A Longitudinal Characterization of Local and Global BitTorrent Workload Dynamics

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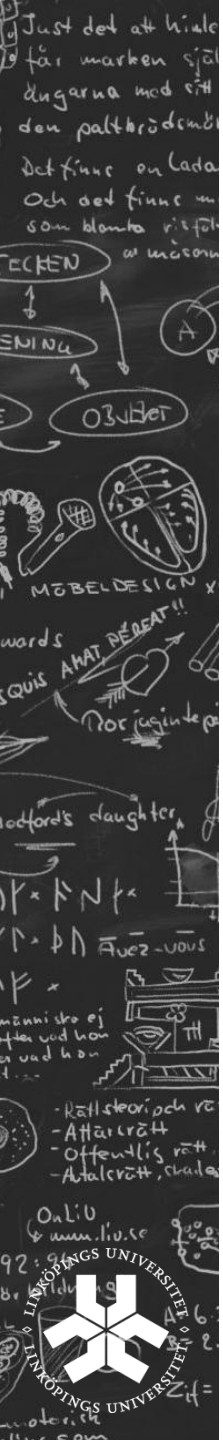
LiU expanding reality



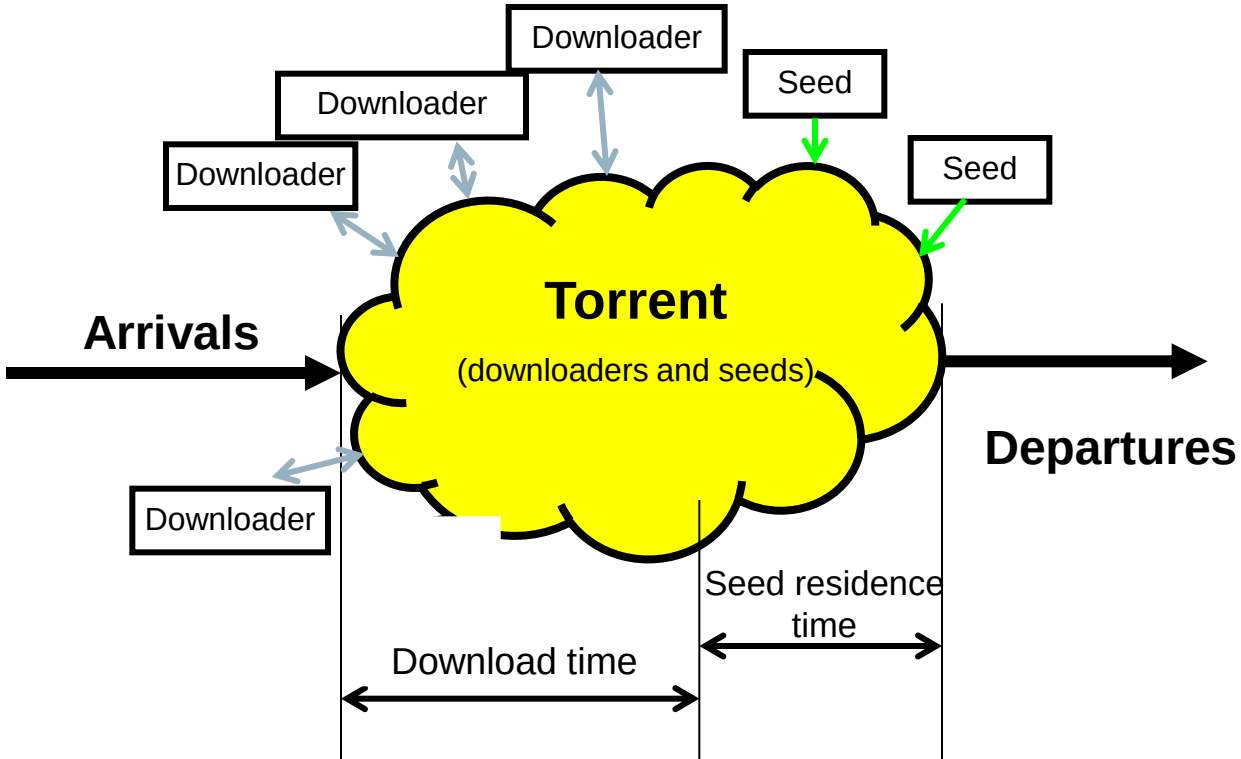
Motivation

- Use of Internet for content delivery is massive … and becoming more so
  - How to make scalable and efficient?
  - Server-based and peer-to-peer
- Chunk-based approach proven scalable
  - Files split into smaller chunks
  - Clients can download from both servers and other clients (peers)
- How to best manage large-scale content replication systems
  - E.g., where to place chunks?
  - Must first understand workload dynamics ...

Background: BitTorrent

Single file download

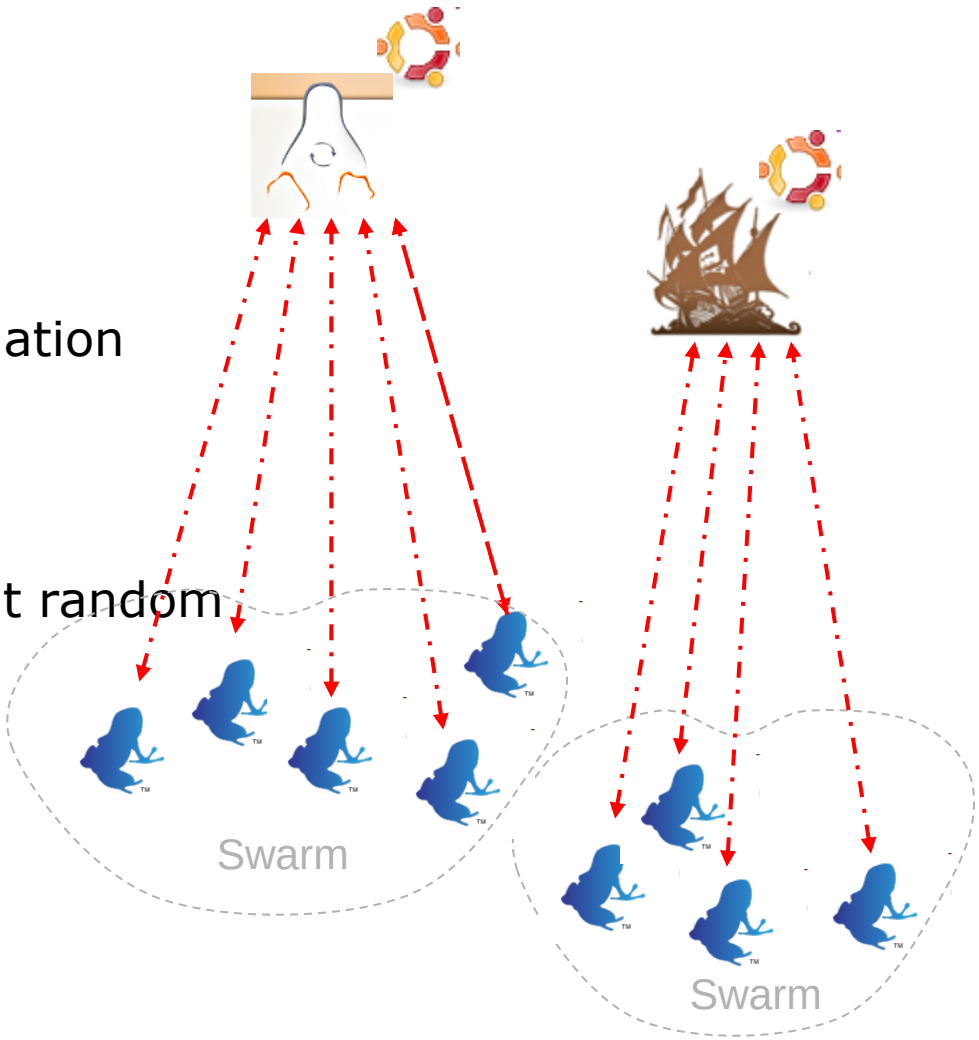
- File split into many smaller chunks
- Downloaded from both seeds and downloaders
- Distribution paths are dynamically determined
  - Based on data availability



Background: BitTorrent

Multi-tracked torrents

- Torrent file
  - "announce-list" URLs
- Trackers
  - Register torrent file
  - Maintain state information
- Peers
  - Obtain torrent file
  - Choose one tracker at random
  - Announce
  - Report status
  - Peer exchange (PEX)



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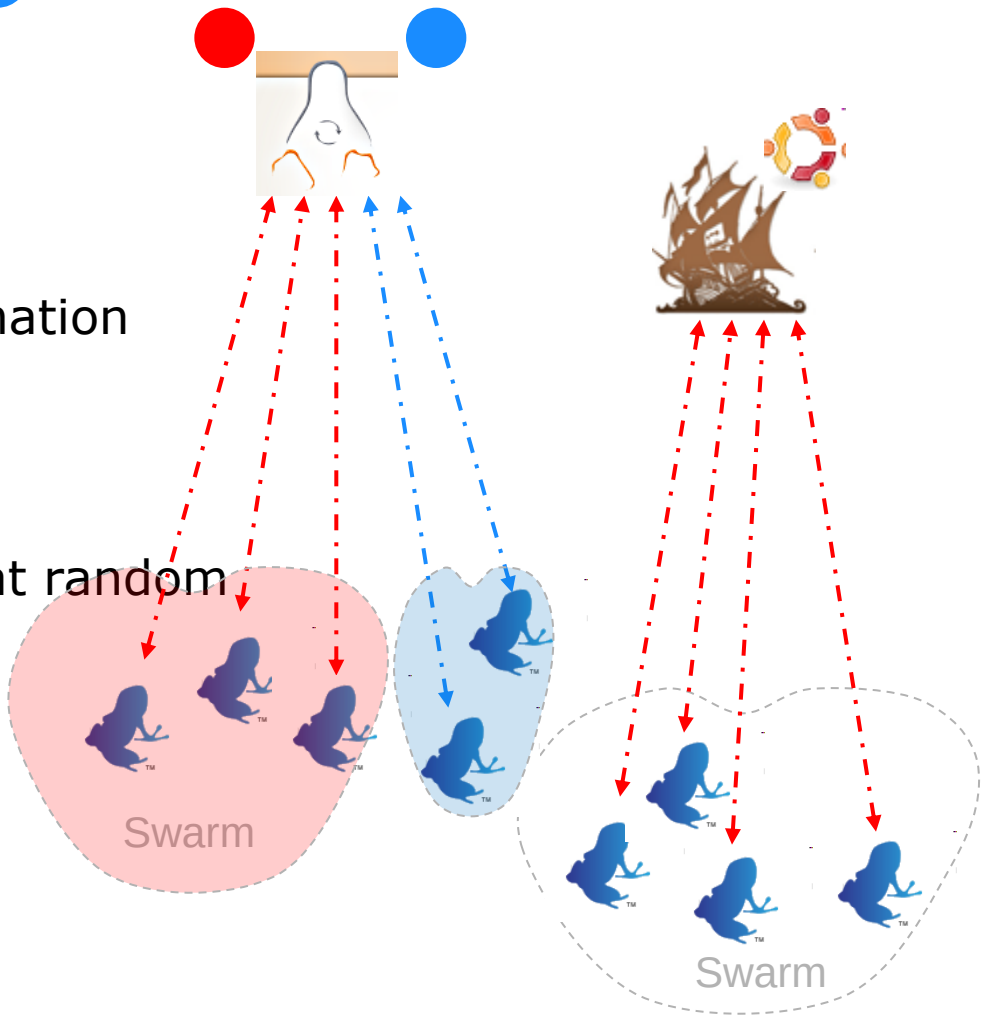
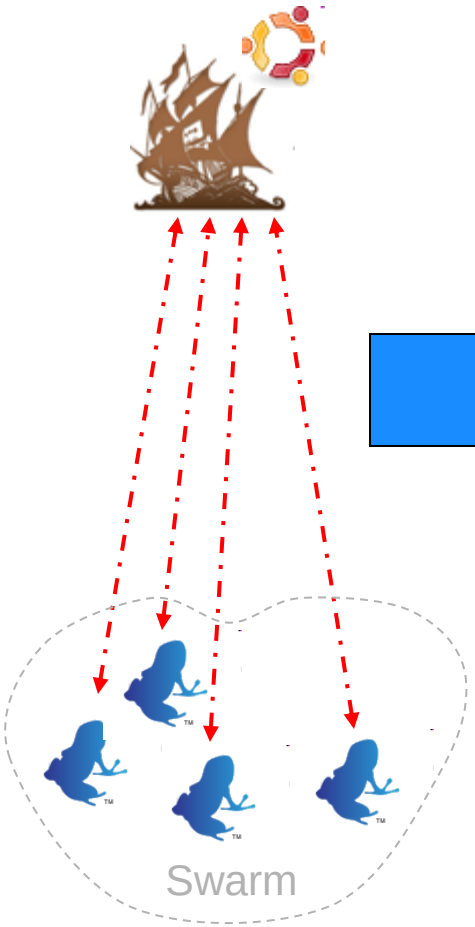


Contributions

- Longitudinal multi-torrent analysis
  - 48 weeks from two vantage points
- Capturing differences in dynamics observed locally and globally
  - University campus vs. global tracker-based
- Example observations
  - Campus users download larger files
  - Campus users early adopters (except music)
  - High popularity churn
  - Most popular content peak later

