Hálózatba kapcsolt erőforrás platformok és alkalmazásaik

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TMIT

2017

BitTorrent

BitTorrent

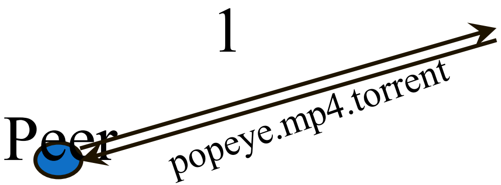
- Written by Bram Cohen (in Python) in 2001
- "Pull-based" "swarming" approach
  - Each file split into smaller pieces
  - Nodes request desired pieces from neighbors
    - As opposed to parents pushing data that they receive
  - Pieces not downloaded in sequential order
- Encourages contribution by all nodes

What is BitTorrent?

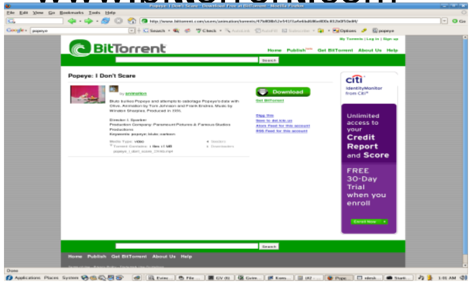
◆ Efficient content distribution system using *file swarming*. Does not perform all the functions of a typical p2p system, like *searching*.

◆ The throughput increases with the number of down loaders via the efficient use of network bandwidth

How does a node starts the download?



www.bittorrent.com


Popeye: I Don't Scare - Download Free at BitTorrent - Mozilla Firefox
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IdentityMonitor from Citi
Unlimited access to your Credit Report and Score
FREE 30-Day Trial when you enroll
Enroll Now
Done
Applications Places System

Popeye: I Don't Scare

by animation

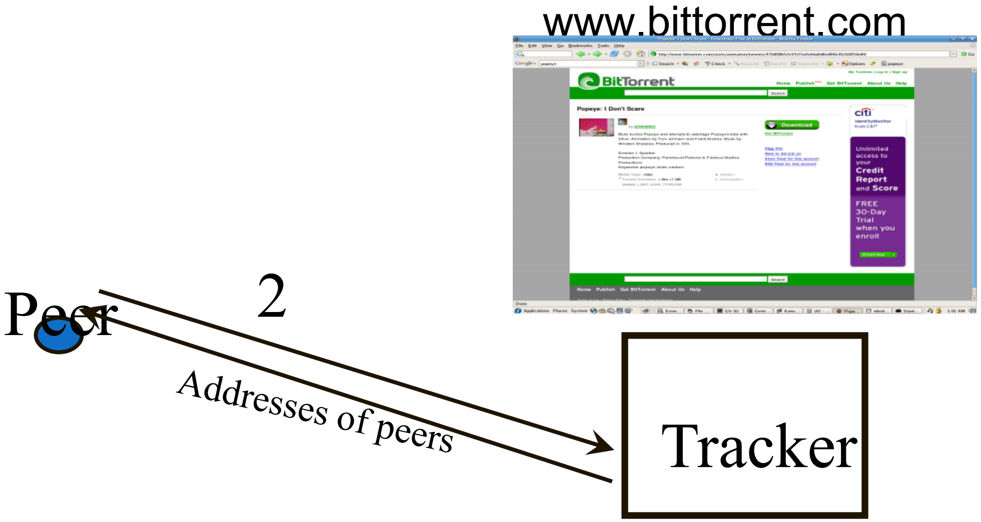
Bluto bullies Popeye and attempts to sabotage Popeye's date with Olive. Animation by Tom Johnson and Frank Endres. Music by Winston Sharples. Produced in 1935.

Director: I. Sparber
Production Company: Paramount Pictures & Famous Studios Productions
Keywords: popeye; bluto; cartoon

Media Type: video
Torrent Contains: 1 files 11 MB
popeye_i_dont_scare_1934b.mp4

- An „**index file**” *popeye.mp4.torrent* hosted at a **(well-known) webserver**

How does a node starts the download?



www.bittorrent.com

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- The .torrent has address of **tracker** for file

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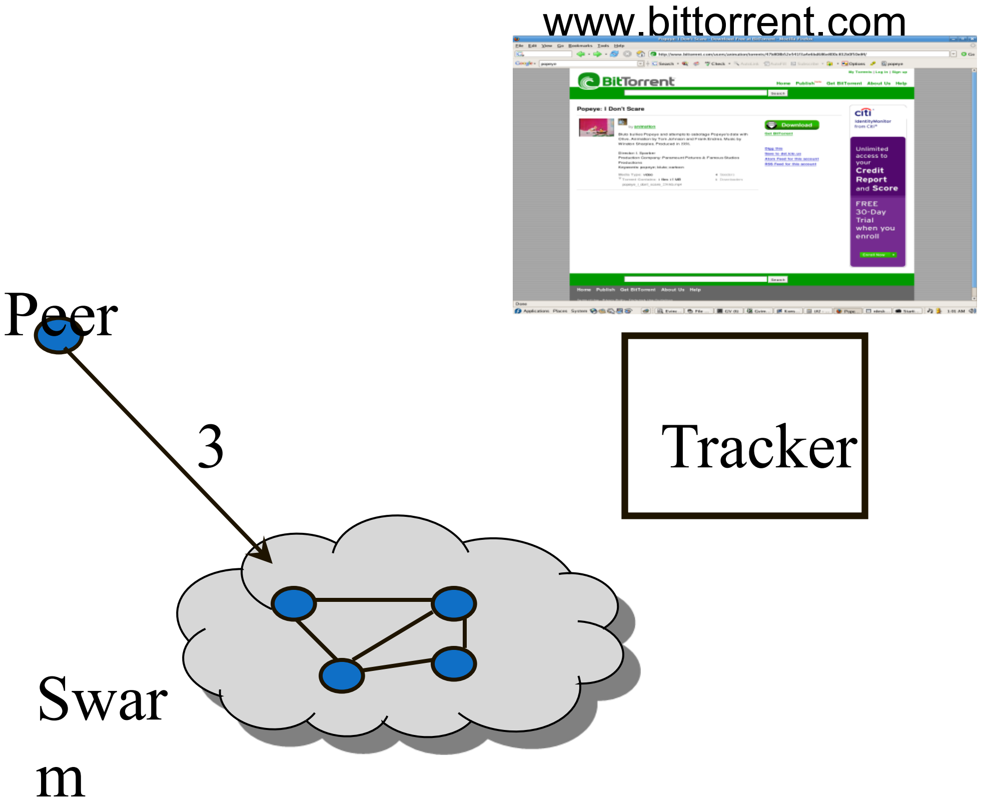

www.bittorrent.com
BitTorrent
Home Publish Get BitTorrent About Us Help
Popeye: I Don't Scare
Download
citi
Unlimited access to your Credit Report and Score
FREE 30-Day Trial when you enroll
Peer
3
Tracker
Swar
m

