P2P

CS 475, Spring 2018
Concurrent & Distributed Systems

Passwords

- How we authenticate *users* is going to vary based on our environment
- Authenticating you when you log in to your local computer is going to be different than in a distributed system, right?
- Plus: what can we use besides passwords?
  - Biometics?
  - Tokens?

Authentication Examples

- Parties: Prover (P), Verifier (V), Issuer (I)
- Issuer supplies credentials; Prover tries to log in to Verifier
- How many verifiers?
- How many different provers?
- What sort of networking is available?
- What sort of computer is P using?
- What is the relationship of P, V, and I?
- What are the adversary's powers?

Passwords: Consumer Website

- Low-value logins
- Can’t afford customer care
- Use email addresses as login names; email new password on request (but why not send out old password?)
- Don’t worry much about compromise

Passwords: Financial Services Site

- High-value login
- Protecting authentication data is crucial
- Customer care is moderately expensive; user convenience is important, for competitive reasons
  - Perhaps use tokens such as SecurID, but some customers don't like them
    - Today, perhaps use smart phones as second factor
    - Do not let customer care see any passwords
- Require strong authentication for password changes; perhaps use physical mail for communication
- Guard against compromised end-systems

Authentication - High level

- The many different forms of authentication have a great deal in common:
  - Secondary authentication
  - Dealing with server compromise
  - Credential loss
  - Susceptibility to guessing attacks
  - Administrative infrastructure
- These pieces interact
- No perfect solution… best seems to be still… passwords

Distributed Denial of Service Attacks (DDoS)

- Model: Attacker has (hundreds of?) thousands of machines at disposal to attack
- Most common form of DoS today
- Exhausts network bandwidth
- Typically rooted in a botnet - some command and control infrastructure setup by an attacker, who then controls all of these machines

Heuristic Defenses

- Overprovision
- Black-hole routing
- Filter anomalies
- Replication

Billion lolz

```
<?xml version="1.0"?>
<!DOCTYPE lolz [
 <!ENTITY lol "lol">
 <!ELEMENT lolz (#PCDATA)>
 <!ENTITY lol1 "&lol;&lol;&lol;&lol;&lol;&lol;&lol;&lol;&lol;&lol;">
 <!ENTITY lol2 "&lol1;&lol1;&lol1;&lol1;&lol1;&lol1;&lol1;&lol1;&lol1;&lol1;">
 <!ENTITY lol3 "&lol2;&lol2;&lol2;&lol2;&lol2;&lol2;&lol2;&lol2;&lol2;&lol2;">
 <!ENTITY lol4 "&lol3;&lol3;&lol3;&lol3;&lol3;&lol3;&lol3;&lol3;&lol3;&lol3;">
 <!ENTITY lol5 "&lol4;&lol4;&lol4;&lol4;&lol4;&lol4;&lol4;&lol4;&lol4;&lol4;">
 <!ENTITY lol6 "&lol5;&lol5;&lol5;&lol5;&lol5;&lol5;&lol5;&lol5;&lol5;&lol5;">
 <!ENTITY lol7 "&lol6;&lol6;&lol6;&lol6;&lol6;&lol6;&lol6;&lol6;&lol6;&lol6;">
 <!ENTITY lol8 "&lol7;&lol7;&lol7;&lol7;&lol7;&lol7;&lol7;&lol7;&lol7;&lol7;">
 <!ENTITY lol9 "&lol8;&lol8;&lol8;&lol8;&lol8;&lol8;&lol8;&lol8;&lol8;&lol8;">
]>
<lolz>&lol9;</lolz>
```

After parsing: this document contains “lol” repeated literally a billion times… ~3GB of RAM

Announcements

- Form a team and get started on the project!
  - http://jonbell.net/gmu-cs-475-spring-2018/final-project/
  - AutoLab available
- Today - P2P:
  - Masterless systems
  - Discussion of course structure
  - Course evaluation

Why P2P?

- Spreads network/cache costs across users instead of provider
- No server might mean:
  - Easier to deploy
  - Less chance of overload
  - Single failure won't take down the system
  - Harder to attack

Why not P2P?

- Hard to find data items over millions of users
- Computers might not be as reliable as a managed server
- Less secure (?)

