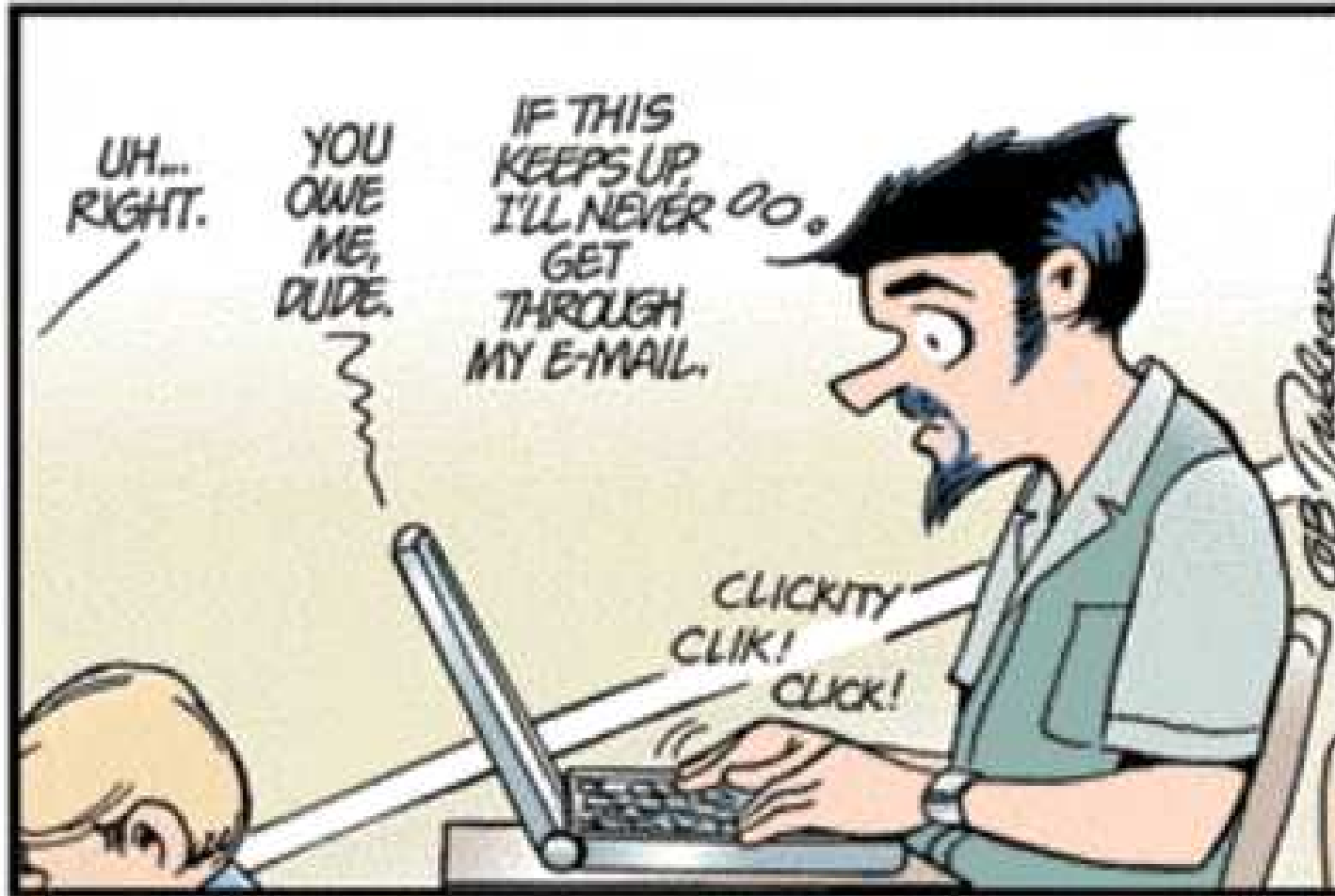


Lecture #4:

The P2P File-Sharing Game

Prof. Dr. Sven Seuken
5.3.2012

Laptops



Housekeeping

- Questions? Concerns?
- NB?
 - Ask questions visible to the class
 - Typos: please make comments visible to “instructors and TAs only”
- Homework assignments...

No Laptop Policy

- You are distracting yourself
- You are distracting me
- Most importantly: you are distracting the students around you!
- Discussion-based learning needs a social atmosphere
- No laptops → better learning experience!

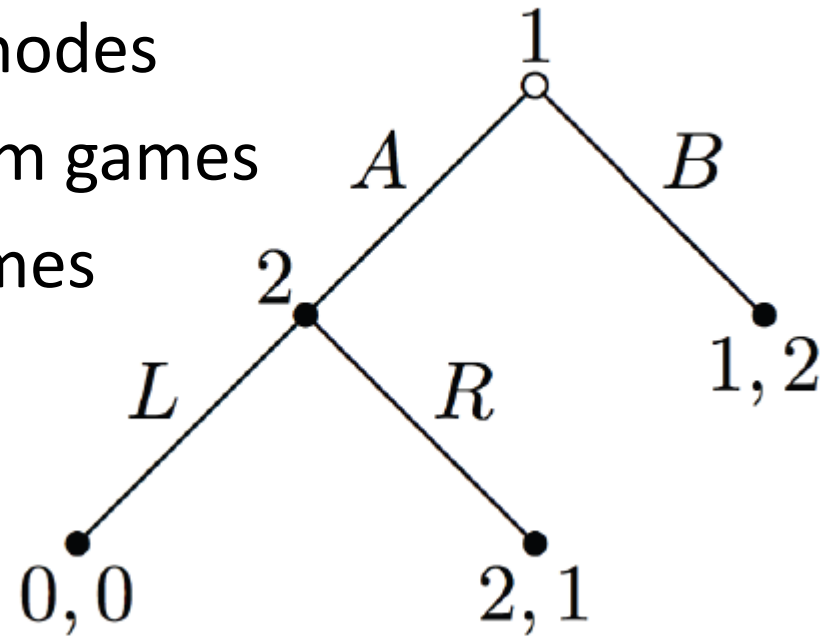
Outline

1. Recap of last lecture
2. Results of the Prisoner's Dilemma Tournament
3. Today's topic: The P2P File-Sharing Game
4. Discussion + Questions

Quick Recap (1/2)

