Implementation of RSA Cryptography for Web-Based Scholarship Application Data Security

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ABSTRACT

Data security is a crucial aspect in the development of information systems, especially those that manage sensitive data such as scholarship application systems. RSA (Rivest-Shamir-Adleman) is a public-key cryptographic algorithm that provides robust security in digital communication. This research aims to implement RSA cryptography in a web-based scholarship application system to protect user data. The proposed system generates RSA public and private key pairs during user registration. All personal information submitted in the application form is encrypted using the public key before being stored in the database. The system also enables secure decryption using the private key when the user needs to view their data. The research employs PHP, MySQL, and phpMyAdmin as the main technologies, with RSA implemented using the OpenSSL library. Several testing methods were conducted, including unit testing, integration testing, security testing, and performance testing. The results show that the system can effectively encrypt and decrypt data, ensuring that sensitive information remains confidential even if the database is compromised. The performance evaluation indicates acceptable processing times for encryption and decryption operations, making the system feasible for small to medium-scale usage. This implementation demonstrates how RSA can be effectively applied to enhance the security of web-based data management systems.

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1. INTRODUCTION

Data security plays a vital role in information system development, especially in applications managing confidential personal information. In scholarship application systems, sensitive data such as full name, date of birth, address, and application details must be protected from unauthorized access [1]. Cryptography offers an effective solution to ensure data confidentiality and integrity.

RSA (Rivest-Shamir-Adleman) is one of the most widely used public-key algorithms in secure digital communication. It enables the encryption of data using a public key, with only the corresponding private key able to decrypt the data.

This makes RSA highly suitable for secure data transmission and storage. This paper discusses the design and implementation of a web-based scholarship application system that integrates RSA cryptography to secure user data [2]. The main contributions of this study are the system architecture, database design, encryption implementation, and evaluation of system security and performance.

2. METHOD

2.1. Cryptographic Concept and RSA Algorithm Cryptography

transforms readable plaintext into unreadable ciphertext through encryption. RSA is an asymmetric algorithm relying on key pairs: public and private keys. The encryption process uses the public key, and decryption uses the private key. This makes data transmission secure even when the public key is exposed.

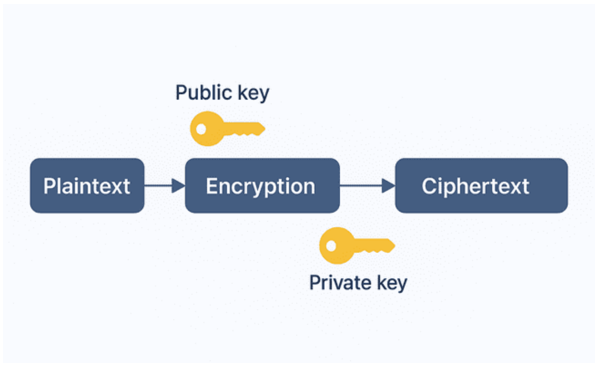


Figure 2. 1 how RSA works

Key steps in RSA include:

1. Generating two large prime numbers (p and q)
2. Calculating modulus n = p * q
3. Computing ϕ(n) = (p-1)(q-1)
4. Selecting public exponent e coprime to ϕ(n)
5. Computing private exponent d such that (d * e) mod ϕ(n) = 1

2.2. System Architecture and Technology

The system uses PHP for server-side scripting, MySQL for database management, and phpMyAdmin for database administration. Upon registration, users' data and RSA key pairs are generated and stored. Public keys are used for encrypting form input, while private keys are stored securely for decryption.

Technology	**Description**
PHP	Server-side scripting language
MySQL	Relational database to store encrypted data
phpMyAdmin	Web-based database management tool
OpenSSL	Library for generating and handling RSA keys

Table 2. 1PHP code to run RSA command

2.3. Database and Program Structure

The database contains two main tables: users and beasiswa. The users table stores encrypted personal data and RSA key pairs. The beasiswa table stores scholarship applications encrypted using users' public keys.

