Peer-To-Peer Applications

Antonio Carzaniga

Faculty of Informatics
Università della Svizzera italiana

October 25, 2017

Outline

- Transferring big files
  - client-server vs. peer-to-peer
- BitTorrent
- Peer-to-peer search
- Miscellaneous

Transferring Big Files

- How long does it take to transfer a *big* file?

Transferring Big Files

- How long does it take to transfer a *big* file?

  Example:

  $size = 6Gb$ (e.g., a movie file)

  $rate = 2Mb/s$

  $T = ?$

Transferring Big Files

- How long does it take to transfer a *big* file?

  Example:

  $size = 6Gb$ (e.g., a movie file)

  $rate = 2Mb/s$

  $T = 3000s = 50min$

Transferring Big Files

- How long does it take to transfer a *big* file?

  Example:

  $size = 6Gb$ (e.g., a movie file)

  $rate = 2Mb/s$

  $T = 3000s = 50min$

  In general:

$$T = \frac{size}{rate}$$

  (we ignore the $O(1)$ propagation delay, which is marginal for large files)

Transferring Big Files

- How long does it take to transfer a *big* file?

  Example:
  $size = 6Gb$ (e.g., a movie file)
  $rate = 2Mb/s$
  $T = 3000s = 50min$

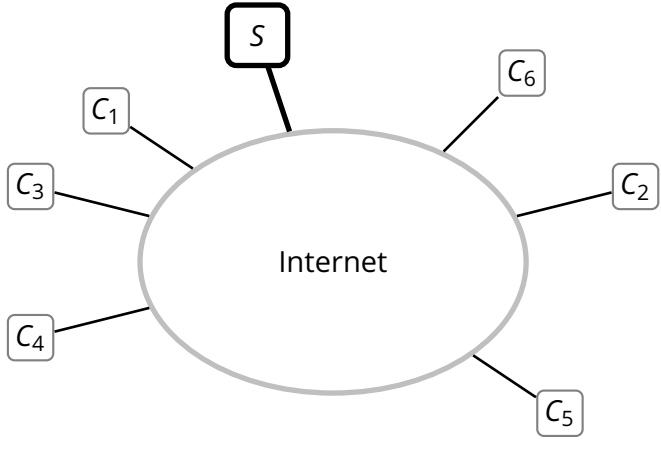
  In general:

  $$T = \frac{size}{rate}$$

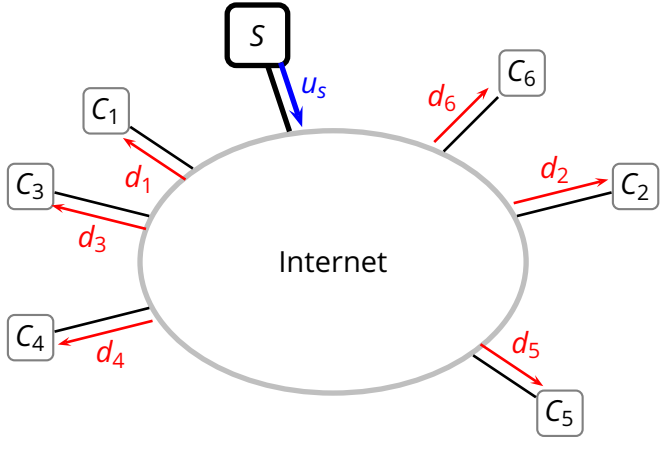
  (we ignore the $O(1)$ propagation delay, which is marginal for large files)

- How long does it take to transfer a *big* and ***very popular*** file?
  - N clients want the file