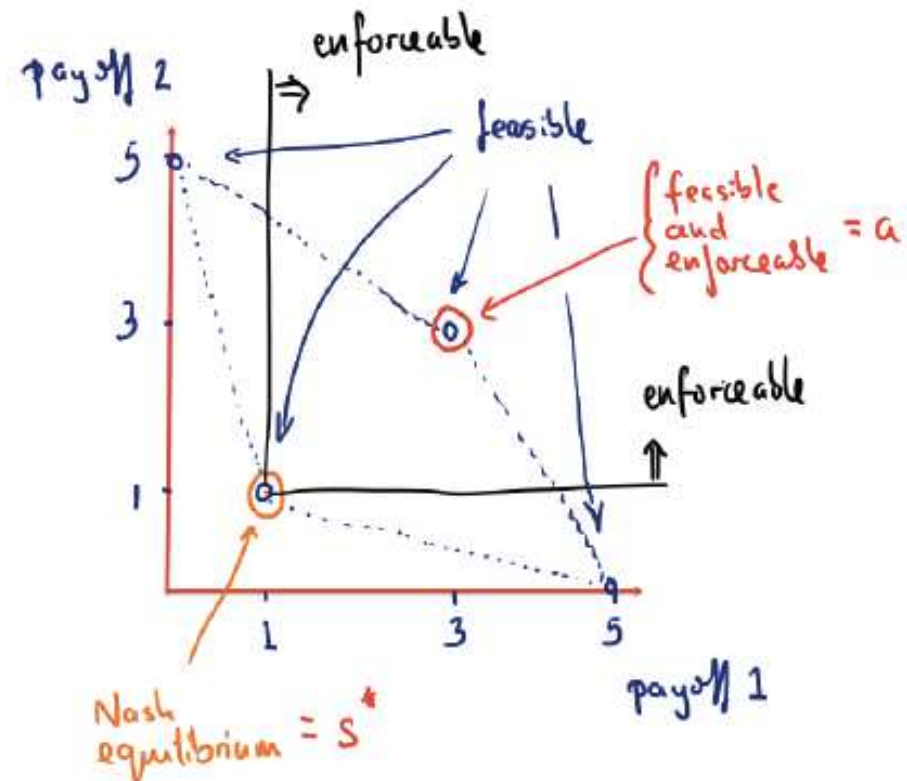
- Extensive form games:

- Tree notation, terminal nodes
- Strategy in extensive form games
- NE in extensive form games
- Incredible threats
- Subgames
- Subgame-perfect NE
- Principle of one deviation
- Backwards induction



Quick Recap (1/2)

- Repeated games:
 - Discounted sum
 - Folk Theorems
 - Feasible payoffs
 - Enforceable payoffs
 - Automaton Strategies
 - Open Loop Strategies



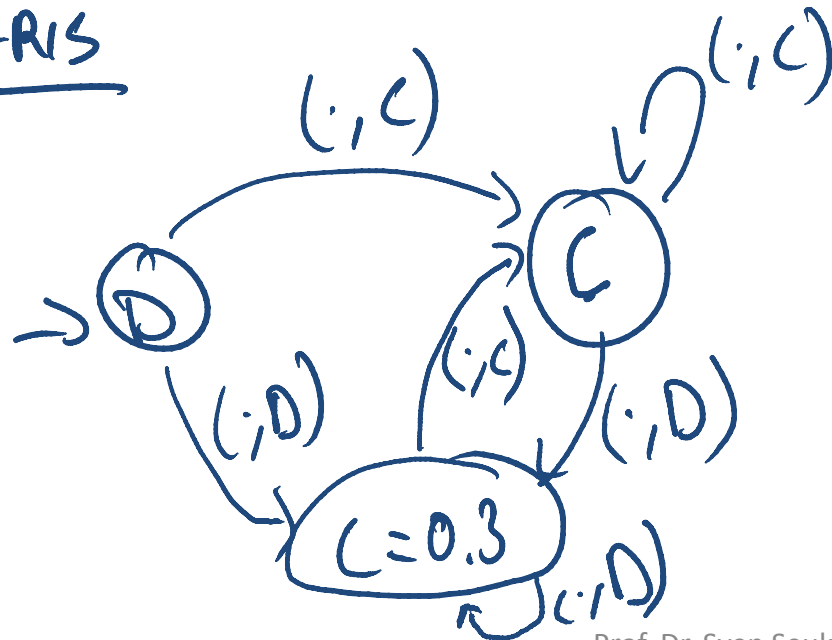
Results of the PD Tournament

	C	D
C	3,3	0,5
D	5,0	1,1

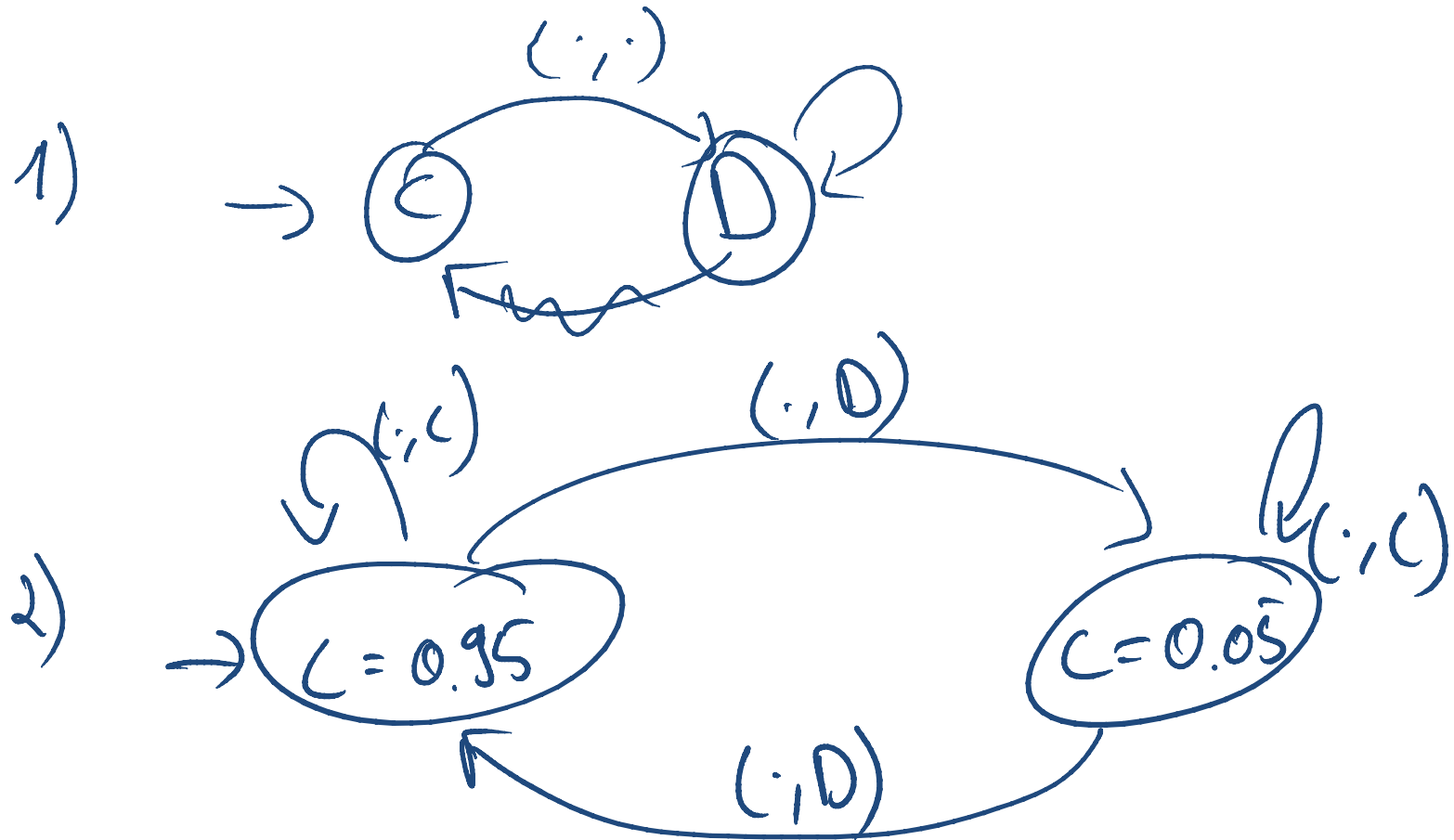
TFT:



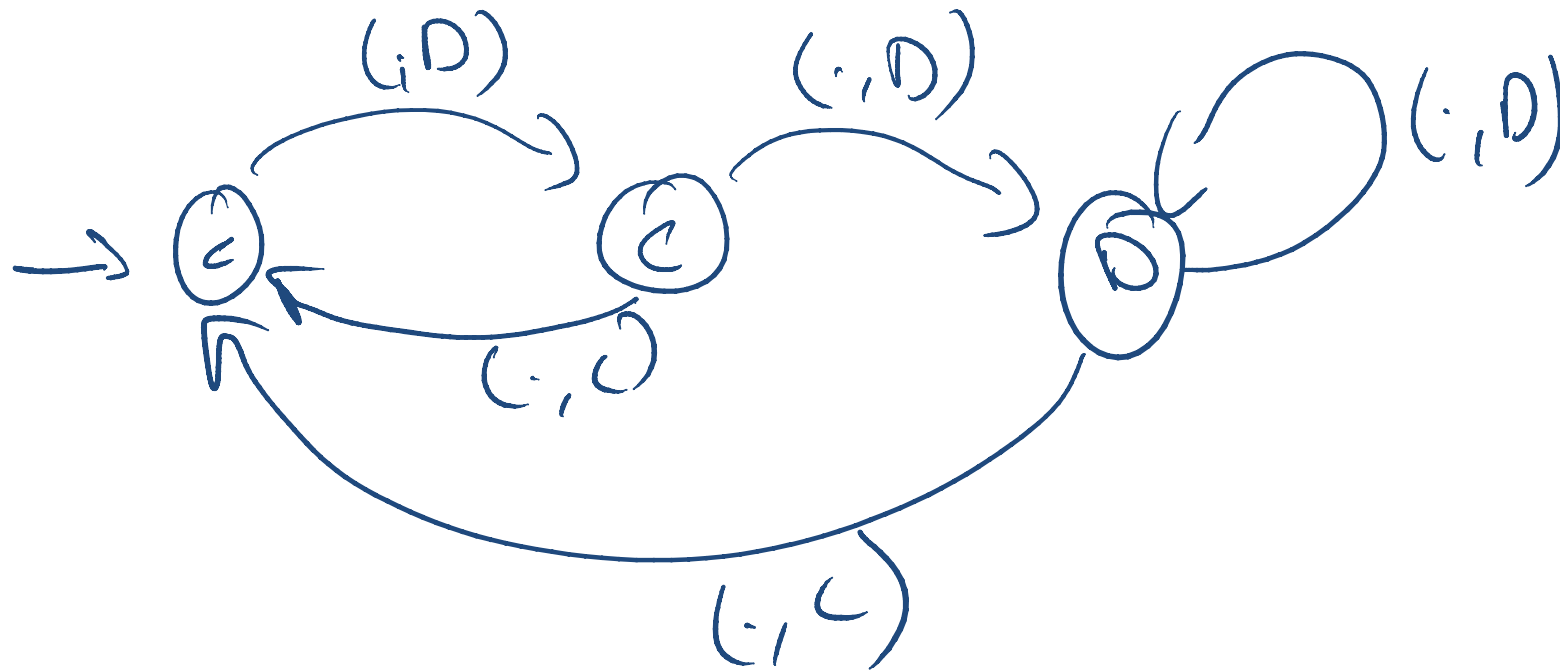
CHRIS



Worst Strategies



A very good strategy...



Today: The P2P File-Sharing Game

P2 File-Sharing Clients

- Who has ever used P2P file-sharing?
- What clients do you use?
- Why?

P2P File-Sharing Speed (1/2)

