Cooperation in Open Distributed Systems

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Distributed Systems 2008/9

Wireless: Many mobile phones today have WLAN (and even Skype)

P2P: Olympic games 2008 live-broadcast over peer-to-peer networks

„Social“ networks: *Facebook*, *Xing*, *Twitter*...

E.g. US elections 2008: Obama makes extensive use of Internet technologies

Get Local! Create Your MyBO Account (or Login) Email Address Zip Code Get Started

EN ESPAÑOL

OBAMA BIDEN

“I'M ASKING YOU TO BELIEVE. Not just in my ability to bring about real change in Washington ... I'm asking you to believe in yours.”

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OBAMABLOG

Open Thread

by Christopher Hass | Sunday, March 15, 2009 3:56:41 PM

Photo: President Obama takes off from the South Lawn of the White House aboard Marine One; by Joyce N. Boghosian

338 Comment(s) Permalink Email to a friend

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HQ Highlights

Host a Pledge Project Canvass

OFA Video: "Ready for the fight"

President Obama's Executive Order on Stem Cell Research: "Restoring scientific integrity"

"Comprehensive health care reform by the end of this year"

The President's Weekly Address: "Gearing up for a fight"

President Obama Submits Budget Outline to Congress

President Obama's Address: "In our hands lies the ability to shape our world for good or for ill"

President Obama Announces Plan to Address the Foreclosure Crisis

President Obama's Weekley Address: "A major milestone on our road to recovery"

ur Stories: Economic Crisis and overy

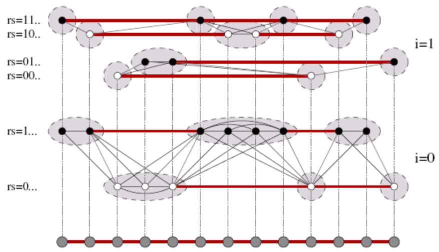
YOUR PHOTOS AND

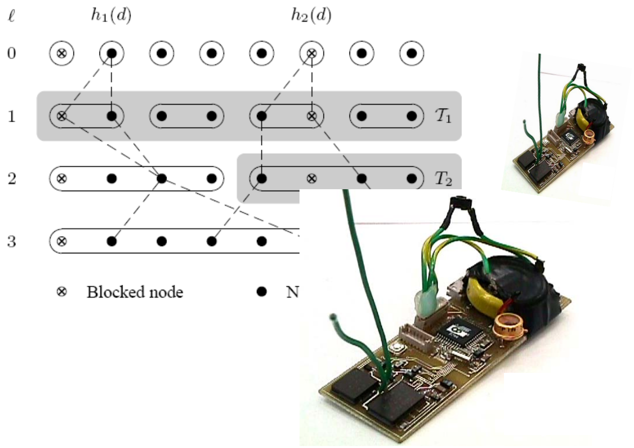
T-Labs, 2009

Challenges in Open Distributed Systems (1)

Dynamic resources

e.g., in peer-to-peer computing: worst-case churn, topological self-stabilization, etc.





Robustness

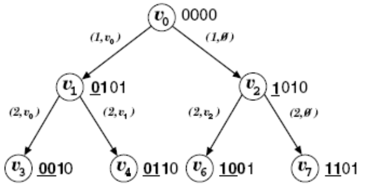
e.g., in wireless networks: jamming

e.g., in peer-to-peer networks: DoS attacks (cf Leighton/Akamai)

Efficiency

e.g., how to deal with huge amounts of data?

e.g., low-overhead p2p live streaming?



Challenges in Open Distributed Systems (2)

Economics

e.g., selfishness / altruism / malicious behavior

e.g., mechanism design for anonymous, money-less networks

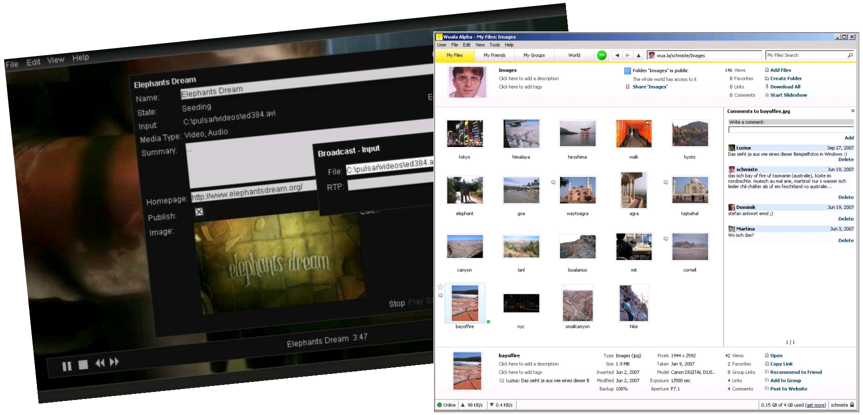
Heterogeneity

e.g., live streaming with heterogeneous peers

Focus of this talk: Cooperation and heterogeneity in peer-to-peer systems!

