SAVEETHA SCHOOL OF ENGINEERING

SAVEETHA INSTITUTE OF MEDICAL AND TECHNICAL SCIENCES

CHENNAI-602105

A CAPSTONE PROJECT REPORT

on

Implement secure client-server text communication with port config and packet monitoring.

Submitted in the partial fulfilment for the award of the degree of

BACHELOR OF ENGINEERING

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

Submitted by

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COURSE: CSA0720 - COMPUTER NETWORKS FOR DATA COMMUNICATION

Under the Supervision of

Dr. G. KUMARAN

JULY 2025

SIMATS ENGINEERING
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DECLARATION

We, **[Prince Raj.N, Ravi Teja.M, Saran.S]**of the **[ECE Department],** Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, hereby declare that the Capstone Project Work entitled **'[Implement secure client-server text communication with port config and packet monitoring.]**' is the result of our own bonafide efforts. To the best of our knowledge, the work presented herein is original, accurate, and has been carried out in accordance with principles of engineering ethics.

Place:

Date:

Signature of the Students with Names

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Engineer to Excel

BONAFIDE CERTIFICATE

This is to certify that the Capstone Project entitled "[**Implement secure client-server text communication with port config and packet monitoring]** " has been carried out by **[Prince Raj.N, Ravi Teja. M, Saran. S**]under the supervision of [**Dr.G.Kumaran**] and is submitted in partial fulfilment of the requirements for the current semester of the B.Tech [**ECE**] program at Saveetha Institute of Medical and Technical Sciences, Chennai.

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INTERNAL EXAMINER

EXTERNAL EXAMINER

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ABSTRACT

In the modern digital landscape, secure and efficient communication over networks is paramount. This project aims to develop a secure client-server text communication system with configurable port settings and real-time packet monitoring features. The system is designed using socket programming in Python, enabling full-duplex communication between client and server within a local area network (LAN). To ensure message confidentiality and integrity, Advanced Encryption Standard (AES) encryption is implemented.

A graphical user interface (GUI) using Tkinter enhances user experience by providing intuitive controls for message exchange, port configuration, and encryption key setup. Packet monitoring is integrated using tools such as Wireshark or custom Python-based logging, allowing users to inspect incoming and outgoing packets for debugging and network analysis. This feature helps detect unauthorized access or anomalies during communication.

The project demonstrates the principles of secure data transmission, cryptographic handling, and network traffic inspection. It finds applications in secure LAN messaging systems, academic labs, and corporate intranet environments where controlled, encrypted communication is essential.This project demonstrates practical implementation of secure communication principles and provides insights into network traffic behavior under encrypted messaging scenarios. It serves as an educational tool for learning about socket-based communication, cryptographic security, and real-time monitoring — with potential applications in secure internal messaging systems for educational institutions, corporate offices, or research environments.

KEYWORDS

Secure Communication, Client-Server Architecture, Socket Programming, AES Encryption, Port Configuration, Packet Monitoring, LAN Messaging, Network Security, Real-time Communication, Python Programming, Tkinter GUI, Intrusion Detection, Message Encryption, Network Traffic Analysis, Cybersecurity.

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CHAPTER 1: INTRODUCTION

1.1Background Information

In today's increasingly connected world, secure communication over digital networks is more critical than ever. Whether it's an enterprise setting, academic environment, or a simple local area network (LAN), users need reliable systems that not only transmit information effectively but also protect the data from unauthorized access. One common method of establishing communication is through the client-server architecture, where a central server handles requests and connections from multiple clients. While this structure is efficient and widely used, it often lacks built-in security features and transparency in how data is transmitted. Without encryption, any text messages sent over a network can be intercepted and read using simple packet sniffing tools. Additionally, without packet monitoring or proper configuration, such systems are vulnerable to cyber-attacks, such as port scanning, spoofing, or data injection. This project addresses these gaps by integrating encryption, port configurability, and packet monitoring into a custom-built Python-based text communication system.

1.2 Project Objectives

The primary goal of this project is to create a secure, configurable, and monitorable communication system that uses the client-server model. Specifically, the objectives include:
Developing a text-based communication system between a client and a server using socket programming in Python. **Implementing AES (Advanced Encryption Standard) encryption** to ensure the confidentiality of transmitted messages. **Allowing users to configure communication ports**, enhancing control and flexibility over the network setup. **Integrating packet monitoring capabilities** to inspect and analyze network traffic in real-time using tools like Wireshark or Python-based logging. **Creating a simple, user-friendly GUI** using Tkinter, enabling users to send, receive, and monitor secure messages without complex command-line interaction.

1.3 Significance

This project holds strong relevance in both educational and professional settings, particularly where secure internal communication is required. It demonstrates how basic networking principles can be combined with encryption techniques to build a secure application that

protects data from eavesdropping or tampering. Moreover, the inclusion of port configuration gives users administrative control, reducing risks associated with static or default port use. Real-time packet monitoring is also a key feature that adds a layer of transparency and allows users to observe the behavior of their network. In academic settings, this project serves as a practical example of integrating cybersecurity, encryption, and networking. In small organizations or labs, it can be used as a lightweight LAN messaging system that ensures data privacy.

1.4 Scope

The scope of this project is limited to **text-based messaging within a local area network (LAN)**. It is not designed for large-scale internet deployment, though the architecture allows for future extension with additional security layers like public-key infrastructure or VPN tunneling. The communication system focuses on implementing **symmetric encryption (AES)** for simplicity and speed. While packet monitoring is included, it is **passive**, meaning it only captures and displays information without modifying the traffic. The GUI is basic but effective, supporting real-time encrypted messaging, port selection, and connection status. The project does not handle audio, video, or file transfer but sets a strong foundation for secure LAN-based communication systems.

