Introduction

This manual provides a comprehensive guide for running the P2P file sharing system built in Go. This system allows peers to register, search, and download files using a super-peer architecture. Additionally, it includes performance-testing capabilities to measure response times across different network topologies.

System Requirements

- **Operating System**: Windows, Linux, or macOS with Go installed.
- **Go Version**: Go 1.16 or higher.
- **Memory**: Minimum 512 MB.
- **Disk Space**: 100 MB for files and logs.

Directory Structure

plaintext

Copy code

P2P-File-Sharing/

```
├── shared_files/           # Directory to store shared files for leaf nodes
├── aggregate_data.py       # Script for data aggregation
├── automatedclient_linear.py  # Automated client script for linear topology
├── config.json             # Configuration file for all-to-all topology
├── config_linear.json      # Configuration file for linear topology
├── go.mod                  # Go module file
├── go.sum                  # Go dependencies
├── main.go                 # Main program file
├── Output_LN1.txt          # Sample output for leaf node LN1
├── Output_SN1.txt          # Sample output for super-peer SP1
└── [Various Python Scripts]  # Scripts for data visualization and analysis
```

Compilation Instructions

1. **Install Go** if not already installed. Follow instructions from the Go website.

2. Open a terminal and navigate to the project root directory:

cd /path/to/P2P-File-Sharing

3. Initialize Go modules if needed:

go mod init p2p-file-sharing

go mod tidy

Running the System

To run the system, you will start various peers (both super-peers and leaf nodes) using the configuration files provided.

