HUST

ĐẠI HỌC BÁCH KHOA HÀ NỘI

HANOI UNIVERSITY OF SCIENCE AND TECHNOLOGY

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Apply Cryptography

GROUP 15
Bùi Duy Anh - 20225563
Chu Trung Anh - 20225564
Phạm Minh Tiến - 20225555

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Project 1:
Password Manager

1. Project 1: Password Manager

1.1 Motivation:

- **Problem:** Users often use weak passwords and find it difficult to remember many strong ones.
- **Solution:** A Password Manager helps store and retrieve strong, unique passwords for each service.
- **Challenge:** Ensuring security when storing sensitive data.
    -

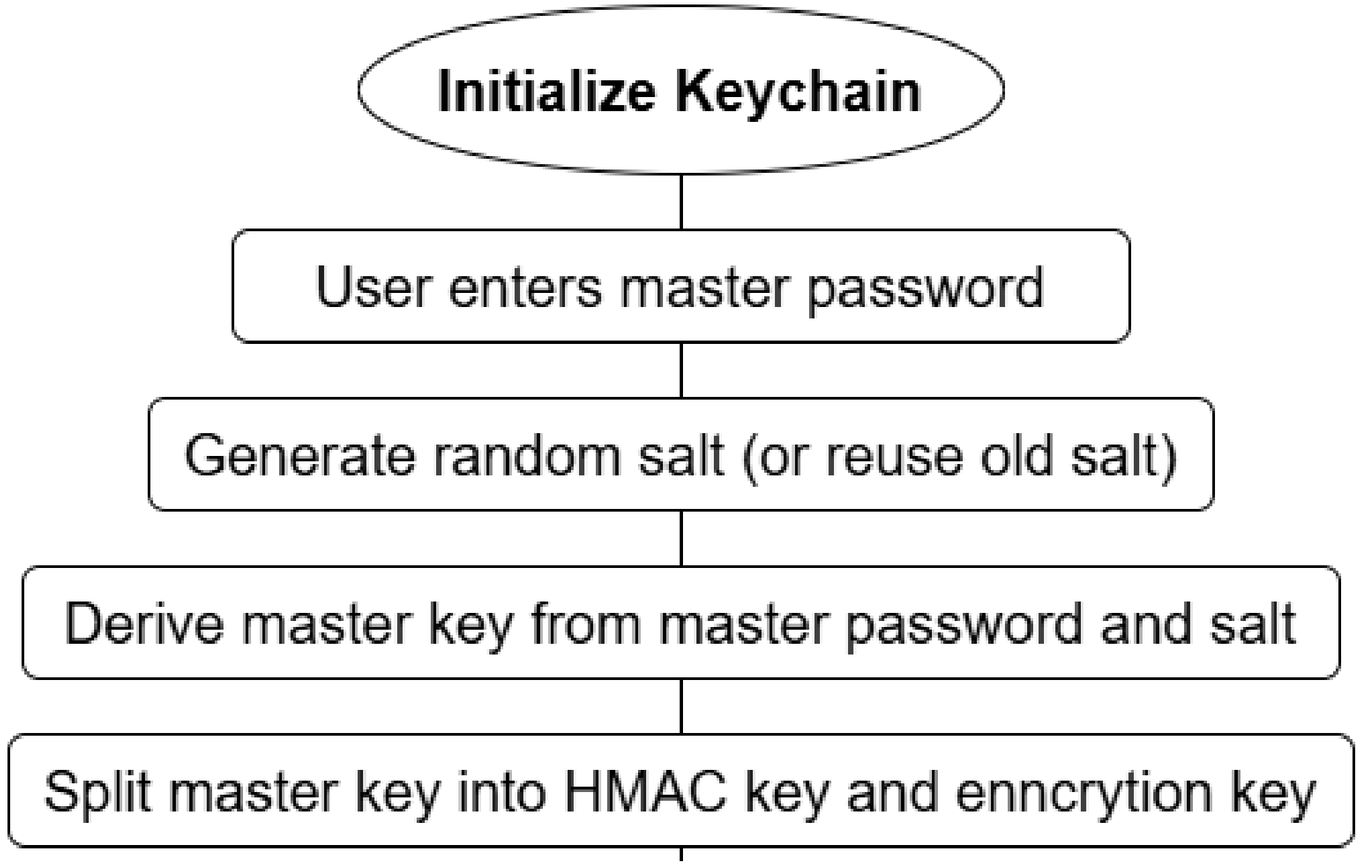
1. Project 1: Password Manager

1.1 Overview:

- **Object:** password manager
- **Motivation:**
- **Encryption and hashing methods:**
  - PBKDF2 + Salt: Anti brute-force, rainbow table.
  - HMAC domain: Hide real domain, anti guessing.
  - AES-GCM: Password encryption, anti modification.

