The BitTorrent File-Sharing System: Measurements and Analysis

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Outline

- Overview of Study
- Introduction
- BitTorrent System – BitTorrent/Suprnova
- Experimental Setup
- Results
- Discussion and Conclusion
- Critique and Issues
- Take Aways

Overview

- Study Focused On Important Aspects That Lead to Popular Adoption of BitTorrent:
  - Availability
  - Integrity
  - Handling of Flashcrowds
  - Download Performance
- Considers BitTorrent and Suprnova.org as a system.
- Study took place over 8 months – June 2003-March 2004.
- Considered over 2 thousand global components.

Introduction – Terminology

▶ Flashcrowding – The effect caused by a sudden huge increase of peers for a popular new file.

▶ Peers – Clients downloading a file and distributing portions they have downloaded.

▶ Seeds – Clients with the full file who simply upload to other peers.

▶ Barter – The tit-for-tat process peers go through to negotiate downloading and uploading chunks of files that is meant to prevent parasitic behavior.

▶ Injector – User who uploads .torrent file and provides the first seed for the file.

▶ Pollution – The presence of fake, malicious, or corrupted files.

Introduction – Popular BitTorrent Websites

Site name	Available files	File transfers
Suprnova.org	46,766	2,267,463
Youceff.com	47,137	1,145,889
Piratebay.org	39,294	749,133
Lokitorrent.com	30,957	816,435

Table 1: Popular BitTorrent web sites (Oct 2004).

Introduction – Listed Contributions

- Adding understanding of the operation of the BitTorrent system and the reasons why it is able to attract millions of users.

- The results of the paper can help in the mathematical modeling of P2P systems.

- Findings about the conflict between data integrity and availability when comparing P2P systems with centralized global components vs. those without centralization.

BitTorrent System – BitTorrent Protocol

▶ P2P file-sharing protocol – Relies on other components such as websites for users to find files.

▶ Peers download via bartering with other peers/seeders.

▶ Peers are responsible for maximizing their download rate through selection of suitable peers to download from.

▶ Peers become seeds by staying online to distribute files after download.

▶ Torrent files are generally found through links on websites

  ▶ Example: Suprnova.org.

▶ Torrent file contents – Metadata and Tracker info.

▶ Made up 53% of all P2P traffic in June 2004.

BitTorrent System – Suprnova.org

- Most popular site for BitTorrent files at the time.

- Torrent files are downloaded from one of several torrent file servers for load balancing.

  - These files are not stored on Suprnova or its mirrors.

- Mirroring System – Used for load balancing of user requests and improving availability.

- Content Moderation – 2 Levels of Users/Injectors:

  - Moderated Submitter – Content must first be inspected by moderators.

  - Unmoderated Submitters – Trusted users may upload without their content being first checked by moderators.

- Moderators – Trusted users who inspect files, unmoderated submitters may request a promotion to become moderators.

BitTorrent System – Combination of BitTorrent and Suprnova

- Mirroring for load balancing of website.

- Meta-data Distribution to different file servers for load balancing.

- Bartering for fair resource sharing.

- P2P moderation and meta-data for integrity.

Global Components in BitTorrent/Suprnova System

- Main Suprnova.org server

- Suprnova.org Mirrors

- .torrent file servers and mirrors

- BitTorrent Trackers

- All considered to be centralized.

Experimental Setup – Monitoring Global BitTorrent/Suprnova Components

▶ Mirrorscript – Measures availability and response time of Suprnova mirrors.

▶ HTMLScript – Parses HTML pages of Suprnova to gather new .torrent files every hour.

▶ TrackerScript – Parses .torrent files for new trackers to add to a list, and checks the status of known trackers.

▶ Goal: Measures uptime of Suprnova mirrors and BitTorrent trackers. Also gather new .torrent files for use in monitoring of peers.

Experimental Setup – Monitoring Peers

- Made use of 100 Nodes of Distributed ASCI Supercomputer (DAS).

- HuntScript – Selects a file to follow and initiates a measurement of peers downloading files. Monitors once per minute for new .torrent files.

- GetPeerScript – Contacts tracker to get IP Addresses of users downloading and seeding the file. Activated after HuntScript selects a file.

- PeerPingScript – Contacts numerous peers in a parallel fashion through the use of the BitTorrent protocol to obtain download progress and uptime. Also activated after HuntScript selects a file.

- Goal: Obtain IP addresses of peers that inject new content and get an estimate of average download speeds.

Experimental Setup - Problems

- Firewalls
  - Widespread useprevented the PeerPingScript from measuring download speeds. Could only measure download speeds for peers that were not blocked by firewalls.

- Inability to get all peer IP Addresses
  - BitTorrent protocol only allows a tracker to return a limited number of randomly selected peers.

- Peer coverage
  - Fraction of peers discovered and for which IP Addresses were found. Still managed around 95% in all measurements.

