

Implementation of RFID and SMTP for a Web-Based Student Attendance Monitoring System at SMAS IT Alia Tangerang

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ABSTRACT

The issues of data inaccuracy, time-consuming recapitulation processes, and the use of manual attendance methods that are prone to errors at SMAS IT Alia Tangerang form the background of this research. The system developed is web-based with the integration of Radio Frequency Identification (RFID) technology to automatically record attendance and Simple Mail Transfer Protocol (SMTP) to send notifications to parents' emails. The development was carried out using the waterfall method, through the stages of analysis, design, implementation, and testing. System testing was conducted using black box testing, User Acceptance Testing (UAT), and the distribution of feedback questionnaires. Testing results showed that the system can record attendance and send notifications in real time according to the scenario. The average response time recorded was 3.74 seconds when the email field was filled and 0.45 seconds when it was empty. The system also provides a manual attendance feature for class teachers if there are device issues. Based on the questionnaire results, teachers and students provided positive feedback, stating that the system is easy to use, helps with attendance recording, and is suitable for continued use.

Keywords: attendance monitoring, attendance system, notification, RFID, SMTP.

1. INTRODUCTION

The rapid advancement of information technology has transformed data management and administrative processes across many sectors, including education, creating opportunities for schools to develop systems that improve operational efficiency and productivity, particularly in student attendance recording. Attendance recording is a fundamental administrative function: it supports discipline enforcement, reflects students' participation in the learning process, and serves as a key indicator in evaluating institutional performance. Despite these digitalization opportunities, many schools including SMAS IT Alia Tangerang continue to rely on conventional manual attendance methods using signature registers, on the grounds that such methods are simple, low-cost, and easy to implement (Alda et al., 2025; Diphan et al., 2023; Iqbal Mustofa et al., 2023; Januartika, 2023; Nuraeni et al., 2022; Parlika & Pratama, 2020; Triyatna & Ardiansyah, 2022)

However, this manual method has significant limitations, as it depends heavily on class secretaries and subject teachers for recording. This dependence increases the risk of human error, negligence, and even data manipulation, ultimately reducing the accuracy of attendance information. In addition, the recapitulation process tends to be time-consuming and requires extra verification effort, limiting the transparency and objectivity of attendance records (Kurniawati et al., 2024; Mukhtar, 2024; Panjaitan et al., 2021; Saputra et al., 2026). These limitations underscore the need to shift from manual attendance systems toward automated systems that are more accurate, efficient, and accountable.

One technology with strong potential to address this need is Radio Frequency Identification (RFID) (Adwar & Wildian, 2020; Dinofa et al., 2024). Several prior studies have examined the effectiveness of RFID for this purpose. demonstrated that RFID card scanning can achieve up to 100% success at optimal read distances of less than 4 cm and can reliably distinguish between registered and unregistered cards; however, its use remains limited to basic presence recording and is highly dependent on stable internet connectivity. (Hardiansyah & Fakhlina, 2023) RFID improves library services in information search, borrowing, return, and security , but faces technical and cost challenges; qualitative descriptive study with data from texts, journals, observations, and interviews.

These findings are reinforced by (Fardela et al., 2023) , who confirmed that RFID-based attendance systems simplify and accelerate the recording process compared with manual methods. Similarly, (Raditya, 2024) showed that RFID attendance systems can automate presence tracking and generate real-time reports, thereby improving efficiency and data accuracy. (Adwar & Wildian, 2020) further validated that integrating RFID attendance systems with web platforms allows educational institutions to manage student attendance data more effectively, covering the entire workflow from recording and storage to centralized documentation. Building on this, incorporated an SMTP client into an attendance application to address the absence of an integrated attendance-control mechanism at a training institution. This integration enabled automatic delivery of attendance information to administrators and parents. However, the study remained focused on institution-specific administrative needs, so the generalizability of its findings to formal education settings such as senior high schools warrants further investigation.

Overall, prior studies have predominantly focused on technical performance and were largely conducted in constrained trial settings such as laboratories or small-scale classroom simulations. Comprehensive studies examining the implementation dynamics of RFID-based attendance systems. Particularly the ongoing interaction among teachers, students, and parents remain relatively scarce. Addressing this research gap, the present study aims to develop an attendance management system that is not only accurate and efficient but also transparent and sustainable. Integrating RFID for automated recording with the SMTP protocol for information delivery is expected to create a coherent data flow from in class presence capture to reporting for teachers and parents thereby supporting data driven school governance.

