6.1800 Spring 2024

Lecture #13: The application layer

serving content as content evolves

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bandwidth-based scheduling: can we allocate specific amounts of bandwidth to some traffic?

round robin: can't handle variable packet sizes (and in its most basic form doesn't allow us to weight traffic differently)

deficit round robin: handles variable packet sizes (even within the same queue), near-perfect fairness and low packet processing overhead

deficit round robin also doesn't require a mean packet size, which is another good thing

```
in each round:

 for each queue q:
  if q is not empty:
    q.credit += q.quantum

    while q.credit >= size of next packet p:
      q.credit -= size of p
      send p
  else:
     q.credit = 0
```

the quantums for each queue are chosen to be **proportionate to the packet sizes**. too big and we have poor short-term fairness, too small and it just takes too long to build credit.

6.1800 in the news

standardizations let us communicate across machines

TCP, DNS, OSPF (link-state routing), etc., all have standards that describe the protocols in detail including packet formats

You won't be able to find these new emoji on your keyboard just yet, though. While version 15.1.0 of the Unicode was approved on Sept. 12 (you can read all of it here), there's always a lag between the approval and its release. Emojipedia had estimated that the new emoji would be available in early 2024.

Tech > Mobile

Ready for New iPhone Emojis? Here Are the 118 Icons Coming in iOS 17.4

The iPhone adds more emoji you never knew you needed.

Gael Cooper

Jan. 29, 2024 2:55 a.m. PT

2 min read

Phoenix, lime and brown mushroom are only a few of the many new emojis coming in iOS 17.4.

Emojipedia

6.1800 in the news

who sets the standards?

read this comic and let my friend keith explain it to you!

https://thenib.com/who-makes-emoji/

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Emojipedia

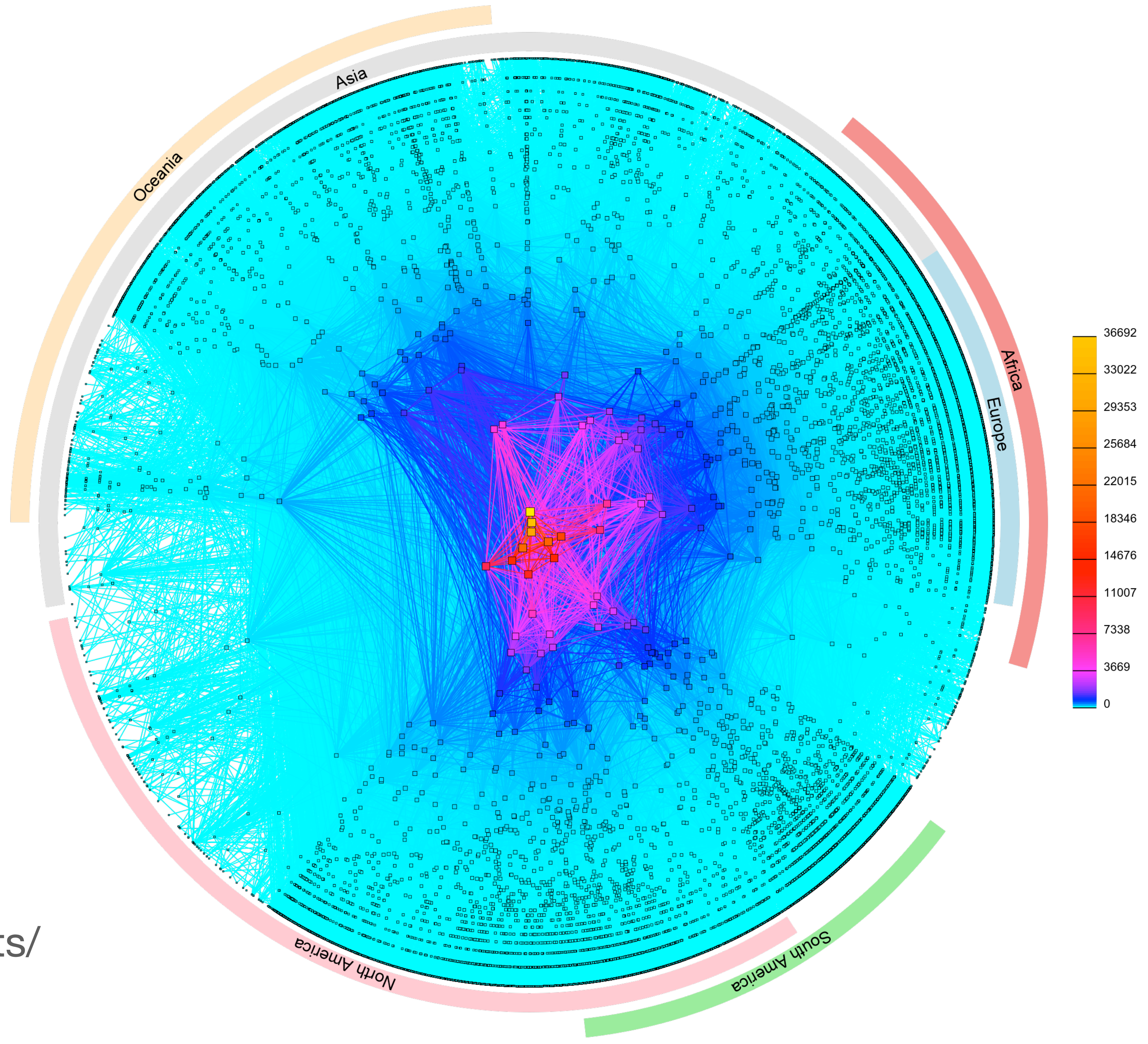
1970s: ARPAnet — hosts.txt

1978: flexibility and layering — distance-vector routing

early 80s: growth → change — TCP, UDP; OSPF, EGP, DNS

late 80s: growth → problems — congestion collapse (which led to congestion control); policy routing; CIDR

1993: commercialization



CAIDA's IPv4 AS Core, January 2020 (https://www.caida.org/projects/cartography/as-core/2020/)

application — the things that actually generate traffic

transport — sharing the network, reliability (or not)

examples: TCP, UDP

network — naming, addressing, routing

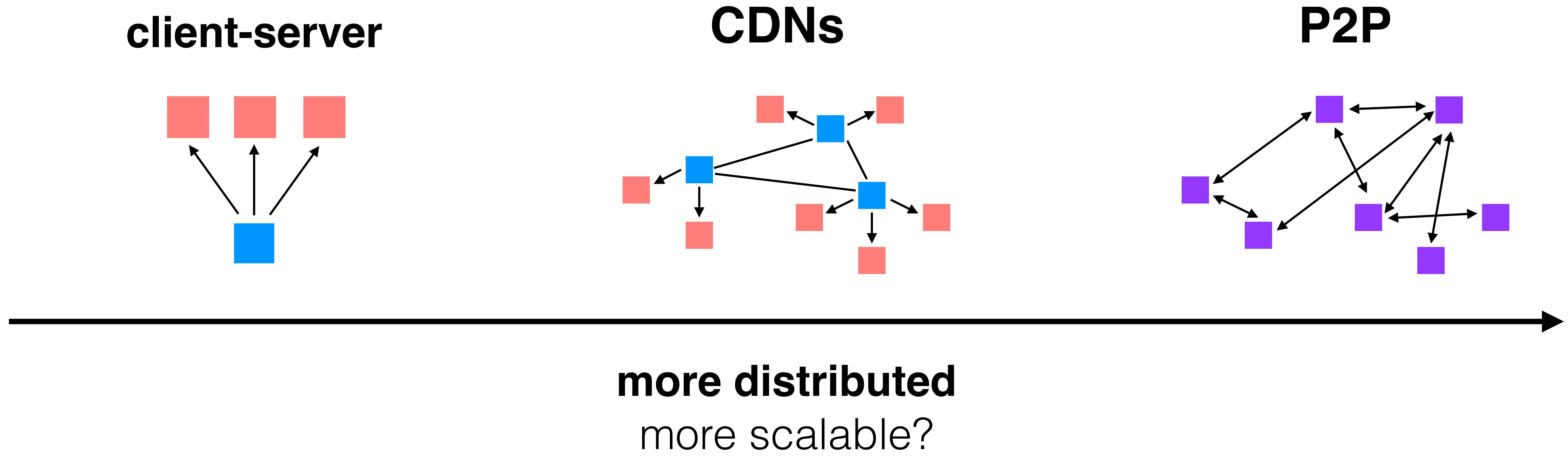
examples: IP

link — communication between two directly-connected nodes

examples: ethernet, bluetooth, 802.11 (wifi)

today: how do all of the lower layers affect application-layer protocols? specifically, how do we **deliver content** on the Internet?

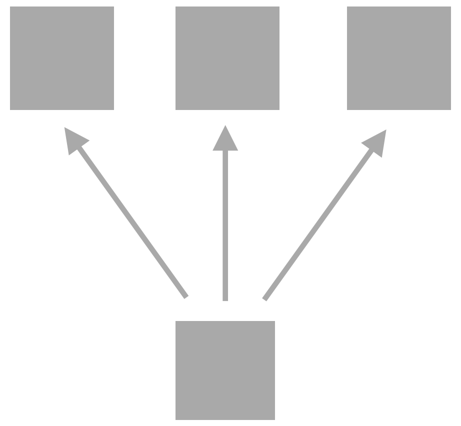
how do we share a file — or **deliver content** — on the Internet?



