

Assignment 2: Peer-to-Peer File Synchronizer

Report (Test Cases & Results)

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GitHub: <https://github.com/ZifanSi/p2p-file-synchronizer>

1 Overview

This project implements a peer-to-peer (P2P) file synchronizer using a centralized tracker for peer discovery and directory aggregation. Each peer:

- establishes one persistent TCP connection to the tracker,
- advertises its working directory file metadata (name, integer mtime) on startup (Init),
- sends periodic keepalive messages to maintain liveness (every 5 seconds),
- receives a directory response from the tracker after each Init/KeepAlive,
- downloads files that are missing locally or have older mtimes,
- serves file requests to other peers using a TCP protocol with a **Content-Length** header and raw bytes.

2 Environment

- OS: Windows 10/11 (local testing)
- Python: 3.12.10
- Network: localhost (127.0.0.1)

3 Project Layout Used for Testing

```
p2p-file-synchronizer/  
src/  
    tracker.py  
    fileSynchronizer.py  
    run_all.bat  
    reset_ports.bat  
Peer1/  
    fileA.txt  
Peer2/  
    fileB.txt  
Peer3/  
    fileC.txt
```

4 How to Run

Tracker

```
cd src
python tracker.py 127.0.0.1 9000
```

Peers (3 terminals)

```
cd src\Peer1
python ..\fileSynchronizer.py 127.0.0.1 9000

cd src\Peer2
python ..\fileSynchronizer.py 127.0.0.1 9000

cd src\Peer3
python ..\fileSynchronizer.py 127.0.0.1 9000
```

Optional batch script

```
cd src
run_all.bat
```

5 Protocol Summary

5.1 Peer → Tracker

Messages are newline-terminated UTF-8 JSON objects.

- Init (sent exactly once on startup):

```
{"port": <p>, "files": [{"name": "...", "mtime": <int>}, ...]}\n
```

- KeepAlive (sent every 5 seconds):

```
{"port": <p>}\n
```

5.2 Tracker → Peer

For every Init/KeepAlive received, the tracker returns one directory response (newline-terminated JSON):

```
{"fileA.txt": {"ip": "...", "port": ..., "mtime": ...}, ...}\n
```

5.3 Peer ↔ Peer

Requester sends:

```
<filename>\n
```

Server responds:

```
Content-Length: <size>\n
<raw file bytes>
```

6 Rubric Coverage Map

The following test cases are designed to cover every graded requirement:

- TC0: `get_file_info()` (1pt)
- TC1: `get_next_available_port()` (1pt)
- TC2: `FileSynchronizer` initializer + tracker communication (1pt)
- TC3: `sync()` discovery + retrieve missing files (1pt)
- TC4: `sync()` overwrite newer mtime + `os.utime()` (1pt)
- TC5: `process_message()` serves file with correct `Content-Length` framing (2pt)
- TC6: timeout/failure handling + discard partial file (1pt)

7 Selected Runtime Output Evidence (excerpt)

Tracker (excerpt)

```
Waiting for connections on port 9000
Client connected with 127.0.0.1:XXXXX
Client connected with 127.0.0.1:YYYYY
Client connected with 127.0.0.1:ZZZZZ
client server127.0.0.1:8000
client server127.0.0.1:8001
client server127.0.0.1:8002
```

8 Test Cases and Results

8.1 TC0 (1pt): Working-directory file filtering via `get_file_info()`

Goal: Verify only valid files in the working directory are advertised; ignore subdirectories and `.py/.dll/.so`; report integer mtimes.

Setup: In `src/Peer1/` create:

- `fileA.txt`
- `junk.dll`, `junk.so`, `temp.py`
- subfolder `sub/` containing `subfile.txt`

Steps:

1. Start tracker and Peer1.

2. Observe directory response received by any peer (or Peer1 itself).

Expected:

- Only fileA.txt appears in the advertised directory from Peer1.
- mtime values are integers.

Observed: Only fileA.txt was listed (filtered files and subfolder were not). Example:

```
"fileA.txt": {"ip":"127.0.0.1","port":800X,"mtime":1771289241}
```

Result: PASS.

8.2 TC1 (1pt): Next available port selection

Goal: Verify each peer binds to an available port (no collisions).

Steps:

1. Start tracker.
2. Start three peers.

Expected: Each peer prints a listening port and no bind errors occur.

Observed (example):

```
Waiting for connections on port 8000  
Waiting for connections on port 8001  
Waiting for connections on port 8002
```

Result: PASS.

8.3 TC2 (1pt): Initializer + tracker connection + keepalive cycles

Goal: Verify sockets are initialized correctly, peers connect to tracker, send Init, and continue with KeepAlive (directory responses repeated over time).

Steps:

1. Start tracker then peers.
2. Observe tracker accepts connections and peers receive directory responses.
3. Wait ≥ 10 seconds and confirm additional directory responses occur (keepalive cycles).

Expected: Tracker logs 3 connections; peers receive directory JSON repeatedly.

