BitTorrent – from swarms to collectives

Some on-going research in the tribler team at TU Delft

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TU Delft

Tribler team: 35 + collaborators

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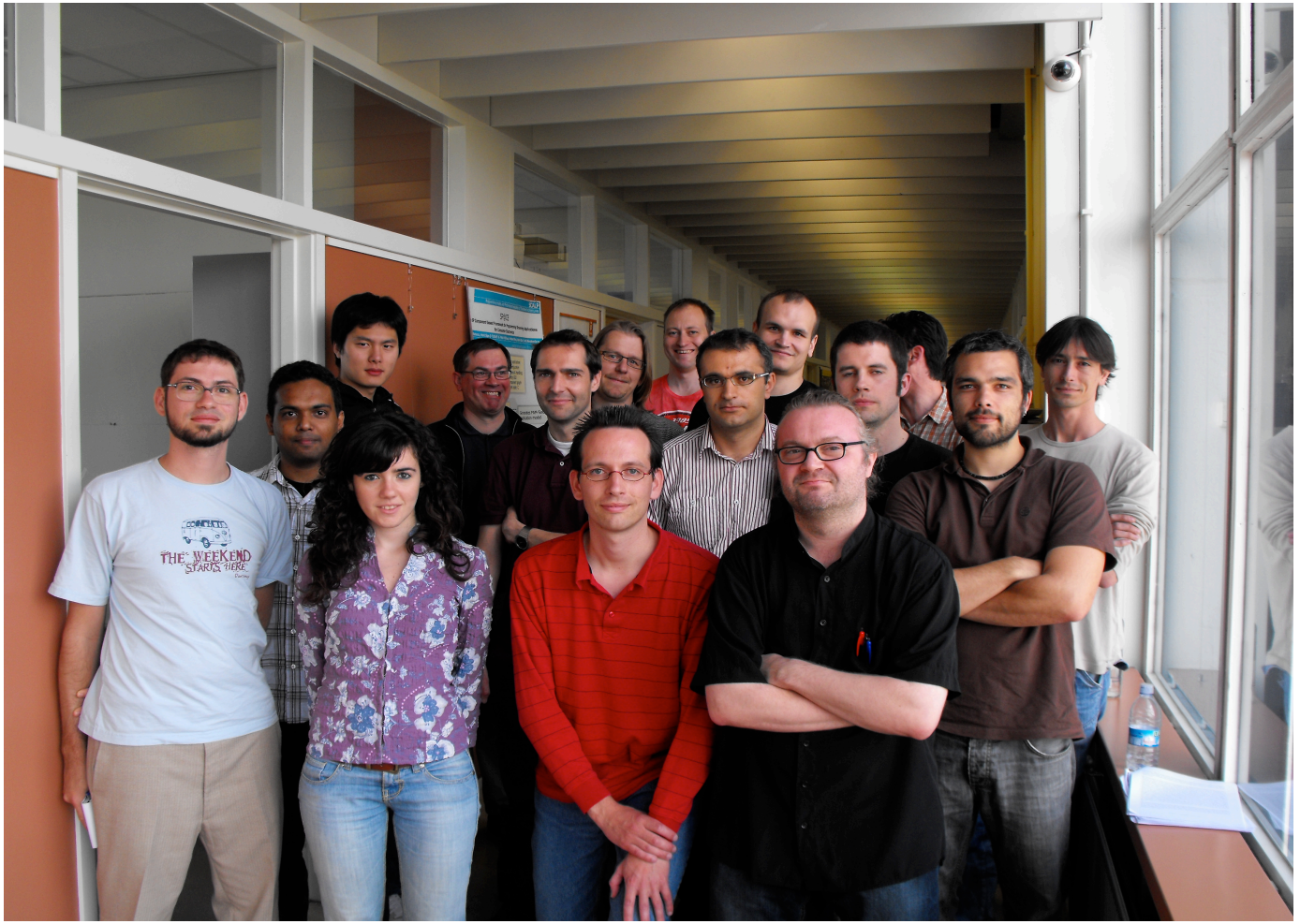
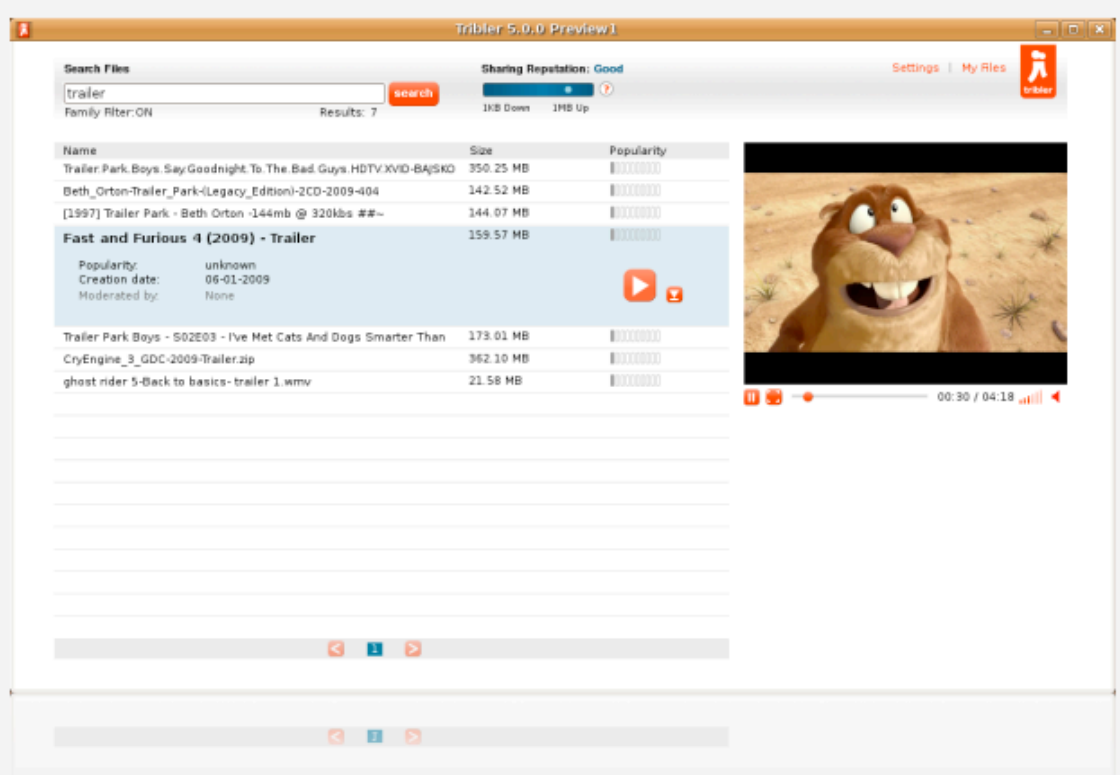


