The BitTorrent Protocol

Taken from

http://www.cs.uiowa.edu/~ghosh/bittorrent.ppt

What is BitTorrent?

Efficient content distribution system using *file swarming*. Usually does not perform all the functions of a typical p2p system, like *searching*.

BitTorrent traffic

CacheLogic estimated that BitTorrent traffic accounts for roughly 35% of all traffic on the Internet.

File sharing

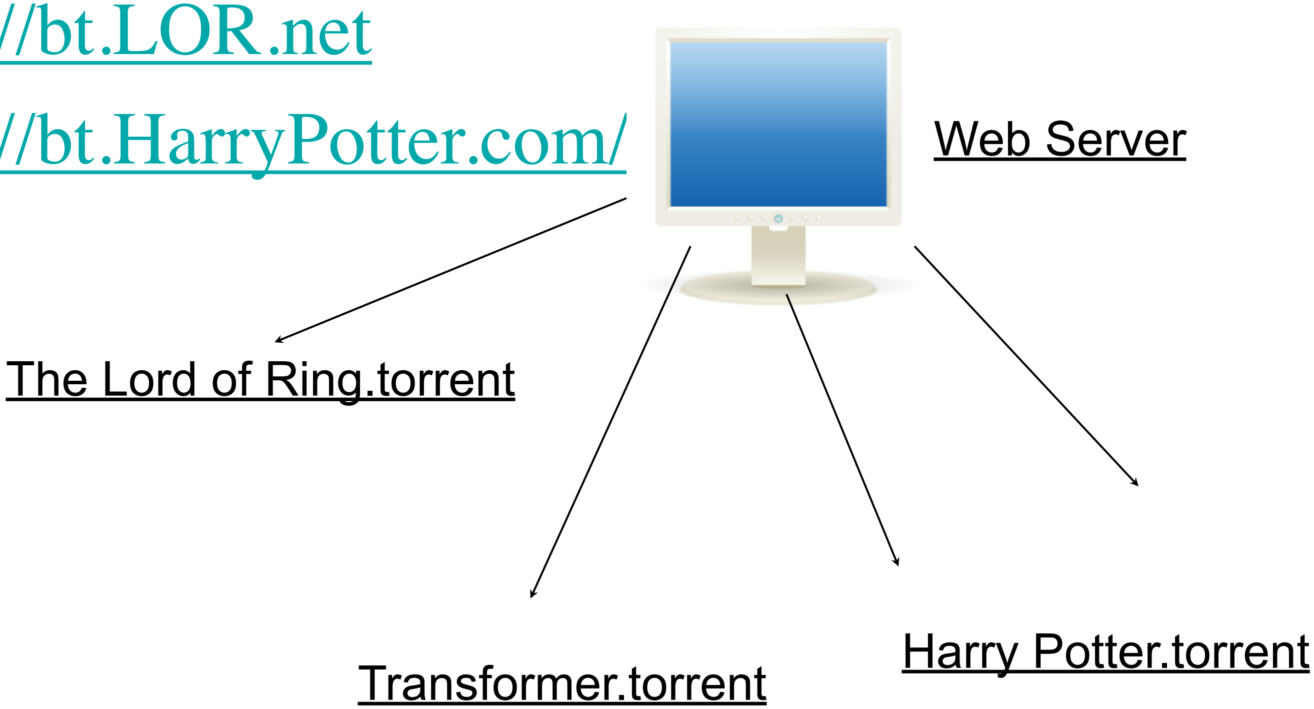
To share a file or group of files, a peer first creates a **.torrent** file, a small file that contains

(1) **metadata** about the files to be shared, and
(2) Information about the **tracker**, the computer that coordinates the file distribution.

Peers first obtain a **.torrent** file, and then connect to the specified **tracker,** which tells them from which other peers to download the pieces of the file.

BT Components

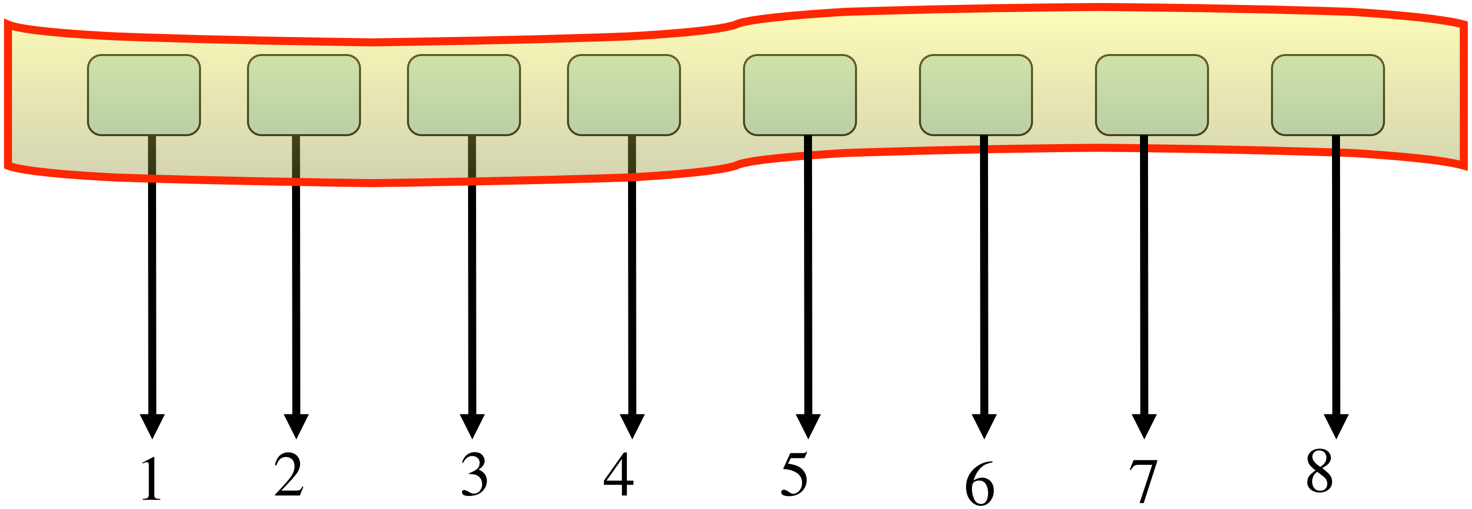
- On a public domain site, obtain .torrent file. for example:
  - http://bt.LOR.net
  - http://bt.HarryPotter.com/



File sharing

Large files are broken into pieces of size between

64 KB and 1 MB

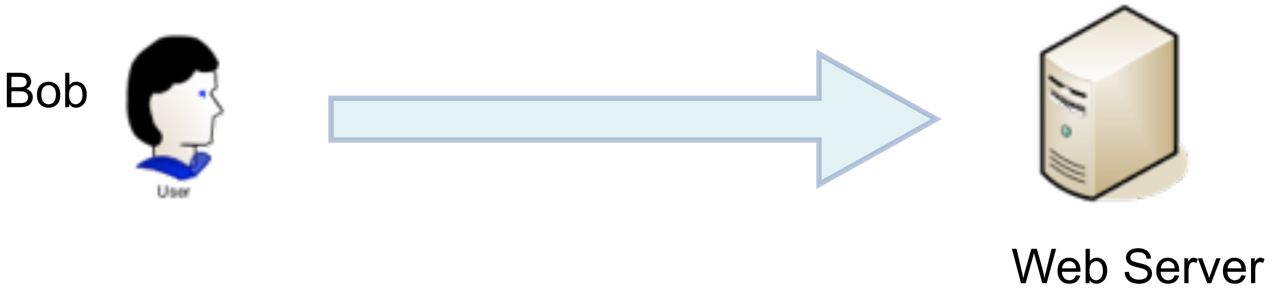


BT: publishing a file

Bob

Web Server

BT: publishing a file



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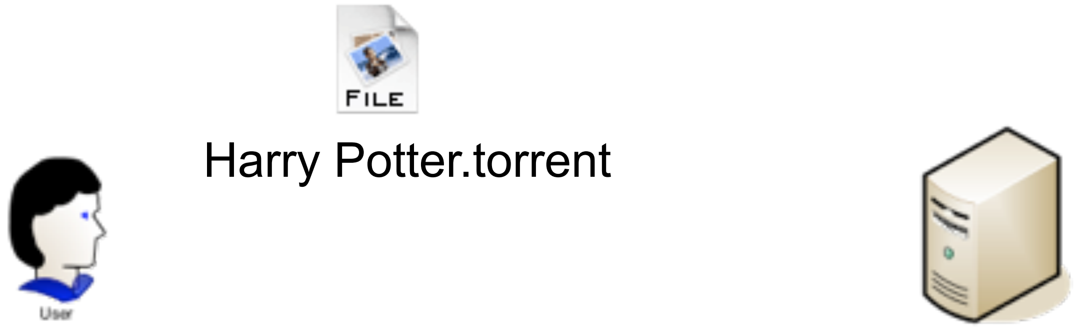

Harry Potter.torrent

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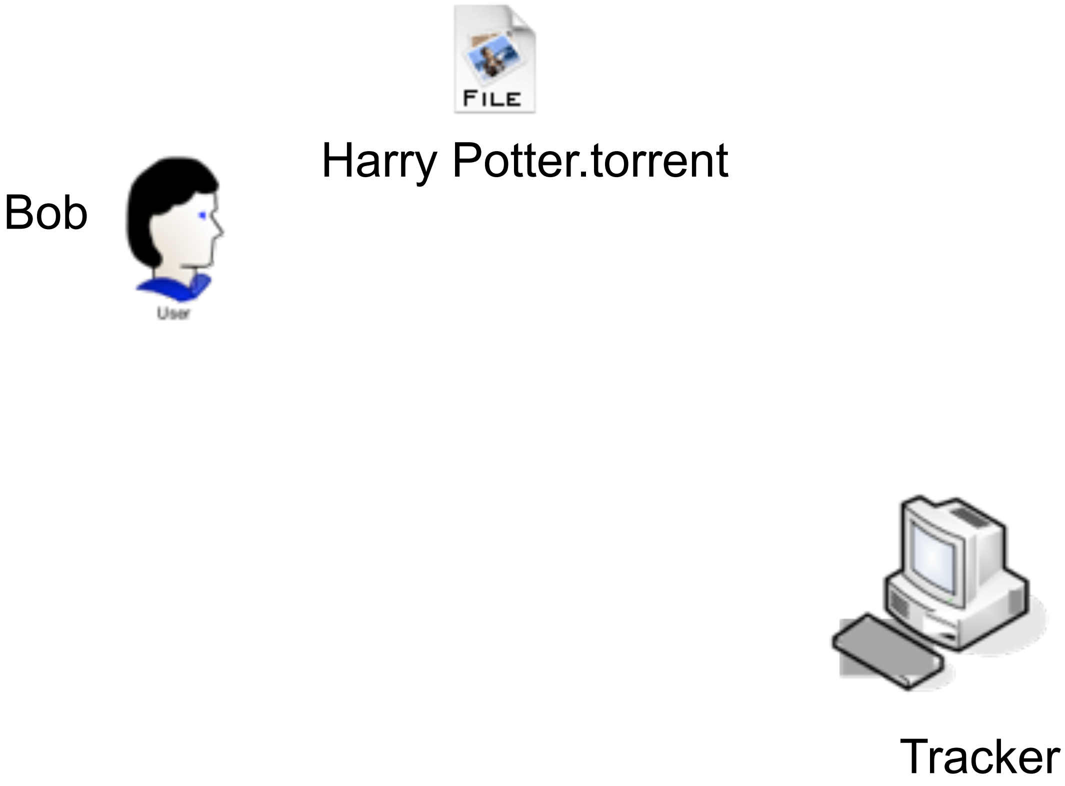