2. METHODS

This study employs a qualitative approach with a case study design to examine the implementation of an RFID-based student attendance monitoring system equipped with automated notification features through the SMTP protocol.

2.1 Development Methodology

The process of developing and evaluating the system follows a simplified waterfall model into six main stages (Saravanos, 2025) seen in Figure 1.



Figure 6. Waterfall Model

Each stage is designed to ensure the linkage between user needs, technical quality and operational aspects in the field.

1. Identification

This stage aims to develop a comprehensive understanding of functional requirements, institutional policies, and operational challenges faced by the school. Primary data are collected through two techniques: in-depth interviews and direct observation. Interviews with the Principal explore institutional needs and policy considerations, while field observations examine the ongoing manual attendance process to identify operational barriers, involving several subject teachers and students.

2. System Design

The design phase involves developing workflow diagrams, block diagrams, and use-case diagrams (Dharwiyanti, 2003) to illustrate the system's structure and the interactions among its components. These visual models ensure clarity regarding both functional and structural aspects of the system.

3. Implementation

This phase focuses on translating the system design into actual software. Development is carried out using PHP with the CodeIgniter framework, integrated with RFID hardware for attendance data capture. Additionally, an SMTP-based notification mechanism is implemented to deliver real-time updates to parents or guardians.

4. System Testing

To verify alignment with user requirements, the system undergoes comprehensive testing through a series of scenarios using black box testing and User Acceptance Testing (UAT). Testing includes evaluating RFID reading functionality and the reliability of SMTP notification delivery. Several teachers and students participate directly by interacting with the system and completing a structured questionnaire.

5. System Deployment

Once testing confirms that the system performs as expected, it is deployed within the school environment for operational use.

6. Ongoing Maintenance

This phase includes routine inspection of RFID hardware, debugging and resolving issues that arise during use, and performing updates when necessary to ensure the system continues to meet its functional and operational objectives.

2.2 Sampling And Sampling Techniques

2.2.1 Student Sample

Student sampling was carried out using a cluster sampling approach based on grade level (grades 10, 11, and 12). The distribution of students per class is recorded in table 1 as follows:

Table 5. Student Sample

No.	Class	Student
1	Class 10 A	31
2	Class 10 B	31
3	Class 10 C	31
4	Class 10 D	31
5	Class 11 A	29
6	Class 11 B	30
7	Class 11 C	29
8	Class 12 A	29
9	Class 12 B	30
10	Class 12 C	29
Total		300

The sample allocation per cluster is calculated using the proportional allocation formula:

$$n = \frac{N \times n_c}{N_c} \quad (1)$$

Description:

- n = number of samples taken from a cluster,
- N = total student population (300 siswa),
- n_c = allocation constants set for calculation (in this design a value of 10 is used as the basis of allocation),
- N_c = the number of individuals in the cluster in question.

Based on equation (1), the sample allocation is obtained:

- Class 10 cluster: $n = \frac{300 \times 10}{124} \approx 24$ student;
- Class 11 cluster: $n = \frac{300 \times 10}{88} \approx 34$ student; dan
- Class 12 cluster: $n = \frac{300 \times 10}{88} \approx 34$ student.

Thus, the number of students who are sampled is determined according to the allocation in each cluster.

2.2.2 Teacher Sample

The clustering for the teacher population is determined based on the subjects taught. The distribution of teachers by field of study is:

Table 6. Teacher Sample

No.	Subject	Teacher
1	Religion	6
2	Indonesian	1
3	Civic Education	2
4	Social	2
5	Sains	3
6	Sports	1
7	English	1

8	Informatics	1
9	Arab Language	1
Total		18

Given that the largest concentration of teachers is in Religion subjects, the selection of teacher samples is carried out purposively in the cluster to obtain an adequate representation of the practical variations in teaching. As a result, 50% of the number of teachers in the Religion subject, as many as 3 people, was selected as a sample for testing and in-depth interviews. This selection is combined with random selection between members in the cluster to minimize selection bias while maintaining the representation of the field of study in the analysis.

