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BitTorrent and fountain codes: friends or foes?

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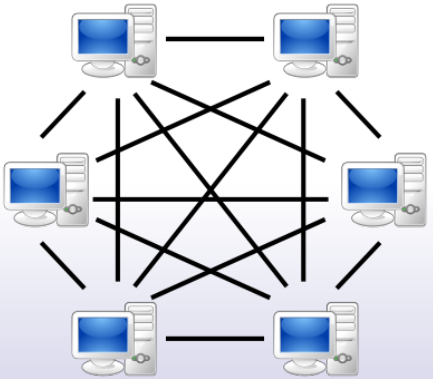
Peer to peer and file sharing applications



Peer to peer paradigm has a huge diffusion nowadays [1]

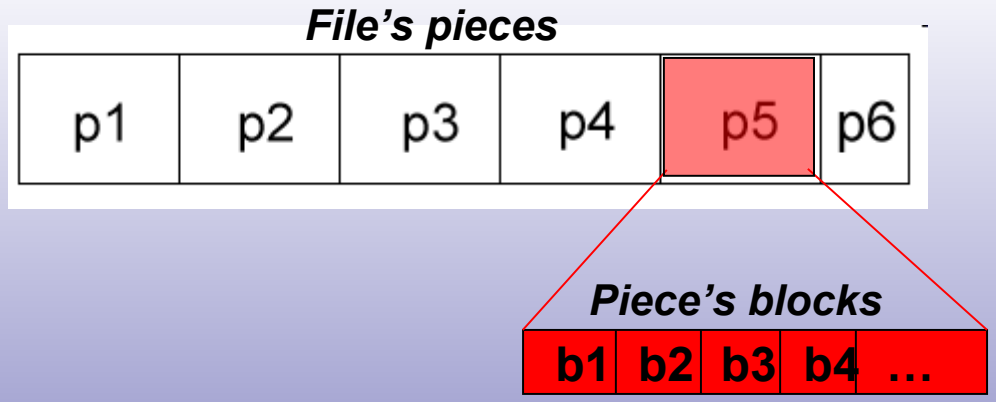
It can be employed for a lot of different applications:

- **File sharing**: BitTorrent [2][3] , eDonkey, eMule, DC++
- **Video Streaming** : SopCast, PPLive, PPStream
- **Distribuited portals:** Osiris
- **Others**: Skype, Sciencenet, Spotify

BitTorrent is doubtless the reference architecture for file sharing

BitTorrent protocol 1

BitTorrent adopts a **multi-part** download **scheme**:



- The file is divided into **pieces**, each piece into **blocks.**
- Peers are **synchronized** between them **at piece level.**
- Each client knows what pieces have been **completely downloaded** from his neighbors.
- Peers exchange between them piece's blocks

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BitTorrent protocol 2: rarest first and tit for tat

Main **BitTorrent**'s strategies:

- **Tit-for-Tat**: assures reciprocity between downloading and uploading rates.

- **Rarest first**: assures a fair distribution of file's pieces
  Note that only complete pieces can be shared and distributed

Many research works claim that BitTorrent has **near-optimal** performance [4] [5] [6]

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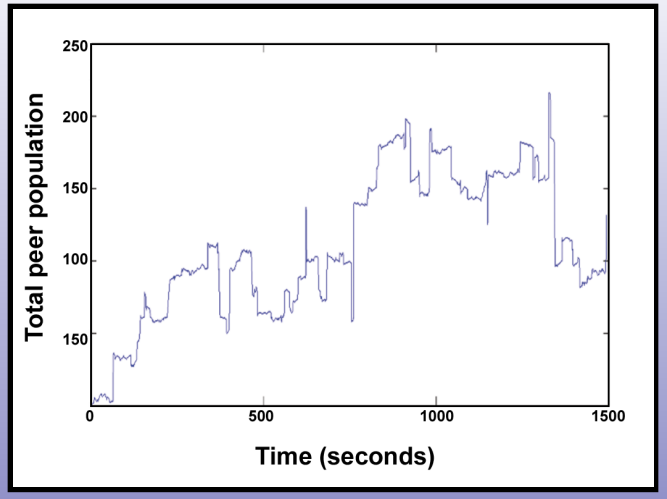
Flash crowd, high churn rates

Some phenomena can **cripple** BitTorrent performance:



Example of simulated population's dynamics in a network affected by flash crowd and high Churn rates.