- Modifications to BitTorrent
  - Created gaps in traces.
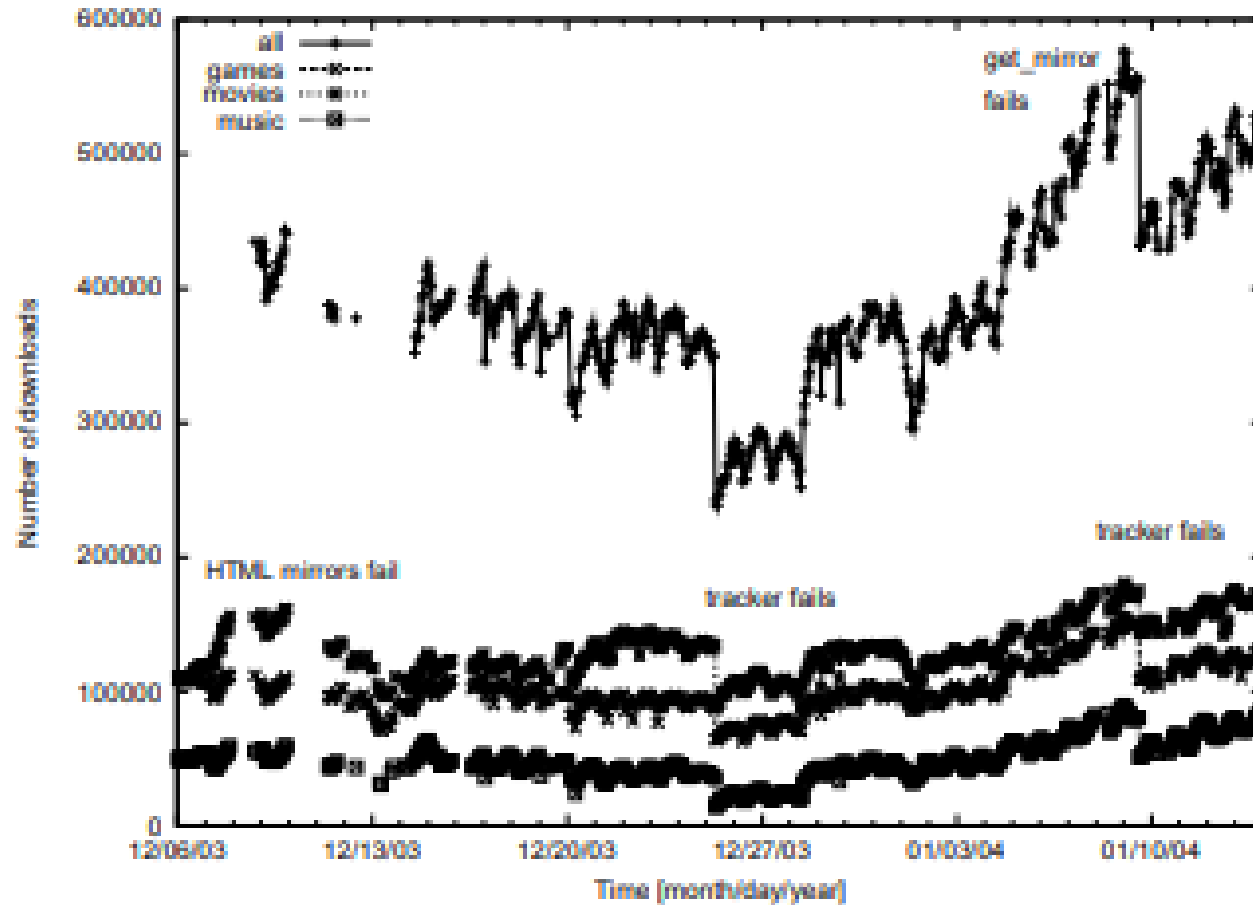
Results - Availability

Figure 1: The number of users downloading or seeding on BitTorrent/Suprnova for one month (Dec'03-Jan'04).