Measurement overview

Active + passive measurements

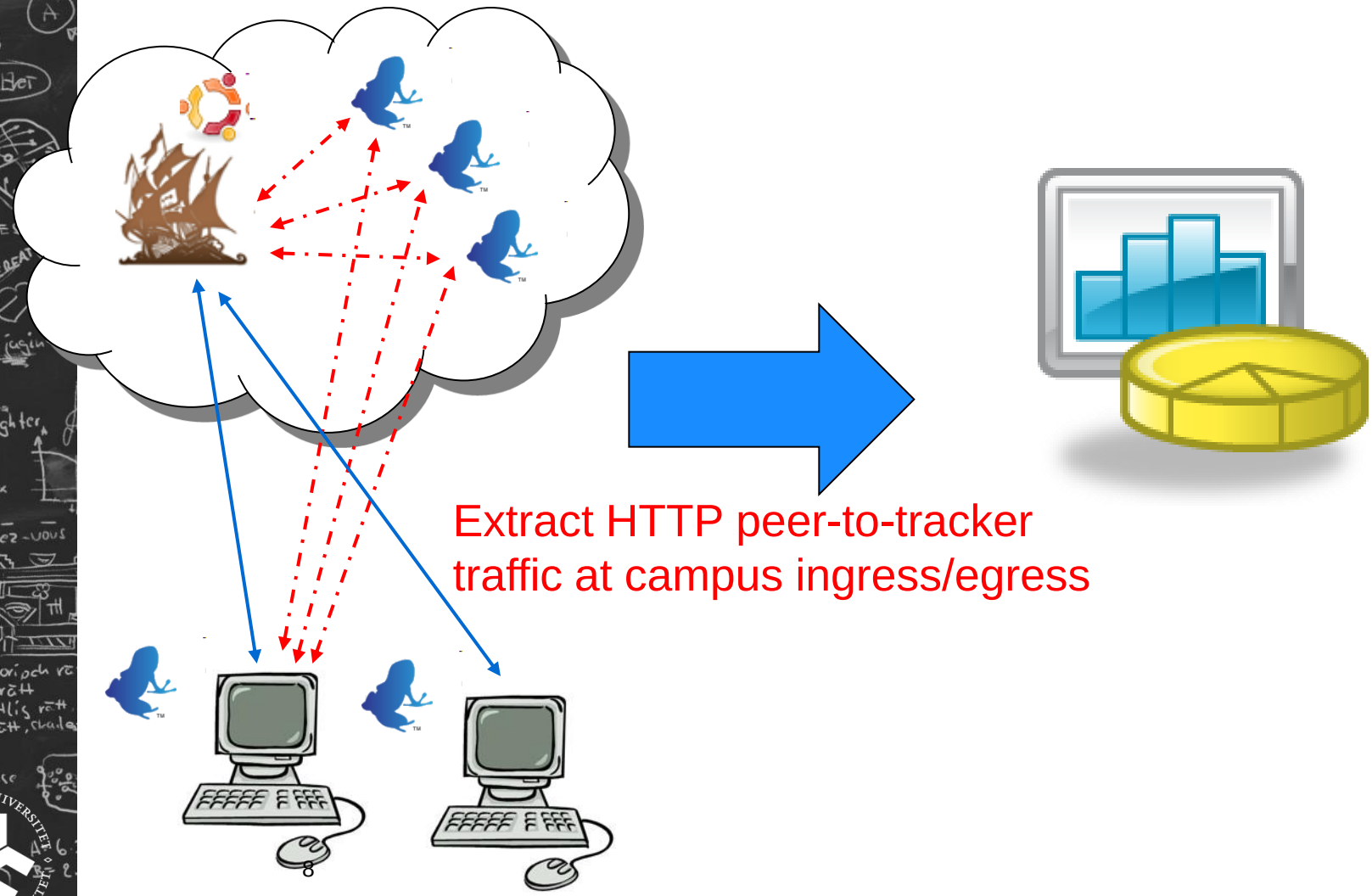


Popularity dynamics

- Longitudinal data
- Two vantage points
  - University campus (ingress/egress)
  - Global trackers

University: tracker communication

Passive measurements



Extract HTTP peer-to-tracker traffic at campus ingress/egress

University: tracker communication

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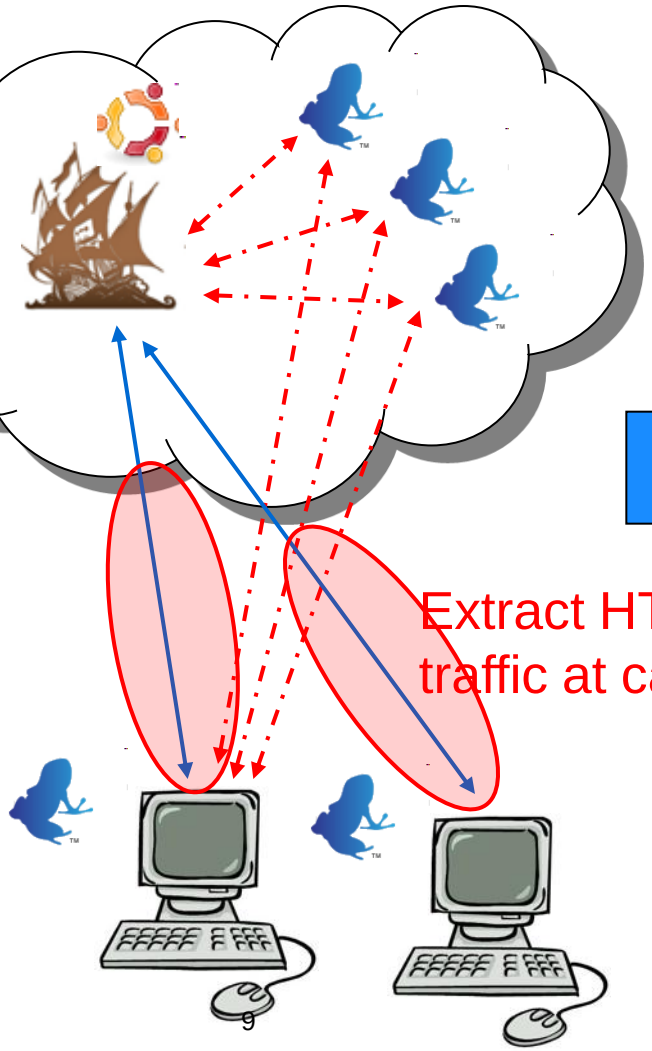

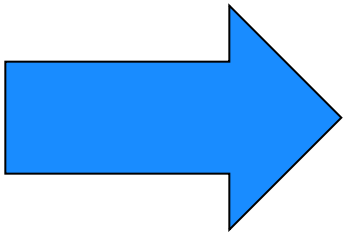

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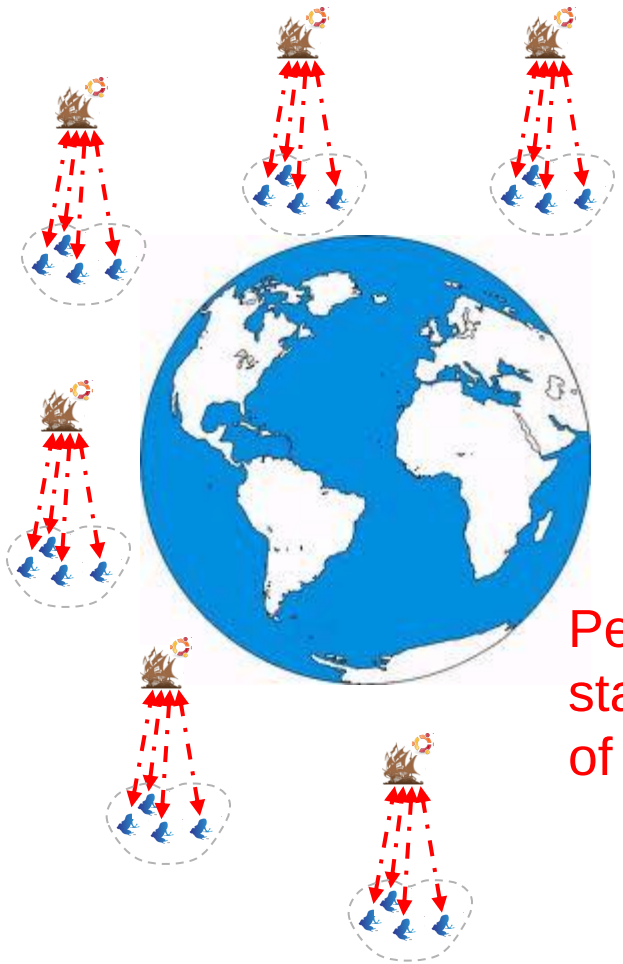
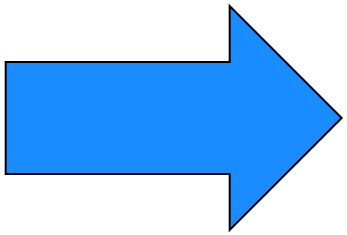
Global: Tracker scrapes

Active measurements





Periodically request the current state as observed at a large set of trackers

Global: Tracker scrapes

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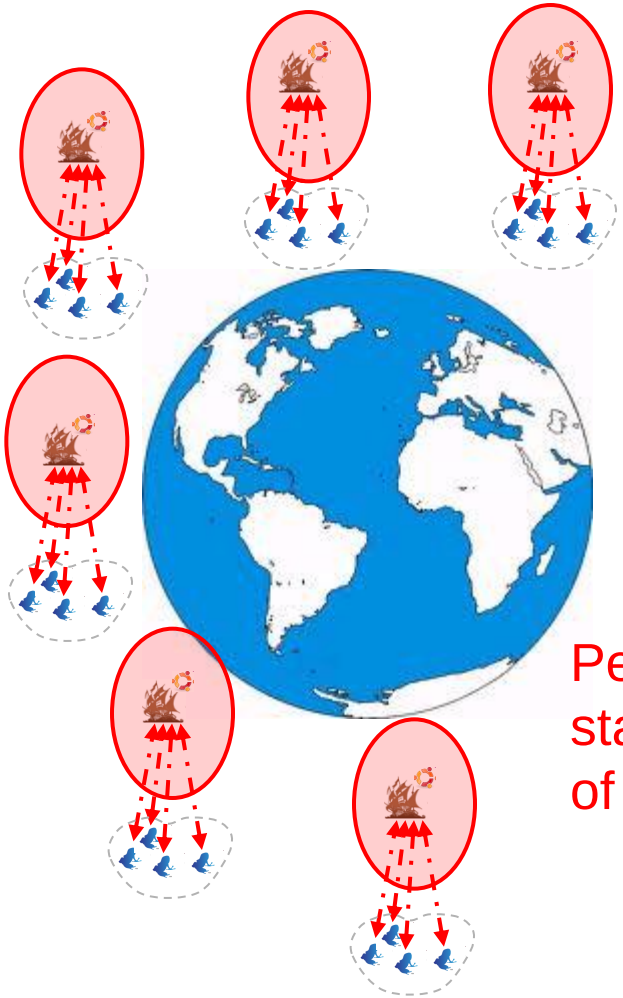

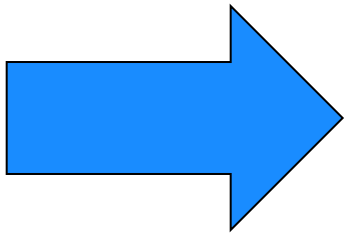

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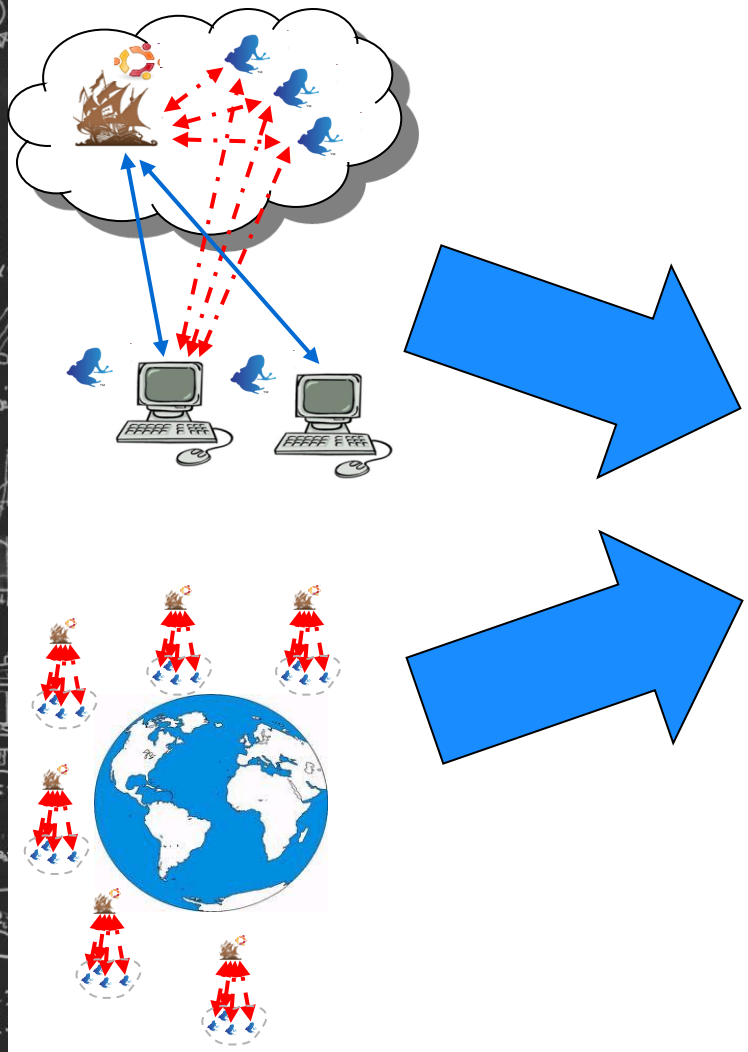
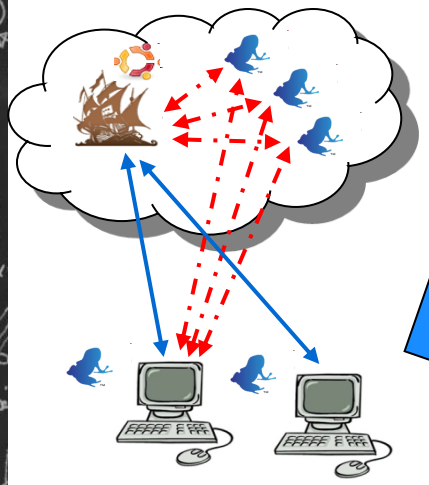
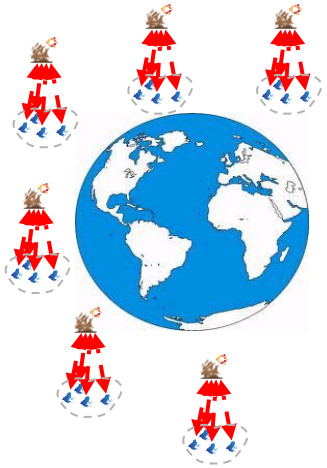
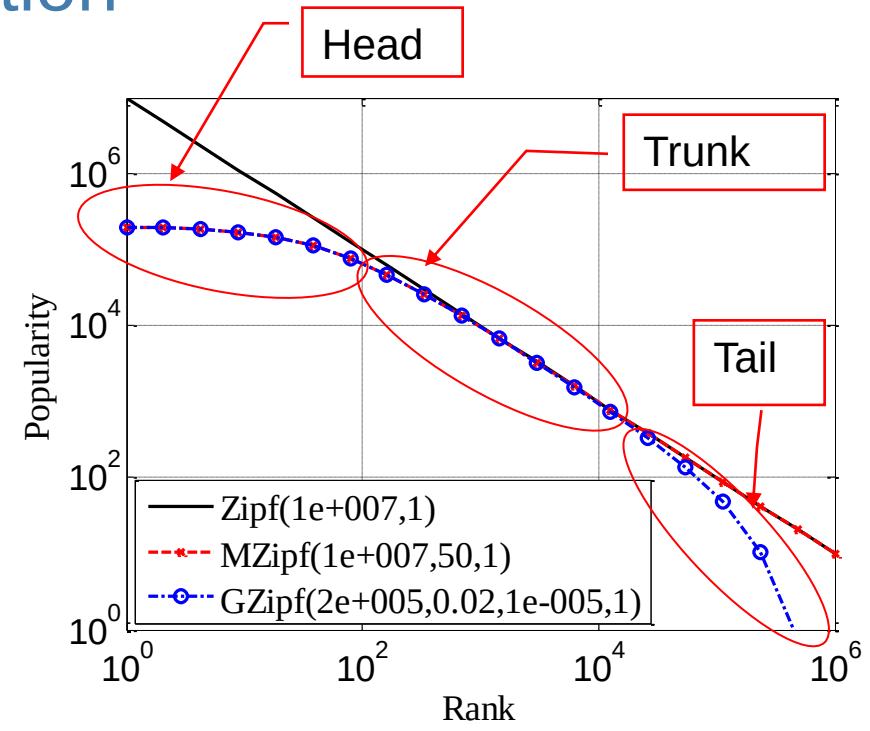