2.3 Flowchart and Block Diagram

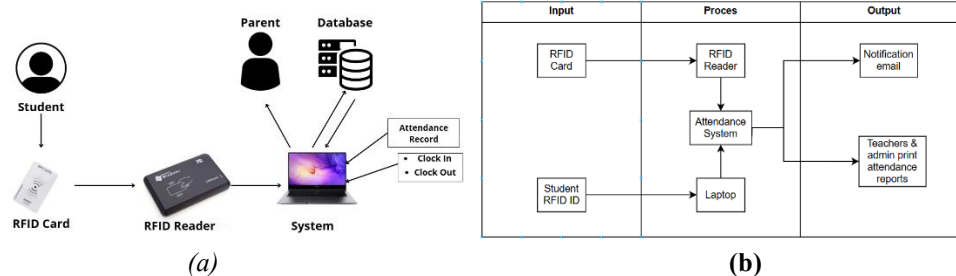


Figure 7. (a) Flowchart system (b) Block diagram

In Figures 2(a) and 2(b), the workflow of the RFID-based attendance system begins with the physical interaction between a student and an RFID card. Each card contains a unique identifier (UID) representing the student's identity within the system. When the card is tapped or brought near the RFID reader, the device captures the UID along with the event timestamp and forwards this raw data to a client application running on a computer or laptop connected to the reader. The client application receives the UID and local timestamp, constructs a structured payload, and sends an authenticated request to the server's API endpoint for further processing.

On the server side, incoming data undergo validation, including checks on UID format, the identity of the transmitting reader, and basic security policies. The server then maps the UID to the corresponding student profile in a reference table to determine the associated student_id. A time-context evaluation is performed using the school's schedule to identify the type of event (e.g., clock-in or clock-out) and determine the attendance status (on-time, late, or absent). Based on this evaluation, the server stores or updates the attendance record in the centralized database, logging key attributes such as date, entry/exit time, attendance status, reader_id, and audit information for tracking and verification.

Database operations are designed to be idempotent and resilient to connection disruptions or repeated requests. Transaction mechanisms are applied when writing to the attendance and event_logs tables to maintain data consistency. To prevent duplicate entries

caused by repeated readings of the same card, a debounce logic is implemented that enforces a minimum time interval between consecutive events from the same UID. Any new or updated attendance entry triggers the system's notification mechanism for parents or guardians, following predefined rules (e.g., notifications upon clock-in, late arrival messages, or daily summaries). Notifications are sent via an SMTP service handled by a background job queue, ensuring that message dispatch does not delay real-time API responses. The queue architecture also supports retry handling for failed deliveries, dead-letter logging for cases requiring manual intervention, and delivery-metric reporting.

2.4 Use Case Diagram

This use case diagram explains the design of the interaction flow in the web-based student attendance monitoring system at SMAS IT Alia Tangerang. The diagram shows how each actor relates to the features available in the system in Figure 3.