Tribler BitTorrent Client



Tribler 5.1

We aim to show just how easy file-sharing can be. Due to our simplified search box you can find your files without the need for a website.

- Most easy to use
- Integrated search box
- Video-on-demand support
- Fully distributed

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Talk Overview

- What is BitTorrent and specifically and Peer-to-Peer (P2P) systems in general?
- Axelrod and tit-for-tat experiment
- From swarms to communities: BitCrunch

What is BitTorrent

- BitTorrent is a Peer-to-Peer (P2P) file sharing protocol
- It lets users connect together to share any data they want to
- It self-organises and scales allowing millions of users to share files easily
- Current powerful economic actors don’t like it due to piracy
- But what is a P2P system in general?

What are Peer-to-Peer Systems?

P2P systems *are* socio-economic systems

- Peers cooperate collectively to achieve their goals
- No peer in the system controls everything
- Performance results from interactions
- At the end-of-day users (people) are in control
- P2P designers confront socio-economic issues

Individualism v. Collectivism

In socio-economic systems individual interests may conflict with collective interests:

- e.g. over exploitation of a common resource (a river, a field, the atmosphere etc.)
- e.g. banks - lending (to those who they know can not repay) to gain a commission by selling on the debt to other banks
- e.g. P2P file sharing system - downloading more than uploading

Individualism v. Collectivism

Consider a P2P file sharing system:

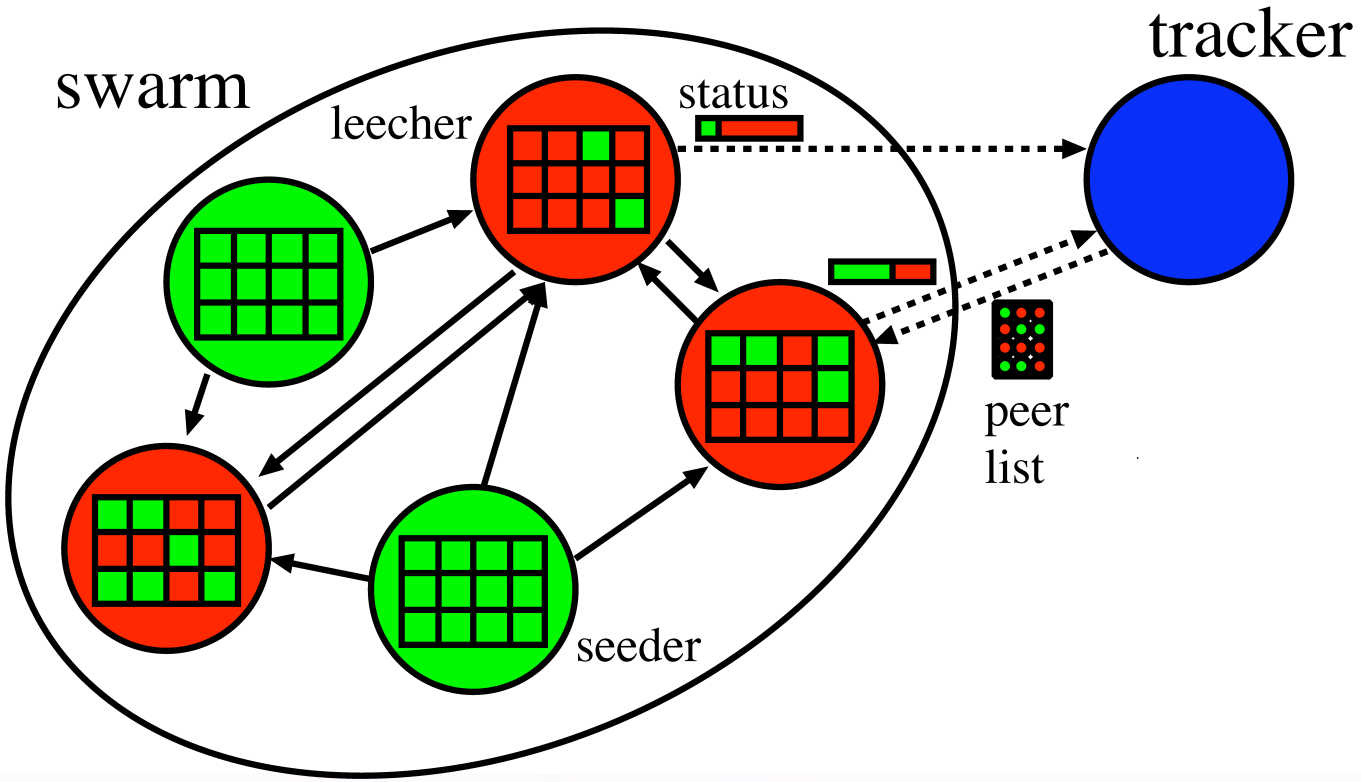
- It is in the *collective interest* for all to upload to others so everyone gets the file quickly
- But it is in the *individual interest* to save bandwidth by only downloading and hence free-riding on others
- Free-riding (or free-loading) is a perennial problem in P2P file-sharing systems
- Any efficient system needs to tackle it in some way

Some BitTorrent Terminology

- Swarm: set of peers interested in a file
  - file is split in smaller chunks called pieces
  - seeder: holds a full copy of the data
  - leecher: holds only a part of the data (initially nothing)
- Tracker: centralized manager
  - keep track of all peers in the swarm
  - return list of current peers in swarm
- Torrent file: meta-data
  - contains pointer to tracker hosting the swarm
  - details about the file - hash, no. of pieces, size etc.

BitTorrent Protocol

- Get a list of other peers in the swarm from the tracker
- Ask peers their list of pieces and tell them what is yours
- Exchange pieces with appropriate peers



How to avoid the commons tragedy?