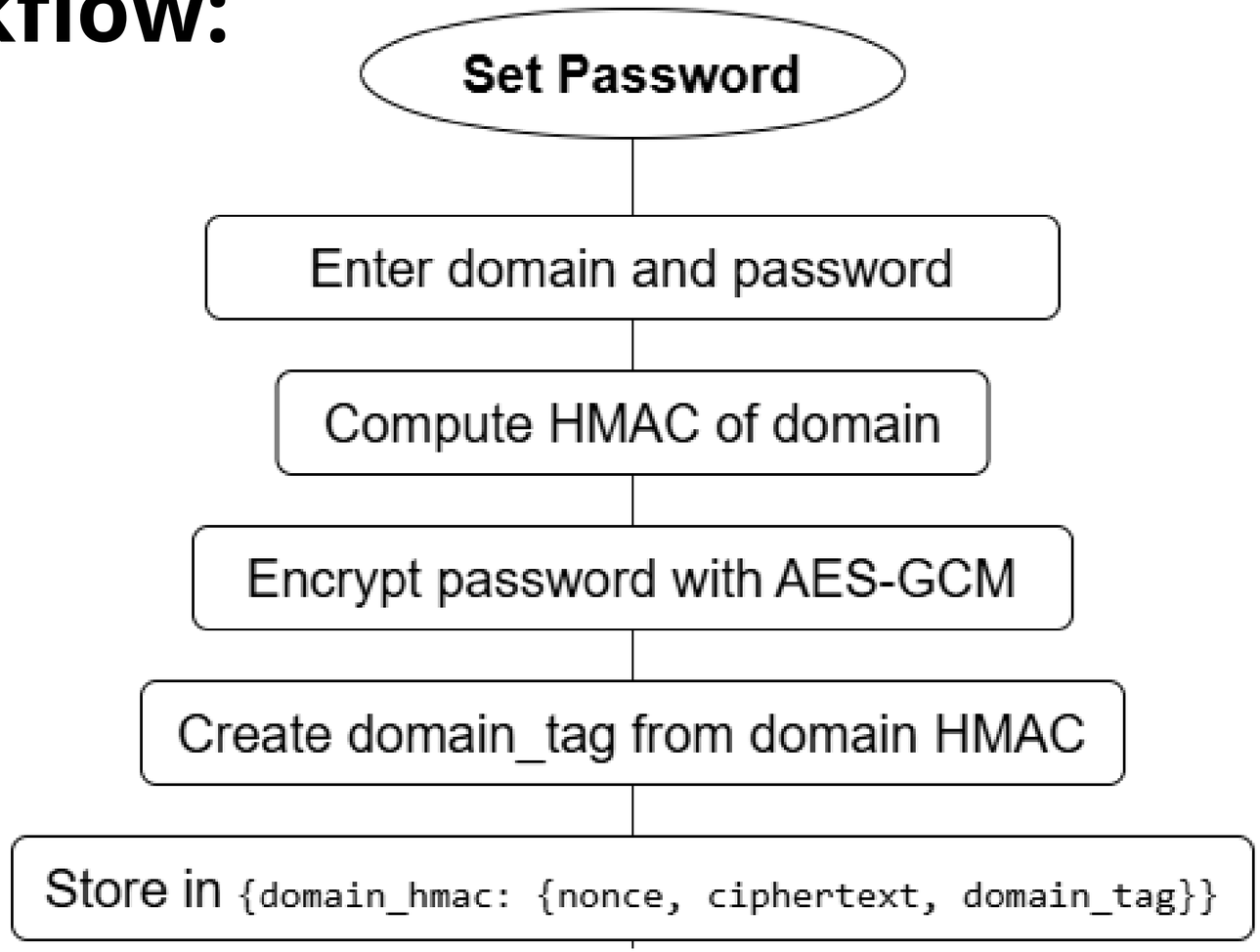
1. Project 1

1.2 Workflow:



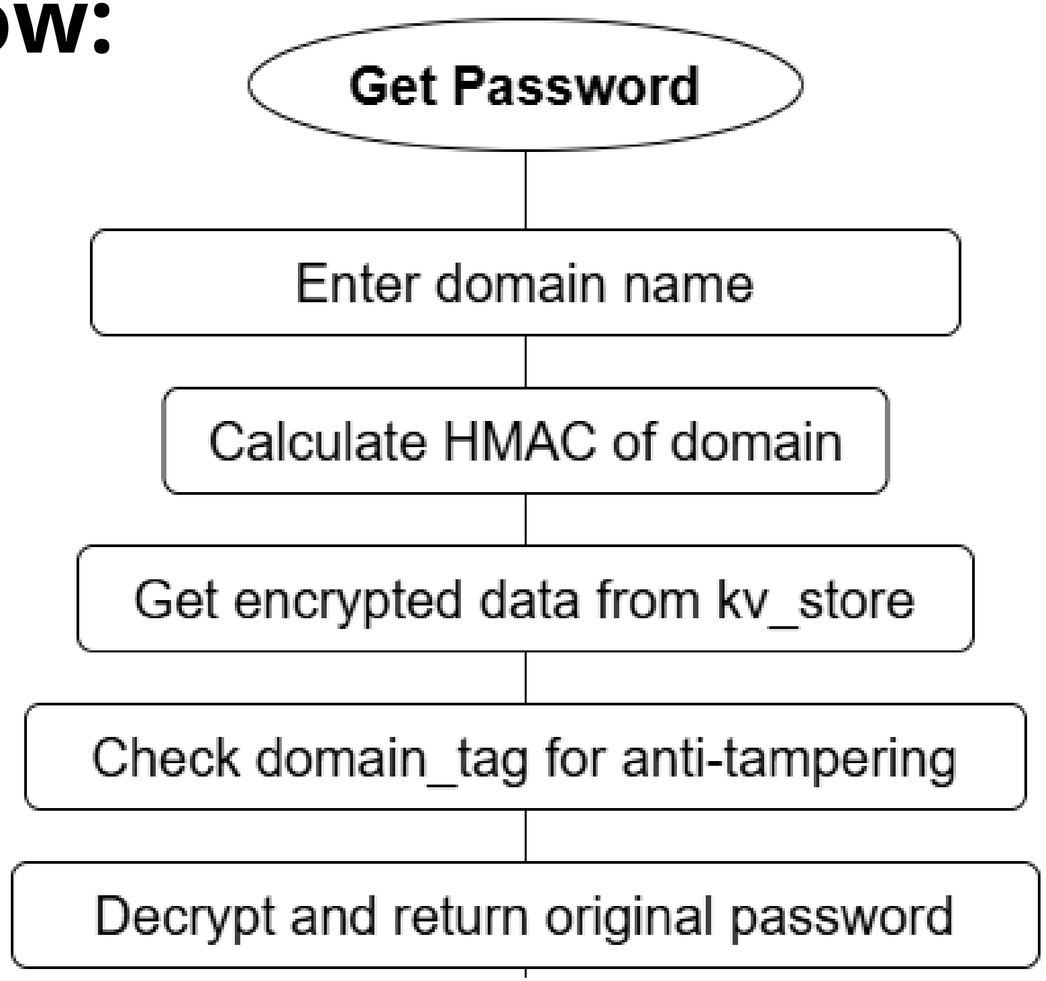
1. Project 1

1.2 Workflow:



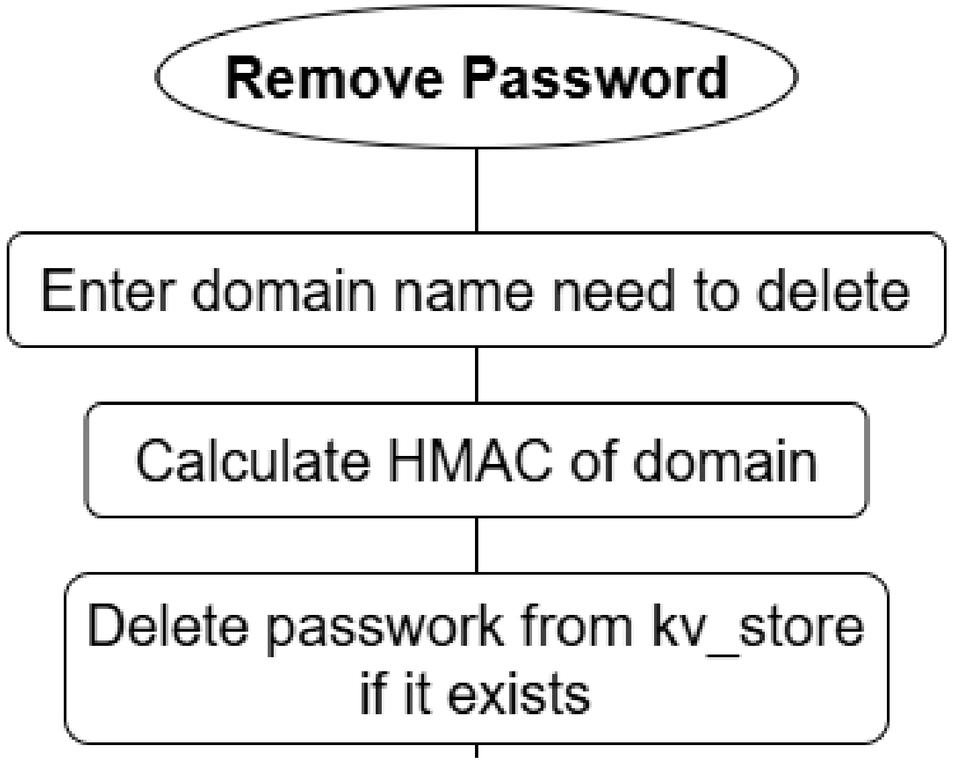
1. Project 1

1.2 Workflow:



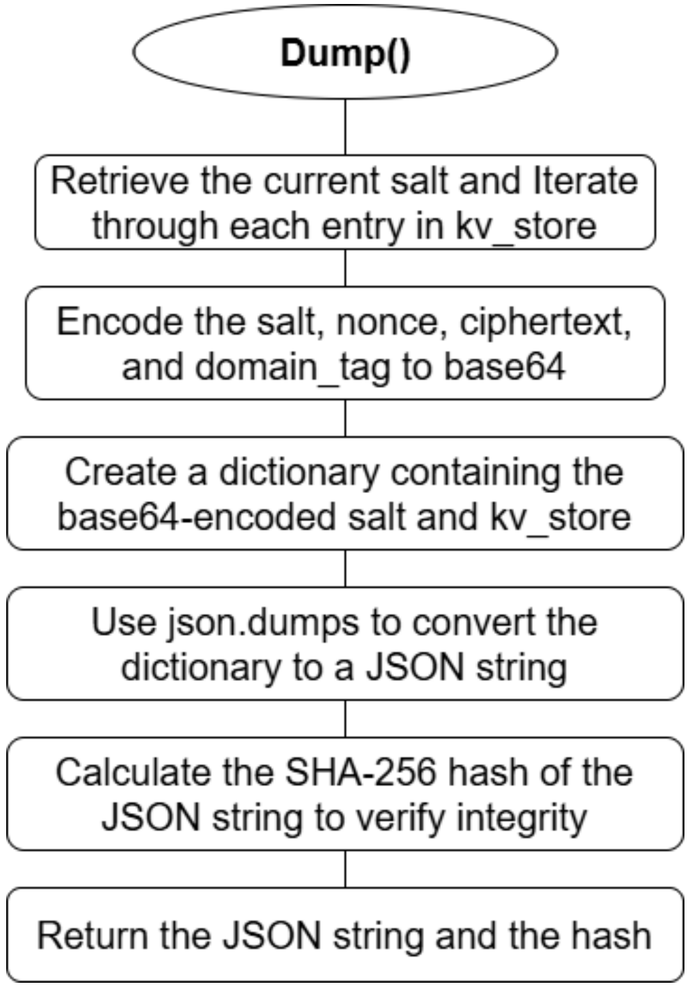
1. Project 1

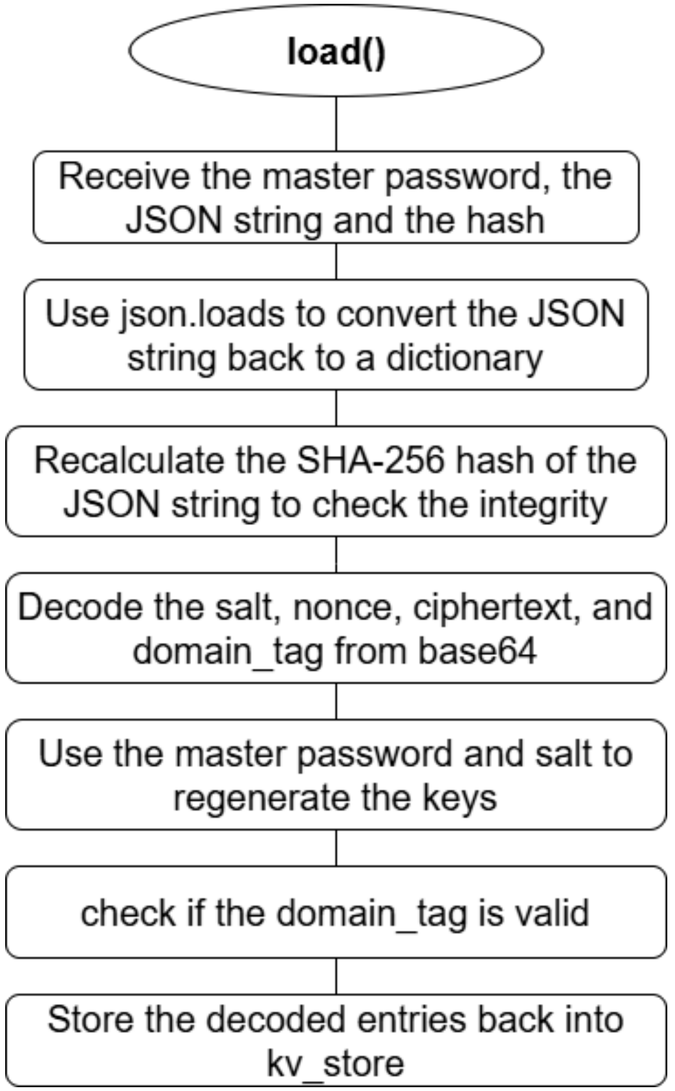
1.2 Workflow:



1. Project 1

1.2 Workflow:





1. Project 1: Password Manager

- **Store key- value**

```
self.kv_store = {} if kv_store is None else kv_store
```

```
{
    "Qk1vZ2F6d2VqR3p3b2t3b2t3b2t3b2t3b2t3b2t3b2t3b2t3b2t3b2t3b2t3b2t3b2t3b2t3b2t3b2t3b2t3b2t3": {
        "nonce": "...",
        "ciphertext": "...",
        "domain_tag": "..."
    },
    "Rk5vZ2F6d2VqR3p3b2t3b2t3b2t3b2t3b2t3b2t3b2t3b2t3b2t3b2t3b2t3b2t3b2t3b2t3b2t3b2t3b2t3b2t3": {
        "nonce": "...",
        "ciphertext": "...",
        "domain_tag": "..."
    }
}
```

1. Project 1: Password Manager

- **Domain name**

```
def _compute_domain_hmac(self, domain):
    ...
    domain_hmac = h.finalize()
    return base64.b64encode(domain_hmac).decode('utf-8')