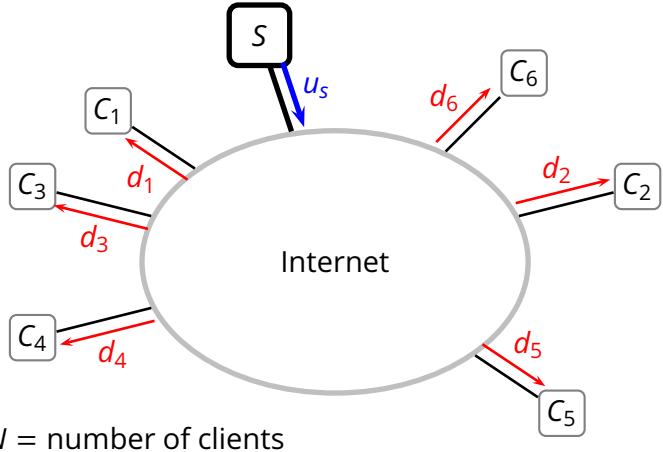
Transferring Big and Popular Files



Transferring Big and Popular Files

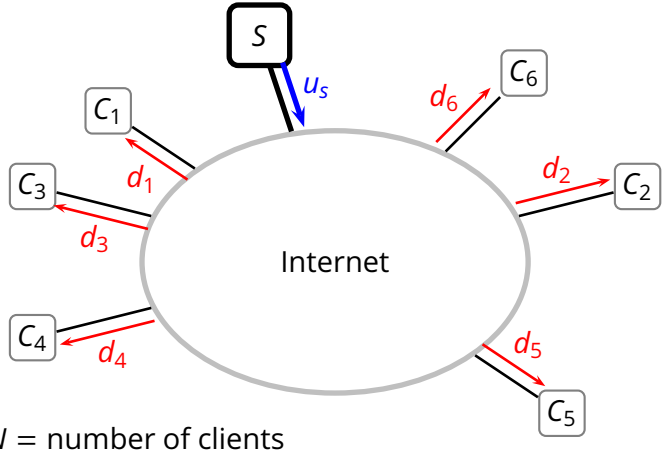


Transferring Big and Popular Files



Let F = file size, N = number of clients

Transferring Big and Popular Files



Let F = file size, N = number of clients

$$T_{CS} \geq \max\left(\frac{NF}{u_s}, \frac{F}{d_{min}}\right)$$

Exploiting Peer-to-Peer Connections

Exploiting Peer-to-Peer Connections

1. Split the file into *blocks*

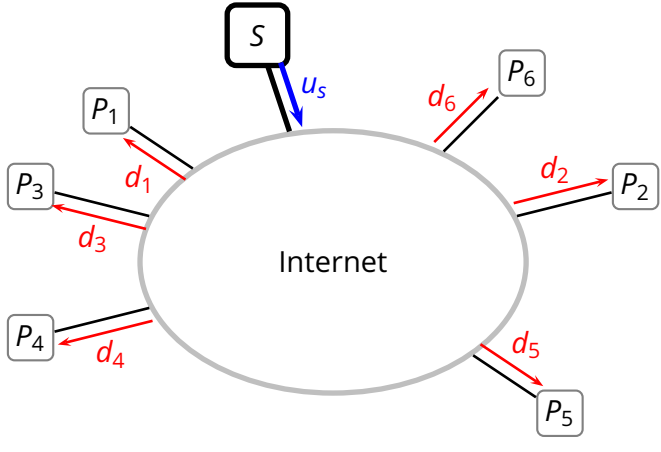
Exploiting Peer-to-Peer Connections

1. Split the file into *blocks*
2. The server sends different blocks to different clients

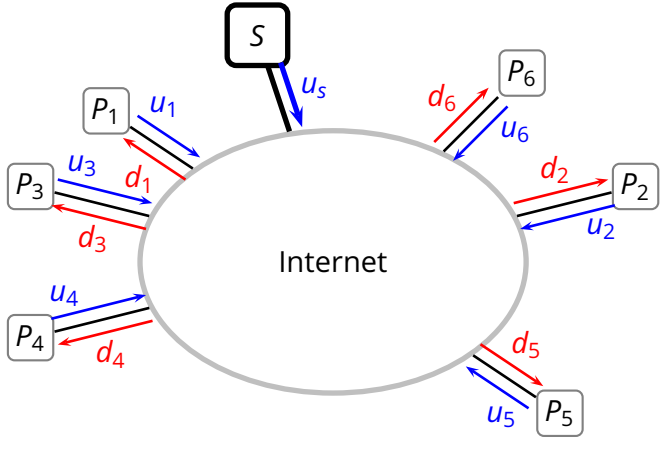
Exploiting Peer-to-Peer Connections

1. Split the file into *blocks*
2. The server sends different blocks to different clients
3. The clients exchange blocks using “peer-to-peer” connections

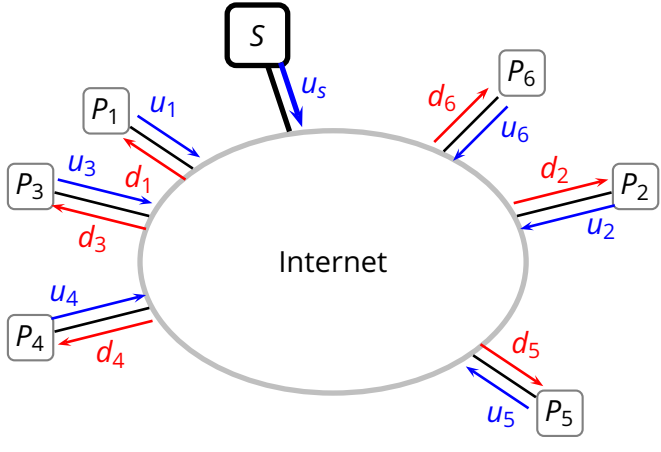
Transfer Time with P2P Connections



Transfer Time with P2P Connections



Transfer Time with P2P Connections



$$T_{P2P} \geq \max\left(\frac{F}{u_s}, \frac{F}{d_{min}}, \frac{NF}{u_s + \sum_{i=1}^{N} u_i}\right)$$