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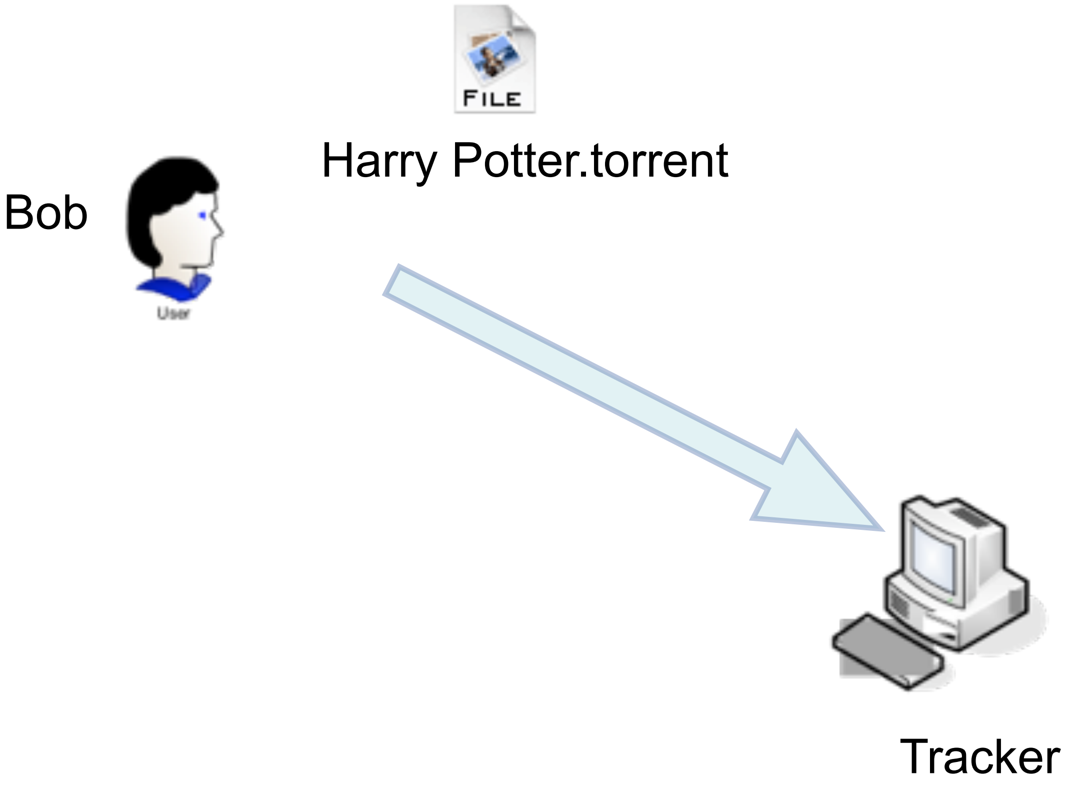

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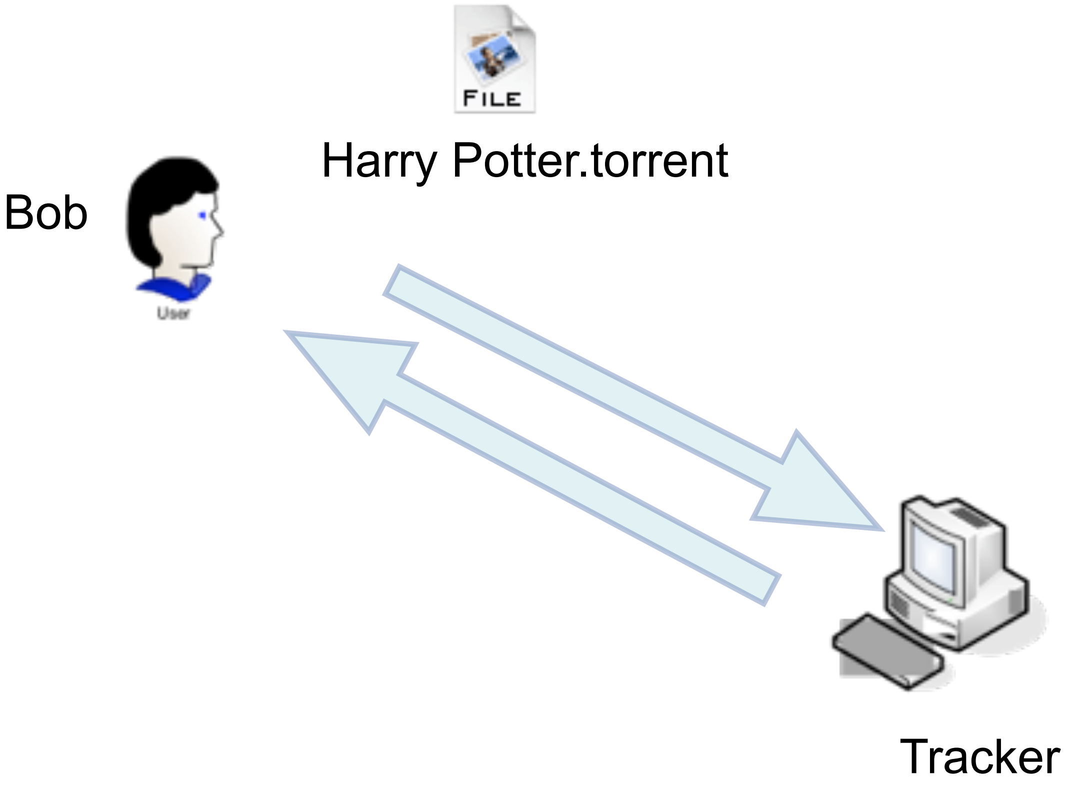

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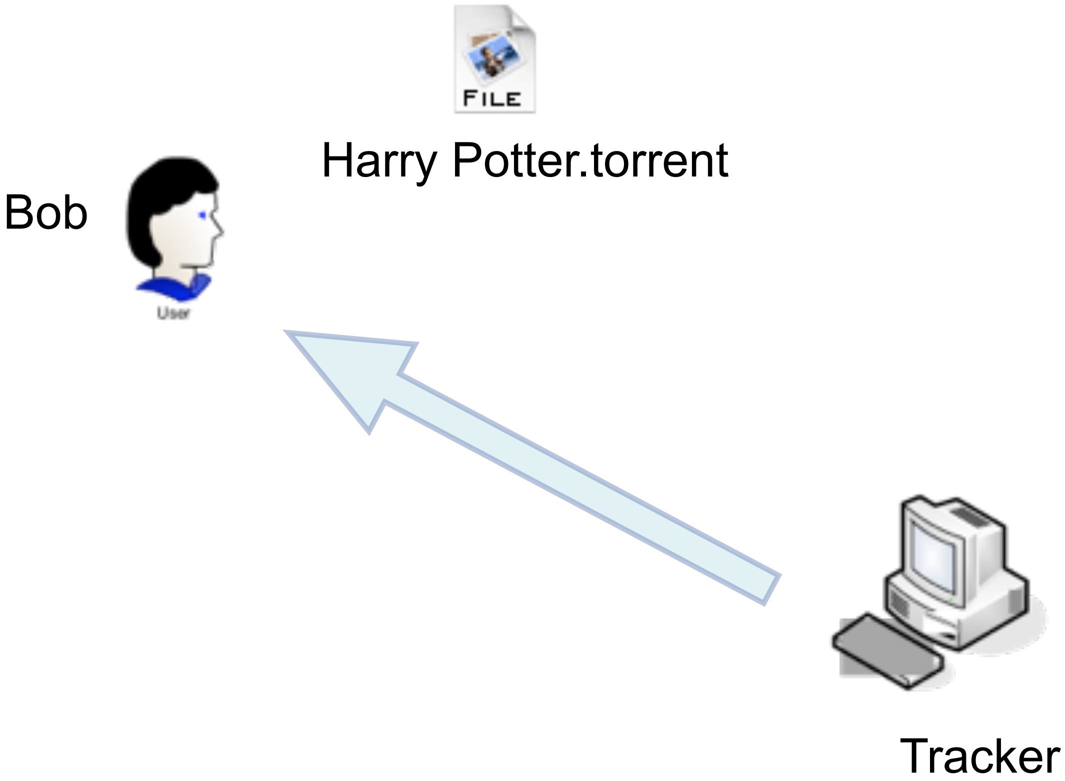

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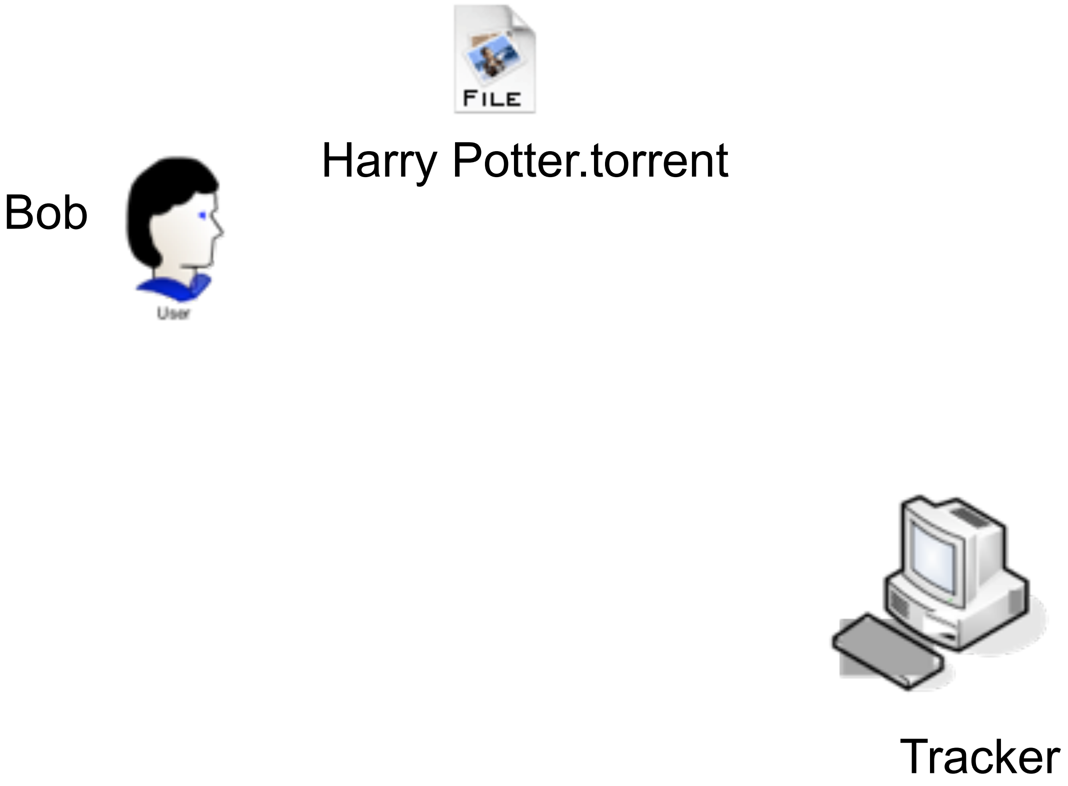