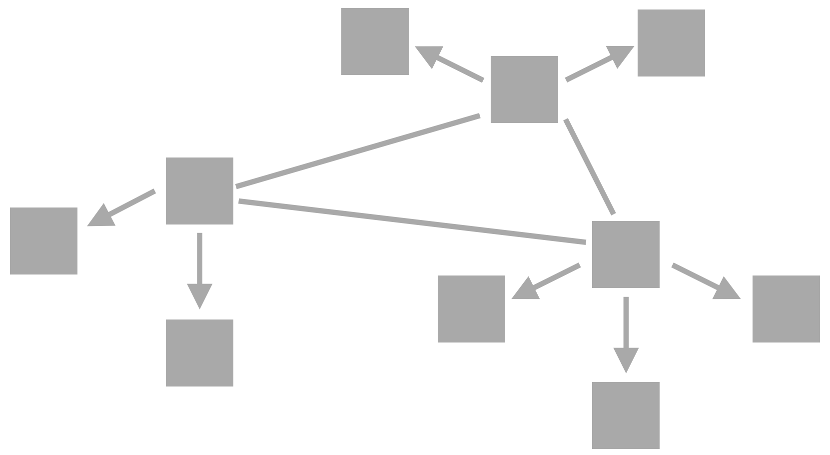
we know that **a client-server model is (relatively) simple, but doesn't scale well**; let's understand more about the other two technologies, to see where they end up in terms of complexity, scalability, etc.

as part of this endeavor, we'll also see why the underlying network matters in these designs

client-server



CDNs



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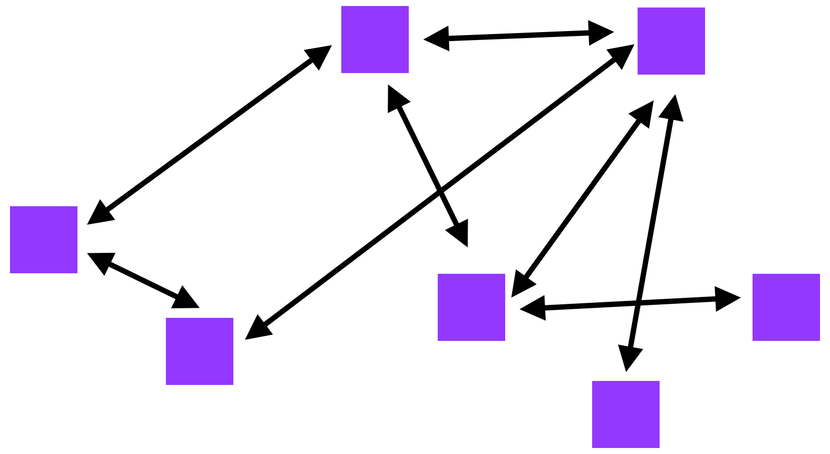
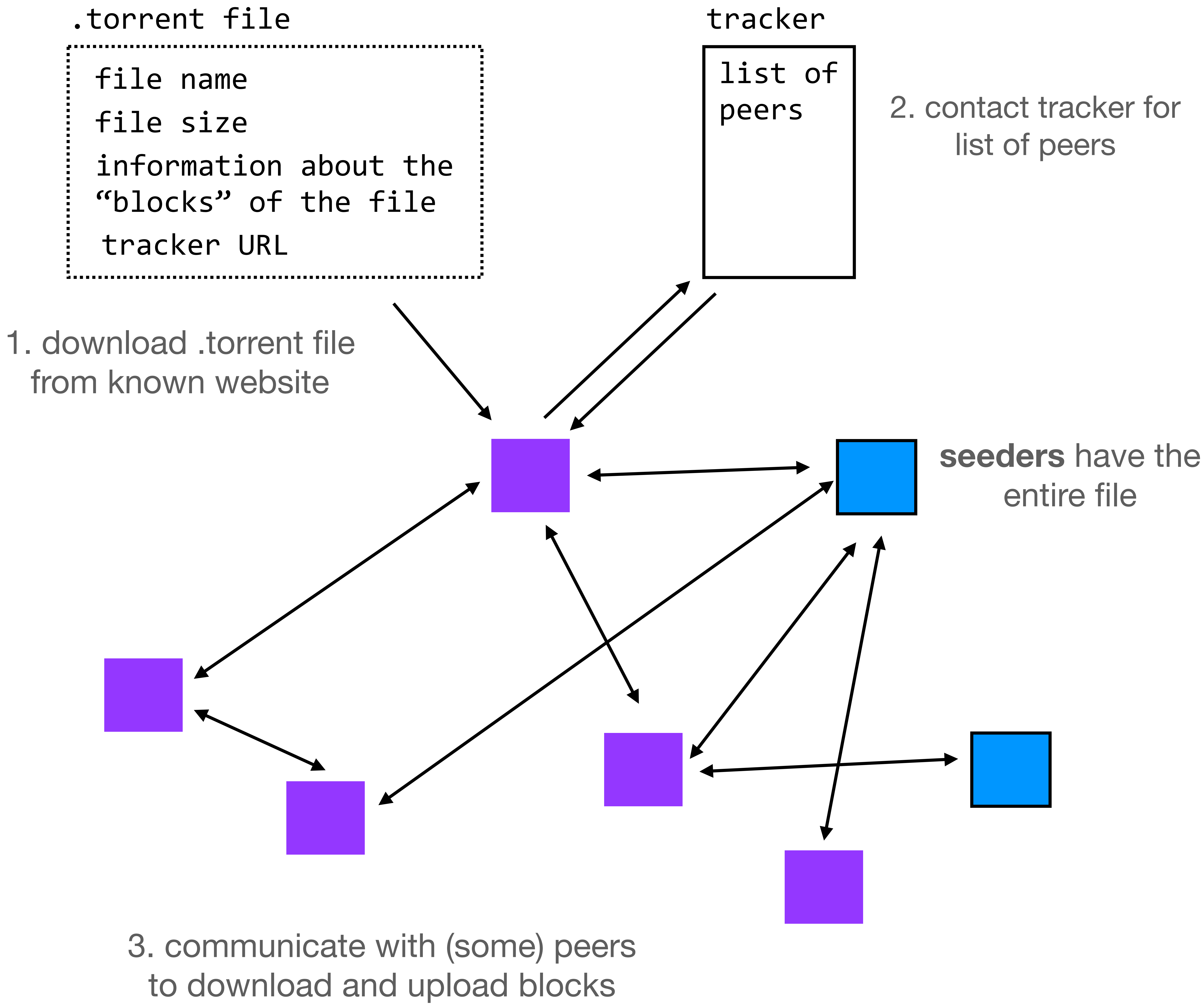
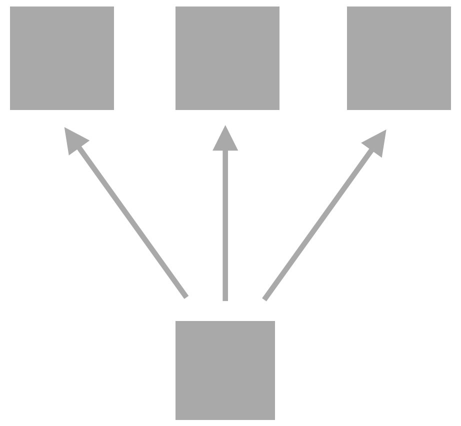




client-server



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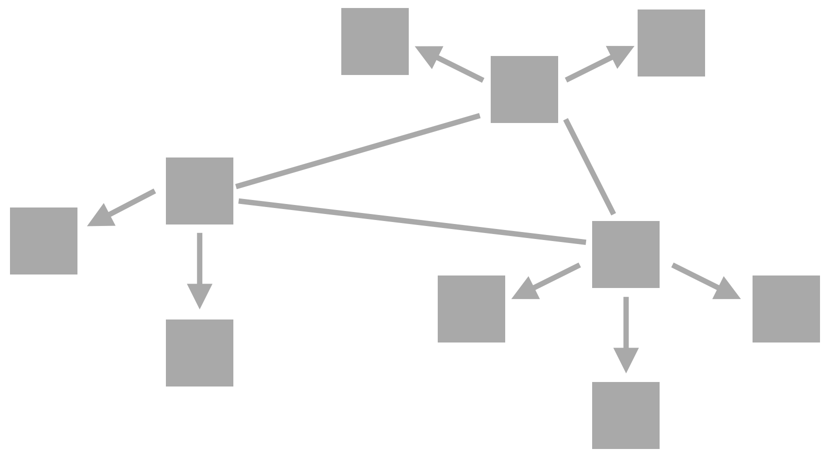

