using the dashboard, the HOD assigns performance scores, appends remarks, and recommends a preliminary yearly salary increment before routing the request up.

3. **Dean Academic Appraisal Review Module:**

This module processes requests that have successfully passed the HOD verification stage. The Dean reviews the HOD's appraisal scores and salary increment recommendations. The Dean evaluates the academic performance from a school-wide perspective, validates resource availability,

appends recommendation comments, and forwards the request to the Director. It ensures that no request can bypass the HOD layer.

4. **Director Executive Sign-off & Salary Hike Module:**

This module serves as the final decision-making terminal. It displays requests that have cleared both HOD and Dean review stages. The Director reviews the aggregated performance appraisal scores and recommendation comments. The Director has the final veto authority to approve the yearly salary increment, which automatically updates the employee's payroll profile in the database, or to decline the request.

5. **Workflow State Routing & Audit Logging Module:**

This module functions as the state machine of the application, managing document status transitions (e.g., Pending_HOD, Pending_Dean, Pending_Director, Approved, Rejected). Simultaneously, it logs an audit trail recording reviewer IDs, timestamps, action.

IV. EXPERIMENTAL RESULTS AND ANALYSIS

Experimental results demonstrated that the implementation of Role-Based Access Control significantly reduced unauthorized access while ensuring that requests were routed to the appropriate authorities at each approval level. The automated workflow mechanism reduced manual intervention and improved processing efficiency compared to traditional paper-based systems.

The analysis indicates that the system successfully handled multiple approval stages with minimal delay and maintained consistent performance as the number of users and requests increased. Overall, the proposed approach provides a secure, scalable, and efficient solution for academic administration workflows, improving transparency, accountability, and operational productivity.

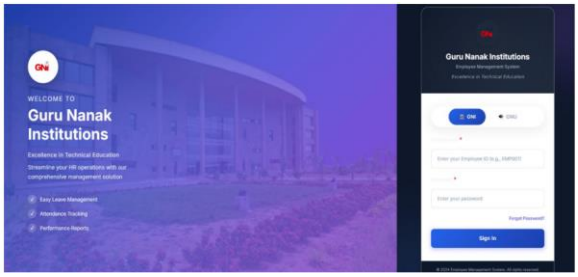


Fig. 2: Home Page

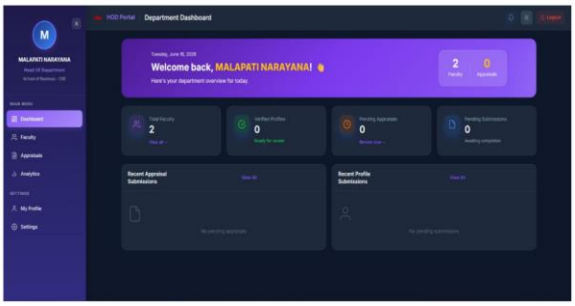


Fig. 3: Hod Dashboard

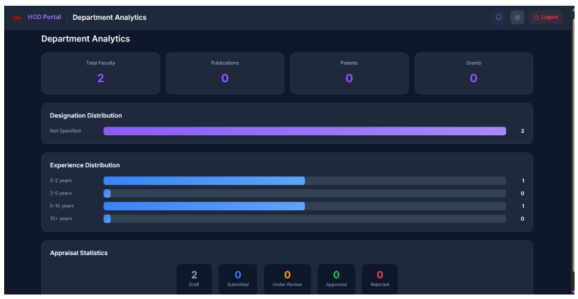


Fig. 4: Department Analytics

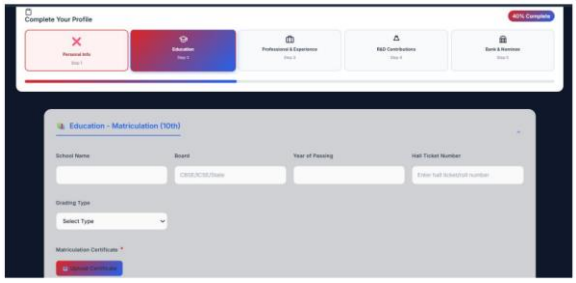


Fig. 5: Employee Details

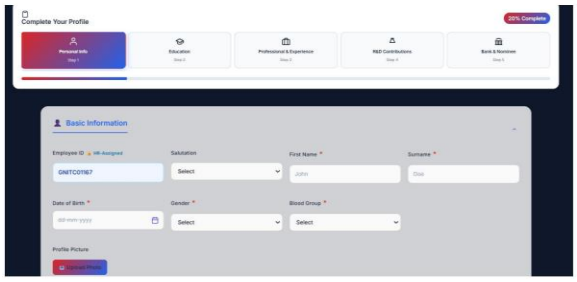


Fig. 6: Detail Entry for Employee

V. CONCLUSION

The design and implementation of the Hierarchical Approval Routing System successfully address the inefficiencies, bottlenecks, and security gaps associated with traditional paperbased and email-based administrative workflows in educational institutions. By digitizing institutional workflows into an automated state-transition model, the system streamlines the review process across Head of Department (HOD), Academic Dean, and Executive Director dashboards.

REFERENCES

1. D. Flanagan, JavaScript: The Definitive Guide, 7th ed. Sebastopol, CA: O'Reilly Media, 2020.

2. D. Crockford, JavaScript: The Good Parts. Sebastopol, CA: O'Reilly Media, 2008.

3. R. Dahl, "Node.js: JavaScript on the Server," in Proceedings of the Joint JSConf & NodeConf Europe, Berlin, Germany, 2009.

4. E. R. M. J. de Jonge, React.js Up and Running: Building Web Applications in JavaScript, 2nd ed. Sebastopol, CA: O'Reilly Media, 2021.

5. T. J. M. Robin, Express in Action: Writing, building, and testing Node.js applications. Shelter Island, NY: Manning Publications, 2016.

6. K. Chodorow, MongoDB: The Definitive Guide, 2nd ed. Sebastopol, CA: O'Reilly Media, 2013.

AUTHORS Profile



Prof. M V Narayana received his Bachelor of Engineering (B.E.) degree in Computer Science in 2004 from JNTU Kakinada, India. He completed his Master of Technology (M.Tech) degree in Computer Science in 2010 from JNTU Hyderabad, India, and was awarded his Ph.D. in Computer Science in 2017 from JNTU Kakinada, India. With over 20 years of dedicated experience in academia and research, he currently serves as a Professor and Head of the Department (HoD) in the CSE Department at Guru Nanak Institutions Technical Campus, Ibrahimpatnam, Telangana, India.



Mr. GOPATHI RAVI VARMA pursuing B. Tech degree in Computer Science and Engineering at Guru Nanak Institutions Technical Campus affiliated to JNTUH in 2022-2026.



Mr. KATKAM SHIVA KUMAR pursuing B. Tech degree in Computer Science and Engineering at Guru Nanak Institutions Technical Campus affiliated to JNTUH in 2022-2026.



Ms. ERAVELLY ASHWITHA RAO pursuing B. Tech degree in Computer Science and Engineering at Guru Nanak Institutions Technical Campus affiliated to JNTUH in 2022-2026.



Mr. SOMA ESHWAR pursuing B. Tech degree in Computer Science and Engineering at Guru Nanak Institutions Technical Campus affiliated to JNTUH in 2022-2026.