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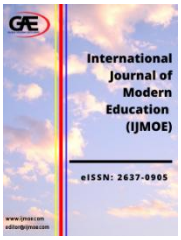

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FROM DIGITALIZATION TO INTELLIGENCE: CURRENT STATUS AND FUTURE TRENDS OF UNIVERSITY OA SYSTEMS

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Abstract:

The rapid evolution of information technology has catalyzed a paradigm shift in higher education administration, driving a transition from foundational digitalization toward the era of the "Smart Campus." This paper provides a comprehensive review of this evolution, analyzing the current architectural standards and forecasting future developmental trajectories of University Office Automation (OA) systems. Currently, the landscape is dominated by B/S (Browser/Server) architectures and modular frameworks like SpringBoot, which have successfully mitigated traditional inefficiencies by centralizing data management and automating core workflows such as course scheduling and grade entry. However, a critical analysis reveals that while these systems excel at data storage and process automation, they often lack the analytical depth required for strategic governance. Consequently, this study identifies a pivotal industry trend: the migration from static administrative tools to dynamic, intelligent decision-support platforms. We explore emerging innovations, including the integration of data mining algorithms for analyzing student performance, the adoption of mobile-first ecosystems for real-time accessibility, and the implementation of robust security models like Role-Based Access Control (RBAC). Ultimately, the paper concludes that the future of university administration lies in establishing interconnected, intelligent ecosystems that empower leadership with actionable insights, thereby

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optimizing resource allocation and significantly enhancing the quality of educational management in the context of Education Informatization 2.0.

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Keyword:

University B/S Architecture, Data Mining, Digitalization, Education Informatization, Intelligent Decision Support, OA Systems, Smart Campus

Introduction

In the past few years, higher educational institutions have undergone a fast digital transformation brought about by “smart campuses” effort. The universities should modernize their management not only teaching-related administration (such as registration of courses, time schedules and managing grade) but also administration of universities for enhancing its operation efficiency, service quality and institutional governance. But many universities are still running daily management in offline ways, like paper-based record and manual coordination or by separate information systems that are built for different departments. It usually ends up with being less efficient, it leads to mistakes happening more frequently, and it isn't very open when different parts of the company work together.

Although there has been a wide use of web-based systems, there are still some common issues in existing university management systems. Firstly, the various system functions are often distributed in separate sections with different interface styles and interaction rules, leading to a poor user experience and high cost for students and teachers to learn and use. Second, many systems do not have an integration standard and do not have unified data governance. It is hard to scale and change policies. Therefore, universities have always been having difficulties with creating a full process that is connected and closed loop and links all the key stakeholders together for the entire process.

Accordingly, the core problem solved in this paper is inefficient current university management process, including 3 aspects. (1) Data Silo: important information is stored and preserved by different parts, leading to overlap, inconsistency, and delay for synchronization. (2) Process inefficiency: handling course selection, grade submission, and timetable manually or semi-automatically is very time-consuming and error-prone, especially with large concurrency. (3)

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Lack of integration: there is no unified platform that connects students, teachers, and administrators into a complete loop of operation, lacking the ability to trace processes, respond to services, and continuously improve. These problems indicate there should be design for uni extensible uni OA oriented mgmt plat which support centralization of data, coordination of process and sustainable evolution of system.

Literature Review

Theory	Role
Digital Transformation Theory	Explains the theoretical logic of OA systems transitioning from digitalization to intelligence, emphasizing the progressive evolution from basic digital tools to intelligent decision-support platforms.
Smart Campus Framework	Positions OA systems as governance nodes within the broader smart campus ecosystem, rather than as isolated administrative tools.
Decision Support Systems (DSS) Theory	Explains the necessity for OA systems to evolve from TPS (Transaction Processing Systems) to DSS, highlighting how analytics and predictive capabilities enhance decision-making.
Data-Driven Governance	Highlights that data integration is not merely a technical challenge but a paradigm shifts in institutional governance, enabling evidence-based strategies and resource allocation.