Popularity dynamics

Previous work
Popularity distribution







E.g., Dan & Carlsson [IPTPS 2010]

- Popularity distribution statistics
  - Over lifetime
  - Over different time period
  - Different sampling methods

Summary of datasets

Property	University	Global	Mininova
Trackers	2,371	721	1,690
Torrents	56,963	11.2 M	911,687
Downloads	1.73 M	37.0 B	--
HTTP requests	249 M	--	--
Start date	Sep. 15, 2008	Sep. 15, 2008	Sep., 2008
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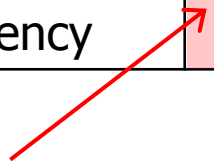

- 48 weeks of overlapping longitudinal data

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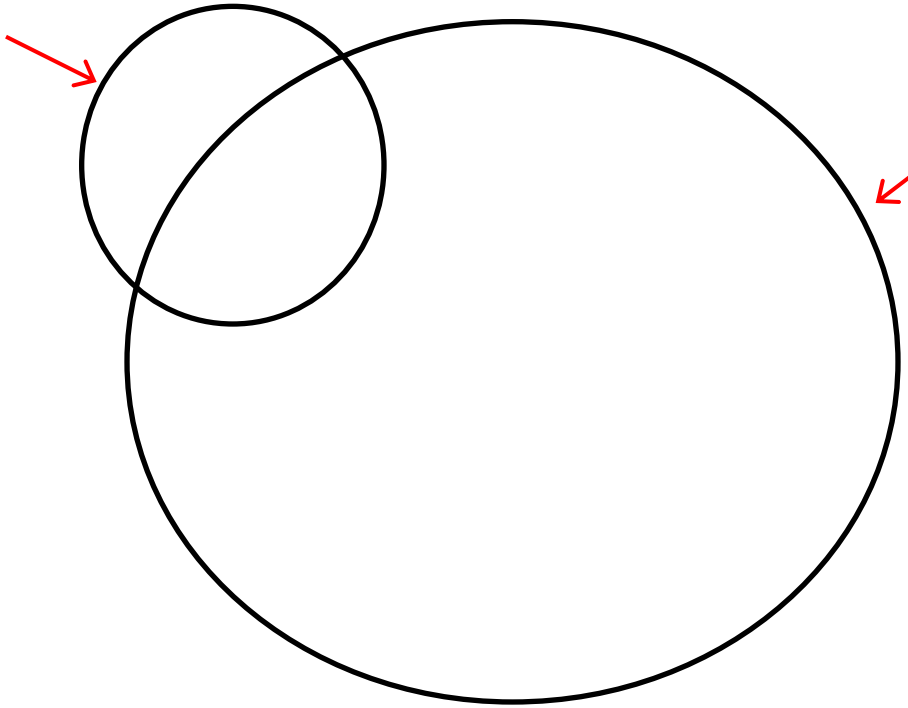
- Many torrents (and downloads) …

Dataset summary

Torrents observed

UNIVERSITY OF CALGARY

56,963



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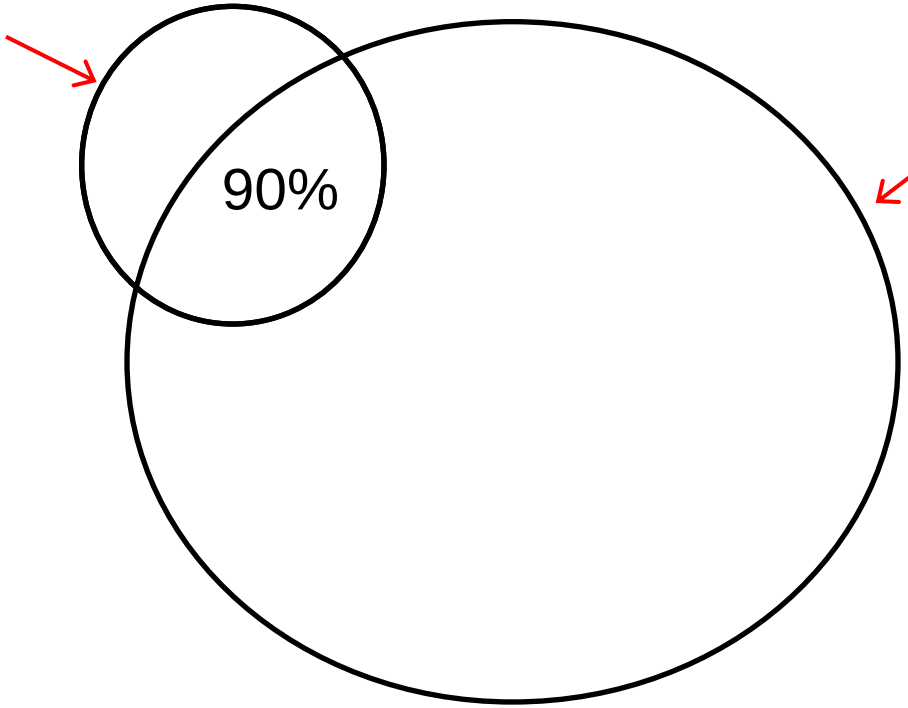

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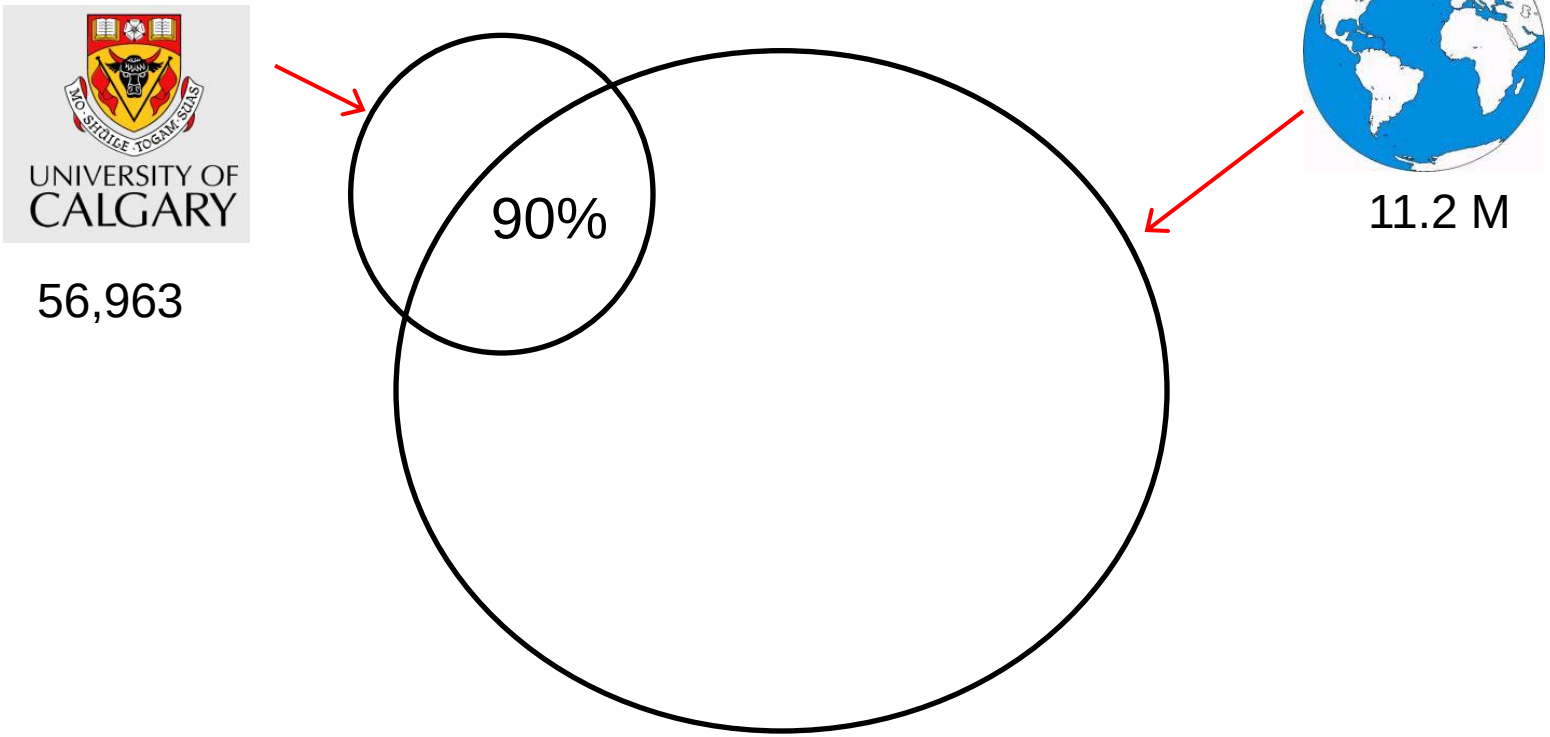

- Most of the files observed locally are also observed in the global dataset

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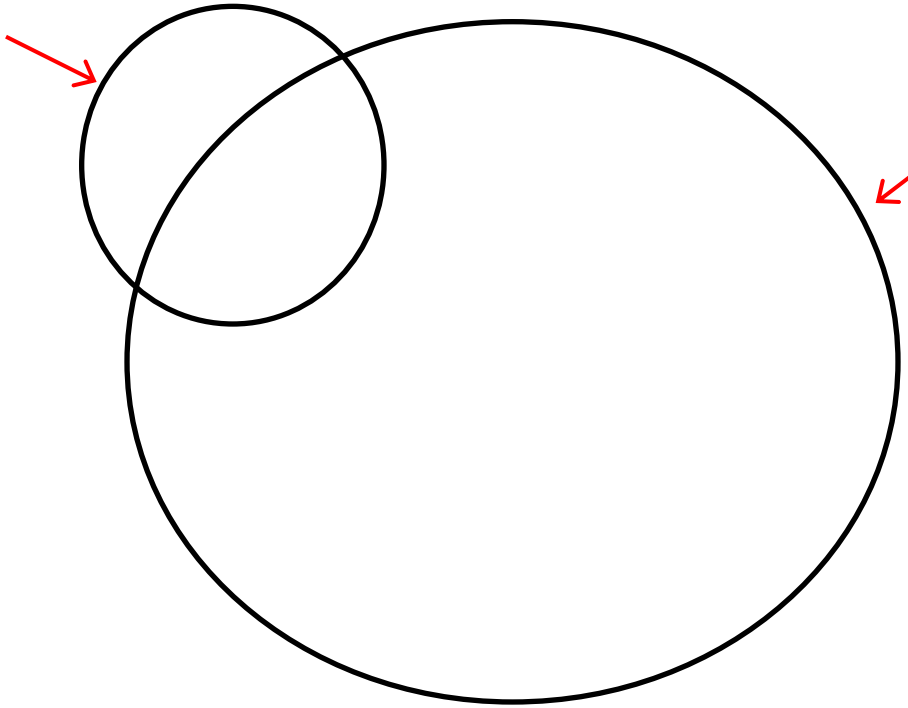

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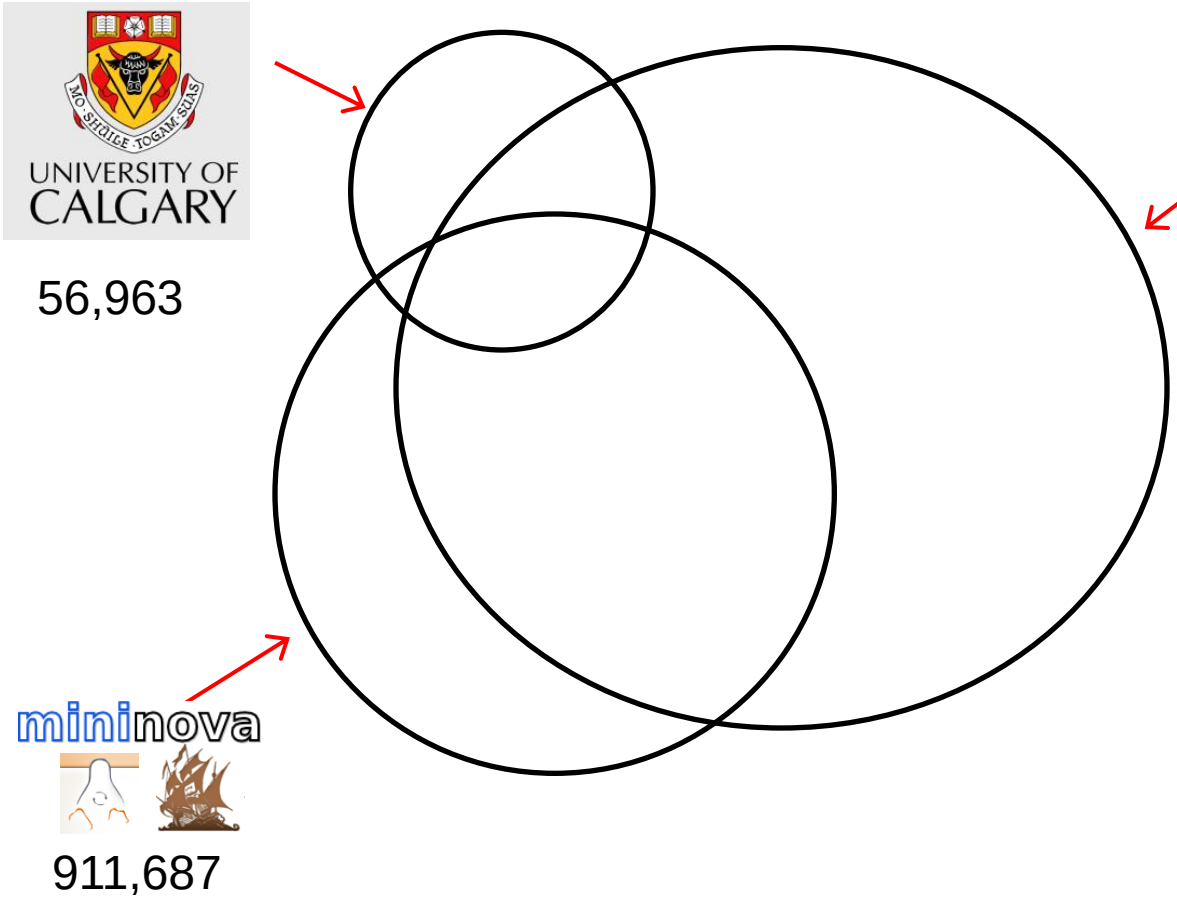