- An „**index file**” *popeye.mp4.torrent* hosted at a **(well-known) webserver**
- The .torrent has address of **tracker** for file
- The tracker, which runs on a webserver as well, keeps track of **all peers downloading** file

File sharing

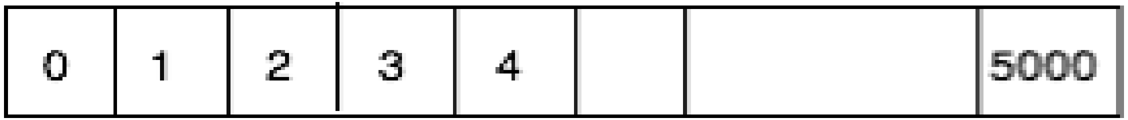
To share a file or group of files, the initiator first creates a **.torrent** file, a small file that contains

- **Metadata** about the files to be shared
- SHA-1 hashes of each piece in file - for reliability
- “files” – allows download of multiple files
- Information (e.g., URL) about the **tracker**, the computer that coordinates the file distribution.

Downloaders 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.

How it works

The file to be distributed is split up into pieces and an SHA-1 hash is calculated for each piece



BT Components

The peers first obtain a metadata file for each object
The metadata contains:

- The SHA-1 hashes of all pieces
- A mapping of the pieces to files
- Piece size
- Length of the file
- A tracker reference

BT Components

The **tracker** is a central server keeping a list of all peers participating in the swarm

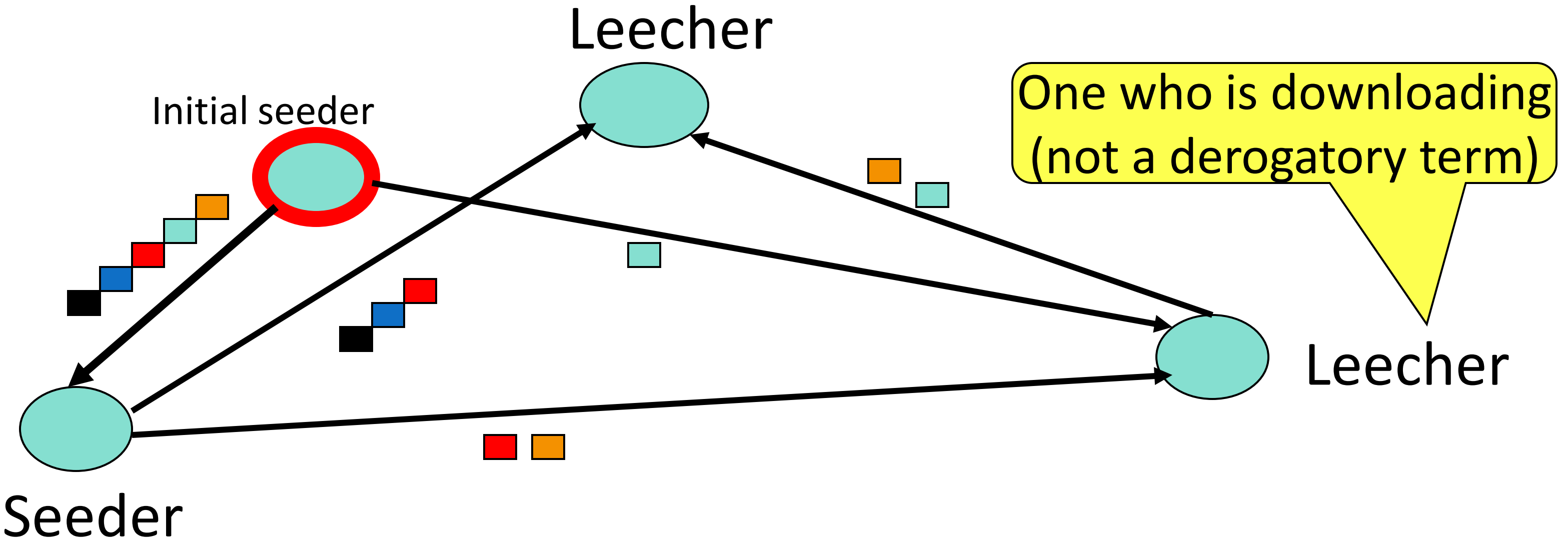
◆ A **swarm** is the set of peers that are participating in distributing the same files

◆ A peer joins a swarm by asking the tracker for a peer list and connects to those peers.