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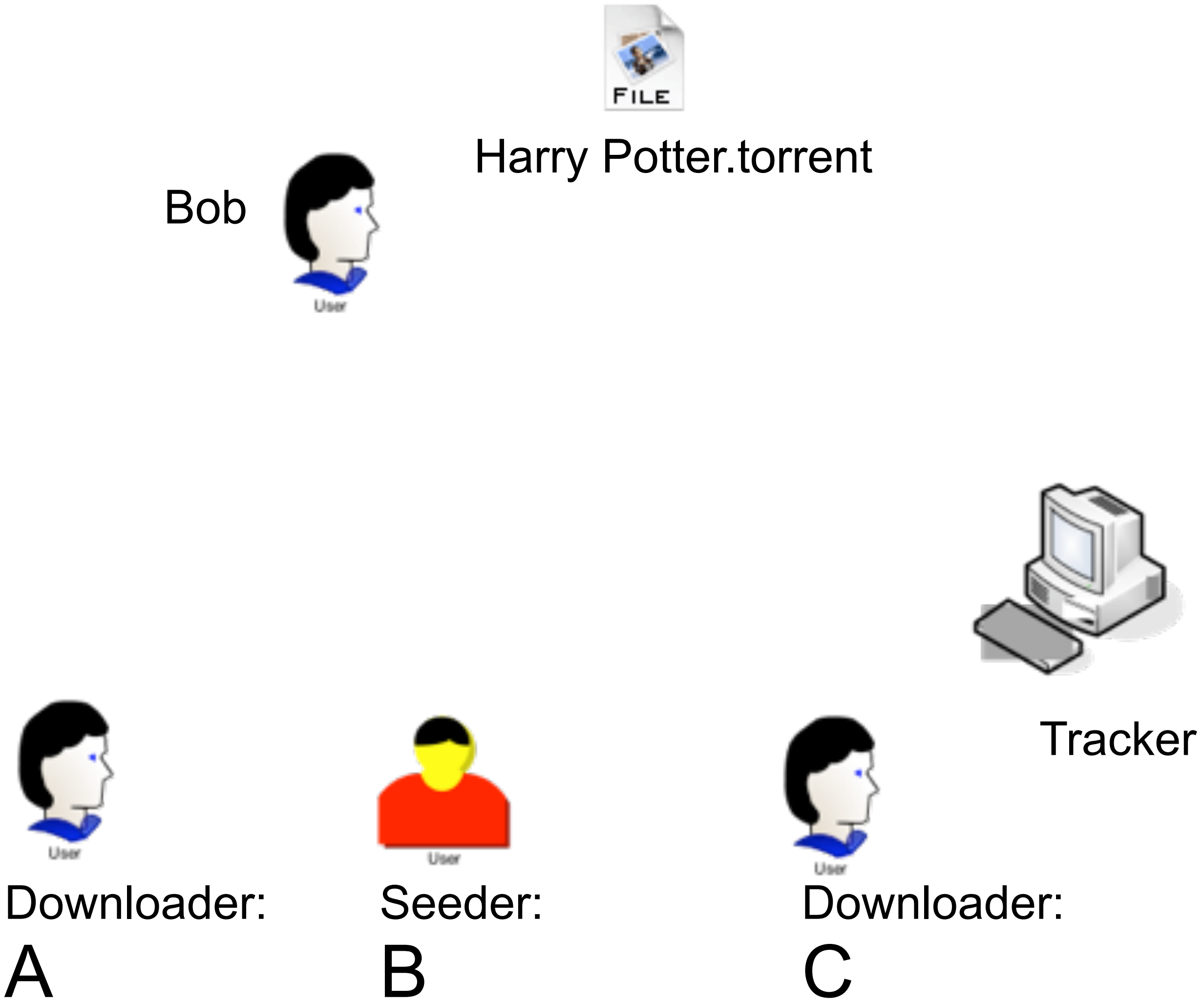

Harry Potter.torrent

Bob

Tracker

Downloader:
A

Seeder:
B

Downloader:
C

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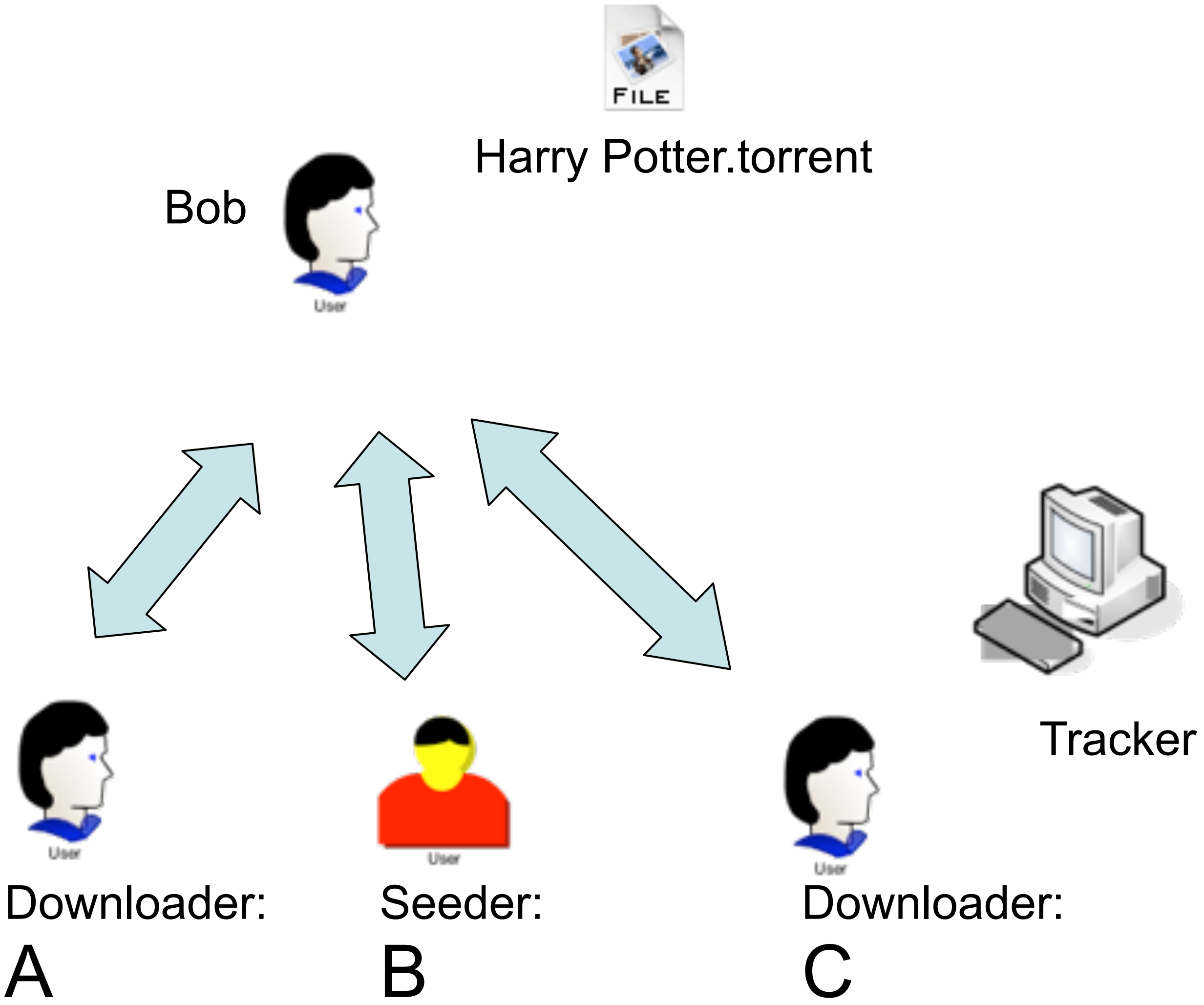

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Downloader:
A

Seeder:
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Downloader:
C

The .torrent file

- The URL of the tracker
- Pieces <hash1,hash 2,….hash n>
- Piece length
- Name
- Length of the file

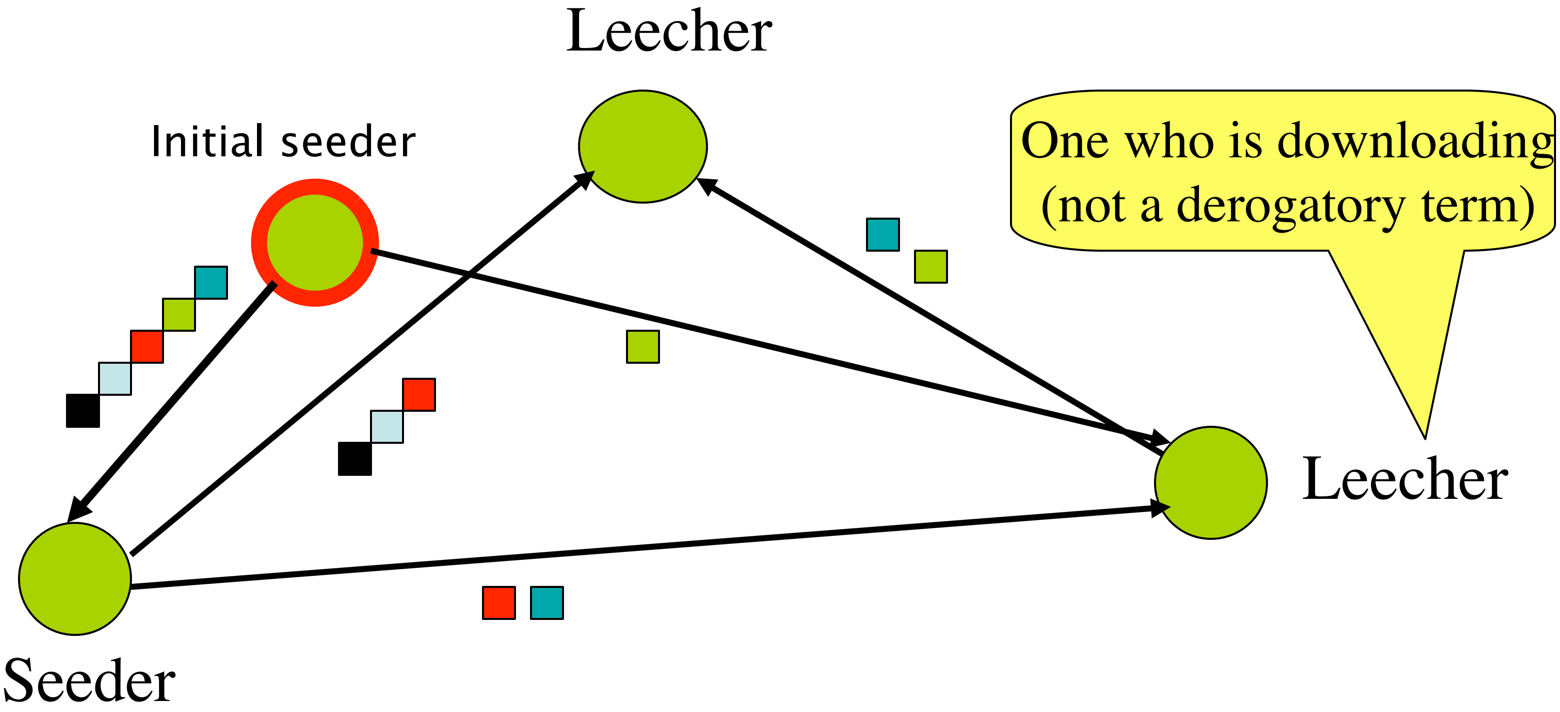
The Tracker

- IP address, port, peer id
- State information (Completed or Downloading)
- Returns a random list of peers

BitTorrent Lingo

Seeder = a peer that provides the complete file.

Initial seeder = a peer that provides the initial copy.