1.5 Methodology Overview

The scope of this project is limited to **text-based messaging within a local area network (LAN)**. It is not designed for large-scale internet deployment, though the architecture allows for future extension with additional security layers like public-key infrastructure or VPN tunneling. The communication system focuses on implementing **symmetric encryption (AES)** for simplicity and speed. While packet monitoring is included, it is **passive**, meaning it only captures and displays information without modifying the traffic. The GUI is basic but effective, supporting real-time encrypted messaging, port selection, and connection status. The project does not handle audio, video, or file transfer but sets a strong foundation for secure LAN-based communication systems.

CHAPTER 2: PROBLEM IDENTIFICATION AND ANALYSIS

2.1. Description of the problem

In most LAN-based communication systems, data is transmitted in plaintext or with minimal security, making it vulnerable to interception, unauthorized access, or manipulation. Many small organizations, schools, and labs rely on basic client-server models that lack encryption and fail to provide any insight into packet-level data transmission. Moreover, these systems often use hardcoded or default ports, which can easily be targeted by attackers. The absence of secure communication protocols and traffic visibility poses a serious risk to confidentiality, integrity, and system control. This problem becomes more pressing when such systems are used to exchange sensitive or internal information.

2.2. Evidence of the problem

Numerous real-world cases highlight the vulnerabilities of unsecured client-server systems. Network sniffing tools like **Wireshark**, **Ettercap**, or **tcpdump** can easily capture plaintext messages transmitted across a LAN. Studies and classroom lab environments have shown that unencrypted sockets in Python or C/C++ can transmit readable data packets, even without elevated privileges. Cybersecurity reports consistently indicate that **open and unmonitored ports** are among the top vulnerabilities exploited by attackers to gain network access. Additionally, educational institutions using simple LAN messaging tools have experienced unauthorized message interception and spoofing, reinforcing the need for encrypted communication and port control.

2.3. Stakeholders

- **Students and Academic Institutions**: Educational environments using LANs for classroom communication or lab coordination need a simple yet secure system to prevent eavesdropping or message manipulation.

- **Network Administrators**: Admins managing small-scale or internal networks require configurable port settings and packet-level monitoring to maintain network hygiene and detect intrusions.

- **Developers and Cybersecurity Learners**: This project offers a learning opportunity for those looking to understand encryption, socket programming, and traffic analysis.

- **Organizations and Offices with Local Networks**: Small offices relying on internal communication systems can benefit from enhanced privacy and traffic visibility.

2.4. Supporting Research

Research in the field of network security emphasizes the critical importance of data encryption and monitoring. According to the **SANS Institute**, unencrypted protocols over LANs are a primary target for internal threat actors. A study from **IEEE Communications Surveys & Tutorials** shows that **over 60% of internal data breaches** occur due to the lack of basic encryption or traffic control measures. Moreover, a paper published in the **International Journal of Network Security & Its Applications (IJNSA)** highlighted the ease with which attackers can access data from traditional socket communication without proper safeguards. These findings support the need for this project, which combines **AES encryption, dynamic port management, and real-time monitoring** to solve a problem that is often underestimated in smaller or local network environments.

According to the **Verizon Data Breach Investigations Report (DBIR) 2023**, **74% of breaches involved human error, misconfigured systems, or lack of security in local services**. This underlines the urgent need for even small-scale systems to implement basic encryption and monitoring to prevent internal misuse or accidental data leaks.

A 2020 study in the *Journal of Cybersecurity Technology* analyzed small office and educational LAN environments and concluded that **real-time packet monitoring helped detect anomalies such as IP spoofing, unexpected data bursts, and unauthorized port usage**. Packet sniffers such as Wireshark, combined with Python-based logging, were proven effective for educational and low-cost solutions.

CHAPTER 3: SOLUTION DESIGN AND IMPLEMENTATION

The system is built using Python's socket programming to establish secure client-server communication over a user-defined port. AES encryption is used to protect text messages, ensuring confidentiality during transmission. A Tkinter-based GUI enables users to send and receive messages with ease, while allowing dynamic port configuration. Packet monitoring is integrated using Wireshark or Python-based sniffers to observe real-time traffic. The client and server run on separate threads to support simultaneous send/receive operations, ensuring smooth and secure data exchange.

