NTRU-ENCRYPTED PAYMENT GATEWAYS FOR QUANTUM-RESISTANT SECURITY

A PROJECT REPORT

Submitted by

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PANIMALAR ENGINEERING COLLEGE

(An Autonomous Institution, Affiliated to Anna University, Chennai)

BONAFIDE CERTIFICATE

Certified that this project report **" NTRU-ENCRYPTED PAYMENT GATEWAY FOR QUANTOM-RESISTANT SECURITY"** is the bonafide work of "**JAYA ANANDA BALAJI K, SAI CHARAN R, VIGNESHWARAN P K"** who carried out the project work under my supervision.

Signature of the HOD with date	**Signature of the Supervisor with date**
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INTERNAL EXAMINER	**EXTERNAL EXAMINER**

DECLARATION BY THE STUDENT

We Jaya Ananda Balaji K (211420104107), Sai Charan R (211420104234) and Vigneshwaran P K (211420104303) hereby declare that this project report titled “NTRU-Encrypted Payment Gateways for Quantum-Resistant Security”, under the guidance of Elangovan ME., is the original work done by us and we have not plagiarized or submitted to any other degree in any university by us.

Name of the student(S)

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NAME OF THE STUDENT(S

ABSTRACT

In the realm of digital commerce, the proliferation of online transactions has undeniably revolutionized the way financial activities are conducted. However, amidst the convenience and efficiency offered by electronic payment systems, the persistent threat of cyberattacks looms large, particularly with the advent of quantum computing. The "NTRU-Encrypted Payment Gateways for Quantum-Resistant Security" project emerges as a beacon of hope in this landscape, aiming to fortify the security of online transactions against quantum threats.

The implementation of NTRU-encrypted payment gateways represents a paradigm shift in cybersecurity, offering a quantum-resistant solution to safeguard sensitive financial data exchanged in online transactions. Through meticulous planning and rigorous testing, the project endeavors to ensure the integrity, confidentiality and authenticity of payment transactions conducted over digital channels. By employing advanced cryptographic techniques including key generation, encryption and decryption processes, the project aims to create a secure infrastructure that instills trust and confidence among users and stakeholders alike.

Furthermore, the project emphasizes the importance of compliance with industry standards and regulations governing online payment systems, ensuring adherence to best practices in cybersecurity. In essence, the "Shielding Online Transactions" project represents a pivotal step towards fortifying the security of online payment systems in the face of evolving cyber threats. By leveraging NTRU encryption technology and adhering to stringent security protocols, the project endeavors to establish a quantum-resistant framework that upholds the principles of confidentiality, integrity, and availability in digital transactions. Through collaborative efforts between industry stakeholders, cybersecurity experts and cryptographic researchers, this project aims to usher in a new era of trust and resilience in the realm of digital commerce ensuring that online transactions remain secure and resilient against emerging threats.

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HLIST OF ABBRIVIATION

FIGURE NO.	ABBREVIATION	DEFINITION
1.	NTRU	N-Th degree Truncated Polynomial Ring Unit
2.	AES	Advanced Encryption Standard
3.	RSA	Rivest-Shamir-Adleman
4.	ECC	Elliptic Curve Cryptography
5.	IVR	Interactive Voice Response
6.	CSP	Cloud Service Provider
7.	API	Application Programming Interface
8.	SQL	Structured Query Language
9.	TLS	Transport Layer Security
10.	HTTPS	Hypertext Transfer Protocol Secure

CHAPTER 1
INTRODUCTION

1.1 PROBLEM DEFINITION

With the pervasive use of online transactions, security concerns have become increasingly paramount, particularly in the face of emerging quantum computing threats. Traditional encryption methods, while effective against classical attacks are vulnerable to the exponentially enhanced computational power of quantum computers. As quantum computing capabilities continue to advance, the risk of cryptographic breaches poses a significant challenge to the security of online payment gateways. This presents a critical dilemma for stakeholders in the digital payment ecosystem, as existing encryption protocols may soon become obsolete in the quantum era. Moreover, the potential ramifications of compromised payment gateways extend beyond financial losses to encompass broader implications for user privacy and trust in online transactions. Recognizing the urgency of this issue, our project endeavors to develop a quantum-resistant payment gateway solution fortified with NTRU encryption technology. By leveraging NTRU encryption which offers robust resistance to quantum attacks, the aim of project is to shield online transactions from the looming threat posed by quantum adversaries. This proactive approach seeks to safeguard the integrity and confidentiality of digital payments ensuring the resilience of payment gateways in the quantum computing era.

1.2 NTRU ENCRYPTION MODULE

The NTRU encryption module employs advanced cryptographic techniques to safeguard online transactions against potential security threats, particularly those posed by quantum computing advancements. It establishes a secure communication channel between users and payment gateways by encrypting sensitive data using the NTRU algorithm. This module ensures confidentiality and integrity throughout the transaction process, as it encrypts data with NTRU encryption keys and decrypts it only with the corresponding private keys. Much like IVR systems interact with users via voice calls, the NTRU encryption module enables computers to communicate securely with users through encryption and decryption processes. Its primary purpose is to protect financial transactions by leveraging the NTRU algorithm's resistance to quantum attacks, thereby mitigating the risk of unauthorized access or tampering with sensitive financial data. Operating seamlessly without human intervention, the module responds to incoming data requests by encrypting information using NTRU encryption keys, providing a secure transmission channel for online transactions.

1.3 AUTHENTICATION MODULE

The authentication module is a pivotal element of the our project, tasked with verifying the identity of users engaging in online transactions. It employs sophisticated algorithms and protocols to authenticate user credentials securely, ensuring that only authorized individuals gain access to sensitive transactional data and services. This module utilizes various authentication factors including passwords, biometric data and cryptographic keys to validate the identity of users effectively. By implementing multi-factor authentication techniques such as two-factor authentication (2FA) or biometric authentication, the system enhances security and mitigates the risk of unauthorized access or fraudulent activities. Additionally, the authentication module incorporates robust encryption mechanisms to safeguard user credentials during the authentication process thereby fortifying the overall security posture of the payment gateway. Through seamless integration with existing authentication frameworks and standards such as OAuth or OpenID Connect, this module facilitates interoperability and ensures compatibility with a wide range of online platforms and services. Overall, the authentication module plays a crucial role in bolstering the security of online transactions providing users with confidence in the integrity and confidentiality of their financial interactions.

1.4 TRANSACTION PROCESSING MODULE

The transaction processing module plays a pivotal role in the seamless execution of online transactions within the proposed system. It serves as the backbone for facilitating secure and efficient payment processing while ensuring the integrity and confidentiality of sensitive financial data. This module encompasses various functionalities including transaction initiation, authorization, validation and settlement. Upon receiving a transaction request from the user, the module initiates the necessary steps to authenticate the transaction and verify its validity. This involves validating the user's credentials, verifying the availability of funds and ensuring compliance with regulatory requirements. Once the transaction is authenticated and authorized, it proceeds to the settlement phase, where the appropriate funds are transferred between the relevant parties. Throughout this process, robust encryption mechanisms are employed to safeguard the confidentiality of transaction details and protect against potential security threats including quantum attacks. Additionally, the module incorporates error handling and logging functionalities to ensure accountability and traceability in the event of transaction discrepancies or failures. By leveraging advanced encryption techniques and robust transaction processing protocols, this module reinforces the security and reliability of online transactions thereby instilling confidence among users and stakeholders in the system's integrity and resilience.

1.5 MONITORING AND ALERTING MODULE

Monitoring and alerting play a pivotal role in ensuring the robustness and security of online transactions within the proposed payment gateway system. This module is designed to continuously monitor various transaction parameters, system logs and network activities in real-time. It employs sophisticated algorithms and rule-based engines to detect anomalies, suspicious activities or potential security breaches proactively. Upon identifying any irregularities or security threats, the module triggers immediate alerts and notifications to designated stakeholders via multiple channels including email, SMS and in-app notifications. Additionally, it maintains comprehensive transaction logs and audit trails facilitating post- transaction analysis, forensic investigations and compliance reporting. Leveraging advanced data visualization techniques, the module provides intuitive dashboards and reports, enabling stakeholders to monitor transaction trends, system performance and security posture effectively. Furthermore, the module integrates with external threat intelligence feeds and security information and event management (SIEM) systems to enhance its detection capabilities and response agility. With its robust monitoring and alerting capabilities, this module ensures timely detection and mitigation of potential security threats thereby safeguarding online transactions and maintaining the integrity and trustworthiness of the payment gateway system.

1.6 PURPOSE OF THE PROJECT

The purpose of the "Shielding Online Transactions: NTRU-Encrypted Payment Gateways for Quantum-Resistant Security" project is to develop a robust payment gateway system that integrates NTRU encryption technology to enhance security and protect online transactions against quantum attacks. This project aims to address the emerging threat landscape posed by quantum computing advancements by implementing encryption algorithms that are resistant to quantum attacks. By leveraging NTRU encryption, the system will ensure the confidentiality, integrity and authenticity of sensitive transactional data thereby mitigating the risk of unauthorized access and data breaches. Furthermore, the project seeks to provide a seamless and secure online transaction experience for users, instilling trust and confidence in the payment gateway system. The proposed system will empower businesses and consumers to conduct online transactions with peace of mind, knowing that their financial information is safeguarded against evolving cyber threats. Additionally, the project aims to contribute to the advancement of quantum-resistant encryption technologies and promote their adoption in the field of online payment security. Through this project, the digital infrastructure is fortified and secure online transactions promoted in the face of emerging cybersecurity challenges posed by quantum computing advancements.

1.7 MOTIVATION

The motivation behind the "Shielding Online Transactions: NTRU-Encrypted Payment Gateways for Quantum-Resistant Security" project stems from the pressing need to address the security vulnerabilities inherent in traditional online payment systems particularly in light of the increasing threat posed by quantum computing advancements. With an estimated 285 million visually impaired individuals worldwide, there is a clear necessity for accessible and secure communication systems tailored to their needs. The existing online payment systems often rely heavily on mouse click events and keyboard inputs posing significant challenges for visually impaired users. By developing a robust payment gateway system incorporating NTRU encryption technology, this project aims to provide a secure and user-friendly solution that caters to the diverse needs of online consumers including those with visual impairments.

