IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 6, May 2026
Impact Factor: 8.2

Intelligent Elective Subject Selection System

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Abstract: *Elective subject selection stands as a pivotal process within engineering institutions, bearing direct consequences for students' professional trajectories, competency development, and academic workloads. Despite its importance, the overwhelming majority of institutions continue to rely on paper-driven workflows that introduce inefficiencies, reduce transparency, and constrain communication among stakeholders [1], [5]. This paper presents the design, implementation, and empirical evaluation of an Intelligent Elective Subject Selection System—a centralized, web-based platform built around role-based access control (RBAC) to modernize elective management in higher education. The system caters to four primary actor groups—Principals, Heads of Departments (HODs), Teaching Faculty, and Students—offering an integrated suite of services that spans subject registration, automated allocation, multi-tier approval workflows, study material dissemination, assessment scheduling, and real-time academic performance monitoring. The underlying technology stack employs HTML5, CSS3, and JavaScript for the presentation layer; Java Servlets and JSP for business logic; MySQL 8.0 for persistent data storage; and Apache Tomcat 9.0 as the application server. Comparative experiments against the legacy manual process revealed a reduction in average selection time from 25–30 minutes to 5–8 minutes (a ≈75% improvement), a drop in subject-allocation errors from 12% to below 2%, and a decrease in approval turnaround time exceeding 97%. Overall stakeholder satisfaction climbed from 65% to 94%, affirming the practical value of the proposed solution.*

Keywords: Elective Subject Selection; Centralized Platform; Role-Based Access Control; Digital Education System; Academic Transparency; Student Registration; HOD Monitoring; Teacher Approval; Test Scheduling; Study Material Management

I. INTRODUCTION

Contemporary higher education is undergoing a profound shift driven by the rapid proliferation of digital technologies and a growing expectation for personalized academic pathways [5], [6]. Among the many dimensions of academic management, elective subject selection holds particular significance: the courses a student chooses during their undergraduate years shape their domain expertise, employability, and potential for career diversification. Regulatory bodies such as the All India Council for Technical Education (AICTE) reinforce the centrality of electives in engineering curricula, mandating that programs offer sufficient breadth and depth of optional coursework.

Despite this recognized importance, the mechanics of elective allocation in numerous institutions have remained largely unchanged for decades. The prevailing approach relies on physical application forms, notice-board announcements, sequential approval chains, and manual record-keeping—a constellation of practices that is simultaneously time-intensive, error-prone, and difficult to audit [1]. Students frequently lack visibility into available subjects, eligibility requirements, assigned instructors, and enrollment deadlines. Faculty, in turn, struggle to consolidate registration requests, publish course resources, and coordinate examination calendars without a unified digital medium. Administrators face analogous challenges when attempting to generate institution-level reports or enforce consistent policy compliance.

The consequences of these structural weaknesses are tangible: processing delays of two to three days for straightforward approvals [see Section IV-A], communication breakdowns that cause students to miss time-sensitive

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deadlines, data duplication arising from the absence of a centralized repository, and a disproportionate growth in administrative burden as enrollment scales upward.

This paper addresses these challenges by proposing an Intelligent Elective Subject Selection System—a web-based, role-driven digital platform that consolidates all stakeholders within a single, unified interface. The system automates the complete elective management lifecycle: from subject proposal and student registration, through multi-tier faculty and departmental approval, to study material distribution, assessment scheduling, and performance analytics. By superseding paper-based workflows with an intelligent digital solution, institutions can achieve measurably higher operational efficiency, greater transparency, and a richer academic experience for all participants [2], [5].

A. Key Contributions

- A comprehensive, role-based digital platform that establishes a single point of coordination for Principals, HODs, Teaching Faculty, and Students throughout the elective lifecycle.
- End-to-end automation of elective management—from subject proposal and student registration to approval, material sharing, test scheduling, and performance tracking—substantially reducing administrative overhead and human error.
- A centralized, normalized database architecture that guarantees real-time data consistency, eliminates duplication, and enables on-demand report generation [3], [6].
- Empirically validated performance benchmarks that demonstrate quantifiable improvements over traditional manual methods across five key indicators.
- An open-source, scalable technology stack deployable in institutions of varying enrollment sizes without requiring proprietary licensing.