```

- **Encrypt**

```
# Encrypt the password
aesgcm = AESGCM(self.encryption_key)
# Use domain_hmac as associated data to bind the ciphertext to the domain
ciphertext = aesgcm.encrypt(nonce, padded_password, domain_hmac.encode('utf-8'))
```

1. Project 1: Password Manager

- **Key derive**

```
def _derive_master_key(self, master_password):
    kdf = PBKDF2HMAC(...)
    master_key = kdf.derive(master_password.encode('utf-8'))
    return master_key
def _derive_sub_keys(self, master_key):
    ...
    hmac_key = h1.finalize()
    encryption_key = h2.finalize()
    return hmac_key, encryption_key
```

1. Project 1: Password Manager

- **Test**

```
PS C:\Users\Chu Trung Anh\Desktop\project1_ChuTrungAnh> pytest .\test_password_manager.py
============================= test session starts =============================
platform win32 -- Python 3.13.2, pytest-8.3.4, pluggy-1.5.0
rootdir: C:\Users\Chu Trung Anh\Desktop\project1_ChuTrungAnh
collected 11 items

test_password_manager.py ...........                                    [100%]

============================= 11 passed in 0.95s ==============================
```

1. Project 1: Password Manager

- **Swap attack**

```
# Verify the domain tag to prevent swap attacks
domain_tag = encrypted_data['domain_tag']
# Fix: Use the correct way to create HMAC with built-in hmac module
h = hmac_module.new(key=self.hmac_key, msg=domain_hmac.encode('utf-8'), digestmod='sha256')
computed_domain_tag = h.digest()

if not hmac_module.compare_digest(domain_tag, computed_domain_tag):
    raise ValueError("Swap attack detected: domain hash verification failed")
```

1. Project 1: Password Manager

Rollback attack

```
def dump(self):
    ...
    hash_value = self._compute_hash(serialized)
    return serialized, hash_value
def load(...):
    ...
    if trusted_data_check is not None:
        current_hash = Keychain._compute_hash(repr_str)
        if current_hash != trusted_data_check:
            raise ValueError("Integrity check failed: data may have been tampered with")
```