Observed: Tracker shows 3 connections and peer servers; peers repeatedly printed:

```
received from tracker: {...}\n
```

Result: PASS.

8.4 TC3 (1pt): Discovery and retrieve missing files (convergence)

Goal: Verify peers download missing files and converge to the same directory.

Setup:

- Peer1 has only fileA.txt
- Peer2 has only fileB.txt
- Peer3 has only fileC.txt

Steps:

1. Start tracker and peers.
2. Wait 1–2 sync cycles.
3. Check each peer folder contents.

Expected: Each peer ends with A/B/C.

Observed:

```
Peer1: fileA.txt fileB.txt fileC.txt
Peer2: fileA.txt fileB.txt fileC.txt
Peer3: fileA.txt fileB.txt fileC.txt
```

Result: PASS.

8.5 TC4 (1pt): Overwrite newer version + verify mtime set via `os.utime()`

Goal: Verify a newer file version overwrites older copies and that the local mtime matches the advertised mtime.

Steps:

1. Stop all peers.
2. In `Peer2/fileB.txt`, append one line and save (updates mtime).
3. Record mtimes *before sync*:

```
cd src\Peer1
python -c "import os; print(int(os.path.getmtime('fileB.txt')))"
cd ../Peer2
python -c "import os; print(int(os.path.getmtime('fileB.txt')))"
```

4. Restart peers; wait 1–2 sync cycles.
5. Record mtimes *after sync* in Peer1 and Peer3:

```
cd src\Peer1
python -c "import os; print(int(os.path.getmtime('fileB.txt')))"
cd ../Peer3
python -c "import os; print(int(os.path.getmtime('fileB.txt')))"
```

6. Optionally confirm content equality (e.g., compare files).

Expected:

- Peer1/Peer3 overwrite their `fileB.txt` to match Peer2 content.
- Peer1/Peer3 mtimes equal the newer advertised mtime (set by `os.utime()`).

Observed: Peer1 and Peer3 mtimes matched Peer2's newer integer mtime after sync; content also matched.

Result: PASS.

8.6 TC5 (2pt): Peer serving protocol (Content-Length header + exact bytes)

Goal: Verify server replies with correct header and sends exactly that many bytes.

Method: Manual request using a small Python client to print the header and byte count received.

Steps:

1. Start a peer that has `fileC.txt` and note its listening port (e.g., 8002).
2. From another terminal, run:

```
python -c "import socket; s=socket.socket(); s.connect(('127.0.0.1',8002)); s.
    sendall(b'fileC.txt\n'); \
buf=b''; \
while b'\n' not in buf: buf+=s.recv(4096); \
hdr,rest=buf.split(b'\n',1); \
print(hdr.decode()); \
n=int(hdr.decode().split(':',1)[1].strip()); \
data=rest; \
while len(data)<n: data+=s.recv(4096); \
print('bytes=',len(data),'expected=',n)"
```

Expected:

- Prints Content-Length: N
- Prints bytes=N expected=N

Observed: Header printed as Content-Length: N and received byte count equaled N.
Result: PASS.

8.7 TC6 (1pt): Timeout/failure + discard partial file

Goal: Verify failed transfers do not leave partial files and sync continues.

Setup: Create a larger file to make partial transfer reproducible (e.g., 5–20MB).

```
cd src\Peer3
python -c "open('big.bin','wb').write(b'A'*10_000_000)"
```

Steps:

1. Start tracker and all peers; confirm directory includes `big.bin`.
2. Delete `Peer1/big.bin` (if present).
3. Trigger a download by waiting for sync to start, then **force-stop Peer3 while transfer is in progress** (close the Peer3 terminal).
4. Check `Peer1/` for leftover partial file: `big.bin.part`.
5. Restart Peer3 and wait for another sync cycle.

Expected:

- If the transfer is interrupted, Peer1 does not keep a partial file (no `.part` remains).
- After Peer3 is restarted, Peer1 successfully downloads `big.bin`.

Observed: When Peer3 was force-stopped mid-transfer, `big.bin.part` was not left behind. After restarting Peer3, Peer1 successfully retrieved `big.bin`.

Result: PASS.

9 Results Summary

Rubric Requirement / Test Case	Result
TC0: <code>get_file_info()</code> filtering rules (1pt)	PASS
TC1: <code>get_next_available_port()</code> (1pt)	PASS
TC2: Initializer + tracker comms + keepalive (1pt)	PASS
TC3: <code>sync()</code> discovery + retrieve missing (1pt)	PASS
TC4: <code>sync()</code> overwrite newer + set mtime (1pt)	PASS
TC5: <code>process_message()</code> Content-Length + exact bytes (2pt)	PASS
TC6: Failure handling + discard partial file (1pt)	PASS

10 Conclusion

Custom test cases were designed to validate all protocol requirements and grading rubric items. The results demonstrate correct directory discovery/filtering, available-port binding, persistent tracker communication and keepalives, peer serving with **Content-Length** framing and exact byte transfer, synchronization convergence, propagation of newer file versions with mtime preservation via `os.utime()`, and robust handling of failures without leaving partial files.