Simple example

{1,2,3,4,5,6,7,8,9,10}

Seeder: A

Simple example

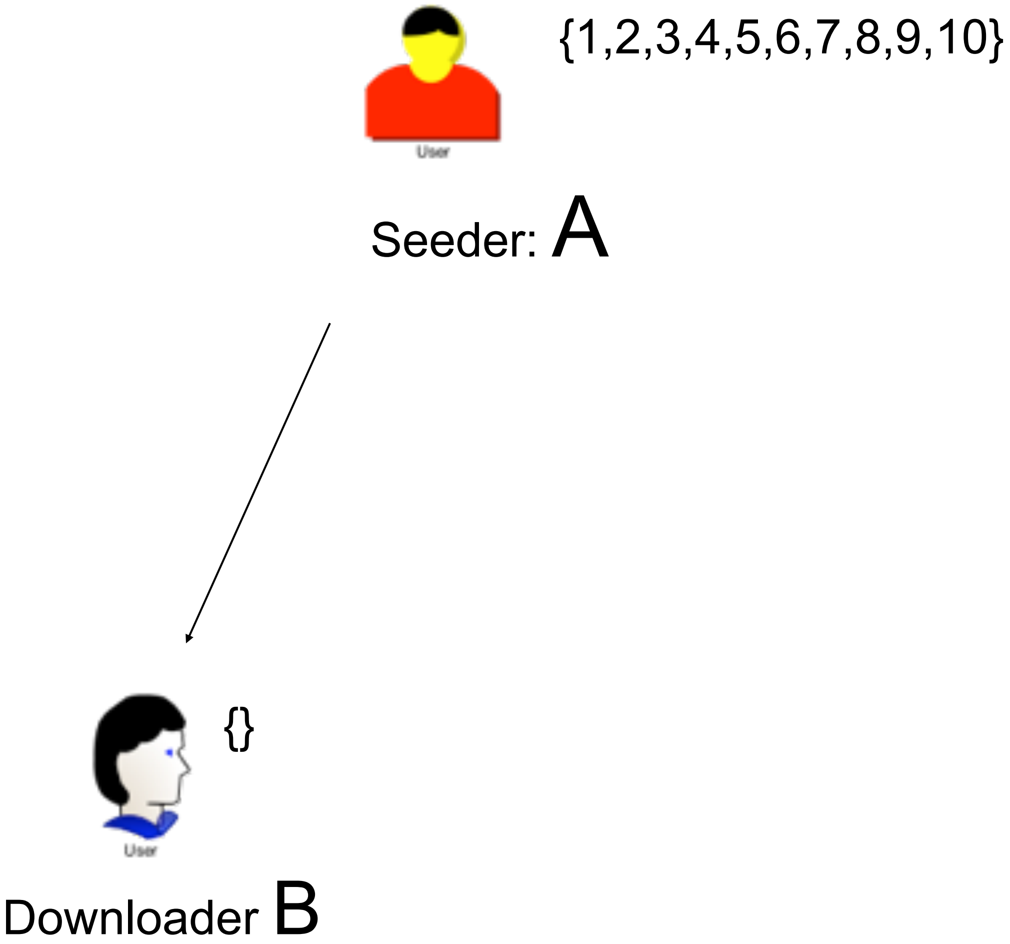
{1,2,3,4,5,6,7,8,9,10}

Seeder: A

{}

Downloader B

Simple example



{1,2,3,4,5,6,7,8,9,10}

Seeder: A

{}

Downloader B

Simple example

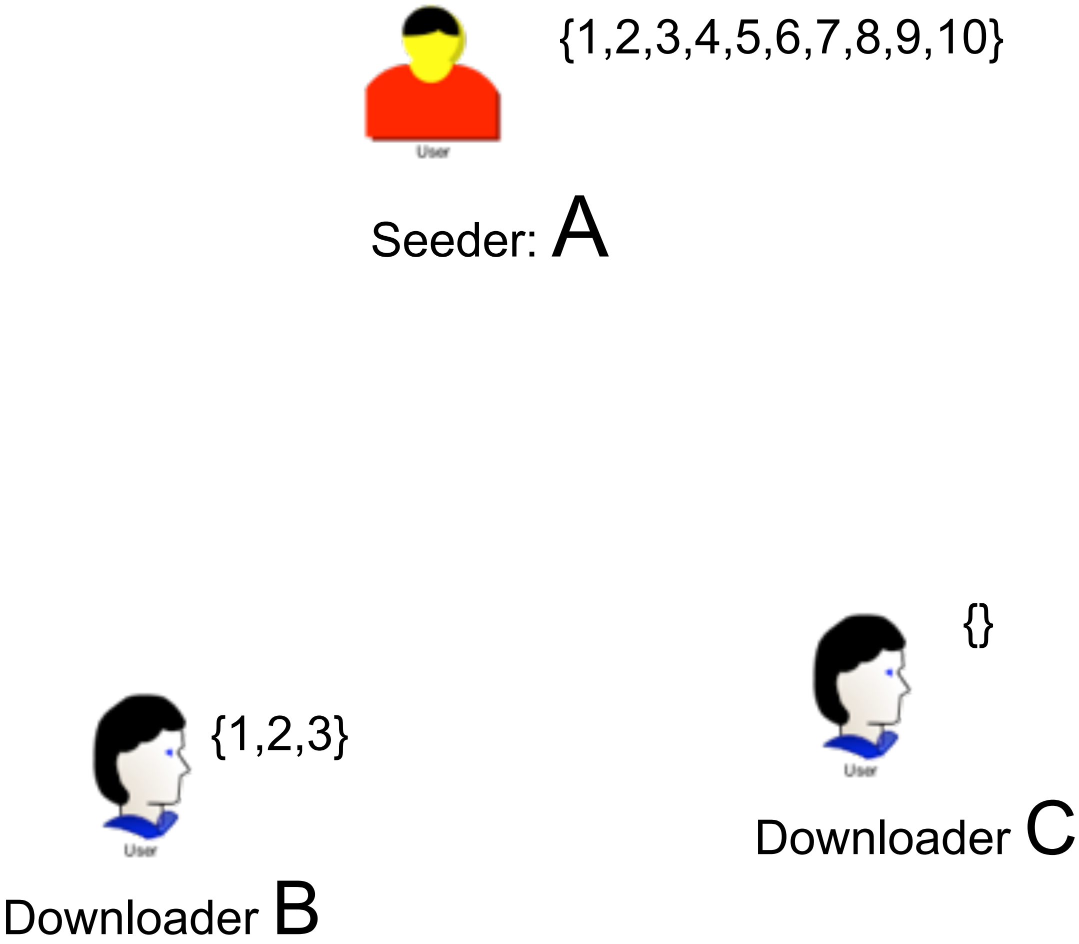
{1,2,3,4,5,6,7,8,9,10}

Seeder: A

{1,2,3}

Downloader B

Simple example



{1,2,3,4,5,6,7,8,9,10}

Seeder: A

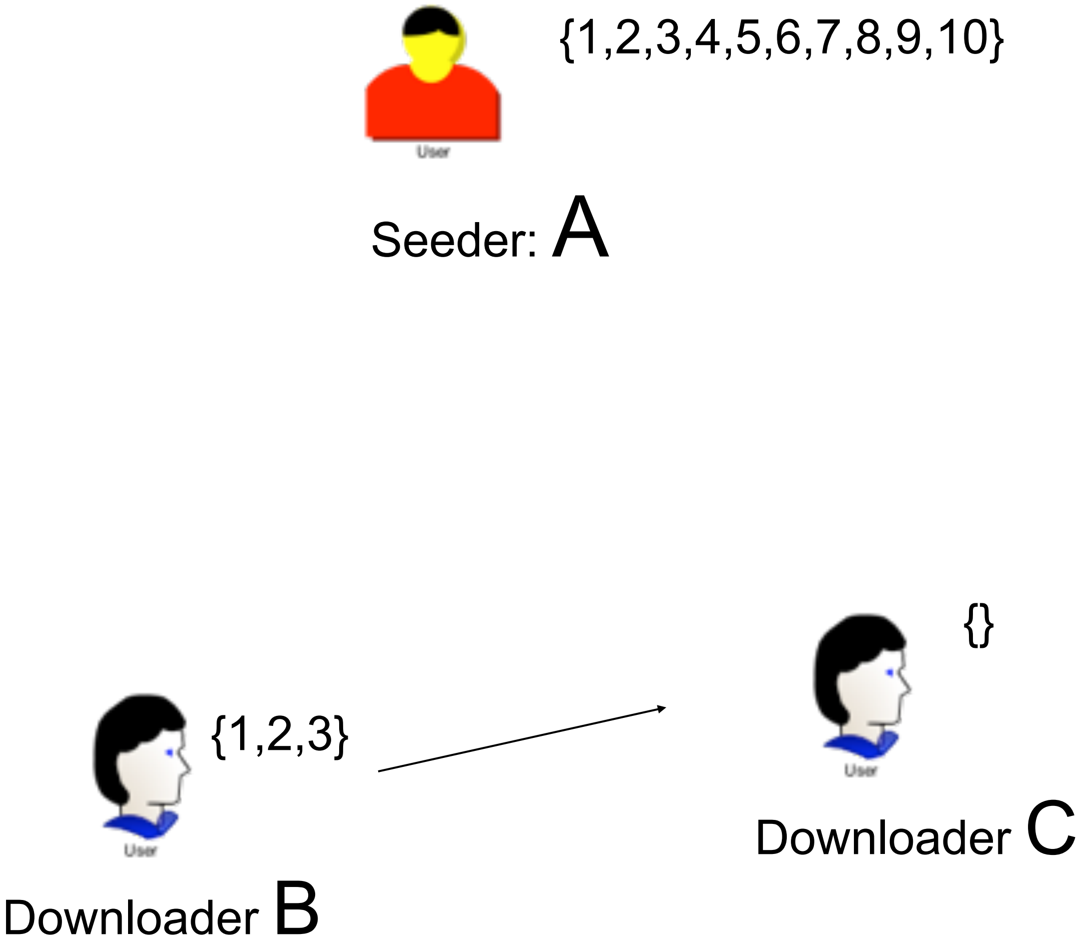
{1,2,3}

Downloader B

{}

Downloader C

Simple example



{1,2,3,4,5,6,7,8,9,10}

Seeder: A

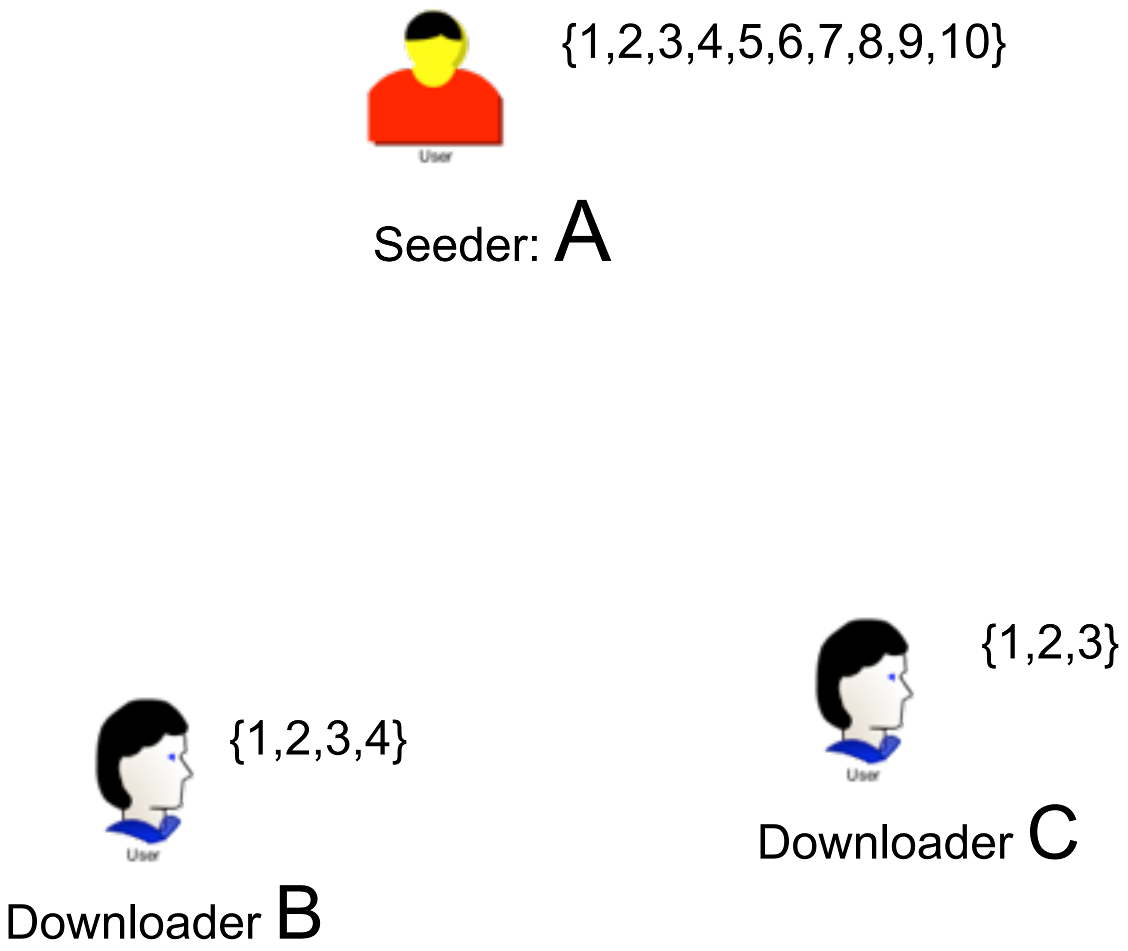