Prior research has primarily focused on screen reader-based technologies for facilitating user interactions. But these systems still present usability challenges and may not fully address the needs of visually impaired individuals. By leveraging IVR technology and eliminating the dependence on traditional input devices such as keyboards and mice, this project seeks to enhance accessibility and usability for visually impaired users. Moreover, by integrating advanced features such as voice-based operations and search functionalities, the proposed system aims to streamline the online transaction process and empower users to navigate the digital landscape with confidence.

In summary, the motivation behind this project lies in its potential to revolutionize online payment security and accessibility for visually impaired individuals, ultimately fostering inclusivity and empowerment in the digital realm. By leveraging cutting-edge encryption technologies and user-centric design principles, this project aims to pave the way for a more secure and inclusive online transaction experience for all users, regardless of their abilities or technological proficiency.

CHAPTER 2

LITERATURE SURVEY

[1] **Li, Q., Wang, Y., & Liu, J. (2020)**, proposed a paper in which a mobile payment scheme is designed to withstand potential quantum attacks. It utilizes the NTRUEncrypt cryptosystem, known for its resistance to quantum algorithms to secure transactions. The scheme involves a third-party entity to facilitate secure communication between users and merchants, ensuring confidentiality and integrity during transactions. By leveraging NTRU encryption, the system provides a robust defense against quantum computing threats enhancing the security of mobile payment platforms in anticipation of future advancements in quantum technology.

“A THIRD-PARTY MOBILE PAYMENT SCHEME BASED ON NTRU AGAINST QUANTUM ATTACKS”

Advantages - The paper presents a robust third-party mobile payment scheme based on NTRU, offering heightened security against quantum attacks. It provides efficient facilitation for secure transactions ensuring resilience against emerging cryptographic threats in mobile payment systems.

Disadvantages - While promising, implementing the proposed scheme may introduce complexities, requiring careful integration into existing mobile payment infrastructures. Additionally, its effectiveness hinges on widespread adoption which may take time to achieve in the market.

[2] **Xuewang Zhang and Linlin Wang** addresses critical aspects of securing payment gateways in e-commerce. The authors highlight the necessity of robust security measures particularly in light of vulnerabilities such as the breakdown of hash algorithms like MD5. They propose a solution that focuses on enhancing security through a fusion-based approach blending SSL and SET protocols. This approach aims to optimize and integrate AES algorithms, establish secure hash algorithms, design security proxies and micro CA systems to bolster the security of payment gateways.

"KEY TECHNOLOGIES FOR SECURITY ENHANCING OF PAYMENT GATEWAY"

Advantages - It emphasizes enhanced security through the integration of advanced encryption standards like AES and robust protocols such as SSL/SET. This ensures that sensitive payment information remains protected from potential cyber threats, bolstering trust and confidence among users. Additionally, the implementation of a micro Certification Authority (CA) system streamlines certificate management processes, facilitating efficient issuance and maintenance of digital certificates.

Disadvantages - One notable challenge is the reliance on foreign SSL and SET protocols, which may present compliance issues with local regulations and potential vulnerabilities inherent in these systems. Moreover, export regulations in China limiting access to high-intensity encryption products could impede the widespread adoption of certain security measures, potentially weakening the overall security infrastructure of payment gateways.

[3] **Abdel Alim Kamal, Amr M. Youssef** proposed an enhanced implementation of the NTRUEncrypt algorithm using graphics cards. Their study explores various GPU implementation options for the NTRU encryption algorithm, achieving a throughput of approximately 77 MB/s for specific parameter settings (N, q, p) = (1171, 2048, 3) on the NVIDIA GTX275 GPU using the CUDA framework.

“ENHANCED IMPLEMENTATION OF THE NTRUENCRYPT ALGORITHM USING GRAPHICS CARDS”

Advantages - Harnesses the high degree of parallelism available in modern GPUs to accelerate encryption computations. It Provides a cost-effective solution for achieving faster implementations of cryptographic algorithms.It addresses the increasing demand for securing data at all stages of its lifecycle, from communication to storage.

Disadvantages - It Requires specialized knowledge and expertise in GPU programming and cryptographic algorithms for effective implementation.The dependency on specific hardware configurations may limit the accessibility of the proposed solution to users with compatible GPUs.

[4] **Yunhao Xia, Lirong You, Zhe Sun, and Zhixin Sun** from Nanjing University of Posts and Telecommunications and Zhongtian Technology Corporation proposed a secure and efficient signature scheme based on NTRU for mobile payment. The traditional public-key encryption algorithms used in mobile payment face limitations due to hardware requirements and vulnerability to quantum computing threats. Their research focuses on enhancing the NTRU encryption algorithm for quantum computation considering the impact of parameters on the probability of generating reasonable signature values. They propose two methods to improve the probability of generating such signatures: increasing parameter q and adding authentication conditions during the signature phase.The experimental results demonstrate that their signature scheme achieves zero leakage of private key information and enhances the probability of generating reasonable signatures while improving signature rates and preventing invalid signature propagation in the network. However, the scheme has certain restrictions on parameter selection.

"SECURE AND EFFICIENT SIGNATURE SCHEME BASED ON NTRU FOR MOBILE PAYMENT"

Advantages - Addresses the limitations of traditional public-key encryption algorithms for mobile payment by enhancing the NTRU encryption algorithm.It achieves zero leakage of private key information and improves the probability of generating reasonable signatures. It enhances signature rates and prevents invalid signature propagation in the network.

Disadvantages - Certain restrictions exist on parameter selection potentially limiting the applicability of the scheme in specific scenarios.

[5] Ali Can Atıcı from Istanbul Technical University, Lejla Batina, Junfeng Fan, and Ingrid Verbauwhede from Katholike Universiteit Leuven, and S. Berna Ors Yalcın from Istanbul Technical University presented low-cost implementations of the NTRU public-key cryptosystem tailored for pervasive security applications such as RFIDs and sensor nodes. Their work introduces compact and low-power NTRU designs with one architecture focusing solely on encryption and the other performing both encryption and decryption operations. The designs employ clock gating of registers, operand isolation and precomputation strategies to optimize performance. Notably, their encryption-only NTRU design features a gate-count of 2.8 kgates and dynamic power consumption of 1.72 µW, while the encryption-decryption design consumes approximately 6 µW dynamic power and consists of 10.5 kgates.

"LOW-COST IMPLEMENTATIONS OF NTRU FOR PERVASIVE SECURITY"

Advantages - It offers compact and low-power NTRU designs suitable for pervasive security applications like RFIDs and sensor nodes.It utilizes clock gating, operand isolation and precomputation strategies to optimize performance.It provides detailed architecture and power consumption results for both encryption-only and encryption-decryption NTRU designs.

Disadvantages - The paper does not extensively discuss the scalability or potential limitations of the proposed designs in larger-scale systems beyond RFIDs and sensor nodes.

[6] **Gurkamal Bhullar, a student from the Department of Computer Science at Lovely Professional University, Phagwara, India, and Navneet Kaur, an assistant professor in the same department,** explored concurrency control and security issues in distributed databases, with a focus on query redirection. They introduced the NTRU encryption-decryption technique to enhance the security of distributed database systems. NTRU, known for its speed and security, offers robust hashing algorithms that improve system security, throughput and processing speed.

"CONCURRENCY AND SECURITY CONTROL WITH NTRU"

Advantages - It addresses concurrency control and security concerns in distributed databases, offering insights into query redirection and the implementation of NTRU encryption-decryption techniques.It highlights the benefits of NTRU including its speed, security and efficiency in handling encryption and decryption tasks.

Disadvantages - The paper lacks in-depth discussion on specific implementation details and practical challenges associated with integrating NTRU into distributed database systems.

[7] **Kaixuan Men, Huapeng Li, Baocheng Wang, and Mingrui Liu** proposed a homomorphic encryption data analysis system named MeSec based on the NTRU cryptosystem, to address privacy threats in data processing systems. MeSec features a novel password-based authorized key exchange protocol (PAKE) and a more efficient NTRU-based homomorphic encryption system. It also includes federated learning schemes for encrypted distributed training models and privacy machine learning prediction schemes. Additionally, a multiuser agent NTRU-based re-encryption module facilitates safe and convenient data intercommunication and sharing among users, breaking down data islands.

“**AN NTRU-BASED HOMOMORPHIC ENCRYPTED DATA ANALYSIS SYSTEM”**

Advantages - It provides a comprehensive solution for privacy protection in data processing, including PAKE protocol, efficient NTRU-based encryption, federated learning and privacy-preserving machine learning.It enables secure and efficient data sharing, analysis and processing across various fields.

Disadvantages - The paper lacks detailed discussion on implementation challenges and potential limitations of MeSec in real-world applications. Further research may be needed to address scalability and interoperability issues.

[8] Mohammed Khalid Yousif, Zena Ez Dallalbashi, and Shahab Wahhab Kareem proposed an information security solution for big data utilizing the NTRUEncrypt method to enhance cloud computing security. The study addresses the increasing concern over data security in cloud computing environments, leveraging Hadoop's NTRU encryption capabilities to accelerate file encryption and decryption processes. By integrating NTRU encryption into Hadoop's Map Task, the proposed method ensures data privacy and security in cloud environments. The combination of cryptography with existing infrastructure enhances cloud security and facilitates web-based operations.

"INFORMATION SECURITY FOR BIG DATA USING THE NTRUENCRYPT METHOD"

Advantages - It enhances cloud security by integrating NTRU encryption into Hadoop's data processing framework.It accelerates file encryption and decryption processes, ensuring data privacy and security in cloud environments.It is compatible with existing cloud computing capabilities and infrastructure.

Disadvantages - The paper lacks detailed discussion on potential implementation challenges and scalability issues of integrating NTRU encryption with Hadoop. Further research may be needed to address performance optimization and interoperability concerns.

[9] Ashok Kumar Nanda and Lalit Kumar Awasthi propose a solution for enhancing Short Message Service (SMS) security using the NTRU cryptosystem. As SMS becomes increasingly popular, particularly in mobile commerce (M-Commerce) ensuring its security is crucial for both businesses and customers. The lack of end-to-end encryption in SMS transmission poses significant security risks especially for business organizations like banks offering mobile banking services. This paper analyzes the NTRU Crypto algorithm and NTRUSign algorithm, comparing their performance metrics with RSA. The theoretical comparison includes key size, key generation time, encryption time, decryption time, CPU computational power, speed, efficiency, memory space and security strength. The theoretical results suggest the potential superiority of NTRU over RSA. As future work, the authors plan to simulate the NTRU cryptosystem and NTRUSign algorithm on mobile phones using the full size of SMS messages.