Step 1: Start Super-Peers

1. Open a terminal window.
2. Run each super-peer as follows:

go run main.go config.json SP1

Replace SP1 with the appropriate super-peer ID (SP2, SP3, ..., SP10) to start each super-peer.

```
2024/10/27 22:29:17 Super-Peer SP1 listening on 127.0.0.1:8000
2024/10/27 22:29:17 Super-Peer SP1 handling neighbor connection with Super-Peer SP7
2024/10/27 22:29:17 Super-Peer SP1 handling neighbor connection with Super-Peer SP3
2024/10/27 22:29:17 Super-Peer SP1 handling neighbor connection with Super-Peer SP2
2024/10/27 22:29:17 Super-Peer SP1 handling neighbor connection with Super-Peer SP4
2024/10/27 22:29:17 Super-Peer SP1 handling neighbor connection with Super-Peer SP5
2024/10/27 22:29:17 Super-Peer SP1 handling neighbor connection with Super-Peer SP9
2024/10/27 22:29:17 Super-Peer SP1 handling neighbor connection with Super-Peer SP6
2024/10/27 22:29:17 Super-Peer SP1 handling neighbor connection with Super-Peer SP10
2024/10/27 22:29:17 Super-Peer SP1 handling neighbor connection with Super-Peer SP8
2024/10/27 22:29:17 Super-Peer SP1 accepted connection from Super-Peer SP7
2024/10/27 22:29:17 Super-Peer SP1 handling neighbor connection with Super-Peer SP7
2024/10/27 22:29:17 Super-Peer SP1 accepted connection from Super-Peer SP2
```

```
2024/10/27 22:29:17 Super-Peer SP1 handling neighbor connection with Super-Peer SP10
2024/10/27 22:29:17 Super-Peer SP1 handling neighbor connection with Super-Peer SP8
2024/10/27 22:29:17 Super-Peer SP1 accepted connection from Super-Peer SP7
2024/10/27 22:29:17 Super-Peer SP1 handling neighbor connection with Super-Peer SP7
2024/10/27 22:29:17 Super-Peer SP1 accepted connection from Super-Peer SP2
2024/10/27 22:29:17 Super-Peer SP1 handling neighbor connection with Super-Peer SP2
2024/10/27 22:29:18 Super-Peer SP1 accepted connection from Super-Peer SP6
2024/10/27 22:29:18 Super-Peer SP1 handling neighbor connection with Super-Peer SP6
2024/10/27 22:29:19 Super-Peer SP1 accepted connection from Super-Peer SP9
2024/10/27 22:29:19 Super-Peer SP1 handling neighbor connection with Super-Peer SP9
2024/10/27 22:29:19 Super-Peer SP1 accepted connection from Leaf-Node LN1
```

```
2024/10/27 22:29:20 Super-Peer SP1 registered file 'file10.txt' from Leaf-Node LN2
2024/10/27 22:29:20 Super-Peer SP1 registered file 'file11.txt' from Leaf-Node LN2
2024/10/27 22:29:20 Super-Peer SP1 registered file 'file12.txt' from Leaf-Node LN2
2024/10/27 22:29:20 Super-Peer SP1 registered file 'file13.txt' from Leaf-Node LN2
2024/10/27 22:29:20 Super-Peer SP1 registered file 'file14.txt' from Leaf-Node LN2
2024/10/27 22:29:20 Super-Peer SP1 registered file 'file5.txt' from Leaf-Node LN2
2024/10/27 22:29:20 Super-Peer SP1 registered file 'file5.txt' from Leaf-Node LN2
2024/10/27 22:29:20 Super-Peer SP1 registered file 'file5.txt' from Leaf-Node LN2
2024/10/27 22:29:20 Super-Peer SP1 registered file 'file6.txt' from Leaf-Node LN2
2024/10/27 22:29:20 Super-Peer SP1 registered file 'file7.txt' from Leaf-Node LN2
2024/10/27 22:29:20 Super-Peer SP1 registered file 'file8.txt' from Leaf-Node LN2
2024/10/27 22:29:20 Super-Peer SP1 registered file 'file9.txt' from Leaf-Node LN2
2024/10/27 22:29:20 Super-Peer SP1 accepted connection from Super-Peer SP5
2024/10/27 22:29:20 Super-Peer SP1 handling neighbor connection with Super-Peer SP5
2024/10/27 22:29:21 Super-Peer SP1 accepted connection from Super-Peer SP8
2024/10/27 22:29:21 Super-Peer SP1 handling neighbor connection with Super-Peer SP8
2024/10/27 22:29:21 Super-Peer SP1 accepted connection from Super-Peer SP3
2024/10/27 22:29:21 Super-Peer SP1 handling neighbor connection with Super-Peer SP3
2024/10/27 22:29:21 Super-Peer SP1 accepted connection from Super-Peer SP10
2024/10/27 22:29:21 Super-Peer SP1 handling neighbor connection with Super-Peer SP10
```

```
2024/10/27 22:29:17 Super-Peer SP2 handling neighbor connection with Super-Peer SP1
2024/10/27 22:29:17 Super-Peer SP2 handling neighbor connection with Super-Peer SP1
2024/10/27 22:29:47 Super-Peer SP2 FileIndex Status:
2024/10/27 22:29:47   File: 'file23.txt' -> Leaf-Nodes: [LN4]
2024/10/27 22:29:47   File: 'file10.txt' -> Leaf-Nodes: [LN4 LN3]
2024/10/27 22:29:47   File: 'file14.txt' -> Leaf-Nodes: [LN3]
2024/10/27 22:29:47   File: 'file17.txt' -> Leaf-Nodes: [LN3 LN4]
2024/10/27 22:29:47   File: 'file18.txt' -> Leaf-Nodes: [LN3 LN4]
2024/10/27 22:29:47   File: 'file20.txt' -> Leaf-Nodes: [LN4]
2024/10/27 22:29:47   File: 'file21.txt' -> Leaf-Nodes: [LN4]
2024/10/27 22:29:47   File: 'file12.txt' -> Leaf-Nodes: [LN3 LN4]
2024/10/27 22:29:47   File: 'file19.txt' -> Leaf-Nodes: [LN3 LN4]
2024/10/27 22:29:47   File: 'file13.txt' -> Leaf-Nodes: [LN3]
2024/10/27 22:29:47   File: 'file22.txt' -> Leaf-Nodes: [LN4]
2024/10/27 22:29:47   File: 'file11.txt' -> Leaf-Nodes: [LN3]
2024/10/27 22:29:47   File: 'file15.txt' -> Leaf-Nodes: [LN4 LN3]
2024/10/27 22:29:47   File: 'file16.txt' -> Leaf-Nodes: [LN3 LN4]
2024/10/27 22:29:47   File: 'file24.txt' -> Leaf-Nodes: [LN4]
2024/10/27 22:30:47 Super-Peer SP2 FileIndex Status:
2024/10/27 22:30:47   File: 'file18.txt' -> Leaf-Nodes: [LN3 LN4]
2024/10/27 22:30:47   File: 'file20.txt' -> Leaf-Nodes: [LN4]
2024/10/27 22:30:47   File: 'file21.txt' -> Leaf-Nodes: [LN4]
2024/10/27 22:30:47   File: 'file23.txt' -> Leaf-Nodes: [LN4]
2024/10/27 22:30:47   File: 'file10.txt' -> Leaf-Nodes: [LN3 LN4]
2024/10/27 22:30:47   File: 'file14.txt' -> Leaf-Nodes: [LN3]
2024/10/27 22:30:47   File: 'file17.txt' -> Leaf-Nodes: [LN3 LN4]
2024/10/27 22:30:47   File: 'file12.txt' -> Leaf-Nodes: [LN4 LN3]
2024/10/27 22:30:47   File: 'file19.txt' -> Leaf-Nodes: [LN3 LN4]
2024/10/27 22:30:47   File: 'file13.txt' -> Leaf-Nodes: [LN3]
2024/10/27 22:30:47   File: 'file22.txt' -> Leaf-Nodes: [LN4]
2024/10/27 22:30:47   File: 'file24.txt' -> Leaf-Nodes: [LN4]
2024/10/27 22:30:47   File: 'file11.txt' -> Leaf-Nodes: [LN3]
2024/10/27 22:30:47   File: 'file15.txt' -> Leaf-Nodes: [LN3 LN4]
2024/10/27 22:30:47   File: 'file16.txt' -> Leaf-Nodes: [LN3 LN4]
```