- **Flash crowd**: many peer join or leave the network at the same time
- **High churn rates**: peers join and leave the network at high rates
- Many peer **leave** the overlay network **at the same time**

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Modifying BitTorrent protocol 1: Luby-transform codes

LT codes [7][8] are a class a *fountain codes* that use simple XOR operations to encode and decode the message. The decoding process has a certain overhead **ε :** the recipient needs to receive a number of packets that exceed in percentage the original size of the message by a certain amount.

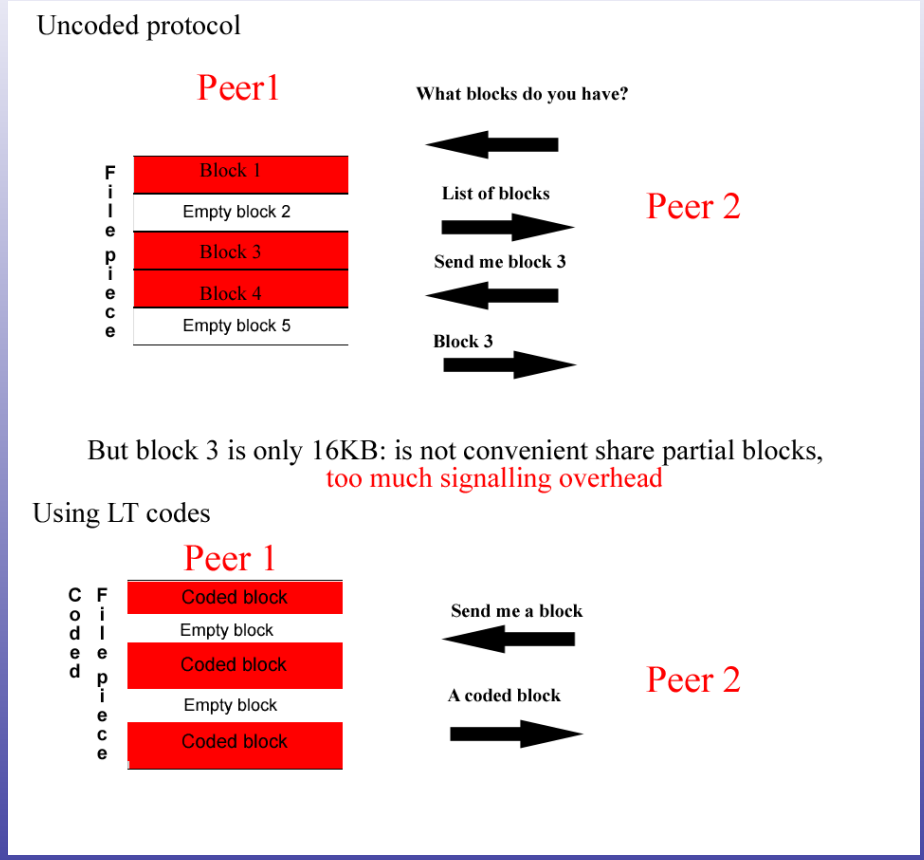
If **k** is the original number of non coded blocks, the decoding process succeeds when **k**(1+ **ε**) packets are received.

Benefits

- Avoid **content reconciliation**
- A peer can share **partially downloaded** file parts
- File parts can be download **concurrently** from different peers

Drawbacks

- Decoding **overhead**
- Encoder/decoder complexity



Coded blocks can be sended without content reconciliation

Modifying BitTorrent protocol 2: Rarest first on partial pieces GPS simulator

Summary of protocol modifications:

- Use **LT codes** to code file's pieces. The file's piece subdivision is different in accordance with the requirements of encoding. The decoding overhead is about 10%
- Share **partial** file's piece
- A piece can be downloaded from **more peers at same time** without content reconciliation
- The protocol requests first **the rarest complete piece**. If there are not complete pieces available, a peer requests the **rarest partial piece**
- If a piece is fully decoded a peer sends **new coded blocks**

We use **General purpose simulator GPS**[9] simulator in order to test our modified protocol