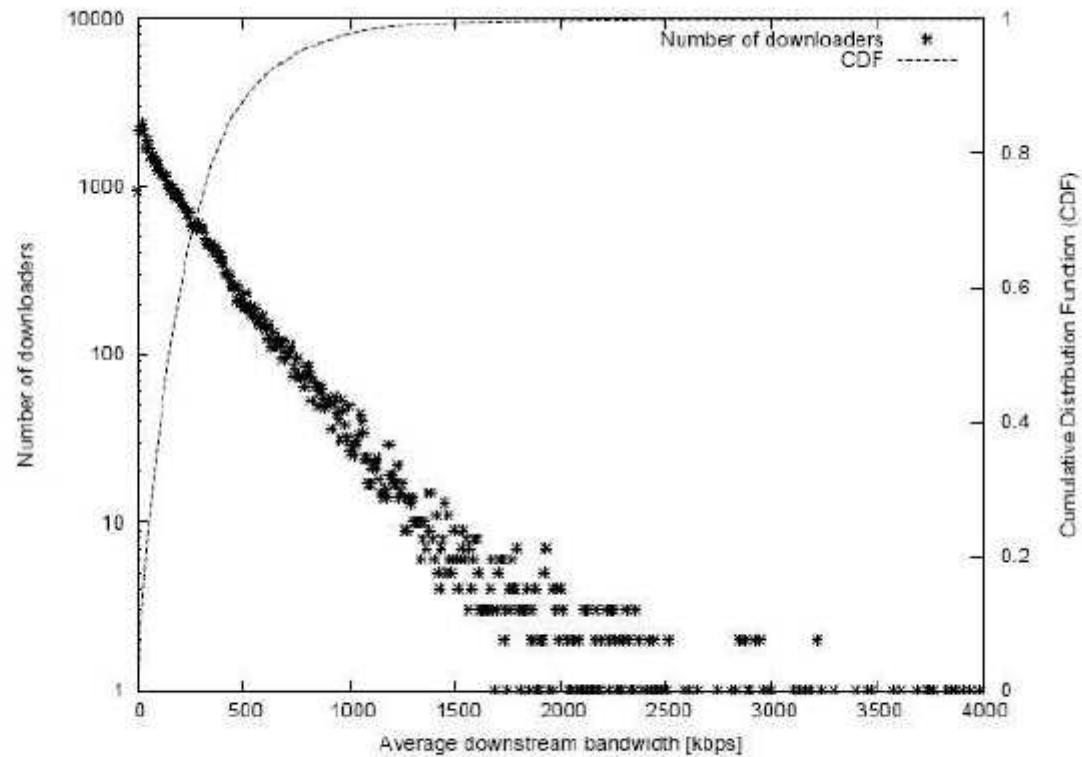
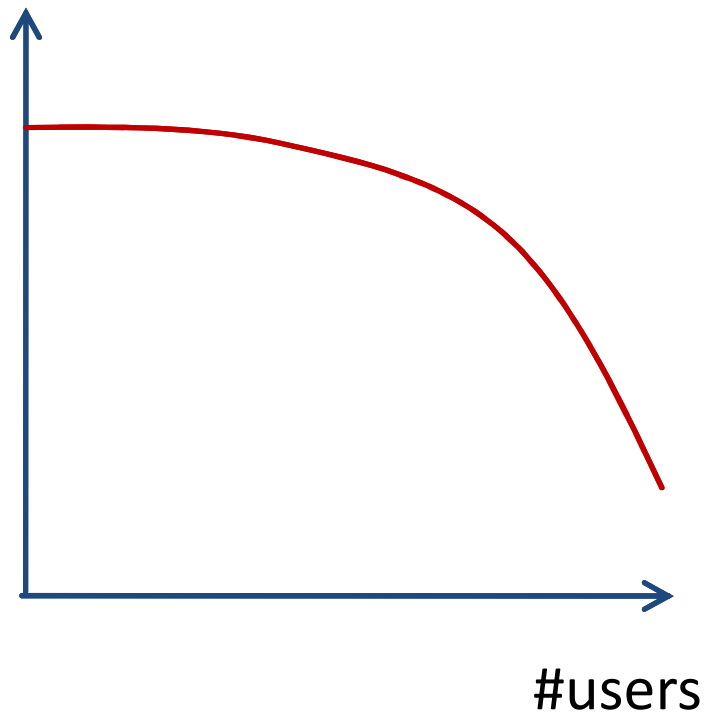


Figure 4.1: The average download speeds of a peer in BitTorrent (Pouwelse et al., 2004).

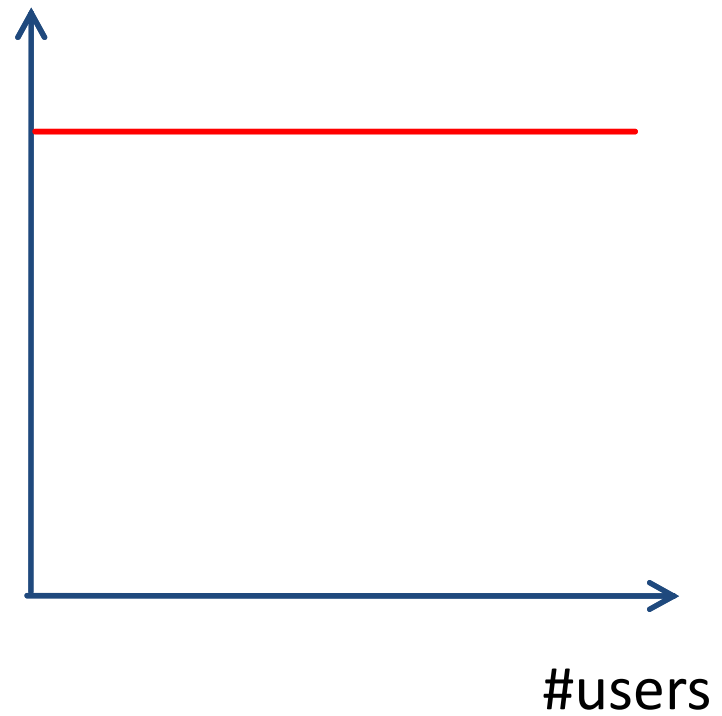
P2P File-Sharing Speed (2/2)

download rate



traditional

download rate



P2P

The Game – Design Goals

- The Game
 - Protocol
 - Reference clients
 - Other compatible clients
 - User behavior
- Design Goals
 - Social Welfare
 - Incentive Properties
 - Fairness Properties

Gnutella

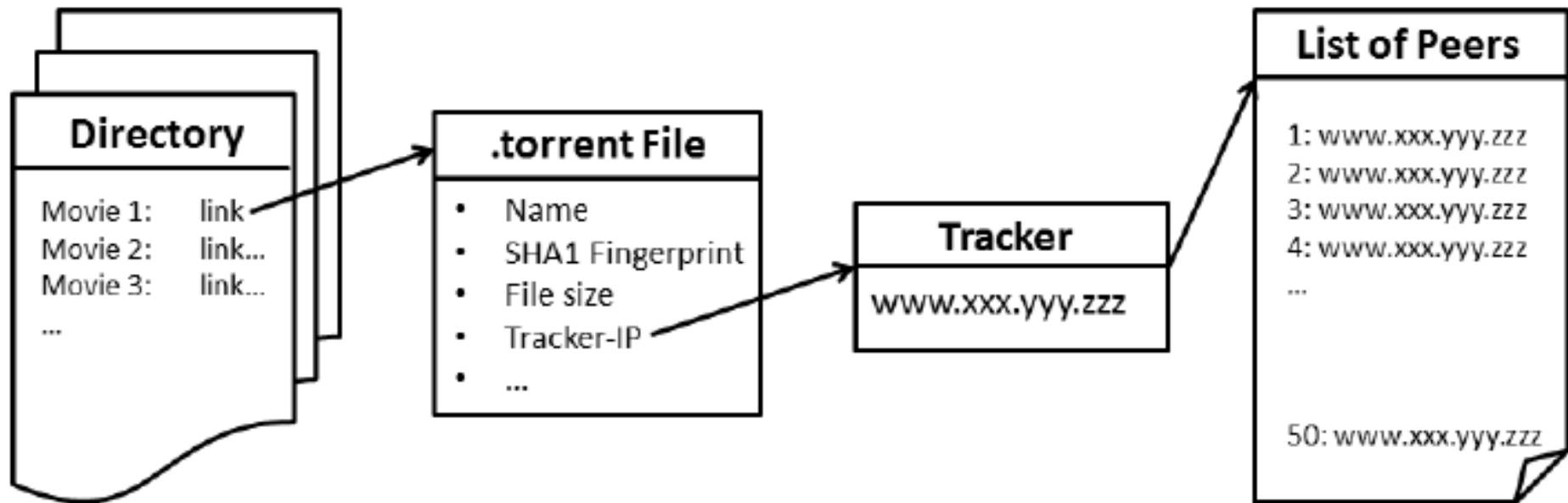
- What was the biggest problem of Gnutella?
- Why does the theory of repeated games not apply? [Q1]
- Why didn't the developers of Gnutella clients implement cooperation-enforcing mechanisms?