P2P

- Goal: IF there must be a master, all that it knows is the address of a few clients using the system
- Otherwise, everyone talks to each other, figures it out
- Replicate files, store them on clients, let clients find files from each other
- Challenges:
  - Where to find data?
  - What to do when clients come and go?

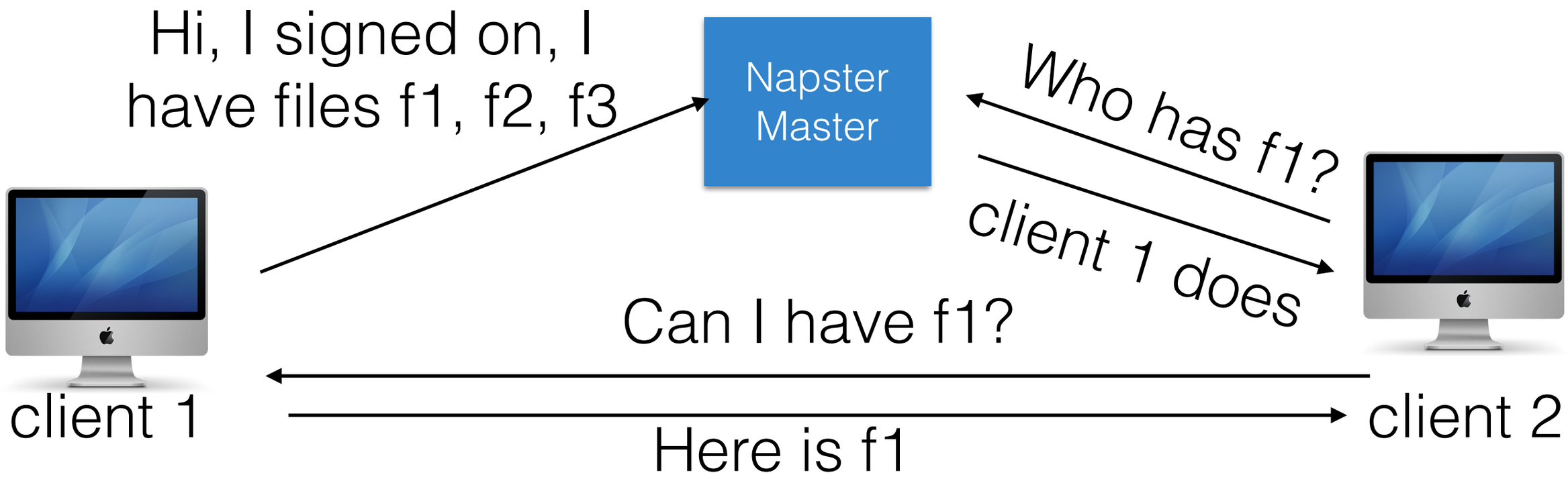
P2P

- Break it down into four operations:
  - **Join** the network and begin participating
  - **Publish** a file to the network, letting others know you have it
  - **Search** for a file that you want
  - **Fetch** a file once it is found

Napster

- Single master (centralized DB) stores metadata and client status
- **Join**: Client contacts master
- **Publish:** Client reports list of files to master
- **Search:** Query the server, find who has the file you want
- **Fetch:** Get directly from that peer client

Napster



Doesn't everything just look like GFS, even things that predated it? :)