Peer-to-Peer Technology

- Well-known p2p systems
  - P2P: contributions of participants
  - Internet telephony: *Skype*, file sharing: *BitTorrent, eMule, ...*, streaming: *Zattoo, Joost, ...*

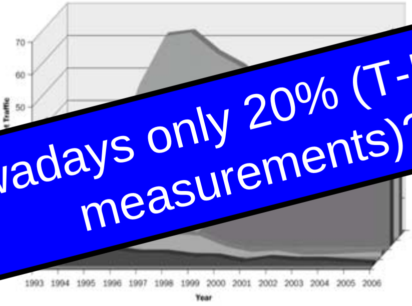


- Other (well-known?) systems
  - Pulsar strea ystem (e.g., till ps?)
  - Wua line storage system

Two startups!

- Impact: Accounts for much Internet traffic!

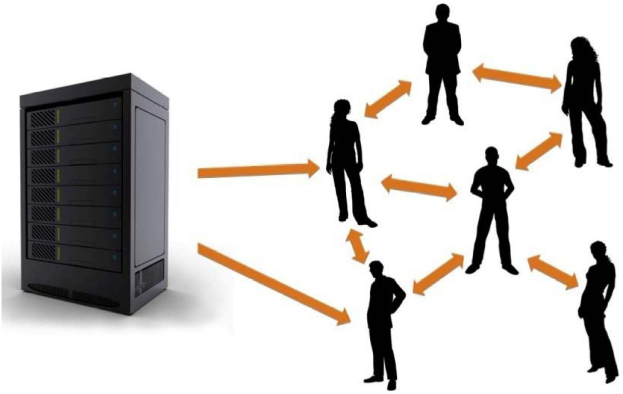
  (old source: *cachelogic.com*)



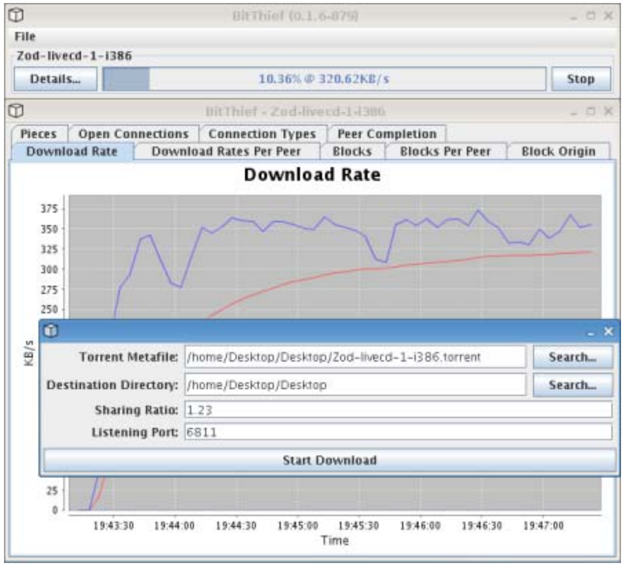
Nowadays only 20% (T-Lab measurements)?

Cooperation in Peer-to-Peer

- Peer-to-peer systems
  - open to „everybody“
  - rely on contributions
  - heterogeneous



- Non-cooperation: threat to the paradigm



BitThief (0.1.6-879)

Zod-livecd-1-i386

10.36% @ 320.62KB/s

BitThief - Zod-livecd-1-i386

Download Rate

Torrent Metafile: /home/Desktop/Desktop/Zod-livecd-1-i386.torrent

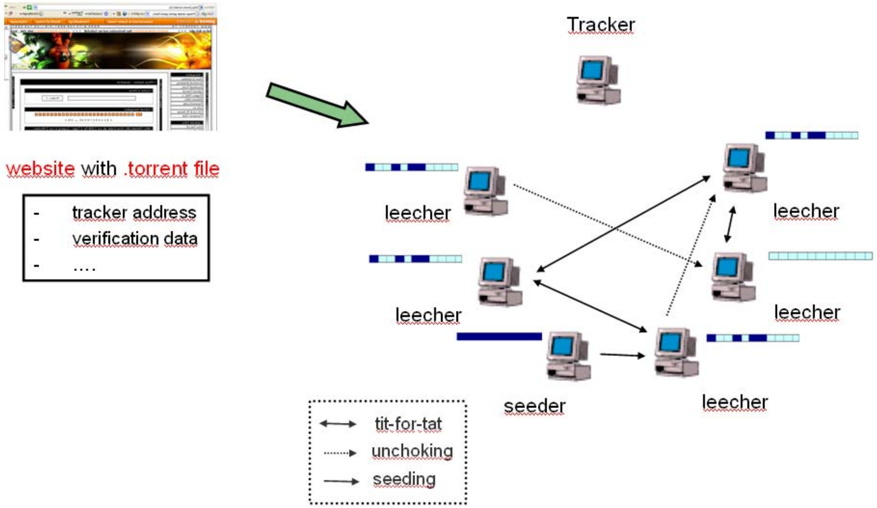
Destination Directory: /home/Desktop/Desktop

Sharing Ratio: 1.23

Listening Port: 6811

- For example BitThief:
  - Proof of concept Java client
  - Downloads without uploading at all
  - despite BitTorrent‘s incentive mechanism!