BitTorrent

- What was the main design difference between Gnutella and BitTorrent, with regard to the resulting incentives? [Q2]
- Repeated Games
- Tit-for-Tat

<http://boredzo.org/bittorrent-simulation/>

The BitTorrent Process



Uploading/Unchoking in BitTorrent

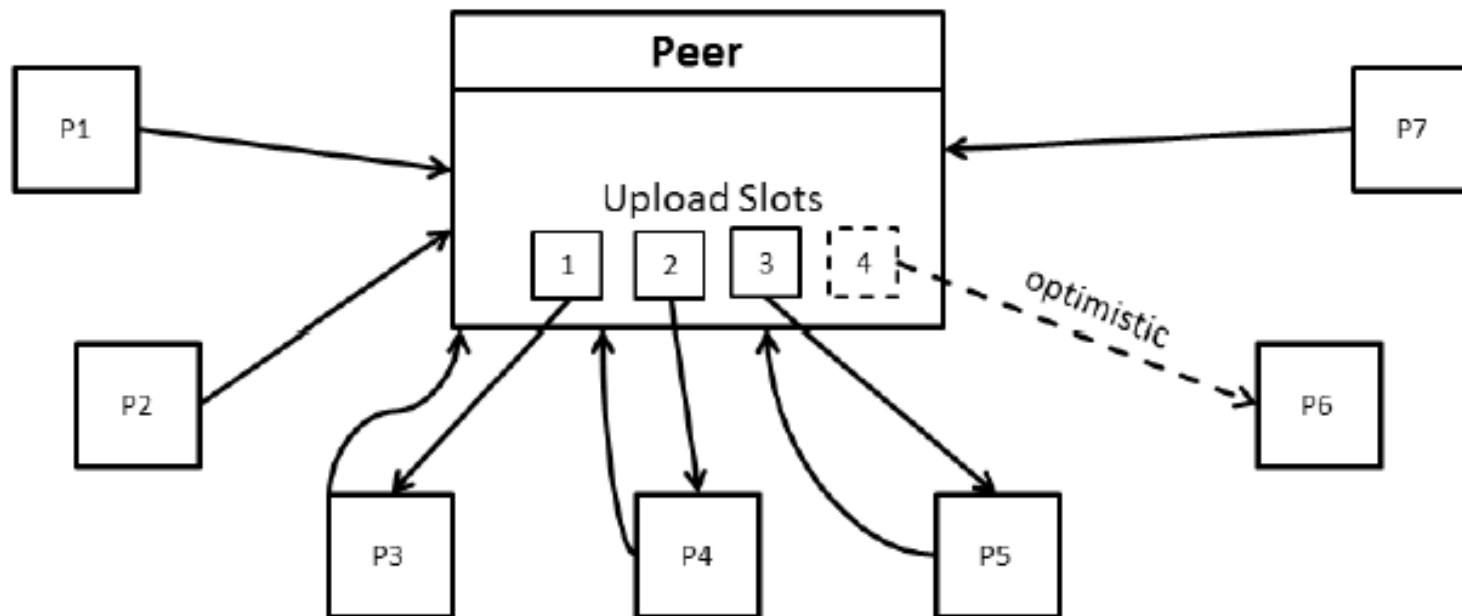


Figure 4.5: Upload and downloading in BitTorrent: the reference client has four upload slots. Three of those are allocated to those peers that reciprocate with the most bandwidth. The fourth one is allocated optimistically to a random peer, to explore the neighborhood.

Possible Attacks on BitTorrent

1. How often to contact the tracker to receive a list of peers?
2. Which pieces to reveal to which agent?
3. How many unchoking slots to use?
4. Which agent to unchoke?
5. How much upload speed to give to each unchoked agent?
6. What data to upload to each unchoked agent?

A List of Clients

- The reference client
- Vuze/Azureus, uTorrent, ...
- BitThief
- BitTyrant
- ...

BitThief

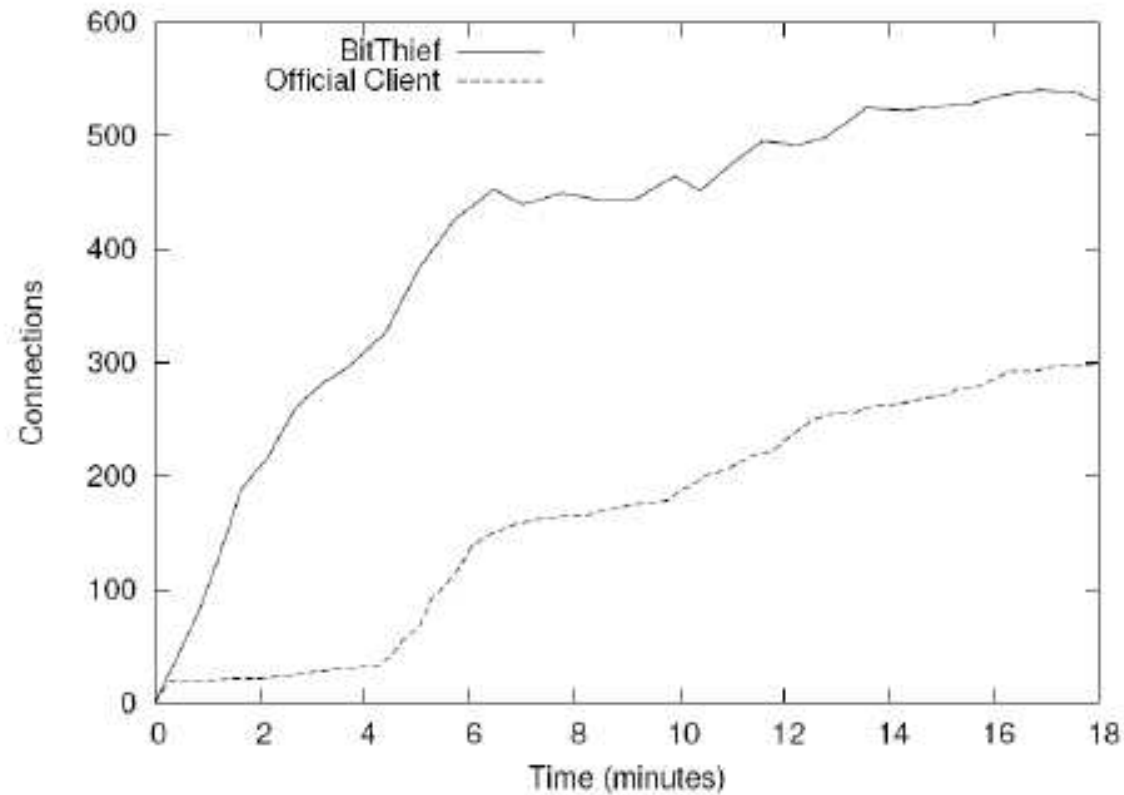


Figure 4.6: Number of open connections over time, comparing *BitThief* with the reference client. (Locher et al., 2006).