{1,2,3}

Downloader B

{}

Downloader C

Simple example



{1,2,3,4,5,6,7,8,9,10}

Seeder: A

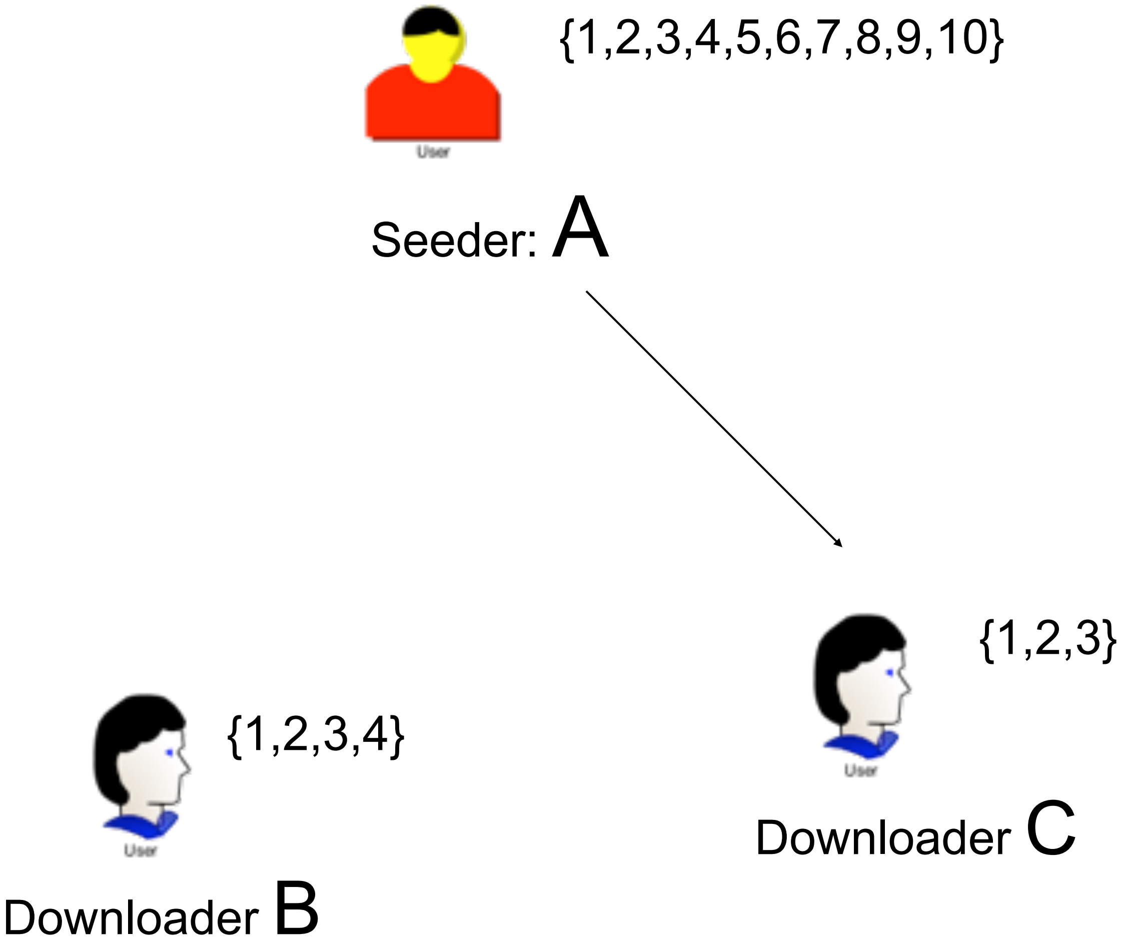
{1,2,3}

Downloader C

{1,2,3,4}

Downloader B

Simple example



{1,2,3,4,5,6,7,8,9,10}

Seeder: A

{1,2,3}

Downloader C

{1,2,3,4}

Downloader B

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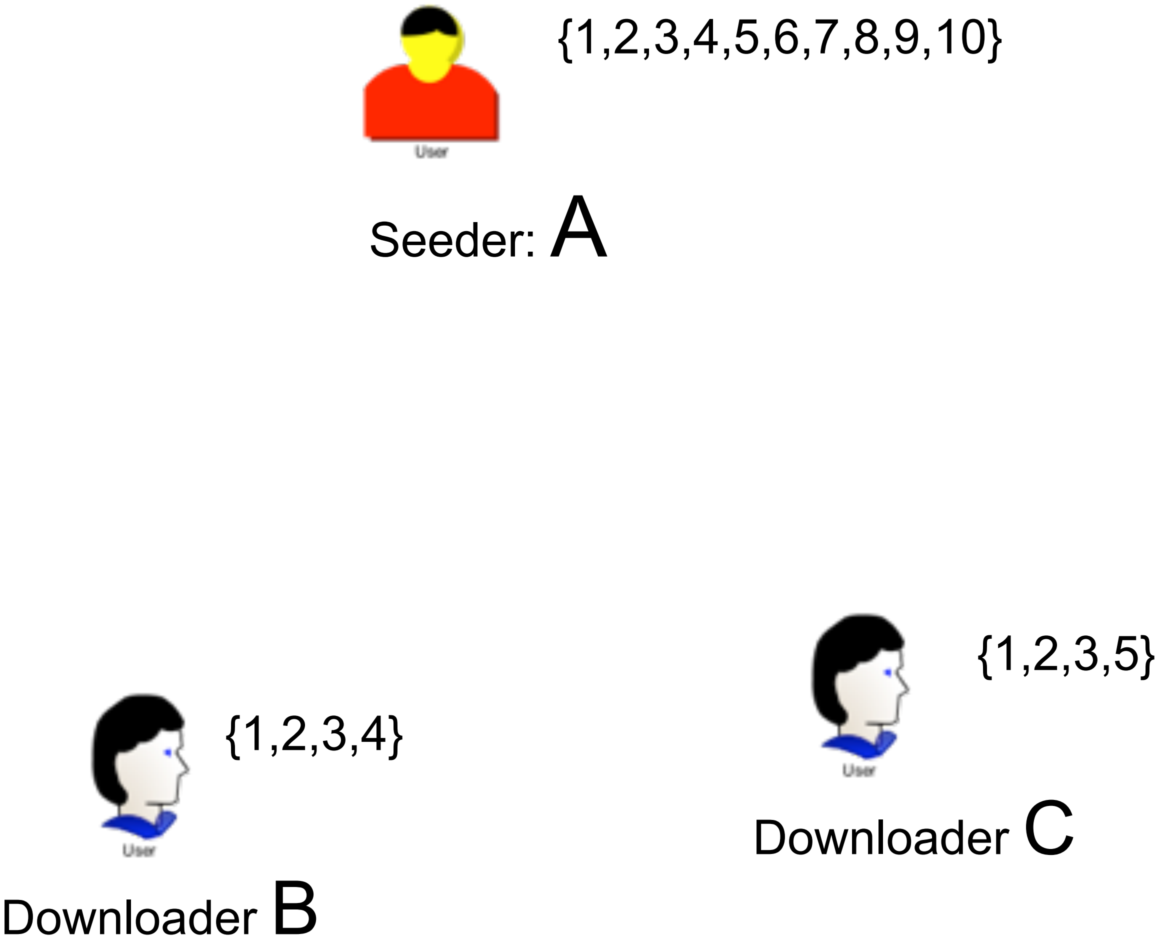

{1,2,3,4,5,6,7,8,9,10}

Seeder: A

{1,2,3,4}

Downloader B

{1,2,3,5}

Downloader C

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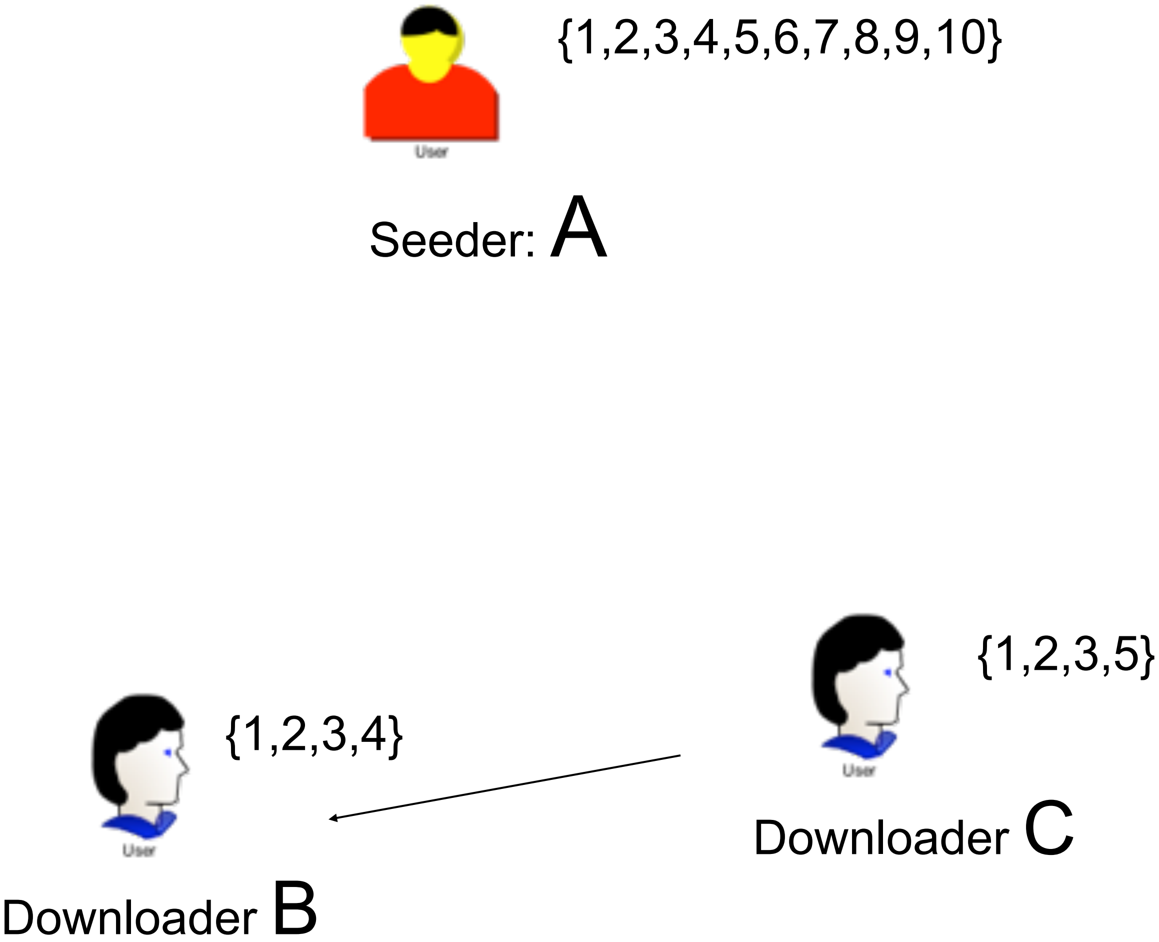