BitThief's Tricks



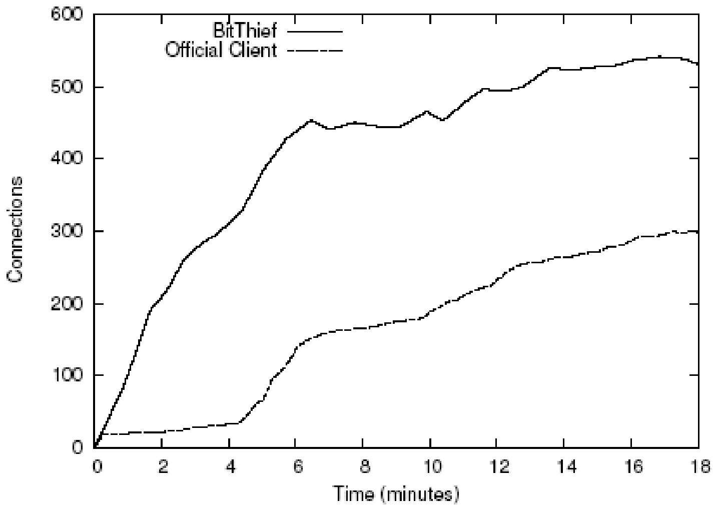
BitThief's three simple tricks:

1. Open many TCP connections
2. Contacting tracker again and again, asking for more peers (never banned!)
3. Pretend being a great uploader in sharing communities

⇒ Exploit optimistic unchoking slots

⇒ „Exploit" seeders

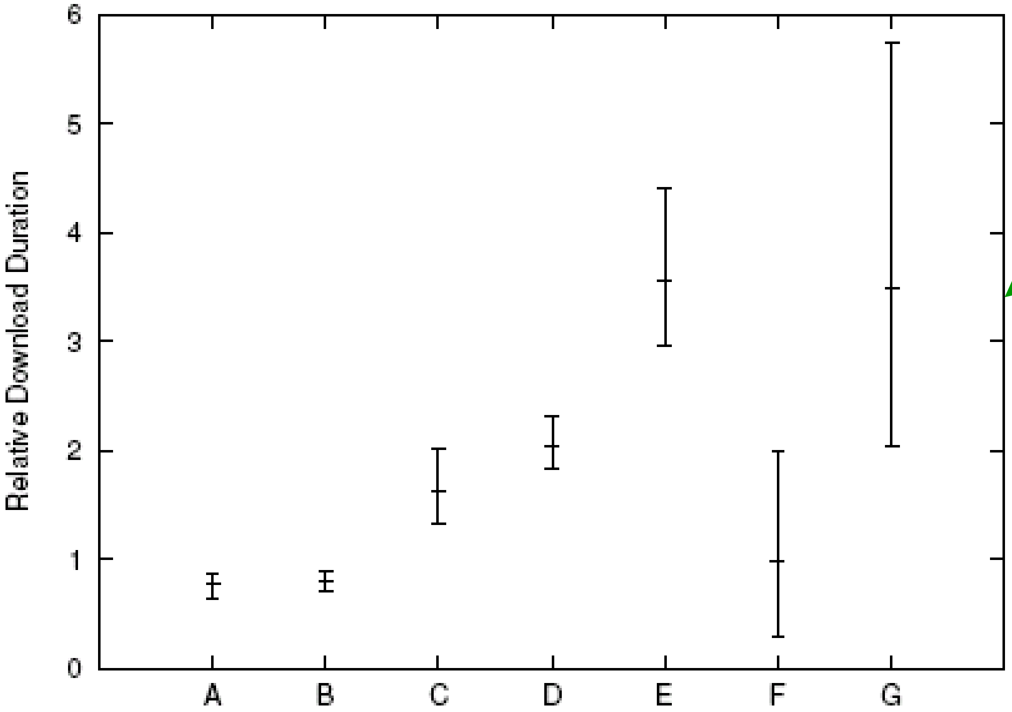
⇒ Exploit sharing communities



BitThief: Results (with Seeders)

2

compared to official client (with unlimited number of allowed connections)

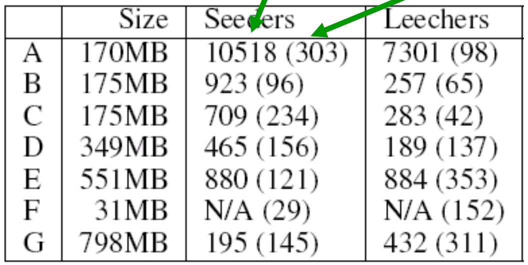


4 BitThief with public IP and open TCP port

number of peers announced by tracker

max peers found by BitThief

1



	Size	Seeders	Leechers
A	170MB	10518 (303)	7301 (98)
B	175MB	923 (96)	257 (65)
C	175MB	709 (234)	283 (42)
D	349MB	465 (156)	189 (137)
E	551MB	880 (121)	884 (353)
F	31MB	N/A (29)	N/A (152)
G	798MB	195 (145)	432 (311)

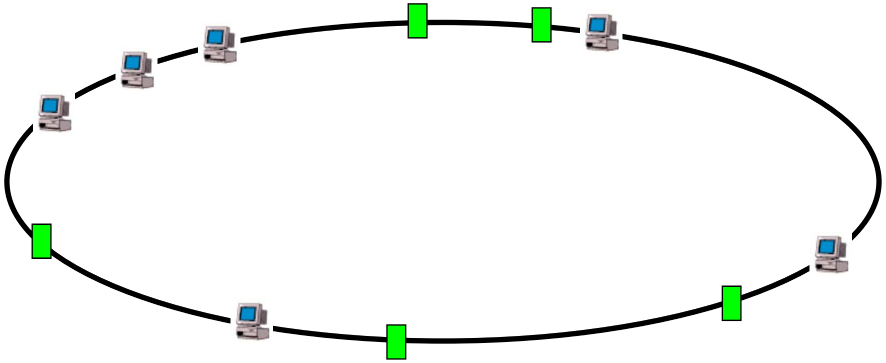
3

- All downloads finished!
- Fast for small files (fast startup), many peers and many seeders!