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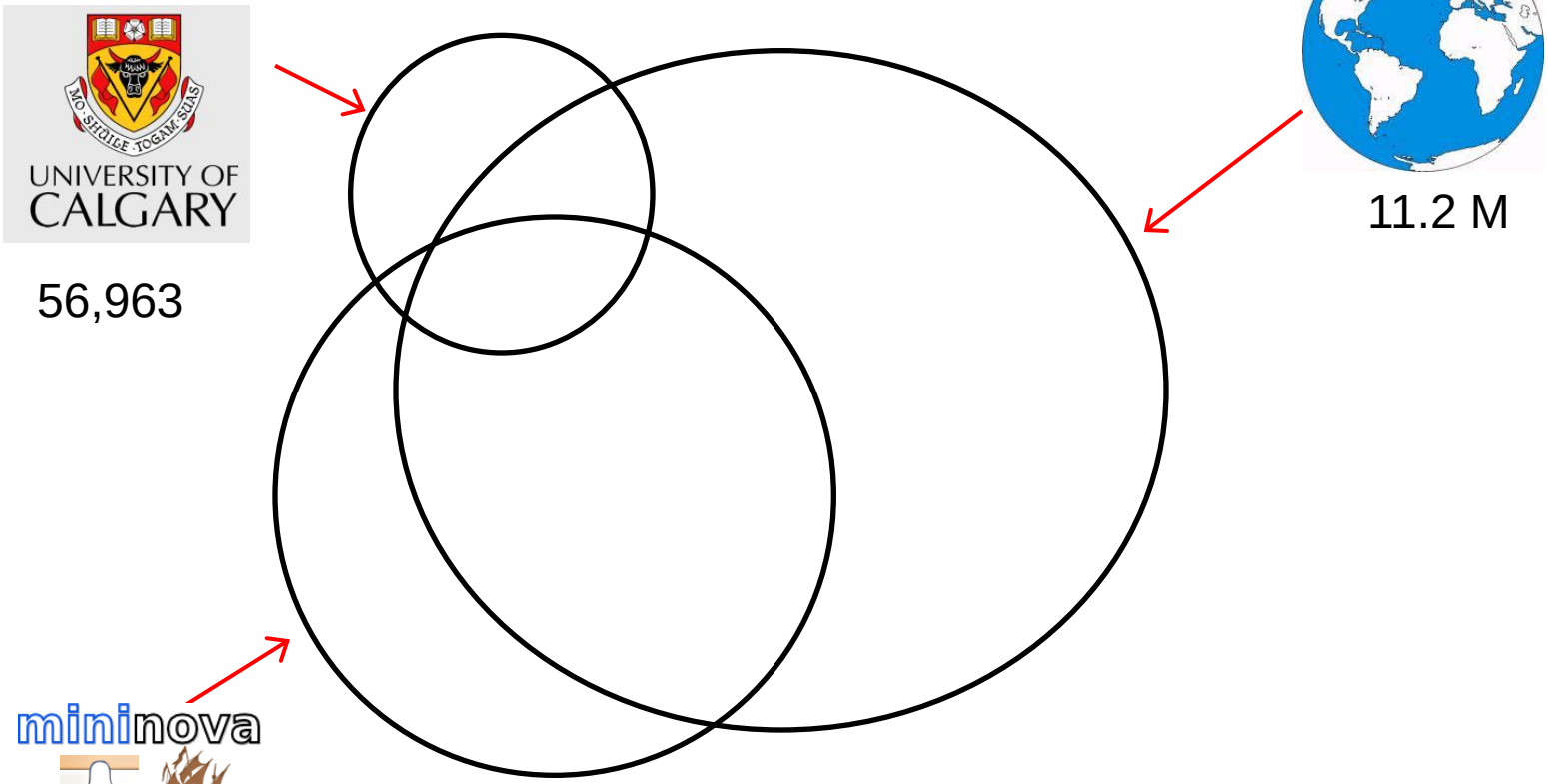

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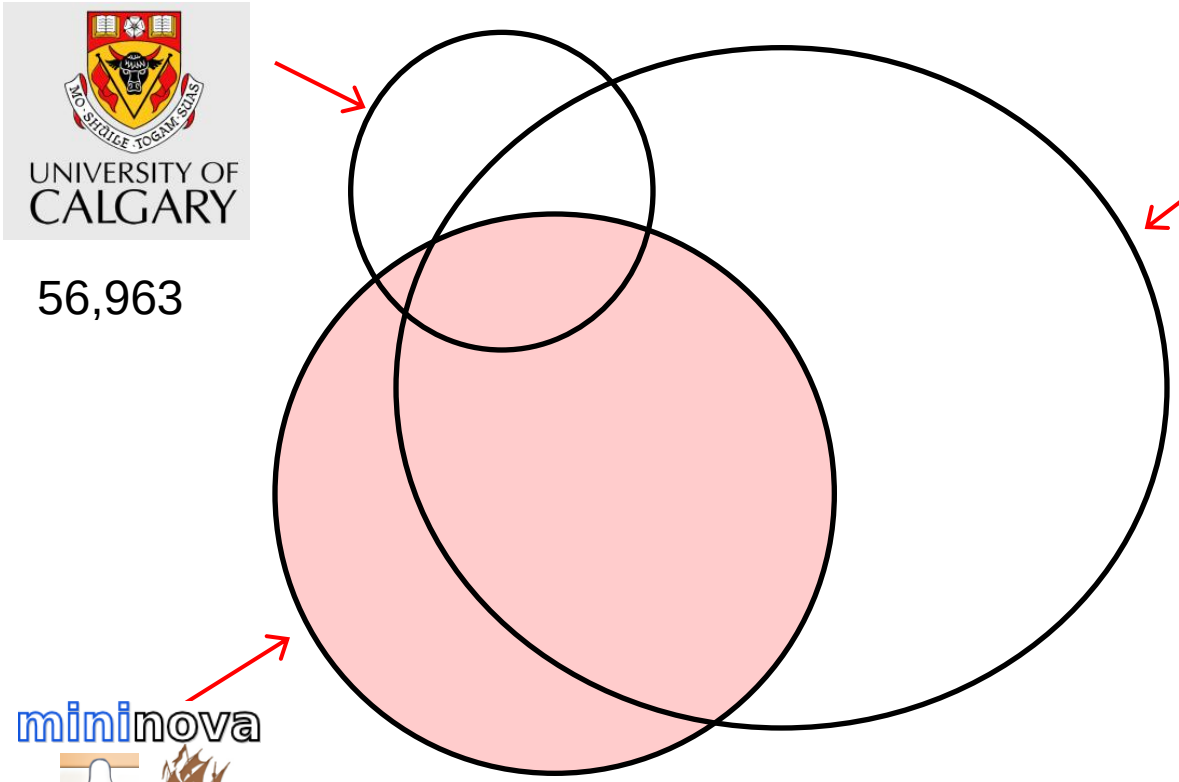

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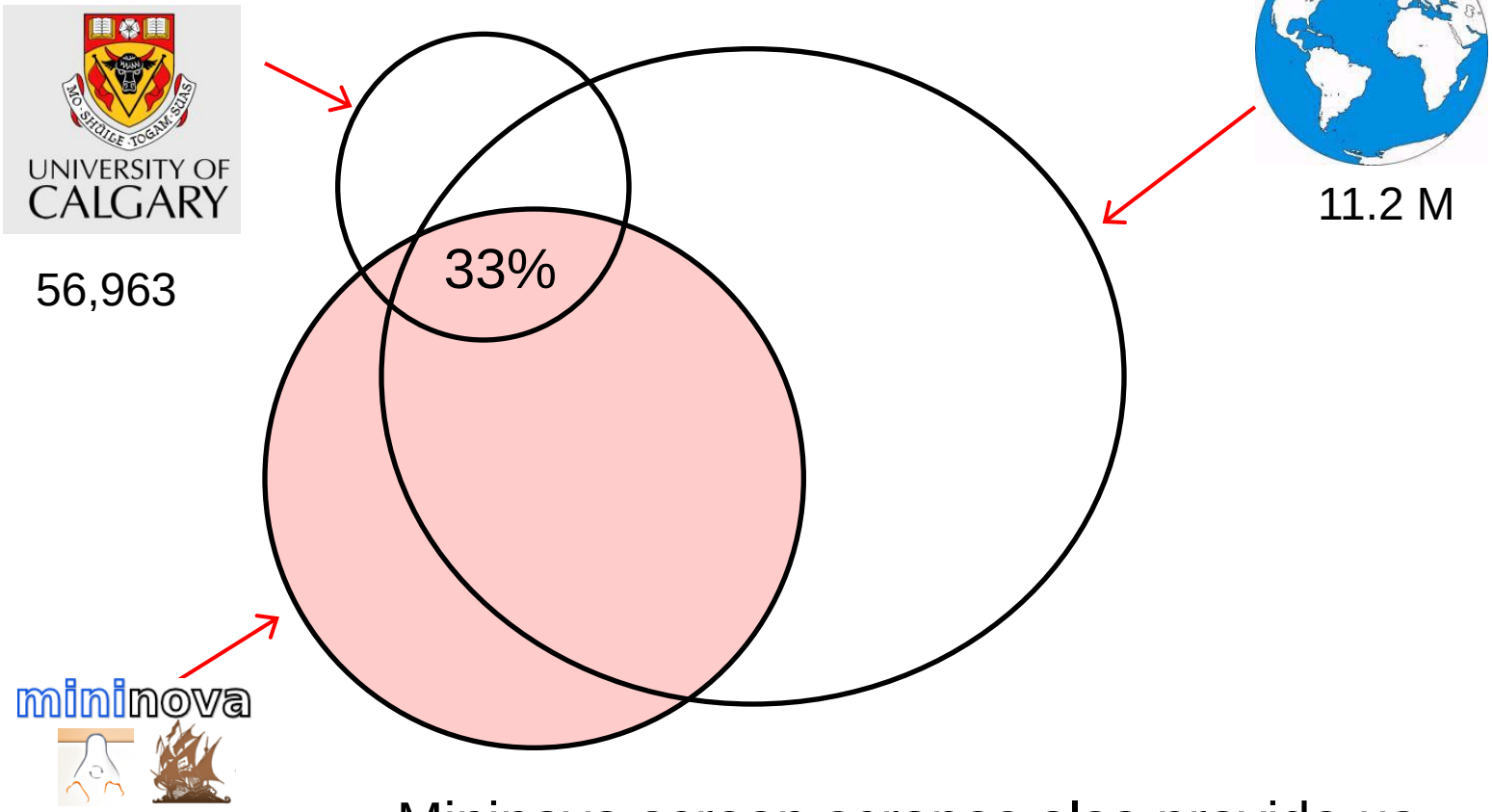

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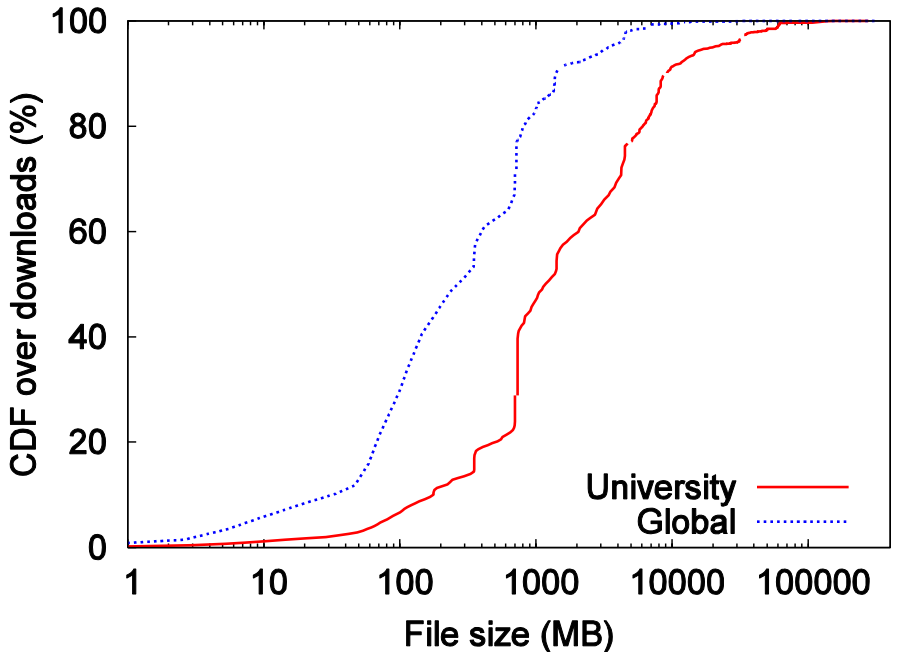
Content download characteristics