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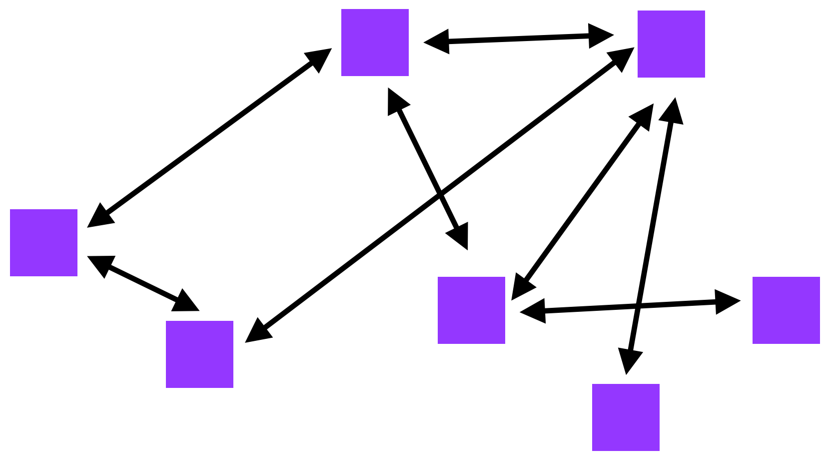
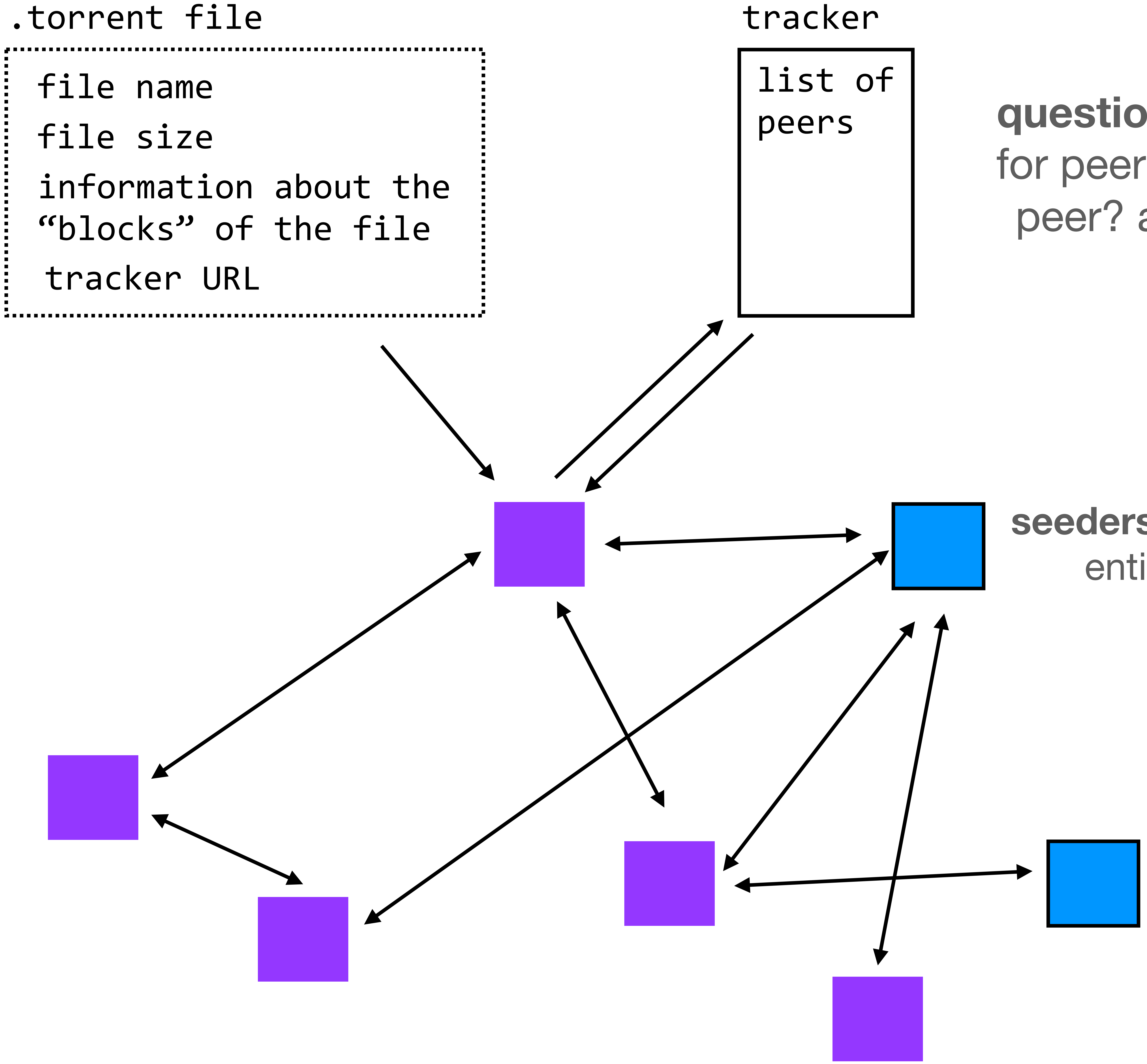
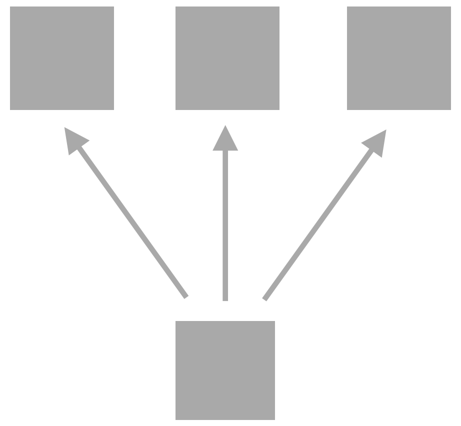




question: are there any **incentives** for peers to upload data to another peer? are there any **drawbacks**?

seeders have the entire file

client-server



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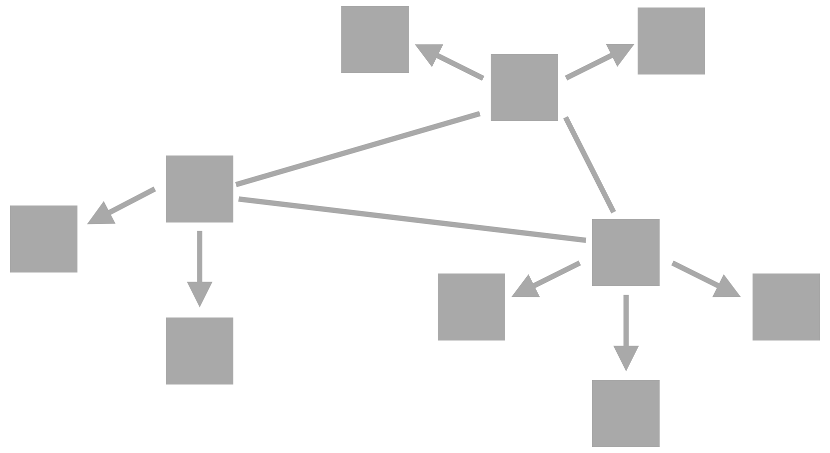