Another Example: Non-cooperation in Kad

- Kad = one of the first widely used distributed hash tables (DHT)

- Basic principle
  - Consistent hashing
  - Peers and data items with identifiers chosen from [0,1)
  - (Pointers to) data items stored on closest peers*

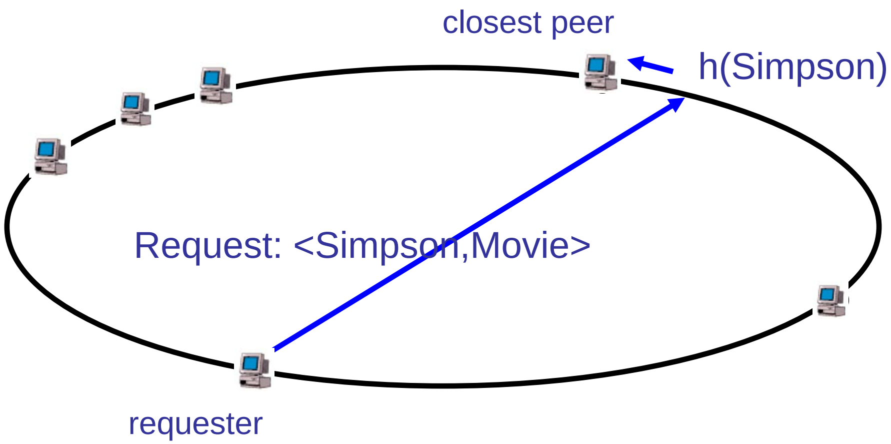


* Attention: this is a simplification (factor 10 replication in „close“ tolerance zone)

Kad Censorship

- Several vulnerabilities

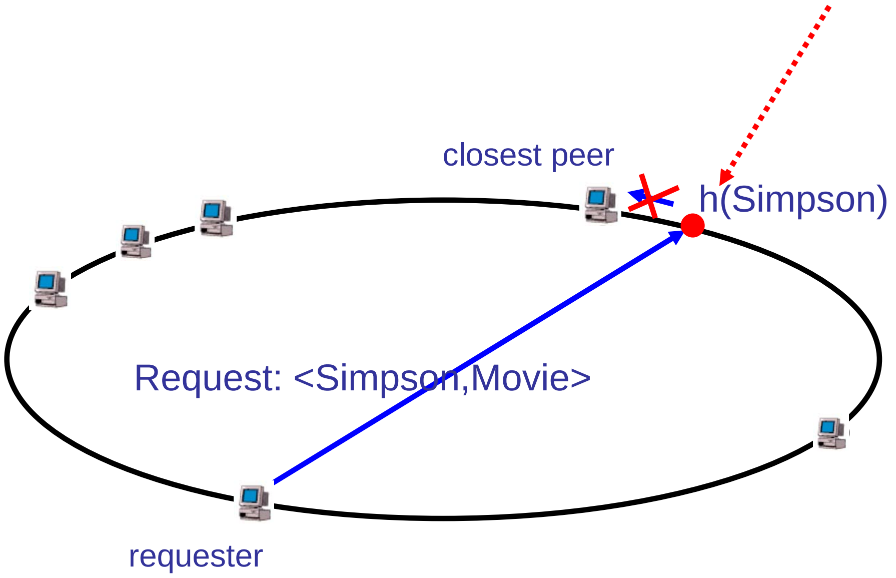
- Example: malicious peers can perform censorhip attack
  - Simply by assuming the corresponding IDs (peer insertion attack)
  - No prescribed ID selection method or verification



Kad Censorship

- Censoring contents in Kad

If peer is inserted here, it can block (or spy on) keyword requests for „Simpsons“, „Simpsons Movie“, etc.