Central enforcement of correct behaviour

- require centralised agencies and policing
- ability to identify and track individuals centrally
- not suitable for pure P2P (but see: private trackers)

Decentralised methods

- self-policing producing incentives for cooperation
- do not require centralised coordination
- more suitable for pure P2P
- can apply ideas from early complexity science results (Robert Axelrod: Iterated Prisoner's Dilemma Tournament)

Robert Axelrod's Tournament - programs as strategies

Axelrod organised an open IPD tournament:

- Academics were asked to submit programs (BASIC or FORTRAN) that would play the IPD against each other
- Nobody knew competitors code
- The only input would be the on-going past history of the game (a string of C's and D's)
- The aim was to get the highest score (utility) based on round-robin playoffs between all pairs of programs
- Axelrod's aim was to see which programs did best against all the others and understand why
- He wrote-up his results in the famous book "the evolution of cooperation"

Axlerod's Tournament - what happened?

Basic results were:

- many strategies were submitted (complex and simple)
- the one with the highest overall score turned out to be simple: *tit-for-tat* (TFT) or "look back"
- starts playing C, then "looked back" at the last move made by opponent and copied that move
- submitted by Psychologist Anatol Rapoport
- didn't "win" against each strategy but did better overall on average against all strategies
- TFT mechanism an example of "*reciprocal altruism*" (Robert Trivers)

What has this got to do with BitTorrent?

In the *BitTorrent protocol*:

- TFT-like method used for sharing files
- nodes form groups interested in a particular file (swarms) and swap or “barter” pieces with each other
- if a node does not upload data then this can be compared to playing defection
- it is punished in the future by being “choked” - not getting upload from others
- even if you hack your client to be selfish the chances are the standard TFT-like protocol will do better overall
- *Bram Cohen* - original BT designer - inspired by Axelrod’s tournaments

The Global Ecology of BitTorrent Clients

Many *bittorrent clients* exist in "the wild"

- Bittorrent 6 (from Bittorrent.com, formally utorrent)
- Others: Azureus, ABC, Transmission, many others...
- Tribler (of course)
- bad guy clients: BitThief, BitTyrant

Hence:

- The current bittorrent ecosystem is a ***global on-going experiment***, like Axelrod's, but with huge user base and rich interactions (not just TFT) incredible strategy sophistication
- This is unprecedented and could lead to new economic theory - in general!

Take home message

- Previous complexity work (Axelrod's IPD) has provided a basis for protocol design in a P2P system
- Deployed variants of the protocol are creating a massive global economic experiment
- Measurements can be made and these could inform new theory and new protocols

From swarms to collectives

Communities have formed around BitTorrent Trackers

Quite a few of these:

ONE BIG TORRENT .ORG

DutchReverge

jamendo
open your ears

bt.etree.org

Demonoid.com

ISOHUNT

TVTORRENTS.COM

The Pirate Bay

BITSOUP

Linux tracker

muslim torrents

TorrentPortal

indietorrents

Public Trackers (e.g. PirateBay)

- BitTorrent uses Trackers to index swarms
- Public trackers let anyone join or create a swarm
- Sharing within a swarm is incentivised via a form of tit-for-tat (as we have seen)
- However there is no incentive for:
  - Seeding (uploading after file is downloaded)
  - Capping (creating and injecting a new file)
  - Maintaining a Tracker in the first instance

Private Trackers (Many)

- Private Trackers have emerged more recently
- Only allow registered users to join swarms
- May track upload / download of each user
- Some keep centralised accounts for each user
  - When users download much more than upload they may be kicked out
  - Many different schemes: ratio, credits, points etc
- Some rely on users to just be nice with various “gentleman's club” methods

A little detail on credit systems

- We will give a little detail on credit systems in private BT communities
- Give a flavour of how economic / collective issues are becoming significant
- Present results from a simple (agent-based) model and some measurements of a real private tracker