{1,2,3,4,5,6,7,8,9,10}

Seeder: A

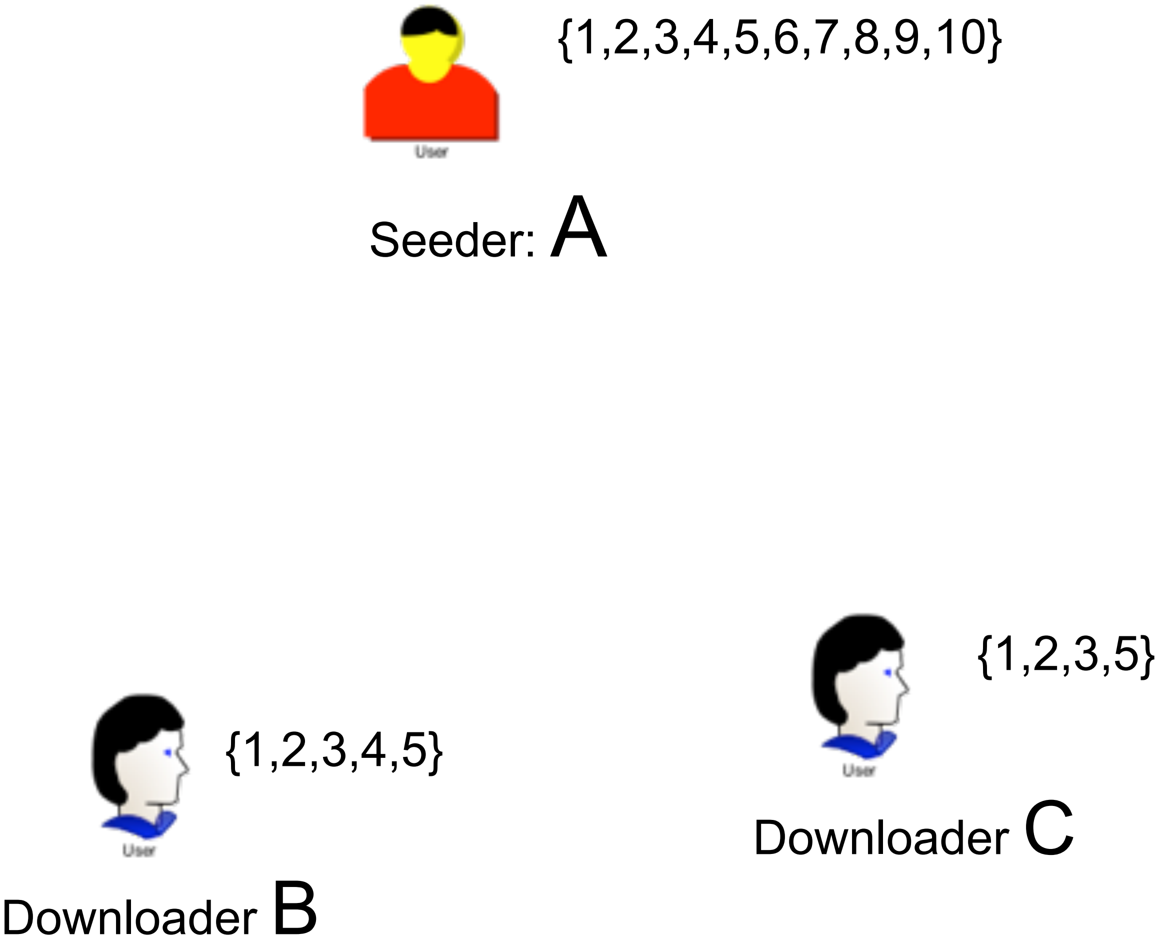
{1,2,3,5}

Downloader C

{1,2,3,4}

Downloader B

Simple example



{1,2,3,4,5,6,7,8,9,10}

Seeder: A

{1,2,3,4,5}

Downloader B

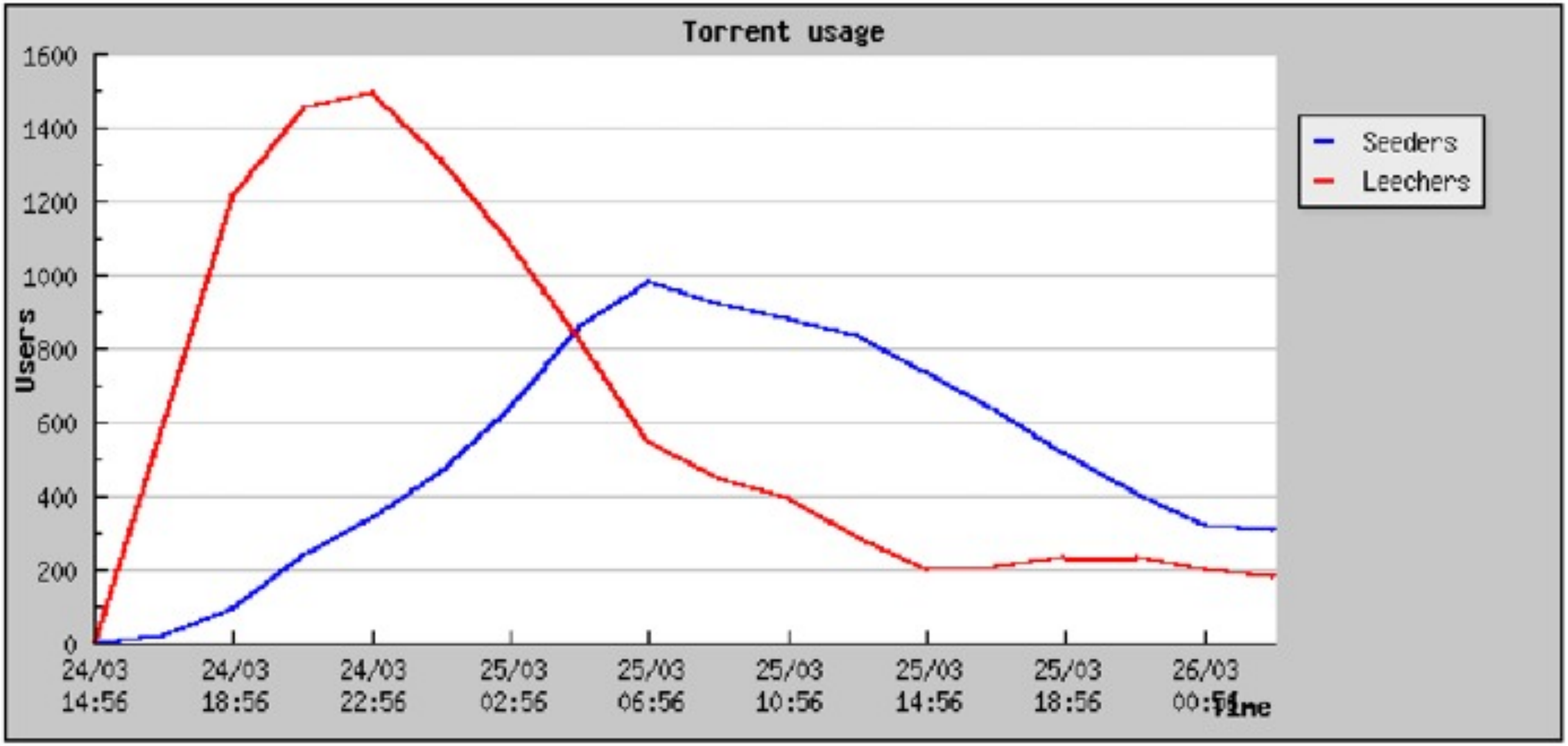
{1,2,3,5}

Downloader C

Basic Idea

- Initial seeder chops file into many pieces.
- Leecher first locates the **.torrent** file that directs it to a **tracker**, which tells which other peers are downloading that file. As a leecher downloads pieces of the file, replicas of the pieces are created. ***More downloads mean more replicas available***
- As soon as a leecher has a complete piece, it can potentially share it with other downloaders. Eventually each leecher becomes a seeder by obtaining all the pieces, and assembles the file. Verifies the checksum.

Operation


Torrent usage
Users
1600
1400
1200
1000
800
600
400
200
0
24/03 14:56
24/03 18:56
24/03 22:56
25/03 02:56
25/03 06:56
25/03 10:56
25/03 14:56
25/03 18:56
26/03 00:56
Time
Seeders
Leechers

Pieces and Sub-Pieces

- A piece is broken into sub-pieces ... typically 16KB in size
- Until a piece is assembled, only download the sub-pieces of that piece only
- This policy lets pieces assemble quickly

Pipelining

- When transferring data over TCP, always have several requests pending at once, to avoid a delay between pieces being sent. At any point in time, some number, typically 5, are requested simultaneously.
- Every time a piece or a sub-piece arrives, a new request is sent out.

Piece Selection

- The order in which pieces are selected by different peers is critical for good performance
- If an inefficient policy is used, then peers may end up in a situation where each has all identical set of easily available pieces, and none of the missing ones.
- If the original seed is prematurely taken down, then the file cannot be completely downloaded! What are "good policies?"

BT: internal Chunk Selection mechanisms

- **Strict Priority**
  - First Priority
- **Rarest First**
  - General rule
- **Random First Piece**
  - Special case, at the beginning
- **Endgame Mode**
  - Special case

Random First Piece

- Initially, a peer has nothing to trade
- Important to get a complete piece ASAP
- Select a random piece of the file and download it

Rarest Piece First

- Determine the pieces that are most rare among your peers, and download those first.
- This ensures that the most commonly available pieces are left till the end to download.

Endgame Mode

- Near the end, missing pieces are requested from every peer containing them. When the piece arrives, the pending requests for that piece are cancelled.
- This ensures that a download is not prevented from completion due to a single peer with a slow transfer rate.
- Some bandwidth is wasted, but in practice, this is not too much.

BT: internal mechanism

- Built-in **incentive** mechanism (where all the magic happens):
  - Choking Algorithm
  - Optimistic Unchoking

Choking

- **Choking** is a *temporary refusal* to upload. It is one of BitTorrent's most powerful idea to deal with **free riders (those who only download but never upload)**.
- *Tit-for-tat strategy* is based on game-theoretic concepts.

Choking

Reasons for choking:

- Avoid free riders
- Network congestion

A good choking algorithm
caps the number of simultaneous
uploads for good TCP performance.
Avoids choking and unchoking
too quickly, (known as fibrillation)..