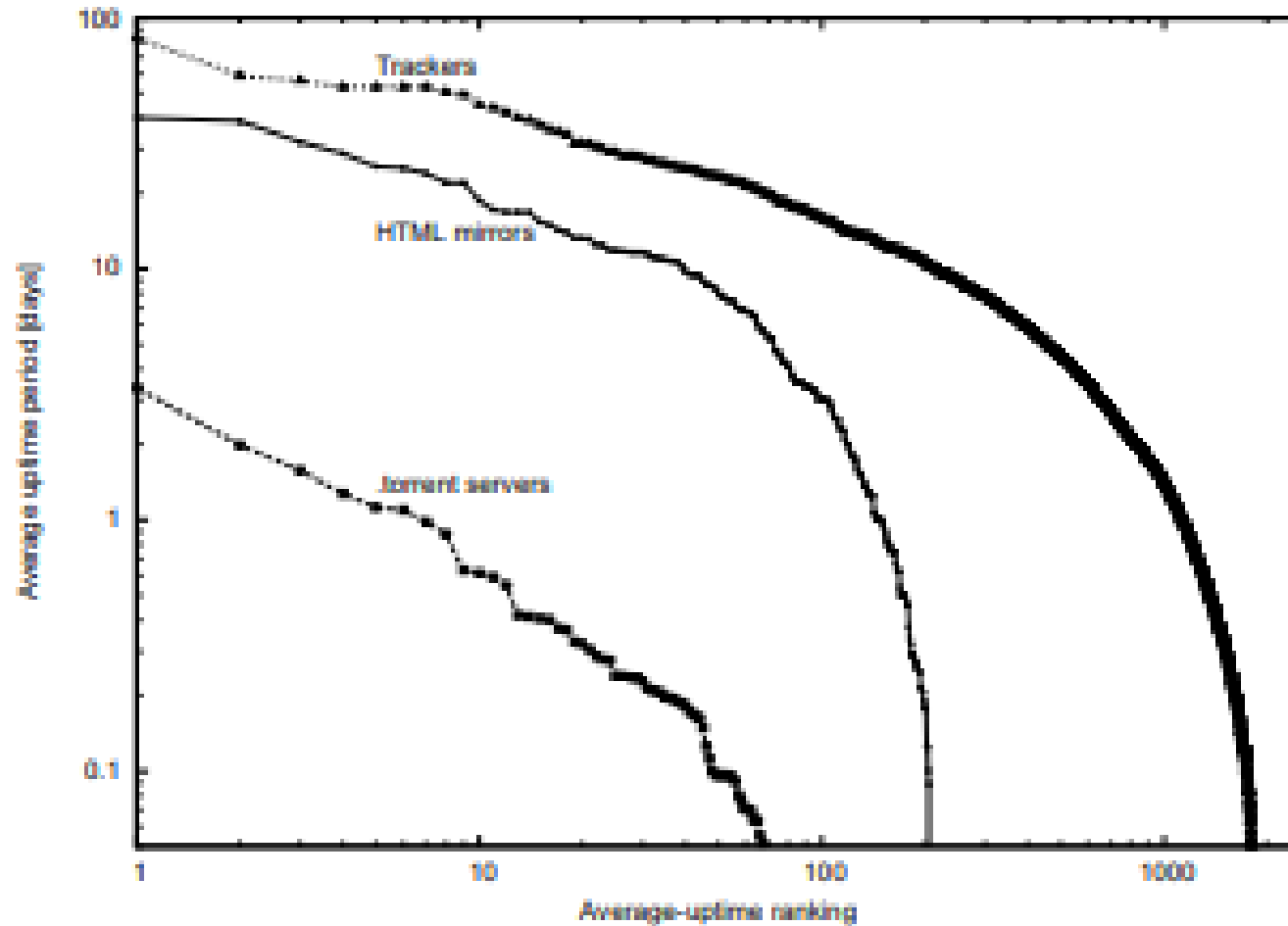# Results - Availability

Figure 2: The uptime ranking of three types of BitTorrent/Suprnova global components.
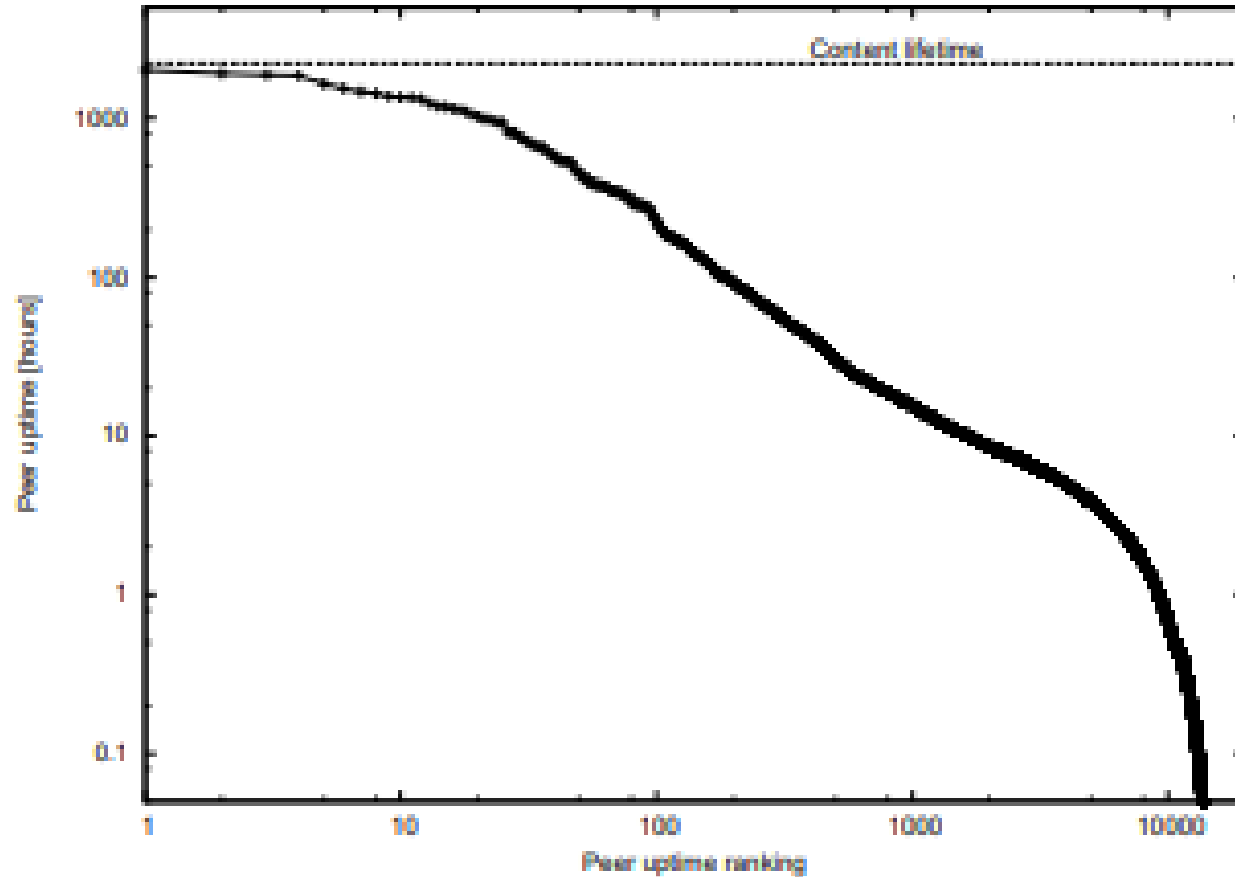
Results - Availability

Figure 3: The uptime ranking of the 53,833 peers down-loading "Beyond Good and Evil".

Results – Availability Conclusions

- Failures in Suprnova mirrors, .torrent file servers, and trackers led to large variation in measurements.

  - Main supernova.org servers – Often switched IP address or was down.

  - Suprnova mirrors – Rarely survived more than a few days due to having over 1,200,0000 visitors.

  - Torrent file servers – Sometimes none were available.

  - Trackers – Frequent targets for DoS attacks. Costly due to daily use of GBs of bandwidth.

- Number of active users strongly influenced by the availability of global components in BitTorrent and Suprnova.

Results – Availability Conclusions

- Reliable webhosting of Suprnova pages is a large issue.

- Trackers show good availability in comparsion.

- Seeds with high availability are rare.

  - Only 9,219 out of 53,883 (17%) peers on one popular file had an uptime longer than 1 hour after finished downloading. This decreased to 0.34% after 100 hours.

  - Seeds should be given incentives to increase their uptimes.

- Unavailability has a significant effect on popularity.