Kad Censorship

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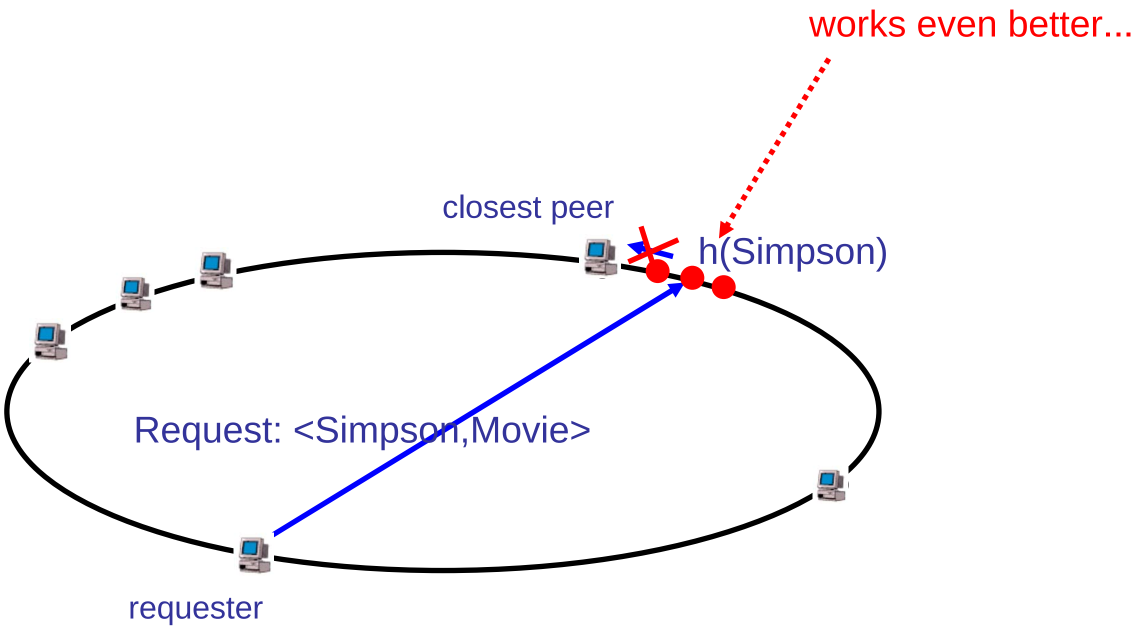
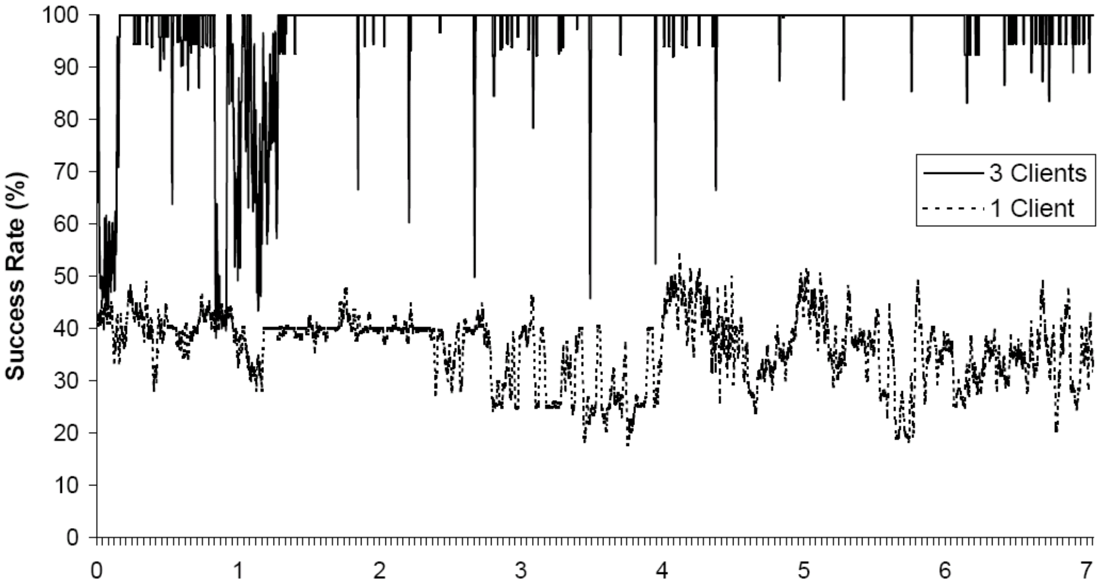


Kad Censorship

- Some results



- Similarly for source requests
- There are also other censorship attacks (e.g., pollute cache of other peers)
- Plus eclipse and denial of service attacks (e.g., pollute cache such that requests are forwarded to external peers)...