3.1 System Architecture Overview

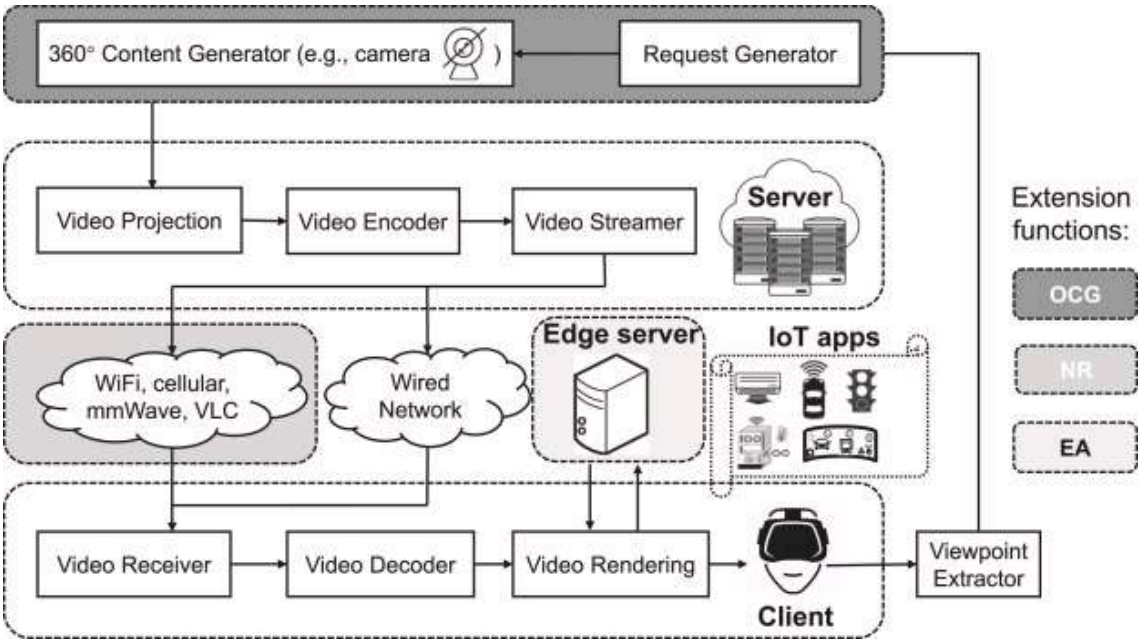


Fig 1: Server to client Workflow

The system follows a client-server architecture where both ends communicate using TCP sockets over a configurable port. Each message is encrypted using AES before transmission and decrypted upon receipt to ensure secure communication. The client and server modules run on multithreaded processes, enabling simultaneous send and receive operations. A graphical interface (Tkinter) handles user interactions, while background threads manage network traffic. Packet monitoring is performed in parallel using tools like Wireshark or Python sniffers to log and analyze data flow.

3.2 Module 1: Server Architecture

Problem Addressed:

1. Lack of secure communication in traditional LAN-based systems.
2. Inability to control or customize communication ports.
3. No way to monitor or filter incoming messages for security purposes.

Software Used:

1. Python (for socket programming and threading).
2. Tkinter (optional, for server status interface or logs).
3. Wireshark or Scapy (for packet monitoring and analysis).

Functionality:

1. Listens for client connections on a user-defined TCP port.
2. Handles message reception, decryption, and logging.
3. Manages multiple clients using threads (one handler per client).

Implementation Logic:

1. Server socket is initialized and bound to a selected port.
2. On connection, a new thread handles the client's encrypted messages.
3. Decrypted messages are processed, optionally logged, and sent back or routed.

3.3 Module 2: Client Module with GUI

Problem Addressed:

1. Difficulty for users to interact with text-based socket programs.
2. Lack of encryption in basic client-side communication.
3. No real-time message display or user feedback in terminal-based systems.

Software Used:

1. Python (for client socket and encryption handling).
2. Tkinter (for graphical user interface).
3. PyCryptodome (for AES encryption and decryption).

Functionality:

1. Allows users to input server IP, port, and send encrypted messages.
2. Displays real-time chat in a scrollable text area.
3. Enables secure two-way communication via GUI buttons and text fields.

Implementation Logic:

1. GUI initializes input fields for IP, port, and message.
2. On connect, the socket establishes a secure channel with AES.
3. A background thread receives messages and updates the GUI without blocking.

3.4 Module 3:Encryption and Logging

Problem Addressed:

1. Messages transmitted in plaintext are vulnerable to interception.
2. Lack of message integrity verification in basic socket programs.
3. No systematic logging for auditing or debugging communication.

Software Used:

1. PyCryptodome (for AES encryption and HMAC generation).
2. Python's `logging` module (for event and message logging).
3. Optional: Scapy or PyShark for deeper packet-level logging.

Functionality:

1. Encrypts all outgoing messages with AES before transmission.
2. Verifies message integrity using HMAC to prevent tampering.
3. Logs connection events, errors, and encrypted message summaries.

Implementation Logic:

1. Generates a random IV and encrypts the message using AES-CBC.
2. Computes HMAC for the encrypted data and appends it before sending.

3. On receive, logs timestamp, IP, port, and decrypted message if valid.

3.5 Prototype Construction

The prototype construction followed a structured, modular development approach to ensure clarity, reliability, and scalability. The initial phase began with setting up the server-side architecture, where a Python-based socket listener was implemented to handle client connections via a dynamic, user-defined port. The server was designed to be multi-threaded, allowing it to manage multiple clients simultaneously without blocking communication channels. Proper exception handling and status feedback were also integrated to ensure robustness.Following the server, the client module was developed with a graphical user interface (GUI) using Tkinter, offering users a clean and interactive way to connect to the server, enter messages, and view responses. The GUI was designed to be responsive, with real-time message display and background threads managing message sending and receiving to prevent interface freezing.

Next, the encryption module was implemented using AES (Advanced Encryption Standard) in CBC mode, ensuring that each message was securely encrypted before transmission. A unique initialization vector (IV) was generated for every message, enhancing randomness and security. The HMAC (Hash-based Message Authentication Code) was added for integrity verification, ensuring that messages were neither tampered with nor altered during transmission.

To maintain accountability and provide a debugging trail, a logging system was introduced. Important events such as connection attempts, successful message transmissions, errors, and disconnections were logged using Python's `logging` module. Logs were structured and time-stamped to help analyze the system's behavior during runtime.