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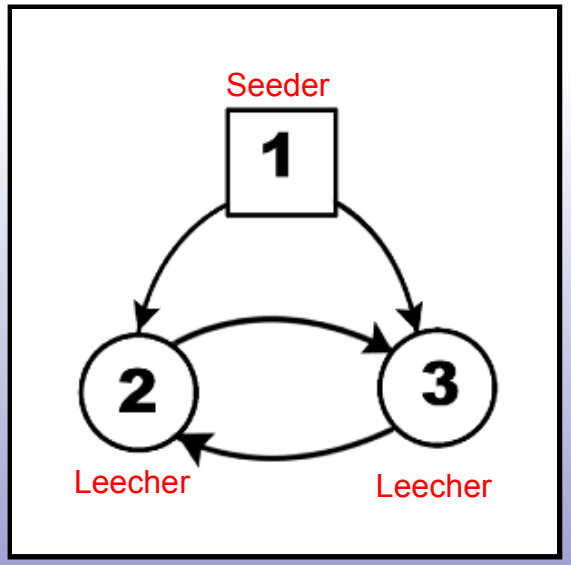
Experimental results: simple three peer topology



A simple topology with a seeder and two leechers

DOWNLOADING TIMES AND ACHIEVABLE BITRATE OBSERVED ON A SIMPLE TOPOLOGY OF THREE PEERS.

File size	BTd [1]	LTd [2]	BTb[1]	LTb[2]	Gain (%)
1 MBytes	38s	35s	210Kbps	228Kbps	8%
2 MBytes	50s	48s	320Kbps	333Kbps	4%
4 MBytes	77s	75s	415Kbps	426Kbps	2.6%

[1] the columns **BTd** and **BTb** show respectively the download times and achievable bitrate of the standart BitTorrent protocol
[2] the columns **LTd** and **LTb** show respectively the download times and achievable bitrate of the modified protocol that use the LT codes

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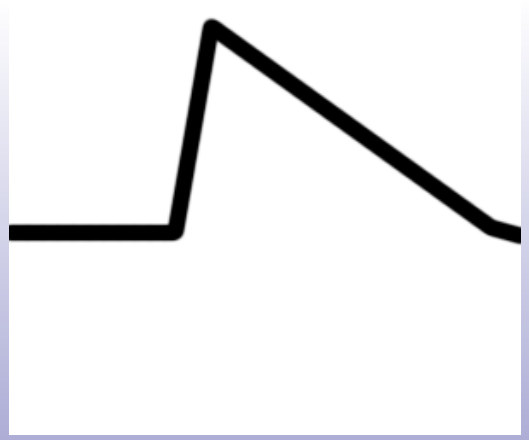
Experimental results: single flash crowd scenario



Single flash crowd scenario set up:

- Time **0**: a flash crowd of 50 peers occurs
- Time **50**: 20 random selected peers leave the network, regardless of the state of the download

DOWNLOADING TIMES AND ACHIEVABLE BITRATE OBSERVED IN A SINGLE FLASH CROWD SCENARIO.

File size	PS[1]	BTd[2]	LTd[3]	BTb[2]	LTb[3]	Gain
1 MByte	S	53.1s	18.1s	151 Kbps	441 Kbps	66%
1 MByte	M	23.9s	17.1s	334 Kbps	467 Kbps	26%

[1] the file subdivision, single (**S**) or multiple (**M**) pieces
[2] the columns **BTd** and **BTb** show respectively the download times and achievable bitrate of the standart BitTorrent protocol
[3] the columns **LTd** and **LTb** show respectively the download times and achievable bitrate of the modified protocol that use the LT codes

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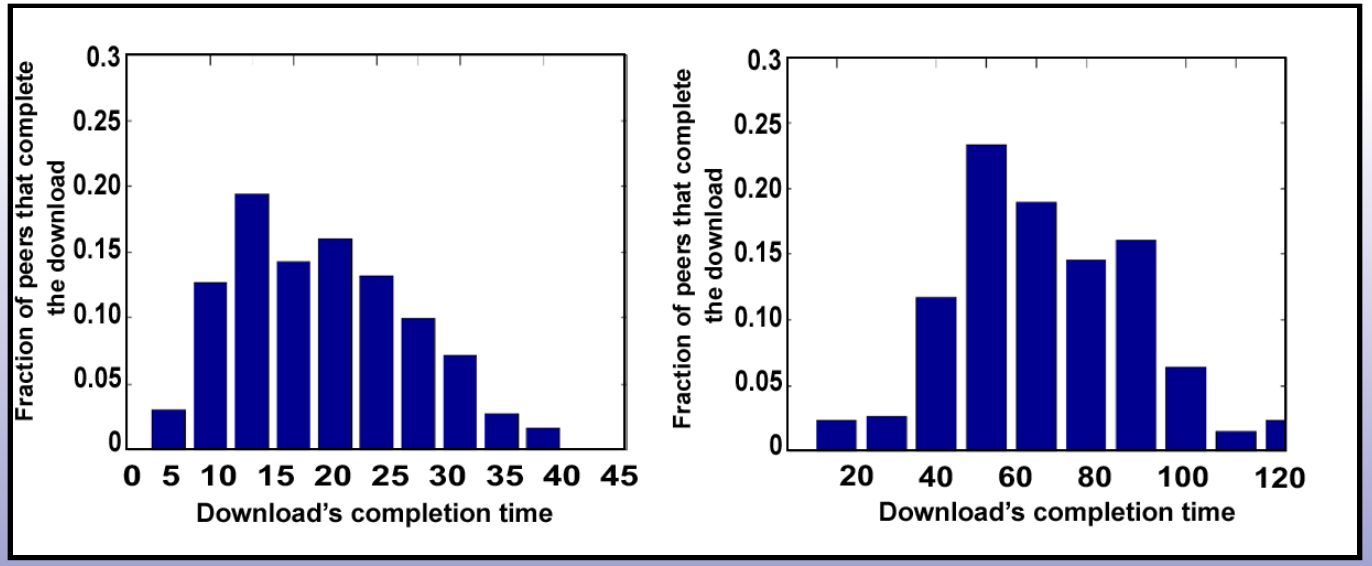
Experimental results: downloading times distribution



