Changing the Unchoking Policy for an Enhnaced *BitTorrent*

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April 25, 2016

Problem Statement

Given:

1. An uploading peer *A* that receives data requests from ν downloaders under a *BitTorrent* swarm.
2. Peer *A* should upload to only *four* downloaders at a time:
   - *Three* regular unchoked peers;
     selected under regular unchoking tit-for-tat schema.
   - *One* optimistic unchoked peer;
     selected under optimistic unchoking schema, **at random**.

We modify:

- The “unbiased” **random** selection of original BT.

Which downloader should be selected optimistic unchoked?

BitTorrent

Statistics

- *BitTorrent* has 150 million active users in 2012 [BT]
- Accounts for 27%-57% of internet traffic in Europe, according to [IPQ]

pre-*BitTorrent* era

- Napster, Gnutella and Fast-Track were used for transferring large multimedia files before *BitTorrent*.
- BT's predecessors were using centralized indexing methods
- BT's predecessors were lacking a tit-for-tat schema among peers.

BitTorrent

Decentralized Nature

- Peers play a dual role by being both a server and/or a client at times.
- No central authority point.
- A tit-for-tat schema is implemented locally in peers.

Operation

- *BitTorrent* operates at there different layers:
  1. At the *swarm layer:* a peer contacts a tracker to receive a list of other peers to connect to.
  2. At the *neighborhood layer:* the core reciprocation mechanism is implemented.
  3. At the *data layer:* a file is viewed as a concatenation of fixed-size data pieces.

Unchoking Policy

We modify the neighborhood selection mechanism, known as peer unchoking [Coh. 03]; Peer unchoking includes:

- **Regular Unchoking**: implements a tit-for-tat schema that allocates bandwidth preferably to peers sending data (top-3 uploaders).
- **Optimistic Unchoking**: an additional peers is kept unchoked regardless of its contribution (a random peer).

Question:

- How an uploader should allocate its optimistic unchoke intervals to downloaders to enhance the cooperation of peers?

Optimistic Unchoking Policy

Why Optimistic Unchoking?

- Guarantees that new peers have a chance of downloading one first piece without having sent any.
- Randomly connect to new peers (reach better uploaders??).

Original BT [Coh. 03]

- The original optimistic unchoking policy uses a round-robin approach.

Enhanced BT [Atlid. 12]

- Modify round-robin selection of native BT.
- Rotate optimistic unchoked peer in a prioritized way.
- Yielding the right-of-way to peers with few clients interested in downloading from them. (**why?**)

Enhanced BT Messages

Peer Messages

- For our enhanced BT we use messages of the original BT.
- We augment the **have** *state-oriented* message with an additional value.
- The latter corresponds to the number of *interested* connection of the sender.

Enhanced BT Messages

The messages in use can be categorized into:

1. *swarm oriented*
2. *state oriented*
3. *data oriented*

Swarm Oriented

join
join_response
peerset
peerset_response
leave

State Oriented

(un)choke
(un)interested
have ← *modify*
bitfield
handshake

Data Oriented

request
piece
cancel

Ratio of Interest

We define the *ratio of interest* of a peer p: $\mathbf{RI_p} = \frac{\mathbf{int_p}}{\mathbf{act_p}}$

- int_p is the number of "interested" connections peer p maintains
- act_p is the number of active connections peer p maintains (usually fixed to 40)
- Any peer p receives data request only via connections marked as interested.

Ratio of Interest

We use the *Ratio of interest RI* as a measure of peers' uploading utilization:

- Peers with a low ratio of interest:
  - Receive few data requests.
  - Are likely to be underutilized and/or idle.
  - Should be selected optimistic unchoked.

Algorithms

- Algorithms 1 and 2 implement our Enhanced Unchoking policy; leech state and seed state, respectively.
- Algorithms are invoked:
  1. every 10 seconds.
  2. every time a peer disconnects from local client.
  3. when an unchoked peer becomes (un)interested;
- When Algorithms invoked, a new round starts; a round ranges from 1 to 3.

Every first round set the peer with $Min\{RI_p\}$ optimistic unchoked.

Evaluation

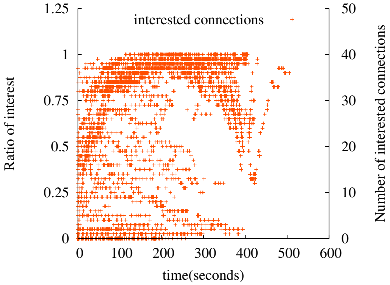
Experimental Setup

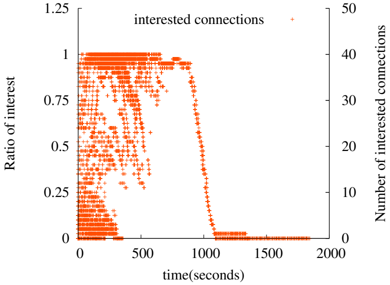
- Use 40 workstations (1 *GHz* clock, 1 *GB* M.M.).
- Local Ethernet network.
- 150 peers: 15 seeders, 135 leechers.
- Distribution of an 700 *MB* file.

Experimental Objectives

- Compare the quality of peer inter-connections.
- Examine pieces uploaded from leechers and seeders.
- Ascertain altruism perented by enhanced BT leechers.