Project 2:
Chat Client

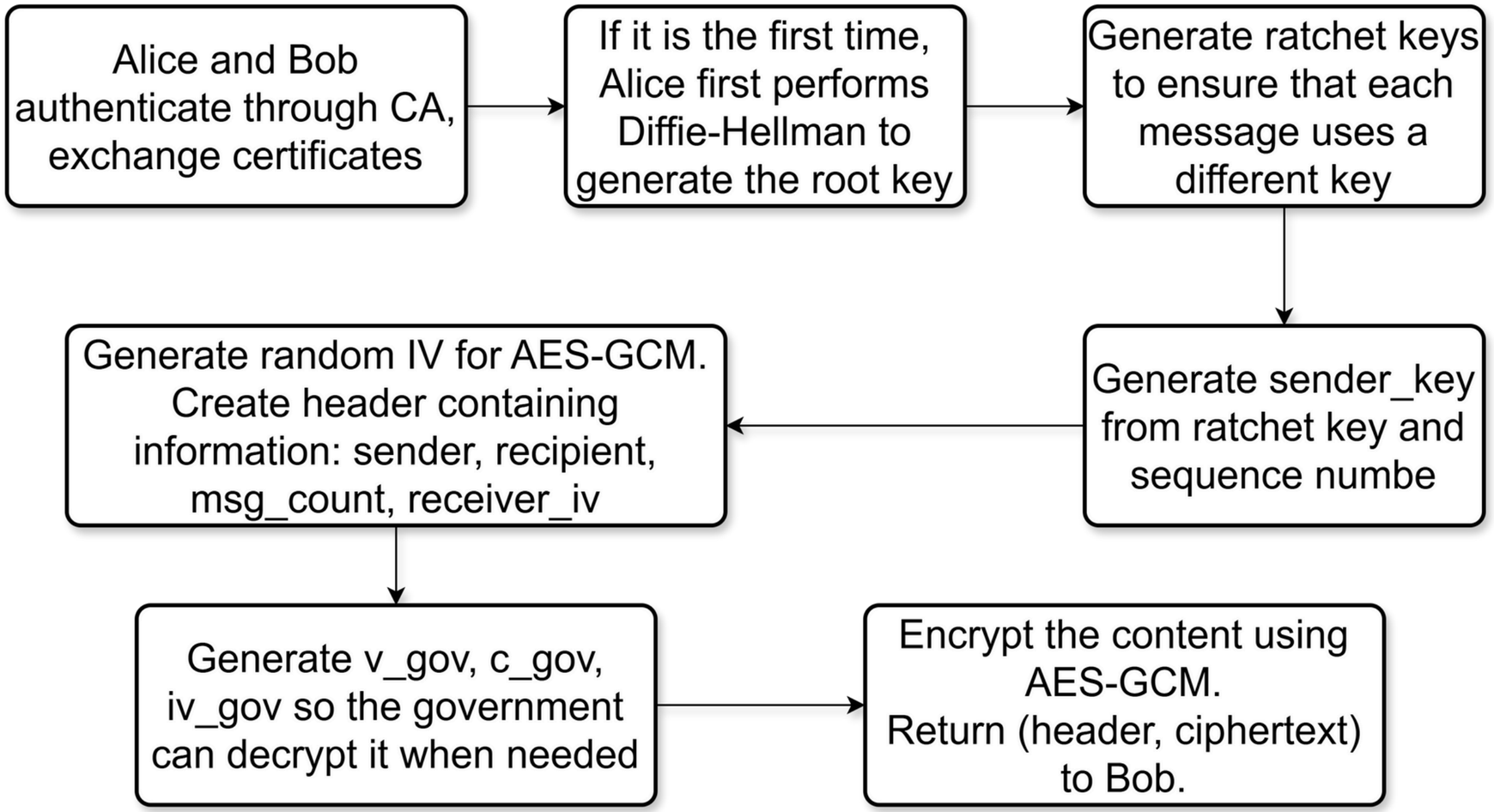
2. Project 2: Chat Client

2.1. Overview:

- **Object:** a secure messaging system between multiple users
- **Components:**
  - User (Messenger Client)
  - Certificate Authority (CA)
  - Government (Gov)
  - Cryptography library (lib.py)

