Comparison of Different Search Algorithms in Unstructured Decentralized Peer-to-Peer Networks

CSC 466 - Overlay and peer-to-peer Networking - Spring 2025
Semester Project
Website

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Overview

Topic

Peer-to-Peer (P2P) networks are decentralized systems where each participant functions as both a client and a server, allowing for direct resource sharing without a central server. This structure provides advantages in scalability, fault tolerance, and security as the nodes within the network can leave and join freely. There are challenges that remain due to the lack of a global index or hierarchy when searching for resources within this structure. For example, when a node requests to find a peer or file, there is not a generalized structure between everyone which can lead to inefficiencies, scalability limitations, and query failures (lookup misses). This research is important because there exists many different approaches for searching within an unstructured decentralized P2P network such as random walks, flooding, and probabilistic approaches. Understanding the strengths and weaknesses of these methods as well as the capability of finding other participants within a network is important to improving search efficiency, scalability and resource consumption.

Previous Work

Flooding is one of simplest search methods used in unstructured P2P networks. However, it suffers from scalability issues and high overhead. To address this, [1] studied and analyzed a random walk approach,

concluding that random k-walkers offer a more scalable solution. Additionally, [2] proposed a hybrid approach, evaluating different algorithms across various network topologies, with mixed results depending on the topology. While these studies provide valuable insights into search algorithm performance, they do not evaluate performance in dynamic network conditions where nodes frequently join and leave.

Method

This study aims to compare search algorithms such as flooding, random walks and other query techniques in unstructured decentralized peer to peer networks. We will focus on how peer-to-peer network topology and query mechanisms influence search efficiency, scalability and resource consumption. In our approach, we will use structured interdependent steps to understand the architecture, and gain a strong foundation for our study. Using a network simulation tool, we will replicate these methods on a smaller scale P2P network based on gnutella architecture. The smaller scale simulation will allow us the ability to conduct tests and control the environment. Will we then implement and compare multiple search strategies documenting metrics like query success rate, latency and bandwidth consumption. Based on this data, we will analyze the results and evaluate the effectiveness to each approach, possibly identifying optimizations.

Scope

Our Main focus will be on understanding Gnutella like networks, then comparing them to other unstructured P2P networks. Using the recommendation of the professor, we will be using the C++ library NS3 to simulate a small P2P network based gnutella architecture which will further be used to test search algorithms. The choice for this library is tentative and is subject for change. As a group we are unaware of alternative libraries which provide the same capabilities as NS3. If, during our research we discover a better alternative we may elect to move forward with that solution as an alternative.

Expected deliverable and schedule

Task	**Date**
Submit Project Proposal	February 7
Research different types of P2P topology	February 7 - 21
Gather information, Download dependencies, run tests	February 14-21
First Bi-weekly update	February 21st

Run simulations, collect data	February - March
Second Bi-weekly Midterm Update	March 7th
Analyze results	March 7-21st
Third Bi-weekly update	March 21st
Final Presentation	April 4th
Final Report due	April 11th

References

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[1] Q. Lv, P. Cao, E. Cohen, K. Li, and S. Shenker, “Search and replication in unstructured peer-to-peer networks,” *ACM SIGMETRICS Performance Evaluation Review*, vol. 30, no. 1, p. 258, Jun. 2002, doi: https://doi.org/10.1145/511399.511369.

[2] R. Dorrigiv, A. Lopez-Ortiz and P. Pralat, "Search Algorithms for Unstructured Peer-to-Peer Networks," 32nd IEEE Conference on Local Computer Networks (LCN 2007), Dublin, Ireland, 2007, pp. 343-352, doi: 10.1109/LCN.2007.65. keywords: {Peer to peer computing;Floods;Clustering algorithms;Network topology;Computer science;Search methods;Computer networks;Mathematics;Statistics;Broadcasting},

[3] J. Wu and X. Li, “Searching Techniques in Peer-to-Peer Networks,” in Handbook on Theoretical and Algorithmic Aspects of Sensor, Ad Hoc Wireless, and Peer-to-Peer Networks, 2005. doi: https://doi.org/10.1201/9780203323687.ch37.