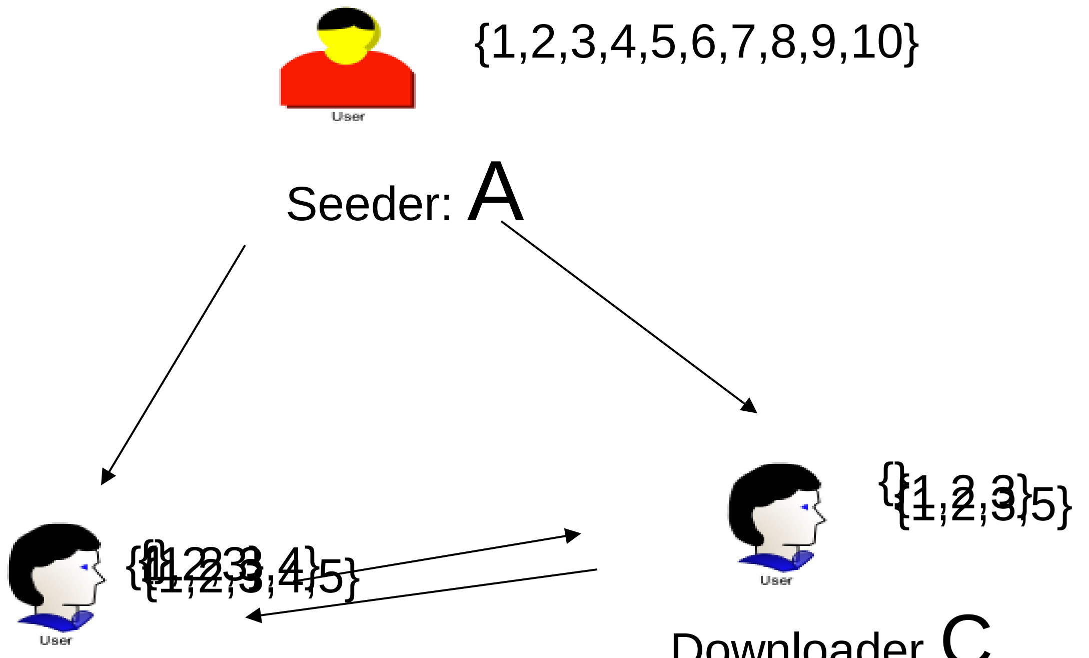
BitTorrent naming conventions

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

{}
{1,2,3}
{1,2,3,4}
{1,2,3,4,5}

{}
{1,2,3}
{1,2,3,5}

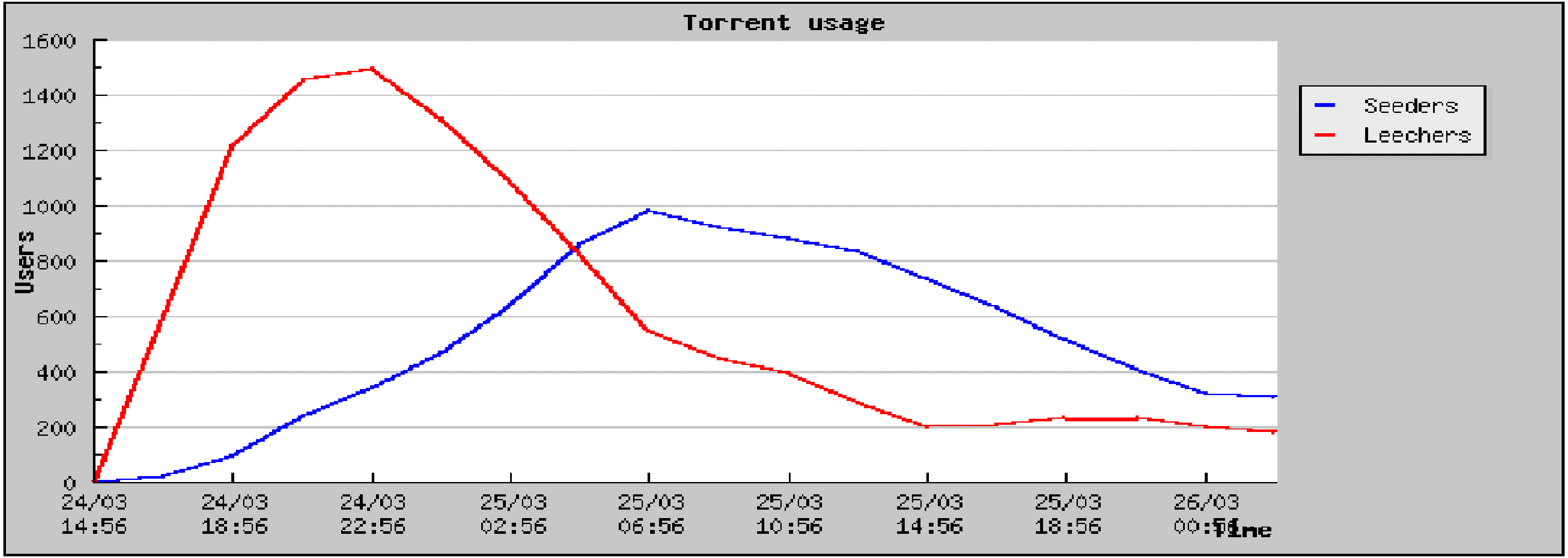
Downloader B

Downloader C

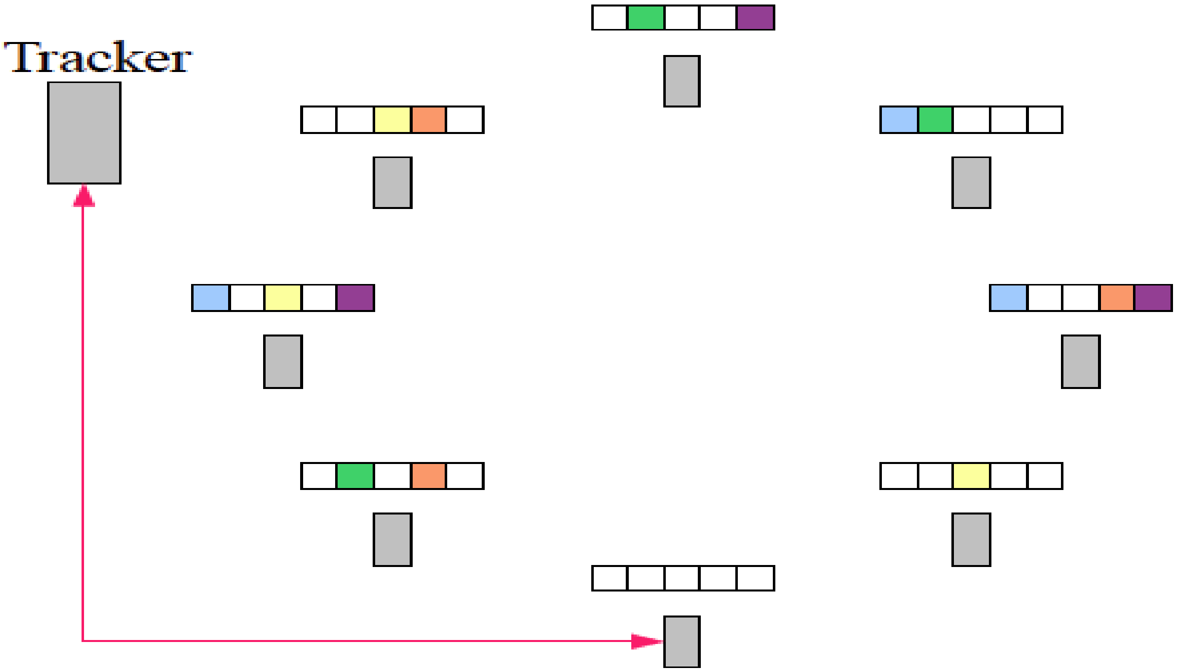
Basic Idea

- 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.
- Each leacher
  - Reports to its peers what pieces it has
  - Starts exchanging these pieces with them
- Torrent file on web server has SHA1 hashes of all the pieces
- Peers don’t report that they have a piece until they’ve checked its hash
  - *Could have used erasure codes*