“A PROPOSAL FOR SMS SECURITY USING NTRU CRYPTOSYSTEM”

Advantages - It addresses the critical need for enhancing SMS security in mobile commerce and business communication.It analyzes and compares the performance metrics of NTRU and RSA algorithms, providing valuable insights for secure communication protocols.It proposes future work to simulate NTRU cryptosystem and NTRUSign algorithm on mobile phones, demonstrating practical implementation possibilities.

Disadvantages - The paper primarily focuses on theoretical comparisons and lacks empirical validation through real-world experiments. Further research and experimentation may be needed to assess the practical feasibility and performance of implementing NTRU-based SMS security solutions on mobile devices.

[10] N. Suba Rani, A. Noble Mary Juliet, and S. Arunkumar propose a novel cryptosystem for files stored in the cloud using the NTRU encryption algorithm. As the cloud becomes an integral part of data storage and processing ensuring data security is paramount. Cloud Service Providers (CSPs) are tasked with safeguarding user data from potential leaks and breaches. To achieve this, encryption algorithms are employed, and efficiency becomes crucial due to the large volume of data handled by CSPs.It current encryption standards in the cloud include Advanced Encryption Standard (AES), Rivest–Shamir–Adleman (RSA), and elliptic curve cryptography (ECC). However, selecting an encryption algorithm that balances computational efficiency with security requirements remains a challenge.

“A NOVEL CRYPTOSYSTEM FOR FILES STORED IN CLOUD USING NTRU ENCRYPTION ALGORITHM”

Advantages -It addresses the need for efficient and secure file encryption in cloud storage systems. Introduces the NTRU encryption algorithm as a potential solution, providing an alternative to existing encryption standards.It discusses both symmetric and asymmetric encryption techniques offering insights into their respective advantages and use cases in cloud security.

Disadvantages - The paper lacks empirical validation or experimentation to demonstrate the effectiveness of the proposed NTRU-based cryptosystem in real-world cloud environments. Further research and experimentation may be necessary to evaluate the performance and practical implementation challenges of deploying NTRU encryption in cloud storage systems.

CHAPTER 3

THEORETICAL BACKGROUND

3.1 IMPLEMENTATION ENVIRONMENT

The implementation environment for the "Shielding Online Transactions: NTRU-Encrypted Payment Gateways for Quantum-Resistant Security" project ensures optimal performance across diverse platforms, catering to both mobile and desktop users. The system is meticulously crafted to operate seamlessly on various devices offering a secure and user-friendly payment gateway experience. For mobile devices, the application is tailored to run flawlessly on Android operating systems, with compatibility starting from version 7 and extending to the latest versions.The enhanced performance is ensured on Android version 10 or higher with a minimum requirement of 4GB RAM for smooth execution. Similarly, for desktop users the application is compatible with Windows operating systems, supporting versions from Windows 7 onwards. However, superior performance is guaranteed on Windows 8 or higher, accompanied by a minimum of 4GB RAM to facilitate efficient processing.The specialized features such as speech recognition are integrated separately for both Android and Windows platforms, enriching the user experience and accessibility.The internet connectivity is indispensable for data retrieval and secure transactions while access to storage is necessary for storing transaction records securely.

Hardware Requirements :

- System Device: Mobile or Desktop
- Processor (RAM): Minimum 4GB (Mobile and Desktop)
- Storage: 32GB (Mobile) / 512GB (Desktop)
- Internet Connection

Software Requirements :

- Mobile OS: Android version 10 or higher
- Desktop OS: Windows 8 or higher
- Computer Clock Speed: Minimum 4.90 GHz

3.2 SYSTEM ARCHITECTURE

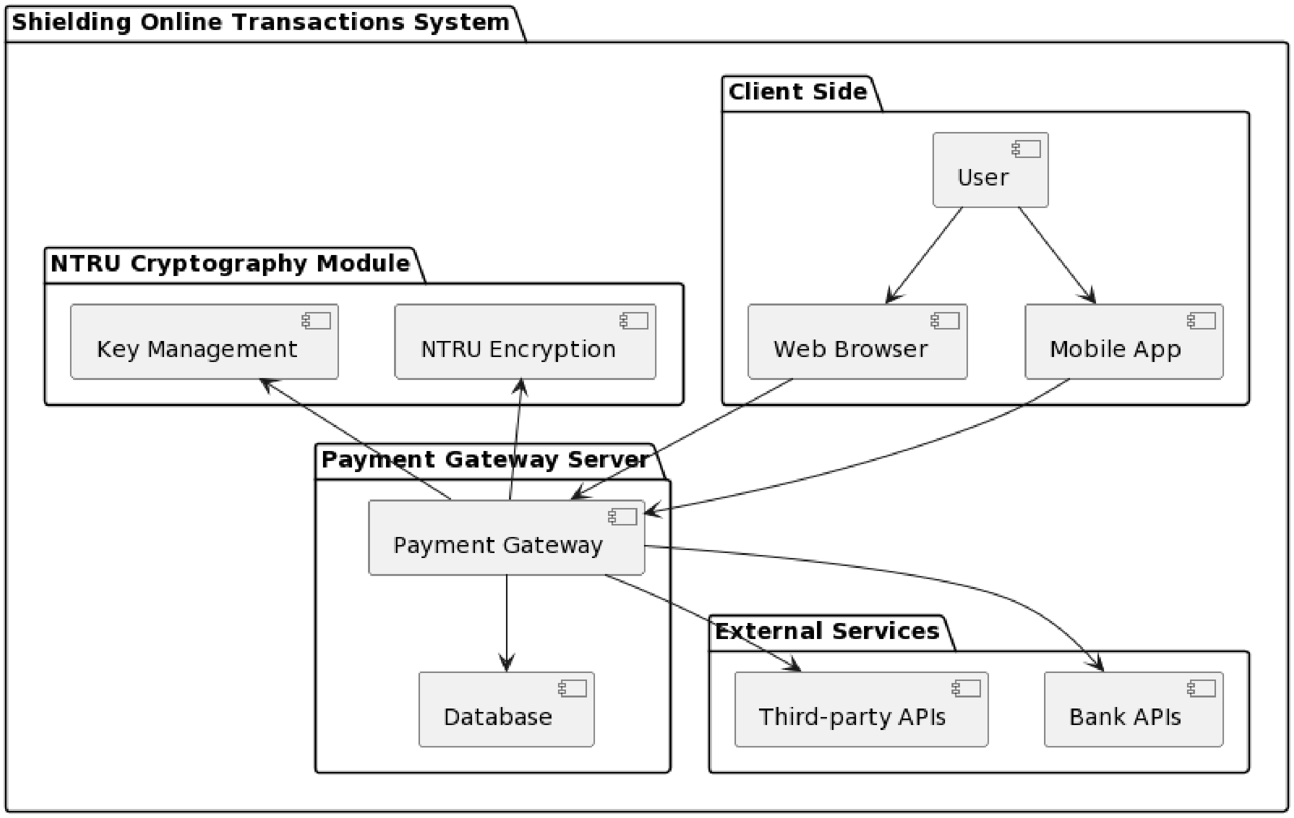


Fig no.1 System Architecture

The system architecture for "Shielding Online Transactions: NTRU-Encrypted Payment Gateways for Quantum-Resistant Security" comprises several key components. At its core lies the NTRU encryption algorithm specifically tailored for quantum-resistant security. The payment gateway serves as the interface between users and financial institutions, facilitating secure online transactions. Additionally, a robust authentication mechanism ensures the legitimacy of transactions, mitigating the risk of fraudulent activities. The architecture also includes secure storage systems for storing encrypted data thus preventing unauthorized access. Overall, the system architecture is designed to provide a resilient framework for online transactions in the face of evolving cybersecurity threats posed by quantum computing advancements.

3.3 PROPOSED METHODOLOGY

The proposed methodology for implementing "Shielding Online Transactions: NTRU-Encrypted Payment Gateways for Quantum-Resistant Security" involves several key steps. A comprehensive analysis of existing payment gateways and their vulnerabilities to quantum computing threats is conducted. This analysis informs the selection of the NTRU encryption algorithm as the cornerstone of the proposed solution due to its quantum-resistant properties.

A thorough design phase focuses on integrating the NTRU encryption algorithm into the payment gateway infrastructure. This involves modifying the existing architecture to incorporate NTRU encryption for securing sensitive transaction data. Additionally, a robust authentication mechanism is designed to ensure the integrity and legitimacy of transactions.

Following the design phase, the implementation process involves the actual integration of NTRU encryption into the payment gateway system. This requires careful testing and validation to ensure compatibility, functionality and security. Moreover, user training and education programs are developed to familiarize stakeholders with the enhanced security measures and promote adoption.

Finally, a comprehensive evaluation assesses the effectiveness of the implemented solution in mitigating quantum computing threats and enhancing overall security in online transactions. This evaluation considers factors such as encryption strength, system performance, user experience and resistance to potential attacks. Any necessary refinements or adjustments are made based on the evaluation results to optimize the system's effectiveness and reliability.

3.3.1 DATABASE DESIGN

The database design for "Shielding Online Transactions: NTRU-Encrypted Payment Gateways for Quantum-Resistant Security" includes several key components to ensure secure and efficient storage of transactional data.

A relational database management system (RDBMS) such as MySQL or PostgreSQL is utilized to store transaction records securely. The database schema is designed to include tables for storing transaction details such as transaction IDs, timestamps, amounts and user information.

The encryption techniques compatible with NTRU encryption are implemented to secure sensitive data within the database. This ensures that even if the database is compromised, the encrypted data remains unreadable and secure.

Furthermore, proper indexing and optimization techniques are employed to enhance the performance of database queries and transactions.The regular backups and disaster recovery measures are also implemented to safeguard against data loss and ensure business continuity.

3.3.2 INPUT DESIGN

The input design incorporates elements such as web forms and secure APIs to facilitate communication between users and the payment gateway.The users can input transaction details, including payment amounts, recipient information and authentication credentials through these interfaces.

To ensure security, input validation techniques are employed to sanitize and verify user inputs, preventing injection attacks and unauthorized access. Furthermore, multi-factor authentication mechanisms such as one-time passwords (OTP) or biometric verification are integrated to enhance transaction security.

Moreover, the input design emphasizes accessibility by accommodating various input methods, including voice commands, touchscreens and traditional keyboard input. This approach caters to users with diverse needs and preferences thus enhancing the overall user experience.

Overall, the input design prioritizes security, accessibility and user-friendliness to facilitate seamless and protected online transactions.

