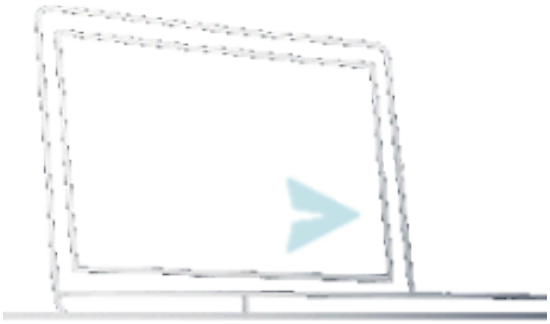
Chat Client

Technical Architecture Overview



Version 1.0 - January 2026

Created by Laurent Barraud.

Technologies Used

C#, .NET, WPF, async/await, TCP networking, custom binary packet protocol, RSA encryption, UTF-8 encoding.

1. System Overview

The solution is composed of three independent but tightly integrated modules:

Module	Role	Description
ChatClient	WPF Application	User interface, message handling, encryption, and network communication.
ChatProtocol	Shared Library	Defines the network protocol, packet types, serialization tools, and framing rules.
ChatServer	TCP Server	Manages connections, relays messages, maintains public keys, and orchestrates the protocol.

The architecture follows a classic client–server model with a simple, robust and extensible custom protocol.

2. Logical Architecture

2.1. ChatClient

Primary Responsibilities

- Reactive WPF interface (light MVVM)
- Asynchronous TCP connection management
- Sending and receiving framed packets
- RSA encryption (public key for encryption, private key for decryption)
- Protocol handling (handshake, messages, errors)
- Real-time message display
- Dynamic UI features (theme switching, language switching, sliders, toggles)

Key Components

Helpers

• EncryptionPipeline.cs – Implements the full RSA workflow: stores the client keypair, encrypts outgoing sensitive data with the server’s public key, and decrypts incoming encrypted payloads.

• EncryptionHelper.cs – Provides low-level RSA utilities such as keypair generation, key export and raw encryption/decryption helpers used by the pipeline.

• Framing.cs – Defines the packet framing rules (length prefix, validation, boundaries) to ensure reliable reconstruction of messages over TCP.

• ClientLogger.cs – Lightweight logging utility for connection events, packet traces and error diagnostics.

• ConsoleManager.cs – Attaches an optional console window during development to display logs in real time.

• LocalizationManager.cs – Handles dynamic language switching at runtime by loading and applying resource dictionaries.

• ThemeManager.cs – Applies light or dark themes instantly and ensures consistent styling across all windows.

• StartupConfigurator.cs – Loads saved settings at startup and applies initial theme, language and configuration before the UI appears.

• RelayCommand.cs – Standard MVVM command implementation used to bind UI actions to ViewModel logic.

Models

• LanguageOptions.cs – Represents available UI languages and the currently selected one.

• PublicKeyEntry.cs – Stores a public key received from the server, including identifier, timestamp and raw key bytes.

• UserModel.cs – Represents a connected user and is used to populate the real-time user list.

Views

• MainWindow.cs – Primary chat interface containing the message list, user list, adjustable input field, theme and language toggles, connection controls and system tray integration.

• MonitorWindow.cs – Diagnostic window dedicated to public key synchronization, displaying all known keys with timestamps and offering a manual sync action.

• SettingsWindow.cs – Configuration window allowing the user to adjust port, language, theme, local mode and other preferences, applied instantly and saved for future sessions.

ViewModel

• MainViewModel.cs – Central ViewModel binding the UI to the network layer: exposes connection state, user list and messages, processes incoming packets, and sends outgoing data through ClientConnection.

Net

• ClientConnection.cs – Manages the entire TCP lifecycle on the client side: opens the connection, performs the RSA handshake, runs the asynchronous receive loop, sends packets without blocking the UI, and forwards parsed data to the ViewModel.

Additional Client Features

- Emoji support through UTF-8 encoding
- Instant language switching (UI updates immediately when the ComboBox changes)
- WPF-friendly settings toggles (properly bound, no code-behind)
- Customizable UI sliders for user preferences
- Dynamic dark theme that can be toggled at any moment
- System tray integration using the *Hardcodet.Wpf.TaskbarNotification* library (the only reliable option for WPF)

2.2. ChatProtocol

A shared, standalone library used by both client and server.

Contains

• PacketBuilder.cs – Shared implementation for constructing framed packets used by both client and server.

• PacketReader.cs – Shared implementation for parsing framed packets consistently across both sides.

• Protocol.cs – Defines the enum of all opcodes used by the chat protocol, including handshake, public key exchange, user list updates, messages and error codes.

Packet Format

Code

[1 byte] PacketType

[4 bytes] PayloadLength

[n bytes] Payload

This design is:

- streaming-friendly
- easy to parse
- fully extensible

Framing Guarantees

- Every packet is length-prefixed, so the reader never desynchronizes
- Unknown opcodes cannot occur unless the stream is corrupted
- Multiple packets in a single TCP read are handled safely

2.3. ChatServer

Responsibilities

- Accept TCP connections
- Maintain the list of connected clients
- Store and distribute public keys
- Relay encrypted messages
- Handle protocol errors
- Implement the handshake and packet routing

Key Components

- Program.cs – Main entry point and listener; accepts incoming TCP clients, manages their lifecycle and broadcasts messages to all connected users.
- ServerConnectionHandler.cs – Handles communication with a single connected client: receives packets, processes opcodes, and forwards messages to the server for distribution.

3. Network Flow

3.1. Initial Handshake

1. The client connects.
2. If encryption is enabled, the client sends its public key.
3. The server updates its registry.
4. The server sends back the full list of known public keys.
5. The client updates its PublicKeyMonitor.
6. The lock icon updates to visually confirm that encryption is ready for all connected peers.

3.2. Sending a Message

1. The user types a message.
2. The client encrypts it using the recipient's public key.
3. The client sends a packet with opcode EncryptedMessage.
4. The server receives and relays the packet.
5. The recipient decrypts it using their private key.
6. The message appears instantly in the UI.

3.3. Public Key Updates

1. A new client connects.
2. The server updates its registry.
3. All connected clients receive a notification.
4. If encryption is enabled, the server distributes the new public key.
5. Each client updates its key store.

4. Encryption Pipeline

- Each client generates its own RSA keypair at startup
- Public keys are distributed through the server and reflected in real time
- All outgoing messages are encrypted using the recipient's public key
- Clear-text messages are only sent when encryption is explicitly disabled

4.1 Source of Truth

The Public Key Monitor is the authoritative source of truth.

It reflects the exact content of KnownPublicKeys at all times.

Whenever a key is added or updated:

- the ObservableCollection raises change notifications
- the UI refreshes automatically
- the lock icon updates to reflect global encryption validity

4.2 Lock Icon Semantics

- All keys valid: colored lock (safe to encrypt for all peers)
- At least one key missing/invalid: gray lock (encryption cannot be guaranteed)

4.3 Mixed readiness states

When the lock is gray, the client will still attempt to send the message, but it will be transmitted in clear text.

If an encrypted client sends a message to a peer who has encryption disabled, the recipient will be prompted to enable encryption before they can continue reading.

5. Installer

The installer is built using Inno Setup, chosen for its simplicity and reliability. Users can choose to install the client, the server, or both.