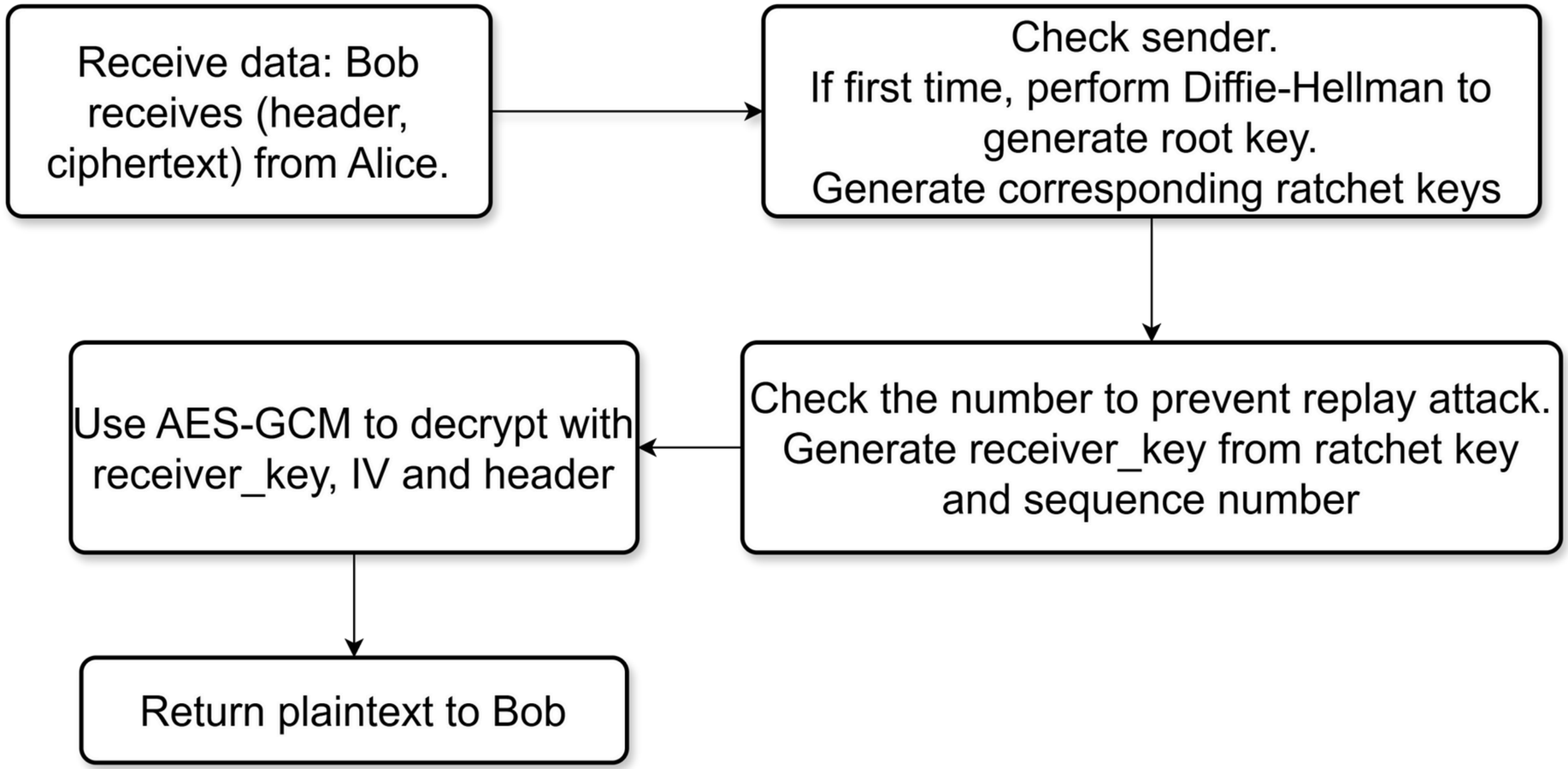
2. Project 2

2.2. Message Sending Process:



2. Project 2

2.3 Message Receiving Process:



2. Project 2

2.4. Cryptographic Techniques Used:

- **ECDSA:** Certificate authentication, ensuring no tampering.
- **Elliptic Curve DH:** Generate secure session keys, support forward secrecy.
- **HMAC & HKDF:** Derive session keys and ratchet keys from root key.
- **AES-GCM:** Message encryption and authentication (confidentiality + integrity).
- **Gov Escrow:** Header contains v_gov, c_gov, iv_gov allowing government to decrypt when needed.

Project 3:
P2P File Sharing

3. Project 3: P2P File Sharing

3.1. Overview:

- **Object:** Build a application allows users to log in, encrypt data, digitally sign files, and securely transfer files between computers over a network (can use ngrok to connect over the internet).
- **Fearture:**
  - File encryption to protect data.
  - Digital signature to authenticate file origin.
  - Supports multiple connection types: LAN, direct, ngrok tunnel.
  - User interface using tkinter.

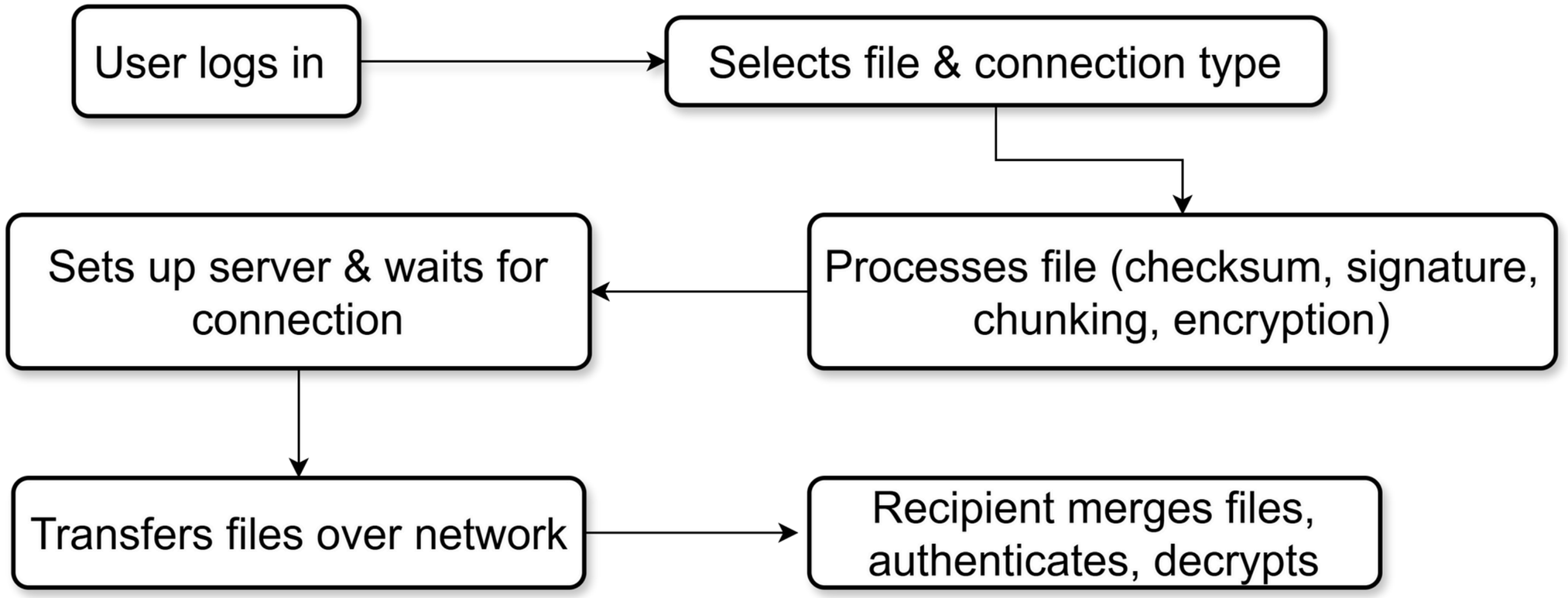
3. Project 3

3.2. Cryptographic Techniques Used:

- **AES (symmetric):** Encrypts file contents.
- **RSA (asymmetric):** Encrypts AES keys for secure transmission.
- **Elliptic Curve (digital signature):** Sign and authenticate files, ensuring integrity and origin authentication.