- Potential need to decentralize components to improve availability

  - However, BitTorrent and Suprnova's popular features depend on centralized components.
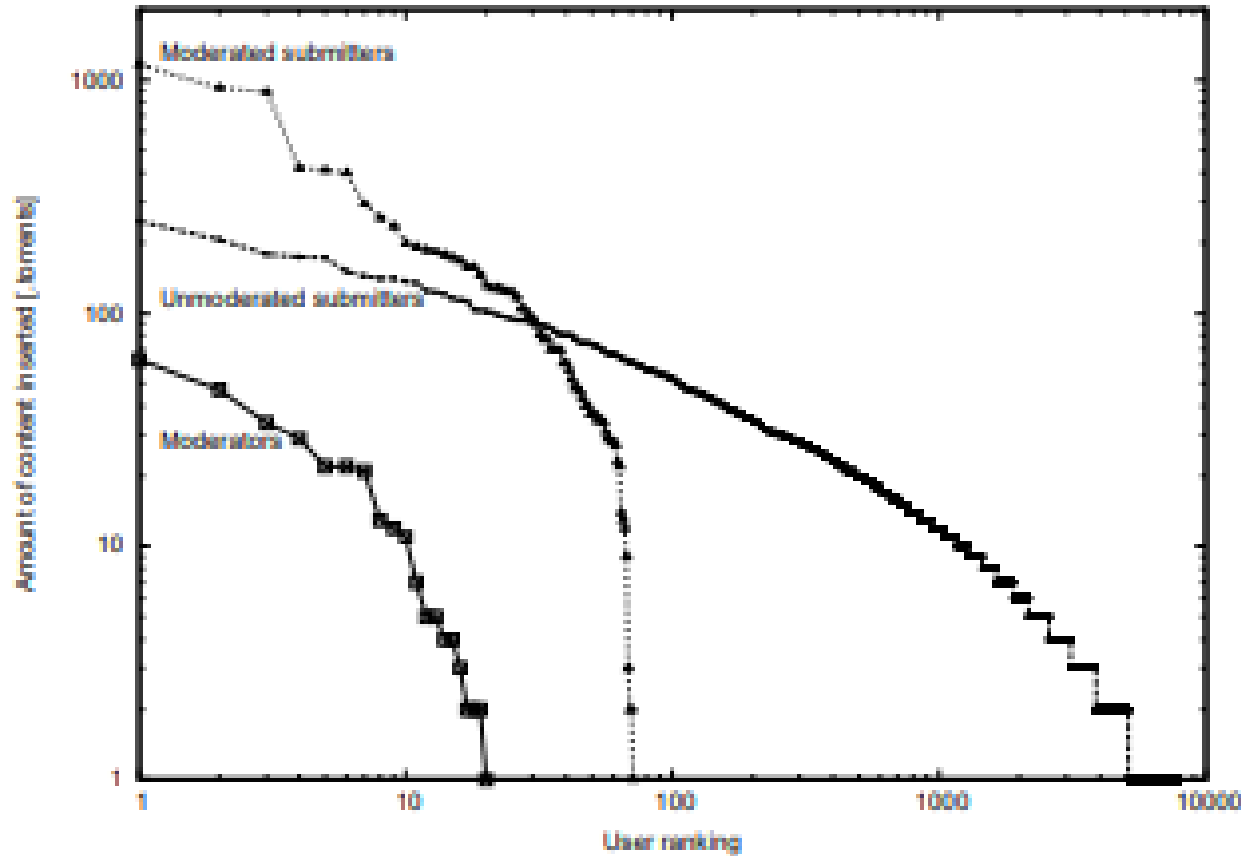
Results - Integrity

Figure 4: The activity of the different content submitters on Suprnova to prevent pollution.

Results – Integrity Conclusions

- Donated mirror to Suprnova with spyware embedded in the site code to register each .torrent file and could have corrupted the meta-data.
    - Found the use of donated resources for hosting of meta-data could easily lead to integrity and privacy issues.