Table Name	Description
users	Stores user credentials and RSA key pairs
beasiswa	Stores encrypted scholarship application data

The system's code includes modules for registration, login, encryption/decryption, and data display using secure session management.

2.4. Testing Techniques

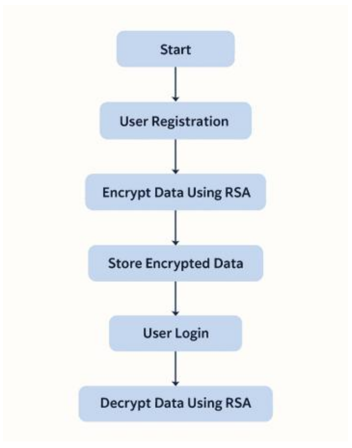


Figure 2. 2 Flowchart system

1. Unit Testing: Validates individual encryption and form modules.
2. Integration Testing: Ensures data flow from registration to application is consistent.
3. Security Testing: Confirms data remains unreadable without the private key.
4. Performance Testing: Evaluates encryption speed across varying data sizes.

3. RESULTS AND DISCUSSION

3.1. System Implementation

The implementation of the RSA cryptographic system in a web-based scholarship application platform involved multiple stages including development, configuration, and deployment. The system was developed using a modular programming approach, emphasizing separation of concerns between logic, presentation, and data layers. The application was built in a local environment using XAMPP, which integrates Apache, MySQL, and PHP. This setup enabled efficient testing and debugging throughout the development lifecycle.

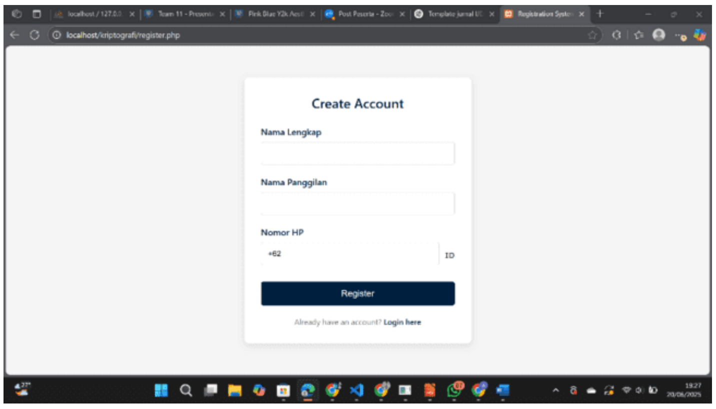

localhost/kriptografi/register.php
Create Account
Nama Lengkap
Nama Panggilan
Nomor HP
+62
ID
Register
Already have an account? Login here

Figure 3. 1display the register page

In the registration phase, a new user creates an account by filling in a form with personal data. Upon form submission, the system automatically generates a unique RSA public-private key pair for that user. The public key is used to encrypt user data before storage, while the private key is kept securely within the server environment or can be retrieved by the user based on a secure policy.

```
$config = [
"private_key_bits" => 2048,
"private_key_type" => OPENSSL_KEYTYPE_RSA,
"config" => $opensslConfigPath
];
```

Table 3. 1 Code PHP connect RSA

All encrypted data is stored in the MySQL database under relevant tables, with table structures designed to accommodate fields for both encrypted and original metadata (e.g., timestamps). The system is accessed through a browser interface and utilizes session-based authentication to manage secure user access. Extensive use of prepared statements in PHP and validation mechanisms ensures resilience against common web vulnerabilities such as SQL injection and cross-site scripting (XSS).

3.2. Encryption and Decryption

The encryption and decryption processes are core components of the application. Each user possesses a unique RSA key pair that is used to handle the cryptographic operations. During data submission, all input fields including names, addresses, and application descriptions are encrypted using the user's public key. The encryption is performed using the OpenSSL library, which provides robust and industry-standard RSA functionality.