Transferring Big and Popular Files

- Transfer time is *at least*

$$T_{P2P} \geq \max\left(\frac{F}{u_s}, \frac{F}{d_{min}}, \frac{NF}{u_s + \sum_{i=1}^{N} u_i}\right)$$

Transferring Big and Popular Files

- Transfer time is *at least*

$$T_{P2P} \geq \max\left(\frac{F}{u_s}, \frac{F}{d_{min}}, \frac{NF}{u_s + \sum_{i=1}^{N} u_i}\right)$$

- Assuming $u_1 = u_2 = \cdots = u_N = u_p$

$$T_{P2P} \geq \max\left(\frac{F}{u_s}, \frac{F}{d_{min}}, \frac{F}{u_s/N + u_p}\right)$$

Transferring Big and Popular Files

- Transfer time is *at least*

$$T_{P2P} \geq \max\left(\frac{F}{u_s}, \frac{F}{d_{min}}, \frac{NF}{u_s + \sum_{i=1}^{N} u_i}\right)$$

- Assuming $u_1 = u_2 = \cdots = u_N = u_p$

$$T_{P2P} \geq \max\left(\frac{F}{u_s}, \frac{F}{d_{min}}, \frac{F}{u_s/N + u_p}\right)$$

- And for large peer groups ($N \gg 1$)

$$T_{P2P} \geq \max\left(\frac{F}{u_s}, \frac{F}{d_{min}}, \frac{F}{u_p}\right)$$

Transferring Big and Popular Files

- Transfer time is *at least*

$$T_{P2P} \geq \max\left(\frac{F}{u_s}, \frac{F}{d_{min}}, \frac{NF}{u_s + \sum_{i=1}^{N} u_i}\right)$$

- Assuming $u_1 = u_2 = \cdots = u_N = u_p$

$$T_{P2P} \geq \max\left(\frac{F}{u_s}, \frac{F}{d_{min}}, \frac{F}{u_s/N + u_p}\right)$$

- And for large peer groups ($N \gg 1$)

$$T_{P2P} \geq \max\left(\frac{F}{u_s}, \frac{F}{d_{min}}, \frac{F}{u_p}\right)$$

The transfer time does not depend on the number of receivers!

BitTorrent: Tracker and Startup

BitTorrent: Tracker and Startup

- A ***tracker*** keeps track of which peers participate in the “torrent”

BitTorrent: Tracker and Startup

- A ***tracker*** keeps track of which peers participate in the “torrent”
  - at startup, Alice requests a list of peers from the tracker
  - then, Alice tries to establish direct connections with her “neighbor peers”
  - periodically, Alice tells the tracker that she is still participating in the torrent

BitTorrent: Tracker and Startup

- A ***tracker*** keeps track of which peers participate in the "torrent"
  - at startup, Alice requests a list of peers from the tracker
  - then, Alice tries to establish direct connections with her "neighbor peers"
  - periodically, Alice tells the tracker that she is still participating in the torrent

- The torrent (one or more files) is split into ***equal-size chunks***
  - peers accumulate chunks and keep track of the chunks they have
  - it might be that no single peer has all the chunks, as long as all the chunks are available from *some* peer

BitTorrent: Exchanging Chunks

BitTorrent: Exchanging Chunks

- Neigboring peers exchange their lists of chunks and eventually exchange chunks

BitTorrent: Exchanging Chunks

- Neigboring peers exchange their lists of chunks and eventually exchange chunks
  - periodically, Alice requests the list of chunks of her peers

BitTorrent: Exchanging Chunks

- Neigboring peers exchange their lists of chunks and eventually exchange chunks
  - periodically, Alice requests the list of chunks of her peers
  - Alice figures who has what chunks, and therefore requests some chunks from her neighbors
    - Alice requests the *rarest chunk first* (why?)