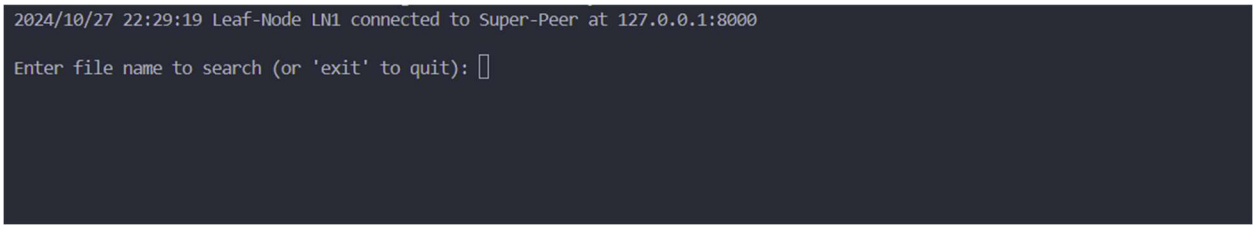
This trend continues upto SP10(All super-peers are interconnected)

Step 2: Start Leaf Nodes

1. Open a new terminal for each leaf node.
2. Run each leaf node as follows:

go run main.go config.json LN1

Replace LN1 with the appropriate leaf node ID (LN2, LN3, ..., LN10).



This trend continues upto LN10

Step 3: Register Files

- Each leaf node will automatically register files located in its respective shared_files directory upon startup. Ensure each directory has the files you wish to share.

Step 4: Search and Download Files

1. On any leaf node terminal, search for a file:

Enter file name to search: file12.txt

2. If the file is found, the system will list peers containing the file. Choose a peer to download the file.

Expected Output:

Super-Peer SP1

```
2024/10/27 15:15:12 Super-Peer SP1 forwarding QueryHitMessage for MessageID LN1-ad97ce08-8ff4-4f71-9eab-63cc1c5c2576
to originator
2024/10/27 15:15:12 Super-Peer SP1 received FileQueryMessage for 'file12.txt' from LN1
2024/10/27 15:15:12 Super-Peer SP1 forwarding QueryHitMessage for MessageID LN1-ad97ce08-8ff4-4f71-9eab-63cc1c5c2576
to originator
2024/10/27 15:15:22 Super-Peer SP1 received FileQueryMessage for 'file12.txt' from LN1
2024/10/27 15:15:22 Super-Peer SP1 forwarding query for 'file12.txt' to neighbor Super-Peer SP2
2024/10/27 15:15:22 Super-Peer SP1 forwarding query for 'file12.txt' to neighbor Super-Peer SP4
2024/10/27 15:15:22 Super-Peer SP1 forwarding query for 'file12.txt' to neighbor Super-Peer SP6
2024/10/27 15:15:22 Super-Peer SP1 forwarding query for 'file12.txt' to neighbor Super-Peer SP7
2024/10/27 15:15:22 Super-Peer SP1 forwarding query for 'file12.txt' to neighbor Super-Peer SP10
2024/10/27 15:15:22 Super-Peer SP1 forwarding query for 'file12.txt' to neighbor Super-Peer SP3
2024/10/27 15:15:22 Super-Peer SP1 forwarding query for 'file12.txt' to neighbor Super-Peer SP5
2024/10/27 15:15:22 Super-Peer SP1 forwarding query for 'file12.txt' to neighbor Super-Peer SP8
2024/10/27 15:15:22 Super-Peer SP1 forwarding query for 'file12.txt' to neighbor Super-Peer SP9
2024/10/27 15:15:22 Super-Peer SP1 forwarding QueryHitMessage for MessageID LN1-0a1c1cae-60ef-4eb2-b323-e3e99972d884
to originator
2024/10/27 15:15:22 Super-Peer SP1 forwarding QueryHitMessage for MessageID LN1-0a1c1cae-60ef-4eb2-b323-e3e99972d884
to originator
2024/10/27 15:15:22 Super-Peer SP1 forwarding QueryHitMessage for MessageID LN1-0a1c1cae-60ef-4eb2-b323-e3e99972d884
to originator
2024/10/27 15:15:22 Super-Peer SP1 received FileQueryMessage for 'file12.txt' from LN1
2024/10/27 15:15:22 Super-Peer SP1 received FileQueryMessage for 'file12.txt' from LN1
2024/10/27 15:15:22 Super-Peer SP1 forwarding QueryHitMessage for MessageID LN1-0a1c1cae-60ef-4eb2-b323-e3e99972d884
to originator
2024/10/27 15:15:22 Super-Peer SP1 forwarding QueryHitMessage for MessageID LN1-0a1c1cae-60ef-4eb2-b323-e3e99972d884
to originator
```

```
2024/10/27 15:15:12 Super-Peer SP1 received FileQueryMessage for 'file12.txt' from LN1
2024/10/27 15:15:12 Super-Peer SP1 forwarding query for 'file12.txt' to neighbor Super-Peer SP8
2024/10/27 15:15:12 Super-Peer SP1 forwarding query for 'file12.txt' to neighbor Super-Peer SP9
2024/10/27 15:15:12 Super-Peer SP1 forwarding query for 'file12.txt' to neighbor Super-Peer SP3
2024/10/27 15:15:12 Super-Peer SP1 forwarding query for 'file12.txt' to neighbor Super-Peer SP5
2024/10/27 15:15:12 Super-Peer SP1 forwarding query for 'file12.txt' to neighbor Super-Peer SP6
2024/10/27 15:15:12 Super-Peer SP1 forwarding query for 'file12.txt' to neighbor Super-Peer SP7
2024/10/27 15:15:12 Super-Peer SP1 forwarding query for 'file12.txt' to neighbor Super-Peer SP10
2024/10/27 15:15:12 Super-Peer SP1 forwarding query for 'file12.txt' to neighbor Super-Peer SP2
2024/10/27 15:15:12 Super-Peer SP1 forwarding query for 'file12.txt' to neighbor Super-Peer SP4
2024/10/27 15:15:12 Super-Peer SP1 forwarding QueryHitMessage for MessageID LN1-ad97ce08-8ff4-4f71-9eab-63cc1c5c2576
to originator
2024/10/27 15:15:12 Super-Peer SP1 forwarding QueryHitMessage for MessageID LN1-ad97ce08-8ff4-4f71-9eab-63cc1c5c2576
to originator
2024/10/27 15:15:12 Super-Peer SP1 forwarding QueryHitMessage for MessageID LN1-ad97ce08-8ff4-4f71-9eab-63cc1c5c2576
to originator
2024/10/27 15:15:12 Super-Peer SP1 received FileQueryMessage for 'file12.txt' from LN1
2024/10/27 15:15:12 Super-Peer SP1 received FileQueryMessage for 'file12.txt' from LN1
2024/10/27 15:15:12 Super-Peer SP1 received FileQueryMessage for 'file12.txt' from LN1
2024/10/27 15:15:12 Super-Peer SP1 forwarding QueryHitMessage for MessageID LN1-ad97ce08-8ff4-4f71-9eab-63cc1c5c2576
to originator
2024/10/27 15:15:12 Super-Peer SP1 forwarding QueryHitMessage for MessageID LN1-ad97ce08-8ff4-4f71-9eab-63cc1c5c2576
to originator
2024/10/27 15:15:12 Super-Peer SP1 received FileQueryMessage for 'file12.txt' from LN1
2024/10/27 15:15:12 Super-Peer SP1 forwarding QueryHitMessage for MessageID LN1-ad97ce08-8ff4-4f71-9eab-63cc1c5c2576
```