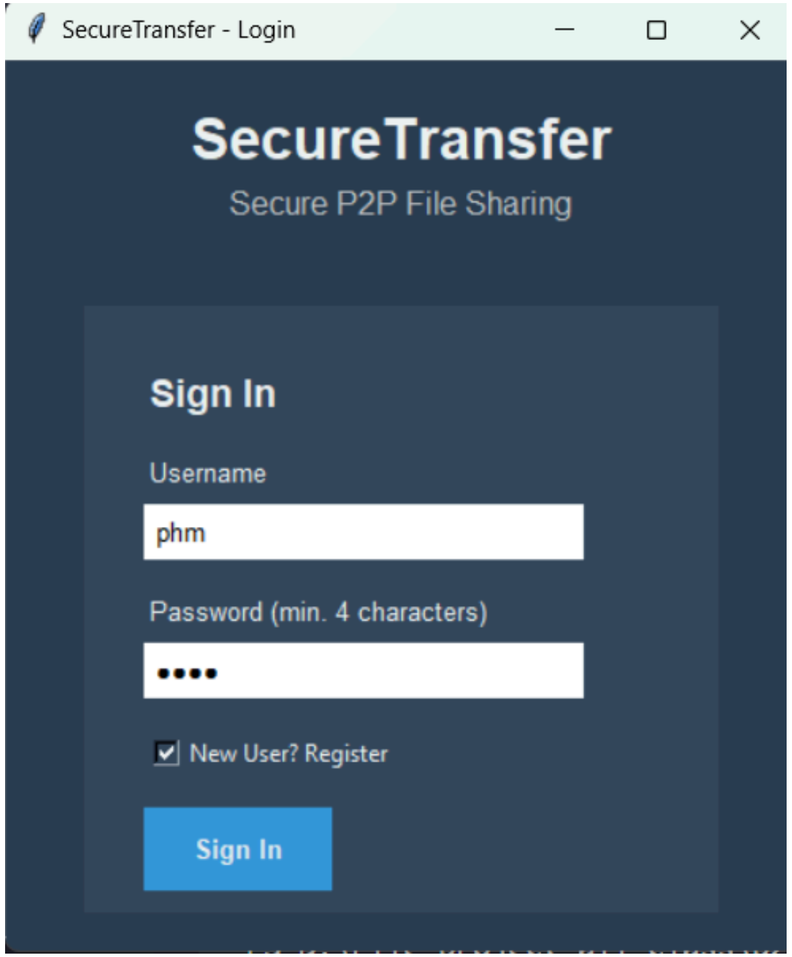
3. Project 3

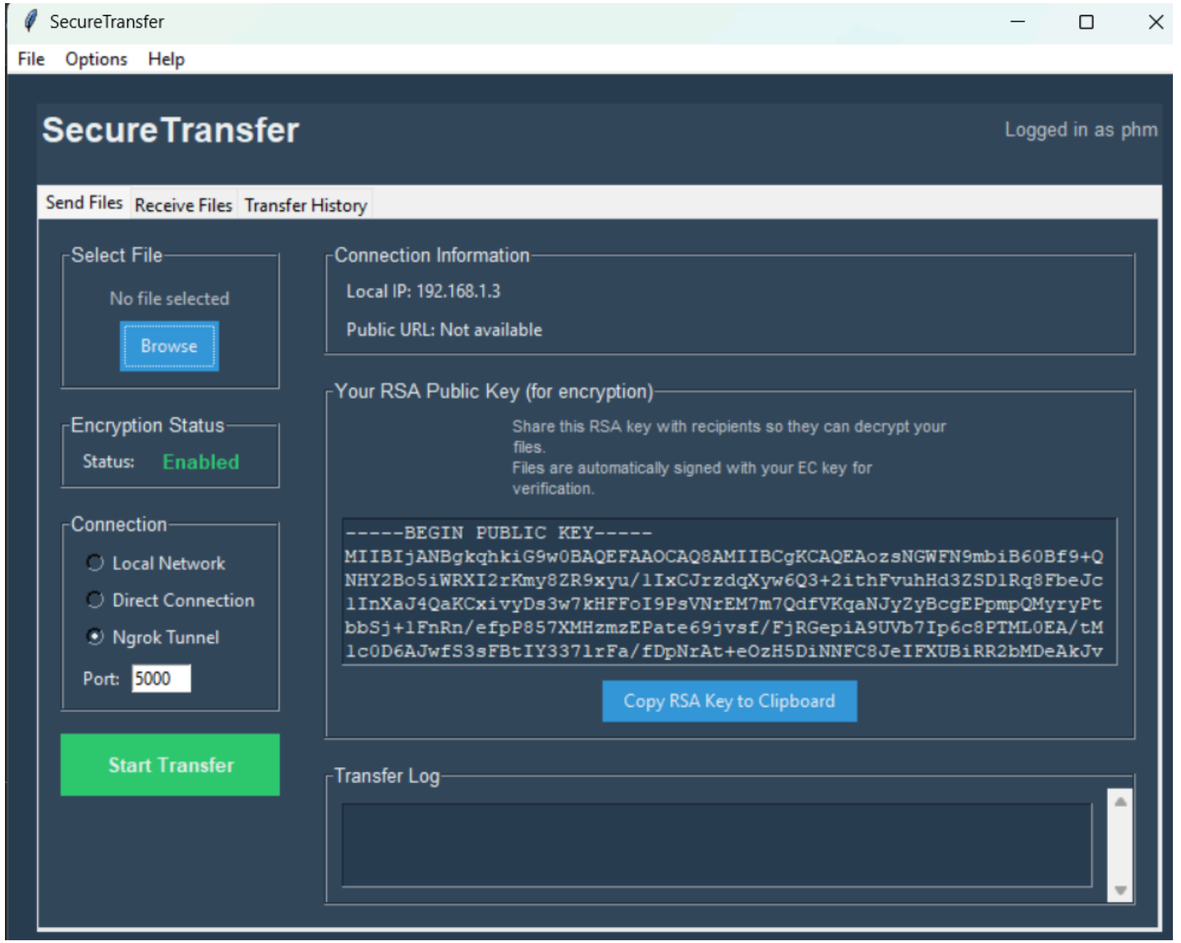
3.3. Workflow:



3. Project 3

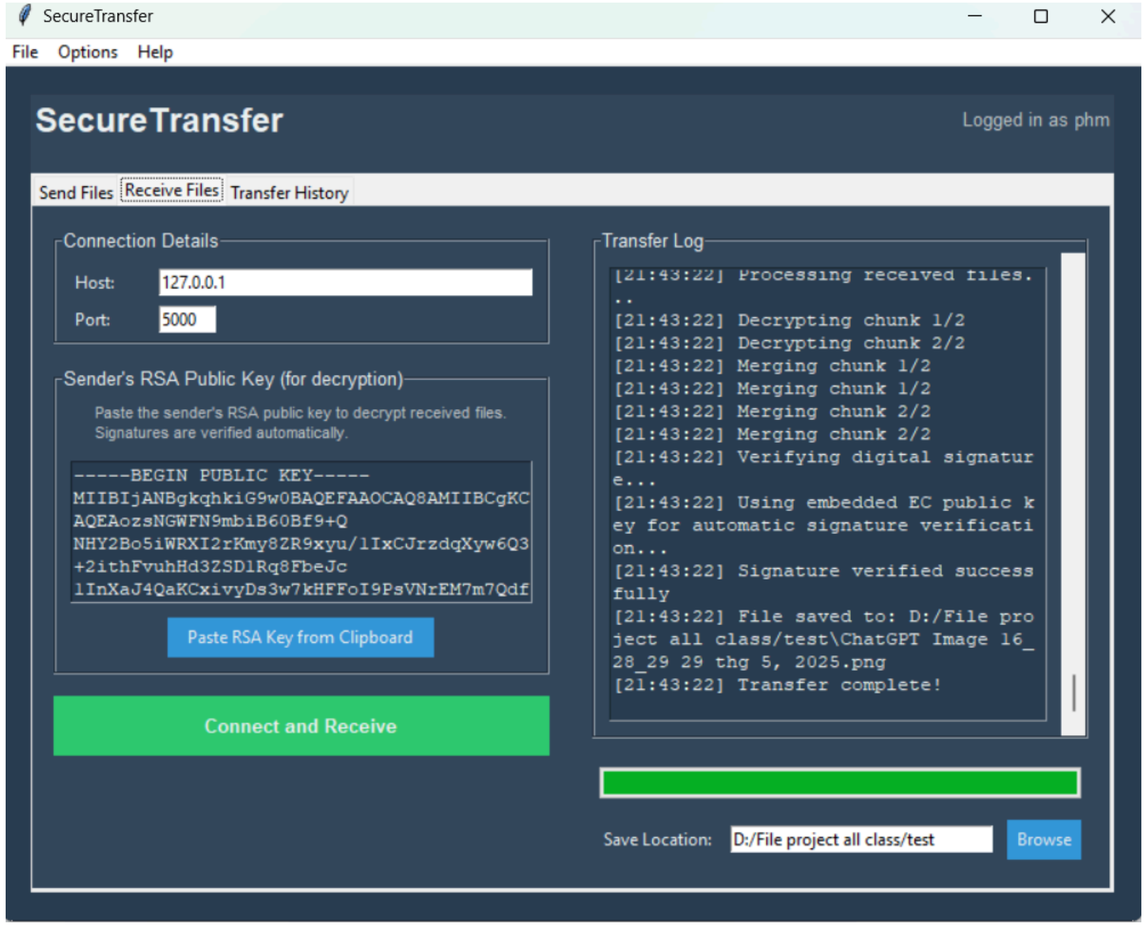
3.4. UI:

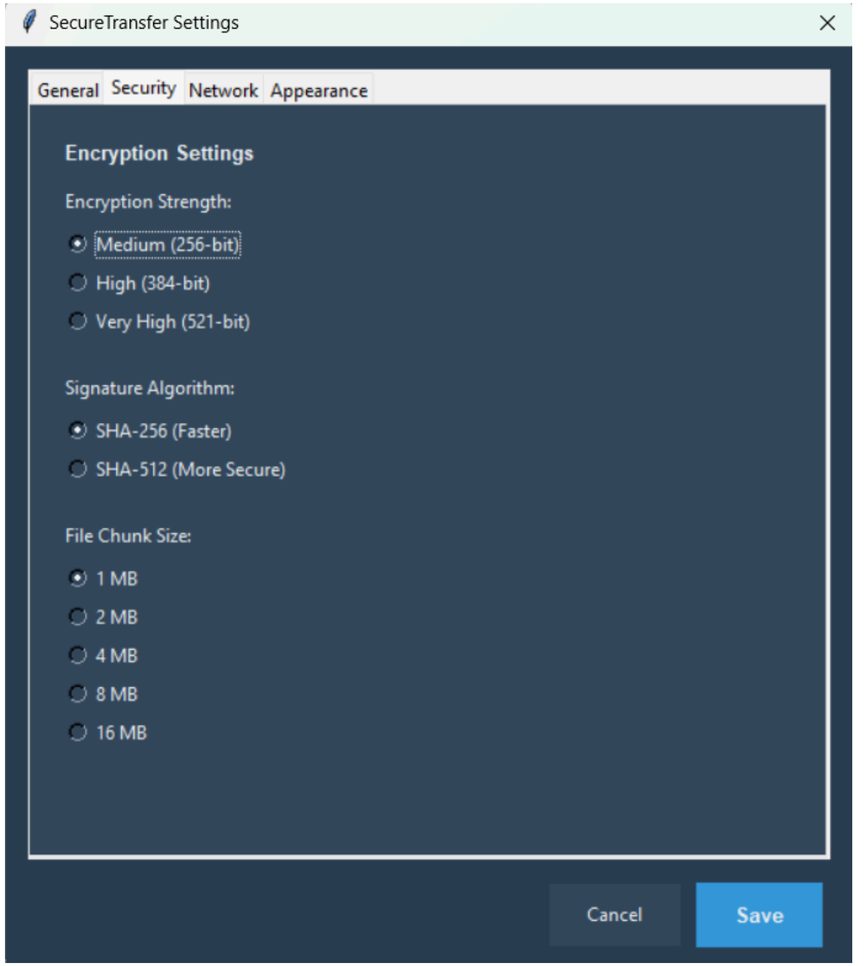




3. Project 3

3.4. UI:





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THANK YOU !