Office automation (OA) system of higher education institutions (HEIs) refers to an integrated information platform which aims at helping the administration and teaching work management of higher education institutions including the managing of course, academic affairs handling, organization coordination, etc. With the continuous progress of information technology, the transformation of higher education from Education Informatization 1.0 to Education Informatization 2.0 has undergone a global transition from emphasizing the basic construction of infrastructure and basic system deployment to the integration of application, data sharing, and intelligent services. In this situation, OA systems have slowly developed into key components of smart campus ecosystems from being an auxiliary office tool, playing an important role in improving the efficiency and governance of the campus.

Literature review of university OA systems based on web technologies, focusing on those adopting B/S (Browser/Server) architecture and serving as comprehensive management platforms. On System Evolution, Main Technical Standards, Evaluation Frameworks and Future Developments trends. Relevant literature was obtained from academic databases such as IEEE Xplore,Scopus and Google Scholar. Keywords like university OA system, smart campus, education informatization, B/S structure, information system evaluation. By means of comparing and synthesizing representative studies, this review intends to come up with general conclusions, predominant difficulties and gaps in the field.

Although university OA systems have reached technical maturity, particularly with modular designs based on B/S architecture and digitalized workflows, several significant research gaps remain:

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Insufficient Data Integration: Current systems are often developed at the departmental level, creating data silos and lacking standardized cross-department data governance and interfaces. While digitalization enables online operations, interoperability and end-to-end workflow tracking remain weak, limiting the systems' potential for intelligent applications.

Limited Evaluation Frameworks: Existing studies primarily focus on technical performance metrics, such as system responsiveness, high-concurrency handling, and stability. There is insufficient research evaluating OA systems in terms of decision support, governance effectiveness, and user experience, lacking comprehensive assessment frameworks.

Limited Intelligent Applications: Although significant administrative and academic data have been accumulated, current research on intelligent decision support, data mining, and predictive analytics is insufficient, and actionable strategies for management and service optimization have not yet been fully developed.

Limited Mobile & Service-Oriented Integration: With the rise of mobile-first strategies and microservices architecture, existing OA systems have limited integration with mobile ecosystems and API-driven service decomposition, making it difficult to achieve flexible scaling and real-time services.

Summary: Research and practice in university OA systems show a pattern of "technical maturity but application lag." Future studies need to address cross-department data integration, intelligent decision support, comprehensive evaluation frameworks, and mobile/microservices integration to advance OA systems from digitalization toward intelligence and fulfill the goals of Education Informatization 2.0.

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This study is a Review Paper. It systematically analyzes and synthesizes existing literature on university OA systems, covering their evolution, current technical standards, evaluation frameworks, and emerging trends. The paper does not collect primary empirical data but provides a comprehensive overview, identifies research gaps, and proposes future directions, which are typical characteristics of a review study.

The Evolutionary Trajectory of University OA Systems

Standalone Automation (1990s–2000s)

During the early days of university informatization, most OA activities involved replacing manual traditional tools with single function digital tools, like word processors and local spreadsheets. Much of the information is on individual computers that don't communicate with each other, making it harder to share and collaborate with information. Although this stage improved the basic efficiency compared to paper-based processing, but it was unable to achieve cross-departmental coordination and centralized data management.

Networked Digitalization (2000s–2015)

Due to the widespread use of local area networks and C/S, universities started using separate departmental systems such as academic affairs, finance, and personnel. While these systems greatly improved efficiency within each department, they created data silos. Because data standards are not consistent and information cannot be exchanged between different systems, there is a lot of repeated information, synchronization is delayed, and management is fragmented.

Integrated Web Platforms (2015–Present)

Since around 2015, university OA systems have increasingly become integrated web-based systems based on B/S architecture. This is some manner in which to allow anybody to make use of a system employing ordinary web browsers that do not call for the installation of any client apps and thereby reduces upkeep whilst also making diverse sorts of gizmos get access. And also now more Model – View – Controller (MVC) design pattern is used for making it easier to maintain and scale the system. Existing research basically think that this is the period of time when digitalization in universities reaches its maturity because most major administrative operations have moved online by now.