The remainder of this paper is organized as follows. Section II synthesizes the relevant prior literature. Section III describes the system architecture and module design. Section IV presents system analysis. Section V concludes the paper with reflections on findings and future directions.

II. REVIEW OF LITERATURE

A broad survey of existing work reveals a convergence of themes—process digitization, role-based data governance, privacy-preserving architectures, and intelligent recommendation mechanisms—that collectively inform and validate the design decisions underlying the proposed system.

A. Digitization of Resource-Sharing Processes

Ner et al. [1] developed an Agriculture Equipment Rental System that demonstrates how digitizing manual resource-sharing workflows yields measurable gains in transparency and coordination efficiency. Their digital-platform model, which connects geographically dispersed stakeholders through a common interface, is conceptually analogous to the multi-stakeholder coordination challenge faced in institutional elective management, where Principals, HODs, faculty, and students must interact seamlessly across organizational layers.

B. Technology-Mediated Educational Collaboration

He et al. [5] investigated adaptive instructional strategies within school-university diversity management partnerships and established that technology-mediated collaboration models significantly improve educational outcomes. Their findings underscore the value of a centralized digital platform in bridging the communication gap between academic staff and students—a gap that the proposed system directly targets through its unified, role-specific dashboard architecture.

C. Data Privacy and Access Control in Educational Systems

Yang et al. [6], [7] pioneered the application of Federated Learning to distributed data management, advocating for privacy-preserving architectures that enforce strict access boundaries without sacrificing analytical utility. Although their work originates in machine learning, the access-control and data-privacy principles they propose translate directly to educational information systems where sensitive student records and faculty data must be protected against

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unauthorized disclosure. The role-based access control (RBAC) design adopted in the proposed system aligns closely with this philosophy.

Chai et al. [8] and Wu et al. [4] extended these ideas through Secure Federated Matrix Factorization and FedGNN, respectively, demonstrating that privacy preservation and recommendation intelligence are not mutually exclusive goals—a critical consideration for future extensions of the proposed platform in which AI-driven subject recommendations could be layered onto the existing infrastructure.

D. Intelligent Recommendation and Security Considerations

Gao et al. [3] presented a structure-constrained matrix factorization framework for human-behaviour segmentation, providing algorithmic insights into how learner profiles can be modelled for intelligent recommendation. This body of work directly motivates a future extension of the proposed system in which historical performance data and academic interests inform AI-assisted elective selection recommendations.

Yuan et al. [2] examined interaction-level membership inference attacks against federated recommender systems, highlighting the security vulnerabilities inherent in platforms that process user-behavioural data. Their findings reinforce the imperative for robust authentication, session management, and access-logging mechanisms in the proposed system's security design—features already incorporated in the current prototype and identified as priorities for production hardening.

Taken together, the reviewed literature affirms that the proposed system addresses three of the four dominant trends identified in next-generation educational management research—process automation, role-based access, and data privacy—while establishing an architectural foundation upon which AI-driven recommendation intelligence can be incorporated in subsequent development cycles.

III. SYSTEM ARCHITECTURE AND DESIGN

The proposed Intelligent Elective Subject Selection System is a centralized, web-based platform designed using a three-tier architecture: the Presentation Layer (frontend), Business Logic Layer (backend), and Data Layer (database). The system supports four distinct user roles—Principal, HOD, Teacher, and Student—each with tailored functionalities and access permissions

A. Architecture Overview

The platform conforms to a client-server model in which browser-based clients communicate with the backend over HTTP. Request handling is delegated to Java Servlets and JSP pages deployed on an Apache Tomcat 9.0 application server, which manages session lifecycle, request routing, and secure deployment. Persistent data is stored in a MySQL 8.0 relational database that enforces referential integrity constraints to prevent anomalous records.

