

CS 550 - Spring 2022
Isaias Rivera
A20442116

P2P File Sharing - Consistency - Design

Initial Constraints

This project code is portable to various devices. This greatly affected the design in terms of what libraries or functionality I had available to me. It runs on Linux, Linux Arm, and Windows (Mac untested). However, I did put my focus on Windows as that is where I did my programming, meaning there might be a bug or two that I missed on Unix systems. For PA3, I only tested on windows.

This project is written in C++20 meaning it requires a more modern compiler and meant to run on newer devices. This does, however, allow me to use more modern C++ features.

Indexing Files

Communication

The super-peer is just a peer alongside an indexing server, meaning, it functions almost identically to the napster style project. The major difference being that the indexing server can now communicate with other indexing servers. The communication between peers and a super-peer's indexing server is purely through RPC. This is because the data being sent between peer and super-peer is often of a known size and the data being sent isn't very large, in most cases.

Hashing

The main idea behind this design for indexing is that each file should be identified by its hash first, name second. Meaning, each file on the super-peer's indexing server has a unique hash, as files do. Because this system was already in place from the first two PAs, I deviated slightly from what PA 3 suggested and compared files using their hash instead of using an additional version number. The only additional thing that I have to do is also compare a file's actual name to ensure file's are consistent across peers.

“Database”

The super-peer's “database” is just three maps. One that associates a unique id to each peer and the other two which associates a hash to a file, where only of these file maps is used when the file is registered from a file server. In other words, we keep track of the local files and file origins. File origins are just entries that have the “master bit”, meaning this is the “true” file that everyone should be using.

Each peer also references all the files that it has and each file references each peer that has it. This circular referencing allows for easier searching of either files or peers and can also help ensure files/peers are properly added/removed.

Watch Folders

Peers are not allowed to directly interact with the register or deregister functions, instead, there are “watch folders” that are defined by passing the program the correct arguments. There is one directory which is only for sending files, this directory denotes what files a peer “owns”, this directory is referred to as the “Origin Folder”. Changes to the “Origin Folder” (added, deleted, or modified a file) will automatically update with their respective function (register, deregister, or both when file is modified). There is another directory which is only used for storing files that a peer does not own, files in this directory will be deregistered if modified, this directory is referred to as the “Remote Folder”.

Searching

Currently, searching is very basic. Peers can search their super-peer’s indexing server by passing a query to the `search` function. It returns file entries whose names contain the query. Origin file entries are also returned whenever possible, meaning, when a super peer has a leaf node that is an origin server.

Peers also have the option of listing every available file, however, this is more meant for testing as it would not make sense to actually have something like this in the real world.

Because we use super-peers, this type of request is first propagated to the other super-peers, how this is done is dependent on the topology chosen.

As the results are returned through the propagation, each super-peer attempts to match each non origin entry to an origin entry. Meaning, if the super-peer has an origin server on it’s local network, or if it received an origin file entry from another super-peer, it will ensure any other entries it is going to return match these origin file entries. This ensures consistency when searching for files, meaning only files which are consistent are returned.

Requesting

Peers can request a file to download to their “Remote Folder” by passing a hash of a file to the `request` function. This will both list available peers from the indexing server and select the first available one. It will then begin the process of requesting the specific file from this peer.

Because we use super-peers, this request is also propagated to the other super-peers, how this is done is dependent on the topology chosen.

Because searching ensures the hashes returned are consistent, requesting is also consistent. The only issue with this, however, is if a peer waits too long to request a file using this hash, it can possibly receive an outdated file or the file requested might not exist at all.

Invalidation

When an origin server invalidates a file when the system is in pushing mode, the invalidation must be propagated to all peers. When the “Origin folder” sees that a file was modified, it will first deregister the old file, then register the new one, and only then does it send the invalidation call. This ensures that any peer requesting the new file will have access to the new file. This function is not exposed to the user, as it is automatic.

Propagated calls

Calls that are propagated include **list**, **search**, **request**, and **invalidate**. Registers and deregisters are only done within a super-peer's local network.

Whenever a request is first received, a unique id representing the request is stored to a vector. This is to ensure the same exact request is not passed back to itself, whether by mistake or because the request looped back to itself. The TTL number allows us to make sure that this is not an issue.