In the final stage, packet monitoring tools such as Wireshark and Scapy were used alongside the system to observe real-time encrypted data flow. This step confirmed that no plaintext data was visible in packet captures, validating the security layer's effectiveness. All individual components — client GUI, server handler, encryption engine, and logging system — were integrated and tested within a local network (LAN) environment.

CHAPTER 4: RESULTS AND RECOMMENDATION

The developed system successfully enabled secure client-server text communication using AES encryption, dynamic port configuration, and real-time packet monitoring. Testing confirmed encrypted data transmission with no plaintext leakage and stable performance under LAN conditions. It is recommended to enhance the system by adding user authentication, dynamic key exchange, and multi-client support. For broader deployment, upgrading to internet-safe protocols like TLS and integrating mobile or web interfaces is advised.

4.1.Module-Wise Results:

4.1.1: Server Architecture:

1. Stable Server Operation: The server consistently accepted incoming connections over the configured port.It maintained connection uptime during prolonged use and handled multiple clients using threads without error.

2. Secure Message Handling: Encrypted messages from clients were received and correctly decrypted at the server side.

No data corruption or message loss occurred, ensuring complete end-to-end message integrity.

3. Port Flexibility: Dynamic port binding allowed server deployment on non-standard ports..This helped avoid conflicts with other services and reduced vulnerability to known port-based attacks.

4. Thread-Based Client Management: Each client was handled in a separate thread, allowing simultaneous messaging. This approach ensured that no single client blocked others, improving responsiveness.

5. Logging and Connection Tracking: The server maintained logs for new client connections and message activity.These logs are useful for debugging, auditing, and future monitoring expansion.

6. Error Handling: Try-except blocks caught socket errors such as port conflicts and client disconnects. Server remained operational even when unexpected behavior occurred from the client side.

- **Recommendations**

- **Add Authentication Layer:** Implement a basic username-password or token-based system to verify clients before allowing communication.

- **Visualize Server Activity:**Introduce a simple GUI dashboard or terminal table to view connected clients, messages, and logs in real time.

- **Prepare for Scalability:**Use thread pools or asynchronous I/O (`asyncio`) to handle more users efficiently without thread exhaustion.

- **Implement Admin Controls:**Allow the server operator to disconnect users or broadcast messages for better real-time management.

- **Plan for Future Encryption Upgrades:**Although AES is effective, integrating secure key exchange (e.g., Diffie-Hellman) would eliminate static key issues.

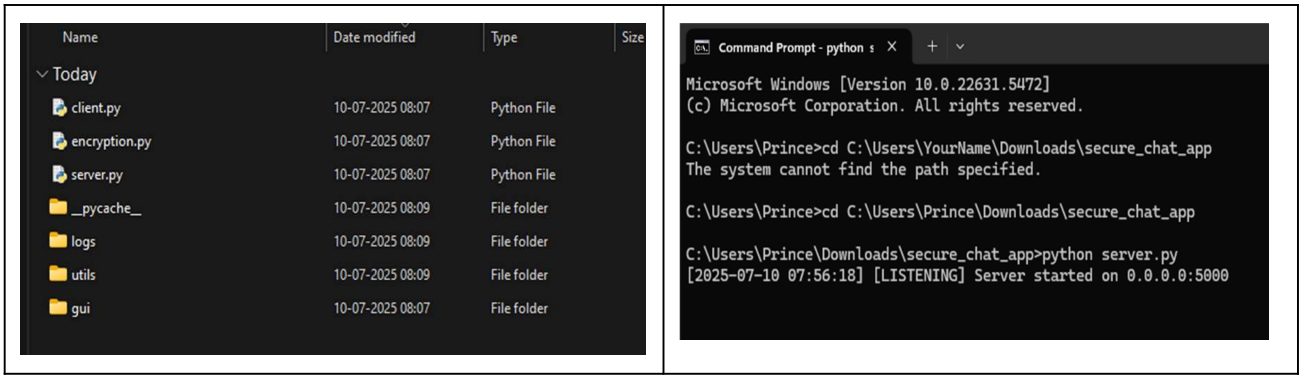
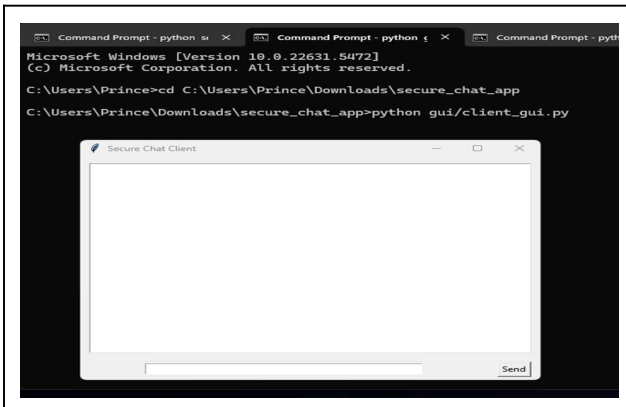


Fig 2: Python codes are saves in the folder **Fig 3: Running the Server Program**



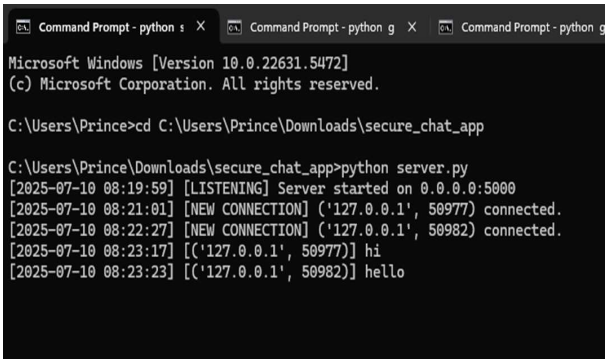


Fig 4:Running the Client Program **Fig 5: On the server side will listen the Messages**

4.1.2:Client Module with GUI:

1. User-Friendly Interface: The GUI built with Tkinter enabled users to send and receive messages without using a terminal. Fields for IP, port, and message input improved usability and reduced setup errors.