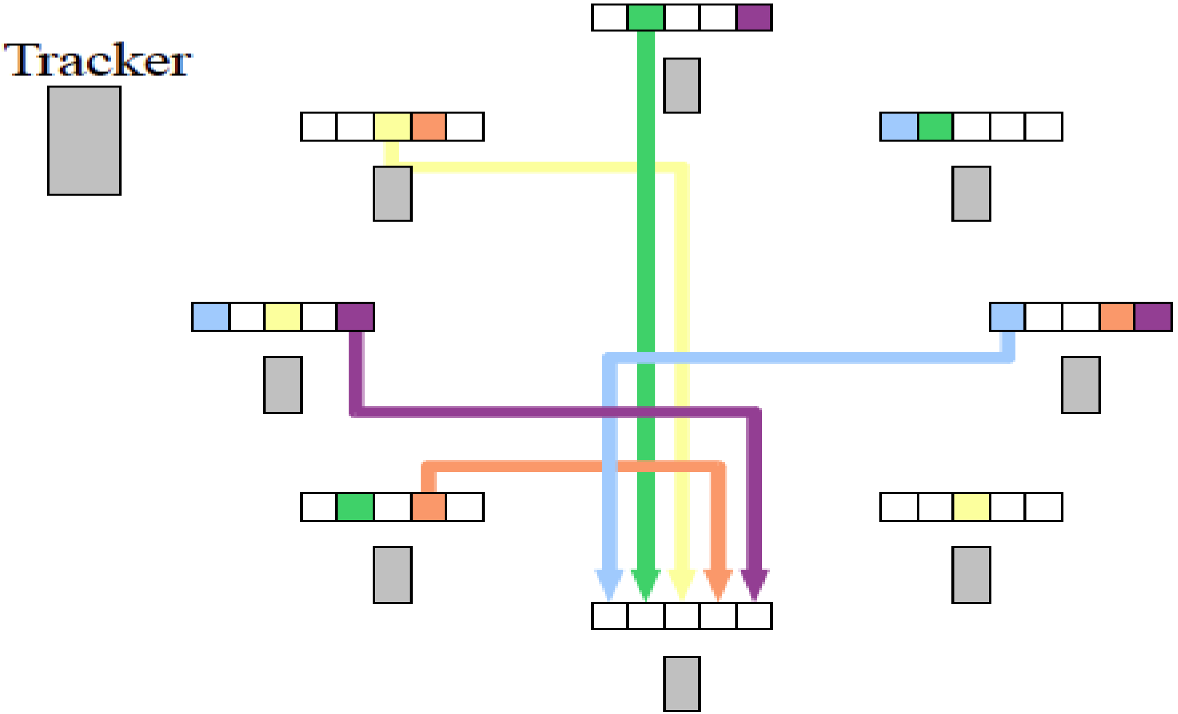
Operation


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

Download in progress



Download in progress



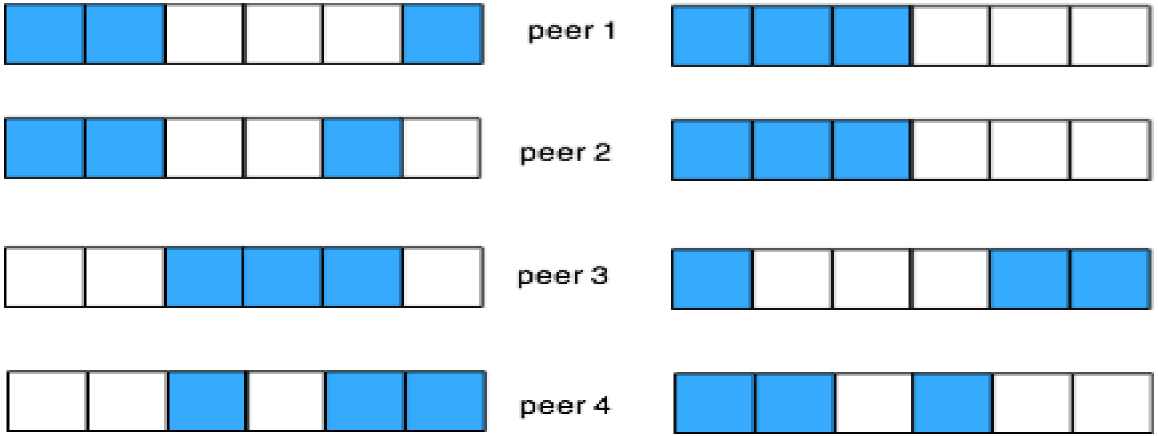
Pipelining

- When transferring data over TCP, always have several requests pending at once (typically 5), to avoid a delay between pieces being sent.
- 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?"

Piece Selection



Small overlap is good

Large overlap is bad
-- wastes bandwidth

Piece selection

- **Strict 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.
  - Increases diversity in the pieces downloaded
    - avoids case where a node and each of its peers have exactly the same pieces; increases throughput
  - Increases likelihood all pieces still available even if original seed leaves before any one node has downloaded entire file

Endgame Mode

- Near the end, missing pieces are requested from every peer containing them.
- 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 BT’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.