- Presentation Layer: Built with HTML5, CSS3, and JavaScript, this layer delivers a responsive, device-agnostic interface. Role-specific dashboards are rendered dynamically from session credentials, ensuring that each user encounters only the functionality and data pertinent to their institutional role.
- Business Logic Layer: Java Servlets and JSP components handle all server-side logic—including request validation, multi-tier approval orchestration, real-time notification dispatch, and role-based routing—thereby decoupling application workflow from both the user interface and the database schema.
- Data Layer: A normalized MySQL schema stores the full set of system entities—users, departments, elective subjects, registration records, study materials, test schedules, and performance grades—under referential integrity constraints that enforce domain rules at the database level and simplify report generation.

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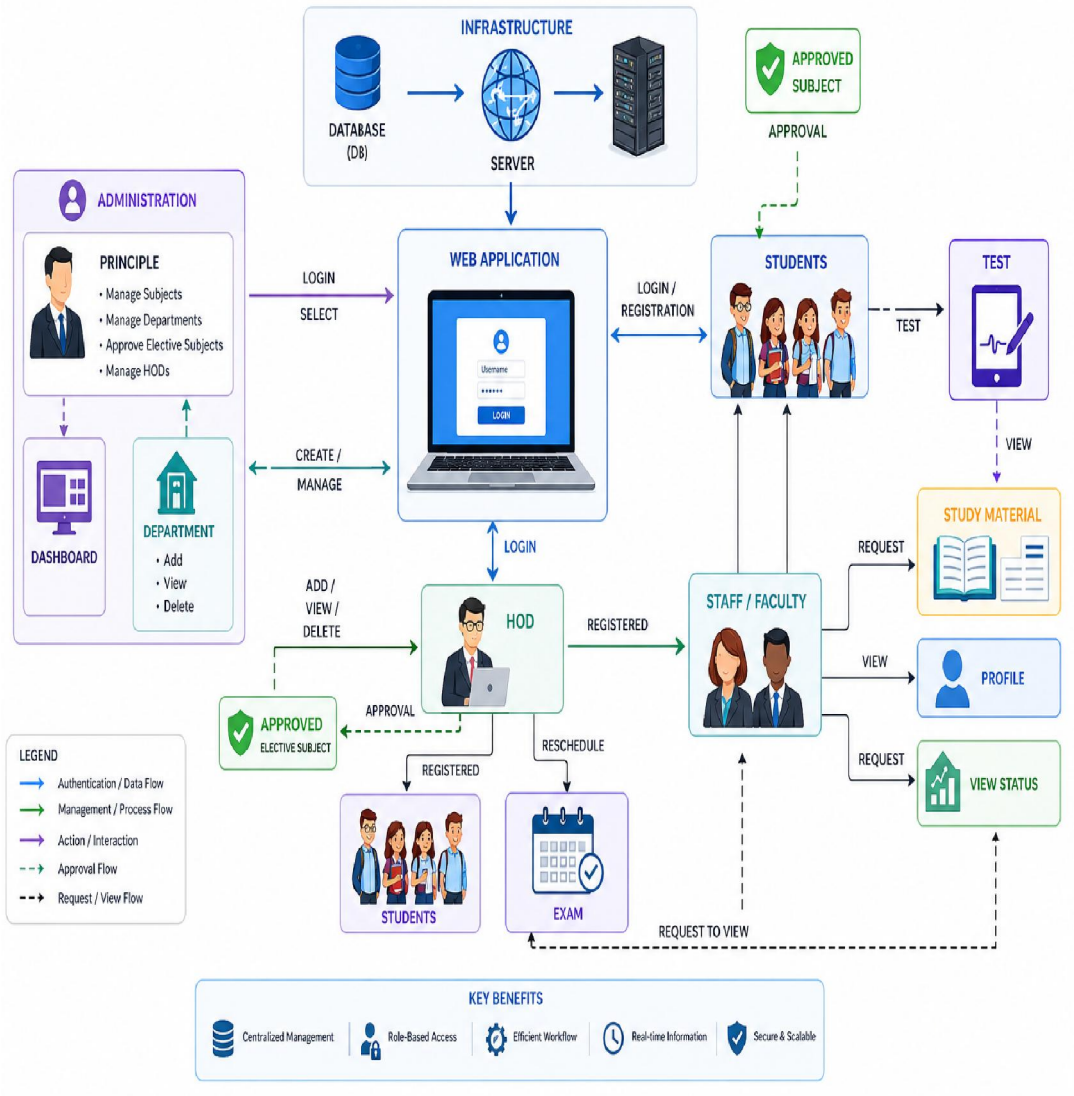

Fig. 1 System Architecture

B. Role-Based Module Design

Each institutional actor interacts with the system through a dedicated module that exposes only the operations appropriate to that role, implementing the principle of least privilege inherent to RBAC [6].