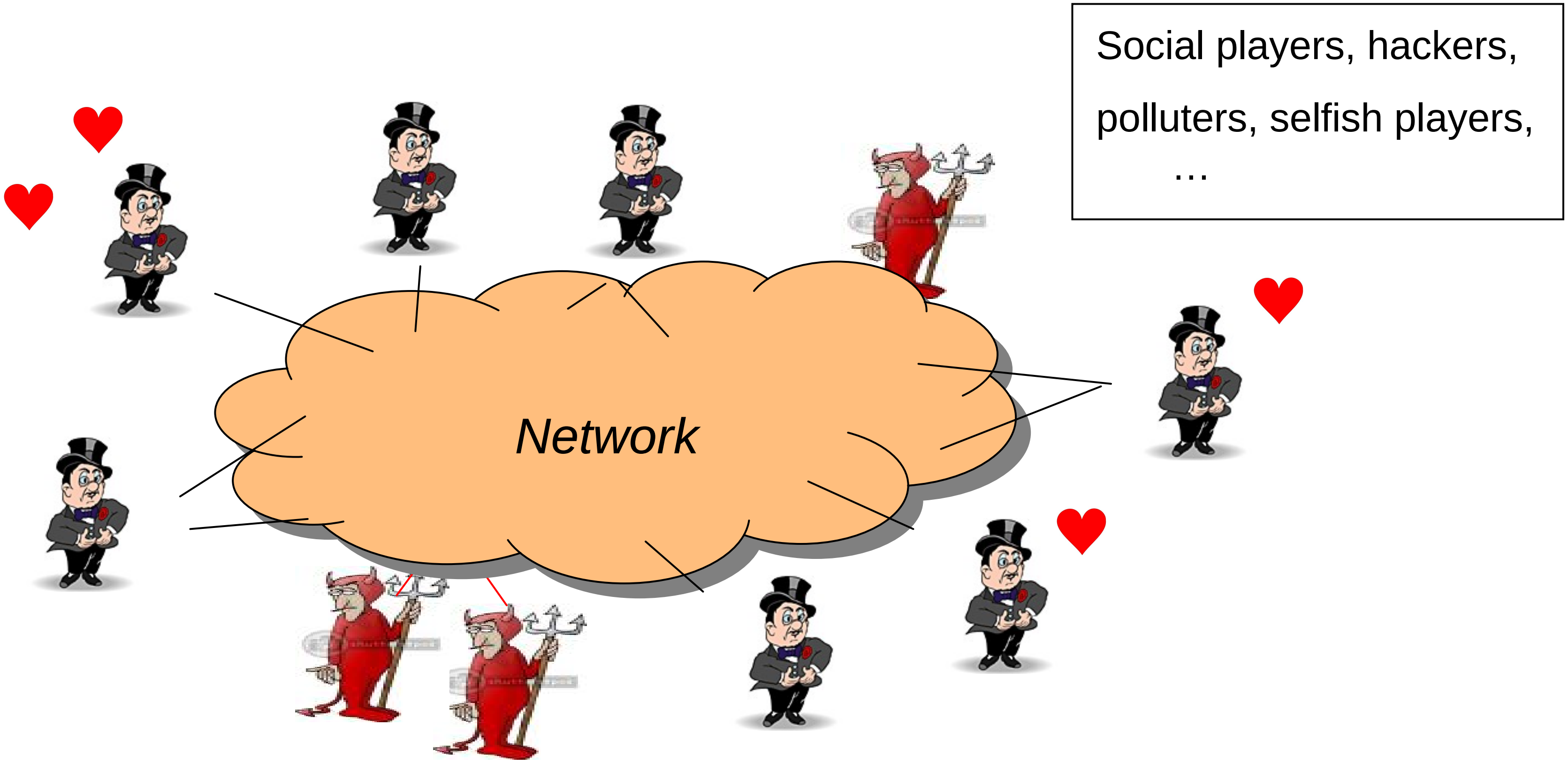
BitThief and Kad Attacks: Easy to Fix?

- **BitThief**
  - Optimistic unchoking can be exploited
  - Just do pure tit-for-tat? Bootstrap problem...
  - Fast extension: subset of pieces only (limited „venture capital“)
  - No direct interest? E.g., inter-swarm incentives?

- **Kad Attacks**
  - Too much information from same peer (e.g., publish attack)
  - Bind ID to peer... But how?
  - Bind to IP? NATs yield same peer IDs? Dynamic IP addresses?
    Credit loss?
  - Generate ID, e.g., by hashing a user phrase?
    But sparsely populated ID space =>
    easy to generate IDs close to the object...

Insights from Game Theory?

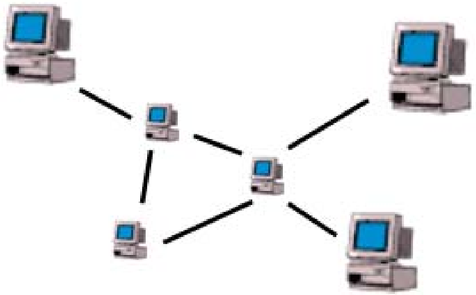
- A model for peer-to-peer networks?



Social players, hackers, polluters, selfish players, …

- Game theory can help to find mechanisms
  - E.g., malicious players may be beneficial
  - E.g., too much altruism can be harmful

Heterogeneity



- Tight connections to the cooperation challenge

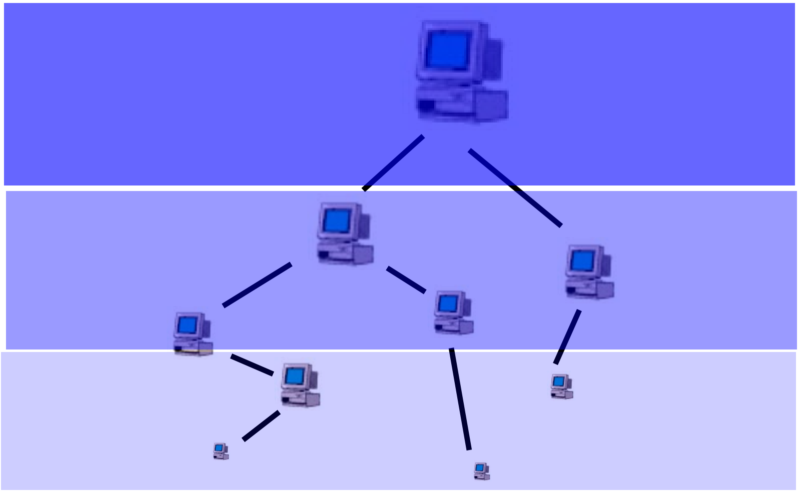
- E.g., streaming: Shall stronger peers support weaker ones?

  - If yes, what about selfishness?

- SHELL: Takes into account heterogeneity

  - Distributed oblivious heap

  - Paths between strong peers do not include weak peers



The Distributed SHELL Heap

- What is a distributed heap?