3.3.3 MODULE DESIGN

DATA FLOW DIAGRAMS

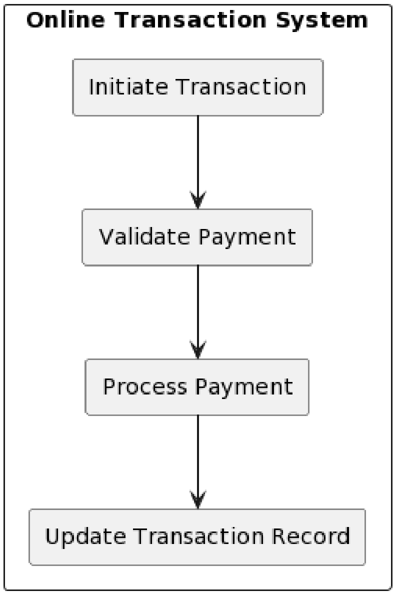


Fig no.2 Level 0 DFD

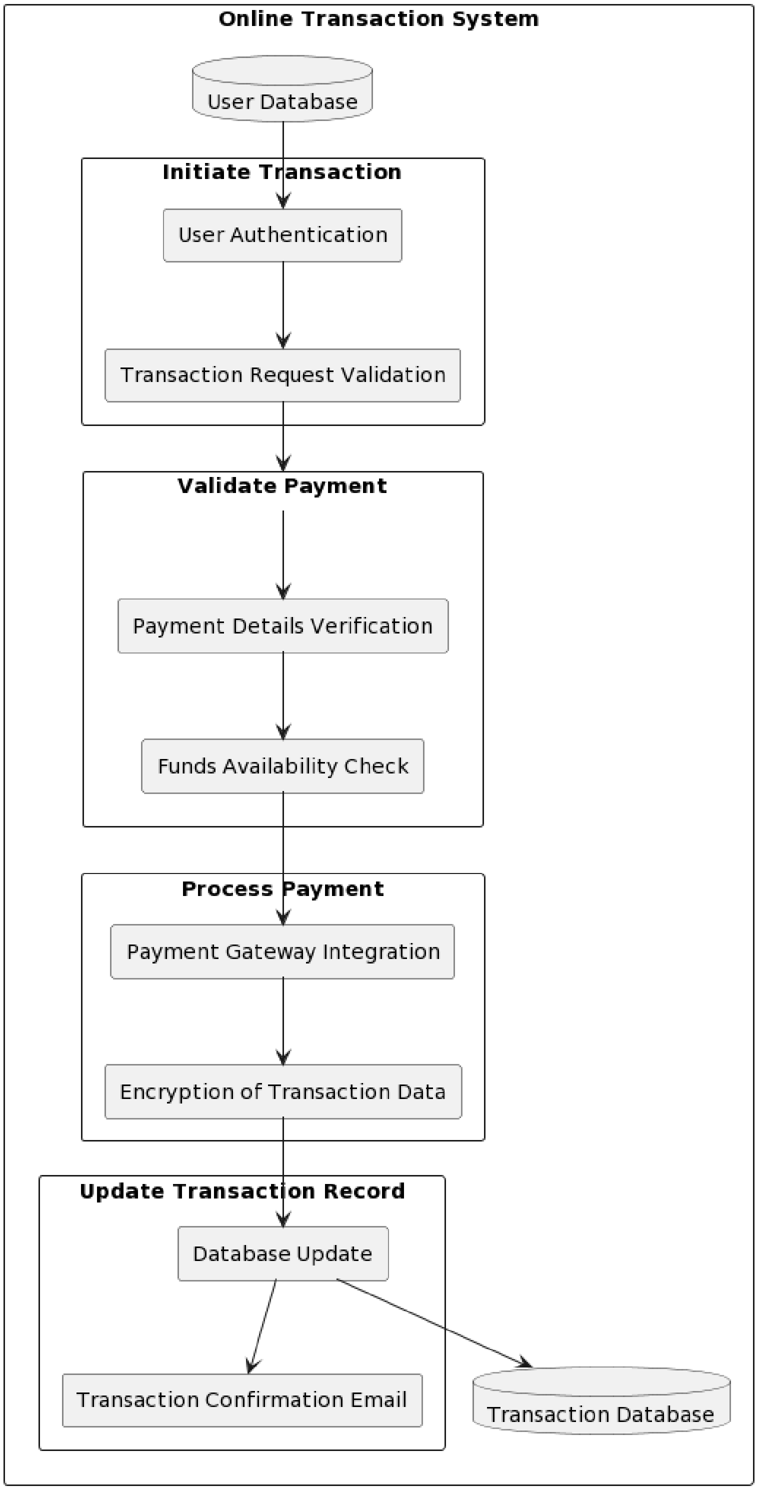

Online Transaction System
User Database
Initiate Transaction
User Authentication
Transaction Request Validation
Validate Payment
Payment Details Verification
Funds Availability Check
Process Payment
Payment Gateway Integration
Encryption of Transaction Data
Update Transaction Record
Database Update
Transaction Confirmation Email
Transaction Database

Fig no. 3 Level 1 DFD

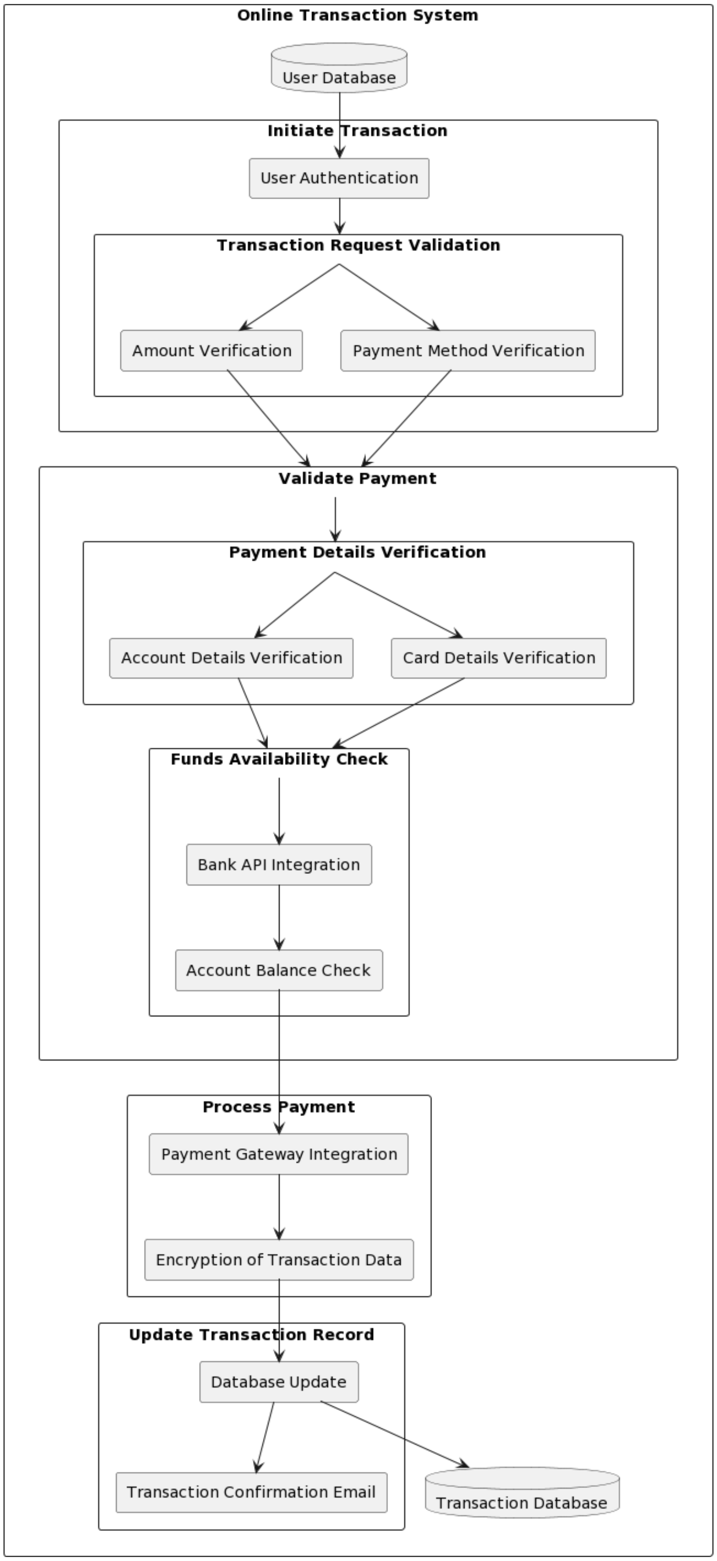

Online Transaction System
User Database
Initiate Transaction
User Authentication
Transaction Request Validation
Amount Verification
Payment Method Verification
Validate Payment
Payment Details Verification
Account Details Verification
Card Details Verification
Funds Availability Check
Bank API Integration
Account Balance Check
Process Payment
Payment Gateway Integration
Encryption of Transaction Data
Update Transaction Record
Database Update
Transaction Confirmation Email
Transaction Database

