Implementation and Simulation of Digital Signatures using RSA & ElGamal

Course: Cryptography and Network Security (BECE411L)

Review 2 Presentation

Team Members:

- Ansu Raj (22BEC0186)
- Astitva Sharma (22BEC0206)
- Sanidhya Saxena (22BEC0296)
- Satyam Saurav (22BEC0134)
- Dhruv Jaipuria (22BEC0116)

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Recap of Review 1

Primary Goal

To compare the performance and characteristics of the RSA and ElGamal digital signature algorithms.

Proposed System

We designed a flowchart for a complete secure messaging system that combines confidentiality (encryption) with authenticity and integrity (digital signatures).

Plan for Review 2

To implement this flowchart through practical simulations to generate tangible performance data.

Simulation 1: Performance Comparison

Objective

To measure and compare the real-world performance of RSA and ElGamal for key digital signature operations.

Methodology

- Developed a Python script using the pycryptodome library.
- Measured the time taken for Key Generation, Signing, and Verification.
- Measured the final signature size in bytes.

Parameters

Both algorithms were tested with a 1024-bit key size for a fair comparison.

Google Colab link-
https://colab.research.google.com/drive/1XeMjTMFffA6ZXxeUQ7N5yGdqzaPxTa-k?usp=sharing

```
Running RSA Performance Test (1024-bit)...
RSA Test Complete.