Current Technical Standards: The Digitalization Status

Architectural Dominance of B/S Structures

In comparison with traditional C/S system, the B/S architecture has some advantages in the university environment in terms of lowering deployment cost, lowering maintenance cost, cross platform compatible, centralized update of the system. The literature shows that when B/S based OA systems combined with load balancing and caching mechanisms can do well in high-concurrency situations such as course registration and grade inquiry period.

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Development Frameworks and Technology Stack

Backend Development uses SpringBoot which is modular and fast development along with a good ecosystem. A relational database like MySQL or Oracle is usually where transactions are consistent and data integrity is maintained, especially when it comes to important school stuff like grades and when people sign up. The front end consists of reactive frames like vue js and react they have given a response interface which can increase the customers' entire experience.

Critical Challenges in Existing Systems

Although the current university OA systems have achieved technical maturity, they still encounter a lot of challenges. Data heterogeneity still exists because of old systems that use different kinds of data forms and rules. And there are lots of systems that use strict, set ways of working that can't get used to university rules changing a lot. These limitations restrict system scalability and stall forward movement to smater, and more adaptable management platforms.

Evaluation Frameworks for OA System Effectiveness

Theoretical Evaluation Models

Among existing evaluation systems, DeLone and McLean Information System Success Model is a commonly used basic model to evaluate the success of a system by evaluating the systems quality, information quality, and service quality. Besides, TAM was widely used to study user acceptance and use, especially students and faculties.

Key Performance Indicators (KPIs)

On the basis of such theoretical models, the researchers put forward some KPIs for assessing OA system effectiveness. Operating effectiveness such as decrease in administrative handling time, operating soundness like uptime at high use intervals, and satisfaction taken from surveys and user remarks. But lots of research mainly looks at technical performance measures, and the bigger organizational and decision-support impacts of OA systems get less attention.

Future Trends: Transitioning from Digitalization to Intelligence

From Data Storage to Data Mining

University OA systems as these systems accumulate large amounts of historical administrative and academic data, the role of the system is increasing from data storage to data analysis. Using data mining technique to discover patterns and trends like predicting the student drop out risk according to the student learning behaviors and performances so as to take management in advance.

Intelligent Decision Support Systems

IDSSs are a key future direction for university OA platforms. Using algorithms like Apriori, K - means clustering, the OA system would find associations between course selection and

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academic performance. This enables personalized and evidence-based decision making for the student as well as for the administration.

Mobile Ecosystems and Microservices

OA system integrated with mobile ecosystem like enterprise messengers and university mobile app is becoming more and more. Architecturally, microservice design is being used to increase the scalability, flexibility and maintainability of the system, so universities can better respond to changing management needs.

Security and Privacy in an Open Environment

The more open systems become and the more sensitive the data, security becomes a problem. RBAC is still a primary mechanism for protecting academic and personal data. Meanwhile, ZT models have started to gain traction as viable approaches for securing a university's information assets in an increasingly connected environment.

After reviewing the relevant literature, it is found that after B/S architecture + such as the current development framework used in universities OA systems, including springboot. At the same time, there are also ongoing issues like data silos and rigid workflows that hold back more progress. In general, the current studies point out that the next university OA system should be more than just a digitalization; instead, it needs to become a data driven intelligent system. Systems like that need to go beyond just doing administrative work and should hand over some know-how and choices to be made, which can be a good step forward for the heads of a university, as well as Education Informatization 2.0.

Methodology & Technical Framework

System Architecture Design

Contemporary university OA systems predominantly adopt Browser/Server (B/S) architectures, reflecting an industry consensus on centralized maintenance and cross-platform accessibility. The main driving force is to unify access through standardized web browsers without any client-side installations, making it especially suitable for a university environment where users have different devices: offices and laboratories have office computers, personal laptops, and mobile devices. In comparison with traditional Client/Server(C/S) model, B/S model has advantage on less deployment and maintenance cost, and easier on version update and more cross-platform compatible. And business logic and data services in a centralized manner on the server side also facilitates unified governance and control of security and scalability of the system in high concurrency scenarios like course registration period.