Fig no. 4 Level 2 DFD

UML DIAGRAMS

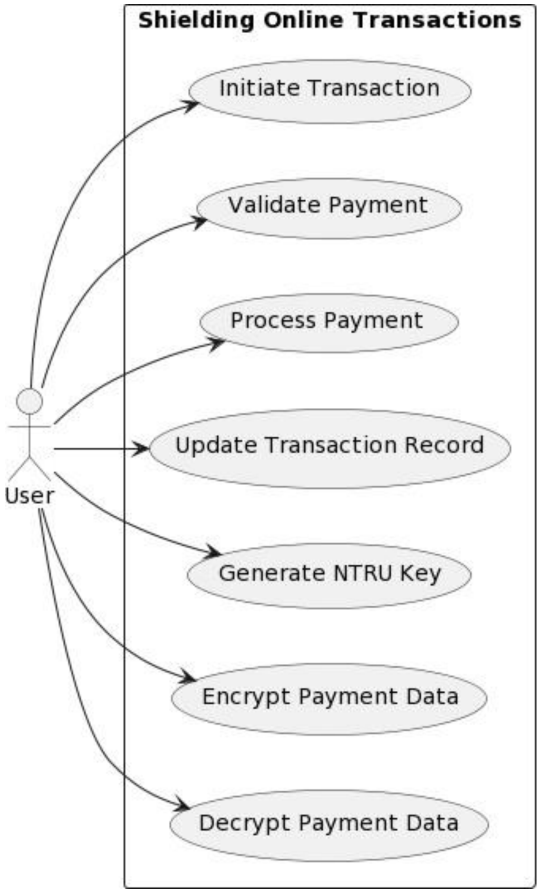


Fig no. 5 Use Case Diagram

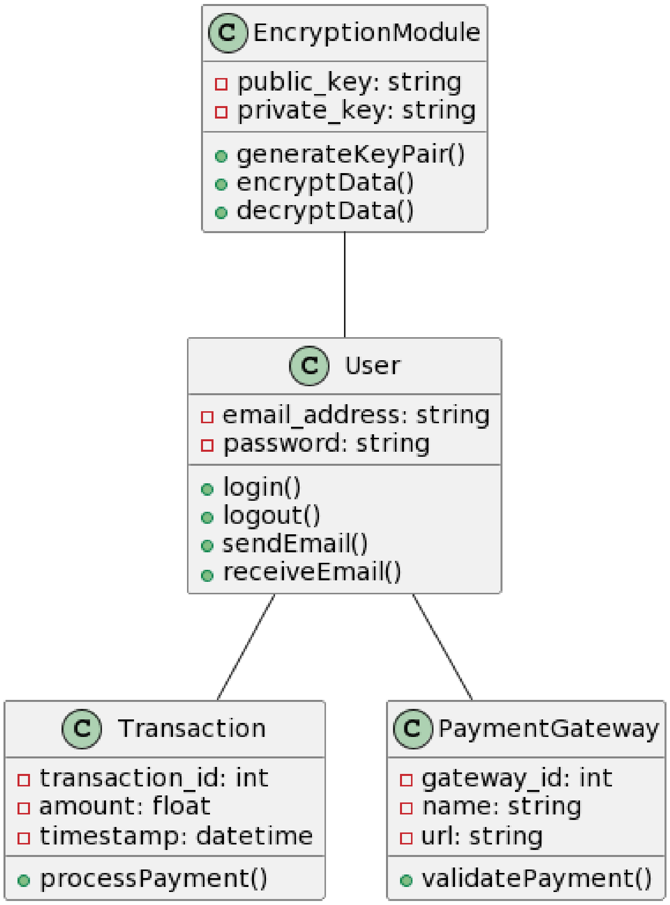


Fig no. 6 Class Diagram

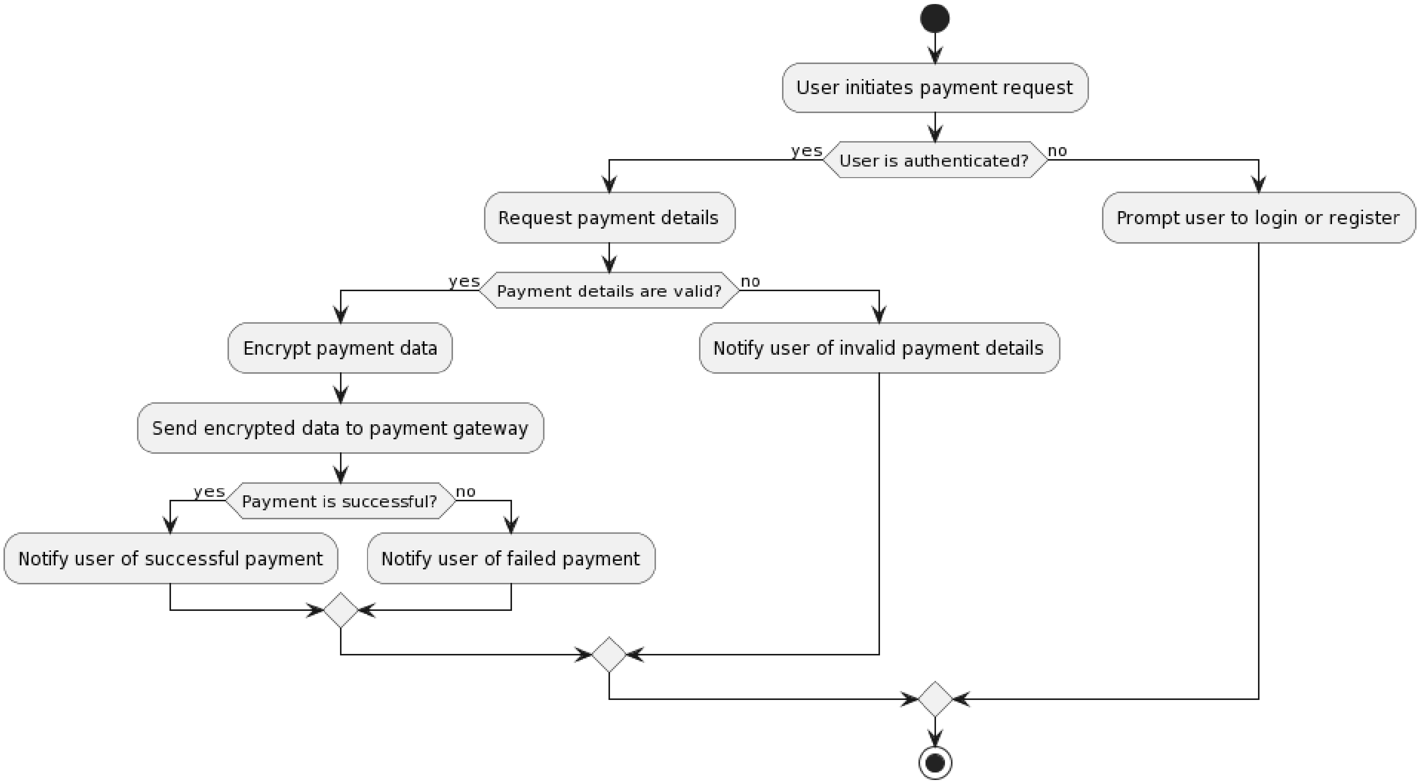

User initiates payment request
User is authenticated?
yes
no
Request payment details
Prompt user to login or register
Payment details are valid?
yes
no
Encrypt payment data
Notify user of invalid payment details
Send encrypted data to payment gateway
Payment is successful?
yes
no
Notify user of successful payment
Notify user of failed payment

Fig no. 7 Activity Diagram

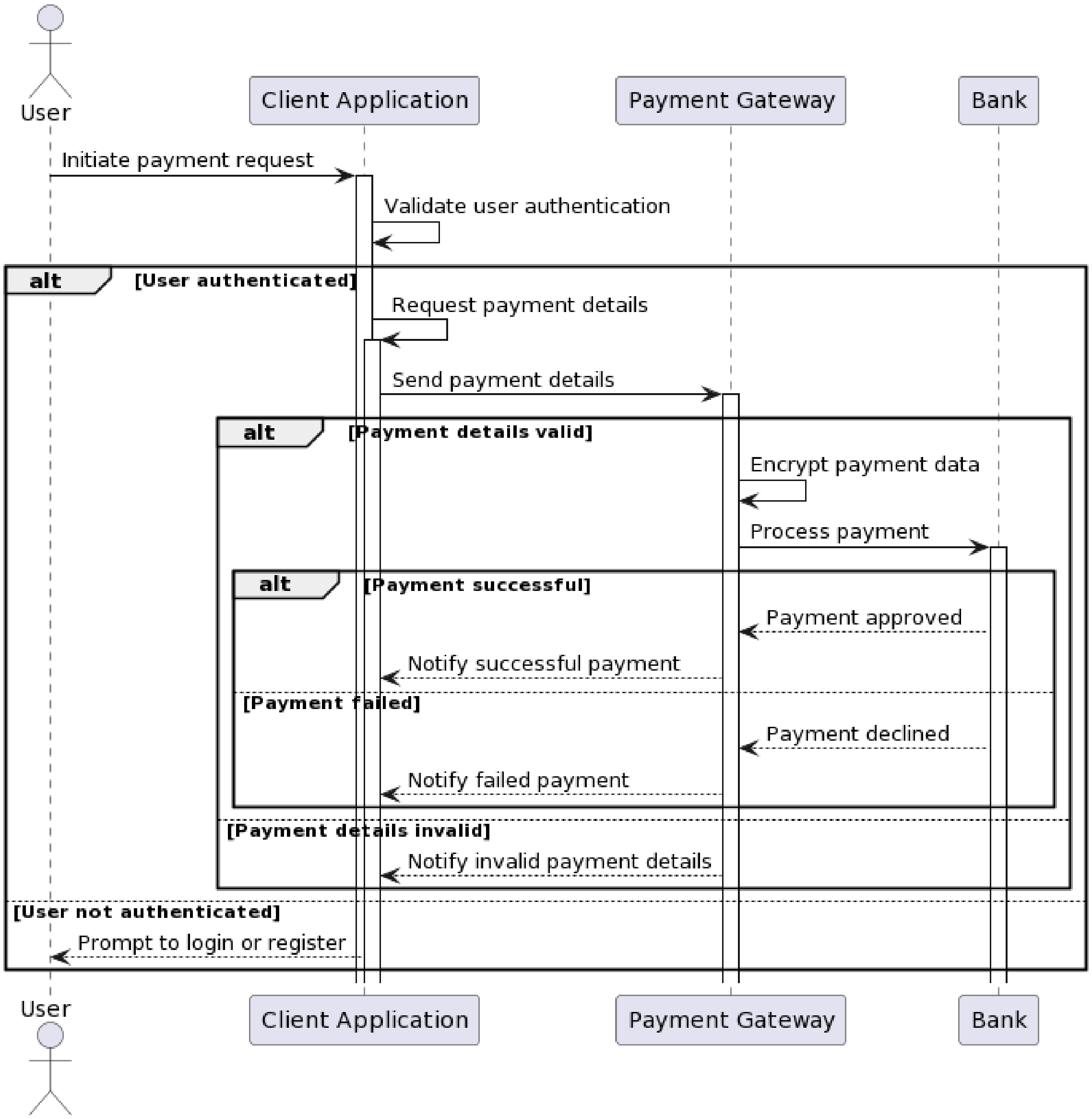


Fig no. 8 Sequence Diagram

CHAPTER 4

SYSTEM IMPLEMENTATION

4.1. USER AUTHENTICATION AND REGISTRATION

The "User Authentication and Registration" process in the "Shielding Online Transactions: NTRU-Encrypted Payment Gateways for Quantum-Resistant Security" project plays a pivotal role in ensuring the security and integrity of online transactions. This component allows users to securely register and authenticate themselves before accessing the NTRU-encrypted payment gateways.