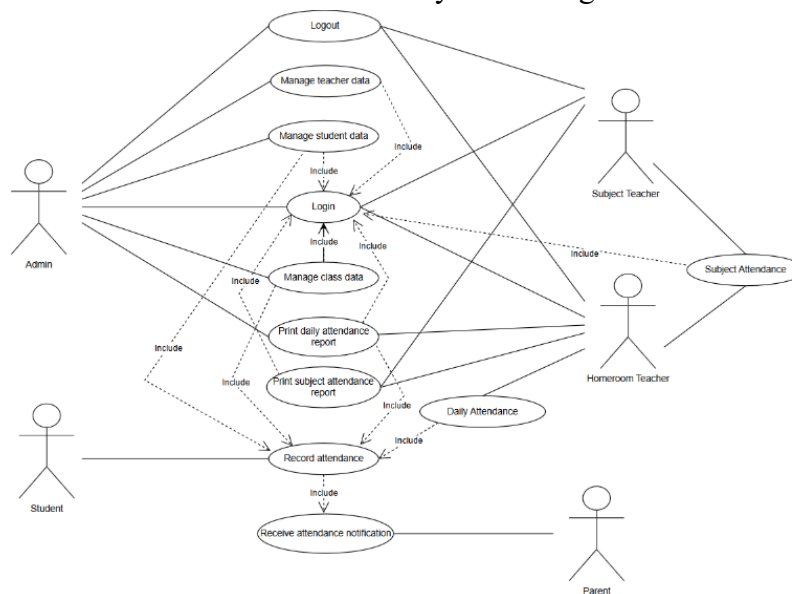


Figure 8. Usecase diagram

Overall, the diagram illustrates five primary actors within the system are the administrator, subject teachers, homeroom teachers, students, and parents or guardians. The three main system operators such as administrator, subject teacher, and homeroom teacher must log in to access features aligned with their respective authorization levels. The administrator holds the broadest privileges, including managing teacher and student data, configuring class information, and generating both daily and subject-specific attendance reports. The homeroom teacher is responsible for recording and managing students' daily attendance and can also produce reports based on these records. Subject teachers handle attendance for the subjects they teach and are likewise able to generate attendance reports specific to their classes. On the end-user side, students perform attendance by scanning their RFID cards. The captured data is processed automatically, after which the system sends email notifications to parents or

guardians. This mechanism enables parents to monitor their child's attendance in real time with accurate and up-to-date information.

3. RESULTS AND DISCUSSIONS

The attendance system built in this research takes the form of a web-based application intended to help teachers record student attendance digitally. On the technical side, the software was developed using the CodeIgniter framework paired with a MySQL database, allowing attendance data to be stored and managed in a centralized, well-organized manner. Because the application is responsive, it can be accessed from a range of internet-connected devices to giving teachers the flexibility to record and monitor attendance whenever needed. To confirm that the system functions as intended, testing was carried out using the black box method , (Ramadan et al., 2025) an approach that examines the output produced by different input combinations rather than inspecting the underlying code. Every module and feature was tested against scenarios reflecting real-world usage, with the goal of confirming that each function operates according to its specifications and meets the practical needs of its users.

3.1 System Testing Through Black Box Scenarios

Testing followed the black box method and covered the system's login mechanism along with student data management functions. Each scenario was run to confirm that the system handled data correctly, stored it accurately, and carried out changes or deletions exactly as instructed.

Table 7. Black Box Testing Results

No	Test Scenario	Expected Outcome	Result
1	Logging in with a correct username and password	System verifies credentials and login succeeds	Pass
2	Logging in with an incorrect username	System shows an error and login fails	Pass
3	Adding new student data with complete details (name, NIS, etc.)	New student record is saved successfully	Pass
4	Editing existing student data	Student record is updated and saved	Pass
5	Deleting student data	Student record is removed from the system	Pass
6	Adding new teacher data with complete details (name, NIP, subject, etc.)	New teacher record is saved successfully	Pass
7	Editing existing teacher data	Teacher record is updated and saved	Pass
8	Deleting teacher data	Teacher record is removed from the system	Pass

No	Test Scenario	Expected Outcome	Result
9	Adding new class data with complete details (class name, homeroom teacher, etc.)	New class record is saved successfully	Pass
10	Editing existing class data	Class record is updated and saved	Pass
11	Deleting class data	Class record is removed from the system	Pass
12	Printing standard attendance reports in Excel format	Report is generated successfully in Excel	Pass
13	Teacher edits existing subject-attendance data	Data is updated and saved	Pass

Table 3 shows the results of testing the system's core data-management functions, covering login, the handling of student, teacher, and class records, and the generation of attendance reports. Each scenario produced the expected outcome, confirming that the system reliably processes, stores, updates, and deletes data, and that it can export reports in Excel format. Together, these results indicate the system is functioning properly and is ready to support student attendance monitoring at the school.

3.2 RFID-Based Attendance Testing

This round of testing assessed how quickly the RFID reader detected cards and how accurately the system recorded attendance status, as well as how well it handled data in real time. Scenarios included excused-absence cases (such as "sick" or "permitted leave") alongside standard tap-in and tap-out procedures. The system's time-based logic operates as follows:

- Clock-in: the official start time is 07:00 WIB; students tapping in before this are marked "Present."
- Grace period: a 15-minute window from 07:00 to 07:15 WIB applies; tapping in during this period results in a "Late" status.
- Absence: tapping in after 07:15 WIB automatically results in an "Absent" (Alpa) status, requiring the student to consult the teacher on duty to correct it.
- Blocking time: 15 minutes after the grace period ends (07:30 WIB), a blocking window activates; a second tap-in by an already-checked-in student during this window is instead registered as a check-out.
- Clock-out: the standard departure time is 14:00 WIB; tapping out earlier is likewise recorded as leaving.