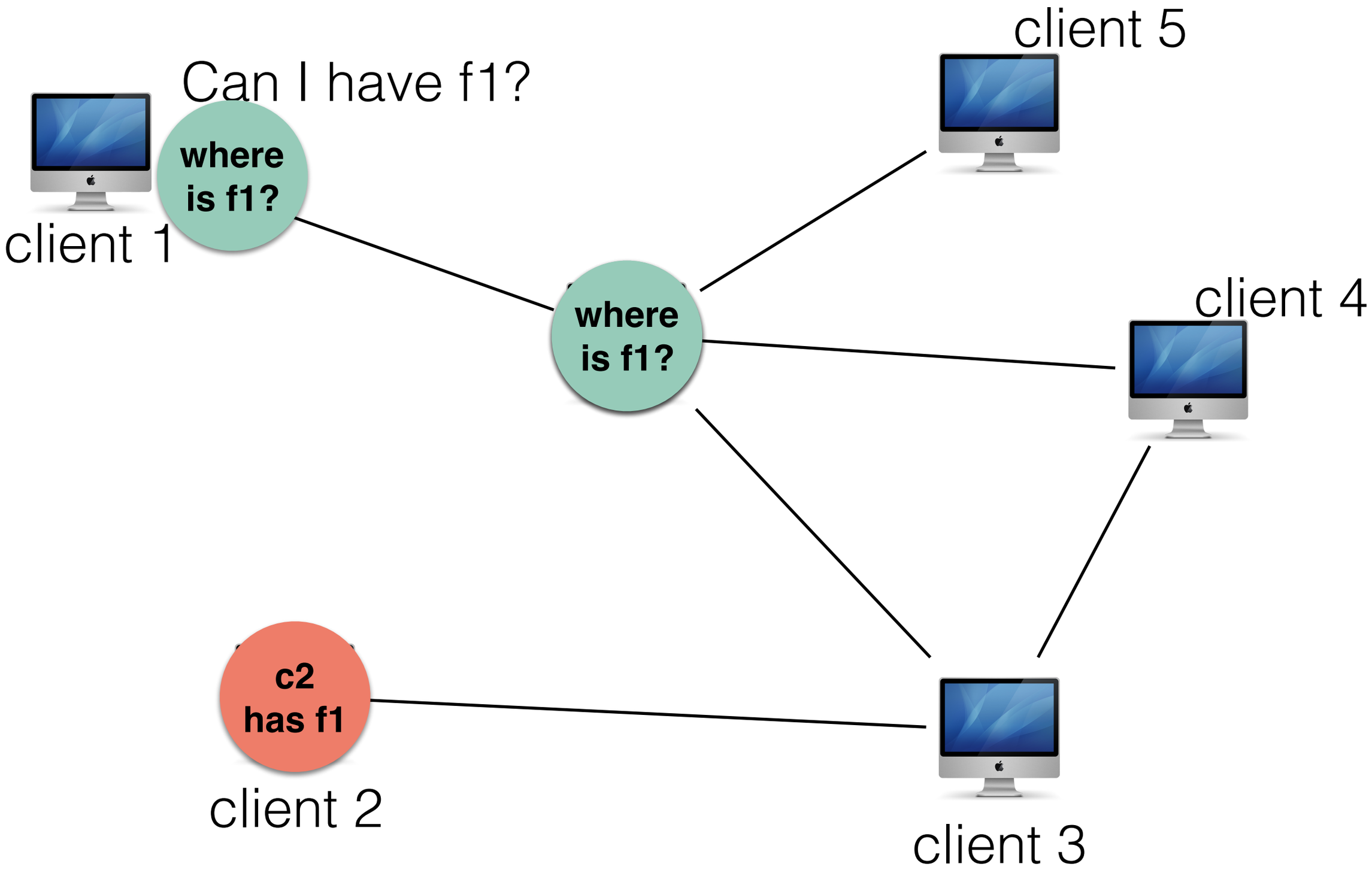
Napster

- The good:
  - Simple
  - Finding a file is really fast, regardless of how many clients there are - master has it all
- The bad:
  - Server becomes a single point of failure
  - Server does a lot of processing
  - Server having all of metadata implies significant legal liabilities

Gnutella 1.0

- **Join:** Client contacts a few other clients to find "neighbors"
  - Requires some initial mechanism to bootstrap
- **Publish:** N/A
- **Search:** Client asks neighbors for file, who ask their neighbors for file, who asks their neighbors out to some depth
- **Fetch:** Clients directly communicate with each other

Gnutella 1.0


client 5
Can I have f1?
where is f1?
client 1
client 4
where is f1?
c2 has f1
client 2
client 3

Gnutella

- This is called "flooding"
- Cool:
  - Fully decentralized
  - Cost of search is distributed - no single node has to search through all of the data
- Bad:
  - Search requires contacting many nodes!
  - Who can know when your search is done?
  - What if nodes leave while you are searching?