BitTorrent: Exchanging Chunks

- Neigboring peers exchange their lists of chunks and eventually exchange chunks
  - periodically, Alice requests the list of chunks of her peers
  - Alice figures who has what chunks, and therefore requests some chunks from her neighbors
    - Alice requests the *rarest chunk first* (why?)
  - Alice also receives requests from her neighbors

BitTorrent: Exchanging Chunks

- Neigboring peers exchange their lists of chunks and eventually exchange chunks
  - periodically, Alice requests the list of chunks of her peers
  - Alice figures who has what chunks, and therefore requests some chunks from her neighbors
    - Alice requests the *rarest chunk first* (why?)
  - Alice also receives requests from her neighbors
    - Alice gives priority to neighbors that share the most (highest rate): she sends her chunks to the top four (why?)

BitTorrent: Exchanging Chunks

- Neigboring peers exchange their lists of chunks and eventually exchange chunks
  - periodically, Alice requests the list of chunks of her peers
  - Alice figures who has what chunks, and therefore requests some chunks from her neighbors
    - Alice requests the *rarest chunk first* (why?)
  - Alice also receives requests from her neighbors
    - Alice gives priority to neighbors that share the most (highest rate): she sends her chunks to the top four (why?)
    - periodically, Alice also selects another trading partner at random (why?)

Searching

- How do you find files in a file-sharing network?

Searching

- How do you find files in a file-sharing network?
- Centralized index (i.e., client-server)
  - typically maps objects (e.g., files, nicknames) to IP addresses
  - not too good: performance bottleneck, single point of failure, etc.

Searching

- How do you find files in a file-sharing network?
- Centralized index (i.e., client-server)
  - typically maps objects (e.g., files, nicknames) to IP addresses
  - not too good: performance bottleneck, single point of failure, etc.
- Distributed peer-to-peer search with ***query flooding***

Searching

- How do you find files in a file-sharing network?
- Centralized index (i.e., client-server)
  - typically maps objects (e.g., files, nicknames) to IP addresses
  - not too good: performance bottleneck, single point of failure, etc.
- Distributed peer-to-peer search with ***query flooding***
  - not too good (why?)

Searching

- How do you find files in a file-sharing network?
- Centralized index (i.e., client-server)
  - typically maps objects (e.g., files, nicknames) to IP addresses
  - not too good: performance bottleneck, single point of failure, etc.
- Distributed peer-to-peer search with ***query flooding***
  - not too good (why?)
  - many variants: limited scope, probabilistic, hierarchical with super-peeers, etc.

Searching

- How do you find files in a file-sharing network?
- Centralized index (i.e., client-server)
  - typically maps objects (e.g., files, nicknames) to IP addresses
  - not too good: performance bottleneck, single point of failure, etc.
- Distributed peer-to-peer search with ***query flooding***
  - not too good (why?)
  - many variants: limited scope, probabilistic, hierarchical with super-peeers, etc.
- Distributed peer-to-peer search with ***structured indexes***
  - a.k.a., ***distributed hash tables (DHTs)***

Searching

- How do you find files in a file-sharing network?
- Centralized index (i.e., client-server)
  - typically maps objects (e.g., files, nicknames) to IP addresses
  - not too good: performance bottleneck, single point of failure, etc.
- Distributed peer-to-peer search with ***query flooding***
  - not too good (why?)
  - many variants: limited scope, probabilistic, hierarchical with super-peeers, etc.
- Distributed peer-to-peer search with ***structured indexes***
  - a.k.a., ***distributed hash tables (DHTs)***
  - many variants, lots of interesting theoretical and practical developments

Skype

- How does Skype work?

Skype

- How does Skype work? . . . or what Skype does not want you to know

- How does Skype work? . . . or what Skype does not want you to know
- ***Search:*** how does Alice find Bob?
  - peer-to-peer index

Skype

- How does Skype work? . . . or what Skype does not want you to know
- ***Search:*** how does Alice find Bob?
  - peer-to-peer index
- ***Connections:*** how does Alice connect to Bob?

Skype

- How does Skype work? . . . or what Skype does not want you to know
- ***Search:*** how does Alice find Bob?
  - peer-to-peer index
- ***Connections:*** how does Alice connect to Bob?
  - direct connections when possible

Skype

- How does Skype work? . . . or what Skype does not want you to know
- ***Search:*** how does Alice find Bob?
  - peer-to-peer index
- ***Connections:*** how does Alice connect to Bob?
  - direct connections when possible
  - indirect connections through a relay “super-peer”

Skype

- How does Skype work? . . . or what Skype does not want you to know
- ***Search:*** how does Alice find Bob?
  - peer-to-peer index
- ***Connections:*** how does Alice connect to Bob?
  - direct connections when possible
  - indirect connections through a relay “super-peer”
- And much more: chat, audio/video codecs, multi-party communication, etc.