Problem Report

The following issues and limitations have been identified in the current implementation:

1. **High Response Time with Concurrent Clients in All-to-All Topology**:

   In tests with a high number of concurrent clients, the All-to-All topology exhibits significant response time increases, likely due to network congestion. This issue impacts performance under heavy loads, as shown in the performance comparison graph.

   Potential Fix: Implement load balancing or connection throttling to mitigate congestion effects in the All-to-All setup.

2. **Inconsistent Response Times with Large Network Sizes**:

   When the network size scales up, particularly in linear topologies with many nodes, occasional spikes in response time are observed. This may be due to inefficient routing or queuing delays as the system scales.

   Potential Fix: Optimize routing algorithms and introduce mechanisms for dynamic reallocation of requests to minimize delays.

3. **Delayed Query Hit Response Propagation**:

   In scenarios where nodes are queried for file availability, delays in Query Hit messages can occur, particularly when queries traverse multiple hops. This could be due to limitations in caching or message forwarding logic.

   Potential Fix: Implement caching for frequently requested files at super-peer nodes to reduce query response times, or adjust the message TTL and caching policies.

4. **Known Limitations in File Download Verification**:

   After a successful query, the file download may sometimes fail if the node that advertised the file goes offline unexpectedly. The current implementation does not have a retry mechanism for failed downloads.

   Potential Fix: Add a retry mechanism for file downloads and implement fault tolerance for disconnected nodes to improve reliability.

5. **Lack of Fault Tolerance in Leaf Node Connections**:

If a leaf node disconnects unexpectedly, the super-peer might not handle the disconnection gracefully, leading to potential orphaned connections or unhandled exceptions.

Potential Fix: Introduce fault-tolerance mechanisms to monitor and handle node disconnections without impacting network stability.

6. **Limited Support for Complex Topology Structures**:

   The current implementation supports only linear and all-to-all topologies. More complex topologies (e.g., hybrid, hierarchical) might improve performance and resilience, but they are not yet supported.

   Potential Improvement: Extend the code to support additional topologies for more flexibility in handling different network configurations.

Summary

While the current codebase performs adequately under moderate loads and limited network sizes, several performance and reliability issues emerge with increased scale and concurrent usage. The suggested fixes and improvements could address these limitations and improve overall system stability and performance.