**Summary of the Secure P2P File Sharing and Inbuilt Chat Application Project**

This project involves building a **secure peer-to-peer (P2P) file-sharing and chat application** with a graphical user interface (GUI). The app allows users to share files and send messages securely over a P2P network using encryption mechanisms to ensure confidentiality and integrity. It is developed using Python, leveraging libraries like tkinter for the GUI, socket for networking, and cryptography for secure communications.

**Key Features:**

1. **P2P File Sharing:**
   * Allows users to share files between peers without relying on a central server.
   * Supports sending large files in chunks (16KB).
   * Includes progress tracking and displays transfer speed.
   * Files are stored in a shared\_files directory.
2. **Encrypted Communication:**
   * Uses **Fernet** encryption (symmetric encryption) to secure messages between peers.
   * Passwords can be securely hashed using **PBKDF2-HMAC** with optional salt.
   * All sensitive data, including messages and file transfers, are encrypted to prevent unauthorized access.
3. **Real-time Chat:**
   * Users can chat in real-time with message delivery and receipt notifications.
   * Supports sending both text and file attachments.
   * Chat interface adapts based on user preferences (light/dark theme).
4. **User-Friendly GUI:**
   * Built using **Tkinter** for a clean and responsive user interface.
   * Themes can be toggled (light/dark modes).
   * Provides clear feedback on the connection status, file transfer progress, and any errors.
5. **Network Handling:**
   * **Socket programming** is used for network communication, allowing dynamic IP discovery and port assignment.
   * The app is capable of automatically selecting an available network port within a specified range.
   * It ensures connection reliability with automatic retries in case of network errors.
6. **Security Considerations:**
   * Encrypted messages and secure password hashing to protect user credentials.
   * Files are verified with **SHA-256** hashes to ensure integrity during transfer.
   * Configurable security settings for better user control.
7. **Error Handling and Logging:**
   * Uses structured **logging** to capture errors, warnings, and other runtime information.
   * Provides **graceful error handling** to ensure smooth user experience, including detailed traceback for debugging.
   * Application logs are saved in a dedicated logs directory for easy troubleshooting.
8. **Cross-Platform Support:**
   * Developed with cross-platform compatibility in mind, making it suitable for various operating systems (Linux, macOS, Windows).
   * The app uses platform-specific handling for tasks like IP retrieval and network connection checks.

**Core Modules:**

1. **config.py**:
   * Defines application configurations, such as port numbers, buffer sizes, retry limits, logging levels, and theme settings.
   * Ensures necessary directories are created (e.g., shared\_files and logs).
2. **utils.py**:
   * Contains utility functions for network management (e.g., checking valid IPs, getting local IP), file operations (e.g., hashing, file searches), and time-related functions.
   * Implements encryption functions for generating keys and encrypting/decrypting messages.
   * Includes functions for validating configuration values and checking dependencies.
3. **main.py**:
   * Main entry point for the application. It sets up the environment by creating necessary directories and checking permissions.
   * Validates dependencies and initializes the application. It then launches the GUI and handles exceptions gracefully.
   * Displays animations and headers during startup to enhance the user experience.
4. **GUI (tkinter)**:
   * The application interface is built using Tkinter, providing a modern and simple look.
   * Supports a theme system (light/dark mode).
   * Includes buttons, text boxes, file pickers, and status indicators for real-time feedback.
5. **Networking (Sockets)**:
   * Implements both **file transfer** and **real-time chat** features using Python’s socket module.
   * Handles peer discovery, connection establishment, and data transfer using TCP sockets.

**System Requirements:**

* Required dependencies:
  + tkinter
  + cryptography
  + pillow (for image-related tasks)
  + ttkthemes (for enhanced GUI styling)

**App Flow Overview:**

1. **Setup**:
   * The application checks if necessary directories exist, like the shared files folder and logs directory. If not, it creates them.
   * It validates the configuration, ensuring ports and settings are within acceptable ranges.
2. **Network Initialization**:
   * The application checks the local network IP, allowing peers to connect to each other using their machine’s address.
   * It dynamically selects available network ports for communication.
3. **File Sharing**:
   * Users can select a file to share, which is broken down into smaller chunks and transmitted to peers.
   * Progress bars show transfer status and speed.
4. **Chat**:
   * A real-time chat interface allows users to send encrypted messages.
   * The chat interface displays messages in the selected theme and handles different message types (text, files).
5. **Encryption**:
   * All messages and files are encrypted using Fernet encryption.
   * Passwords and sensitive data are hashed securely using PBKDF2.
6. **Error Handling**:
   * The application handles connection issues and retries automatically.
   * It logs errors and provides feedback in the terminal or GUI.
7. **Exit**:
   * The app can be stopped gracefully with proper cleanup. It handles termination signals and unexpected shutdowns.

**🔐 Secure P2P File Sharing & Chat Application — Summary**

**📡 Network Protocol**

* **TCP (Transmission Control Protocol)** is used.
  + Ensures **reliable**, **ordered**, and **error-checked** data transfer.
  + Perfect for **file sharing** and **chat**, where data integrity matters.

**🧱 Architecture**

* **Peer-to-Peer (P2P)** model:
  + Each user (peer) can **act as both server and client**.
  + Eliminates the need for a central server.
* Communication happens via **Python Sockets**.
  + Each peer sets up a **listening socket** to accept incoming connections.
  + **Threading** handles multiple connections simultaneously.

**🧩 Modules & Functionalities**

1. **💬 Chat Module**
   * Real-time text messaging between peers.
   * Messages are sent over TCP for reliability.
   * Notification animation for new messages.
2. **📁 File Transfer Module**
   * Supports **sending/receiving files** between peers.
   * Progress tracking and transfer status animations.
   * Error handling for incomplete/corrupt transfers.
3. **🖼 GUI Module**
   * Built using **tkinter**.
   * Clean, user-friendly interface.
   * Animations for:
     + ✅ Success
     + ❌ Error
     + 📤 File transfer
     + 🔗 Connection status
     + 💬 Chat notifications
4. **🔐 Security Layer (Optional/Planned)**
   * Encryption can be added using ssl or libraries like cryptography.
   * Prevents eavesdropping on chats or files.

**⚙️ Technical Highlights**

* **Language**: Python
* **Libraries**:
  + socket – for networking
  + threading – for handling multiple peers
  + tkinter – for GUI
  + Optional: os, shutil, time, hashlib, ssl (for security)
* **Scalable**: Can support multiple peers with proper connection handling.
* **Modular Design**: Separate files/functions for chat, file transfer, UI, and networking.