Private Trackers - Credit

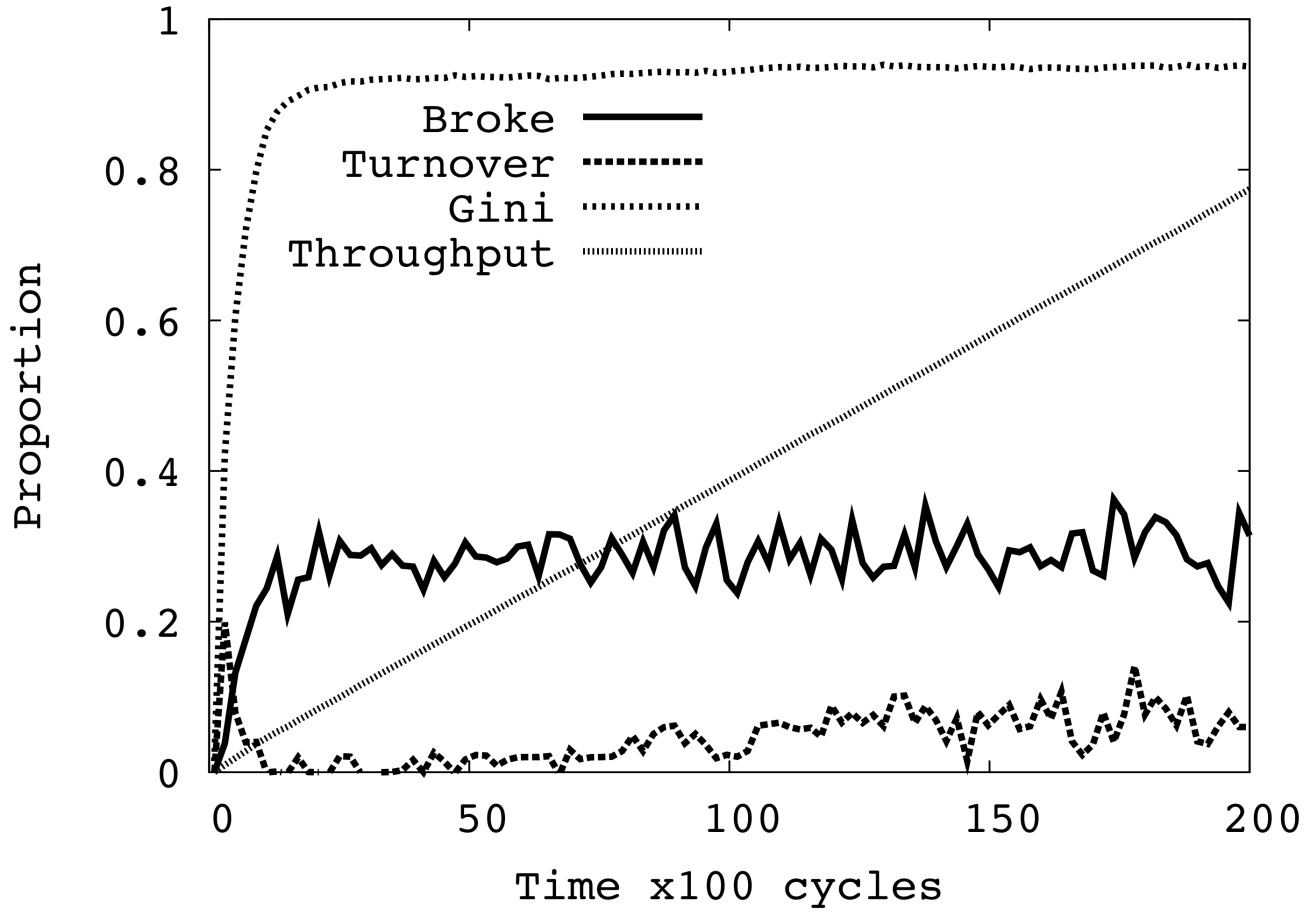
- Consider a scheme based on credits
  - Uploading 1MB earns one credit
  - Downloading 1MB costs one credit
  - A user with no credits can’t download
- Users must be given some initial credit
- In fixed size pop. total credit remains constant
- Similar to a fixed supply of money in an economy (loose analogy!)

Private Trackers - Credit

- How much credit should be put into the system?
- How would it effect the efficiency of the system?
- When do credit squeezes occur?
- How can they be avoided?

We define a credit squeeze as a situation in which, due to lack of credit, the efficiency of the system is significantly reduced.

