Can identical BitTorrent peers experience different download times?

Fabrício Murai[1], Antonio Rocha[2],
Daniel Figueiredo[1], Edmundo de Souza e Silva[1]
1 COPPE/Computer and System Engineering Dept., Federal University of Rio de Janeiro, Brazil
2 Mathematics Dept., Rural Federal University of Rio de Janeiro, Brazil
E-mails:{fabricio, daniel, edmundo}@land.ufrj.br guto@ufrrj.br

Motivation

- Modeling BitTorrent (BT) has been an active topic of research due to its complexity and efficiency.
- Previous models predict identical peers (same upload capacity) will have identical performance. Our simulations and real experiments indicate that this is not always true.
- Consider a swarm formed by 1 seed and 5 leechers, all with **identical upload capacities** and unconstrained download capacities.

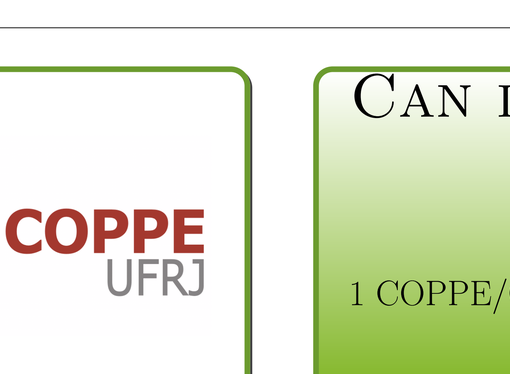

Figure 1: Evolution of the swarm size (arrival intervals: 10sec, 10min, 4min, 4min, 4min).

- Observations:
  - peers leave in the order they arrived (FIFO);
  - download times are similar.
- Now consider a **different arrival pattern**.

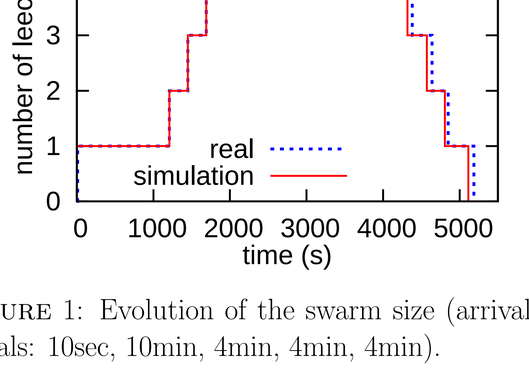

Figure 2: Evolution of the swarm size (arrival intervals: 10sec, 4min, 4min, 4min, 10min).

- Observations:
  - peers leave nearly at the same time (bursty departures);
  - **download times are very different.**

What is happening?

- Evolution of the # of downloaded pieces:

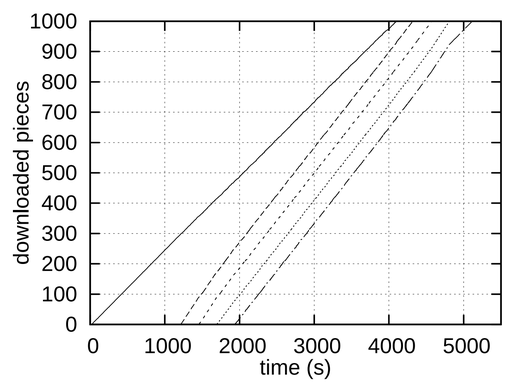

Figure 3: Evolution of the number of downloaded pieces (corresponding to Figure 1).

- Observations:
  - 1^{st} peer's download rate is constant and the smallest;
  - others have similar slope (download rate);
  - curves never meet.

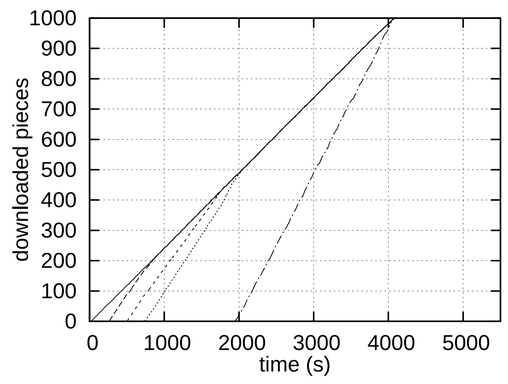

Figure 4: Evolution of the number of downloaded pieces (corresponding to Figure 2).

- Observations:
  - 1^{st} peer's slope is constant and the smallest;
  - others have similar slope (except by the 5^{th});
  - peers don't overtake the 1^{st}, they follow it;
  - there is **content synchronization**.

Consequences

- Consequences of different download rates are:
  1. **Variability in download times:** different download rates imply different download times;
  2. **Unfairness w/ respect to arrival order:** download times depend on arrival order, system is unfair;
  3. **Content Synchronization:** since 1^{st} peer downloads at a rate equal to seed's capacity, peers w/ the same # of pieces are synchronized;
  4. **Bursty departures:** peers leave the system within a small interval (relative to the time between arrivals).