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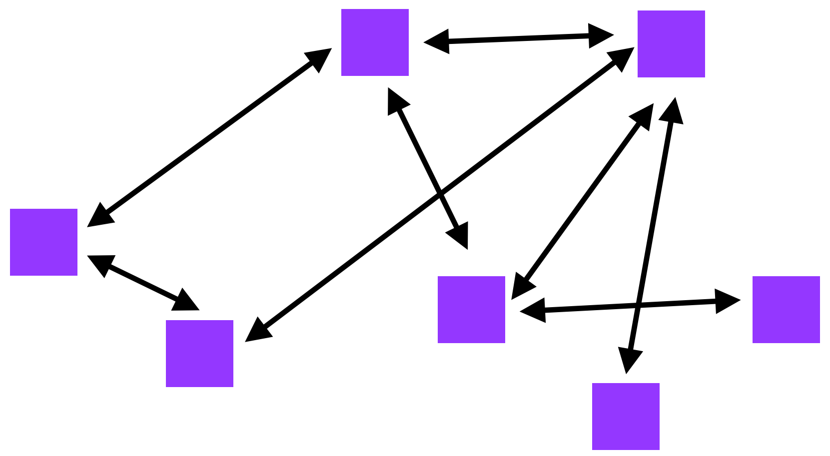
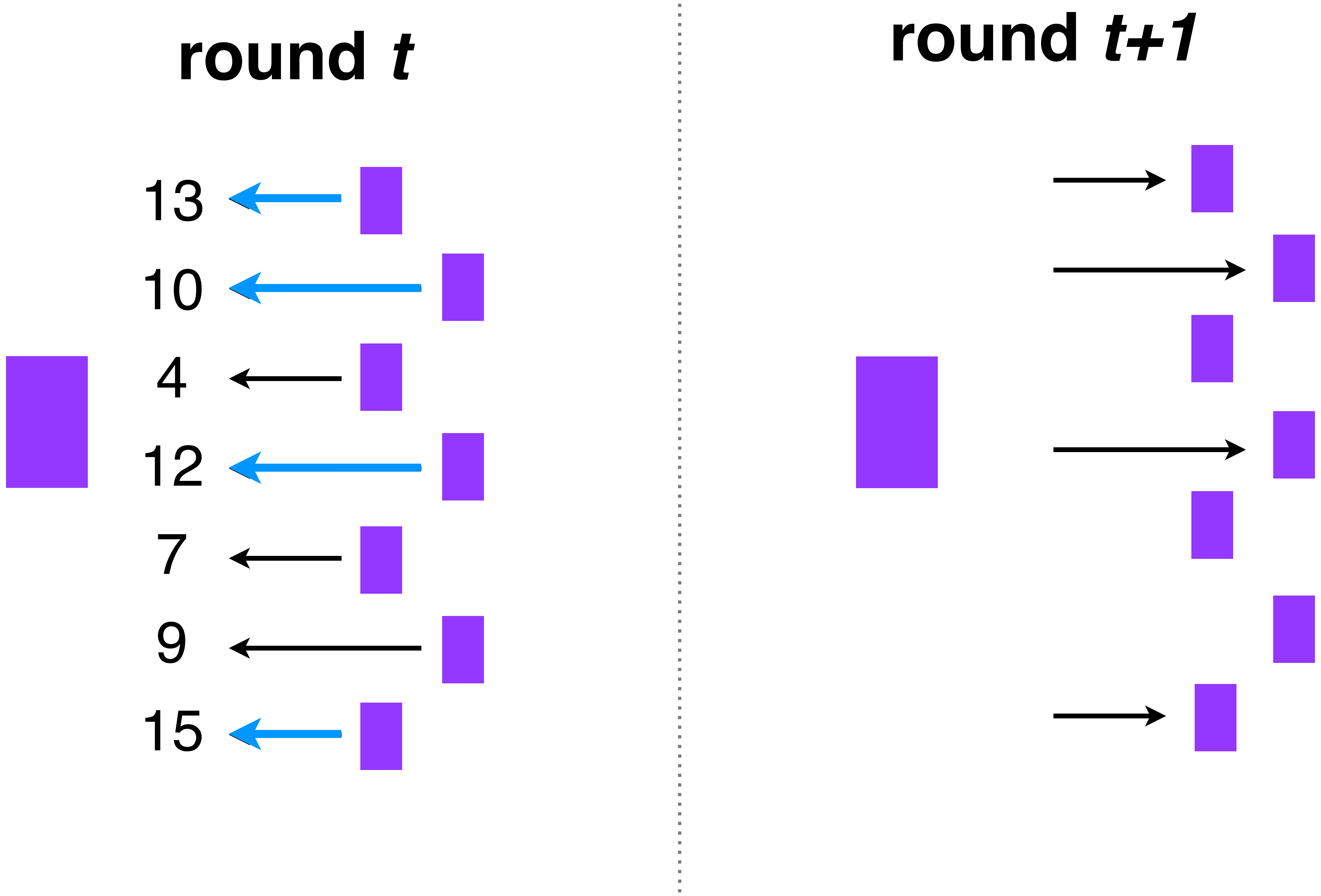
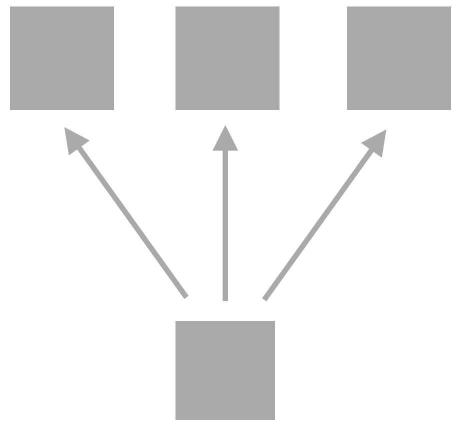


how do we incentivize users to upload?



client-server



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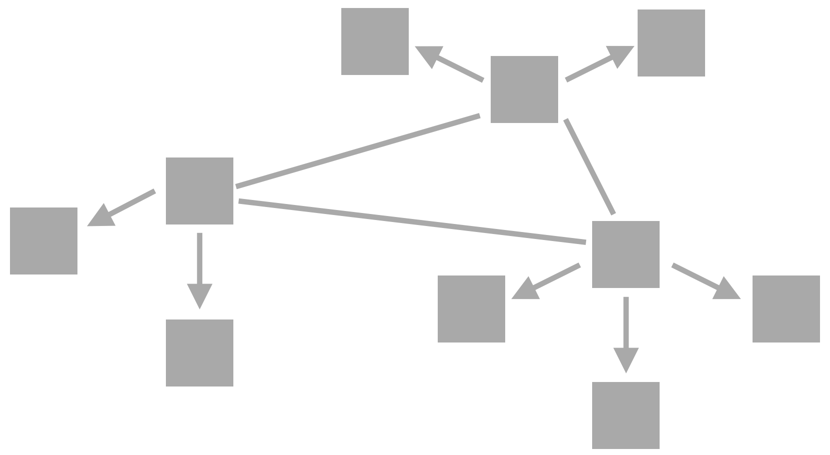

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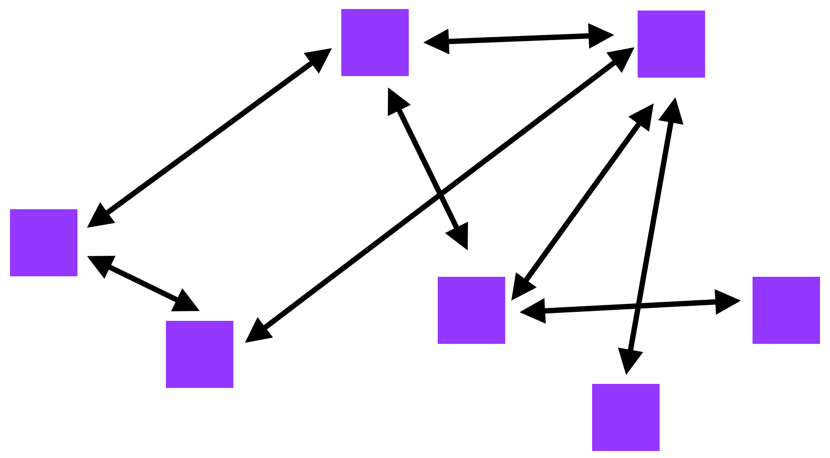
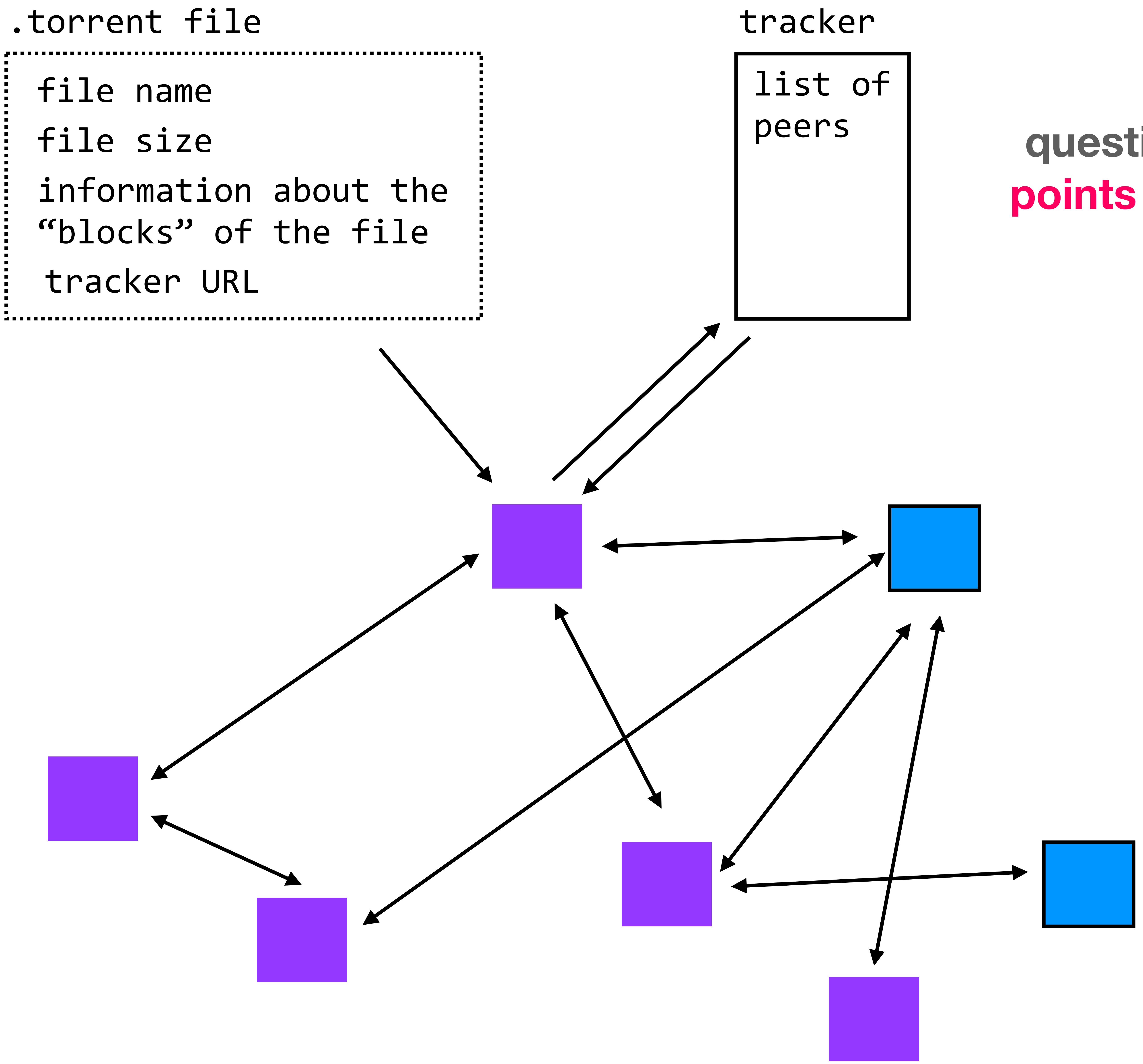
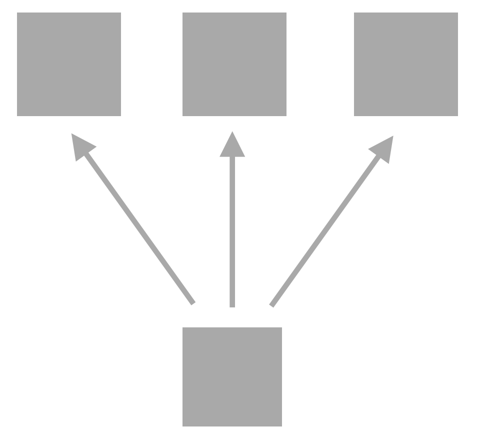




question: are there any **central points of failure** in this network?