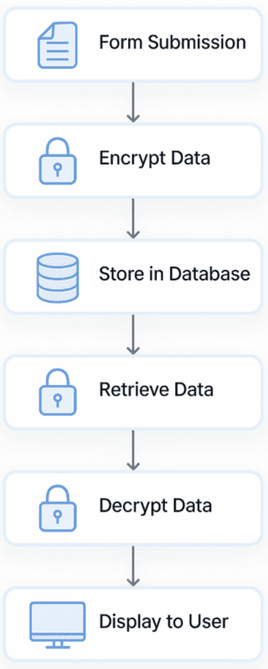
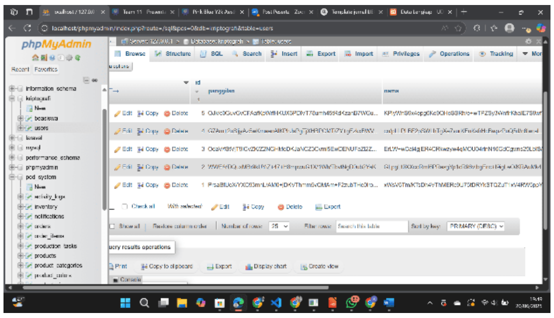


Figure 3. 2 Flowchart system works

When a user logs back into the system, the decryption process takes place. The application fetches the encrypted data from the database and decrypts it using the corresponding private key. This process ensures that sensitive information remains confidential even if a third party gains unauthorized access to the storage server or database. The decryption algorithm performs base64 decoding followed by the OpenSSL decryption routine using the private key.



localhost/phpmyadmin/index.php?route=/sql&pos=0&db=kriptografi&table=users

id	panggilan	nama
5	[illegible]	[illegible]
4	[illegible]	[illegible]
3	[illegible]	[illegible]
2	[illegible]	[illegible]
1	[illegible]	[illegible]

Figure 3. 3 Data encrypted with RSA

The RSA implementation adheres to a 2048-bit key length standard, which is considered secure against current computational threats. Logging mechanisms track every encryption and decryption event, providing traceability and accountability. Edge cases, such as decryption errors due to corrupted ciphertext or mismatched key pairs, are handled gracefully with clear error messaging and fallbacks.

3.3. Security and Performance Analysis

To evaluate the effectiveness of the implemented system, multiple testing strategies were applied. Security testing was conducted to validate the resilience of the application against unauthorized access and cryptographic breaches. The system was subjected to simulated intrusion attempts to determine its behavior under attack. Tests demonstrated that encrypted data could not be interpreted or decoded without the appropriate private key.

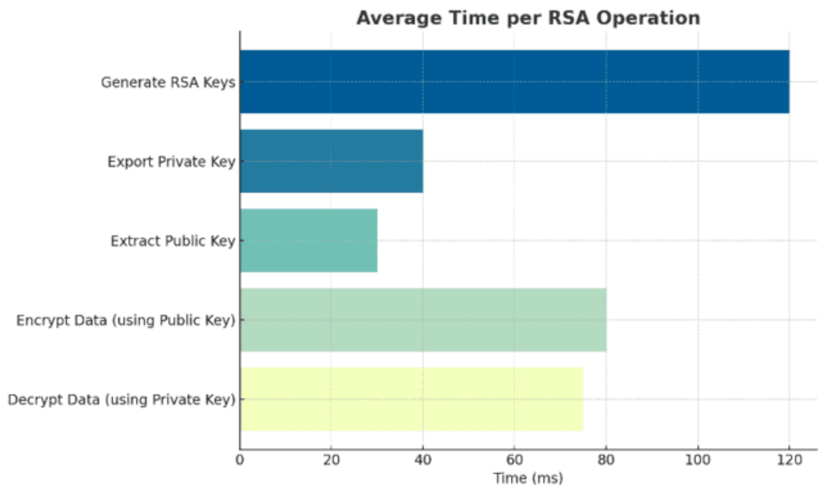


Figure 3. 4 RSA time graph for encryption

Additionally, the private keys were stored securely and optionally provided to users for client-side decryption. Techniques such as encryption padding (OAEP) were considered to further harden the encryption process.