During the registration phase, users are required to provide essential details such as their username, email address and password. This information is securely stored in the project's database, utilizing robust encryption mechanisms provided by the NTRU cryptosystem. Additionally, measures like email verification and CAPTCHA challenges may be implemented to enhance account validation and prevent unauthorized access.

Once registered, users undergo a stringent authentication process when accessing the payment gateways. They are prompted to enter their credentials, which are then verified against the stored information in the encrypted database. To further bolster security, multi-factor authentication (MFA) techniques or biometric verification may be integrated into the authentication process adding an extra layer of protection against unauthorized access attempts.

In essence, the User Authentication and Registration component ensures that only legitimate users with verified identities can securely engage in online transactions through the NTRU-encrypted payment gateways thus fortifying the overall security posture of the project.

4.2. PAYMENT PROCESSING AND ENCRYPTION

This module encompasses several key functionalities, starting with the initiation of payment transactions by users. When a user initiates a payment, the system securely collects the relevant transaction details, including the recipient, amount and transaction purpose. These details are then encrypted using the NTRU encryption algorithm to prevent unauthorized access or tampering during transmission.

Once encrypted, the payment transaction undergoes processing, where it is securely transmitted to the designated recipient or payment gateway. Throughout this process, robust encryption mechanisms provided by NTRU ensure that the transaction data remains confidential and resistant to quantum attacks.

Upon reaching the recipient or payment gateway, the encrypted transaction data is decrypted using the corresponding decryption keys thereby enabling the recipient to verify and process the payment securely. The decryption process ensures that only authorized parties with the appropriate decryption keys can access and interpret the transaction details.

Overall, the "Payment Processing and Encryption" module integrates advanced encryption techniques offered by NTRU to ensure the confidentiality, integrity and security of online payment transactions thereby enhancing the resilience of the payment gateway against emerging cyber threats including quantum-based attacks.

4.3. DATABASE MANAGEMENT AND SECURITY

This module encompasses various functionalities aimed at ensuring the integrity and confidentiality of the database.It involves the creation and maintenance of database schemas tailored to accommodate user account information, transaction details and encryption key repositories. These schemas are designed to optimize data retrieval and storage efficiency while adhering to industry-standard security protocols.

Furthermore, the module implements robust access control mechanisms to regulate user access to the database.The role-based access control (RBAC) or similar techniques are employed to assign privileges and restrict unauthorized access to sensitive data. Additionally, encryption techniques such as Transparent Data Encryption (TDE) or column-level encryption may be applied to safeguard data at rest.

The continuous monitoring and auditing of database activities are integral aspects of this module to detect and respond to potential security breaches promptly. Intrusion detection systems (IDS) and security information and event management (SIEM) tools may be utilized to monitor database traffic as well as detect anomalous behavior indicative of security threats

The regular backups and disaster recovery protocols are also established to mitigate the risk of data loss or corruption.The automated backup routines ensure that critical data can be restored in the event of system failures or cyberattacks.

Overall, the "Database Management and Security" module plays a vital role in safeguarding sensitive data assets within the system thereby bolstering the overall resilience of the payment gateway against cyber threats and ensuring compliance with data protection regulations.

CHAPTER 5

TESTING & RESULT

5.1 TESTING

The testing phase is crucial to ensure the reliability, security and functionality of the payment gateway system.The testing serves as the final evaluation of the system's adherence to specifications, design standards and coding practices offering a comprehensive assessment of its performance.

5.1.1 Testing objectives

1. Testing aims to execute the payment gateway system with the objective of identifying any errors or defects present in the software.
2. A well-designed test case is characterized by its ability to uncover previously undetected errors within the system.
3. The success of a test is measured by its ability to reveal previously unknown errors, enhancing the overall robustness of the payment gateway system.

5.1.2 Testing Principles

- All testing activities are aligned with end-user requirements, ensuring that the system meets the needs and expectations of its users.
- Test planning is conducted meticulously in advance, outlining the scope, objectives, and methodologies to be employed throughout the testing process.
- Testing commences on a smaller scale and gradually expands to encompass more comprehensive testing scenarios, allowing for the identification of potential issues at various stages of development.
- While exhaustive testing is impractical, efforts are made to cover critical functionalities and use cases to maximize test coverage.
- Independent third-party testing is advocated to ensure impartial evaluation and validation of the payment gateway system's performance and security features.

5.1.1 TEST CASES

6

S.NO	Test Cases	Test Procedure	Test Input	Expected Result	Actual Result
1	Valid User Registration	• Navigate to the registration page. • Enter valid user details (name, email, password, etc.). • Submit the registration form.	Valid user details	User should be successfully registered.	User registration is successful.
2	Invalid User Registration	• Navigate to the registration page. • Enter invalid user details (e.g., incomplete email address, weak password). • Submit the registration form.	Invalid user details	Error message indicating invalid input.	Error message is displayed correctly.
3	Transaction Encryption	• Initiate a transaction on the payment gateway. • Enter payment details. • Proceed with the	Valid payment details	Transaction data should be encrypted using NTRU algorithm.	Transaction data is successfully encrypted.

		transaction.			
4	Transaction Decryption	• Receive encrypted transaction data. • Decrypt the transaction data using NTRU algorithm. • Verify the decrypted transaction details.	Encrypted transaction data	Decrypted transaction details should match the original transaction.	Transaction data is successfully decrypted.
5	Integration Testing	• Simulate end-to-end transaction process. • Ensure seamless communication between payment gateway and database. • Verify data integrity and security measures.	• End-to-end transaction simulation	All components should function harmoniously with no data loss or security breaches.	Integration testing passes without issues.
6	Database Connection	• Log in to the wesite. • Verify that the app communicates with the database.	Access with valid user credentials	Successful connection to the database.	Successful connection to the database.

5.2 RESULT

The results of the "Shielding Online Transactions: NTRU-Encrypted Payment Gateways for Quantum-Resistant Security" project demonstrate significant advancements in enhancing the security and resilience of online transactions. Through the implementation of NTRU-encrypted payment gateways, the project achieved robust protection against quantum computing threats, ensuring the integrity and confidentiality of financial transactions conducted over the internet.The Key outcomes include enhanced security, improved transaction integrity, efficient performance and positive user experience, with the encryption algorithms fortifying the payment gateways and mitigating the risk of data breaches while maintaining optimal performance levels. These results signify a significant step forward in safeguarding online transactions against emerging threats laying the groundwork for future advancements in quantum-resistant cybersecurity solutions.

CHAPTER 6

CONCLUSION & FUTURE SCOPE

6.1 CONCLUSION

Our project, "Shielding Online Transactions: NTRU-Encrypted Payment Gateways for Quantum-Resistant Security," marks a significant milestone in the realm of online payment security. With the exponential growth of online transactions and the ever-evolving landscape of cyber threats, ensuring the integrity and confidentiality of sensitive financial data has become paramount. Our dedicated team has undertaken the challenge of developing a robust payment gateway system that not only meets the stringent security requirements of today but also anticipates the cryptographic challenges of tomorrow.

Through meticulous research and development, the NTRU encryption algorithm, renowned for its quantum-resistant properties is leveraged, to fortify our payment gateway against potential quantum attacks. By doing so, The system is positined at the forefront of quantum-safe cryptography, offering users peace of mind knowing that their transactions are shielded from emerging threats.

Furthermore, The project embodies a commitment to inclusivity and accessibility, ensuring that all users, regardless of their technological proficiency or physical abilities, can seamlessly engage in online transactions. Through intuitive user interfaces and support for diverse platforms, we have democratized access to secure online payments is democratized thereby empowering individuals from all walks of life to participate in the digital economy confidently.

The project represents not only a technological achievement but also a testament to our unwavering dedication to advancing online security and fostering digital inclusion. The payment gateway system, is continuously refined and enhanced a more accessible online environment for users is created worldwide.The future of online transactions is not only secure but also more inclusive and user-friendly than ever before.

6.2 FUTURE SCOPE

A. Enhanced Security Measures:

As cyber threats continue to evolve, implementing advanced security measures, such as biometric authentication or multi-factor authentication, can further fortify our payment gateway system against unauthorized access and fraudulent activities.

B. Integration with Emerging Technologies:

Exploring the integration of emerging technologies like blockchain can revolutionize the landscape of online payments offering unprecedented transparency, decentralization, and security. By leveraging blockchain technology, a decentralized payment ecosystem is created that eliminates the need for intermediaries and enhances transactional integrity.

C. Integration with IoT Devices:

With the proliferation of Internet of Things (IoT) devices, integrating The payment gateway system with IoT ecosystems can streamline and enhance the payment experience. By enabling seamless transactions through smart devices, such as wearable gadgets or connected appliances, an unparalleled convenience and accessibilityis offer to the usser.

D. Collaboration with Industry Partners:

Collaborating with industry partners such as financial institutions, technology firms, and regulatory bodies, can facilitate knowledge sharing, innovation and collective efforts to address cybersecurity challenges and regulatory compliance requirements.

E. Continuous Improvement and Optimization:

Continuously refining and optimizing our payment gateway system based on user feedback and market trends is essential to stay competitive in the ever-evolving fintech landscape. By prioritizing user experience and leveraging data analytics, areas is identified for improvement and implement iterative enhancements to bolster overall system performance and usability.

