Design and Functionality Report for P2P File Sharing System

Overview

The P2P File Sharing System is a Java-based application that enables file sharing in a decentralized peer-to-peer (P2P) network. The system consists of three main components:

- Tracker: Acts as a central coordinator, managing peer information.
- Seeder: Shares files with other peers.
- Leecher: Downloads files from Seeders and later becomes a Seeder.

The system supports parallel downloads, re-seeding, and a graphical user interface (GUI) for monitoring download progress.

System Workflow

The execution of the system follows these logical steps:

1. Tracker Initialization: The Tracker starts, listening for registration and queries.
2. Seeder Activation: A Seeder registers a file with the Tracker and starts serving chunks.
3. Leecher Request: A Leecher queries the Tracker for available Seeders and begins downloading.
4. File Download Process: The Leecher downloads chunks in parallel and reconstructs the file.
5. Transition to Seeder: Once the download completes, the Leecher becomes a Seeder.

This workflow ensures efficient file distribution among peers.

1. Tracker

The Tracker class is responsible for managing active peers and directing Leechers to Seeders. It listens on UDP port 5000 and handles:

- REGISTER requests from Seeders.
- QUERY requests from Leechers.
- UPDATE messages to track active peers.
- Cleanup of inactive peers.

Key Methods:

- main(String[] args): Initializes the Tracker and starts listening.
- cleanupPeers(): Removes stale Seeders that haven't sent updates in 60 seconds via a Scheduled Thread in the Executor service.

- processRequest(String message, InetAddress address, int
  port): Processes incoming messages.

2. Seeder

The Seeder class is responsible for making a file available to the network. The
Seeder:

1. Splits the file into 512 KB chunks.
2. Registers with the Tracker by sending a REGISTER message.
3. Starts a TCP server to serve file chunks.
4. Sends periodic UPDATE messages to keep its availability status via a Scheduled Thread in the
   Executor service.

Key Methods:

- splitFile(String filePath): Reads the file and splits it into chunks.
- register(): Sends REGISTER message to the Tracker.
- update(): Sends periodic heartbeats via a Scheduled Thread in the Executor service
- handleClient(Socket socket, byte[][] chunks): Serves requested
  chunks to Leechers by a thread pool in the ExecutorService to handle
  them simultaneously.

3. Leecher

The Leecher class downloads a file from Seeders and then transitions into a
Seeder.

1. Queries the Tracker for Seeders using QUERY.
2. Downloads file chunks in parallel from multiple Seeders using a thread pool in the
   ExecutorService.
3. Reconstructs the file from downloaded chunks.
4. Becomes a Seeder and shares the file.

Key Methods:

- queryTracker(String fileHash): Finds available Seeders.
- downloadChunk(String ip, int port, int chunkNumber):Downloads
  a chunk from a Seeder.
- startDownload(): Manages the download process in a separate thread.
- updateProgress(int progress, String message): Updates the GUI
  with download status.

Communication Protocol

The system uses UDP and TCP for communication.

a) Tracker Messages (UDP)

- REGISTER: REGISTER|<fileHash>|<SeederIP>|<SeederPort>
- UPDATE (Heartbeat): UPDATE|<fileHash>|<SeederIP>|<SeederPort>
- QUERY: QUERY|<fileHash>
- QUERY Response: List of available Seeders.

b) Leecher-Seeder Communication (TCP)

- Chunk Request: The Leecher requests a chunk number.
- Chunk Response: The Seeder sends the requested chunk.

Design Considerations

a) Parallel Downloads

- The Leecher uses a thread pool to download chunks in parallel from multiple Seeders.

b) Re-Seeding

- Once the Leecher finishes downloading, it becomes a Seeder and registers with the Tracker.

c) GUI for Download Progress

- The Leecher provides a GUI with a progress bar and status updates.