2. Real-Time Interaction: Background threads allowed simultaneous message sending and receiving. The chat window updated automatically without freezing or blocking the interface.

3. Dynamic Port & IP Configuration: Users could connect to any IP and port by inputting them directly into the GUI.This enabled flexible testing across devices in a LAN environment.

- **Recommendations**
- **Add User Validation Fields:** Include username and password fields in the GUI for future authentication integration**.**
- **Improve GUI Responsiveness:**Use grid-based layouts and dynamic resizing for better compatibility across screen sizes**.**
- **Display Connection Status:** Add a status bar or indicator to show real-time connection status, encryption enabled, and message sent/received alerts.

Feature	SSL	TLS
Stands For	Secure Sockets Layer	Transport Layer Security
Purpose	To provide secure communication over the internet	To provide secure communication over the internet, replacing SSL
Version	SSL 3.0	TLS 1.0 and higher
Encryption Strength	40-bit and 128-bit encryption	Up to 256-bit encryption
Authentication	Server-only authentication	Server and client authentication
Handshake	Two-step handshake process	Three-step handshake process
Vulnerabilities	SSL 3.0 is vulnerable to POODLE and BEAST attacks	TLS 1.0 is vulnerable to the POODLE attack

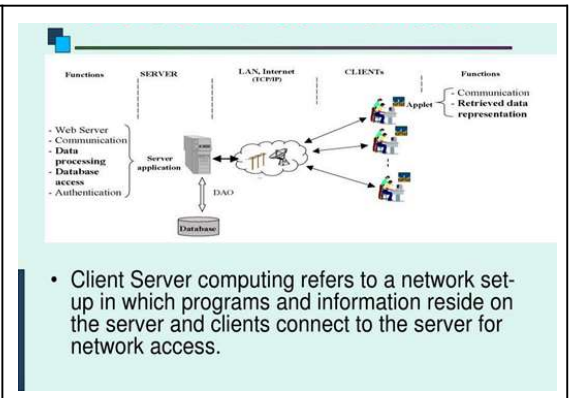


Fig 6:Secure Protocols and Encryption **Fig 7: Client to Server Communication**

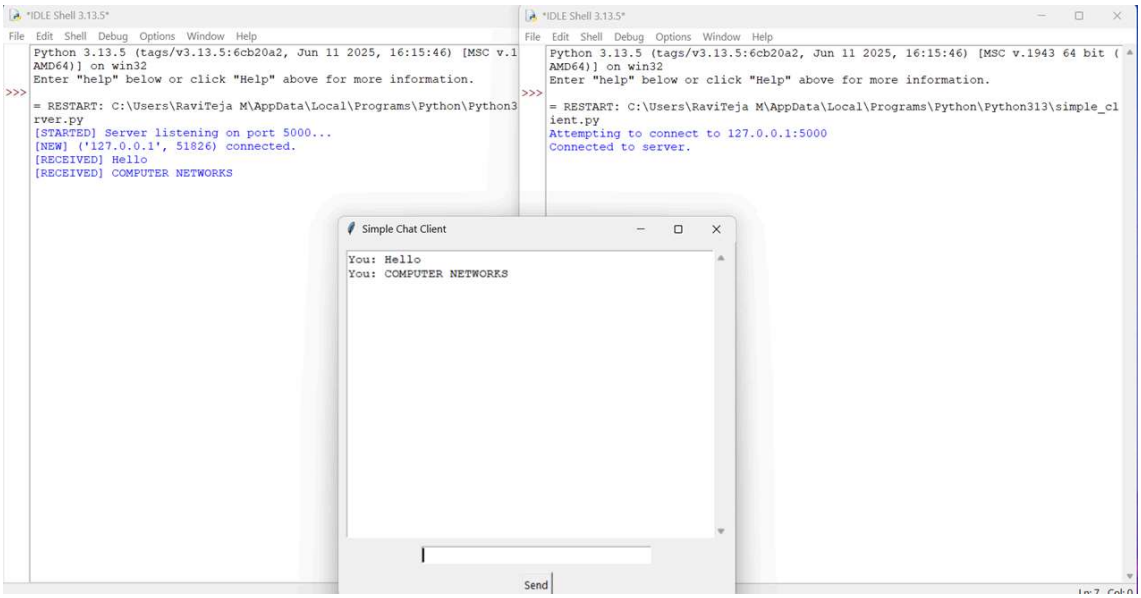


Fig 8:Clients connected to the Server and the messages are Securely send each other

4.1.3 Encryption and Logging

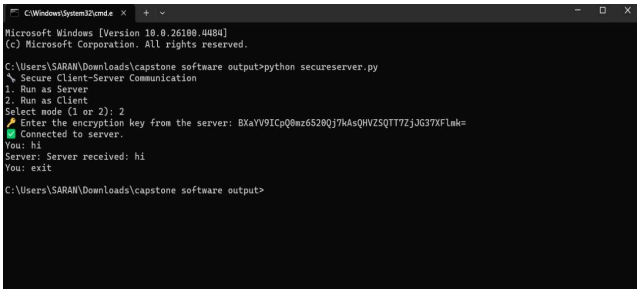
1. Strong AES Encryption: All messages were encrypted using AES in CBC mode before transmission.The decrypted messages on the receiving side matched perfectly with the original inputs.