File size distribution, per download



- Campus users download larger files

Content download characteristics

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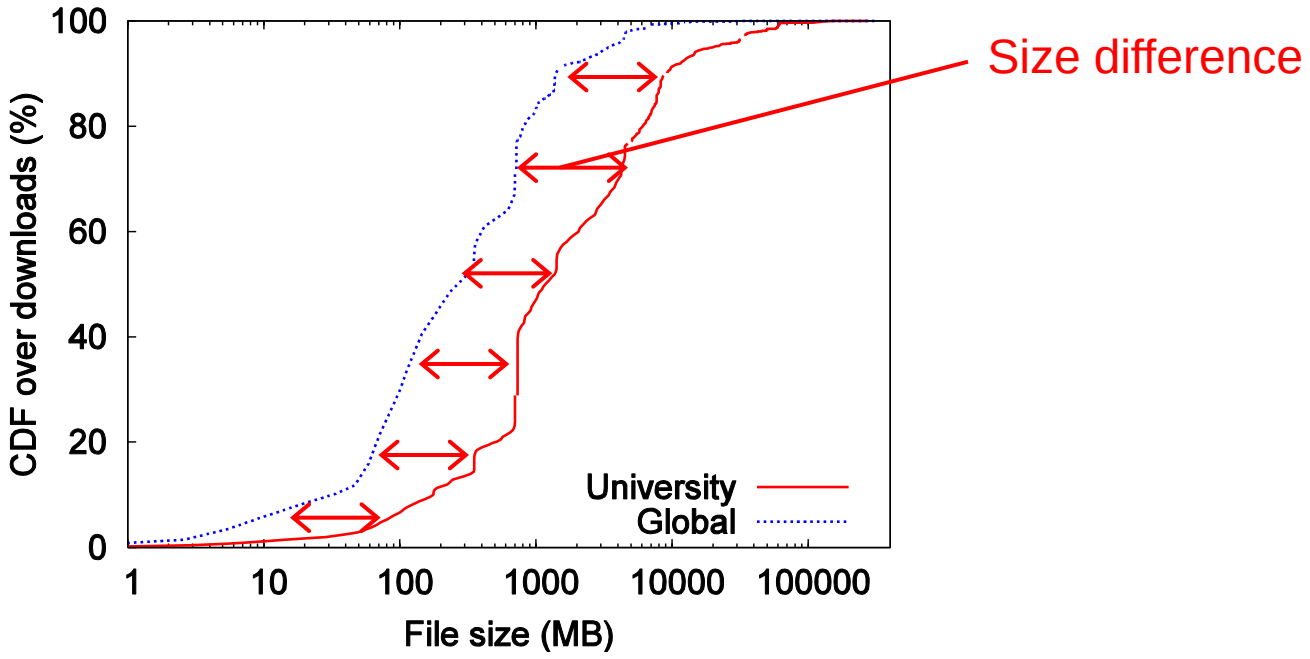

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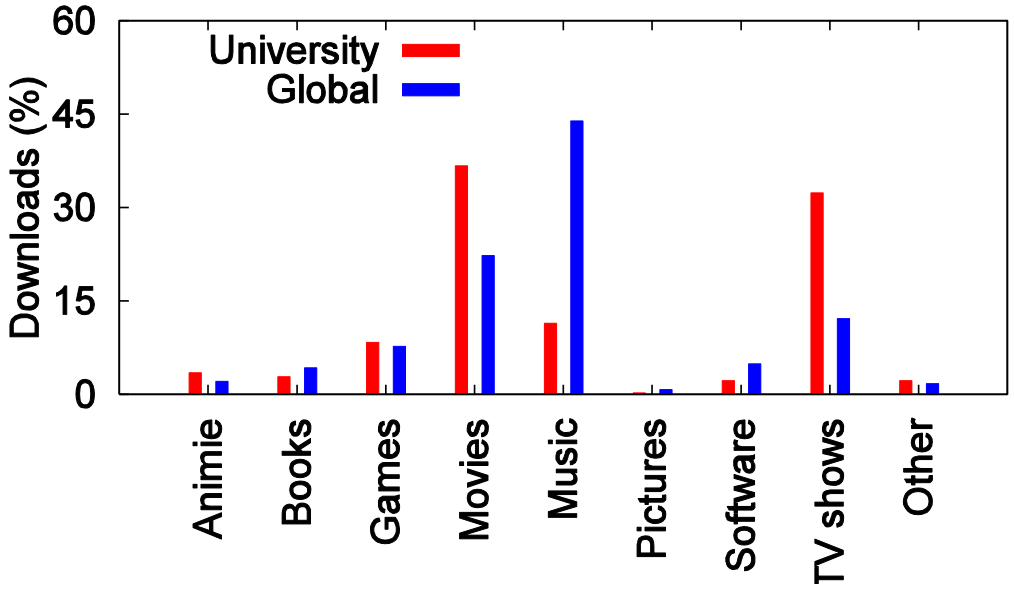
Content download characteristics
Breakdown per category



- Campus users download
  - More movies and TV shows
  - Less music

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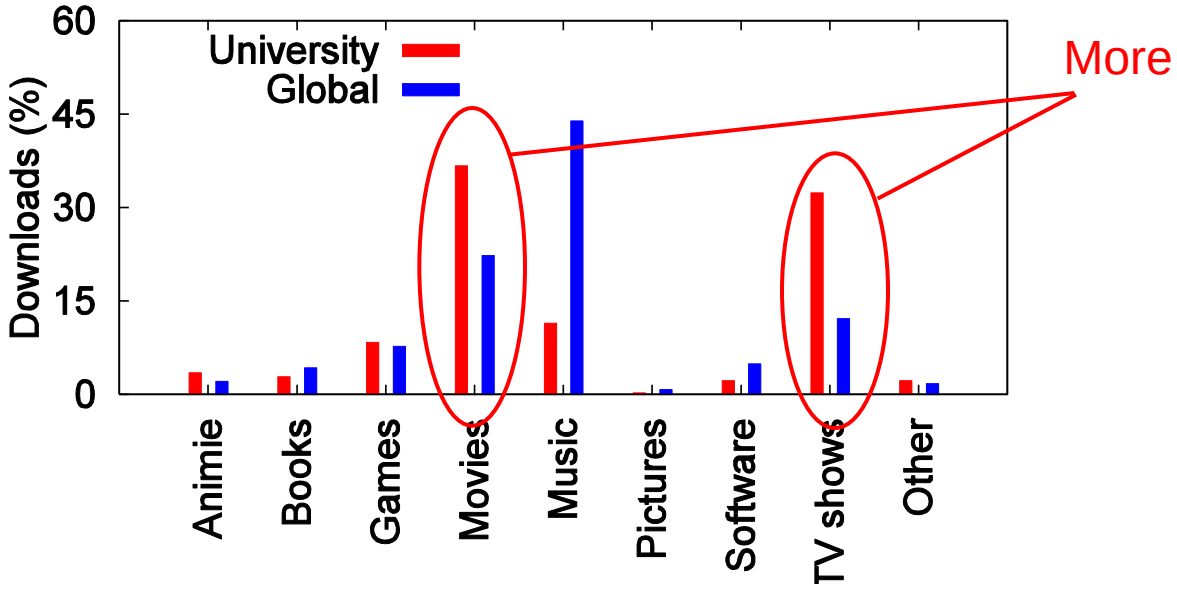

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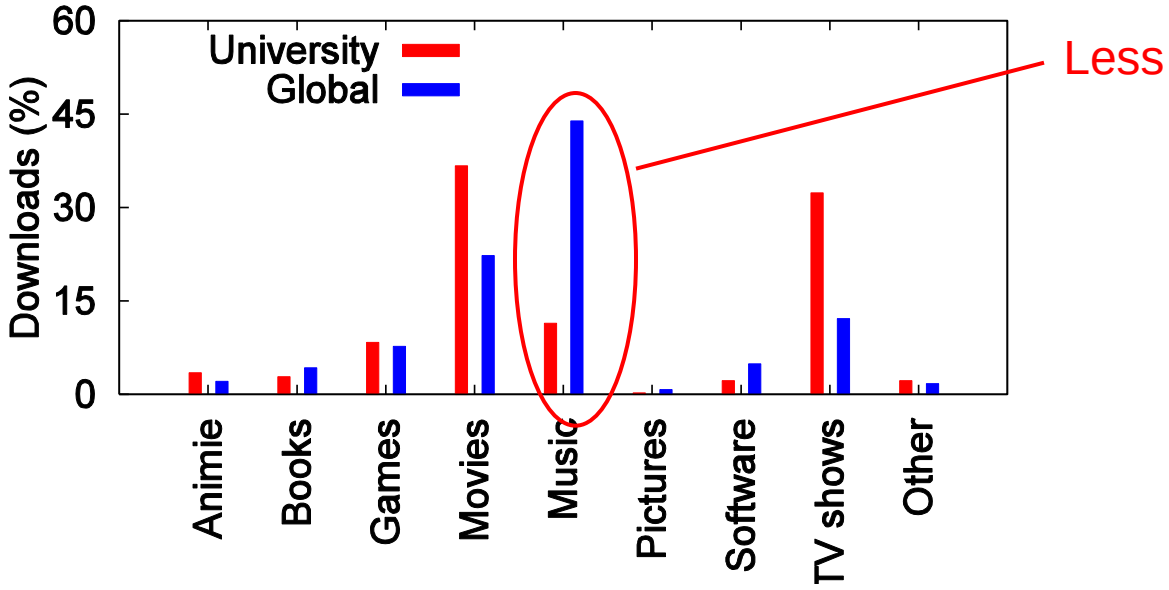

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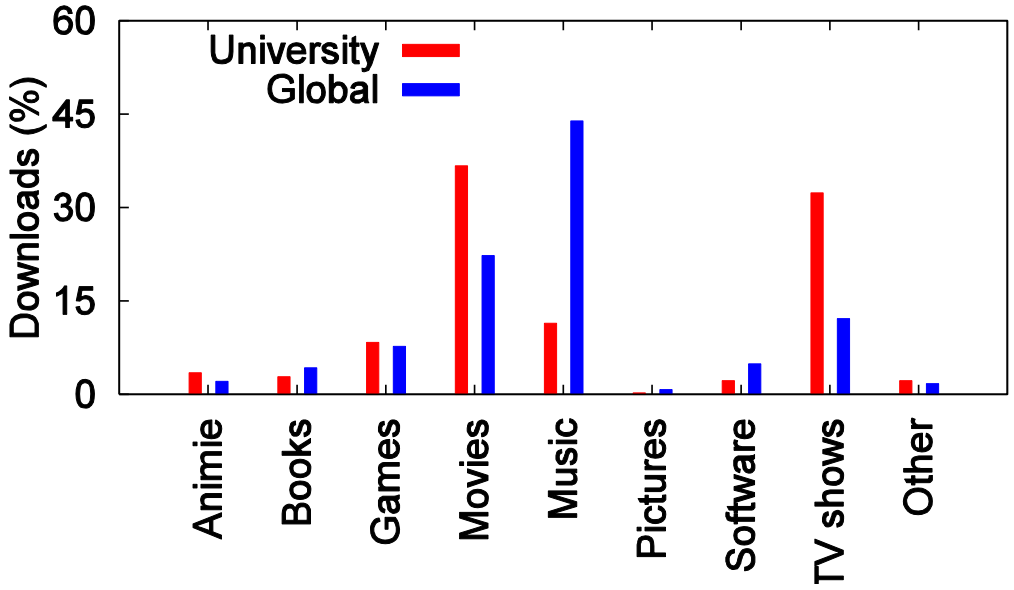

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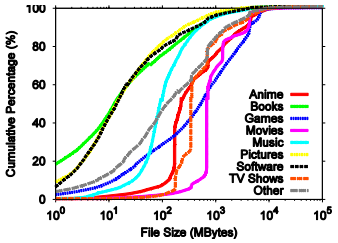
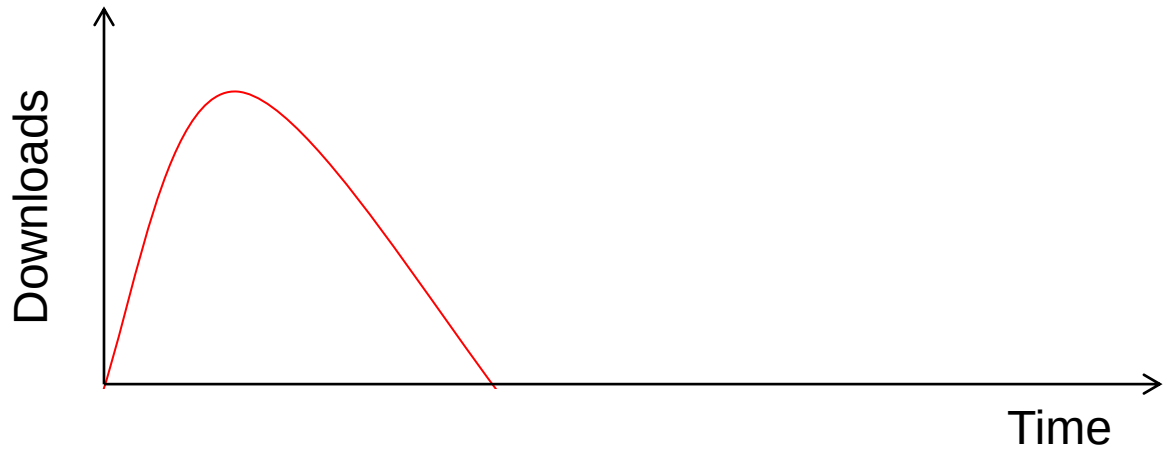
- Again, biased towards larger contents ...