Strategic Piece Revelation (1/2)

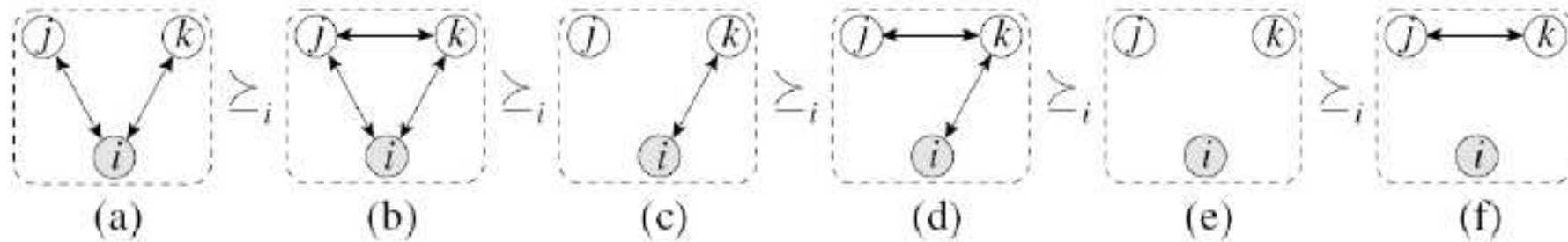


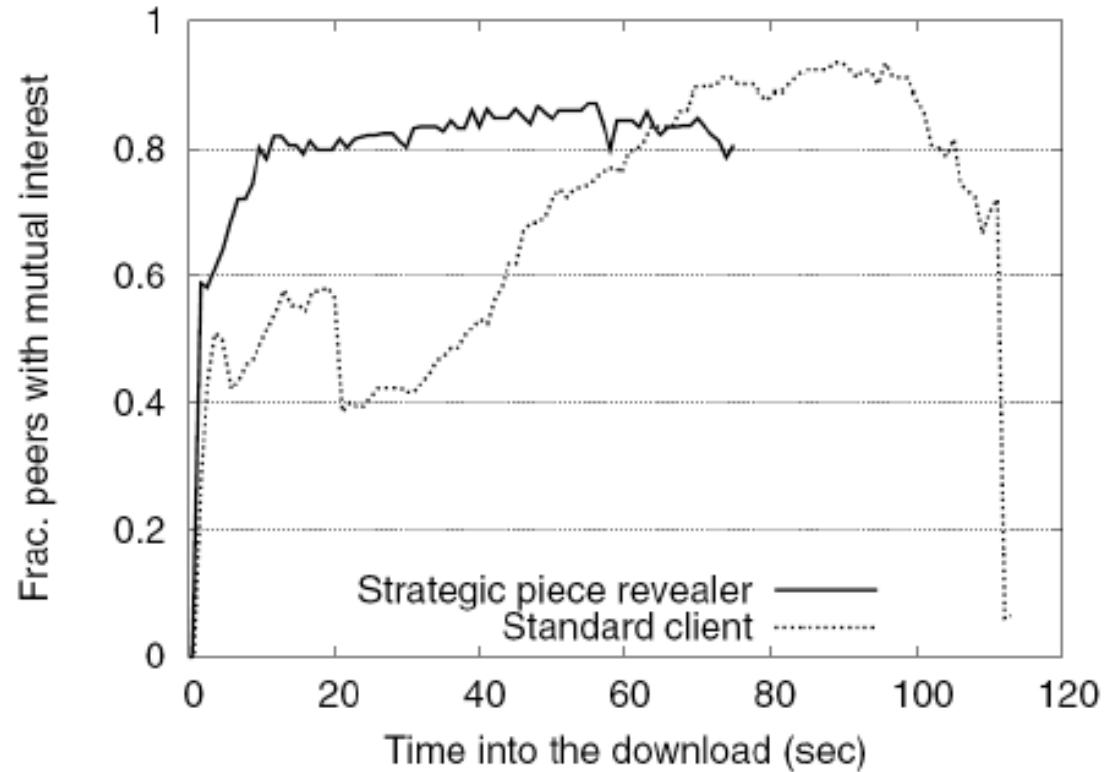
Figure 4.7: Strategic Piece Revelation: Peer i prefers to remain as interesting as possible (Levin et al., 2008).

Strategic Piece Revelation (2/2)

Algorithm 1: Strategic Piece Revelation Algorithm (Levin et al., 2008).

1. Let β_i represent i 's true bit-field, $\hat{\beta}_j$ denote j 's bitfield as j has announced it to i , and $L_i(j)$ the list of pieces that i has revealed to j .
 2. If there does not exist any piece p such that $\hat{\beta}_j(p) = 0$ and $\beta_i(p) = 1$ then quit; i cannot truthfully gain j 's interest.
 3. Find the piece p with $\hat{\beta}_j(p) = 0$ and $\beta_i(p) = 1$ that maximizes the number of other neighbors l for which (a) l also has piece p , or (b) i has revealed p to l before.
 4. Send a have-message to j , revealing that i has piece p , and add p to $L_i(j)$.
-

Effect of Strategic Piece Revelation



- Social Welfare? [Q3]

BitTyrant

- Ideas: [Q4]
 - Variable number of upload slots
 - Allocate upload slots based on return = down/up ratio
 - No equal split policy, instead, upload as much as necessary

The BitTyrant Unchoking Algorithm

Algorithm 2: The BitTyrant Unchoking Algorithm (Piatek et al., 2007).