Ratio of Interest





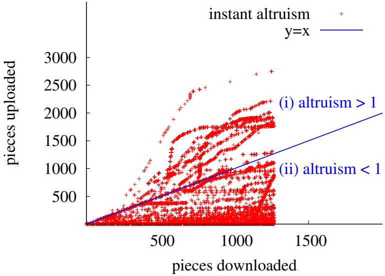
Enhanced BT

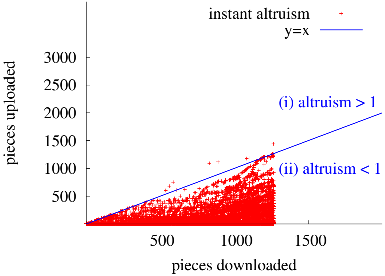
- Average ratio of interest: 0.30 per peer.
- High coverage of samples near Max value.
- All peers act as intermediaries (downloading and uploading).
- The *ratio of interest* is uniformly decreased.

Native BT

- Average *ratio of interest*: 0.22 per peer.
- More underutilized peers with low *ratio of interest*.
- Ratio of interest asymptotically reaches zero when the majority complete downloading.
- Idle peers experience a severely increased downloading time.

Uploading Contribution – Altruism





$$\textbf{Altruism} = \frac{\textbf{pieces up}}{\textbf{pieces down}}$$

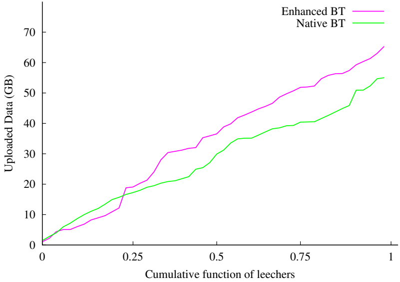
Enhanced BT

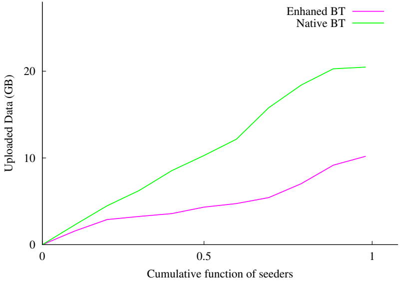
- A non-negligible number of peers clustered into area **(i)**.
- “Altruistic” leechers upload more than $2,500$ pieces.
- Leechers in the area **(i)** act **more as uploaders** than downloaders.
- Provide swarm with additional uploading capacity.

Native BT

- Only a handful of peers in area **(i)**.
- Leechers upload at most $1,300$ pieces.

Aggregate Uploading Contribution





Leechers

- **Altruistic** enhanced BT leechers uploaded 70*GB*.
- Native BT leechers uploaded 60*GB*

Seeders

- **Decongested** BT seeders uploaded 10*GB*.
- Native BT seeders uploaded 20*GB*.

Conclusions–Future Work

Conclusions

- Enhanced BT displays a higher number of directly-connected and interested-in-cooperation peers.
- Creating altruistic leechers who act more as uploaders than downloaders.
- More peers act as data intermediaries, relieve the burden of seeders.

Future work

- Experimentation in PlanetLab [PL].
- Present a mathematical model that captures performance improvement under our approach.

Related Work

Analytical Models

- Downloading time, effectiveness: [Qiu 04].
- Heterogeneous Users: [Alix 09], [Liao 07].
- Game theoretic analysis: [Rah. 11].

Unchoking Policy

- Reciprocation/Incentive compatibility: [Men. 10], [Pia. 07].
- Free riding: [Sir. 07], [Ju. 05], [Shin 09], [Pet. 09].

Related Work

Differences from prior work

- The very first to modify *optimistic policy*.
- No complex incentive policy is suggested.cd
- Treat underutilized peers as nodes that lack data to upload.
- Locate idle peers and reward them with “bonus” *optimistic unchoking slots*.

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Appendix - Algorithm 1

Algorithm 1 peer unchoking algorithm for client in *leech* state

Input: Uploaders, Downloaders, $RI_{p \in Downloaders}$

$Interested \leftarrow \{p : \forall p \in Downloaders\ AND\ p\ interested\ in\ local\ client\}$
if $round = 1$ **then**
    OU $\leftarrow \{p : Min\{RI_p\} \forall p \in Interested\}$
    unchoke OU
end if
RU $\leftarrow \{p : p \in Top3\ Uploaders\}$
for $p \in Interested$ **do**
    if $p \in RU$ **then**
        unchoke p
    else
        choke p
    end if
end for
if $OU \subseteq RU$ **then**
    repeat
        choose $p \in Downloaders$
        unchoke p
    until $p \in Interested$
end if

Appendix - Algorithm 2

Algorithm 2 peer unchoking algorithm for client in *seed* state

Input: $Downloaders$, $RI_{p \in Downloaders}$

$temp1 \leftarrow \{p : \forall p \in Downloaders\ AND\ has\ pending\ requests\ OR\ recently\ unchoked\}$
sort $temp1$ according to last unchoke time
$temp2 \leftarrow \{p : \forall p \in Downloaders\ AND\ p \notin temp1\}$
sort $temp2$ according to downloading rate
if $round = 1, 2$ **then**
    $RU \leftarrow \{p_{i=1,2,3} \in temp1 + temp2\}$
    $OU \leftarrow \{p : Min\{RI_p\} \forall p \in temp1 + temp2\}$
    unchoke OU
else
    $RU \leftarrow \{p_{i=1,2,3,4} \in temp1 + temp2\}$
end if
for $p \in D$ **do**
    if $p \in RU$ **then**
        unchoke p
    else
        choke p
    end if
end for

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