d) Fault Tolerance

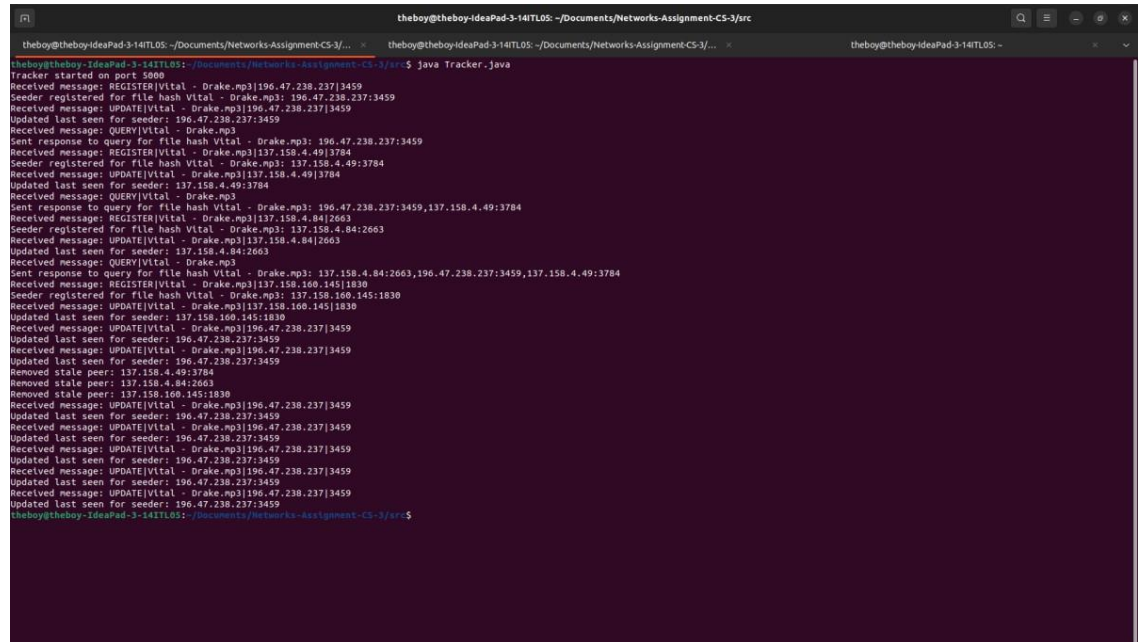- The Tracker periodically removes stale peers.

Conclusion

The P2P File Sharing System effectively distributes files using a decentralized approach. The combination of parallel downloads, automatic re-seeding, and GUI-based monitoring enhances performance and usability. The protocol ensures scalability and reliability, making it well-suited for distributed networks.

Screenshots

The below screenshots show how the program works (without the GUI). I removed it so certain things can be seen clearer. Initially there's one seeder and a tracker.

TRACKER

FIRST SEEDER


```
theboy@theboy-IdeaPad-3-14ITL0S:~/Documents/Networks-Assignment-CS-3/src$ java Seeder "Vital - Drake.mp3" 196.47.238.237 196.47.238.237 3459
File split into 9 chunks.
Seeder started on port 3459
Registered with tracker for file: Vital - Drake.mp3
Sent heartbeat to tracker.
New client connected: /137.158.4.49
Sent total chunks to client: 9
New client connected: /137.158.4.49
Sent chunk 0 to client.
New client connected: /137.158.4.49
Sent chunk 1 to client.
New client connected: /137.158.4.49
Sent chunk 2 to client.
New client connected: /137.158.4.49
Sent chunk 3 to client.
New client connected: /137.158.4.49
Sent chunk 4 to client.
New client connected: /137.158.4.49
Sent chunk 5 to client.
New client connected: /137.158.4.49
Sent chunk 6 to client.
New client connected: /137.158.4.49
Sent chunk 7 to client.
New client connected: /137.158.4.49
Sent chunk 8 to client.
New client connected: /137.158.4.84
Sent total chunks to client: 9
New client connected: /137.158.4.84
New client connected: /137.158.4.84
Sent chunk 0 to client.
Sent chunk 2 to client.
New client connected: /137.158.4.84
New client connected: /137.158.4.84
Sent chunk 4 to client.
Sent chunk 6 to client.
New client connected: /137.158.4.84
Sent chunk 8 to client.
New client connected: /137.158.160.145
New client connected: /137.158.160.145
Sent chunk 4 to client.
Sent chunk 1 to client.
New client connected: /137.158.160.145
Sent chunk 7 to client.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
```

```
New client connected: /137.158.4.49
Sent chunk 6 to client.
New client connected: /137.158.4.49
Sent chunk 7 to client.
New client connected: /137.158.4.49
Sent chunk 8 to client.
New client connected: /137.158.4.84
Sent total chunks to client: 9
New client connected: /137.158.4.84
New client connected: /137.158.4.84
Sent chunk 0 to client.
Sent chunk 2 to client.
New client connected: /137.158.4.84
New client connected: /137.158.4.84
Sent chunk 4 to client.
Sent chunk 6 to client.
New client connected: /137.158.4.84
Sent chunk 8 to client.
New client connected: /137.158.160.145
New client connected: /137.158.160.145
Sent chunk 4 to client.
Sent chunk 1 to client.
New client connected: /137.158.160.145
Sent chunk 7 to client.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
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Sent heartbeat to tracker.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
Sent heartbeat to tracker.
^Ctheboy@theboy-IdeaPad-3-14ITL0S:~/Documents/Networks-Assignment-CS-3/src$
```