Linear topology In linear mode, each super peer will propagate a call to it's neighbor. Along side this, it also passes a TTL number equal to the number of super peers, where it is decremented at each super-peer. This is done to ensure the request does not loop back to the original caller. Once this happens, requests are returned and combined until it is finally returned to the original caller.

All to All topology In All to All mode, the calling super peer simply sends the request to all neighbors at once and then combines them as they are returned. TTL is only used by the calling super peer to differentiate that it is the calling super peer.

Peer to Peer

Communication

The actual peers connect to each other using only sockets. This allows it to be faster than RPC but it also means that communication is at a lower level.

State Machine

The protocol for communication is known between both peers and is setup as a state machine. The following sections are each state for communication. For this section, *client* refers to the peer making a request and *server* refers to the peer receiving the request.

Connection Client sends request for connection the the server known to have the correct file. This step is handled by separate threads that are either accepting or sending requests.

Confirm ID The server sends it's ID to the client to confirm it connected to the correct server. If so, the client sends the file hash, otherwise it disconnects.

Find File The server receives the hash and attempts to find the file locally. If found, it will return the file size and begin waiting for confirmation to start streaming data. If not found, disconnect.

Allocate Space As the name suggests, this is where the client would pre-allocate space for the incoming file, unfortunately, I did not get to implementing this part. Regardless, this is where the client opens a new file to write to. It then sends a confirmation that it can begin streaming data.

Streaming Server streams chunks of the file to the client and the client writes these chunks onto the open file. Streaming is finished once the client no longer receives any data.

If in pulling mode, the server also sends a TTR to the client to tell them when to check back for an updated file.

Invalidation

This communication can also handle invalidation notifications when using pushing mode. The appropriate super-peer will connect using sockets to the peer to notify it that it has an invalid file that it should update. The peer will then attempt to connect to the origin server of this file to download the new file.

Whether in pulling or pushing mode, if the client requests an update (and therefore a new TTR) and the file the client has is still consistent, the server simply passes back a new TTR and disconnects.

Error handling

When an error occurs with a peer, ID mismatch, hash mismatch, file not found, etc. The client peer attempts to request the next peer in the list it initially received from its super-peer. An error is printed if it fails with all peers.

Console interaction

Clients have various functions exposed for them to use.

- **ping**
 - Ping a client's superpeer's indexing server to check its response time
- **list**
 - List all the files available on the network
- **refresh**
 - Force an update to check for and update invalid files
- **search [query]**
 - Search for the query as a substring in the name of all the files on the network
- **request [hash]**
 - Request a specific file, given the hash
- **register & deregister**
 - Not allowed but still listed
- **q || quit || exit**
 - Stop the Interactive Console

Program arguments

Every client is passed, on start up, its unique ID, the static config, the directory path for both watch folders, whether to enable pulling and/or pushing mode, the delay to use when in pulling mode, and whether it should use an "all to all" topology

Improvements

There are a lot of things that I would like to have implemented but did not have time to, the following is a list of some of those things.

- Peer offline detection
 - Server would ping each peer periodically to check that they are on, if they are not it would delete every entry for that peer
- Server offline detection
 - If the indexing server were to go offline the peer would attempt to reconnect and re-register all of it's files
- Ignore files that are being actively modified
 - Files that are located in the “watch folder” will hash and send the file information to the indexing server each time it is edited. I found this is especially bad when editing a file on a Unix device, as each edit even without saving would ping the indexing server. This also includes files that are being downloaded to the “watch folder”
- True concurrent file indexing
 - Currently the “Database” is just two unordered maps, there should be a way to allow fully concurrent read/write to this data structure, currently a mutex is used to ensure no race conditions.
- Communication between peers is rather crude
 - It would be best to use RPC alongside sockets instead of just sockets when it comes to peers
- Peer file verification
 - Peer should also pre-allocate space for the file when it receives the file size
- Multi peer download
 - Especially for larger files, add capability to download separate chunks of a file from multiple peers
- Smarter peer selection
 - Instead of picking the first available peer, ping each peer, or only a couple if there are many, and choose the fastest one
- Better search function
 - Use a proper search function instead of just checking each file for a substring when searching for files