client-server



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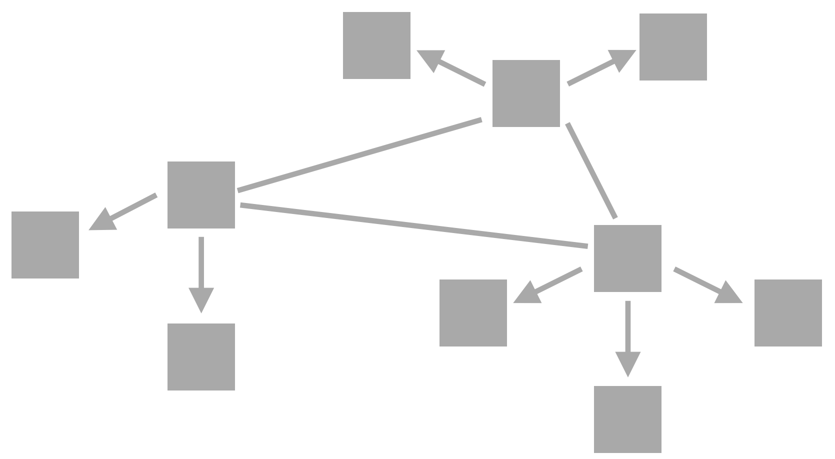

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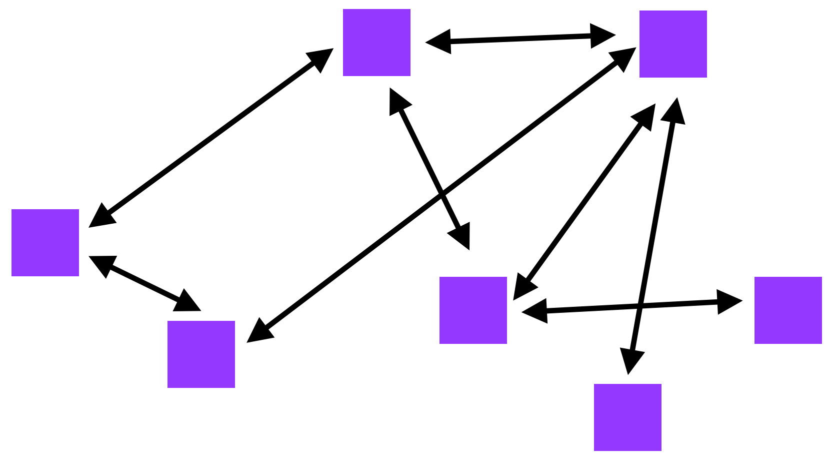
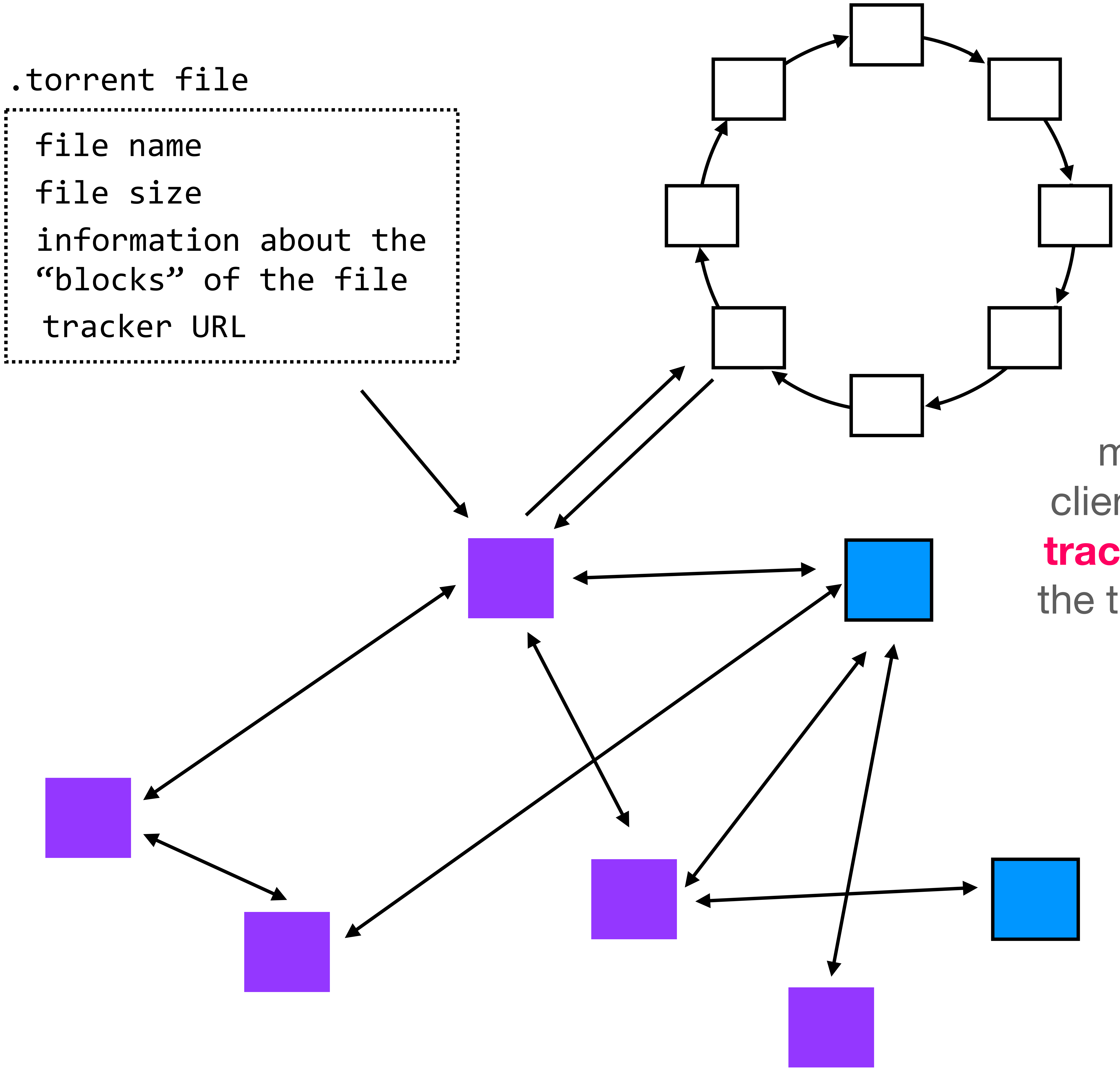
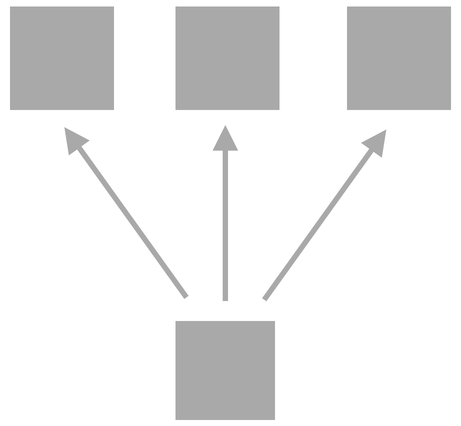




most modern BitTorrent clients used a **decentralized tracker**, where no machine in the tracker network knows the full set of peers

client-server



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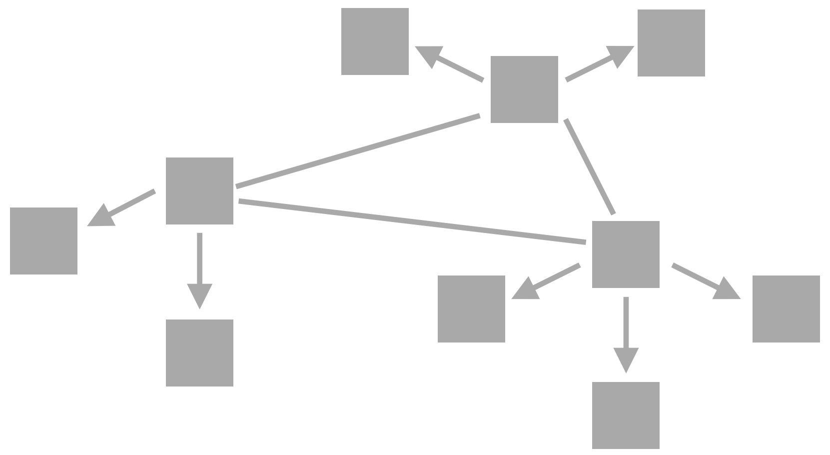