FIRST LEECHER


```
lthman009@nightmare:~/Documents/src$ java Leecher "Vital - Drake.mp3" 196.47.238.237 137.158.160.145 1830
Starting download for file: Vital - Drake.mp3
Seeders found: [137.158.4.84:2663, 196.47.238.237:3459, 137.158.4.49:3784]
Fetching total chunks from seeder: 137.158.4.84:2663
Total chunks to download: 9
Starting parallel download of chunks...
Downloading chunk 0 from seeder: 137.158.4.84:2663
Waiting for all chunks to be downloaded...
Downloading chunk 1 from seeder: 196.47.238.237:3459
Downloading chunk 2 from seeder: 137.158.4.49:3784
Successfully downloaded chunk 0
Downloading chunk 3 from seeder: 137.158.4.84:2663
Successfully downloaded chunk 2
Downloading chunk 4 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 3
Downloading chunk 5 from seeder: 137.158.4.49:3784
Successfully downloaded chunk 5
Downloading chunk 6 from seeder: 137.158.4.84:2663
Successfully downloaded chunk 6
Downloading chunk 7 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 4
Downloading chunk 8 from seeder: 137.158.4.49:3784
Successfully downloaded chunk 8
Successfully downloaded chunk 1
Successfully downloaded chunk 7
All chunks downloaded successfully. Assembling file...
File downloaded successfully: Vital - Drake.mp3
Starting seeder to share the downloaded file...
File split into 9 chunks.
Seeder started on port 1830
Registered with tracker for file: Vital - Drake.mp3
Sent heartbeat to tracker.
^Clthman009@nightmare:~/Documents/src$
```

SECOND LEECHER


```
PS C:\Users\lthman009\CS3\noplease-main> java Leecher "Vital - Drake.mp3" 196.47.238.237 137.158.4.84 2663
Starting download for file: Vital - Drake.mp3
Seeders found: [196.47.238.237:3459, 137.158.4.49:3784]
Fetching total chunks from seeder: 196.47.238.237:3459
Total chunks to download: 9
Starting parallel download of chunks...
Waiting for all chunks to be downloaded...
Downloading chunk 1 from seeder: 137.158.4.49:3784
Downloading chunk 0 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 1
Downloading chunk 2 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 0
Downloading chunk 3 from seeder: 137.158.4.49:3784
Successfully downloaded chunk 3
Downloading chunk 4 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 2
Downloading chunk 5 from seeder: 137.158.4.49:3784
Successfully downloaded chunk 5
Downloading chunk 6 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 4
Downloading chunk 7 from seeder: 137.158.4.49:3784
Successfully downloaded chunk 7
Downloading chunk 8 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 6
Successfully downloaded chunk 8
All chunks downloaded successfully. Assembling file...
File downloaded successfully: Vital - Drake.mp3
Starting seeder to share the downloaded file...
File split into 9 chunks.
Seeder started on port 2663
Registered with tracker for file: Vital - Drake.mp3
Sent heartbeat to tracker.
New client connected: /137.158.160.145
Sent total chunks to client: 9
New client connected: /137.158.160.145
```

```
Windows PowerShell                                                                    —  □  ×
Waiting for all chunks to be downloaded...
Downloading chunk 1 from seeder: 137.158.4.49:3784
Downloading chunk 0 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 1
Downloading chunk 2 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 0
Downloading chunk 3 from seeder: 137.158.4.49:3784
Successfully downloaded chunk 3
Downloading chunk 4 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 2
Downloading chunk 5 from seeder: 137.158.4.49:3784
Successfully downloaded chunk 5
Downloading chunk 6 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 4
Downloading chunk 7 from seeder: 137.158.4.49:3784
Successfully downloaded chunk 7
Downloading chunk 8 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 6
Successfully downloaded chunk 8
All chunks downloaded successfully. Assembling file...
File downloaded successfully: Vital — Drake.mp3
Starting seeder to share the downloaded file...
File split into 9 chunks.
Seeder started on port 2663
Registered with tracker for file: Vital — Drake.mp3
Sent heartbeat to tracker.
New client connected: /137.158.160.145
Sent total chunks to client: 9
New client connected: /137.158.160.145
Sent chunk 0 to client.
New client connected: /137.158.160.145
Sent chunk 3 to client.
New client connected: /137.158.160.145
Sent chunk 6 to client.
PS C:\Users\lthman009\CS3\noplease-main> |
```