- We assume that peers have a key / rank / order / id

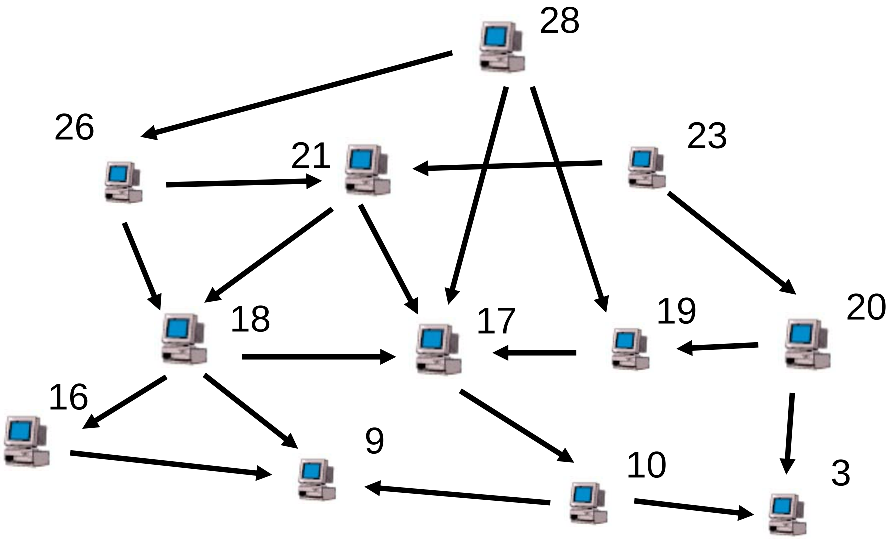
  - for example: inverse of peer capability

- (Min-) heap property: only connect to lower rank peers

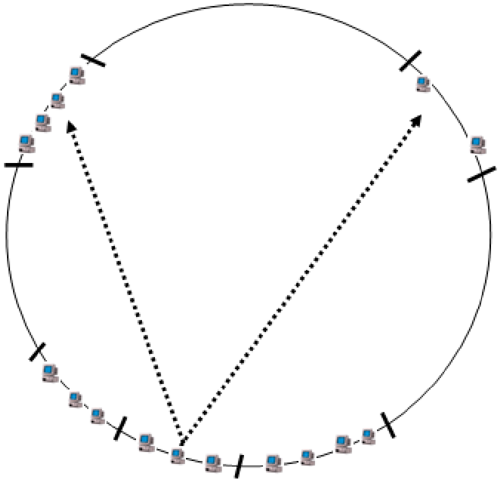
  - for example: peers only connect to stronger peers

  - SHELL constructs a directed overlay

    (routing along these edges only)

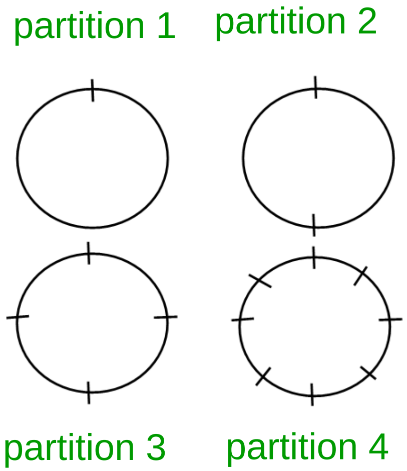


The SHELL Topology



- Continuous-discrete approach: de Bruijn network

- Problem: de Bruijn neighbor may have larger rank



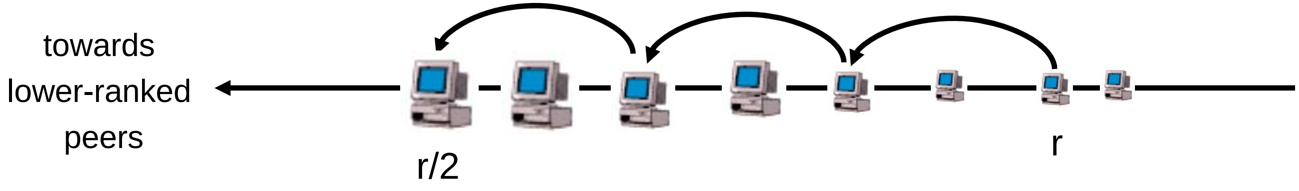
- Solution

  - peer at position x: connects to all lower-ranked peers in an interval around x/2 and (x+1)/2
  - i.e., space divided into intervals
  - size of interval depends on number of low-rank peers there
  - larger degree, but still logarithmic diameter etc.

- Oblivious: Very fast joins and leaves!

Routing

- Routing paths are augmenting (no weak peer between)



- E.g., live streaming: quality of transmission depends on weaker of the two peers, but not on peers in-between