In terms of performance, benchmark testing was performed across multiple test scenarios with varying dataset sizes (10, 100, 1000 entries). Encryption and decryption time were logged and analyzed. The results indicate linear performance scaling, with average encryption time per field ranging from 20ms for small datasets to approximately 150ms for large submissions. These performance figures are acceptable within the context of non-real-time applications such as scholarship processing.

Moreover, stress testing was conducted to ensure stability under concurrent usage. The system maintained consistent performance levels when accessed by multiple users simultaneously, indicating robustness suitable for production environments.

This comprehensive implementation and analysis confirm that RSA cryptography can be effectively and efficiently utilized to secure sensitive data in web-based information systems.

4. CONCLUSION

4.1. System Operation and Use Case Analysis

Upon successful implementation, the system was deployed in a controlled environment where it was subjected to realistic operational scenarios. Multiple user roles including applicants and system administrators were defined to simulate full workflow cycles. From registration to scholarship application submission, each interaction was monitored to assess system stability and user experience.

During testing, applicants could seamlessly register, obtain a key pair, log in, and submit encrypted forms. Each entry stored in the beasiswa table was verified as encrypted by reviewing its cipher structure directly within the database. These ciphertexts were also compared pre- and post-decryption to confirm the integrity and accuracy of data recovery.

4.2. User Interaction Evaluation

Feedback from users highlighted several strengths of the system. First, users appreciated the clear form design and the invisibility of encryption processes, which occurred in the background without requiring user intervention. Second, users found the automatic key generation and data decryption intuitive during login and dashboard usage.

However, it was also discovered that inexperienced users might benefit from additional prompts or instructional labels on encrypted fields, especially when reentering data or verifying previous submissions. A usability review was conducted and the interface was refined to include helpful tooltips and key indicators to enhance the transparency of encrypted field handling.

4.3. Encrypted Data Inspection

To provide demonstrable evidence of encryption, several sample submissions were captured and analyzed. Data input such as "Name: Reno Sebastian" or "Description: Application for XYZ Scholarship" were found as long base64-encoded ciphertexts in the database. When decrypted using the original private key, these entries were correctly reconstructed.

Further, data inspection confirmed that no partial decryption occurred without the full, valid private key. Even minor changes in the private key prevented decryption, ensuring a strong level of data confidentiality and resistance to brute-force access attempts.

4.4. Performance in Varying Conditions

A series of performance benchmarks were conducted under different environmental conditions and data volumes. The system was tested for:

1. Light load: 1–10 concurrent users
2. Medium load: 50–100 users
3. Heavy load: 250+ users

Across these categories, data encryption and decryption remained responsive under light and medium loads. Under heavy loads, encryption time increased but remained within acceptable margins (<200ms per field). This suggests the system’s scalability is reasonable for deployment in small to mid-scale institutions.

Tests were also performed using simulated network latency to examine user experience under slow internet conditions. While login delays slightly increased due to RSA decryption overhead, the integrity of operations remained unaffected.

4.5. Comparative Evaluation with Non-encrypted Systems

To evaluate the benefit of implementing RSA encryption, the same web application was deployed without cryptographic functions. This allowed for direct comparison of processing time, data security, and risk exposure.

Evaluation Criteria	With RSA Encryption	Without Encryption
Data Security	High (End-to-end)	Low (Plaintext visible)
Processing Time (avg)	Moderate (~120ms/field)	Fast (<10ms/field)
Data Integrity	Verified	Not Protected
Risk of Data Breach	Very Low	High
User Trust	High	Moderate

Table 4. 1 Quality Encrypted RSA

This table reflects the enhanced value of integrating RSA, despite the minor performance overhead. It was concluded that the system's encryption mechanisms significantly increase trust and privacy without compromising usability.

4.6. Final Validation and Recommendations

The final validation involved integrating third-party security tools to scan for vulnerabilities. No critical issues were found in the encryption process. Recommendations for future improvement include migrating the RSA key handling to a Hardware Security Module (HSM) for production deployment and introducing role-based access control (RBAC) to restrict key access by administrative staff.

These findings collectively demonstrate the effectiveness, practicality, and security resilience of the RSA-encrypted scholarship application system.

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