Technology Stack

Backend

SpringBoot-based microservice backends have become the de facto standard in higher-education OA platforms, offering modular scalability and rapid deployment. It supports quick development using convention-over-configuration. It can provide strong modularization ability and is easy to integrate with some common middleware modules, such as authentication

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module, log framework, cache module. So that it will be able to maintain the responsibility for it, and as university policies and management requirements change the system’s function can be added.

For better data access efficiency and maintainability, we use MyBatis as persistence layer. MyBatis can make flexible correspondence between the domain object and the relational table and enable fine tuning of the SQL at the time of processing complex query problem that usually found in academy management system like timetable query and multiple condition’s course selection restriction.

Database

Relational database management systems (e.g., MySQL, Oracle) remain the dominant persistence layer, ensuring ACID compliance for transactional academic data such as enrollment and grading records. University teaching and administrative data like students' enrollment records, course selection information, grades, and evaluations should have strong consistency and integrity guarantees. And then I could be like MySQL is transactional, some of that ACID stuff I think it is nice to know about, because if lots of people are all enrolling in a course at once, which is cool also just prevents like by accident putting like ones score like a little bit higher or making some sort of mistake where it’s enrolling them in two courses instead of just one. So transaction management is used to make sure that important business operations are done all at once and consistently, especially when lots of people are signing up at once.

Frontend

The system offers a web-based user interface available by common browsers. It is able to achieve cross-platform access and lower learning and installation barriers for various users. The front end design has usability and a role based navigation for students,teachers and administrators to make the pertinent feature to their role easy to navigate to.

Core Modules

Taking into account the stakeholders and conventional process of a typical university, the system is mainly composed of three typical roles and their related functional modules.
1.Student Module: timetable inquiry, online course add/drop, grade inquiry, teaching evaluation. This is the improvement of students' self-service ability and the reduction of teachers' workload.

2.Teacher Module: it can do teaching schedule management, grade entry and student evaluation. It is given particular attention to the data's validation as well as its permission control so as to make sure the right and confidential status of those academic records.

Administrator Module: can achieve management of students, teachers and courses, as well as maintenance of class and course data. This module is for centralized governance functions, policies such as enrollment rules, evaluation criteria, etc., can be set and updated without any hassle.

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Project Implementation Plan

This is by a system engineering methodology combining requirements-driven designs modular development, and a test-based verifications. It is carried out in four stages

Phase 1: Requirements Analysis

Then it shows the users' role in this stage, its either Student, Teacher, or Administrator, also we'll talk about boundaries of functions of its role. And functional requirements are given, as we'll as key non-functional requirements, such as high concurrency and the system should respond quickly during peak periods like course selection weeks. Common business scenarios get turned into use cases that steer following design and testing efforts.

Phase 2: System and Data Design

The system is constructed through modular decomposition and layered architecture approach in the second phase. E - R model is used to create a database schema with main entities like user, course, class, course selection record, grade record and evaluation data. Relationship constraints, index strategies have been set up to facilitate effective querying and safeguard data integrity. Application level: Key workflows such as course selection, grade submissions etc. are modeled to find out transaction boundaries and exceptions.

Phase 3: Development and Integration

Development phase implements the functional module based on SpringBoot+MyBatis. Vital aspects have been introduced with a transaction, to reduce the chances of a double enrollment or overwriting of grades data. Business rules (course capacity constraints, prerequisite checks, time-window restrictions for add/drop) are enforced at the service layer to be correct under concurrent requests. At the same time, there is logging and auditing mechanism in place for troubleshooting and accountability.

Phase 4: Testing and Evaluation

Testing is done to confirm both the right function and the system's speed.
Functional Testing: checks all the main business logic from every role, like if a student can add and drop classes during the right times, if a teacher can put and change grades with the right permissions, and if admins can control user accounts and course data properly. There is some test cases made for normal flows, boundaries and exceptions.