1. For each peer j , peer i maintains estimates of expected download rate d_j and expected upload rate required for reciprocation u_j .
 - (a) If client i is unchoked by j , then d_j is the observed download bandwidth. Otherwise, d_j is inferred indirectly from j 's block announcement rate.
 - (b) Initialize u_j using the distribution of equal split capacities observed in prior measurements (Figure 4.9).
2. Each round, rank order peers by decreasing ratio $\frac{d_j}{u_j}$ and unchoke those of top rank until the upload capacity is reached.

$$\underbrace{\frac{d_0}{u_0}, \frac{d_1}{u_1}, \frac{d_2}{u_2}, \frac{d_3}{u_3}, \frac{d_4}{u_4}, \dots}_{\text{choose } k \mid \sum_{j=0}^k u_j \leq \text{cap}_i}$$

3. At the end of each round, for each unchoked peer j :
 - (a) If peer j does not unchoke i : $u_j \leftarrow (1 + \alpha)u_j$
 - (b) If peer j unchokes i : $d_j \leftarrow$ observed rate.
 - (c) If peer j has unchoked i for the last r rounds: $u_j \leftarrow (1 - \gamma)u_j$

Estimating u_j (1/2)

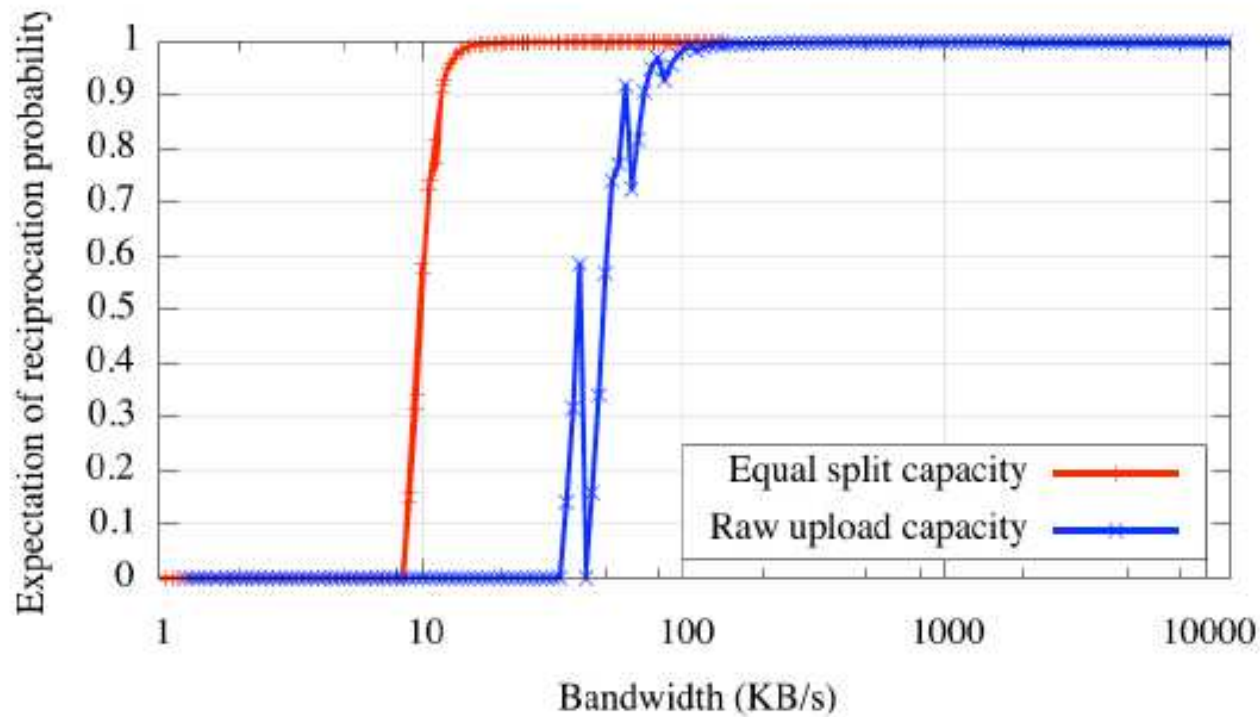


Figure 4.9: Reciprocation probability for a peer as a function of raw upload capacity as well as reference BitTorrent equal split bandwidth (Piatek et al., 2007).

Estimating u_j (2/2)

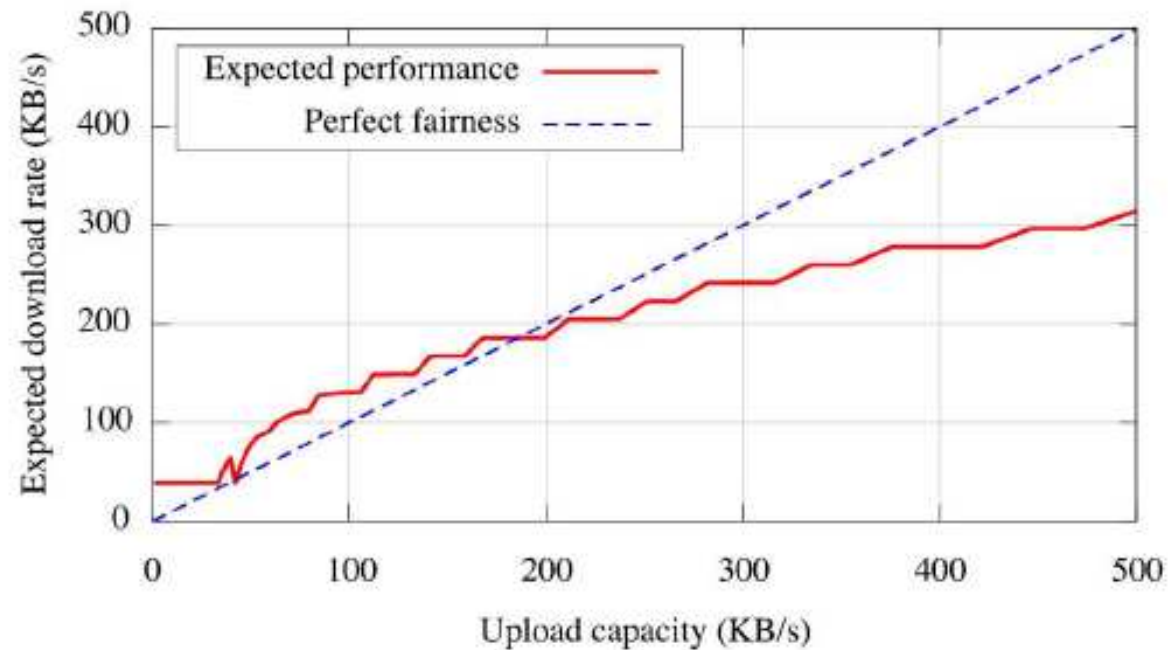


Figure 4.10: Expectation of download performance as a function of upload capacity (Piatek et al., 2007).