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

- A BT peer has a single “optimistic unchoke” to which it uploads regardless of the current download rate from it. This peer rotates every 30s

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

Anti-snubbing

- A peer is said to be snubbed if each of its peers chokes it
- To handle this, snubbed peer stops uploading to its peers

➢Optimistic unchoking done more often

  - Hope is that will discover a new peer that will upload to us

Upload-Only mode

- Once download is complete, a peer can only upload. 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

.torrent

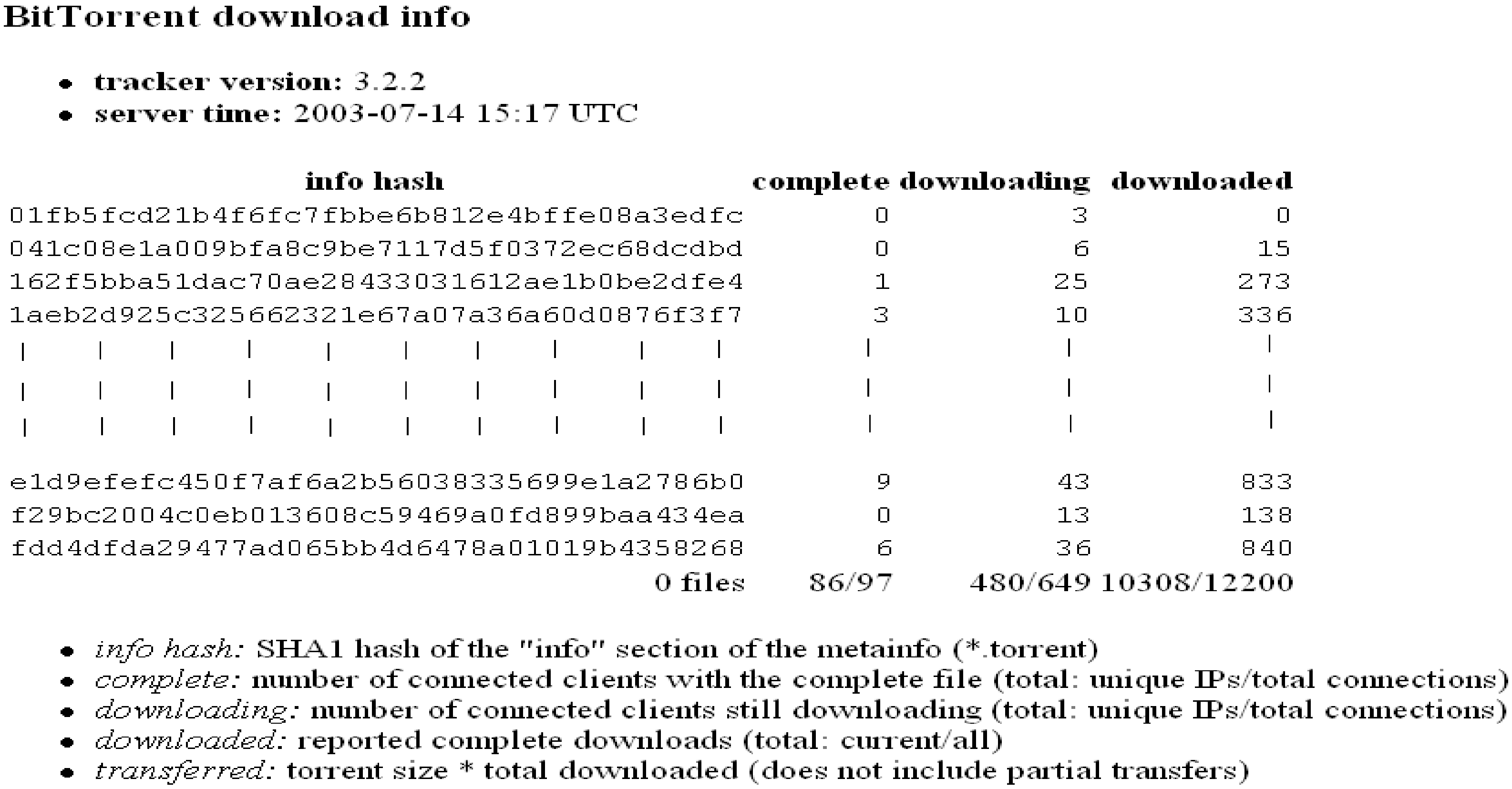
- url of the tracker
- Pieces <hash1,hash2,....hashn>
- Piece length
  - pieces maps to a string whose length is a multiple of 20. It is to be subdivided into strings of length 20, each of which is the SHA1 hash of the piece at the corresponding index.
- Name
- Length
- Files
  - Path
  - length

Bencode

- All data passed in BT is bencoded (BEE – Encoded).
- This is a representation convention used to avoid interoperability problems.

Tracker

- Peer cache
  - IP, port, peer id
- State information
  - Completed
  - Downloading
- Returns random list



BitTorrent download info

- **tracker version:** 3.2.2
- **server time:** 2003-07-14 15:17 UTC

info hash	complete	downloading	downloaded
01fb5fcd21b4f6fc7fbbe6b812e4bffe08a3edfc	0	3	0
041c08e1a009bfa8c9be7117d5f0372ec68dcdbd	0	6	15
162f5bba51dac70ae28433031612ae1b0be2dfe4	1	25	273
1aeb2d925c325662321e67a07a36a60d0876f3f7	3	10	336
| | | | | | | | | |	|	|	|
| | | | | | | | | |	|	|	|
| | | | | | | | | |	|	|	|
e1d9efefc450f7af6a2b56038335699e1a2786b0	9	43	833
f29bc2004c0eb013608c59469a0fd899baa434ea	0	13	138
fdd4dfda29477ad065bb4d6478a01019b4358268	6	36	840
0 files	86/97	480/649	10308/12200

- *info hash:* SHA1 hash of the "info" section of the metainfo (*.torrent)
- *complete:* number of connected clients with the complete file (total: unique IPs/total connections)
- *downloading:* number of connected clients still downloading (total: unique IPs/total connections)
- *downloaded:* reported complete downloads (total: current/all)
- *transferred:* torrent size * total downloaded (does not include partial transfers)

Peer > Tracker:
GET requests has following keys

- info_hash – hash of the .torrent.
- peer_id – My unique ID.
- My IP / Port
- uploaded / Downloaded
- left – Can not be calculated from Downloaded, because of errors / restart.
- event - Why I do the GET.

GET events

- Reasons for calling the GET:
    - Started
    - Completed
    - Stopped
    - Empty - done at regular intervals

Tracker > Peer : tracker GET responses

- failure
- interval – next time to GET
- List of peers

Peer <> Peer communication

Actual packet structure

Peers protocol

- operates over TCP
- Peer connections are symmetrical
- Refers to pieces by index from .torrent
- Connections contain : choked and interested

Peer messages

- Handshake
- Keep alive (0 size, every 2 minutes)
- 0 - choke
- 1 - unchoke
- 2 - interested
- 3 - not interested
- 4 - have
- 5 - bitfield
- 6 - request
- 7 - piece
- 8 - cancel

Change connection state

- 'choke', 'unchoke', 'interested', and 'not interested' have no payload.
- Data transfer takes place:
  - one side is interested, other side is not choking
  - state must be kept up to date at all times
- This is a precondition for upload / download – REQUEST / PIECE

BITFIELD

- Only ever sent as the first message.
- bitfield - a bit for each piece –
  - 1 – Have
  - 0 – Don’t have
- May skip if has 0 pieces.