- BitTorrent/Suprnova is considered by many P2P users to be pollution free.
    - Tested this by actively trying to pollute the system with fake files.
    - Found direct measurement of corrupted files through manually checking to not be viable.
    - Content was filtered out by moderators.

- Found that moderators were effective in remove fake and corrupted files with only a few volunteers – 20 in the study.
    - However, the system cannot be easily distributed due to moderation requiring a centralized area for checking the files.
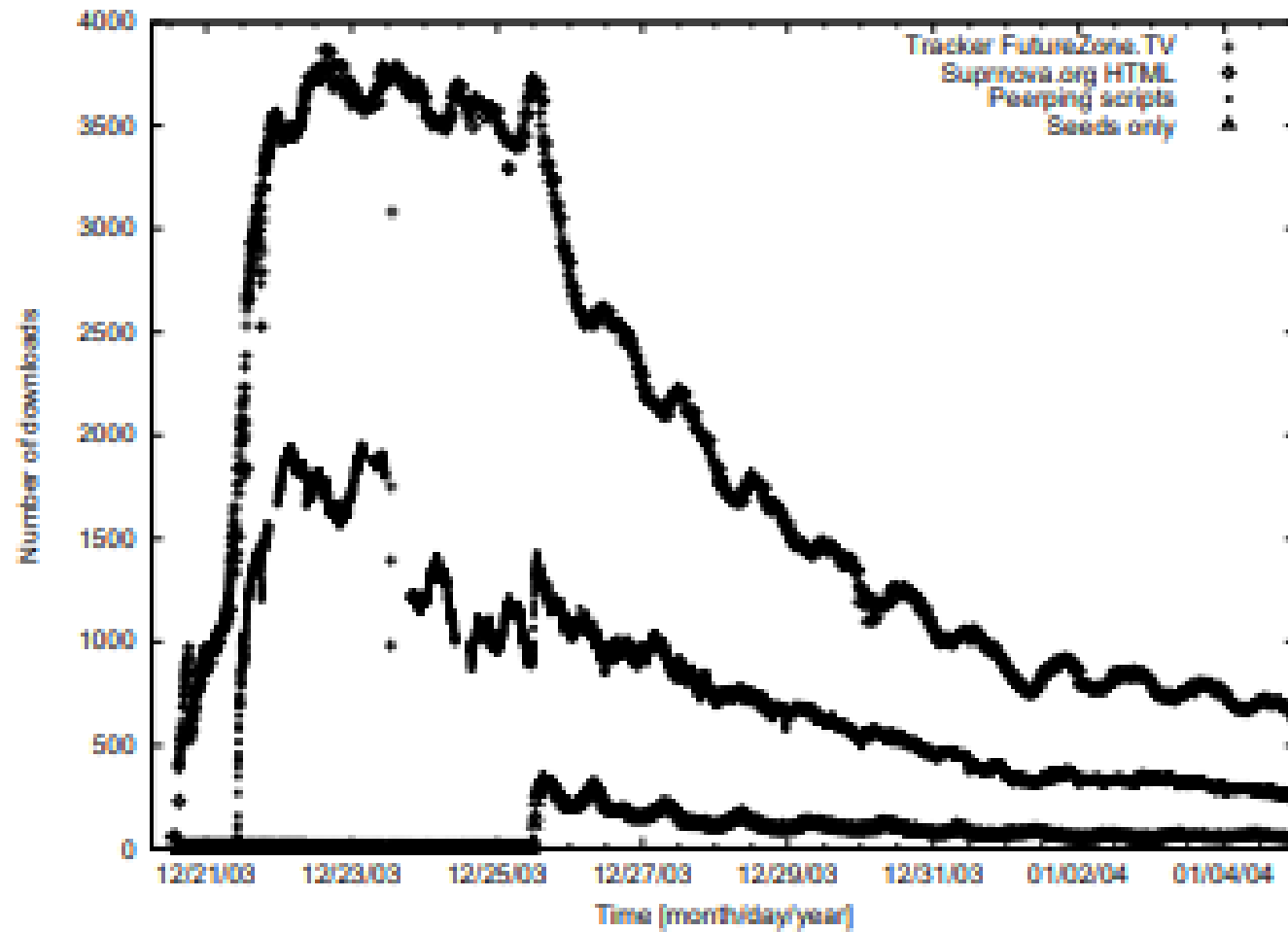
Results - Flashcrowds