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Alice

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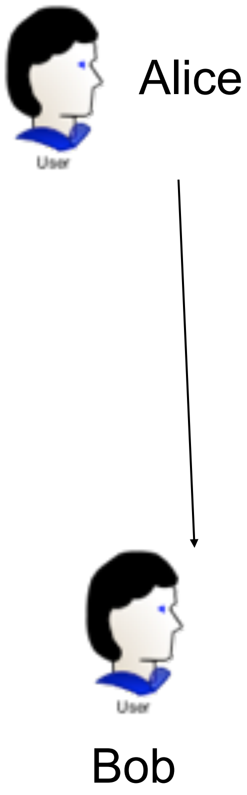

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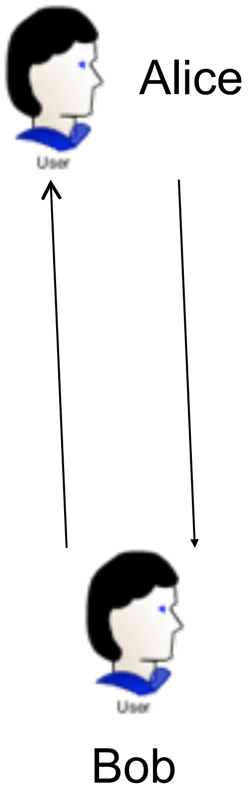

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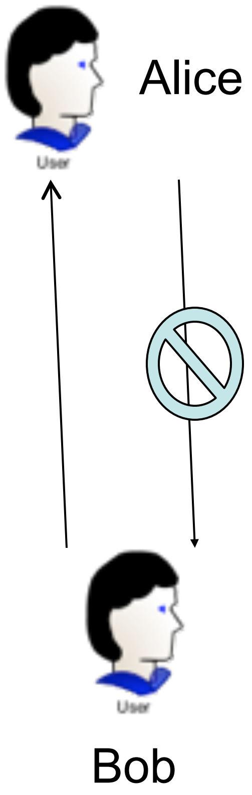

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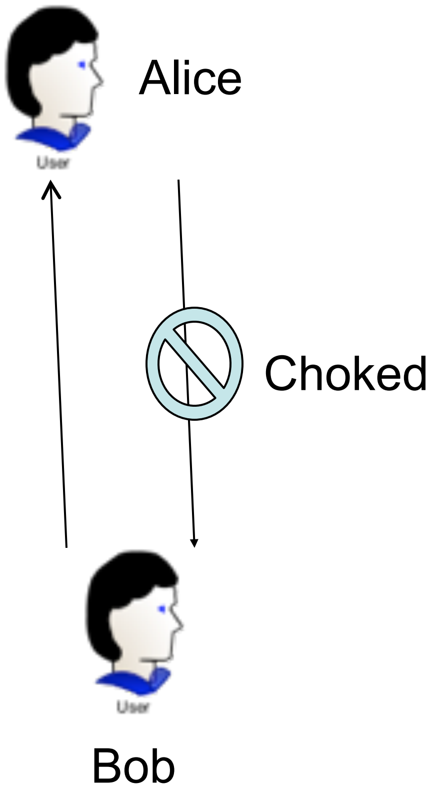

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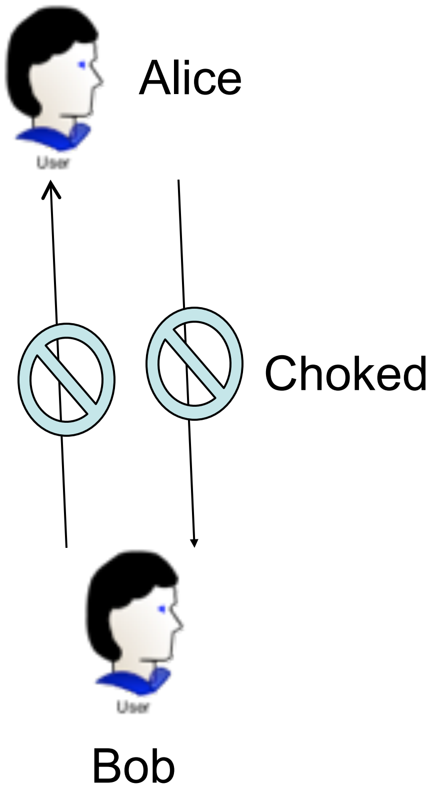

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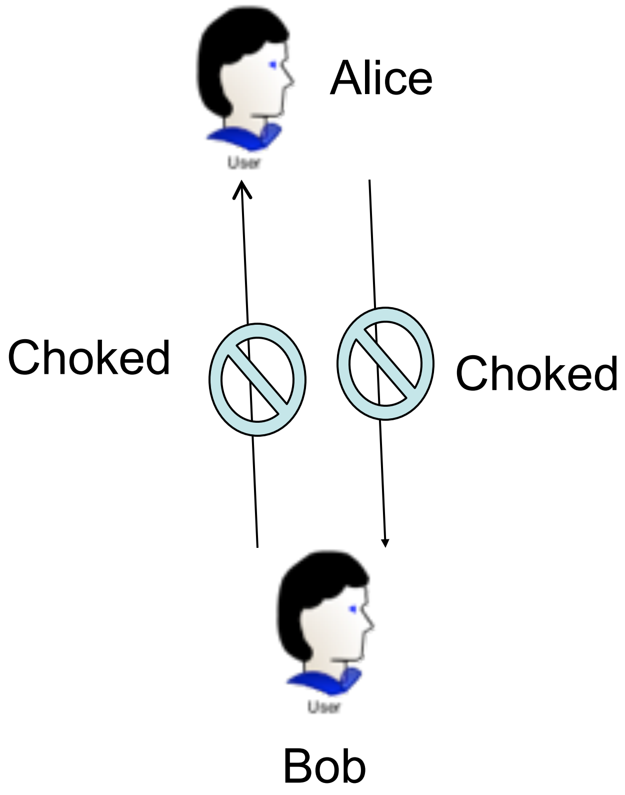

More on Choking

Peers try out unused connections once in a while to find out if they might be better than the current ones (optimistic unchoking).

Optimistic unchoking

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- Reasons:
  - To discover currently unused connections are better than the ones being used
  - To provide minimal service to new peers

Upload-Only mode

- Once download is complete, a peer has no download rates to use for comparison nor has any need to use them. The question is, which nodes to upload to?

- Policy: Upload to those with the best upload rate. This ensures that pieces get replicated faster, and new seeders are created fast

Questions about BT

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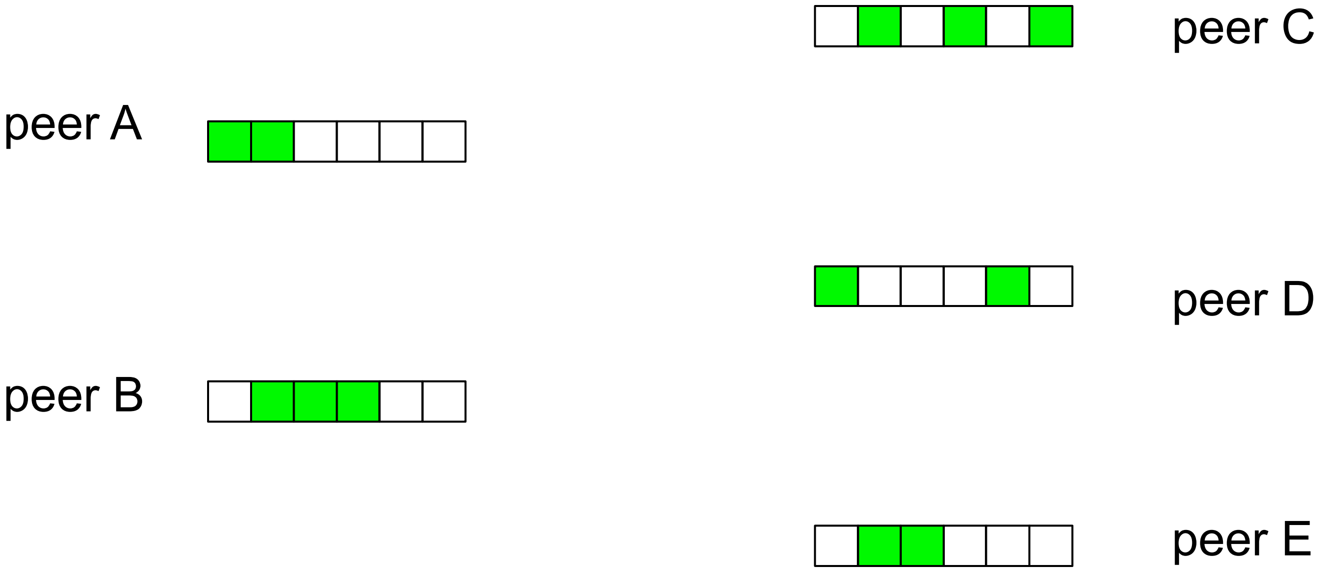
- Which features contribute to the efficiency of BitTorrent?
- What is the effect of bandwidth constraints?
- Is the Rarest First policy really necessary?
- Must nodes perform seeding after downloading is complete?
- How serious is the Last Piece Problem?
- Does the incentive mechanism affect the performance much?

One more example



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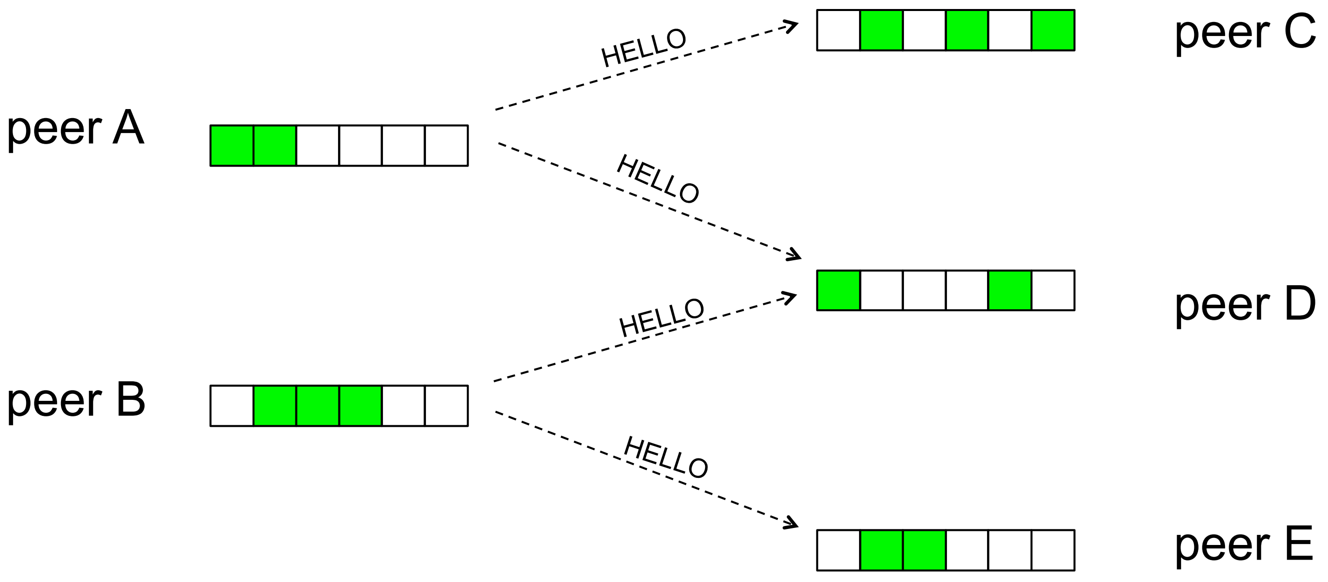