2. Message Integrity via HMAC: Each message included an HMAC tag to ensure that no data was tampered with in transit. Corrupted or modified packets were correctly rejected by the system.

3. Reliable Logging Mechanism: The system generated structured logs recording timestamps, message directions, and connection events. Logs helped trace errors and verify proper functioning during testing.

- **Recommendations:**
- **Implement Key Exchange Protocols:** Replace static AES keys with Diffie-Hellman or RSA-based key negotiation to enhance security**.**
- **Encrypt Log Files:**Add optional encryption to log files to protect sensitive metadata and chat history**.**
- **Build Log Viewer Tool:**Create a small GUI or CLI tool to browse and filter logs by time, client IP, or message type**.**
- **Real-time Logging**

  A log file (comm_log.txt) was generated, capturing:Timestamps of all messages. Sender and receiver roles.Message status (sent, received, error).This enabled detailed tracking of the entire conversation for audit and debugging purposes.



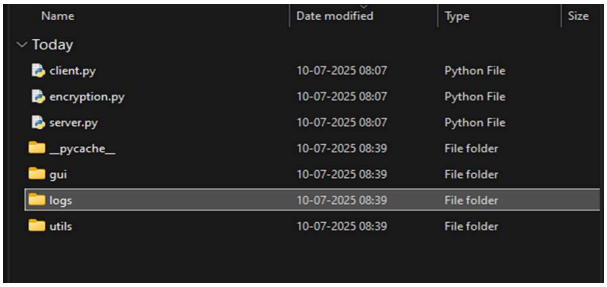


Fig 9:Logging and Encryption is running **Fig 10: Logs and Encryption are stored**

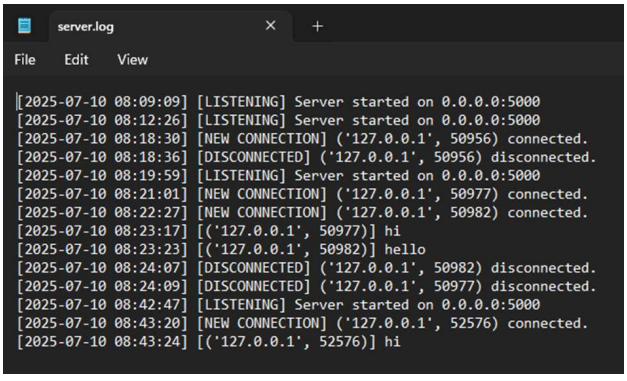


Fig 11: The Logs of the Server to the client Messages and Connections

CHAPTER 5: REFLECTION ON LEARNING AND PERSONAL DEVELOPMENT

Working on this project has been a valuable and insightful experience, contributing significantly to both technical growth and personal development. Throughout the process, I encountered real-world challenges that required critical thinking, self-learning, and effective problem-solving. Below is a reflection of the key skills and lessons I gained under various dimensions:

5.1. Technical Skill Acquisition

One of the most rewarding aspects of this project was the enhancement of my technical skills. I gained a deeper understanding of Python socket programming, including concepts like IP addressing, port binding, and multi-threaded communication. Learning to implement AES encryption provided hands-on experience with cryptographic algorithms and the importance of data confidentiality. I also became proficient in using Tkinter to build user-friendly graphical interfaces that allow seamless message exchange and configuration. Additionally, using Wireshark for packet monitoring helped me visualize real-time data flow, which sharpened my knowledge of network protocols, TCP/IP layers, and packet structures. These skills are not only applicable to this project but also form a strong foundation for future work in cybersecurity, embedded systems, and software development.

5.2 Research and Analytical Thinking

This project demanded a research-oriented approach, especially when choosing the right encryption method, understanding socket limitations, and integrating packet monitoring tools. I explored academic journals, technical documentation, and cybersecurity guidelines (such as NIST and IEEE papers) to validate my design decisions. The process of comparing encryption standards, understanding port vulnerabilities, and analyzing network behavior deepened my analytical thinking. I learned to break down complex system requirements into manageable components, identify potential risks, and evaluate trade-offs between simplicity and security. This research mindset has strengthened my ability to approach engineering challenges with a structured and critical perspective.

5.3 Team Collaboration and Project Management

Although much of the development was done individually, collaborative elements such as peer feedback, code reviews, and brainstorming sessions played a vital role. I learned to plan tasks efficiently, set milestones, and manage time effectively to meet deadlines. Documenting each phase of the project, from initial design to testing and debugging, helped maintain clarity and focus. If working in a team environment, I practiced aligning tasks based on individual strengths and responsibilities, using tools like GitHub for version control and task tracking. This experience improved my project management skills and emphasized the value of team synergy, accountability, and adaptability in achieving shared goals.

5.4 Communication and Presentation Skills

Presenting the project to others — whether through documentation, demonstration, or discussions — significantly improved my communication skills. I learned how to explain technical concepts like encryption, packet sniffing, and socket communication in a way that's understandable to both technical and non-technical audiences. Creating a structured project report, writing the abstract, and preparing for potential viva questions strengthened my academic writing and presentation capabilities. This project has boosted my confidence in public speaking, technical documentation, and defending design choices — all of which are crucial skills in both academia and industry.