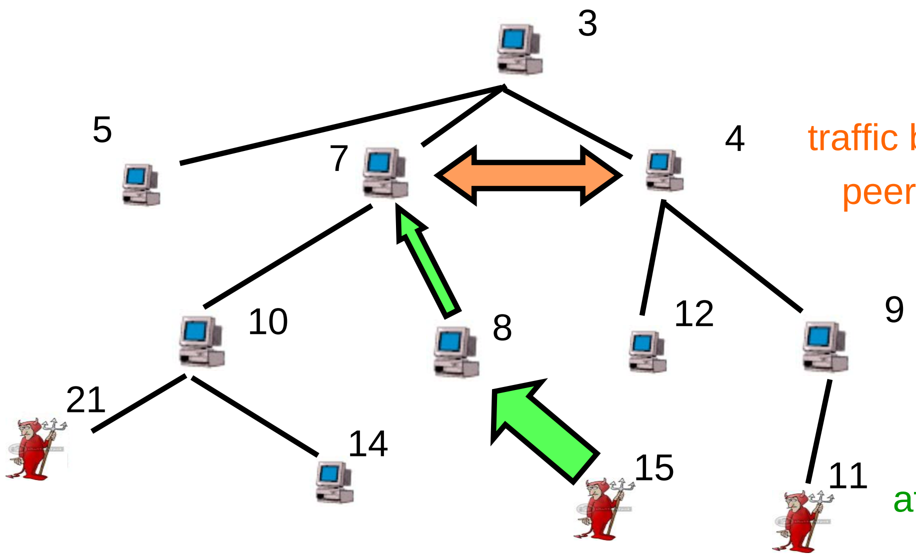
- Congestion guarantee

  - „first phase“ ends at peer rank at least t/2 w.h.p.
  - second phase short...

SHELL Solves Cooperation Problems!

- Approach also useful as robust distributed information system

- Idea: de Bruijn heap, but different peer ranks
  - Use rank ~ join time
  - Thus: peers only connect to older peers
  - i.e., maintain join time order



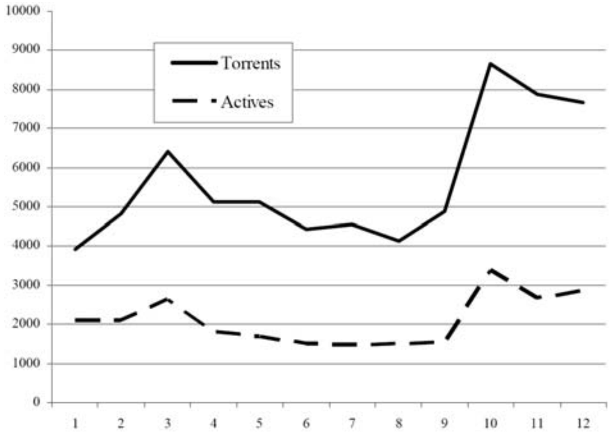
traffic between older peers unaffected

higher peers can perform a rate control algorithm

attack originates from lower peers

Conclusion

- Presence of unequal participants
  interesting and important challenge
  - Unequal = voluntarily or involuntarily little or no contribution
  - How to distinguish the two cases in a distributed environment?



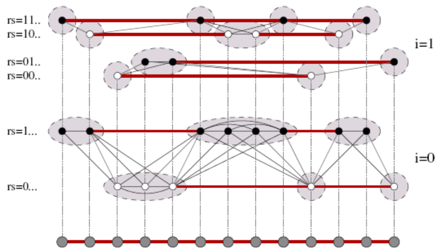
- Reality check: are people selfish?

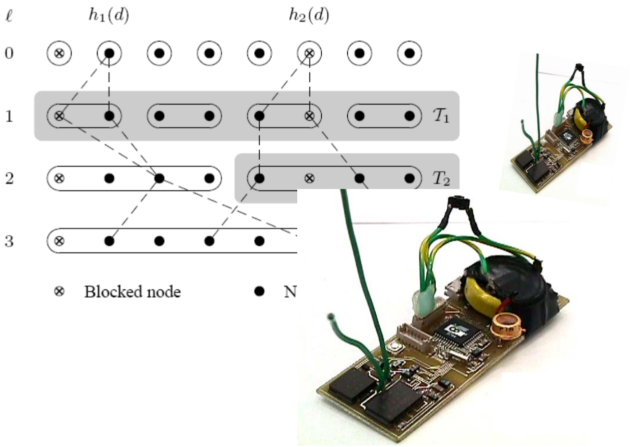
Thank you for your attention!

Some Literature

Dynamic resources

e.g., in peer-to-peer computing: worst-case churn (IPTPS 2005), topological self-stabilization (PODC 2009), etc.





Robustness

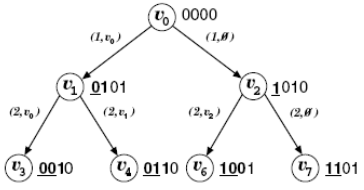
e.g., in wireless networks: jamming (DCOSS 2009)

e.g., in peer-to-peer networks: DoS attacks (SPAA 2009)

Efficiency

e.g., how to deal with huge amounts of data? (PODC 2008)

e.g., low-overhead p2p live streaming? (DISC 2007)

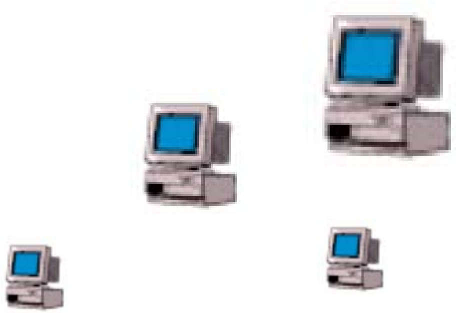


Some Literature

Economics

e.g., selfishness / altruism / malicious behavior (PODC 2006, EC 2008)

e.g., mechanism design for anonymous, money-less networks (INFOCOM 2009)



Heterogeneity

e.g., live streaming with heterogeneous peers (ICALP 2009)