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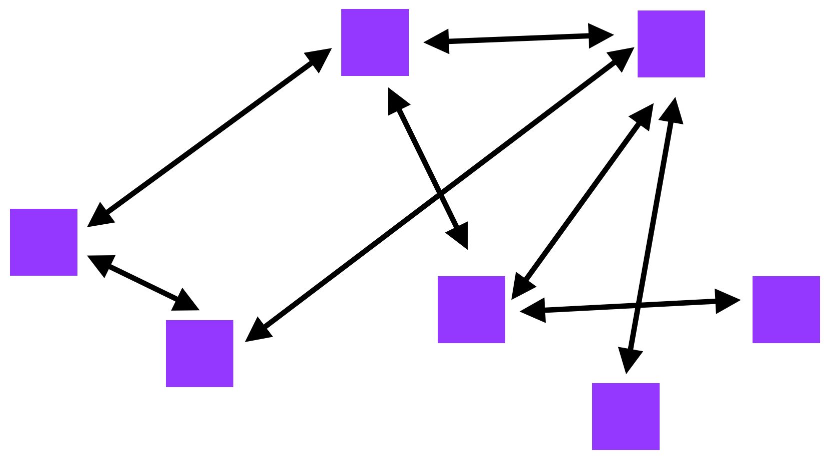
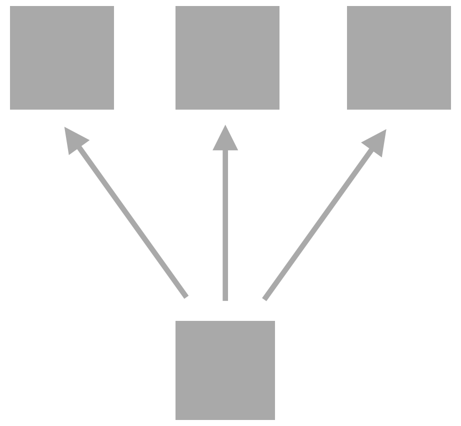


requires some specific organization of the content (e.g., well-defined “blocks”), the ability to discover other peers, and some incentives to get users to upload. in practice, scalability is limited by end-users’ upload constraints

client-server



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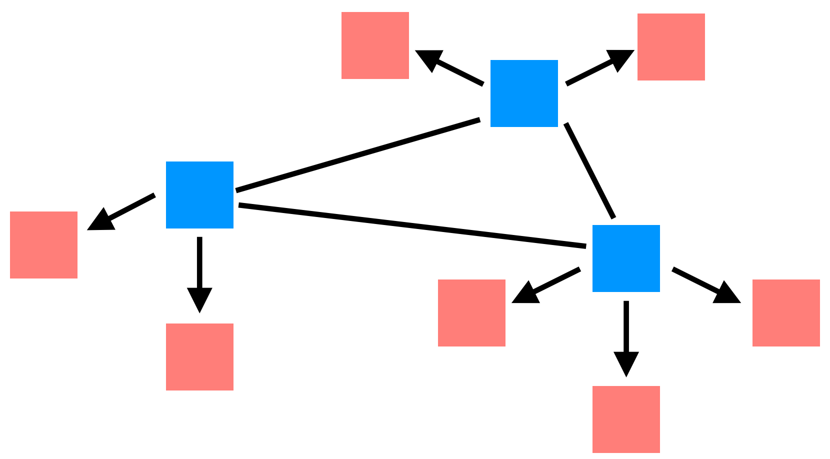

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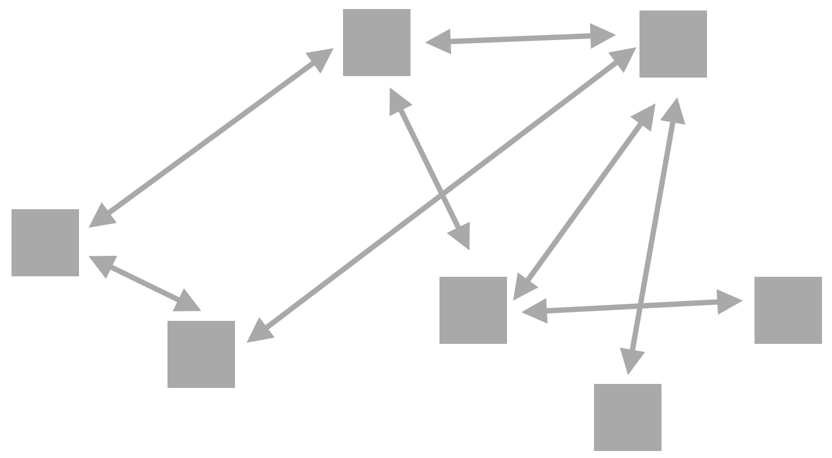
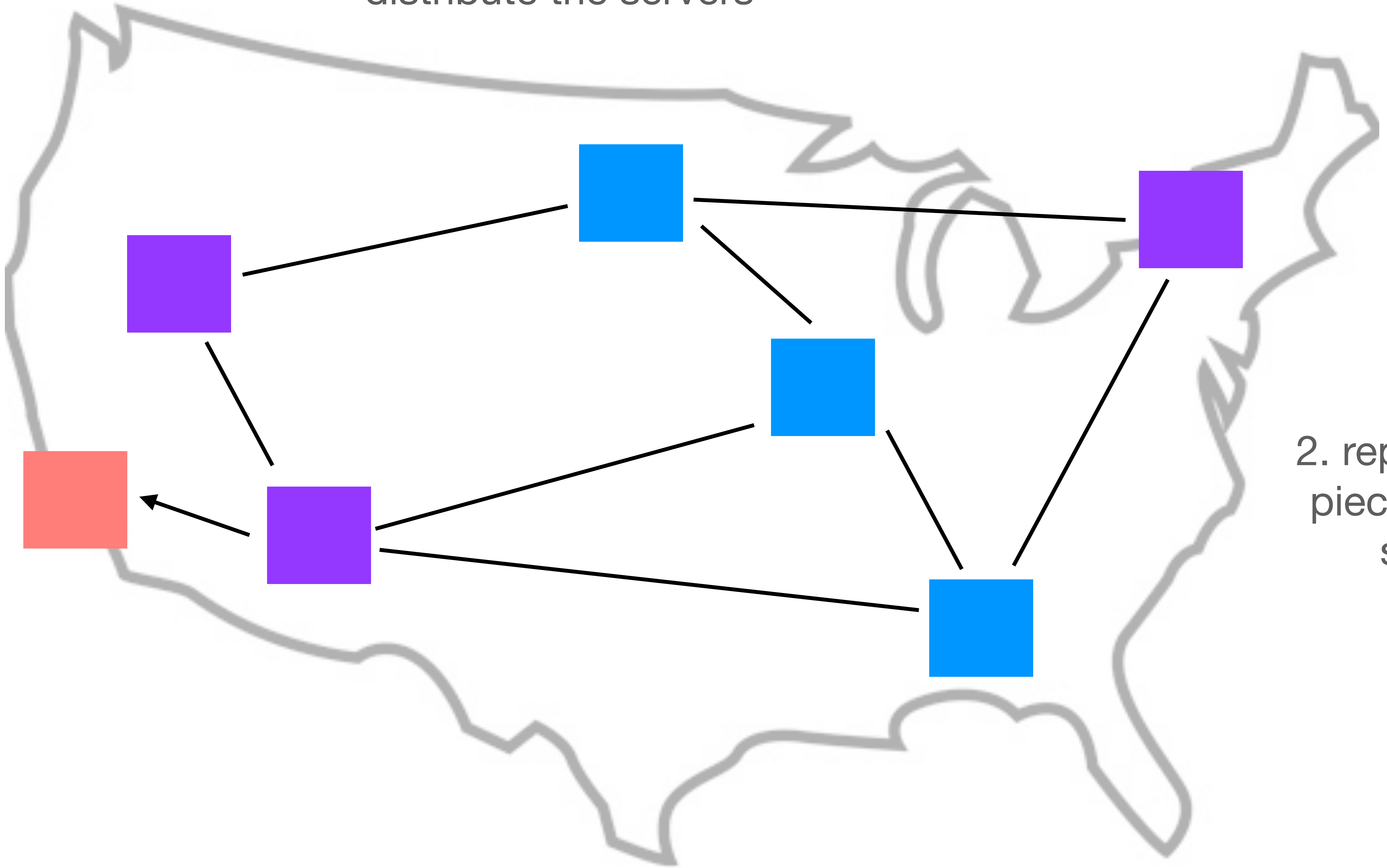