Early adopters
Terminology



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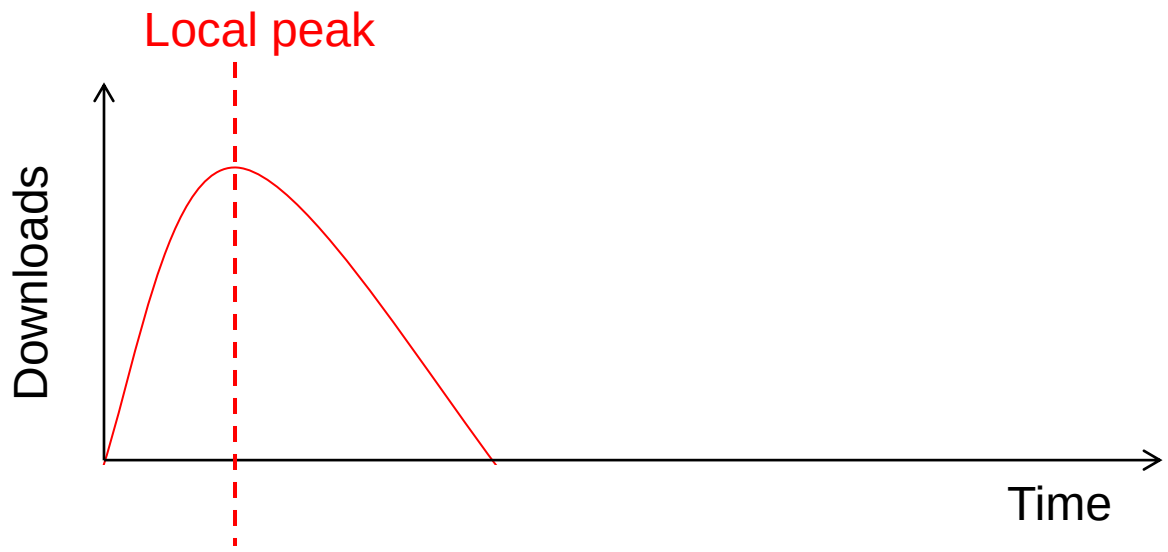

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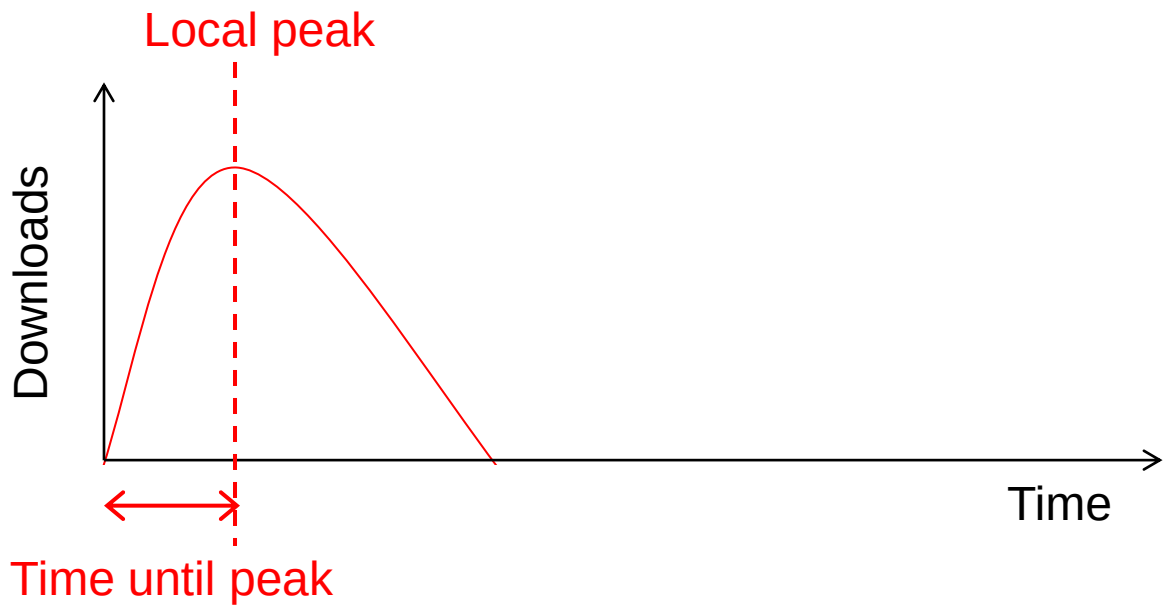

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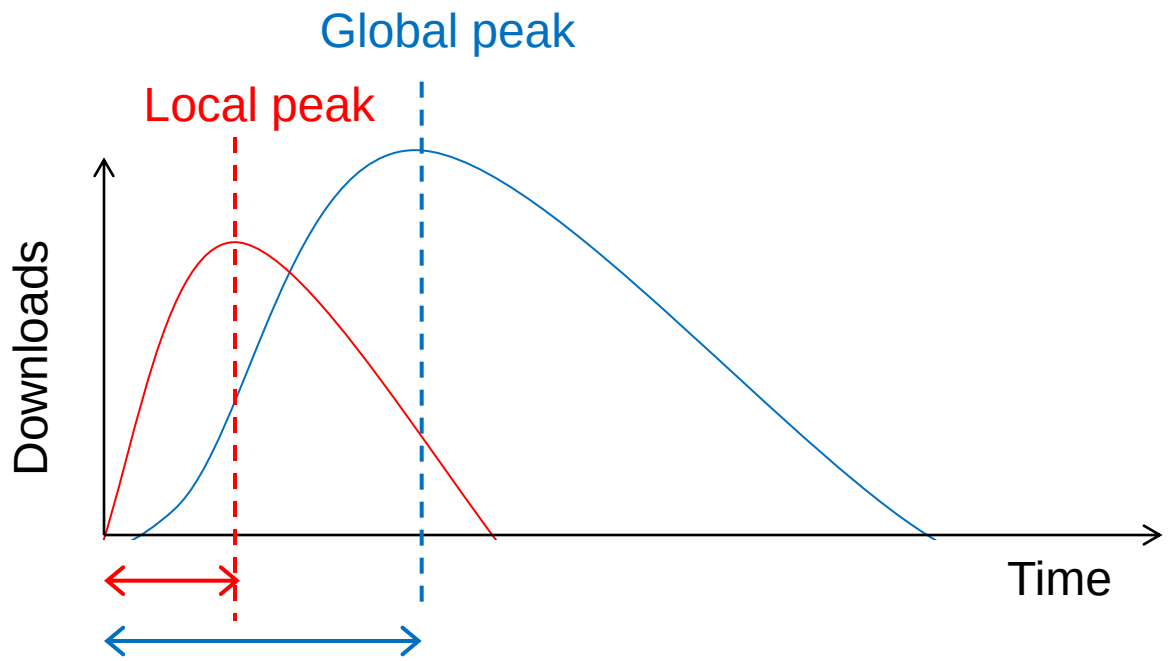

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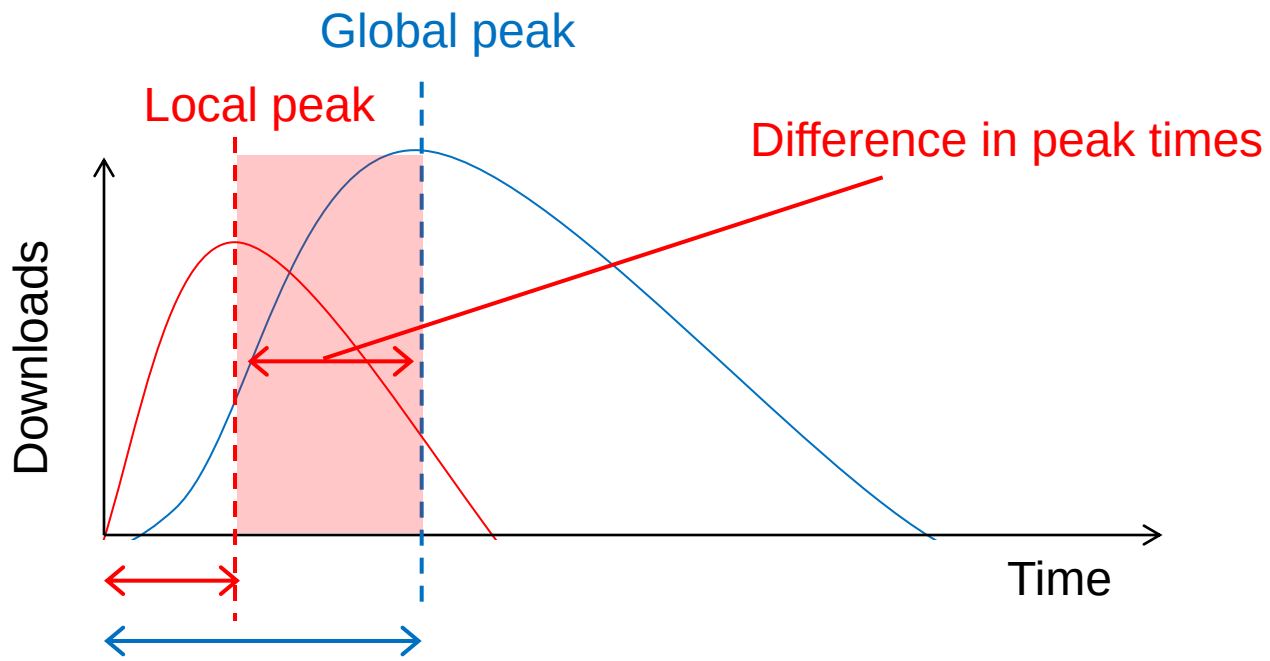

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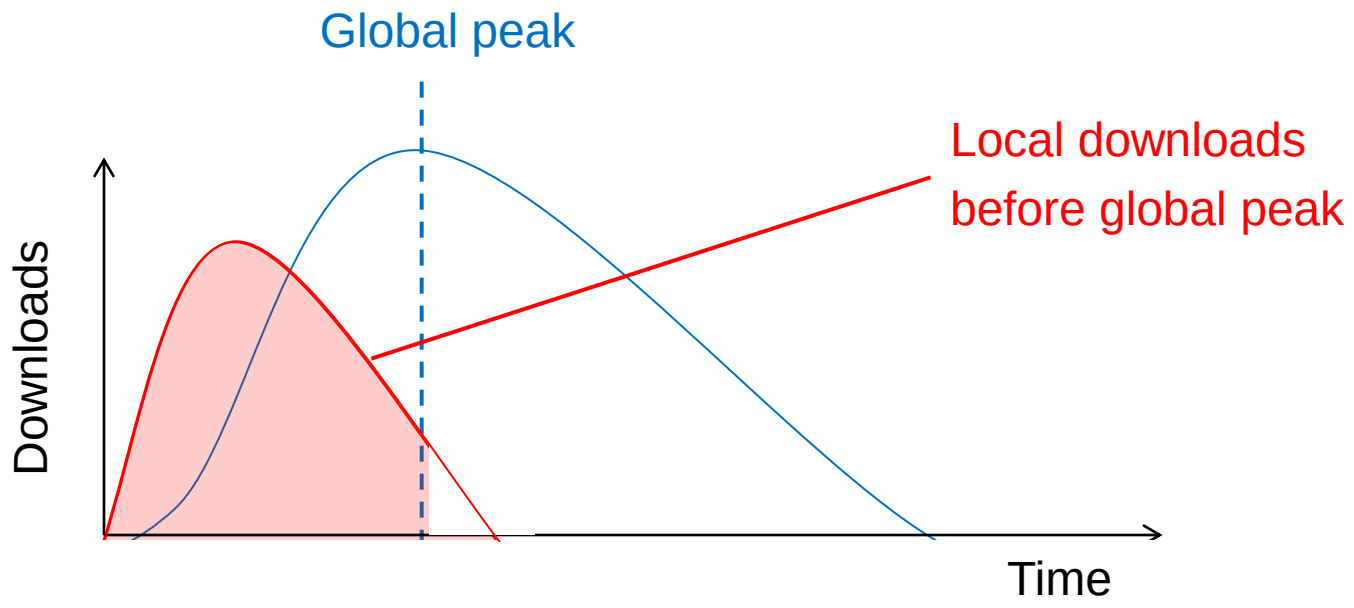
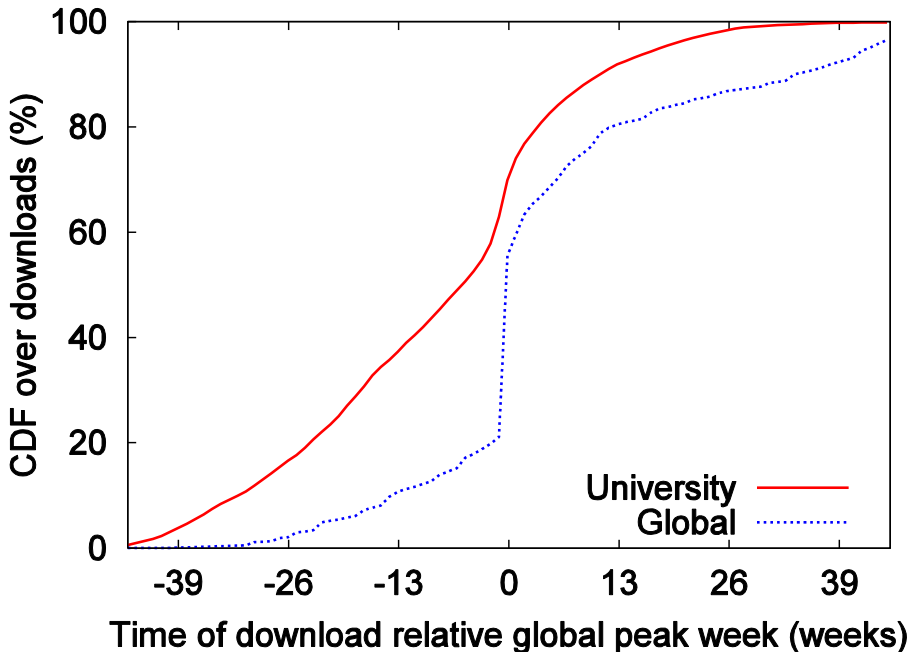


Early adopters

Downloads relative to global peak



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  - 70% of downloads before global peak
  - 40% of downloads at least 10 weeks before global peak

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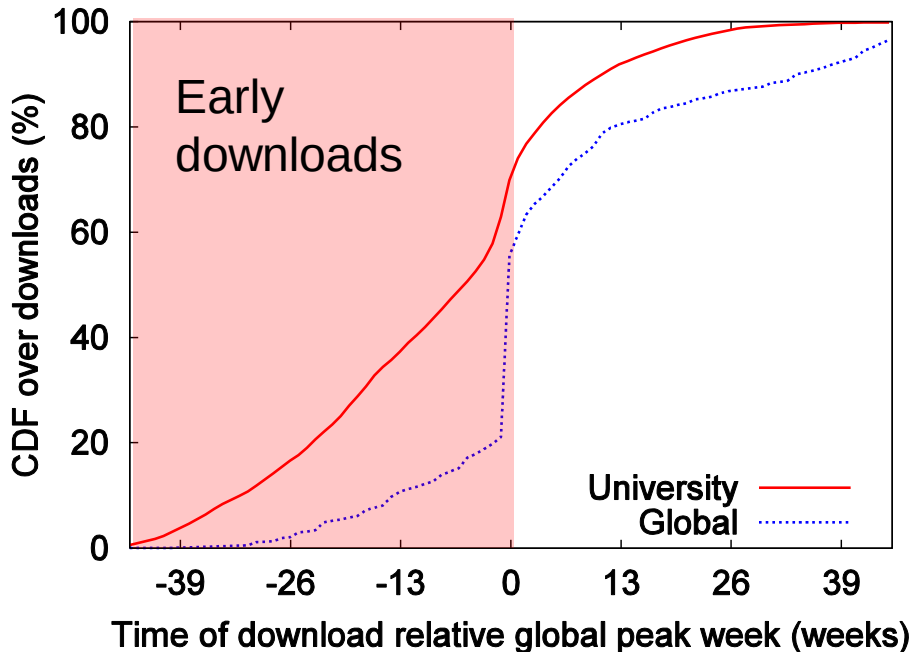