THIRD LEECHER

```
Windows PowerShell                                                                    —  □  ×
PS Microsoft.PowerShell.Core\FileSystem::\\technet.wf.uct.ac.za\profiledata$\lthman009\Documents\noplease-main> java Leecher "Vital — Drake.mp3" 196
.47.238.237 137.158.4.49 3784
Starting download for file: Vital — Drake.mp3
Seeders found: [196.47.238.237:3459]
Fetching total chunks from seeder: 196.47.238.237:3459
Total chunks to download: 9
Starting parallel download of chunks...
Waiting for all chunks to be downloaded...
Downloading chunk 0 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 0
Downloading chunk 1 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 1
Downloading chunk 2 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 2
Downloading chunk 3 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 3
Downloading chunk 4 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 4
Downloading chunk 5 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 5
Downloading chunk 6 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 6
Downloading chunk 7 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 7
Downloading chunk 8 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 8
All chunks downloaded successfully. Assembling file...
File downloaded successfully: Vital — Drake.mp3
Starting seeder to share the downloaded file...
File split into 9 chunks.
Seeder started on port 3784
Registered with tracker for file: Vital — Drake.mp3
Sent heartbeat to tracker.
New client connected: /137.158.4.84
Sent chunk 1 to client.
```

```
Successfully downloaded chunk 2
Downloading chunk 3 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 3
Downloading chunk 4 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 4
Downloading chunk 5 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 5
Downloading chunk 6 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 6
Downloading chunk 7 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 7
Downloading chunk 8 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 8
All chunks downloaded successfully. Assembling file...
File downloaded successfully: Vital - Drake.mp3
Starting seeder to share the downloaded file...
File split into 9 chunks.
Seeder started on port 3784
Registered with tracker for file: Vital - Drake.mp3
Sent heartbeat to tracker.
New client connected: /137.158.4.84
Sent chunk 1 to client.
New client connected: /137.158.4.84
Sent chunk 3 to client.
New client connected: /137.158.4.84
Sent chunk 5 to client.
New client connected: /137.158.4.84
Sent chunk 7 to client.
New client connected: /137.158.160.145
Sent chunk 2 to client.
New client connected: /137.158.160.145
Sent chunk 5 to client.
New client connected: /137.158.160.145
Sent chunk 8 to client.
PS Microsoft.PowerShell.Core\FileSystem::\\technet.wf.uct.ac.za\profiledata$\lthman009\Documents\noplease-main>
```

GUI

```
PS Microsoft.PowerShell.Core\FileSystem::\\technet.wf.uct.ac.za\profiledata$\lthman009\Pictures\noplease-main> java Leecher "Vital - Drake.mp3" 196.
47.238.237 137.158.4.84 2663
Starting download for file: Vital - Drake.mp3
Seeders found: [196.47.238.237:3459]
Fetching total chunks from seeder: 196.47.238.237:3459
Total chunks to download: 9
Starting parallel download of chunks...
Waiting for all chunks to be downloaded...
Downloading chunk 0 from seeder: 196.47.238.237:34
Successfully downloaded chunk 0
Downloading chunk 1 from seeder: 196.47.238.237:34
Successfully downloaded chunk 1
Downloading chunk 2 from seeder: 196.47.238.237:34
Successfully downloaded chunk 2
Downloading chunk 3 from seeder: 196.47.238.237:34
Successfully downloaded chunk 3
Downloading chunk 4 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 4
Downloading chunk 5 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 5
Downloading chunk 6 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 6
Downloading chunk 7 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 7
Downloading chunk 8 from seeder: 196.47.238.237:3459
Successfully downloaded chunk 8
All chunks downloaded successfully. Assembling file...
File downloaded successfully: Vital - Drake.mp3
Starting seeder to share the downloaded file...
File split into 9 chunks.
Seeder started on port 2663
Registered with tracker for file: Vital - Drake.mp3
Sent heartbeat to tracker.
```

Download Progress

Starting seeder to share the downloaded file...

100%

SEQUENCE DIAGRAM

```
   Seeder            Tracker            Leecher

      | REGISTER(fileHash, IP, Port) |              |
      |----------------------------->|              |
      |  UPDATE(fileHash, IP, Port)  |              |
      |----------------------------->|              |
      |              |       QUERY(fileHash)        |
      |              |<-----------------------------|
      |  UPDATE(fileHash, IP, Port)  |              |
      |----------------------------->|              |
      |              |       List of seeders        |
      |              |----------------------------->|
  ┌ loop  [Request/Send Chunks] ──────────────────────┐
  │   |         Request chunk n                     | │
  │   |<-------------------------------------------| │
  │   |         Send chunk n                        | │
  │   |------------------------------------------->| │
  └───────────────────────────────────────────────────┘
      |  UPDATE(fileHash, IP, Port)  |              |
      |----------------------------->|              |
      |              |  REGISTER(fileHash, IP, Port)|
      |              |<-----------------------------|

   Seeder            Tracker            Leecher
```