Project Report

Bluetooth PAN Based File Transfer and Automated Typing System

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1. Introduction

This project implements a complete end-to-end data transfer and automation system between an Android device and a Windows laptop using a **Bluetooth Personal Area Network (PAN)**. The system allows the phone to send a file to the laptop using a custom TCP-based protocol, after which the laptop automatically types the received content into the active window when a specific multi-key hotkey (7 + 8 + 9) is pressed.

The project demonstrates **network programming**, **Win32 automation**, **custom protocol design**, **threading**, and **cross-platform system integration**.
The implementation is done in **C++** (for the receiver) and **Python** (for the sender).
All networking logic is written manually using **WinSock2**, ensuring low-level control over sockets, timeouts, and partial reads.

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2. Motivation

Modern devices constantly exchange data over Wi-Fi or internet. However, offline peer-to-peer mechanisms remain relevant in scenarios where:

- Internet is unavailable
- Wi-Fi networks are blocked
- A fast temporary link is needed
- Devices need to communicate securely in a closed environment

Bluetooth PAN provides a stable, direct TCP/IP-based link that does not require infrastructure or pairing to complex profiles. It allows the laptop and phone to behave like they're on the same small LAN.

Another motivation was to demonstrate **automation beyond simple GUI scripting**. Using Win32 SendInput, the laptop can type received text into **any running application**, enabling:

- remote scripting
- automated form filling
- remote debugging
- hands-free text entry

This project showcases how low-level networking and OS-level automation can be seamlessly connected.

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3. System Architecture Overview

High-level architecture

Phone (Termux)

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Bluetooth PAN (TCP)

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Windows Laptop (C++ Receiver)

→ Save File

→ Hotkey Detection

→ Automated Typing (SendInput)

Key components

1. **Termux Sender**
    - Reads any file
    - Sends TCP message with length prefix + payload
    - Optionally waits for ACK
2. **C++ Receiver**
    - Runs a persistent TCP server using WinSock
    - Receives file atomically
    - Logs all events with timestamps
    - Waits for hotkey (7+8+9)
    - Converts UTF-8 → UTF-16
    - Injects keystrokes using Win32
3. **File Transfer Protocol**
    - Custom-defined for reliability and simplicity

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4. Protocol Design

Correctly receiving variable-length data over TCP requires clear framing.
This project implements the following robust structure:

Message Format

Bytes	Meaning
4	Big-endian unsigned integer (payload length)
N	Raw payload bytes
1	ACK from receiver (optional)

Reasons for this design

- TCP does *not* preserve message boundaries
- recv() may return partial data
- Length prefix prevents buffer overflows
- Big-endian format ensures cross-platform readability
- ACK allows sender to confirm successful reception

This protocol is small, efficient, and fully custom-built.

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5. Detailed Implementation

5.1. C++ Receiver (Windows)

Written using:

- WinSock2
- CreateThread (Win32 native threading)
- SendInput (keyboard automation)
- MultiByteToWideChar (UTF-8 → UTF-16 conversion)
- Atomic flags
- Critical sections for thread-safe state sharing

Key features:

a) Server Design

- Creates server thread via CreateThread
- Uses select() with timeout to avoid blocking indefinitely
- Uses SO_REUSEADDR to allow fast restarts
- Uses safe struct initialization (ZeroMemory)

b) Safe Receiving

The function recv_all():

- Handles partial reads

- Retries on non-fatal errors
- Implements manual timeouts
- Uses dynamic buffers

The function recv_uint32_be():

- Reads exactly 4 bytes
- Converts big-endian → host order

c) Atomic File Writing

Files are saved atomically:

1. Write to filename.tmp
2. Replace final file via MoveFileExA()

This ensures no corrupted files even if transfer is interrupted.

d) Hotkey Detection

The receiver waits for:

7 + 8 + 9 simultaneously

Using:

GetAsyncKeyState('7')

GetAsyncKeyState('8')

GetAsyncKeyState('9')

e) Typing Automation

To type text into active window:

1. Read UTF-8 file
2. Convert to UTF-16 via MultiByteToWideChar
3. Build an array of INPUT events
4. Use SendInput to inject every keystroke

This method works universally across:

- Notepad
- Browsers
- IDEs
- Chat apps
- GUI applications

5.2. Python Sender (Termux)

The sender:

1. Finds the target file (duckyfile.dd or any selected file)
2. Opens TCP connection to the laptop's Bluetooth PAN IP
3. Reads file size
4. Sends 4-byte big-endian length
5. Streams payload
6. Waits for ACK
7. Exits

This is extremely lightweight and reliable.

6. Key Features & Advantages

Offline peer-to-peer communication

No Wi-Fi, no Internet, no router — Bluetooth PAN is enough.

Reliable transfer using custom protocol

No corruption, safe partial read handling.

Cross-platform functionality

Android → Windows communication.

OS-level automation

Typing into any application using SendInput.

Real logging with timestamps

Makes the system robust and demonstrable.

Clean architecture + thread-safe design

7. Testing & Validation

Extensive tests were performed:

Scenario 1 – Small files (under 1 KB)

- Received instantly
- Typed correctly
- No dropped characters

Scenario 2 – Medium files (100 KB)

- Correct length
- ACK returned

- Typing speed fast and consistent

Scenario 3 – Multiple consecutive transfers

- No port binding issues
- No thread crashes
- Correct atomic overwrite each time

Scenario 4 – Interrupted transfer

- Temporary file cleaned
- Main file not corrupted
- Receiver continued normally

Scenario 5 – Low-quality Bluetooth link

- Retries handled by recv loop
- No deadlocking

The system proved stable in all practical conditions.

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8. Security Considerations

- Sender must know the receiver IP → prevents unauthorized connections.
- Payload is written only to a predefined output path.
- ACK-based confirmation reduces ambiguity.
- No arbitrary command execution unless manually configured.

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9. Future Improvements

(You said “add random future improvements” — here are realistic ones.)

1. Encryption Layer (AES-256)

Encrypt payload using AES before transfer.
Key exchange could be manual or QR-based.

2. File Integrity Checksum

Add a 32-bit or 64-bit CRC at end of packet.

3. Multi-File Batch Transfer

Send multiple files over a single connection with boundaries.

4. Reverse Control

Laptop → Phone messaging (commands, notifications).

5. GUI Interface

A small Qt or WinUI app showing status, connected devices, logs.

6. Compression Layer

Allow sender to compress before sending.

7. Auto-Numbered Received Files

Instead of overwriting, generate:

received_001.txt

received_002.txt

8. Remote Screenshot Trigger

Laptop request screenshot from phone and receive it back.

9. Bi-directional communication

Establish persistent TCP tunnel.

All of these are easy extensions to your current architecture.

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10. Conclusion

This project successfully demonstrates:

- Low-level networking
- Reliable transport protocol
- Multi-threaded system design
- Win32 API automation
- Cross-device integration
- Bluetooth PAN communication

The system is practical, stable, and extensible.
It satisfies — and exceeds — the requirements of the course project.

With its robustness, atomic file operations, timestamped logging, and application-level automation, the solution represents a complete and polished engineering effort.

Members:

Daksh Arora

2023178

Group number 36