1. geographically distribute the servers

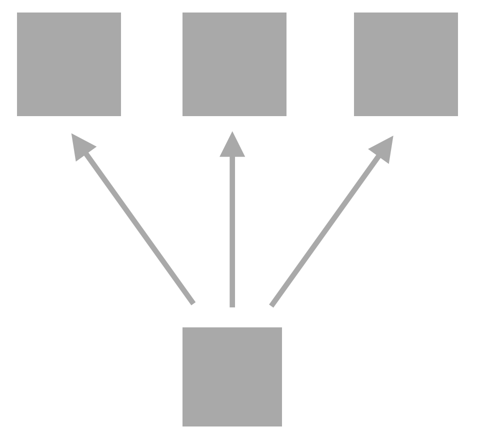


2. replicate a particular piece of content ***p*** on some of them

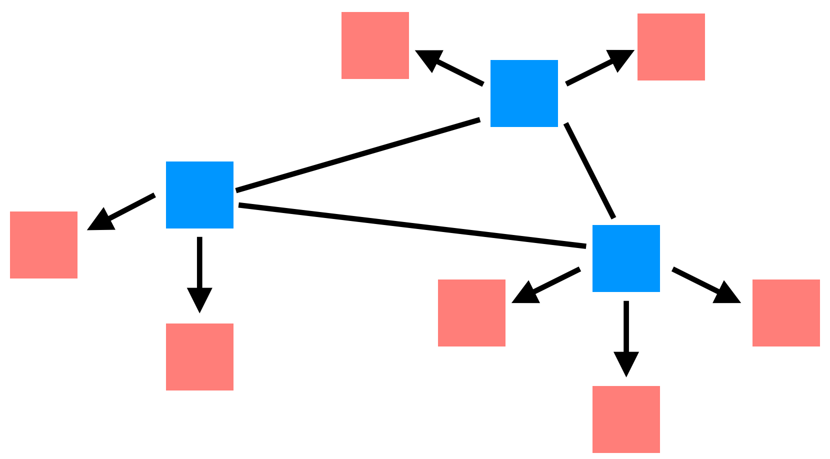
3. when a client requests ***p***, direct them to the "best" server that has a copy of ***p***

question: what do you think makes a server the "**best**"?

client-server



CDNs



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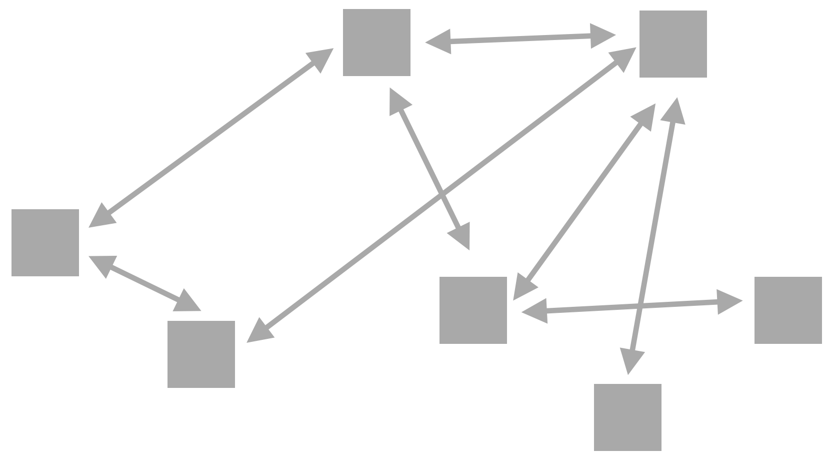

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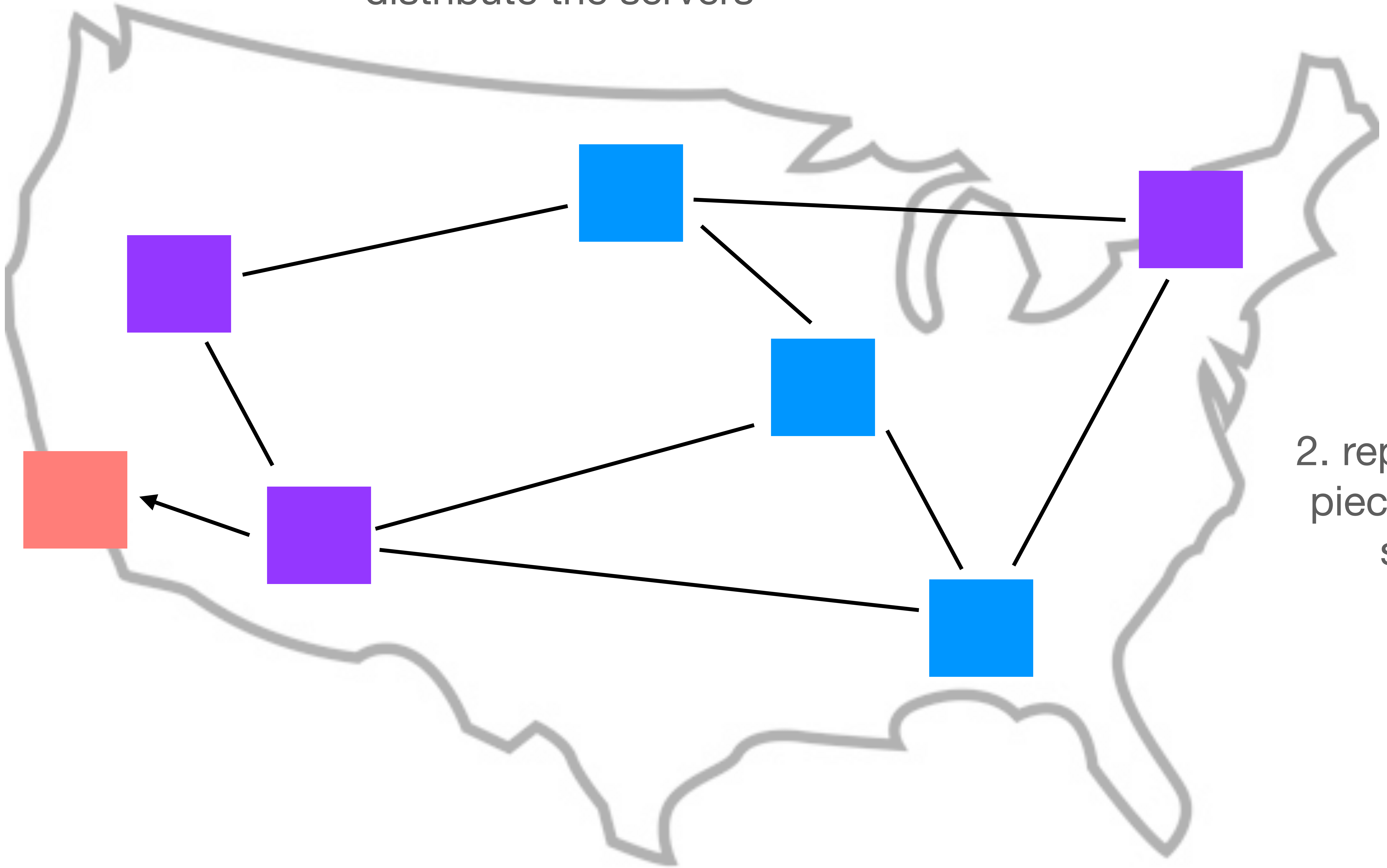

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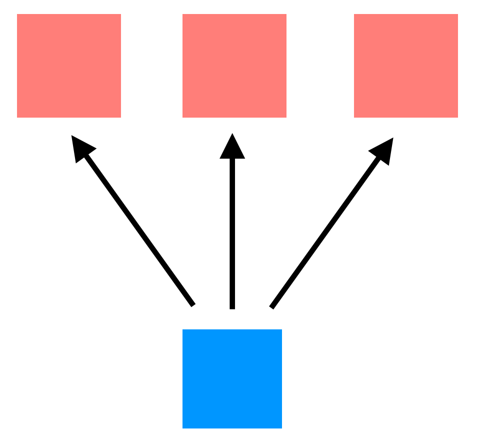
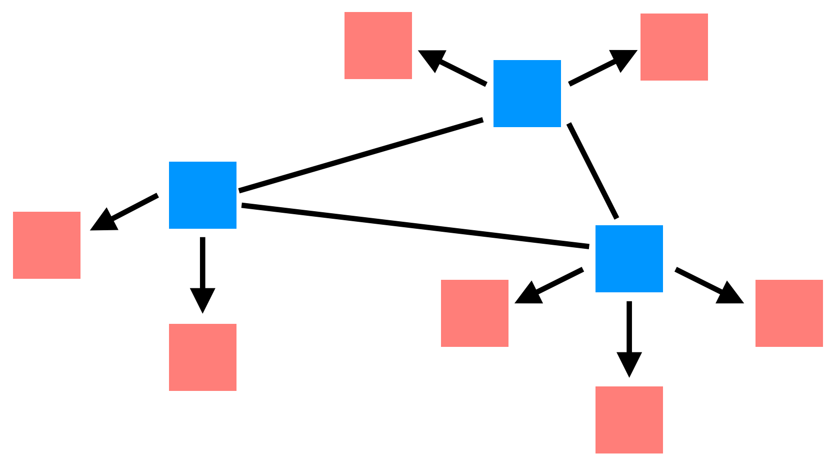


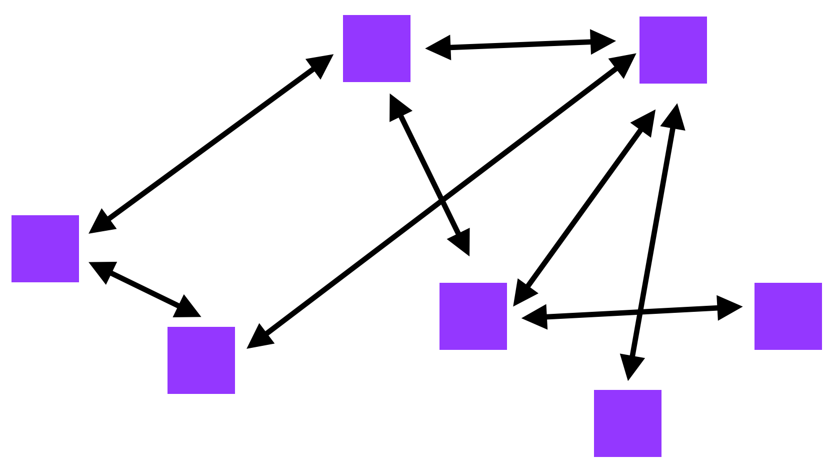
doesn't scale well, but a lot (*a lot*) less complicated than CDNs!