Table 8. RFID Testing Scenarios

No	Test Scenario	Expected Outcome	Result
1	Student taps RFID card on reader	Reader successfully captures card UID	Pass

No	Test Scenario	Expected Outcome	Result
2	Determine maximum read distance	Reader reads card up to 7 cm	Pass
3	Card presented beyond 7 cm	Reader fails to capture UID	Pass
4	Measure scan-to-system response time	UID transmitted in under 5 seconds	Pass
5	Real-time processing and display after scan	System processes and displays attendance instantly	Pass
6	Tap-in before clock-in time	Status recorded as Present	Pass
7	Two tap-ins before clock-in time	Only first event stored; status Present	Pass
8	Pre-marked Sick, then tap-in before clock-in	Status remains Sick	Pass
9	Pre-marked Excused, then tap-in before clock-in	Status remains Excused	Pass
10	Second tap-in before grace period ends	Only first tap retained; status Present	Pass
11	Tap-in within grace period, pre-marked Sick	Status remains Sick	Pass
12	Tap-in within grace period, pre-marked Excused	Status remains Excused	Pass
13	Tap-in within grace period, no prior status	Status recorded as Late	Pass
14	Additional tap after Late status set	Status remains Late	Pass
15	Tap-out 15 minutes after grace period	Status recorded as Checked out	Pass
16	Tap-out 15 minutes before scheduled clock-out	Status recorded as Checked out	Pass
17	Tap-out after scheduled clock-out	Status recorded as Checked out	Pass

Across all seventeen scenarios in Table 4, the system performed exactly as expected, correctly handling RFID reading, status assignment, and the various special-case rules governing attendance.

3.3 SMTP Testing

Email notifications are generated automatically. The system pulls its SMTP configuration directly from the CodeIgniter configuration file. Once a student checks in, the system retrieves the relevant attendance data and builds the email content, including the student's name, class, and check-in time, then addresses it to the parent or guardian. The process

proceeds as follows: a connection to the SMTP server is opened, credentials are submitted for authentication, the email is sent once verification succeeds, delivery status is logged as confirmation, and the connection is closed automatically. To test the reliability of this feature, several delivery scenarios were simulated under different network conditions using browser-based network throttling tools.

Table 9. SMTP Delivery Test Result

No	Test Scenario	Expected Outcome	Result
1	Send attendance email to parent/guardian	Email delivered to inbox	Pass
2	System sends 184 emails	All 184 emails sent successfully	Pass
3	Send email in predefined format	Email received with correct content	Pass
4	Send email to invalid address	Email not delivered	Pass
5	Delivery on stable Wi-Fi	Email delivered	Pass
6	Delivery on weak Wi-Fi	Email delivered	Pass
7	Delivery on stable mobile data	Email delivered	Pass
8	Delivery on weak mobile data	Email delivered with delay	Pass
9	Delivery with no connectivity	Email not delivered	Pass

3.4 Analysis of RFID and SMTP Results

Testing went beyond ideal-case scenarios to also identify possible points of failure and the corresponding safeguards. Table 6 summarizes the conditions under which each feature succeeds or fails, along with the mitigation in place.

Table 10. RFID and SMTP Failure Analysis

No	Feature	Status	Condition	Solution
1	RFID attendance	Pass	Valid card, appropriate reading distance	
2	RFID attendance	Fail	Distance too far (>7 cm), damaged/unregistered card, disconnected reader	Prompt user to move card closer; homeroom teacher can record manually; routine hardware/card checks
3	SMTP notification	Pass	Stable connection, valid parent email on file	
4	SMTP notification	Fail	No connection, missing/invalid parent email	Check connection; verify parent email data

The RFID feature works reliably when a registered card is tapped within the effective range (under 7 cm). Failures arise mainly from excessive distance, a damaged or unregistered card, or a disconnected reader. To address this, the interface prompts users to move closer, homeroom teachers can fall back to manual entry, and routine hardware and card checks are recommended as a preventive measure. Similarly, the SMTP notification feature performs reliably given a stable connection and a correctly filled parent/guardian email field, while failures stem from connectivity loss or missing/invalid email data addressed through connection checks and periodic verification of stored contact information by the administrator or homeroom teacher.