APPENDICES

APPENDIX 1 : SOURCE CODE

padding.py:

```
import numpy as np
def padding_encode(input_arr, block_size):
    n = block_size - len(input_arr) % block_size
    if n == block_size:
        return np.pad(input_arr, (0, n), 'constant')
    last_block = np.pad(np.ones(n), (block_size - n, 0), 'constant')
    return np.concatenate((np.pad(input_arr, (0, n), 'constant'), last_block))
def padding_decode(input_arr, block_size):
    last_block = input_arr[-block_size:]
    zeros_to_remove = len(np.trim_zeros(last_block))
    return input_arr[:-(block_size + zeros_to_remove)]
```

mathutils.py:

```
import math
from sympy import GF, invert
import logging
import numpy as np
from sympy.abc import x
from sympy import ZZ, Poly
log = logging.getLogger("mathutils")
def is_prime(n):
    for i in range(2, int(n ** 0.5) + 1):
        if n % i == 0:
            return False
    return True
def is_2_power(n):
    return n != 0 and (n & (n - 1) == 0)
```

```
def random_poly(length, d, neg_ones_diff=0):
    return Poly(np.random.permutation(
        np.concatenate((np.zeros(length - 2 * d - neg_ones_diff), np.ones(d), -np.ones(d + neg_ones_diff)))),
        x).set_domain(ZZ)
def invert_poly(f_poly, R_poly, p):
    inv_poly = None
    if is_prime(p):
        log.debug("Inverting as p={} is prime".format(p))
        inv_poly = invert(f_poly, R_poly, domain=GF(p))
    elif is_2_power(p):
        log.debug("Inverting as p={} is 2 power".format(p))
        inv_poly = invert(f_poly, R_poly, domain=GF(2))
        e = int(math.log(p, 2))
        for i in range(1, e):
            log.debug("Inversion({}): {}".format(i, inv_poly))
            inv_poly = ((2 * inv_poly - f_poly * inv_poly ** 2) % R_poly).trunc(p)
    else:
        raise Exception("Cannot invert polynomial in Z_{}".format(p))
    log.debug("Inversion: {}".format(inv_poly))
    return inv_poly
```

ntrucipher.py:

```
from ntru.mathutils import *
import numpy as np
from sympy.abc import x
from sympy.polys.polyerrors import NotInvertible
from sympy import ZZ, Poly
import logging
from collections import Counter
log = logging.getLogger("ntrucipher")
```

```
class NtruCipher:
    N = None
    p = None
    q = None
    f_poly = None
    g_poly = None
    h_poly = None
    f_p_poly = None
    f_q_poly = None
    R_poly = None
    def  _init_(self,  N,  p,  q):
        self.N = N
        self.p = p
        self.q = q
        self.R_poly = Poly(x ** N - 1, x).set_domain(ZZ)
        log.info("NTRU(N={},p={},q={}) initiated".format(N, p, q))
    def generate_random_keys(self):
        g_poly = random_poly(self.N, int(math.sqrt(self.q)))
        log.info("g: {}".format(g_poly))
        log.info("g coeffs: {}".format(Counter(g_poly.coeffs())))
        tries = 10
        while tries > 0 and (self.h_poly is None):
            f_poly = random_poly(self.N, self.N // 3, neg_ones_diff=-1)
            log.info("f: {}".format(f_poly))
            log.info("f coeffs: {}".format(Counter(f_poly.coeffs())))
            try:
                self.generate_public_key(f_poly, g_poly)
            except NotInvertible as ex:
                log.info("Failed to invert f (tries left: {})".format(tries))
                log.debug(ex)
                tries -= 1
        if self.h_poly is None:
            raise Exception("Couldn't generate invertible f")
    def generate_public_key(self, f_poly, g_poly):
        self.f_poly = f_poly
        self.g_poly = g_poly
        log.debug("Trying to invert: {}".format(self.f_poly))
        self.f_p_poly = invert_poly(self.f_poly, self.R_poly, self.p)
        log.debug("f_p ok!")
        self.f_q_poly = invert_poly(self.f_poly, self.R_poly, self.q)
        log.debug("f_q ok!")
        log.info("f_p: {}".format(self.f_p_poly))
        log.info("f_q: {}".format(self.f_q_poly))
        log.debug("f*f_p mod (x^n - 1): {}".format(((self.f_poly * self.f_p_poly) % self.R_poly).trunc(self.p)))
        log.debug("f*f_q mod (x^n - 1): {}".format(((self.f_poly * self.f_q_poly) % self.R_poly).trunc(self.q)))
        p_f_q_poly = (self.p * self.f_q_poly).trunc(self.q)
        log.debug("p_f_q: {}".format(p_f_q_poly))
        h_before_mod = (p_f_q_poly * self.g_poly).trunc(self.q)
        log.debug("h_before_mod: {}".format(h_before_mod))
        self.h_poly = (h_before_mod % self.R_poly).trunc(self.q)
        log.info("h: {}".format(self.h_poly))
    def encrypt(self, msg_poly, rand_poly):
        log.info("r: {}".format(rand_poly))
        log.info("r coeffs: {}".format(Counter(rand_poly.coeffs())))
        log.info("msg: {}".format(msg_poly))
        log.info("h: {}".format(self.h_poly))
        return (((rand_poly * self.h_poly).trunc(self.q) + msg_poly) % self.R_poly).trunc(self.q)
    def decrypt(self, msg_poly):
        log.info("f: {}".format(self.f_poly))
        log.info("f_p: {}".format(self.f_p_poly))
        a_poly = ((self.f_poly * msg_poly) % self.R_poly).trunc(self.q)
        log.info("a: {}".format(a_poly))
```

```
        b_poly = a_poly.trunc(self.p)
        log.info("b: {}".format(b_poly))
        return ((self.f_p_poly * b_poly) % self.R_poly).trunc(self.p)
```

ntru.py:

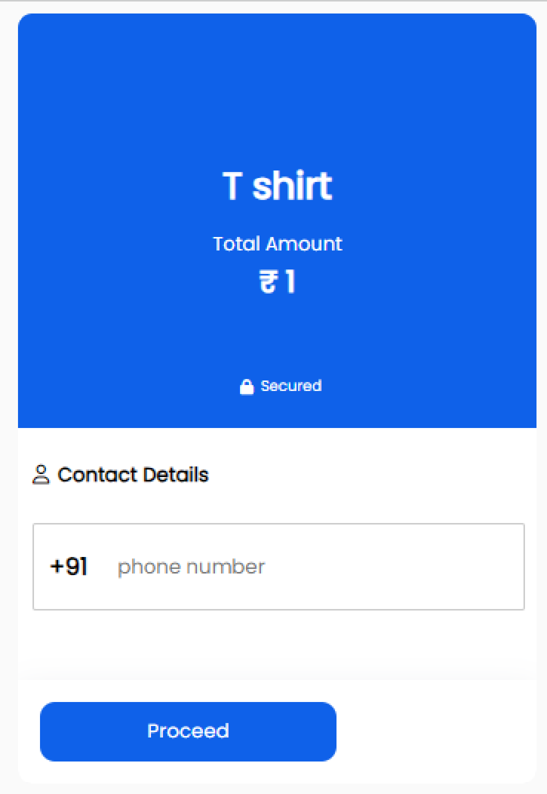
```
from docopt import docopt
from ntru.ntrucipher import NtruCipher
from ntru.mathutils import random_poly
from sympy.abc import x
from sympy import ZZ, Poly
from padding.padding import *
import numpy as np
import sys
import logging
import math
log = logging.getLogger("ntru")
debug = False
verbose = False
def generate(N, p, q, priv_key_file, pub_key_file):
    ntru = NtruCipher(N, p, q)
    ntru.generate_random_keys()
    h = np.array(ntru.h_poly.all_coeffs()[::-1])
    f, f_p = ntru.f_poly.all_coeffs()[::-1], ntru.f_p_poly.all_coeffs()[::-1]
    np.savez_compressed(priv_key_file, N=N, p=p, q=q, f=f, f_p=f_p)
    log.info("Private key saved to {} file".format(priv_key_file))
    np.savez_compressed(pub_key_file, N=N, p=p, q=q, h=h)
    log.info("Public key saved to {} file".format(pub_key_file))
def encrypt(pub_key_file, input_arr, bin_output=False, block=False):
    pub_key = np.load(pub_key_file, allow_pickle=True)
    ntru = NtruCipher(int(pub_key['N']), int(pub_key['p']), int(pub_key['q']))
    ntru.h_poly = Poly(pub_key['h'].astype(np.int)[::-1], x).set_domain(ZZ)
    if not block:
        if ntru.N < len(input_arr):
            raise Exception("Input is too large for current N")
        output = (ntru.encrypt(Poly(input_arr[::-1], x).set_domain(ZZ),
                               random_poly(ntru.N, int(math.sqrt(ntru.q)))).all_coeffs()[::-1])
    else:
        input_arr = padding_encode(input_arr, ntru.N)
        input_arr = input_arr.reshape((-1, ntru.N))
        output = np.array([])
        block_count = input_arr.shape[0]
        for i, b in enumerate(input_arr, start=1):
            log.info("Processing block {} out of {}".format(i, block_count))
            next_output = (ntru.encrypt(Poly(b[::-1], x).set_domain(ZZ),
                                        random_poly(ntru.N, int(math.sqrt(ntru.q)))).all_coeffs()[::-1])
            if len(next_output) < ntru.N:
                next_output = np.pad(next_output, (0, ntru.N - len(next_output)), 'constant')
            output = np.concatenate((output, next_output))

    if bin_output:
        k = int(math.log2(ntru.q))
        output = [[0 if c == '0' else 1 for c in np.binary_repr(n, width=k)] for n in output]
    return np.array(output).flatten()


def decrypt(priv_key_file, input_arr, bin_input=False, block=False):
    priv_key = np.load(priv_key_file, allow_pickle=True)
    ntru = NtruCipher(int(priv_key['N']), int(priv_key['p']), int(priv_key['q']))
    ntru.f_poly = Poly(priv_key['f'].astype(np.int)[::-1], x).set_domain(ZZ)
    ntru.f_p_poly = Poly(priv_key['f_p'].astype(np.int)[::-1], x).set_domain(ZZ)
    if bin_input:
        k = int(math.log2(ntru.q))
        pad = k - len(input_arr) % k
        if pad == k:
            pad = 0
        input_arr = np.array([int("".join(n.astype(str)), 2) for n in
                              np.pad(np.array(input_arr), (0, pad), 'constant').reshape((-1, k))])
    if not block:
        if ntru.N < len(input_arr):
            raise Exception("Input is too large for current N")
        log.info("POLYNOMIAL DEGREE: {}".format(max(0, len(input_arr) - 1)))
        return ntru.decrypt(Poly(input_arr[::-1], x).set_domain(ZZ)).all_coeffs()[::-1]

    input_arr = input_arr.reshape((-1, ntru.N))
    output = np.array([])
    block_count = input_arr.shape[0]
    for i, b in enumerate(input_arr, start=1):
        log.info("Processing block {} out of {}".format(i, block_count))
        next_output = ntru.decrypt(Poly(b[::-1], x).set_domain(ZZ)).all_coeffs()[::-1]
        if len(next_output) < ntru.N:
            next_output = np.pad(next_output, (0, ntru.N - len(next_output)), 'constant')
        output = np.concatenate((output, next_output))
    return padding_decode(output, ntru.N)


if __name__ == '__main__':
    args = docopt(__doc__, version='NTRU v0.1')
    root = logging.getLogger()
    root.setLevel(logging.DEBUG)
    ch = logging.StreamHandler(sys.stdout)
    if args['--debug']:
```

```
    ch.setLevel(logging.DEBUG)
elif args['--verbose']:
    ch.setLevel(logging.INFO)
else:
    ch.setLevel(logging.WARN)
root.addHandler(ch)

log.debug(args)
poly_input = bool(args['--poly-input'])
poly_output = bool(args['--poly-output'])
block = bool(args['--block'])
input_arr, output = None, None
if not args['gen']:
    if args['FILE'] is None or args['FILE'] == '-':
        input = sys.stdin.read() if poly_input else sys.stdin.buffer.read()
    else:
        with open(args['FILE'], 'rb') as file:
            input = file.read()
    log.info("---INPUT---")
    log.info(input)
    log.info("-----------")
    if poly_input:
        input_arr = np.array(eval(input))
    else:
        input_arr = np.unpackbits(np.frombuffer(input, dtype=np.uint8))
    input_arr = np.trim_zeros(input_arr, 'b')
    log.info("POLYNOMIAL DEGREE: {}".format(max(0, len(input_arr) - 1)))
    log.debug("BINARY: {}".format(input_arr))

if args['gen']:
    generate(int(args['N']), int(args['P']), int(args['Q']), args['PRIV_KEY_FILE'], args['PUB_KEY_FILE'])
```