HAVE

- Single number, the index which that downloader just completed and checked the hash of.

REQUEST

- Contain - index, begin, and length
- Length is generally a power of two unless it gets truncated by the end of the file.

Why BitTorrent took off

- Better performance through “pull-based” transfer
  - Slow nodes don’t bog down other nodes
- Allows uploading from hosts that have downloaded parts of a file
  - In common with other end-host based multicast schemes

Why BitTorrent took off

- Practical Reasons (perhaps more important!)
  - Working implementation (Bram Cohen) with simple well-defined interfaces for plugging in new content
  - Many recent competitors got sued / shut down
    - Napster, Kazaa
  - Doesn’t do “search” per se. Users use well-known, trusted sources to locate content
    - Avoids the pollution problem, where garbage is passed off as authentic content

Pros and cons of BitTorrent

- Pros
  - Proficient in utilizing partially downloaded files
  - Discourages “freeloading”
    - By rewarding fastest uploaders
  - Encourages diversity through “rarest-first”
    - Extends lifetime of swarm
- Works well for “hot content”

Pros and cons of BitTorrent

- Cons
  - Assumes all interested peers active at same time; performance deteriorates if swarm "cools off"
  - Even worse: no trackers for obscure content

Pros and cons of BitTorrent

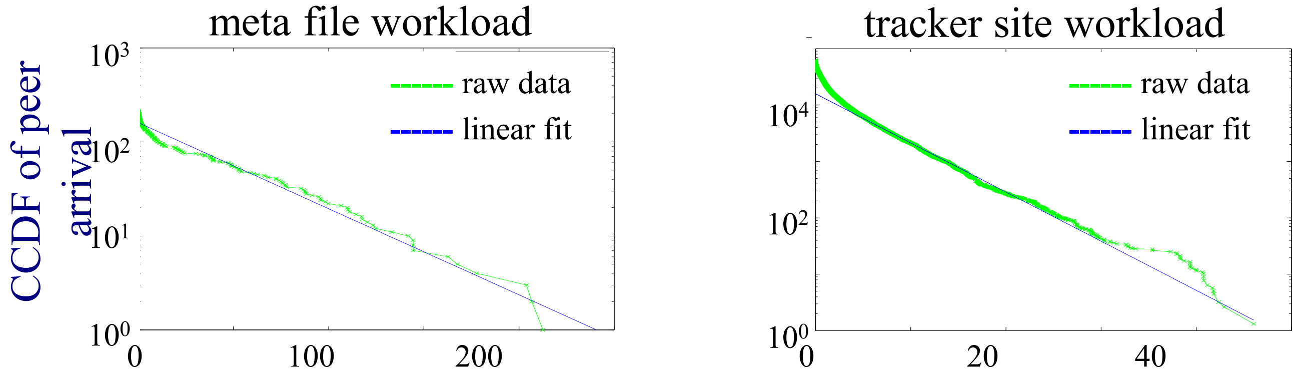
- Dependence on centralized tracker: pro/con?
  - ☹ Single point of failure: New nodes can’t enter swarm if tracker goes down
  - Lack of a search feature
    - ☺ Prevents pollution attacks
    - ☹ Users need to resort to out-of-band search: well known torrent-hosting sites / plain old web-search

“Trackerless” BitTorrent

- To be more precise, “BitTorrent without a centralized-tracker”
- E.g.: Azureus
- Uses a Distributed Hash Table (Kademlia DHT)
- Tracker run by a normal end-host (not a web-server anymore)
  - The original seeder could itself be the tracker
  - Or have a node in the DHT randomly picked to act as the tracker

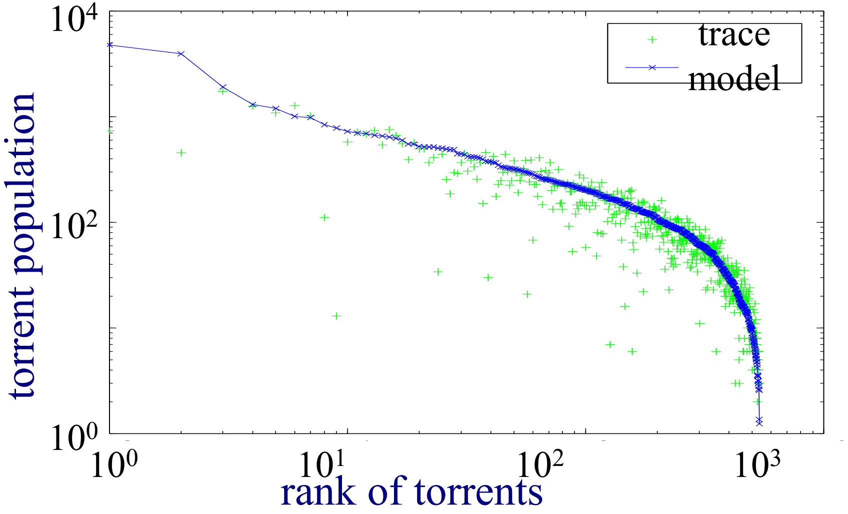
Dynamics of a torrent

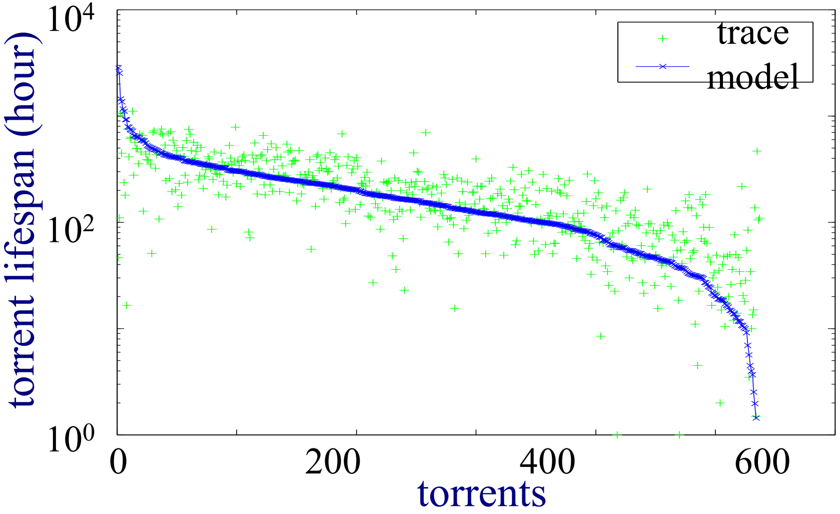
Peer arrival rate $= \dfrac{\text{number of arrivals}}{\Delta t}$