CDNs



requires a great deal of coordination and organization among the edge servers (all of which are owned by a single company). not as "organic" as P2P networks, but can provide better performance guarantees, in part by finding alternate routes and improving transport-layer performance

P2P



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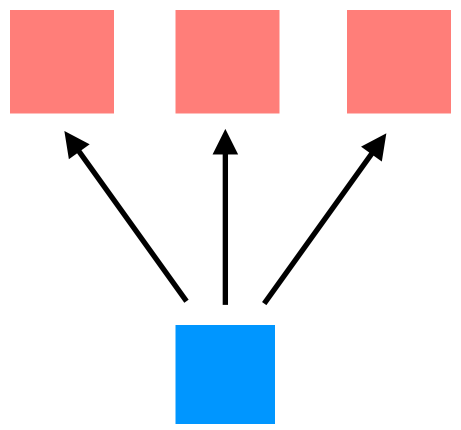
client-server



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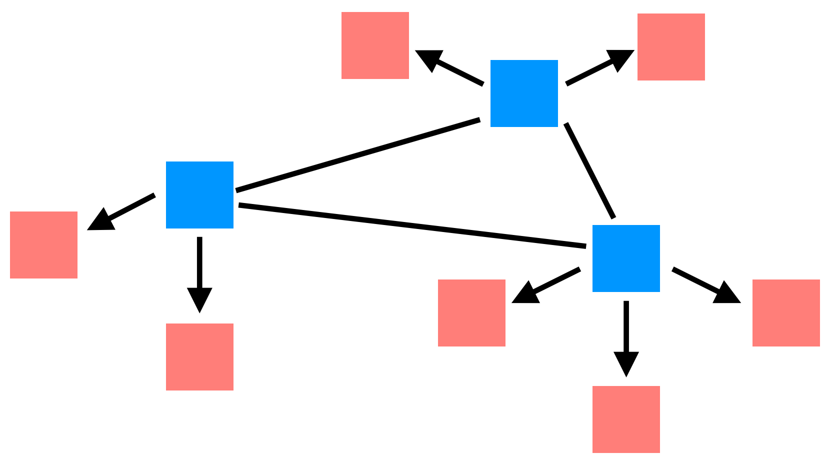
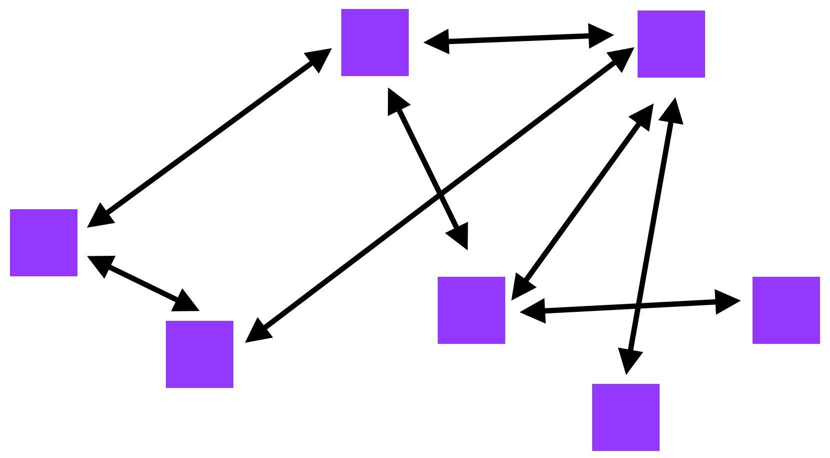


P2P



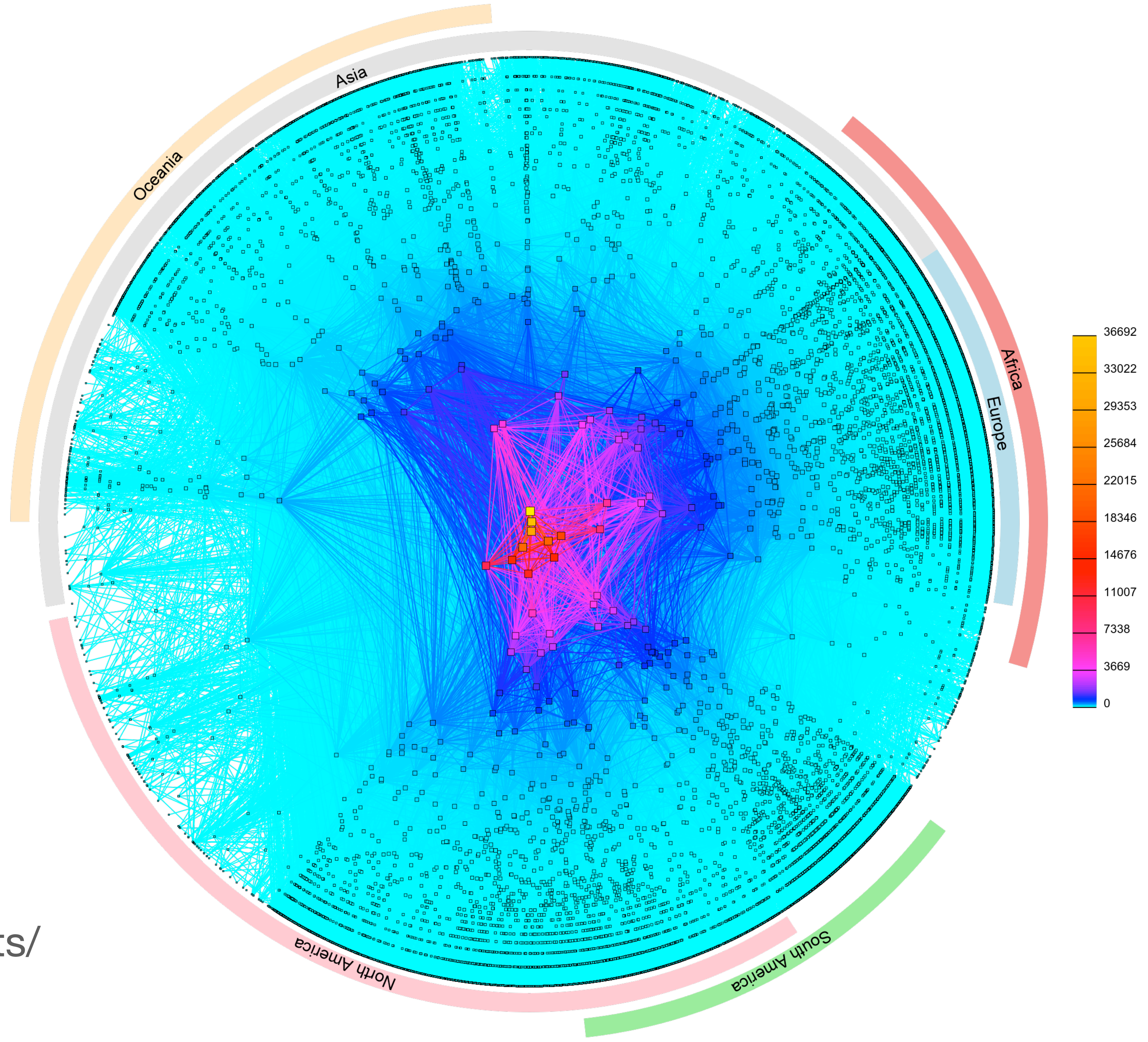
the technologies for sharing content on the Internet have changed as the way we use the Internet has changed

the underlying network affects how well these technologies work, and there are also interesting challenges in terms of how to keep data up-to-date and **consistent** across multiple machines, and how to deal with **failures**

these are challenges we'll address starting after spring break

1970s: ARPAnet	1978: flexibility and layering	early 80s: growth → change	late 80s: growth → problems	1993: commercialization

hosts.txt · distance-vector routing · TCP, UDP · OSPF, EGP, DNS · congestion collapse · policy routing · CIDR



CAIDA's IPv4 AS Core, January 2020 (https://www.caida.org/projects/cartography/as-core/2020/)

on the Internet, we have to solve all of the "normal" networking problems (addressing, routing, transport) **at massive scale, while supporting a diverse group of applications and competing economic interests**

`application`	`the things that actually generate traffic`
`transport`	`sharing the network, reliability (or not)` *examples: TCP, UDP*
`network`	`naming, addressing, routing` *examples: IP*
`link`	`communication between two directly-connected nodes` *examples: ethernet, bluetooth, 802.11 (wifi)*