LeafNode-1:

```
PS C:\Users\dattu\p2p-file-sharing> go run main.go config.json LN1
>>
Starting Leaf-Node LN1
2024/10/27 15:13:30 Leaf-Node LN1 discovered 12 files
2024/10/27 15:13:30 Leaf-Node LN1 starting file server at 127.0.0.1:9000
2024/10/27 15:13:30 Leaf-Node LN1 connected to Super-Peer at 127.0.0.1:8000

Enter file name to search (or 'exit' to quit): file12.txt
2024/10/27 15:15:12 Leaf-Node LN1 sent file query for 'file12.txt' with MessageID LN1-ad97ce08-8ff4-4f71-9eab-63cc1c5c2576
Issued Query: Looking for file 'file12.txt' with MessageID LN1-ad97ce08-8ff4-4f71-9eab-63cc1c5c2576

Enter file name to search (or 'exit' to quit): 2024/10/27 15:15:12 Response time for MessageID LN1-ad97ce08-8ff4-4f71-9eab-63
cc1c5c2576: 507.5µs
file12.txt
2024/10/27 15:15:22 Leaf-Node LN1 sent file query for 'file12.txt' with MessageID LN1-0a1c1cae-60ef-4eb2-b323-e3e99972d884
Issued Query: Looking for file 'file12.txt' with MessageID LN1-0a1c1cae-60ef-4eb2-b323-e3e99972d884

Query Hit: File 'file12.txt' is available at Leaf-Node LN2 (127.0.0.1:9001)
2024/10/27 15:15:22 Response time for MessageID LN1-0a1c1cae-60ef-4eb2-b323-e3e99972d884: 4.8111ms
Do you want to download this file? (yes/no): yes
2024/10/27 15:15:26 Downloading file from http://127.0.0.1:9001/file12.txt
2024/10/27 15:15:26 File 'file12.txt' already exists. Skipping download.
```

Performance Testing

Automated clients and scripts can be used to simulate various request loads on the network:

automatedclient.py

Run the automated client script for all to all topology:

python automatedclient.py 1 200

python automatedclient.py 2 200

python automatedclient.py 3 200

Repeat till 10 Concurrent Clients

```
 [Client 1] Connection closed.
 [Client 2] Connection closed.
 [Client 3] Connection closed.

 Average Response Time: 3.59 ms over 1200 hits
```

```
[Client 1] All queries sent. Waiting for responses...
[Client 2] All queries sent. Waiting for responses...
[Client 1] Connection closed.
[Client 2] Connection closed.

Average Response Time: 1.19 ms over 800 hits
```

```
[Client 1] All queries sent. Waiting for responses...
[Client 1] Connection closed.

Average Response Time: 1.24 ms over 400 hits
```

Client Id 1 response.csv:

client_id	message_id	response_time_ms	leaf_node
1	Client-1-3739af8c-6925-4a8a-9943-60a03064d35b	0.169100007	LN1
1	Client-1-3739af8c-6925-4a8a-9943-60a03064d35b	0.464000041	LN2
1	Client-1-380d7865-7098-404e-84bd-c2194900e91d	0.173899985	LN1
1	Client-1-380d7865-7098-404e-84bd-c2194900e91d	0.51849999	LN2
1	Client-1-ec9e7cb8-3e55-43db-ad64-3b72d2ac721f	0.80139999	LN1
1	Client-1-ec9e7cb8-3e55-43db-ad64-3b72d2ac721f	1.041600015	LN2
1	Client-1-7ddfa3d9-dab7-4251-96df-8c169666eaf6	0.460499956	LN1
1	Client-1-7ddfa3d9-dab7-4251-96df-8c169666eaf6	0.930899987	LN2
1	Client-1-c58e4d56-d5c8-4cc3-ae18-19e6b2839506	0.443500001	LN1
1	Client-1-c58e4d56-d5c8-4cc3-ae18-19e6b2839506	0.630100025	LN2
1	Client-1-cda5f01d-746e-4bcb-980d-9a859bbbf5e8	0.834300008	LN1
1	Client-1-cda5f01d-746e-4bcb-980d-9a859bbbf5e8	1.189800038	LN2
1	Client-1-ffaf3a82-79c6-479c-afb7-be9a988b97d7	0.469199964	LN1
1	Client-1-ffaf3a82-79c6-479c-afb7-be9a988b97d7	0.726500002	LN2
1	Client-1-48192610-34dd-46b6-9628-17fc40e7cf38	0.446099963	LN1
1	Client-1-48192610-34dd-46b6-9628-17fc40e7cf38	0.740399992	LN2
1	Client-1-6fcfdad7-a8f0-48a0-b42a-2c08f91296bf	0.424800033	LN1
1	Client-1-6fcfdad7-a8f0-48a0-b42a-2c08f91296bf	0.841600006	LN2
1	Client-1-eabe38ce-efd9-4fb4-aff5-878143301818	1.078200003	LN1
1	Client-1-eabe38ce-efd9-4fb4-aff5-878143301818	1.7123	LN2
1	Client-1-2fdaeff4-ba74-462e-910b-034f5b4dddc5	0.868300034	LN1

1 Client-1-2fdaeff4-ba74-462e-910b-034f5b4dddc5 1.137300045 LN2

Compute Average:

python compute_average.py

Number of Clients	Average Response Time (ms)
1	1.241784096
2	1.194810867
3	3.589022756
4	151.9603299
5	511.718574
6	879.7311022
7	1650.128609
8	1535.959898
9	1812.33182
10	2146.979025

Linear Topology

python super_peer.py config_linear.json SP1

python super_peer.py config_linear.json SP2

python super_peer.py config_linear.json SP3

python super_peer.py config_linear.json SP4

python super_peer.py config_linear.json SP5

python super_peer.py config_linear.json SP6

python super_peer.py config_linear.json SP7

python super_peer.py config_linear.json SP8

python super_peer.py config_linear.json SP9

python super_peer.py config_linear.json SP10

python leafnode.py --id LN1 --port 57210 --super_peer_id SP1 --super_peer_port 8000 --file file12.txt

python leafnode.py --id LN2 --port 57226 --super_peer_id SP1 --super_peer_port 8000 --file file12.txt

python leafnode.py --id LN3 --port 57228 --super_peer_id SP2 --super_peer_port 8001 --file file12.txt

python leafnode.py --id LN4 --port 57237 --super_peer_id SP2 --super_peer_port 8001 --file file12.txt

python leafnode.py --id LN5 --port 57285 --super_peer_id SP3 --super_peer_port 8002 --file file12.txt

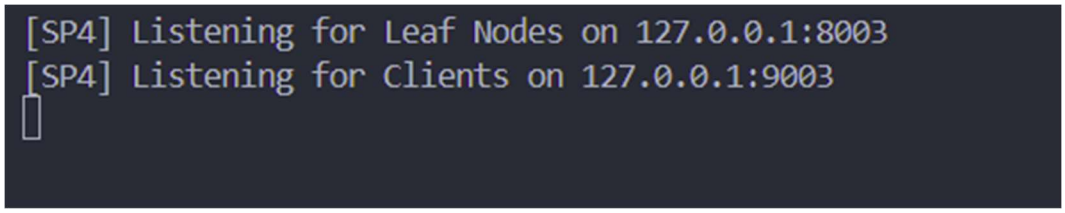
python leafnode.py --id LN6 --port 57292 --super_peer_id SP3 --super_peer_port 8002 --file file12.txt

