POST-QUANTUM BASED KEY EXCHANGE AND AUTHENTICATION IN TLS 1.3: A PURE POST-QUANTUM CRYPTOGRAPHY APPROACH

A PROJECT REPORT

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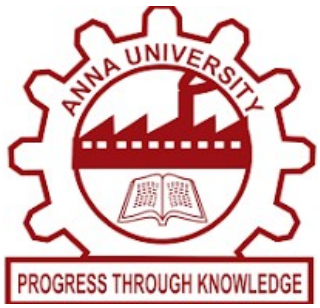

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BONAFIDE CERTIFICATE

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ABSTRACT

Classical cryptographic algorithms such as Rivest–Shamir–Adleman (RSA), Elliptic Curve Cryptography (ECC), and Elliptic Curve Diffie–Hellman (ECDH) currently secure critical network protocols like TLS and SSH. However, with the advent of quantum computing, algorithms like Shor's and Grover's threaten these classical methods by exploiting their mathematical weaknesses, creating an urgent need for cryptographic algorithms resilient to quantum attacks.

This project implements pure Post-Quantum Cryptography (PQC) within TLS 1.3, replacing classical mechanisms with quantum-resistant alternatives for key exchange and authentication, specifically integrating ML-KEM and ML-DSA, lattice-based algorithms designed to resist quantum threats.

To evaluate the practical deployment of these algorithms, a custom test environment is developed, utilizing a PQC-signed Root Certificate Authority (CA). This setup enables comprehensive benchmarking of PQC-enabled TLS performance, assessing metrics such as handshake time, certificate size, and communication delays.

In addition to performance analysis, the project investigates the security benefits, computational overhead, and compatibility challenges associated with adopting pure PQC in TLS. These insights are essential for understanding the trade-offs and feasibility of transitioning to quantum-secure communication protocols in future internet infrastructures.

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PQC	-	Post Quantum Cryptography
TLS	-	Transport Layer Security
ML-KEM	-	Module-Lattice Key Encapsulation Mechanism
ML-DSA	-	Module-Lattice Digital Signature Algorithm
RSA	-	Rivest-Shamir-Adleman
ECC	-	Elliptic Curve Cryptography
AES	-	Advanced Encryption Standard
ECDH	-	Elliptic-curve Diffie-Hellman
CSR	-	Certificate Signing Request
CA	-	Certificate Authority
RTT	-	Round Trip Time
OpenSSL	-	Open Secure Sockets Layer
libOQS	-	Open Quantum Safe Library
OQS-Provider	-	Open Quantum Safe Provider
NGINX	-	Engine X (High performance HTTP Server)
cURL	-	Client URL
NIST	-	National Institute of Standards and Technology
HTTP	-	Hypertext Transfer Protocol
SSH	-	Secure Shell
ECDLP	-	Elliptic Curve Discreate Logarithm Problem
KDF	-	Key Derivation Function
SVP	-	Shortest Vector Problem
CVP	-	Closest Vector Problem
LWE	-	Learning with Errors

SIS	-	Shortest Integer Solutions
FIPS	-	Federal Information Processing Standards