Stress Testing: System stability and response under high concurrency. A large-scale concurrent access simulation is done, for example 3000 users at the same time to represent a peak enrollment scenario. Such as response time, throughput, the rate of error, the use of resources, etc. are also all checked to see if the system could keep running steadily even with real-world working loads.

Through the above methods and technology framework, the study will make sure that the proposed university OA-oriented management platform can not only be fully functional, but also scalable and reliable for most universities to operate under regular conditions.

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Discussion

The theoretical framework, combining Digital Transformation, Smart Campus, DSS, and Data-Driven Governance theories, guides our analysis of OA systems and informs the interpretation of findings. This section will combine the literature review and the system design choices presented in this paper to support the central argument that university OA systems are transitioning from a digitalization-based paradigm to an intelligence-oriented paradigm. Especially on (i) why digitalization can be largely seen as mature from the architectural and functional perspective, (ii) what evaluation deficiencies still remain in the current academic research and practice, and (iii) what kind of technological and managerial forces are pushing the university OA platform forward to the next phase of evolution.

The Maturity of Digitalization: Current Status of University OA Systems

As for the result continuously drew from research and production, B/S(Browser/Server) architecture became the most common form of deploying OA system for universities, finally overturned C/S. The widespread adoption of B/S structure preference is mainly because of the centralized maintenance advantage, cross-platform advantage and less client-side deployment costs that match the diverse devices in university. And using the latest Engineering Pattern (MVC) or BackEnd using SpringBoot also represents that a pattern is that Admin Website will become Standardised and Modularized.

As well as architectural consensus, standardization of functional blocks also shows that digitization is fairly developed. Across a number of university platforms, key role-based modules centered around students, teachers and administrators have stabilized. The student-facing function emphasizes self-service (timetable inquiry, course add/drop, grade inquiry, and teaching evaluation), the teacher-facing function focuses on teaching (teaching schedules, grade entry), and the administrator-facing function focuses on governance (user management, course/class configuration, and system maintenance). This kind of standardized role‑module map gives us an indication that the basic purpose of digitalization‑to take routine processes away from offline workflows and put them on online, trackable, and re-usable workflows‑has mostly been accomplished.

When all of them are taken as a whole it looks like “Digitalization” the phase is not the major problem. Though universities can still differ in how well they do things, most of them have pretty much gone for the basic idea of having web pages, little services that can be used separately, and ways of doing work that are written down and can be seen on a screen. Therefore, the more important question becomes how to go beyond going online, rather than how to go online.

The Evaluation Gap: Limitations and Persistent Challenges

Even though digitalization is rather developed, the same can be said about the evaluation gap. Many other research take a look at university OA systems just from the perspective of technical performances, they only look into technical things like how fast it is, if it can handle many people using it at once, and that it doesn't break during the busiest times. Although the figure is necessary to guarantee the reliability of this system, it is not the most important part that contains everything we think of as the value brought about by the service quality and the

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usability experience of the user and the organization. In other words, a system might be technically sound yet still not provide any substantive enhancement in governance effectiveness, user satisfaction, or decision support.

One recurring constraint associated with this evaluation gap is the recurring data silo problem. Process digitization may still leave systems fragmented at the level of data and integration. Take academic affairs platforms for instance, it might not be able to sync up smoothly with student affairs systems, finance modules, or other departmental databases, leading to redundant data entry, inconsistent records, and delayed updates. This fracture negates the chance for an "end-to-end" administrative procedure where information flows from beginning to end among departments and parties. As a result, although there are some benefits to digitalization, the integration barriers partially negate it and cross-departmental collaboration still requires manual reconciliation.

These are all indicating that now it is no longer the online system being available that is the real issue, but the level of integration, as well as the evaluation of effectiveness, to be comprehensive. Henceforth future work must shift toward assessment systems which contain several aspects of success, such as service quality, user effect, and net institution advantages, as opposed to solely depending on performance relating to technology.