Peer arrivals: decrease with time exponentially

Torrent Population and Lifespan

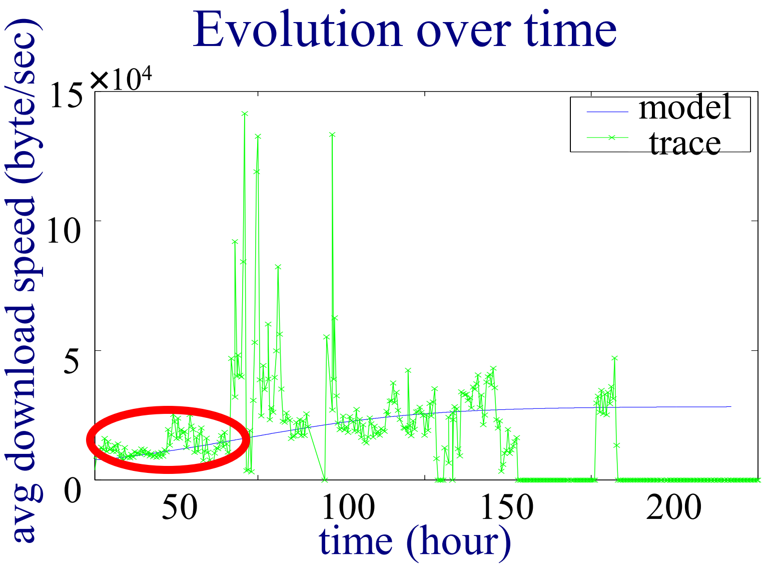


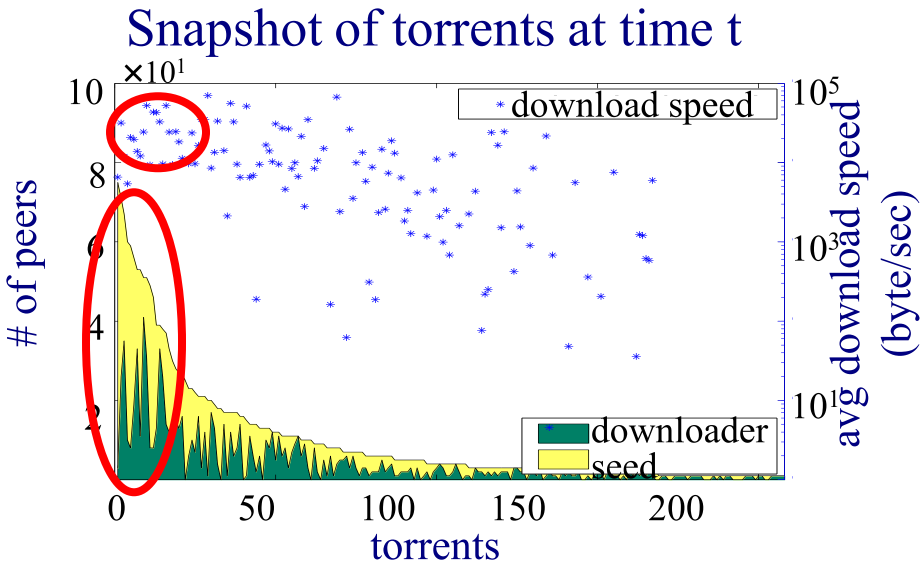


Most torrents are small (avg 102)

Most torrents are short live (avg 8 days)