BitTyrant: Results

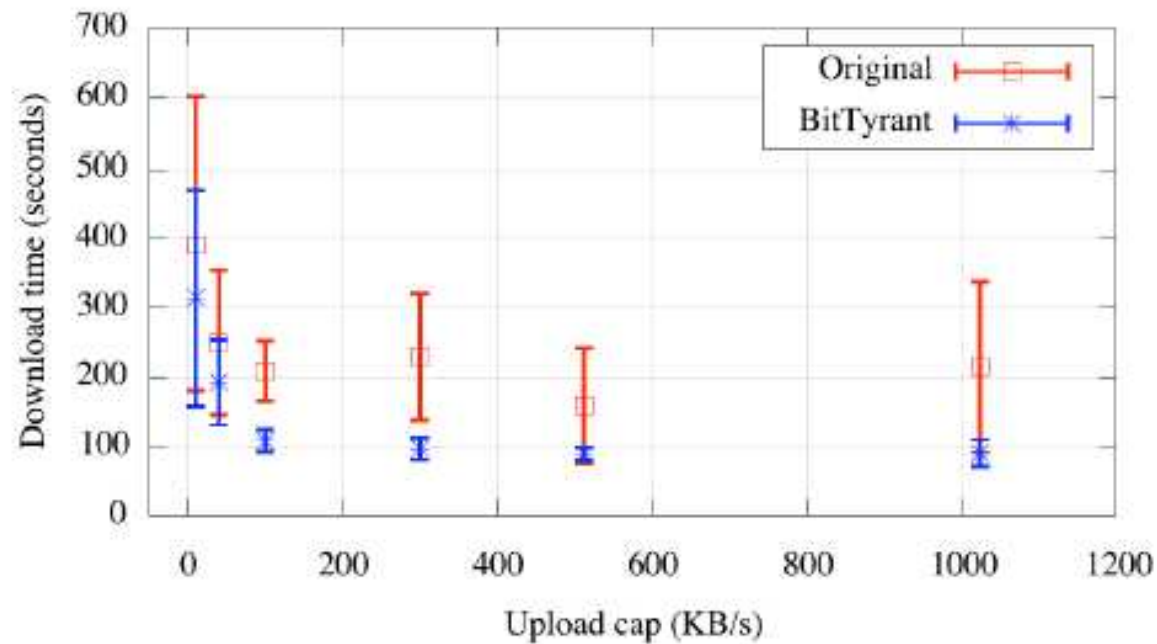
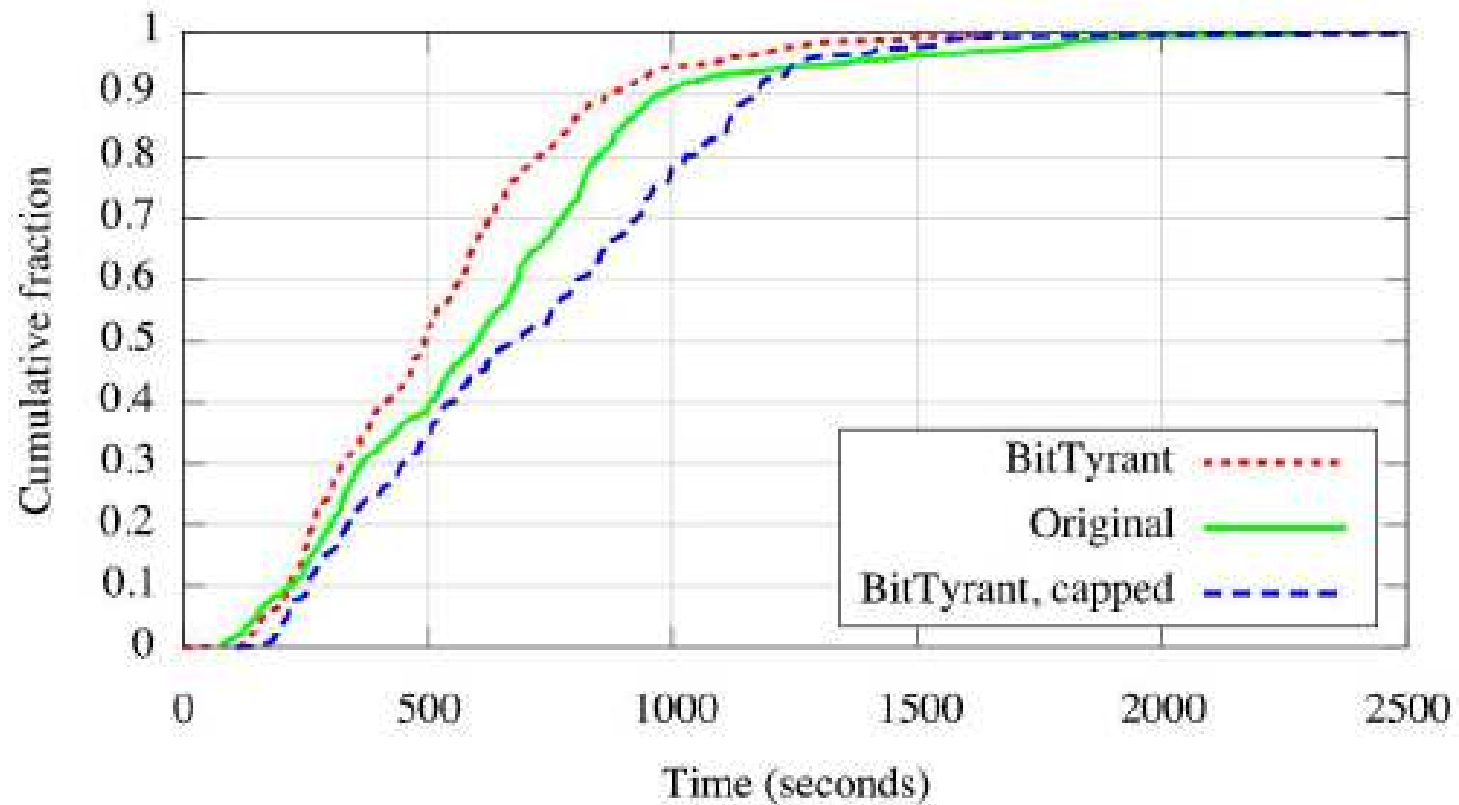


Figure 4.11: Download times and sample standard deviation comparing performance of a single BitTyrant client and an unmodified Azureus client on a synthetic Planet-Lab swarm (Piatek et al., 2007).

BitTyrant: Social Welfare

- [Q5]



Extensions...

- Cross-swarm incentives?
- Incentivize Seeding?

- Ideas:
 - Private trackers
 - Accounting mechanisms

Going forward...

- If you use BitTorrent:
 - Will you use BitThief?
 - Will you use BitTyrant?
 - Upload until 1:1 ratio?
 - ...?