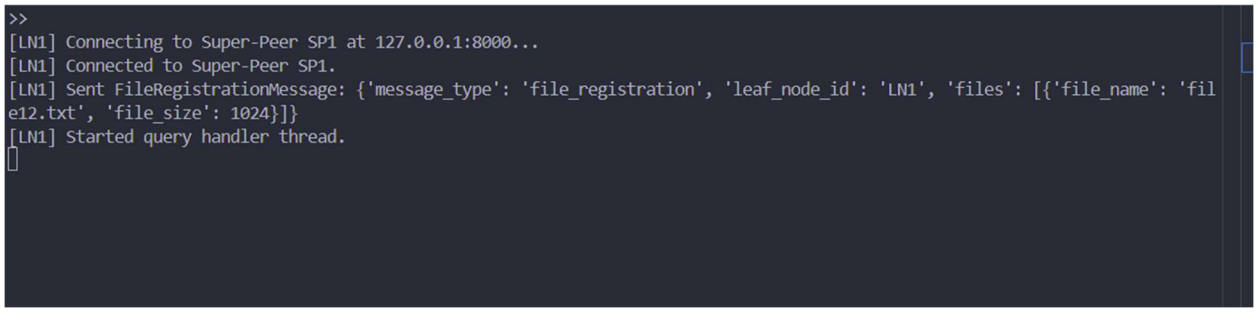
python leafnode.py --id LN7 --port 57301 --super_peer_id SP4 --super_peer_port 8003 --file file12.txt

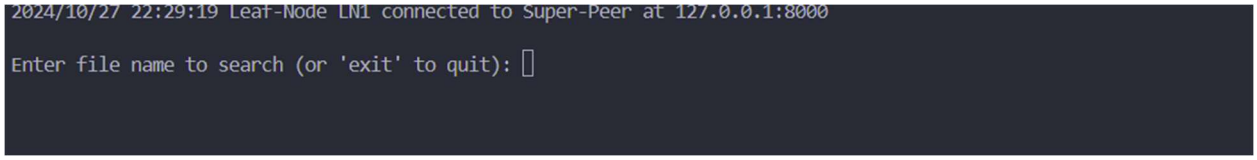
python leafnode.py --id LN8 --port 57309 --super_peer_id SP5 --super_peer_port 8004 --file file12.txt

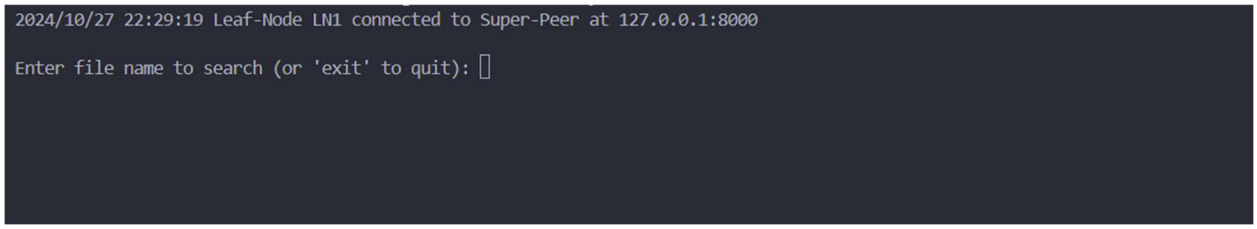
python leafnode.py --id LN9 --port 57312 --super_peer_id SP6 --super_peer_port 8005 --file file12.txt

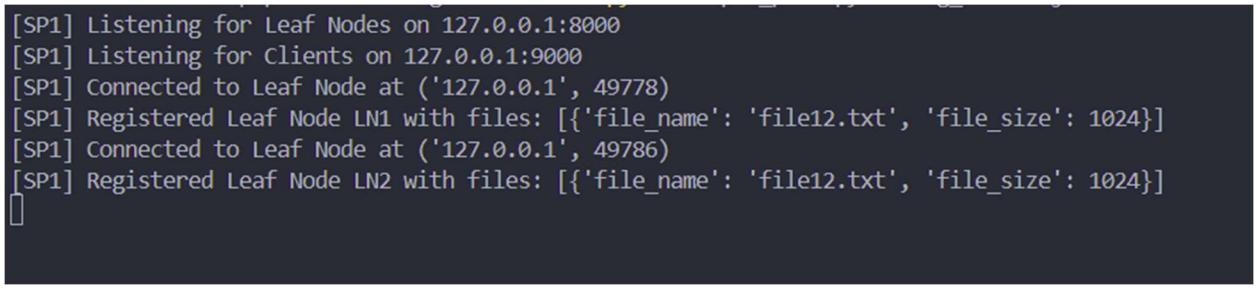
python leafnode.py --id LN10 --port 57339 --super_peer_id SP7 --super_peer_port 8006 --file file12.txt