Figure 5: Flashcrowd effect of "Lord of the Rings III".

Results – Flashcrowds Conclusions

- Futurezone.tv Tracker used as it provided detailed statistics.

- The long time period before peers finished downloading could provide an opportunity to identify users violating copyrights.

- Statistics from Suprnova were in agreement with the total tracker results.

- Peerping script showed a 40% lower amount of downloads due to the firewall problem.

- Gaps in the Peerping results were due to technical issues caused by disk quota problems.

- Ultimately, conclude that BitTorrent/Suprnova are capable of handling large flashcrowds efficiently.
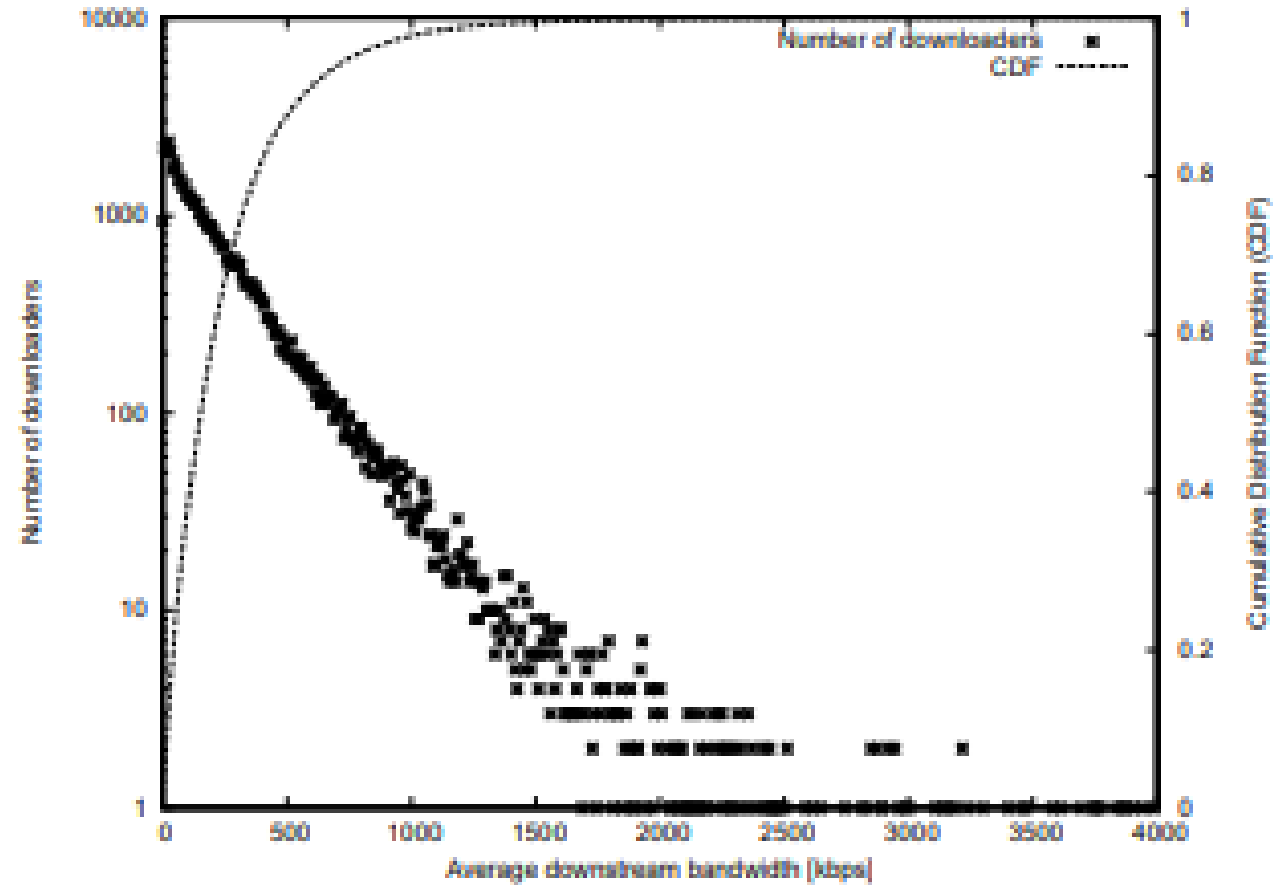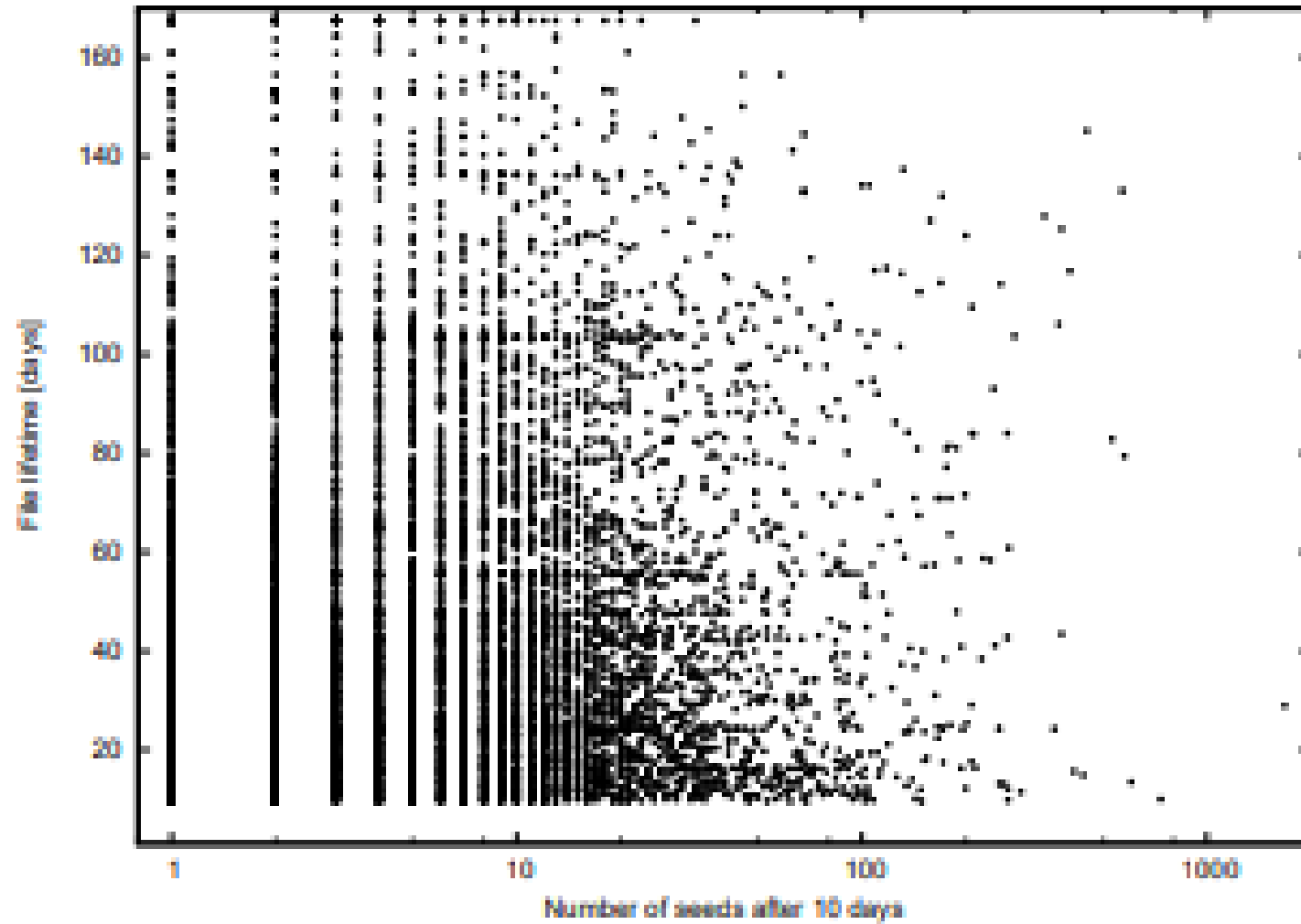
Results – Download Performance

Figure 6: The average download speed of peers.