Performance Stability



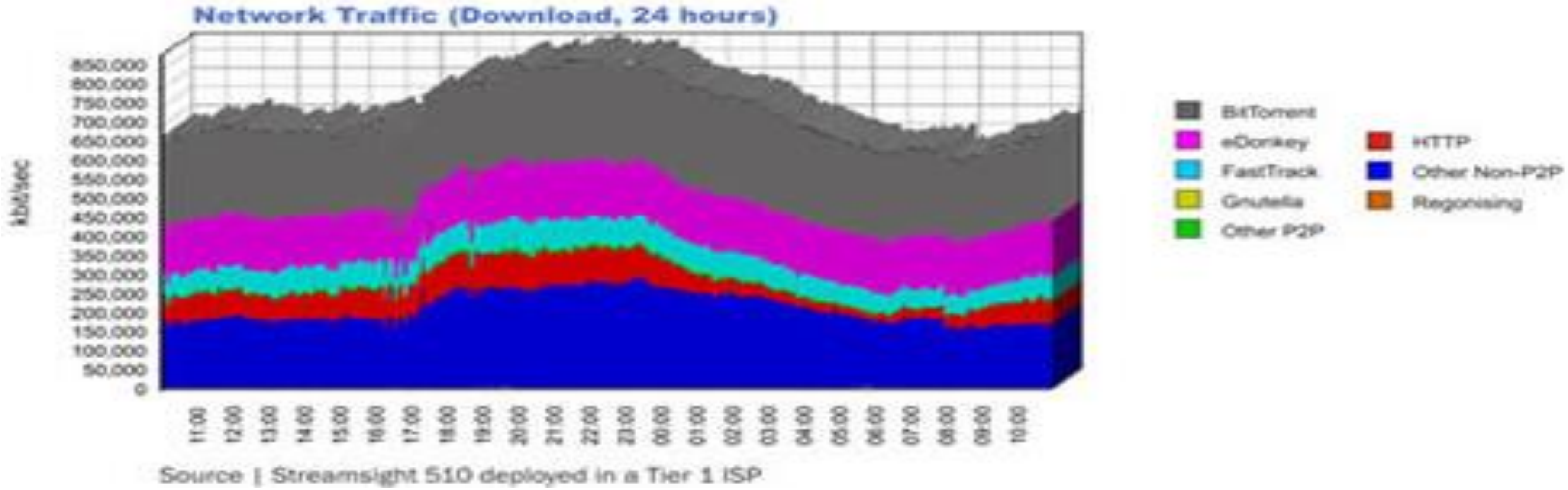


Only stable when torrent is large

Fluctuate significantly after peak time

Larger torrents have higher and more stable performance

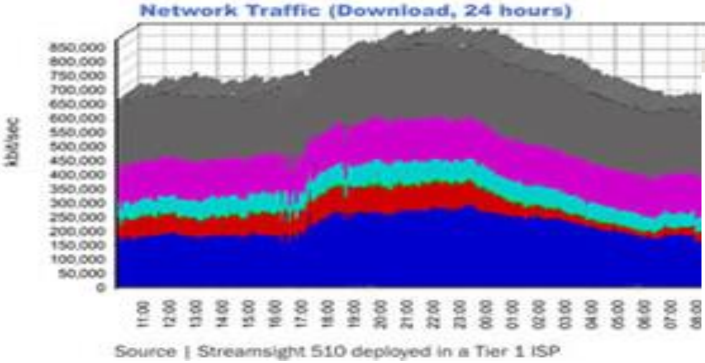
Why is (studying) BitTorrent important?



Source | Streamsight 510 deployed in a Tier 1 ISP

(From CacheLogic, 2004)

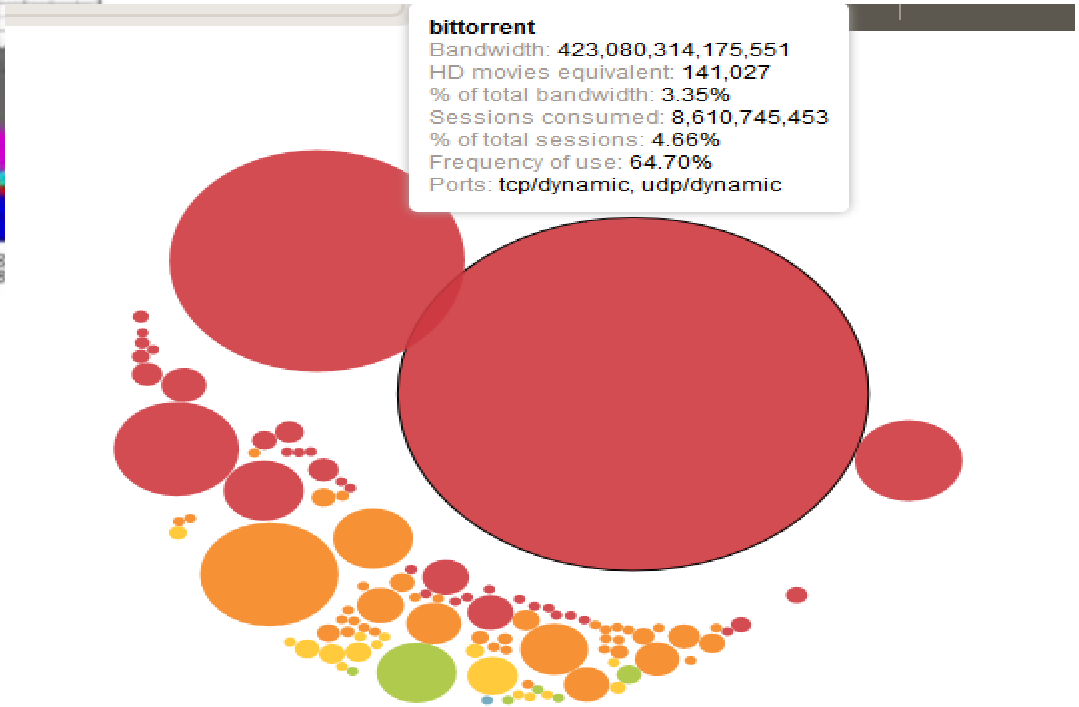
Why is (studying) BitTorrent important?



Network Traffic (Download, 24 hours)

Source | Streamsight 510 deployed in a Tier 1 ISP

(From CacheLogic, 2004)



bittorrent
Bandwidth: 423,080,314,175,551
HD movies equivalent: 141,027
% of total bandwidth: 3.35%
Sessions consumed: 8,610,745,453
% of total sessions: 4.66%
Frequency of use: 64.70%
Ports: tcp/dynamic, udp/dynamic

(From PaloAltoNetworks.com, 2013)

Why is (studying) BitTorrent important?

- BitTorrent consumes significant amount of internet traffic today
  - In 2004, BitTorrent accounted for 30% of all internet traffic (Total P2P was 60%), according to CacheLogic
  - Slightly lower share in 2005 (possibly because of legal action), but still significant
  - BT always used for legal software (linux iso) distribution too
  - Recently: legal media downloads (Fox)

Questions about BT

- 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?

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.

BitTorrent links

- Hivatalos oldal
  - http://bittorrent.com
- FAQ
  - http://www.dessent.net/btfaq/#what
- Torrent-ek
  - http://www.suprnova.org/
    - 2004 végén bezárták
  - http://isohunt.com/
    - 159.000 tracker, 6.8 millió aktív torrent, 161 millió fájl, 12.2 PB adat, 25.8 millió peer

Pirate parties

Pirate Party is a label adopted by political parties in different countries.

Pirate parties support

- civil rights,
- direct democracy and participation in government,
- reform of copyright and patent law,
- free sharing of knowledge (open content),
- information privacy,
- transparency,
- freedom of information,
- anti-corruption
- Internet neutrality
- 7.1% at the Swedish EU elections

The Pirate Bay

- http://thepiratebay.org
- Az egyik legnépszerűbb weboldal a neten
  - 2003 novemberében indult
- 2006. május 31-én a svéd rendőrség lefoglalja a szervereket, 3 napig offline a weboldal
- A per
  - 2009. április 17-én a szolgáltatás működtetőit (Peter Sunde, Fredrik Neij, Gottfrid Svartholm és Carl Lundström) 1 év börtönre és 30 millió SEK (~ 700 millió HUF) büntetésre ítélik
  - Fellebbezés, a bírót elfogultsággal vádolják
- > 25 millió peer (2008 nov.)
- 4 millió regisztrált (2009 dec.) felhasználó
  - A letöltéshez nem kell regisztrálni, csak a kommentekhez és a feltöltéshez