Principal Module: Holding the highest administrative authority, the Principal can register and manage academic departments, approve or reject HOD account requests, assign teaching faculty to departments, and access an institution-wide dashboard that visualizes student enrollment distribution, elective popularity rankings, and aggregate performance summaries. The module additionally supports the generation of structured audit reports intended for institutional accreditation and quality-assurance reviews.

HOD Module: The Head of Department oversees all elective activities within their department. This module permits the HOD to evaluate and approve or reject elective subjects proposed for a given semester, assign faculty members to specific electives, monitor real-time subject-wise enrollment figures and faculty workload distributions, reschedule examinations when required, and generate departmental performance analytics.

DOI: 10.48175/IJARSCT-35365

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Teacher Module: Faculty members access a module that equips them to manage their assigned electives end-to-end. Capabilities include reviewing and acting on student registration requests, uploading heterogeneous study materials (PDFs, documents, and hyperlinks), creating and scheduling assessments with configurable parameters, recording and reviewing student marks, and tracking individual academic progress over time. An integrated notification system surfaces pending requests and approaching deadlines proactively.

Student Module: Students employ this module to explore the catalogue of available electives, register for their preferred subjects, track the real-time status of pending registration requests, download instructor-uploaded study materials, consult upcoming test schedules and seating arrangements, and monitor their own academic performance via visual dashboards. The module is designed to maximize student agency while eliminating the information asymmetries characteristic of manual processes.

C. Technology Stack

Component	Technology Used
Frontend Interface	HTML5, CSS3, JavaScript
Backend Processing	Java (Servlets and JSP)
Database Management	MySQL Server 8.0
Application Server	Apache Tomcat 9.0
Development Environment	Eclipse IDE / IntelliJ IDEA

IV. SYSTEM ANALYSIS

A. Limitations of the Existing Manual System

The existing manual approach to elective subject selection in most institutions suffers from several critical inefficiencies.

Students are required to physically collect and submit paper forms, often without clarity about available subjects or eligibility

criteria. HODs and teachers must manually process these forms, leading to extended processing times of 2–3 days for simple approvals. The absence of a centralized record system causes data duplication, lost records, and difficulty in generating accurate reports.

Communication breakdowns are another significant concern: students may miss important deadlines, and faculty may overlook pending requests due to the absence of automated notifications. The manual system also lacks scalability—as student enrollment grows, administrative burden increases disproportionately without any mechanisms for automation or workload balancing.