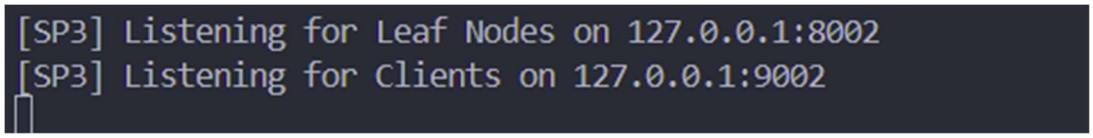












Performance of Linear Topology:

python super_peer.py

python leafnode.py

python automatedclient_linear.py --config config_linear.json --clients 1 --queries 200

python automatedclient_linear.py --config config_linear.json --clients 2 --queries 200

python automatedclient_linear.py --config config_linear.json --clients 3 --queries 200

python automatedclient_linear.py --config config_linear.json --clients 4 --queries 200

python automatedclient_linear.py --config config_linear.json --clients 5 --queries 200

python automatedclient_linear.py --config config_linear.json --clients 6 --queries 200

python automatedclient_linear.py --config config_linear.json --clients 7 --queries 200

python automatedclient_linear.py --config config_linear.json --clients 8 --queries 200

python automatedclient_linear.py --config config_linear.json --clients 9 --queries 200

python automatedclient_linear.py --config config_linear.json --clients 10 --queries 200

```
[Client 2] Connection closed.
[Client 3] Connection closed.
[Client 1] Connection closed.

Results have been written to results_3_clients.csv

Average Response Time: 0.64 ms over 1200 hits
```

```
[Client 2] Connection closed.
[Client 1] Connection closed.

Results have been written to results_2_clients.csv

Average Response Time: 0.50 ms over 800 hits
```

```
[Client 1] Connection closed.

Results have been written to results_1_clients.csv

Average Response Time: 0.73 ms over 400 hits
```

```
[Client 2] Connection closed.
[Client 1] Connection closed.
[Client 4] Connection closed.
[Client 3] Connection closed.
[Client 8] Connection closed.
[Client 10] Connection closed.
[Client 5] Connection closed.
[Client 7] Connection closed.
[Client 9] Connection closed.
[Client 6] Connection closed.

Results have been written to results_10_clients.csv

Average Response Time: 0.41 ms over 2000 hits
```

client_id	message_id	response_time_ms	leaf_node
1	Client-1-3739af8c-6925-4a8a-9943-60a03064d35b	0.169100007	LN1
1	Client-1-3739af8c-6925-4a8a-9943-60a03064d35b	0.464000041	LN2
1	Client-1-380d7865-7098-404e-84bd-c2194900e91d	0.173899985	LN1

1	Client-1-380d7865-7098-404e-84bd-c2194900e91d	0.51849999	LN2
1	Client-1-ec9e7cb8-3e55-43db-ad64-3b72d2ac721f	0.80139999	LN1
1	Client-1-ec9e7cb8-3e55-43db-ad64-3b72d2ac721f	1.041600015	LN2
1	Client-1-7ddfa3d9-dab7-4251-96df-8c169666eaf6	0.460499956	LN1
1	Client-1-7ddfa3d9-dab7-4251-96df-8c169666eaf6	0.930899987	LN2
1	Client-1-c58e4d56-d5c8-4cc3-ae18-19e6b2839506	0.443500001	LN1
1	Client-1-c58e4d56-d5c8-4cc3-ae18-19e6b2839506	0.630100025	LN2
1	Client-1-cda5f01d-746e-4bcb-980d-9a859bbbf5e8	0.834300008	LN1
1	Client-1-cda5f01d-746e-4bcb-980d-9a859bbbf5e8	1.189800038	LN2

Overall average:

python compute_avg_linear

Client Number	Average Response Time (ms)	Total Hits
Client 1	0.73	400
Client 2	0.5	800
Client 3	0.64	1200
Client 4	0.43	1400
Client 5	0.39	1600
Client 6	0.48	1800
Client 7	0.46	2000
Client 8	0.48	2000
Client 9	0.54	2000
Client 10	0.41	2000

Known Issues

1. **File Directory Setup**: Ensure files are manually placed in the shared_files directory for each leaf node.
2. **Configuration**: Make sure to use the correct configuration file (config.json for all-to-all topology and config_linear.json for linear topology).
3. **Static Neighbor Connections:** The code uses a fixed configuration for neighbor connections without dynamic adjustments. Changes require updating the config.json file, making the system inflexible to real-time network adjustments.