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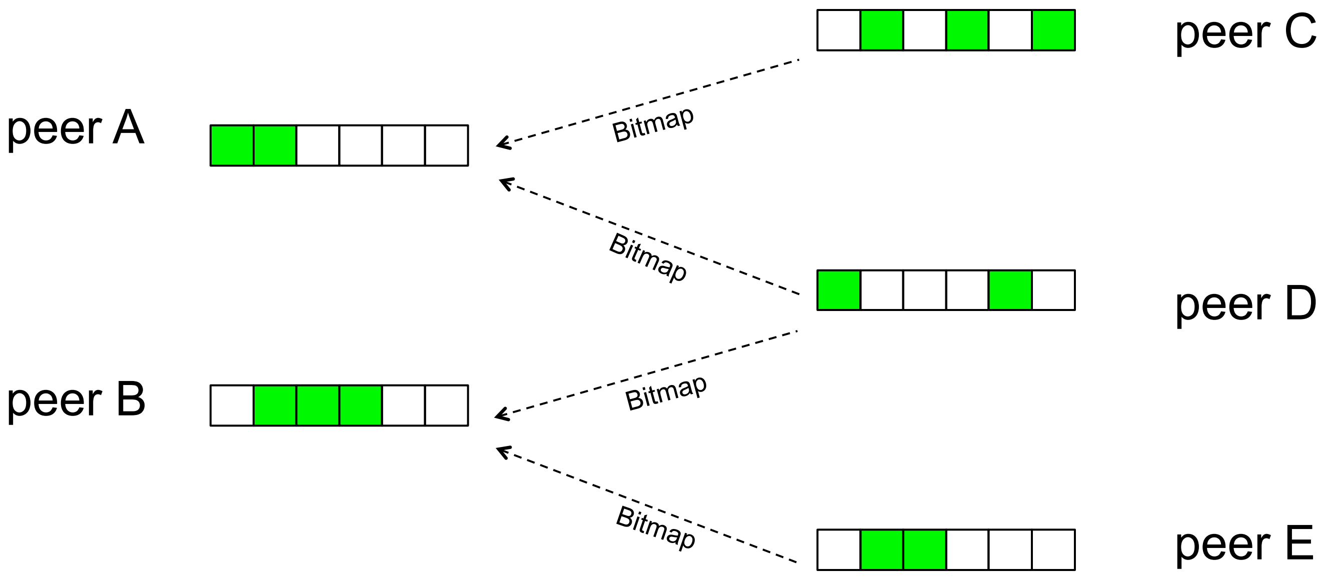

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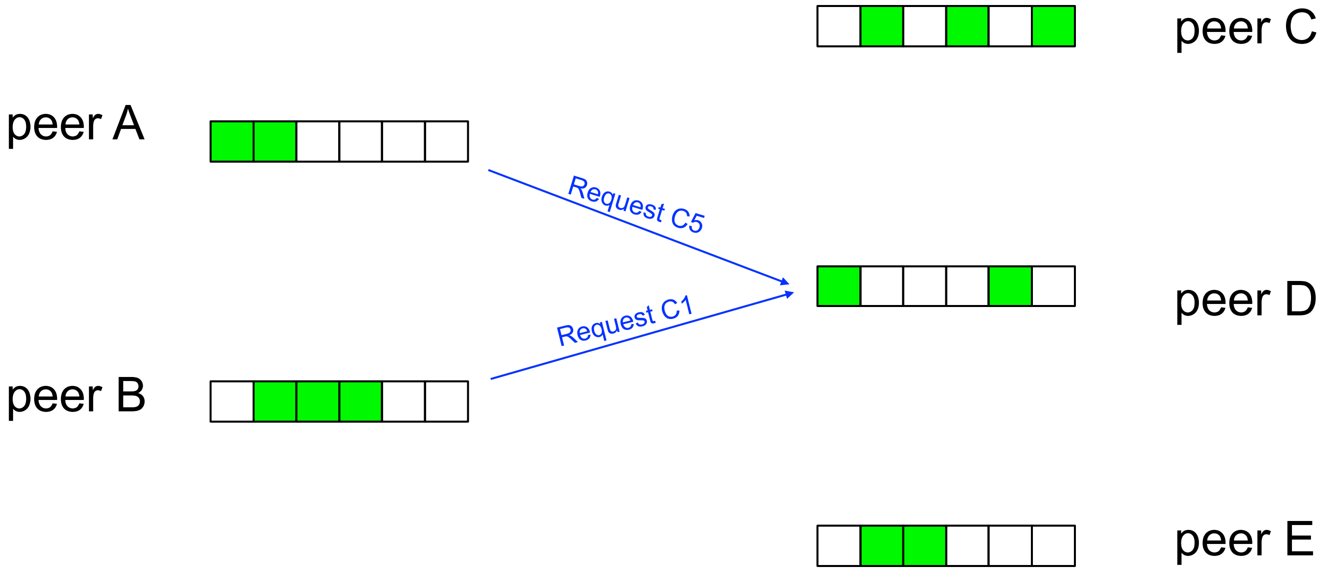
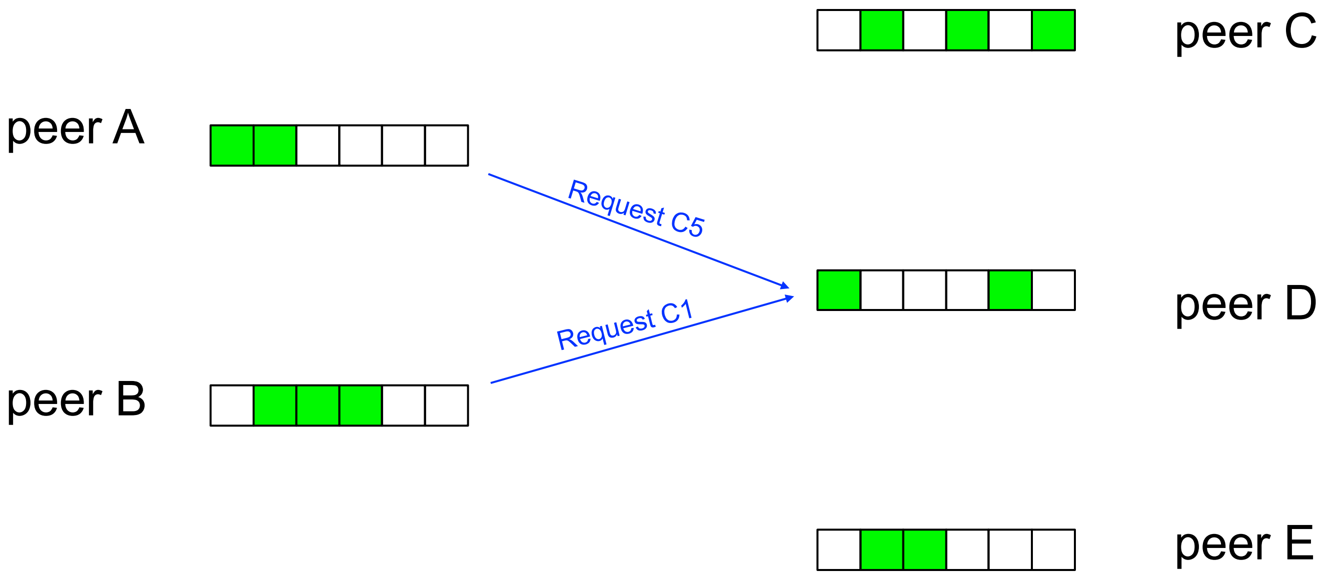


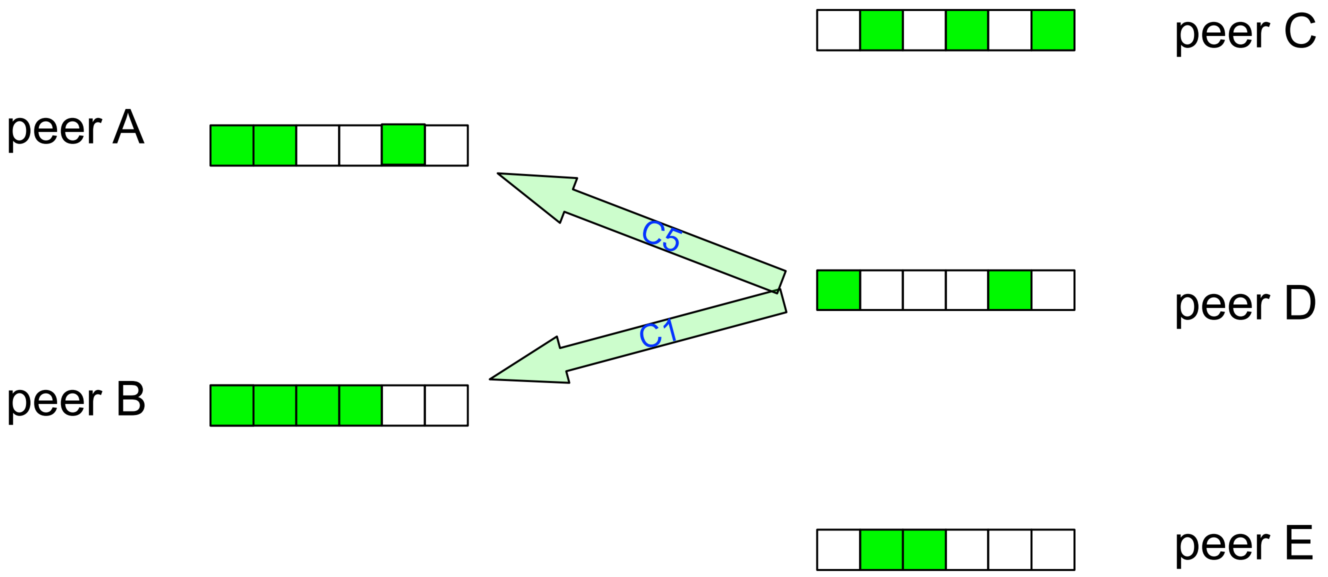
One more example

Without upload constraint



One more example

Without upload constraint



peer C

peer A

peer D

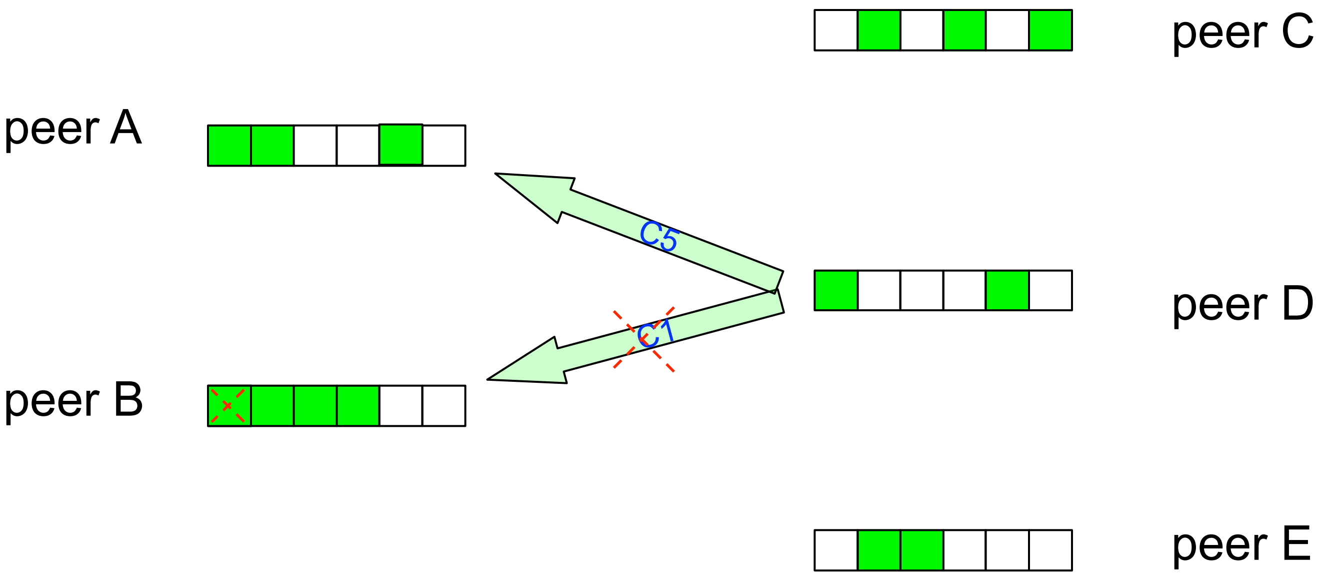
peer B

peer E

One more example

Without upload constraint

With upload constraint



peer C

peer A

peer D

peer B

peer E

Trackerless torrents

BitTorrent also supports "trackerless" torrents, featuring a DHT implementation that allows the client to download torrents that have been created without using a BitTorrent tracker.