Running ElGamal Performance Test (1024-bit)...
ElGamal Test Complete.

---------------------------------------------
     PERFORMANCE COMPARISON RESULTS
---------------------------------------------
Metric                    | RSA (1024-bit)      | ElGamal (1024-bit)
---------------------------------------------
Key Generation Time (s)   | 0.138117            | 31.215764
Signing Time (s)          | 0.002199            | 0.001023
Verification Time (s)     | 0.000419            | 0.026995
Signature Size (bytes)    | 128                 | 256
---------------------------------------------
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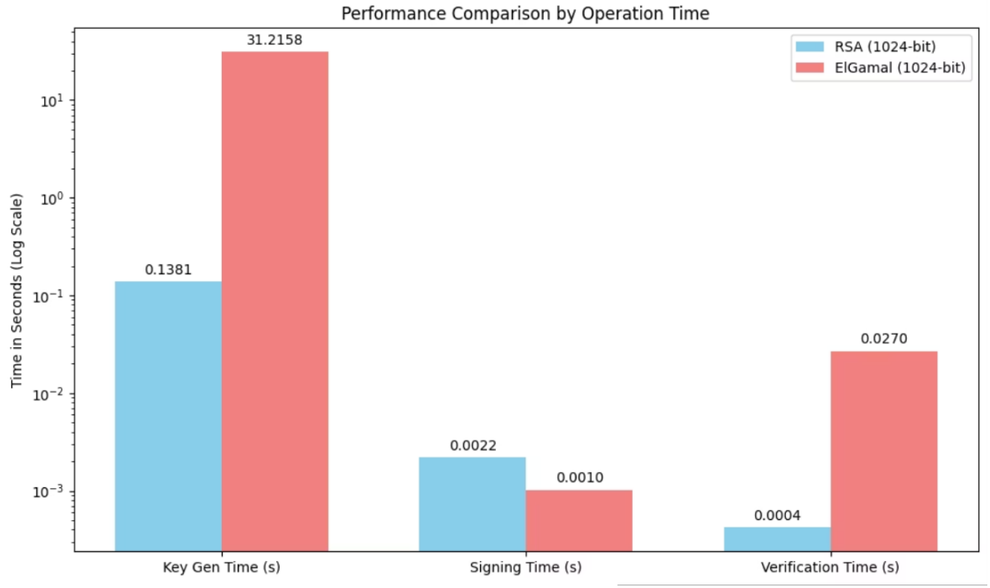


Performance Results: The Data

Our Python simulation produced the following results:

Metric	RSA (1024-bit)	ElGamal (1024-bit)	Winner
Key Generation Time (s)	~ 0.14s	~31.22 s	RSA
Signing Time (s)	~0.002 s	~0.001 s	ElGamal
Verification Time (s)	~0.0004 s	~0.027 s	RSA
Signature Size (bytes)	128 bytes	256 bytes	RSA

Analysis of Performance Results

Key Findings

The simulation clearly demonstrates that for 1024-bit keys, RSA is significantly more performant than our ElGamal implementation across all metrics.

100x

Key Generation

RSA was over 100 times faster.

70x

Verification

RSA was approximately 70 times faster.

50%

Efficiency

RSA produced a signature half the size of ElGamal's.

Connection to Literature Survey