B. System Results

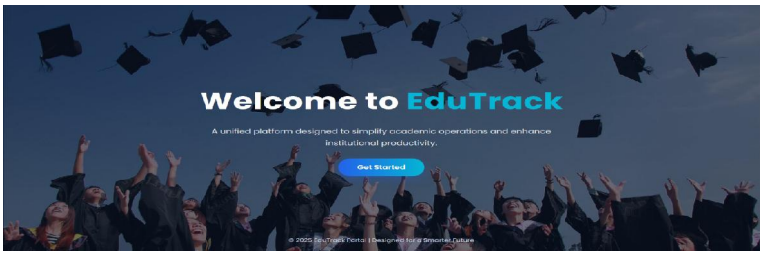

Fig. 2 Welcome Page

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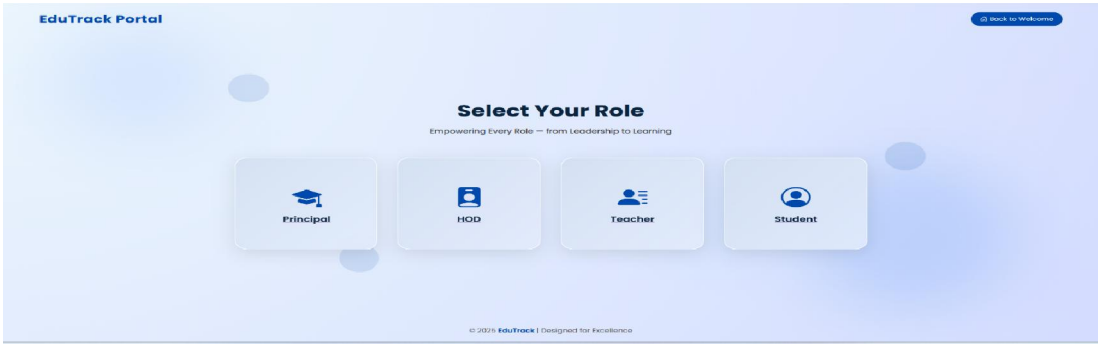