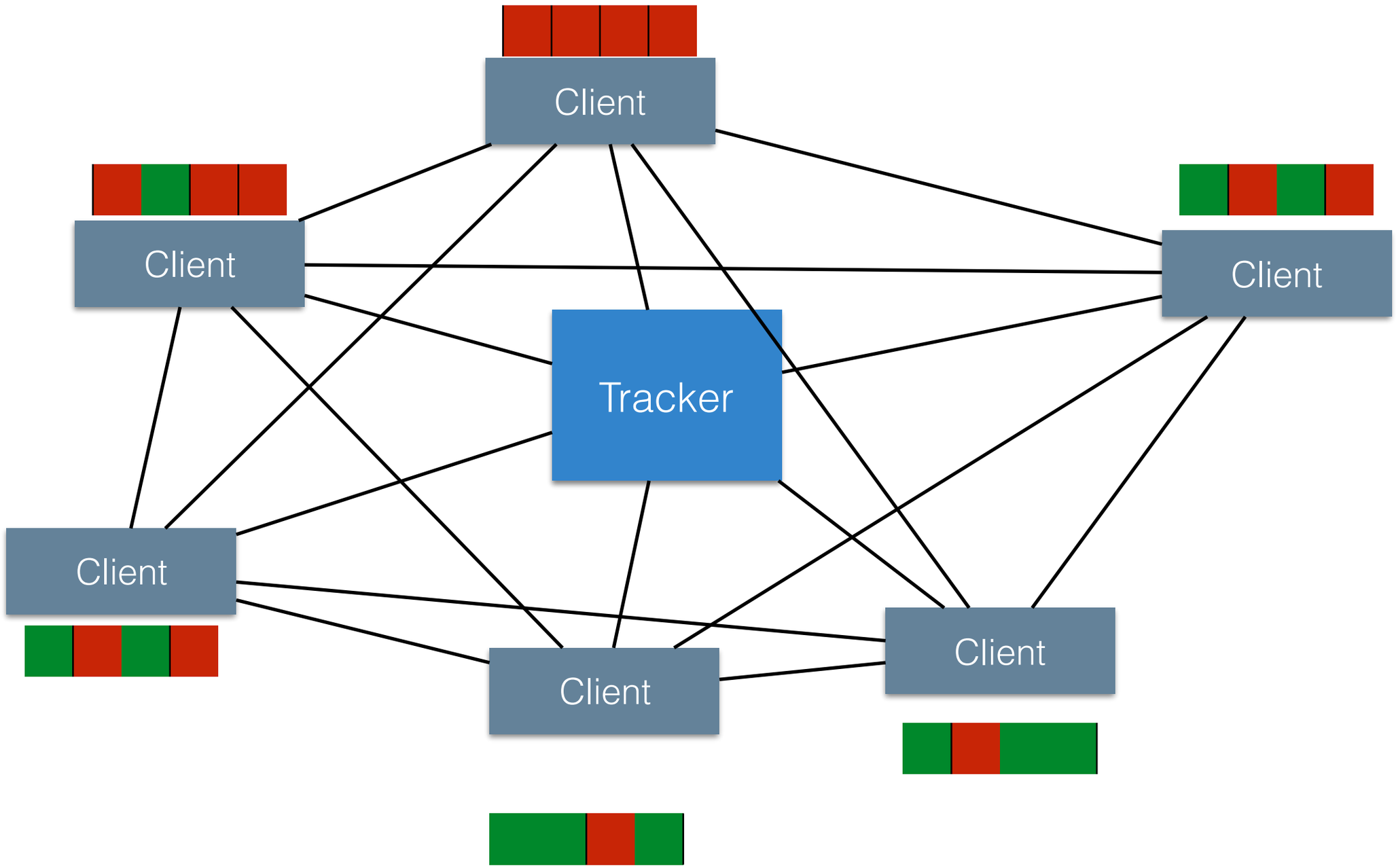
BitTorrent

- "Swarming"
- **Join**: Contact master "tracker," get list of peers
- **Publish**: Run a tracker server
- **Search**: Out-of-band (e.g. google)
- **Fetch**: Download chunks of files from peers

BitTorrent vs Napster

- Focus on **less** files, each of which is **larger**
- Files are broken into chunks -> can get different pieces of a file from different clients
- Anti-freeloading mechanisms - if you don't share, you don't get to play!
    - Since a big file is many chunks, once you get a chunk you can immediately share it with others
- Trackers are still single-points of failure, but assumption is 1 tracker per file