The Shift to Intelligence: Emerging Directions Beyond Digitalization

With the help of the digitization platform, universities have collected a large amount of data such as operation and academic data, so the role of OA system is no longer limited to recording and executing, but has evolved to analyzing, predicting and making decision supports. Data mining forecast analytic to be included is quite a notable new trend. Intelligent OA platform rather than storing the historical grades or attendance records but can use the multiple source behavioral data like learning activity logs, library usage pattern, attendance trend, and performance history to find the students who are at risk of dropping out, predict the dropout risk, and suggest timely interventions. This is an active assistant for the business and the student, not a passive storage center.

Another big trend is getting more in depth with mobile ecosystems and “super apps” practically anything. In lots of places, enterprise comm lines and mobile super apps (like WeChat enterprise sols, dingtalk systems, or special uni mobile portals) are turning into where most regular admin talk happens. Universities will be able to make services timelier and encourage users to take advantage by putting OA service functionality on mobile channels where universities can send users timely notifications about service availability, users can do things with fewer steps, and there can be more times when students are talking to the service and using it. And further such integration would likely also push toward an architectural evolution to a service decomposition, to API-driven interoperability, for continuous upgrading and scaling.

In sum, toward intelligence, means that the next generation of university OAs will not just be defined by whether their workflow digitization is effective but by if they can create insights from the data, enable strategy-making, and create value sustainably via data-driven governance.

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Conclusion

It reviewed the evolutionary tracks of universities' OA systems' tech foundations and rising trends, associated them to design rationales and evaluative stress of present-day university OA platforms. In accordance with the synthesized evidence, the conclusion of the current state of university OA systems is given as well as the priorities for the future development of these systems.

Summary of Findings

First, the above result implies that the university OA systems have basically finished the digitalization process. Many different institutions have transitioned core administrative operations as well as primary educational procedures from being performed offline and conducted through physical documentation to now being processed through online activities carried out through web platform support. From a technical standpoint, B/S(Browser/Server) structure has become the main way of installation, with engineering standards and modular development platforms. And that maturation is telling us it's not that it's online, a university doesn't have that problem, right? What's the hard part now is figuring out how to take your institution's value online and not just automating.

Second, it is found that the biggest problem preventing us from making more progress is data integration. OA functions can be accessed online but institutional systems tend to be developed and operated in departmental silos, creating ongoing data silos, data standards, and interoperability. The fragmentation of the process leads to a loss of end-to-end continuity, redundant manual data entry and weakens a university's ability to do systematic governance and optimization. Hence breaking the silos via unified data governance and interoperable platforms continue to be the most critical pre-requisite for the subsequent phase of OA progression.

Managerial Implications

Findings offer a number of implications for university management and system stakeholders. For university CIOs and IT decision makers, focus on data governance, integration over just more features in isolation. In other words, this is to set up unified data standards, establish API-based integration mechanisms, and promote cross-department data sharing under suitable governance rules. We can get more institutional benefits from the improved interoperability than adding some new modules, because we can create a loop process, real-time synchronization and visibility of comprehensive management through integration.

Developers and architects have to pay attention to maintainable, scaleable and secure. Microservices or services decomposition architecture can reduce coupling and allow incremental upgrades, it can also support elastic scaling under peak load. And, at the same time, as universities become more inviting targets for cyber-attacks, security must become a first-class design requirement. Implement finer granular authorizations as RBAC, improve auditing and traces, and use secure principles similar to Zero Trust so that confidential academic and personal information is safeguarded yet the platform remains more widely connectable.

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Future Outlook

Looking forward, university OA system would shift from being "digital record-keeper" to "intelligent governance enabler". In the intelligent campus vision, OA platform not only carries out and stores the administrative transaction, it can also give the forward-looking and data based service such as process bottleneck detection, risk early warning, resources allocation suggestion, personalized guidance for student and staff. Incorporate data mining, intelligent decision support capability, with mobile-first service channel in future OA ecosystem so that it can give actionable intelligence to university leaders and improve the timeliness and quality of educational administration. In the end, it all lines up with the aims of Education Informatization 2. 0, wherein combined data, intelligent services, and ongoing administration form the essence of contemporary higher education administration.

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