- These findings align with the research from our Review 1 literature survey.
- For example, Maqsood et al. (2013) and Adeniyi et al. (2021) also concluded that RSA generally offers better performance in terms of speed and space complexity.
- Our practical simulation successfully validates existing academic research.

Simulation 2: Interactive Secure Messenger

Objective

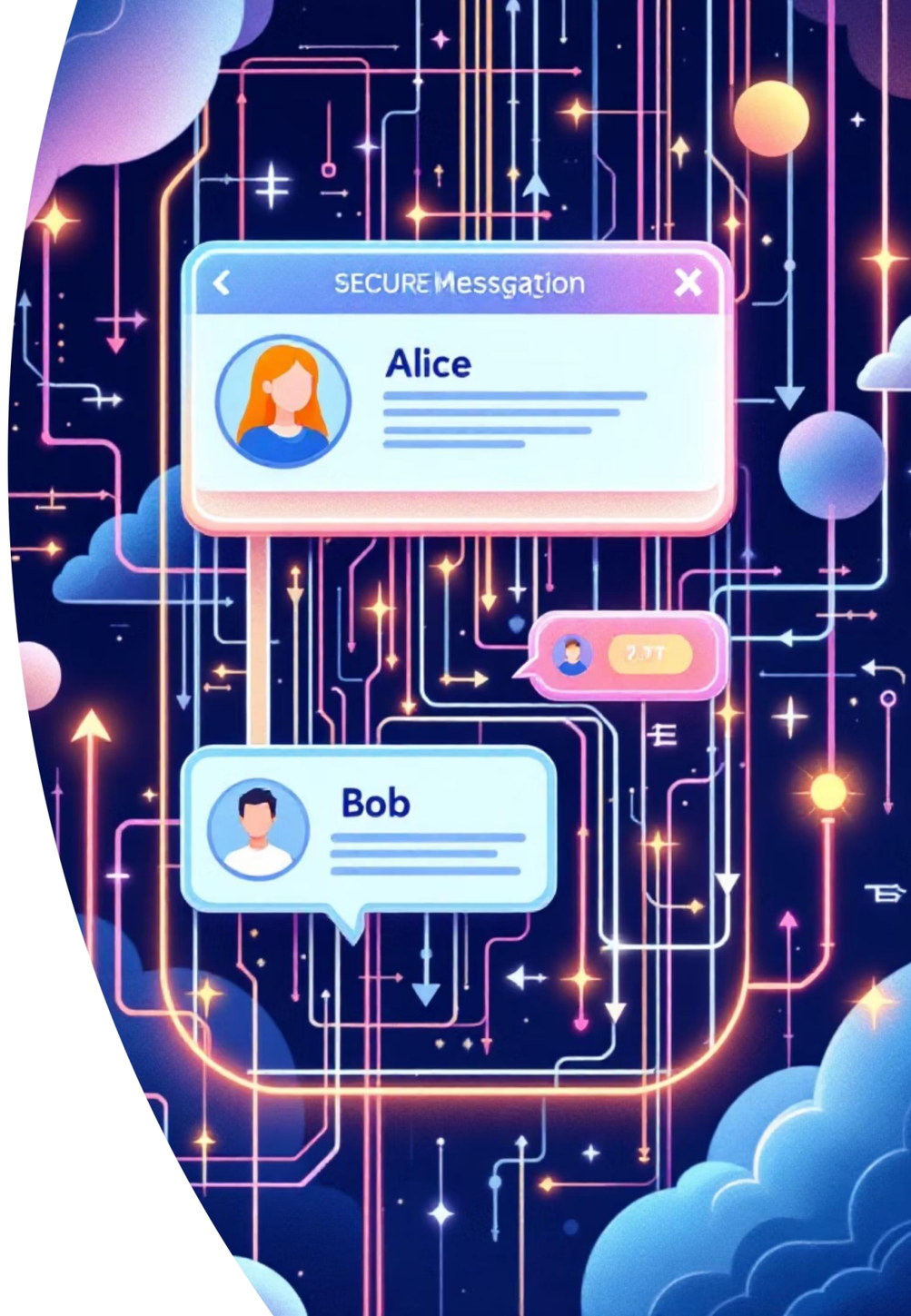
To move beyond raw numbers and create a visual, interactive demonstration of our full proposed flowchart.

Goal

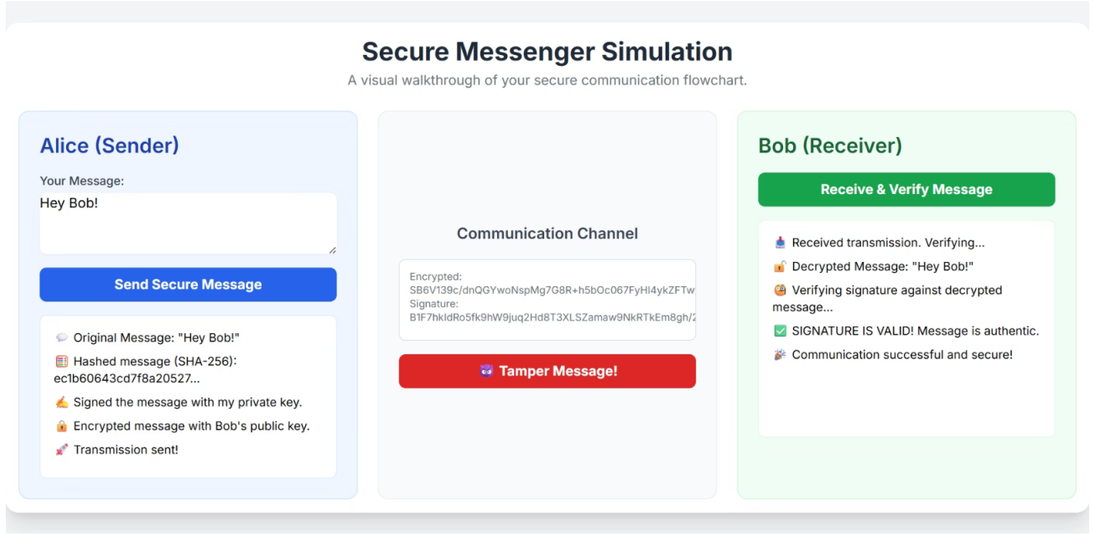
To build a web application that simulates a secure conversation between "Alice" and "Bob," proving both confidentiality (encryption) and authenticity (signatures).

Tools

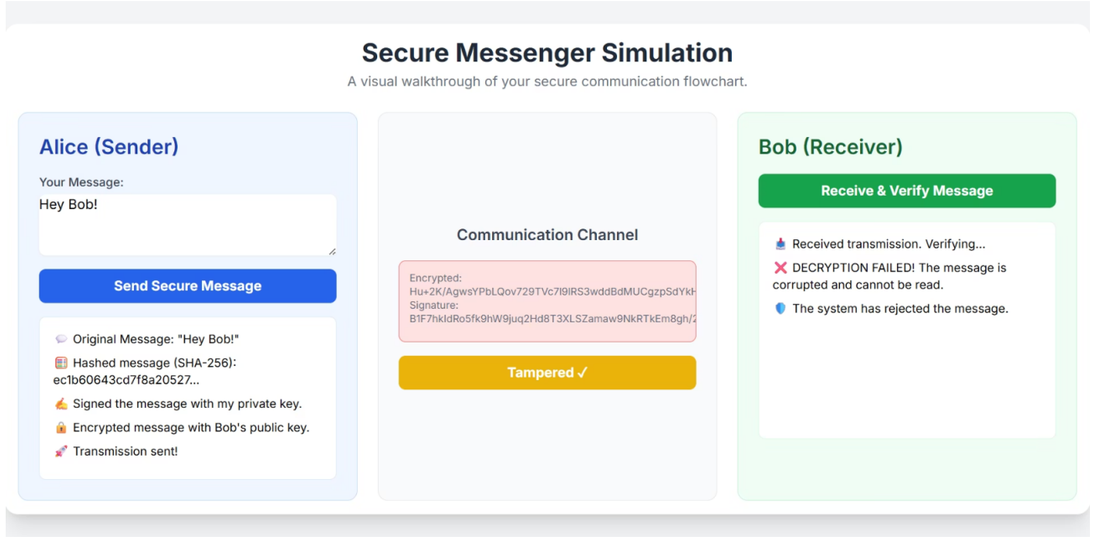
HTML, TailwindCSS, and the JSEncrypt & CryptoJS JavaScript libraries.



Live Demonstration



Scenario 1: Successful Communication



Scenario 2: Man-in-the-Middle Attack

Demonstration Walkthrough

Scenario 1: Successful Communication

1

Step 1

Alice types a message.

2

Step 2

She clicks "Send," which signs the message with her private key and encrypts it with Bob's public key.

3

Step 3

Bob receives the garbled ciphertext.

4

Step 4

He clicks "Receive & Verify," which decrypts the message with his private key.

5

Step 5

The system then verifies the signature using Alice's public key.

Result: ☑ The signature is valid. The message is authentic