BitTorrent



BitTorrent

- "Tit-for-tat" sharing strategy
- A is getting data from B, C, D
  - A will let the fastest of those get data from A
  - A will be optimistic though, and let nodes who haven't shared anything yet have some data so that they can have a chance to share

DHT (Distributed Hash Table)

- Goal:
  - Guarantee that a file is always found within some bounded and reasonable number of steps
- Abstraction:
  - Create a lookup table, mapping from file to node that has that file (much like Napster)
  - BUT distribute this lookup table amongst the nodes participating (no single master)

DHT

- **Join:** Contact some other node to bootstrap: integrate yourself into the DHT, get a node ID and list of participating nodes
- **Publish:** Tell "mostly the correct" node that you have a file
- **Search:** Query for a file, asking first a "mostly correct" node
- **Fetch:** Contact node that has it directly
- How do we know where to route? Consistent hashing!

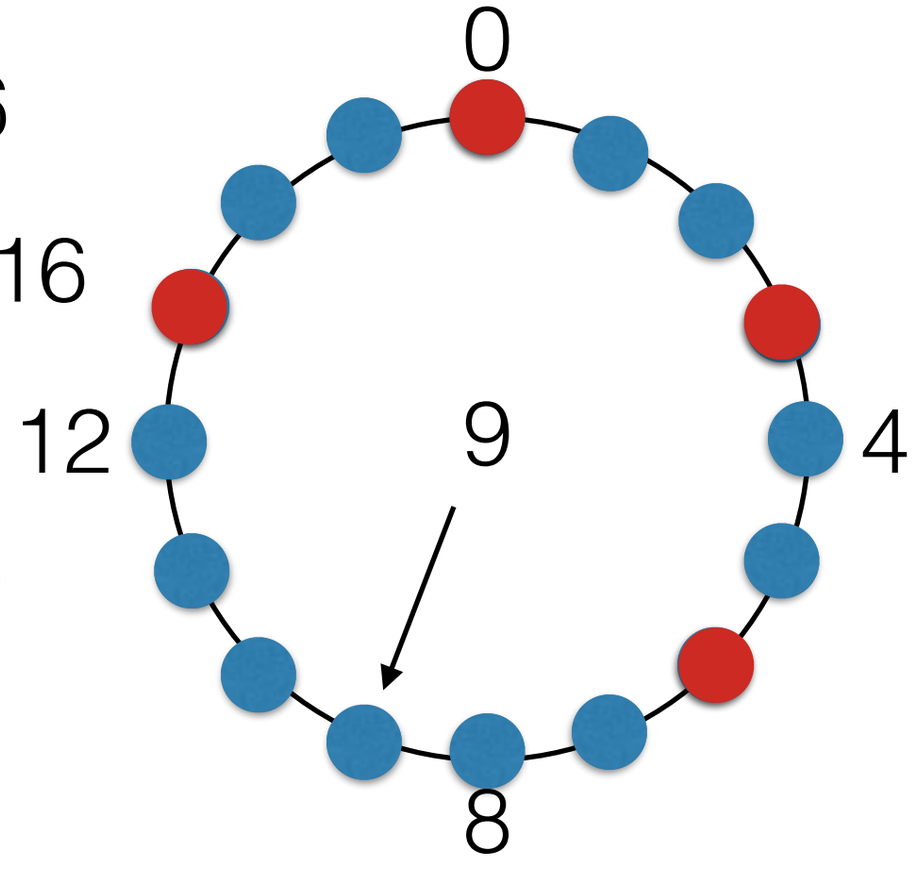
Reminder: Consistent Hashing

Example: hash key size is 16

Each ● is a value of hash % 16

Each ● is a bucket

Example: bucket with key 9?



DHT

- Pros:
  - Guarantees that if the data is in the network, you'll find it in log(n) time (compare to Gnutella - pseudo-random search)
  - Good for caching, infrequently written data
- Cons:
  - Can really only match on exact keys
  - The node join/leave story is really bad - if we are distributed across the internet, a node leaving/joining might involve moving hundreds of GBs around

DHT Applications

- Use a DHT instead of a tracker for BitTorrent!
- Bootstrap: find a DHT peer
- Application: As you acquire files or look for files, add those facts into the DHT

Discussion of course structure

- More/less concurrency discussion at start?
- More/less programming?
- More/less detail on some topics?