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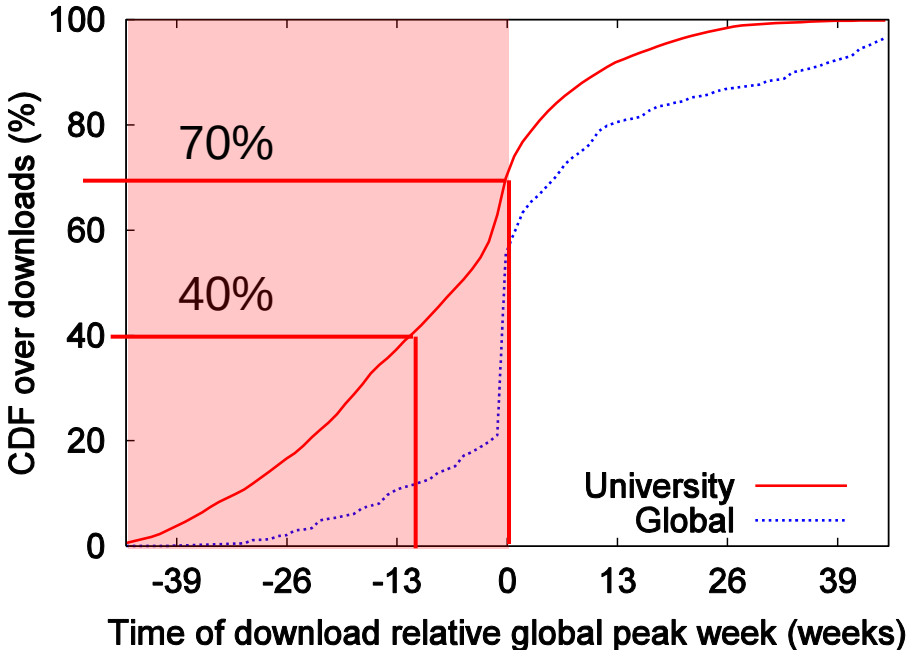

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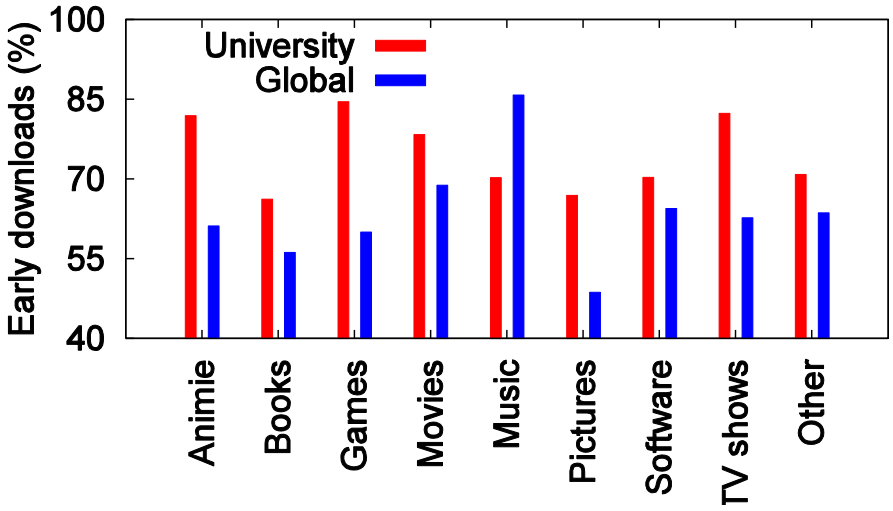

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- Perhaps campus users can be used to predict some future popularity ...
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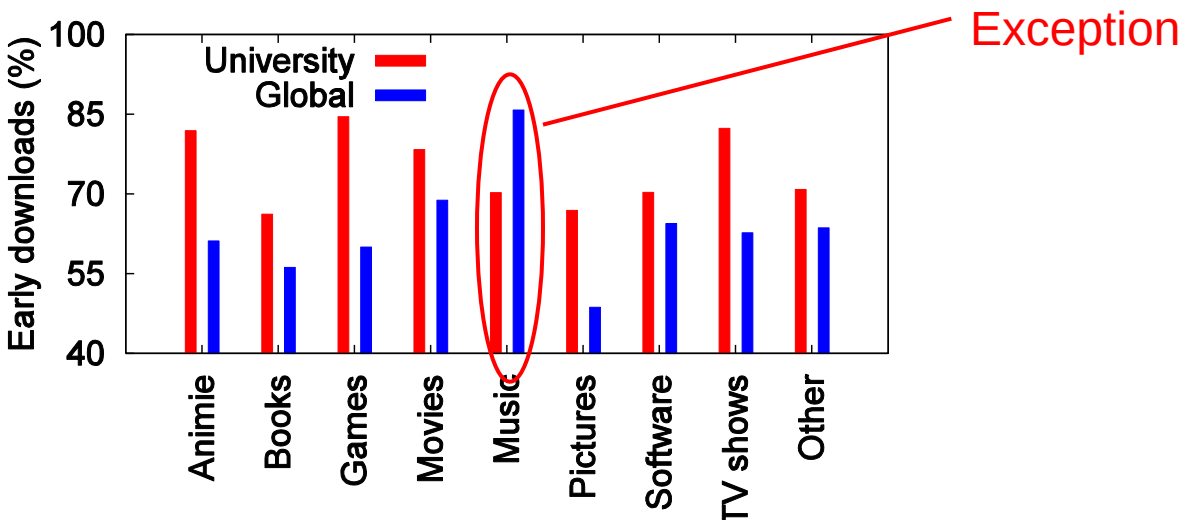

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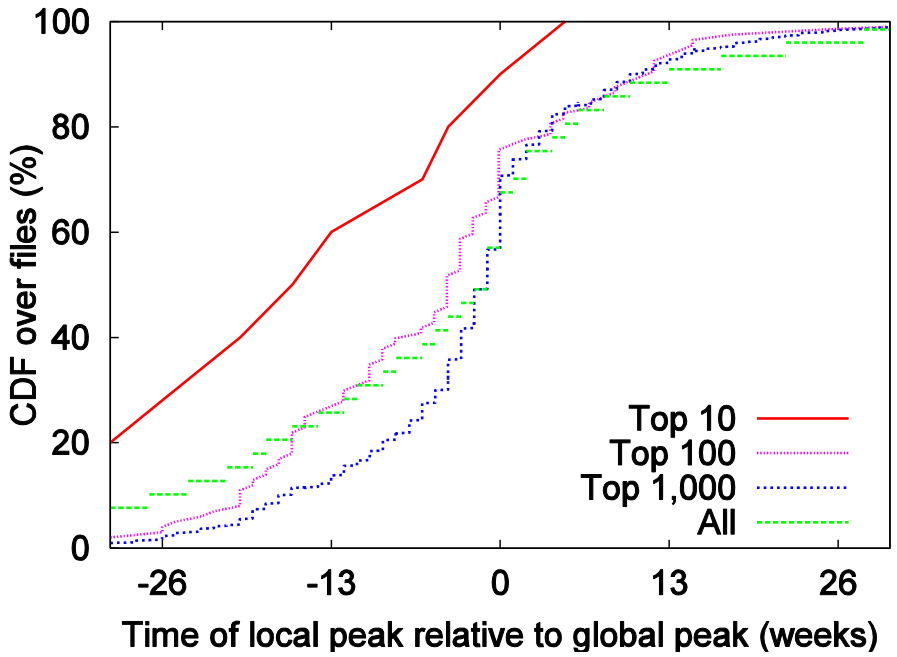

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  - As well as for some niche content ...

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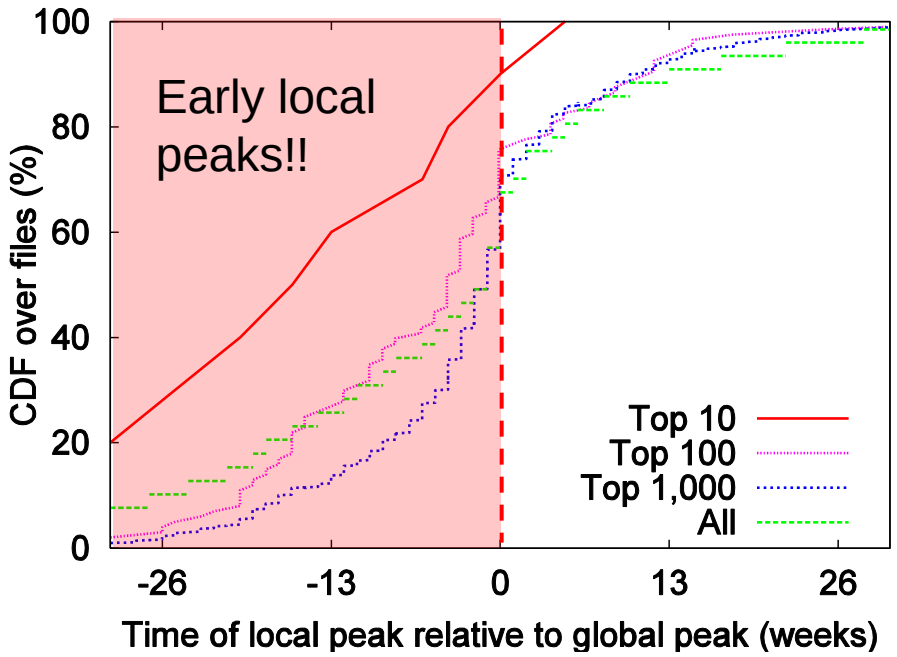

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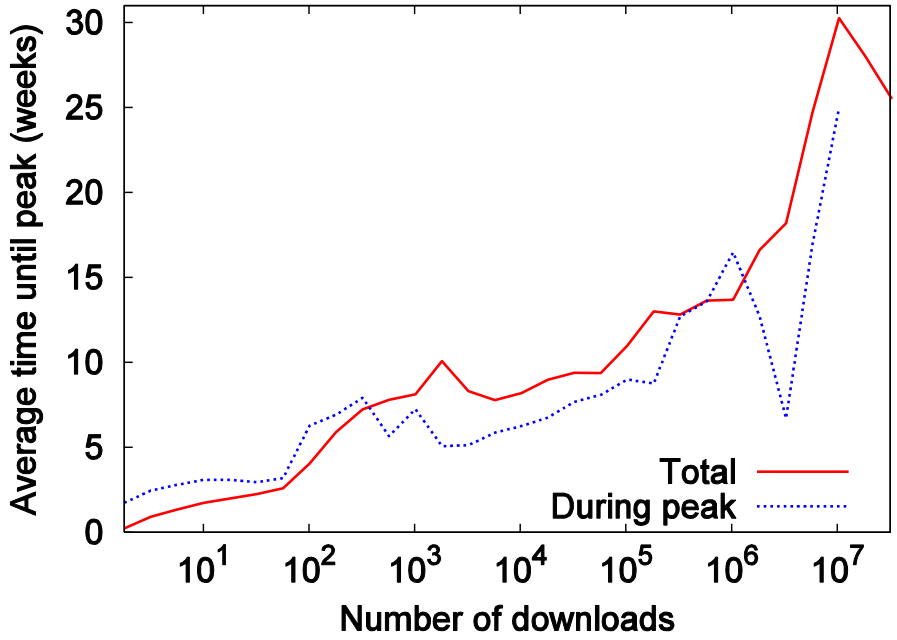
Time until peak

Global popularity peaks ...



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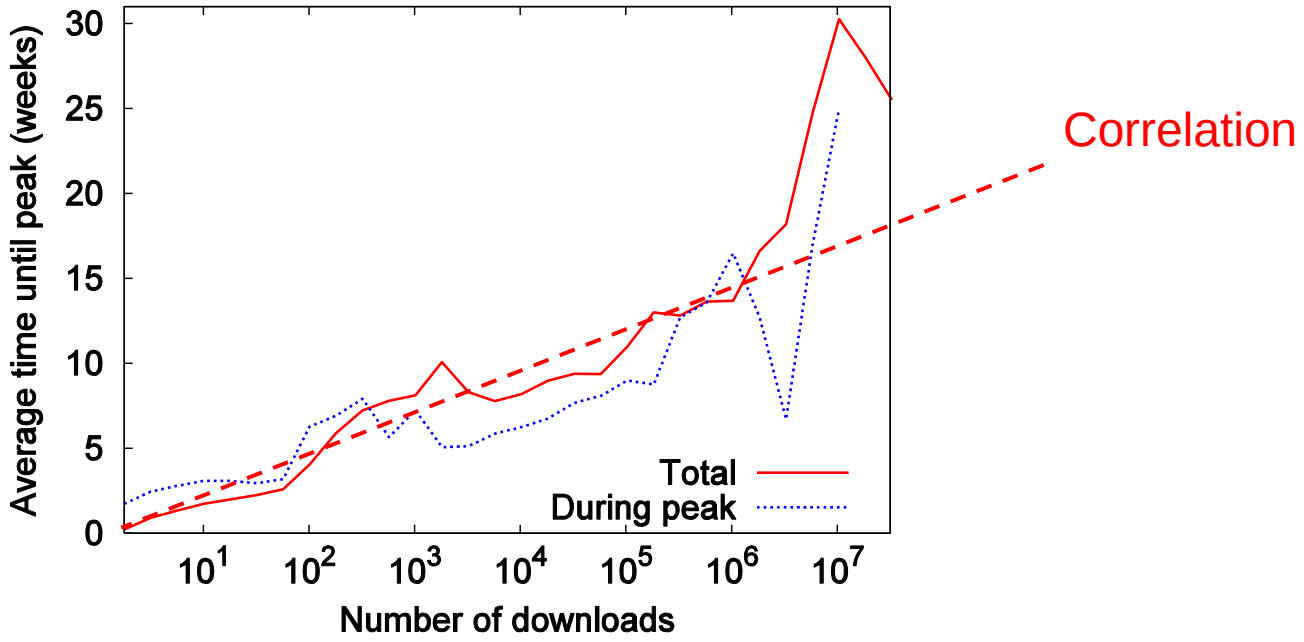
  - Early flash crowds do not dominate the popularity
  - Perhaps a sign that rich-gets-richer a better model ...

Time until peak

Global popularity peaks ...