Comparison of downloading time distributions between original protocol and the modified one

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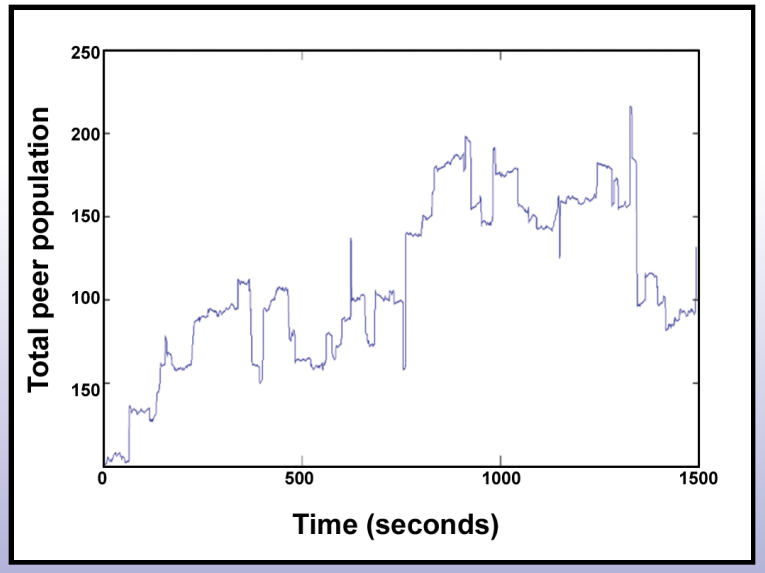
Experimental results: a more complex scenario 1



Example of simulated population's dynamics in a network affected by flash crowd and high Churn rates.

During the simulation multiple flash crowd and massive departure of peer occur

DOWNLOADING TIMES AND ACHIEVABLE BITRATE OBSERVED IN A SCENARIO AFFECTED BY MULTIPLE FLASH CRWOD AND MASSIVE DEPARTURE OF PEERS.

File size	BTd[1]	LTd[2]	BTb[1]	LTb[2]	Gain
4 MBytes	65 s	56 s	492 Kbps	571 Kbps	14%
8 MBytes	145 s	129 s	441 Kbps	496 Kbps	12%

[1] the columns **BTd** and **BTb** show respectively the download times and achievable bitrate of the standart BitTorrent protocol
[2] the columns **LTd** and **LTb** show respectively the download times and achievable bitrate of the modified protocol that use the LT codes

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Conclusions

In this paper we proposed a novel modifications of the **BitTorrent protocol** by introducing the **LT encoding** Then we proved by simulations that better performance can be achieved considering **file of small size** and in **adverse network conditions**. In such situation our proposed protocol yields a gain that is above the 10% in all simulated scenarios, in spite of the decoding overhead that the LT codes introduce.

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Thank you for your kind attention

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[2] http://www.bittorrent.com/

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[4] A. Legout, G. Urvoy-Keller, P. Michiardi, *Understanding bittorrent: An experimental perspective. Technical report*, CNRS : FRE2660 EURECOM

[5] A. Legout, G. Urvoy-Keller, P. Michiardi, *Rarest First and Choke Algorithms Are Enough*, IMC '06: Proceedings of the 6th ACM SIGCOMM conference on Internet measurement, Rio de Janeriro, Brazil, 2006.

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