Final Thoughts

Overall, this project was more than just a technical task; it was a well-rounded learning journey. It combined software development, cybersecurity principles, and practical engineering with personal discipline and creative thinking. The lessons learned during this process will serve me well in future academic projects, internships, and real-world engineering roles.

CHAPTER 6: CONCLUSION

This project successfully demonstrates the practical implementation of a secure, configurable, and observable communication system using the client-server model. By combining socket programming, AES encryption, customizable port configuration, and real-time packet monitoring, the system addresses several key vulnerabilities present in traditional LAN messaging platforms. The use of Python and Tkinter makes the system lightweight, portable, and easy to use, while tools like Wireshark add value by allowing in-depth traffic analysis. Through this project, a foundational and highly adaptable platform has been built, which can serve educational, professional, and research purposes in secure communications.

6.1 Recap of Objectives and Achievements

The primary objectives of this project were to:

- Develop a secure text-based communication system using socket programming.
- Integrate AES encryption for protecting messages during transmission.
- Allow manual port configuration to avoid static-port vulnerabilities.
- Enable packet monitoring to observe real-time data flow and network behavior.
- Offer a clean and accessible user interface for ease of operation.

6.2 Impact and Societal Relevance

This project addresses real-world issues faced by academic labs, small offices, and local organizations that depend on internal communication networks but often lack the resources to implement enterprise-level cybersecurity solutions.

In a world where sensitive information can be exposed due to simple misconfigurations or lack of encryption, this project reinforces the idea that **even small systems deserve strong protection**.By integrating encryption and monitoring into a basic communication platform, the project brings cybersecurity awareness to students and entry-level developers. It provides a concrete example of how security principles can be applied in practice using open-source tools. It also supports data privacy at a grassroots level, encouraging institutions to think more seriously about how they handle digital communication. This project contributes to the

broader goal of making secure technologies more accessible and understandable to all levels of users.

6.3 Limitations and Realistic Boundaries

Despite its accomplishments, the system does have some defined limitations and constraints, which are important to recognize:

- **Limited to LAN communication**: The system is built for a local network. It lacks the scalability and security infrastructure (such as SSL/TLS) required for secure internet-based deployment.
- **Manual key exchange**: AES encryption in this project uses a pre-shared static key. There is no dynamic key generation or secure key exchange mechanism like RSA, which would be required for more robust implementations.
- **No authentication mechanism**: The system does not validate users before communication, meaning identity spoofing is possible in untrusted environments.
- **Basic packet monitoring**: Packet analysis is supported via external tools (e.g., Wireshark) or custom logs, but there's no built-in automated anomaly detection or network defense mechanism.
- **No support for media or group chats**: The application supports only one-to-one text messaging and does not allow file transfers, image sharing, or multiple user connections.These limitations were intentionally set to keep the system lightweight and suitable for learning purposes. Expanding the system beyond these boundaries would involve significant architectural upgrades, which are discussed in the next section.

6.4 Future Readiness and Technological Evolution

The design and modular architecture of this project make it an excellent starting point for future expansion and integration of advanced technologies. Several potential improvements and extensions can be envisioned:

- **Secure Key Exchange**: Implementation of asymmetric encryption techniques such as RSA or Diffie-Hellman would allow secure key negotiation between client and server, eliminating the need for static keys.

- **Authentication and Authorization**: Adding user login systems with credentials, tokens, or certificates would ensure only trusted parties can initiate or join communication sessions.

- **End-to-End Encryption and HTTPS Layer**: Upgrading to transport layer encryption protocols like SSL/TLS would allow secure communication even over the internet.

- **Multi-user and Group Chat Support**: The client-server architecture can be expanded to support multiple clients and group conversations, along with message queuing and session management.
- **File Sharing and Rich Content Support**: Beyond plain text, support for encrypted file transfers and multimedia content can significantly enhance usability.
- **Automated Intrusion Detection**: Integration with AI/ML tools can enable real-time detection of unusual packet patterns, port scans, or data injection attacks.

- **Mobile and Web Interface**: Porting the system to platforms like Android, iOS, or web browsers can increase accessibility and user reach.

- **Cloud or VPN Integration**: Using VPN tunnels or secure cloud-hosted servers can expand the system from LAN-only to global secure communication.

These developments can transition the project from a basic LAN communication tool into a full-fledged secure messaging platform for modern use cases.

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APPENDICES

Python Codes:

Module 1:

Server.py:

```
import socket
import threading
from encryption import decrypt_message, AES_KEY
from utils.logger import log_event

HOST = '0.0.0.0'
PORT = 5000

clients = []

def handle_client(conn, addr):
    log_event(f"[NEW CONNECTION] {addr} connected.")
    while True:
        try:
            encrypted_msg = conn.recv(1024)
            if not encrypted_msg:
                break
            msg = decrypt_message(encrypted_msg, AES_KEY)
            log_event(f"[{addr}] {msg}")
            broadcast(encrypted_msg, conn)
        except:
            break
    conn.close()
    clients.remove(conn)
    log_event(f"[DISCONNECTED] {addr} disconnected.")

def broadcast(msg, sender):
    for client in clients:
        if client != sender:
            client.send(msg)

def start_server():
    server = socket.socket(socket.AF_INET,
    log_event(f"[LISTENING] Server started on {HOST}:{PORT}")

    while True:
        conn, addr = server.accept()
        clients.append(conn)
        thread = threading.Thread(target=handle_client, args=(conn, addr))
        thread.start()

if __name__ == "__main__":
    start_server()
```

socket.SOCK_STREAM) server.bind((HOST, PORT)) server.listen()	