Time series of simple model



Some aggregate results

C	T	β	G	φ
1	0.56	0.39	0.90	0.82
10	0.71	0.32	0.93	0.44
100	0.77	0.29	0.94	0.06
100++	0.97	0.01	0.71	0.00

C = initial credit
T = total throughput = total number of units uploaded as proportion of maximum possible (infinite credit)
B = proportion of nodes that are “broke” (zero credit)
G = Gini measure (simple measure of inequality of credit)
Phi = turnover of top 10% of peers ranked by credit (credit mobility)
100++ indicates initial credit of 100 with 1.5 credit seeding bonus

Observations from simulations

- Even when all peers are equal and are good guys performance of the system may be inhibited by credit shortages
- Adding extra capacity to the system, in the form of upload and download, can *actually reduce* the performance
- By injecting new credit into the system in the form of a “seeding bonus” a credit squeeze can be ameliorated

Statistics from a Private Tracker

Day	T	Δ	Δ_0	δ	S/L
1	48	24	17	0.23	26
2	40	20	15	0.25	26
3	50	25	12	0.16	25
4	67	33.5	17	0.17	25
5	52	26	19	0.24	25
6	46	23	15	0.21	25
7	87	43.5	17	0.13	25
Ave.	56	28	16	0.19	25

Approx. 50,000 peers per day, 10,000 swarms,
access to credit balances of top 10%

T = throughput in TB over all swarms
Delta = total credit increase that day in the entire system
Delta0 = total credit increase for top 10% of peers
Delta = minimum fraction of credit increase that goes to top 10% of peers
S/L = seeder to leecher ratio over all swarms

Statistics from a Private Tracker

- Indicates “rich getting richer” since top 10% are getting a lot of the new credit
- High Seeder / Leecher ratio suggestive that a credit squeeze is happening for many
- But need more information to verify this
- Would be interesting to see what happened to throughput if there was a “free day” or seeding bonus was increased

Take home message

- Communities formed around trackers provide an on-going global socio-economic experiment
- Self-organisation of socio-economic structures in measurable forms
- Ideas, models and theories from complexity science may inform and learn from this
  - Cultural group selection, Indirect reciprocity, Altruistic Punishment etc.
- Such communities so strong don't be surprised if they start influencing the "real world" (e.g. the PirateParty)

On-going work in Tribler team

- Community measurements and studies, including qualitative - Nazareno Andrade et al
- Alternative economic incentive models, incl. Participatory Econ.- Rameez Rahman et al
- Distributed credit systems, including currency-type approaches – Michel Meulpolder et al
- Self-organising locality for increased performance - Maciej Wojciechowski et al
- Many many others…

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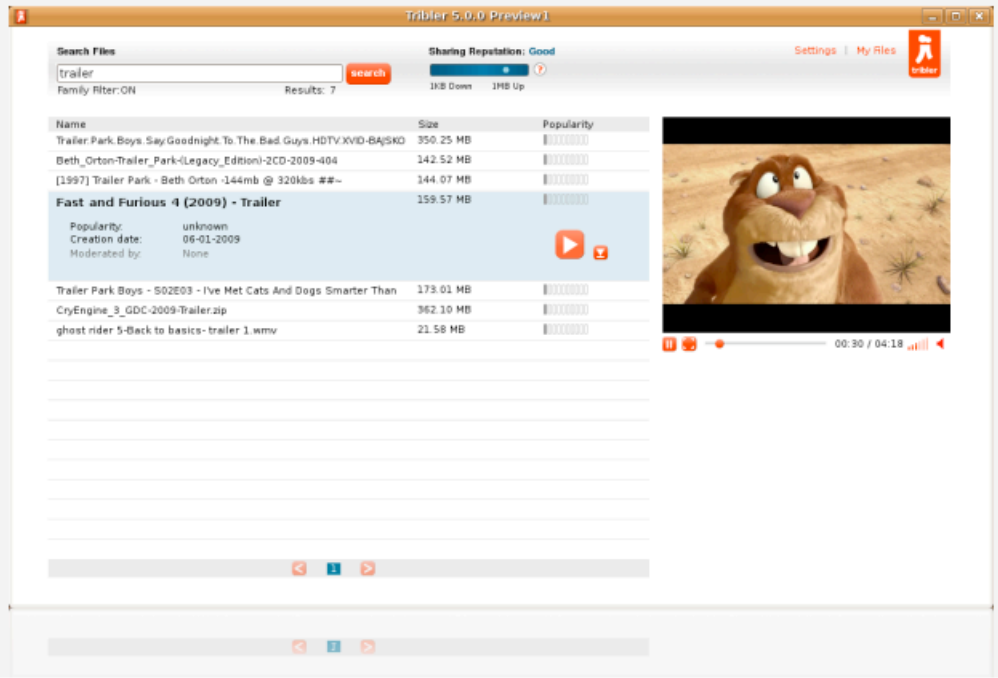

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