

Secure Connection Flow

This document explains how the `sender`, `unsecureTunnel`, and `receiver` establish a secure communication channel using a Hybrid Encryption scheme (RSA + AES).

Components

1. **Receiver (`receiver.py`)**: The server that holds the RSA Private Key and waits for messages.
2. **Unsecure Tunnel (`unsecureTunnel.py`)**: A "Man-in-the-Middle" proxy that forwards traffic between Sender and Receiver. It can see the traffic but cannot decrypt the secure messages.
3. **Sender (`sender.py`)**: The client that initiates the connection and sends encrypted messages.

Protocol Steps

1. Initialization (Receiver)

- **Action**: When `receiver.py` starts.
- **Operation**: It generates a fresh **RSA 2048-bit Key Pair** (Public Key and Private Key).
- **State**: The Receiver is now listening on port 65433.

2. Connection & Public Key Exchange

- **Action**: `sender.py` connects to `unsecureTunnel.py` (port 65432), which forwards the connection to `receiver.py`.
- **Handshake**:
 1. **Receiver** immediately sends its **RSA Public Key** (in PEM format) to the **Sender**.
 2. **Sender** receives and loads the Public Key.
 - *Note: The Tunnel sees this Public Key, but it is public information.*

3. Session Key Exchange (Hybrid Encryption)

- **Goal**: Establish a shared symmetric key for fast encryption (AES).
- **Action**:
 1. **Sender** generates an **AES session key** using the Collatz-based generator in `key_generator.py` (`generate_key_bytes(16)`).
 2. **Sender** encrypts this AES Key using the **Receiver's RSA Public Key** (using OAEP padding with SHA-256).
 3. **Sender** sends the encrypted key with the prefix **KEY**: (e.g., `KEY:<Base64 Encrypted Data>`).
 4. **Receiver** receives the message, extracts the payload, and decrypts it using its **RSA Private Key**.
- **Result**: Both Sender and Receiver now possess the same **AES Key**. The Tunnel only saw the encrypted blob and cannot derive the key.

4. Secure Messaging

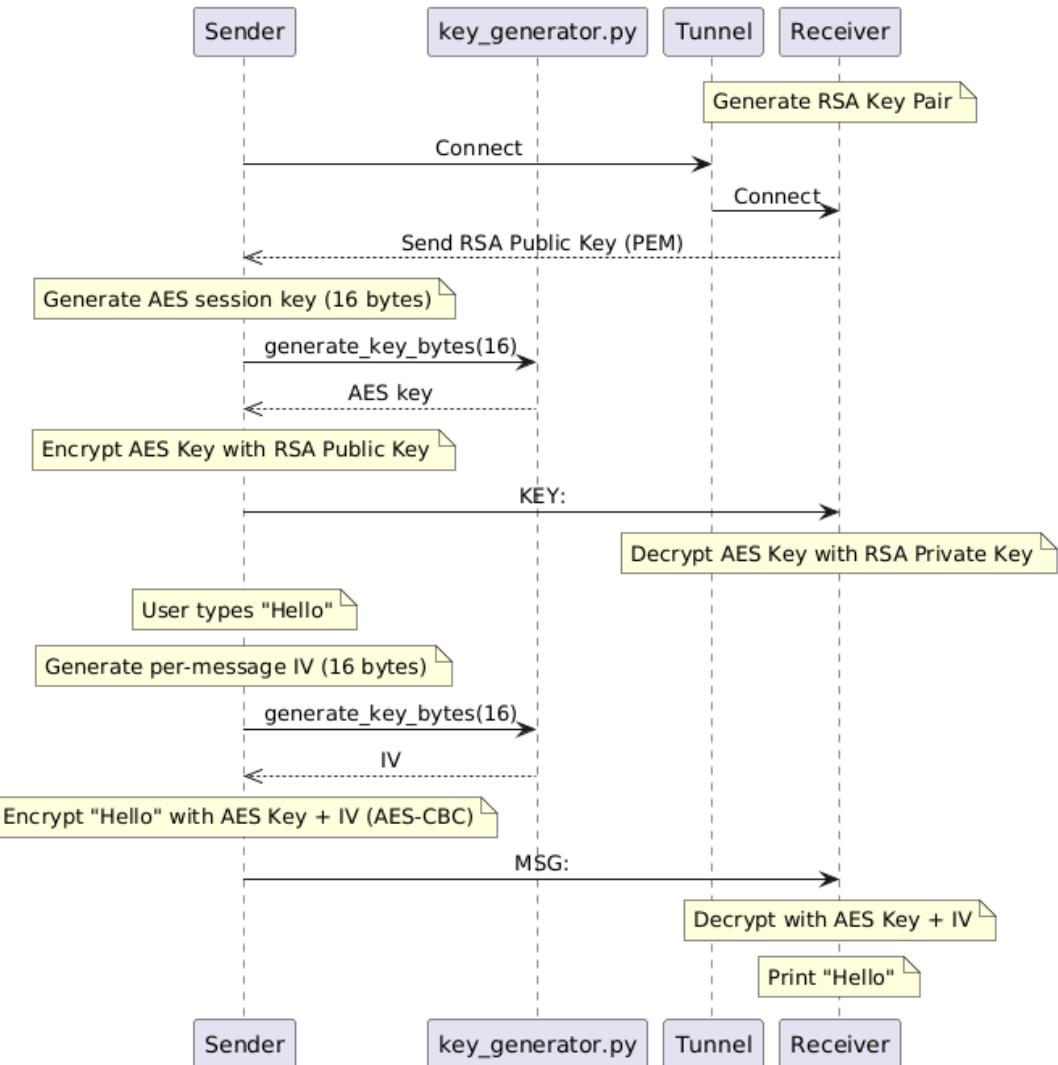
- **Action:** User types a message in the Sender terminal.
- **Encryption (Sender):**
 1. Generates a **16-byte IV** (Initialization Vector) for this specific message using the Collatz-based generator (`generate_key_bytes(16)`).
 2. Pads the message to be a multiple of 16 bytes (AES block size).
 3. Encrypts the message using **AES-CBC Mode** with the Session Key and IV.
 4. Concatenates IV + Ciphertext.
 5. Encodes the result in Base64.
 6. Sends MSG:<Base64 Payload>.
- **Forwarding:** The Tunnel logs the message MSG: . . . but sees only gibberish.
- **Decryption (Receiver):**
 1. Decodes the Base64 payload.
 2. Extracts the first 16 bytes as the **IV**.
 3. Decrypts the rest using **AES-CBC** with the Session Key and extracted IV.
 4. Unpads the result to get the original plaintext.
 5. Prints the decrypted message.

What is an IV (Initialization Vector)?

An **IV** is a per-message value used by CBC mode.

- **Why it exists:** It prevents identical plaintext messages encrypted with the same key from producing identical ciphertext.
- **Is it secret?** No. The IV is sent along with the ciphertext so the receiver can decrypt.
- **In this project:** The IV is the **first 16 bytes** of the MSG: payload (IV + Ciphertext).

Diagram



Notes / Limitations

- This demonstrates a **hybrid encryption** idea (RSA for key exchange + symmetric cipher for data).
- AES is widely used in practice; this project still uses **AES-CBC** for learning/demo purposes.
- The Tunnel can see all traffic (public key, encrypted AES key, encrypted messages) but cannot decrypt without the RSA private key or AES session key.