Results – Download Performance

▶ Huntscript followed first 108 files added to Suprnova on March 10, 2004.

▶ 54,845 peers measured over a time frame of 2 weeks.

▶ Cumulative Distribution Function (CDF) – Probability that a peer had a download speed with a value of less than or equal to 520 kbps.

  ▶ $F(x) = (X \leq x) for\ all\ x\ \varepsilon R$ [2]

  ▶ 90% of peers were below 520 kbps.

▶ Average download speed of 240 kbps.

▶ Relation between average download speed and the number of downloads at that speed.

Results – Download Performance

Results – Download Performance Conclusions

- High average download speed allows peers to fetch large files in one day.

- When popularity drops and the last peer/seed with chunks of files go offline, the content dies.

- Number of seeds after 10 days is not an accurate measure of content lifetime.

- BitTorrent implementations punish peers for seeding by making use of their maximum bandwidth capacity to seed to others.

    - Instead, peers should receive incentives to seed with the chance to pick the amount of bandwidth to use.

Related Work

- D. Qiu and R. Srikant proposed a fluid model to determine the average download time of a single file. [15]
  - Assumes Poisson arrival and departure processes, equal upload and download bandwidth for all peers, and no flashcrowd effect.
- Decentralization of BitTorrent tracker leads to easy corruption of files due to the lack of a central integrity checking mechanism. [18]
- Studies of Other P2P networks
  - Most availability studies do not show long term peer behavior due to short time frames. [4, 6, 8]
  - Integrity not well explored, one study found that up to 70% of popular songs on Kazaa were polluted. [12]
  - Found nearly 70% of peers in Gnutella networks did not contribute any bandwidth. [3]
  - Content lifetime not explored.

Discussion and Conclusions

- Authors published all raw, anonymized data files, measurement software, and documentation for public use.

- Found overall high levels of integrity in the BitTorrent/Suprnova system with a relatively low amount of moderators.

  - This comes at a price of centralization, which leads to availability issues.

- Decentralization would help availability, but make meta-data more vulnerable to corruption and integrity attacks. Needs future research.

  - Kazaa has many issues with fake files due to its decentralized nature.

- Creating incentives to seed is important.

  - Suggest giving seeds more preference for bartering with other files.

Critique

- Good structure overall.
  - Conclusion split into results sections made their findings easier to follow.
- Many issues with their experimental setup.
  - Few files measured in depth – Only two measured for availability and integrity. Could lead to biases in conclusions.
  - Issues with firewalls bring download speed results into question.
  - Claim to be able to corrupt meta-data on a mirror, but do not provide an example of actually doing so successfully.
  - For content lifetime, only considered lifetime of files over 10 days for files with at least 10 seeds.
- Do not present many solutions, only vague suggestions like offering incentives through giving preference to barter for other files.
- Not much info on .torrent file servers.

Potential Improvements

- Disk Quota
  - Try to better estimate or measure the amount of users in a flashcrowd situation beforehand to ensure proper disk space is available.
  - This issue calls results from Peerping script into question.
- Time Frames
  - Consider measuring data over longer periods of time such as months.
  - Study took place over 8 months, but many measurements were only take over a period of days to weeks – Download speed, content lifetime, etc.
- Meta-data Corruption
  - Actually corrupt meta-data on mirror and show results.
  - Would users report this? Would moderators be able to respond and take the mirror down?

Potential Improvements

- Content Lifetime
  - Consider content lifetime from another angle.
  - With a persistent seed (provided by the study), how long would peers continue to download the file?
  - Also, how long till a random sampling of popular files no longer have seeds or enough file chunks available to recreate the file.
  - How often do files get revived after they no longer have seeds or the full file available?
  - When they do, does the flashcrowd effect occur again, or does the peer count stay low.
- Trackers
  - Measure the amount of downtime caused by DoS attacks vs. other reasons.

Potential Improvements

- Integrity of Files
  - Download random sampling of files, both popular and unpopular.
  - Determine if their content is true.
  - May be able to make a threshold to see if unpopular content tends to have more issues with integrity.

Takeaways

- BitTorrent is good for providing for file integrity, as long as the centralized components can be trusted.

- Should check assumptions before going too far in experimental setup.

- BitTorrent has many potential issues with availability.

- Seeds should be provided with good incentives to promote better availability.

- Decentralized integrity checking is a large issue, but could solve the availability issues if a good solution was found.

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THANK YOU!
ANY QUESTIONS?