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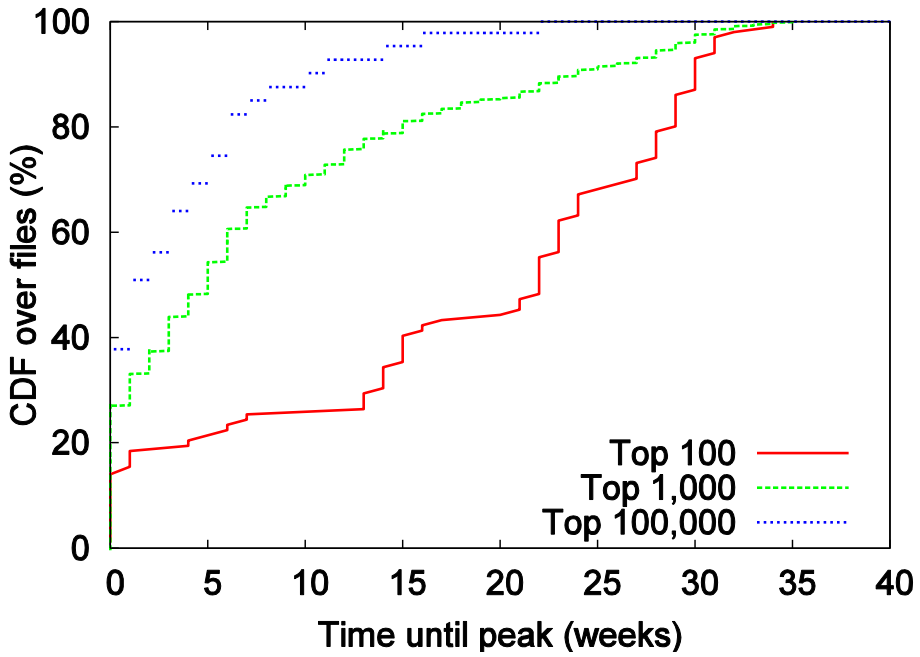
Time until peak

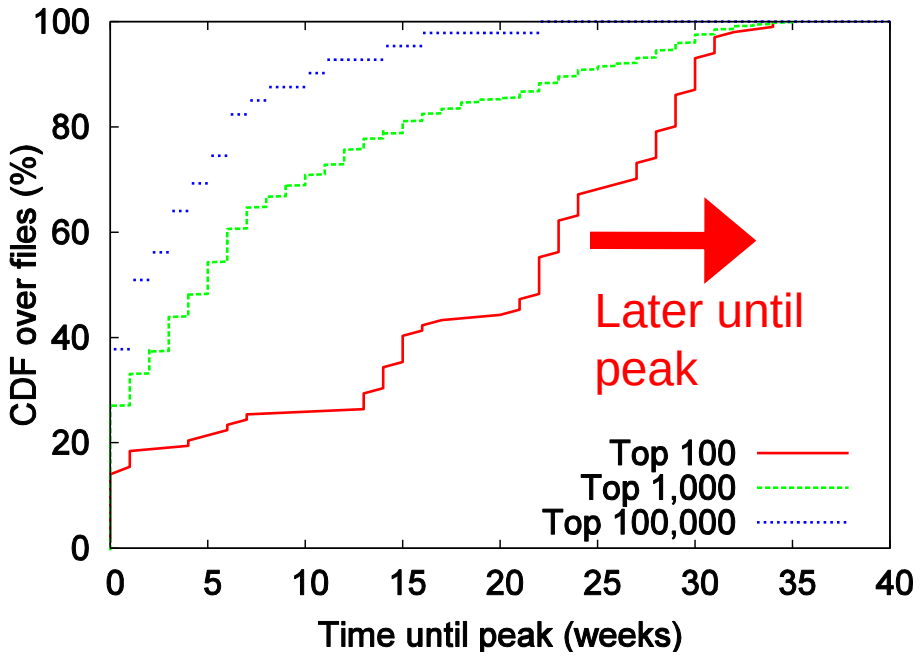
Global popularity peaks ...



- The more popular the content
  - The later it peaks ...

Time until peak

Global popularity peaks ...



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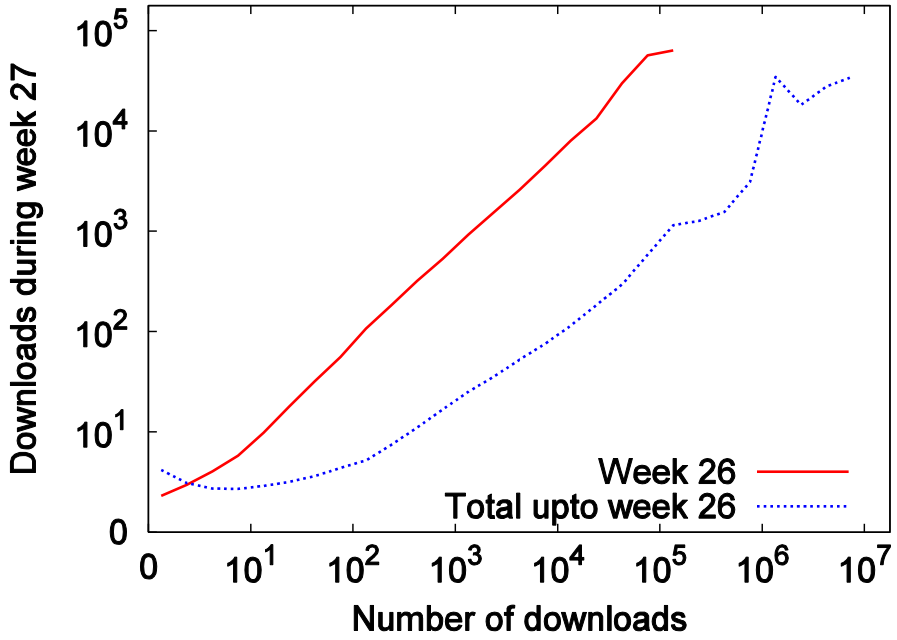
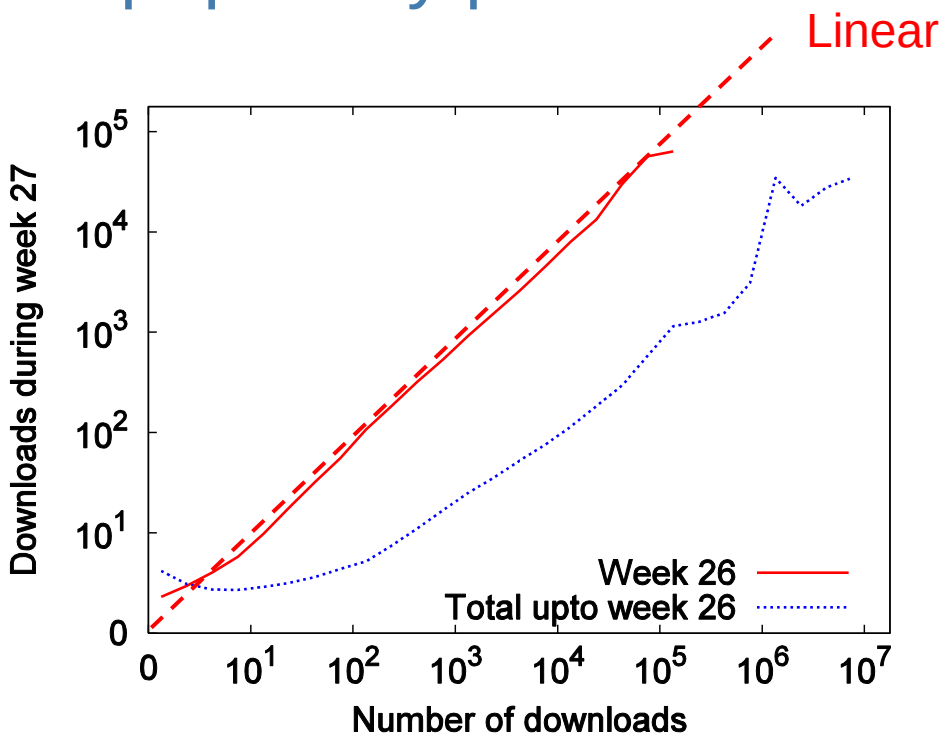


- Rich-gets-richer
  - Close to linear from week-to-week
  - Cumulative total downloads show weaker (sub-linear) rich-gets-richer behavior

Time until peak

Global popularity peaks ...



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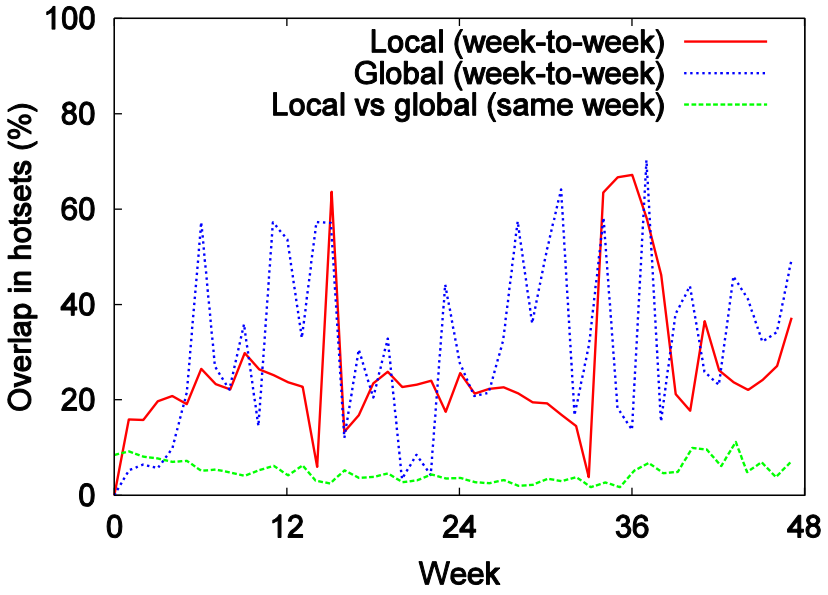
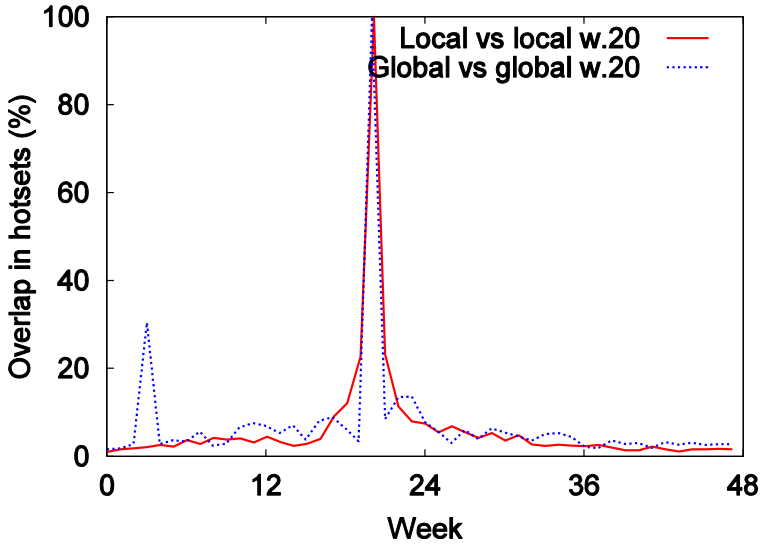
Hotset analysis

Popularity churn

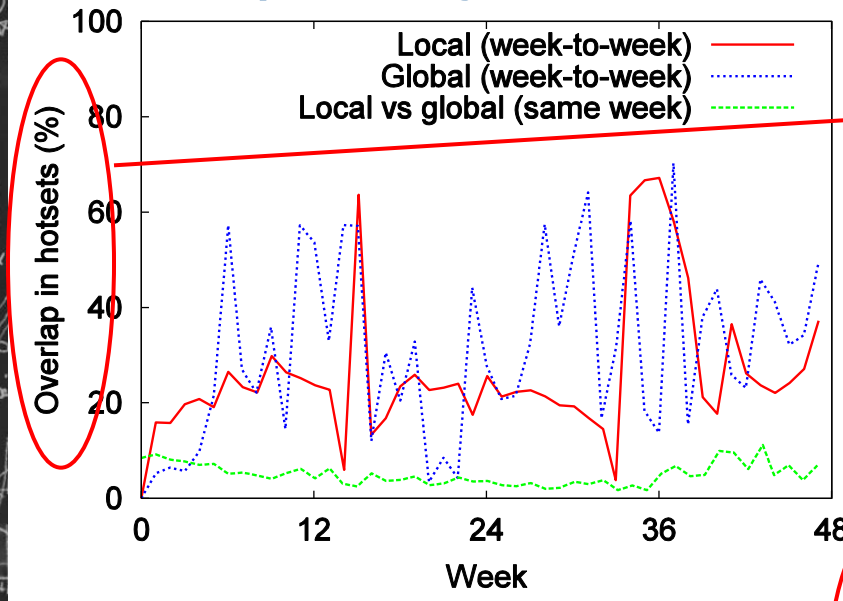


- High popularity churn
  - Roughly 50-60% new videos each week
  - Some files reoccur
- Some video reoccur in hotset



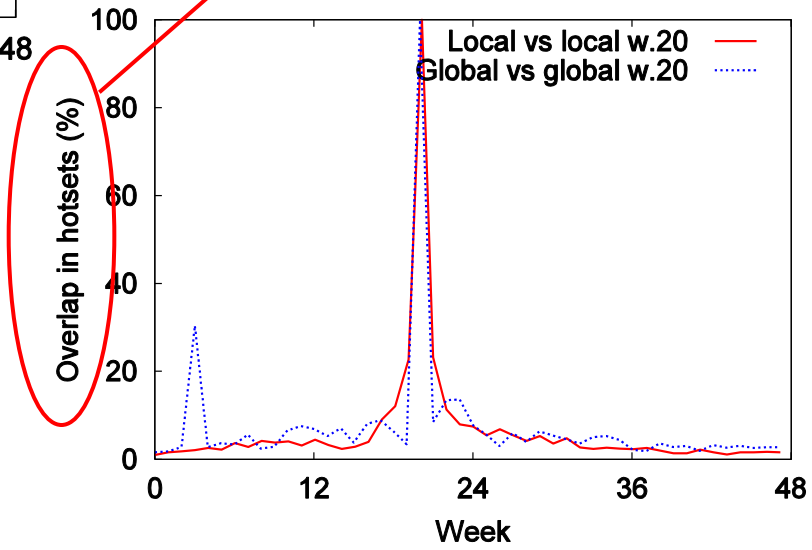
Hotset analysis

Popularity churn



Similarity between weeks

Similarity with week 20



- High popularity churn
  - Roughly 50-60% new videos each week
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Conclusions

- Large-scale longitudinal multi-torrent analysis
  - University campus
  - Global trackers
- Campus users download more large files (TV shows and movies) and a smaller fraction of music
- Campus users are “early adopters”
  - Except for music
- High weekly churn in set of popular files
- Most of the popular files peak well after their initial use
  - Signs of rich-gets-richer behavior

Thank you!

- Niklas Carlsson — Linköping University
- György Dan — KTH Royal Institute
- Anirban Mahanti — NICTA
- Martin Arlitt — HP Labs and University of Calgary