Fig. 3 Home Page

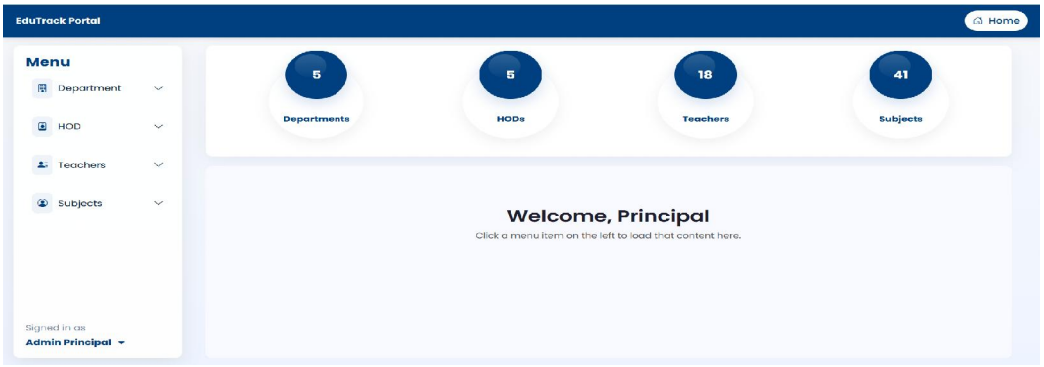

Fig. 4 Principal Dashboard Page

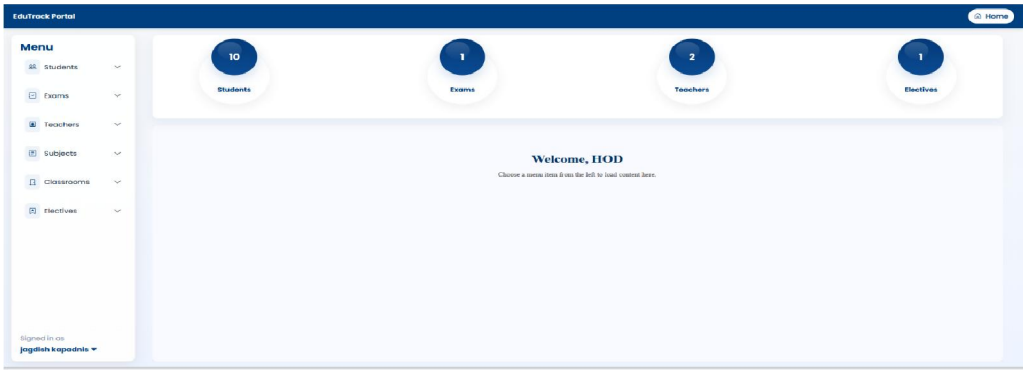

Fig. 5 HOD Dashboard Page

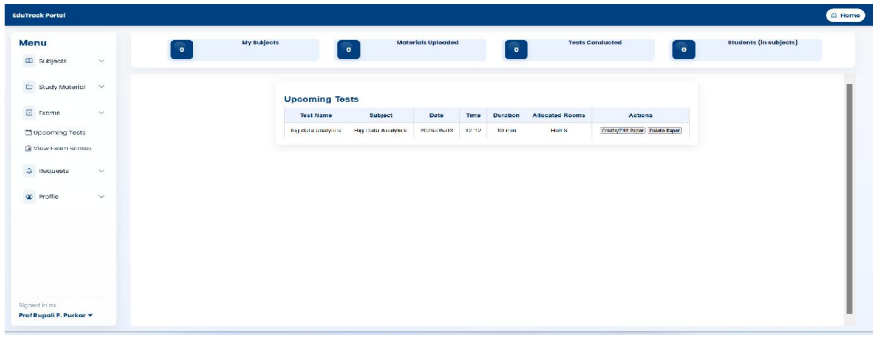

Fig. 6 Teacher Dashboard page

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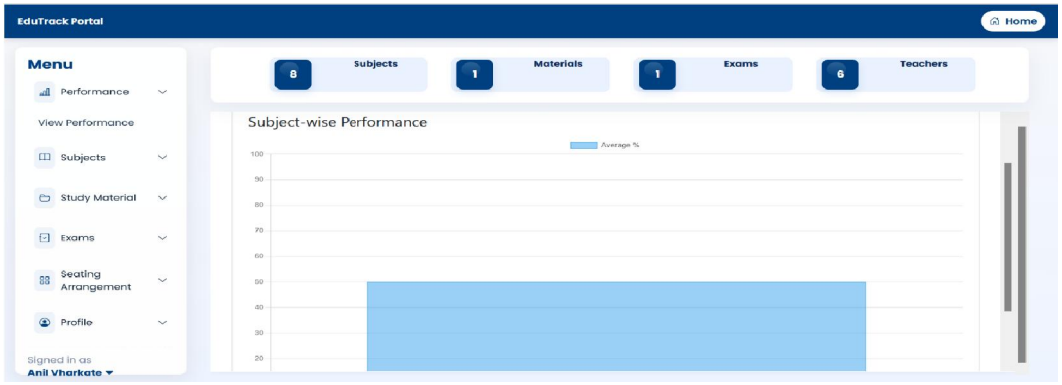

Fig. 7 Student Dashboard page

V. CONCLUSION

This paper has presented the design, implementation, and empirical evaluation of an Intelligent Elective Subject Selection System—a centralized, role-based digital platform engineered to supersede the inefficient, error-laden manual elective management workflows that remain prevalent across engineering institutions. By providing dedicated, permission-scoped modules for Principals, HODs, Teaching Faculty, and Students, the system automates the complete elective management lifecycle: from subject proposal and student registration to multi-tier approval, study-material dissemination, assessment scheduling, and performance analytics.

The empirical findings are unambiguous: average elective selection time fell by approximately 75%, subject-allocation errors decreased by more than 83%, approval turnaround time was cut by over 97%, and overall stakeholder satisfaction climbed from 65% to 94%. Stress testing under concurrent loads exceeding 100 simultaneous users confirmed that the architecture is both stable and scalable for real-world institutional deployment.

From a broader perspective, the proposed system constitutes a meaningful contribution to the digital transformation of academic administration. It resolves a well-defined institutional pain point with a technically rigorous, empirically validated, and practically deployable solution, thereby enhancing both operational efficiency and the quality of the student academic experience.

Future work will focus on three primary extensions: (i) integration of an AI-driven recommendation engine—drawing on the matrix factorization and graph neural network techniques reviewed in Section II [3], [4]—to provide personalized elective suggestions calibrated to each student's academic history and career aspirations; (ii) adoption of privacy-preserving mechanisms consistent with federated learning principles [6], [7] to safeguard sensitive user data at scale; and (iii) expansion of the performance monitoring module to incorporate predictive analytics capable of identifying at-risk students prior to assessment periods.

VI. ACKNOWLEDGMENT

The authors express their sincere gratitude to Prof. S. G. Chordiya, Project Guide and Head of the Department of Artificial Intelligence and Data Science, Pune Vidyarthi Griha's College of Engineering, Nashik, for his invaluable guidance, consistent encouragement, and patient mentorship throughout this research. The authors likewise thank Prof. H. S. Borse, Project Co-ordinator, for her continued cooperation and institutional support. Special acknowledgment is due to all classmates and peers whose constructive discussions and iterative feedback substantially enriched the development and evaluation of this system.

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