3.5 RFID and SMTP Response Time Testing

A further round of testing examined read success and end-to-end response time as a function of (i) whether the parent email field was populated and (ii) the tap distance, running ten trials across distances from 10 cm down to 6 cm (two repetitions each).

Table 11. RFID Reading and SMTP Delivery Success Rates

Distance (cm)	Trial	Response Time (sec)	Email Field	RFID Read	Email Sent	Result
10	1	10	Filled	Not Read	Not Sent	Pass
10	2	10	Not Filled	Not Read	Not Sent	Pass
9	1	10	Filled	Not Read	Not Sent	Pass
9	2	10	Not Filled	Not Read	Not Sent	Pass
8	1	10	Filled	Not Read	Not Sent	Pass
8	2	10	Not Filled	Not Read	Not Sent	Pass
7	1	3.92	Filled	Read	Sent	Pass
7	2	0.86	Not Filled	Read	Not Sent	Pass
6	1	3.86	Filled	Read	Sent	Pass
6	2	0.33	Not Filled	Read	Not Sent	Pass

Applying the success-rate formula ($\text{Number of successes} \div \text{Number of trials} \times 100\%$) to these results yields a 100% pass rate across all ten trials. Confirming that the system reads cards correctly and triggers automatic email notifications whenever the operating conditions (proper reading distance and a valid, populated email field) are met.

3.6 Comparison Manual System and RFID

The proposed system was benchmarked against the previous manual process across several operational dimensions, summarized in Table 8.

Table 12. Manual Attendance vs. RFID & SMTP Attendance

Criteria	Manual System	RFID & SMTP
Recording Method	Handwritten logbook	RFID card tap
Process Time	3–5 minutes (whole class)	Under 4 seconds per student
Data Accuracy	Prone to human error/manipulation	Automated, highly accurate
Data Reporting	Manual, slow	Automated, real-time
Parent Notification	None / manual (e.g., letter)	Automatic via email
Tools Used	Paper, pen, books	RFID card and reader
Documentation & Archiving	Physical, prone to damage/loss	Digital, secure
Reliability	Depends on teacher, inconsistent	Automated, consistent
Notification Speed	Not applicable	Under 4 seconds

These results indicate that the developed system clearly outperforms the manual method in terms of speed, accuracy, instant parental notification, and streamlined reporting. Contributing both to the digitalization of school administration and to greater transparency in attendance monitoring.

4. CONCLUSION

This research resulted in the successful design and implementation of an integrated web-based attendance system at SMAS IT Alia Tangerang, effectively addressing the long-standing inefficiencies of manual attendance recording by combining RFID and SMTP technologies. The system automates daily presence logging through RFID card taps, achieving 100% accuracy when scanned within the optimal range ≤ 7 cm, while concurrently sending real-time email notifications to parents via a reliable SMTP protocol. Thorough testing demonstrated strong operational performance: attendance data was processed in an average of 0.45 seconds without email notification and 3.74 seconds when email delivery was included, with all 13 black box test scenarios and 17 RFID/SMTP functional test cases completed successfully. Beyond its technical achievements, the system also bridges administrative and removing dependence on error manual paperwork, cutting per-class recording time from 3–5 minutes down to under 4 seconds per student, and introducing a level of transparency previously unavailable through instant parental notifications.

Stakeholder feedback further reinforces the system's practical benefits. All teachers reported encountering no usability obstacles, with 80% describing the system as "highly suitable" for daily operations and all respondents supporting its continued institutional use.

Students likewise responded positively, with 93.8% rating the RFID-based process as "very easy," citing its speed and consistency as key strengths. In its broader significance, this implementation reframes attendance management as more than a technical upgrade. It becomes a driver of collaborative educational governance. By directly linking classroom activity with parental awareness, the system encourages shared responsibility for student punctuality while reducing the administrative workload placed on teachers. Planned future developments, including offline mobile access, biometric backup options, and dedicated parent portals, are expected to strengthen the system's potential as a scalable model for schools undergoing digital transformation. This case study ultimately illustrates that when technology is designed with both usability and technical accuracy in mind, it moves beyond mere operational efficiency to become a genuine instrument of pedagogical trust and institutional integrity.

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