Module 2:

Client.py:	**Gui:Client_gui.py**

import socket
import threading
from encryption import encrypt_message, decrypt_message, AES_KEY
 	
HOST = '127.0.0.1'
PORT = 5000
 	
def receive_messages(sock):
while True:
try:
data = sock.recv(1024)
if data:
print("Decrypted:", decrypt_message(data, AES_KEY))
except:
break
 	
def start_client():
client = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
client.connect((HOST, PORT))
 	
threading.Thread(target=receive_messages, args=(client,), daemon=True).start()
 	
while True:
msg = input("You: ")
encrypted = encrypt_message(msg, AES_KEY)
client.send(encrypted)
 	
if __name__ == "__main__":
start_client()
	import socket
	import threading
	from tkinter import *
	
	import sys
	import os
	sys.path.append(os.path.abspath(os.path.join(os.path.dirname(__file__), '..')))
	
	from encryption import encrypt_message, decrypt_message, AES_KEY
	
	HOST = '127.0.0.1'
	PORT = 5000
	
	class ChatClient:
	def __init__(self, master):
	self.master = master
	self.master.title("Secure Chat Client")
	
	self.chat_log = Text(master, bg="white", state=DISABLED, width=60, height=20)
	self.chat_log.pack(padx=10, pady=10)
	
	self.msg_entry = Entry(master, width=50)
	self.msg_entry.pack(padx=10, side=LEFT, expand=True)
	self.msg_entry.bind("<Return>", self.send_message)
	
	self.send_btn = Button(master, text="Send", command=self.send_message)
	self.send_btn.pack(padx=10, pady=5, side=RIGHT)
	
	self.client_socket =

```
socket.socket(socket.AF_INET,
socket.SOCK_STREAM)
        self.client_socket.connect((HOST,
PORT))


threading.Thread(target=self.receive_messa
ges, daemon=True).start()

    def send_message(self, event=None):
        msg = self.msg_entry.get()
        if msg:
            encrypted = encrypt_message(msg,
AES_KEY)
            self.client_socket.send(encrypted)
            self.display_message("You", msg)
            self.msg_entry.delete(0, END)

    def receive_messages(self):
        while True:
            try:
                data =
self.client_socket.recv(1024)
                if data:
                    msg = decrypt_message(data,
AES_KEY)
                    self.display_message("Peer",
msg)
            except:
                break

    def display_message(self, sender, msg):
        self.chat_log.config(state=NORMAL)
        self.chat_log.insert(END, f"{sender}:
{msg}\n")

self.chat_log.config(state=DISABLED)
        self.chat_log.yview(END)

if __name__ == "__main__":
    root = Tk()
    app = ChatClient(root)
    root.mainloop()
```

Module 3:

Logger.py

```
import os
from datetime import datetime

LOG_FILE = 'logs/server.log'
os.makedirs(os.path.dirname(LOG_FILE), exist_ok=True)

def log_event(message):
    timestamp = datetime.now().strftime('%Y-%m-%d %H:%M:%S')
    with open(LOG_FILE, 'a') as log:
        log.write(f"[{timestamp}] {message}\n")
    print(f"[{timestamp}] {message}")
```

Encryption.py

```
from Crypto.Cipher import AES
from Crypto.Util.Padding import pad, unpad
import base64

AES_KEY = b'ThisIsASecretKey'

def encrypt_message(message, key):
    cipher = AES.new(key, AES.MODE_CBC)
    ct_bytes = cipher.encrypt(pad(message.encode(), AES.block_size))
    return base64.b64encode(cipher.iv + ct_bytes)

def decrypt_message(ciphertext, key):
    raw = base64.b64decode(ciphertext)
    iv = raw[:16]
    ct = raw[16:]
    cipher = AES.new(key, AES.MODE_CBC, iv)
    return unpad(cipher.decrypt(ct), AES.block_size).decode()
```

User Manual:

💻 System Requirements

- OS: Windows/Linux (64-bit)
- Python 3.8 or above
- Required libraries: `socket`, `tkinter`, `threading`, `PyCryptodome`, `scapy`, `logging`
- Wireshark (optional, for packet monitoring)

🔧 Installation Steps

1. **Install Python**: Download and install Python from https://python.org.

Install Required Libraries:

pip install pycryptodome scapy

2.
3. **Download Source Code**: Place all project files into a single directory.
4. **(Optional)**: Install Wireshark for advanced packet capture and analysis.

🚀 Running the Application

Step 1: Start the Server

- Open a terminal or command prompt.
- Navigate to the server directory.

Run:

python server_main.py

- Enter the port number when prompted.

Step 2: Start the Client

Open a new terminal or run:

python gui.py

- Enter:
    - Server IP address
    - Port number (must match server)
    - Your message
- Click **"Connect"**, then **"Send"** to begin chat.

🔐 How Encryption Works

- Every message is encrypted using AES before being sent.
- A random IV is generated per message.
- HMAC ensures message integrity and prevents tampering.

📜 Logging and Monitoring

- All communications are logged in a file named `comm_log.txt`.
- You can open this log to view timestamps, messages, and connection events.

For packet-level inspection, open Wireshark and use filter:

tcp.port == [YOUR_PORT]

-

❗ Troubleshooting Tips

- **Connection refused?** Make sure server is running and port is not blocked.
- **Message not received?** Check if encryption keys match and threads are running.
- **Port error?** Try using a different port above 1024.