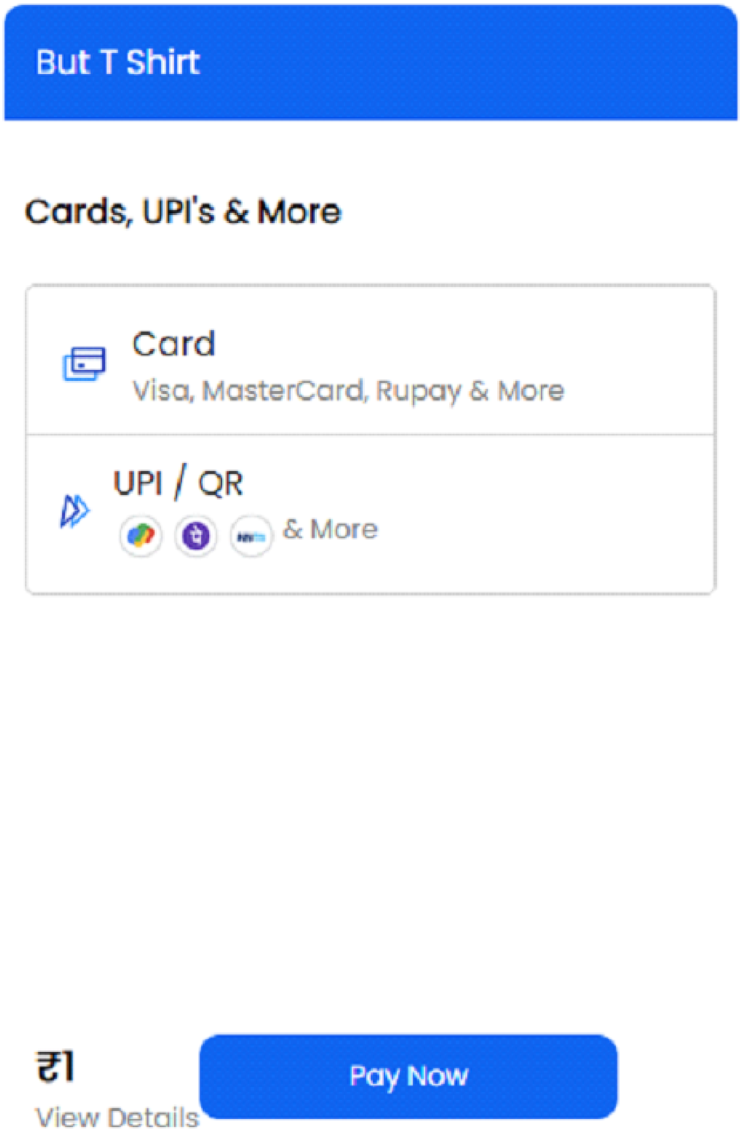
```
elif args['enc']:
    output = encrypt(args['PUB_KEY_FILE'], input_arr, bin_output=not poly_output, block=block)
elif args['dec']:
    output = decrypt(args['PRIV_KEY_FILE'], input_arr, bin_input=not poly_input, block=block)

if not args['gen']:
    if poly_output:
        print(list(output.astype(np.int)))
    else:
        sys.stdout.buffer.write(np.packbits(np.array(output).astype(np.int)).tobytes())
```

APPENDIX 2 : SCREEN SHOTS

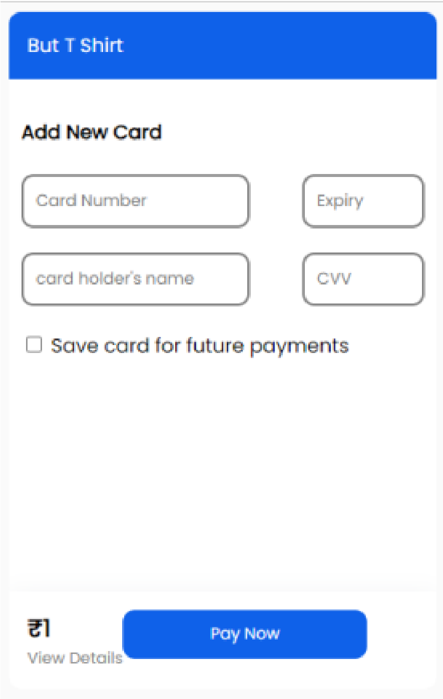
payment image



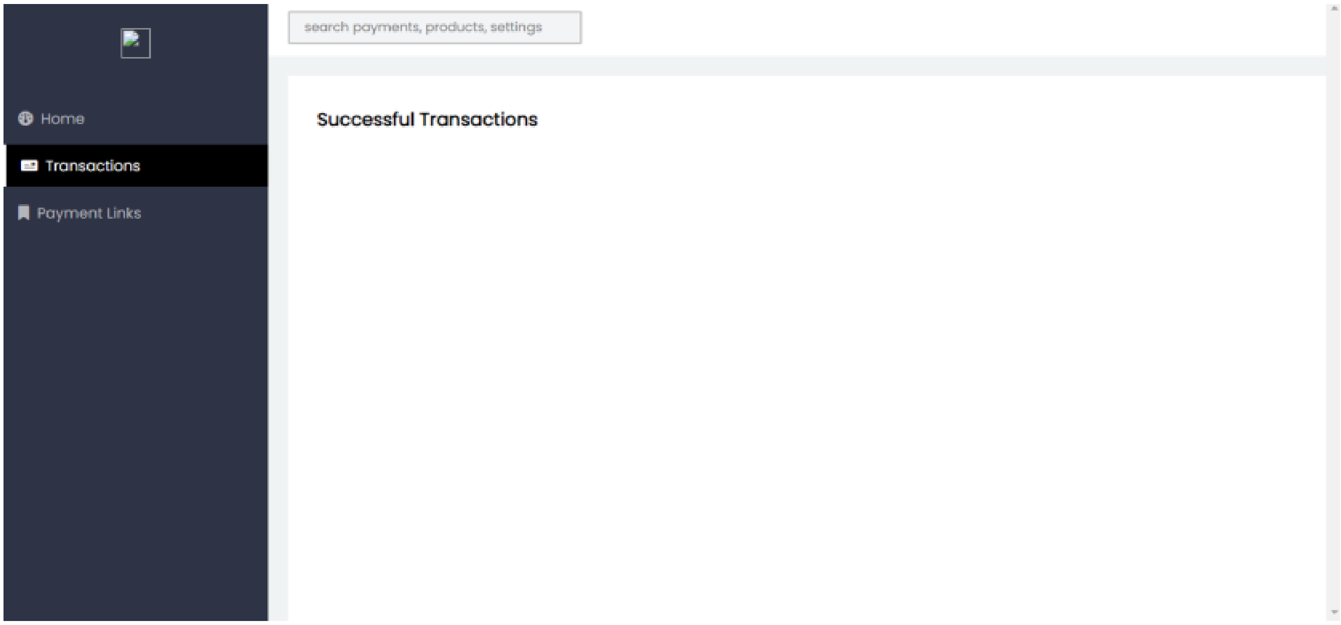
Choose payment method



Entering the details

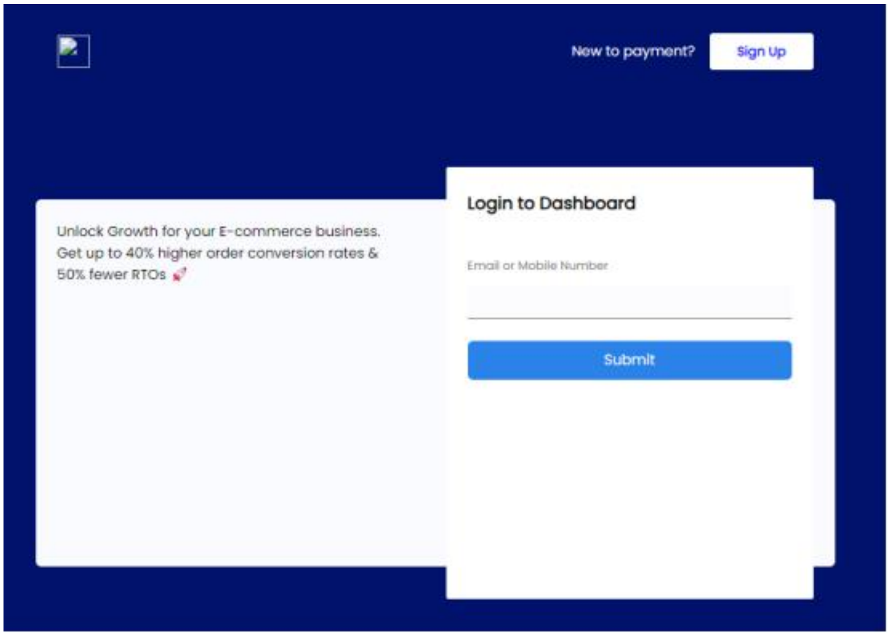


Transaction image



Successful Transactions

Login image



Unlock Growth for your E-commerce business. Get up to 40% higher order conversion rates & 50% fewer RTOs 🚀

Login to Dashboard

Email or Mobile Number

REFERENCE :

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