Heterogeneity under Poisson arrivals

- Behavior doesn't require deterministic arrivals or crafted leecher arrival pattern.
- Experiment results depicted in Figures 5 and 6 show **bursty departures** and **variability in download times** ($c_s = c_l = 50$ kBps, $\lambda = 1/125$ leechers/sec, $S = 20$ MB):

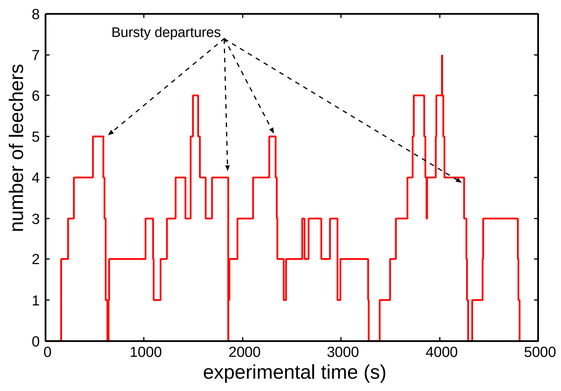

Figure 5: Evolution of swarm size.

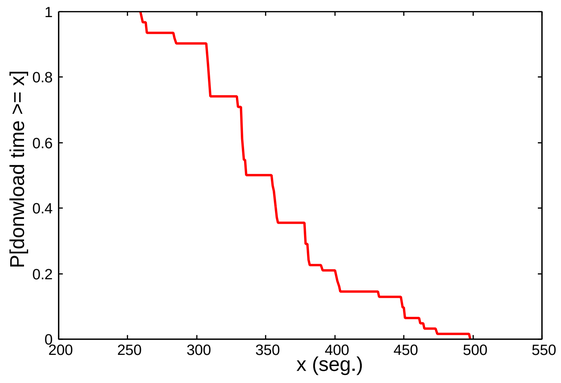

Figure 6: CCDF of download time (same experiment).

- Simulation results depicted in Figure 7 illustrate unfairness with respect to peer arrival order ($\lambda = 1/1000$ leechers/sec, $S = 256$ MB).

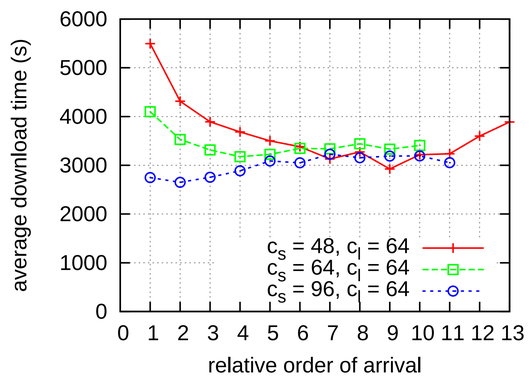

Figure 7: Average download time as a function of arrival order in a busy period.

The Model

- We developed a model to characterize this behavior and its consequences [MRFSeS11].
- **Fact:** younger peers download at faster rates.
- **Intuition:** younger peers have few pieces to offer to older ones.
- **Idea:** represent each peer as a set of bins containing the balls (pieces) interesting to each neighbor.
  - Assumption: small swarms, upload to all peers simultaneously;
  - Uplink capacity is shared by bins.

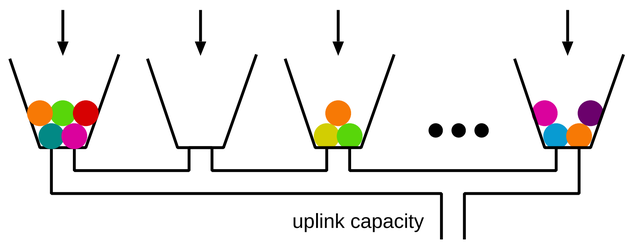

Figure 8: Leecher i represented as a set of bins (neighbors) containing balls (pieces).

- Seed upload rate: c_s/N
- Leecher upload rate depends on the pieces owned by each peer (complicated). We use only the number of pieces.

  Remark 1. *If $b_i > b_j$, then i has at least $b_i - bj$ interesting pieces to j.*

  Remark 2. *If $0 < b_i \leq b_j$, nothing can be said about the # of interesting pieces to j.*
- Assumption: If $b_i < b_j$, i has **no** pieces interesting to j; but, i may upload to j as long as i downloads from peers that have more pieces than j.
- Thus, the rate at which i could upload to j assuming no capacity constraints is:

$$g_{ij} = \begin{cases} c_s/N + \sum_{k|b_k>b_j} u_{ki} & \text{, if } b_i \leq b_j \\ \infty & \text{, otherwise.} \end{cases}$$

References

[MRFSeS11] F. Murai, A. Rocha, D. Figueiredo, and E. Souza e Silva. Heterogeneous download times in a homogeneous bittorrent swarm. In *IEEE IPDPS (submitted work)*, Anchorage (Alaska), USA, May 2011.