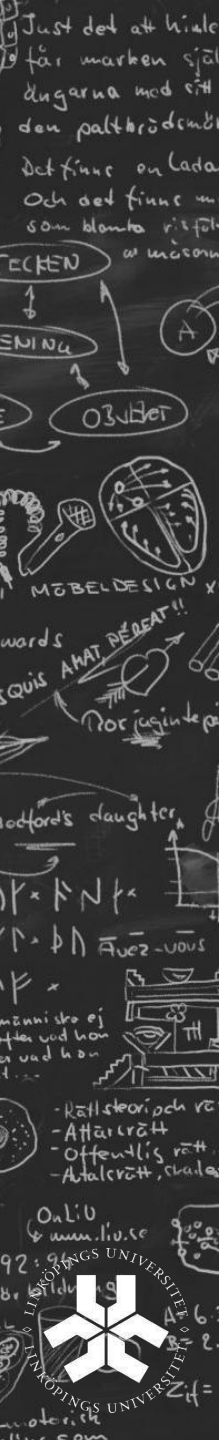
A Longitudinal Characterization of Local and Global BitTorrent Workload Dynamics

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

March 14, 2012

LiU expanding reality



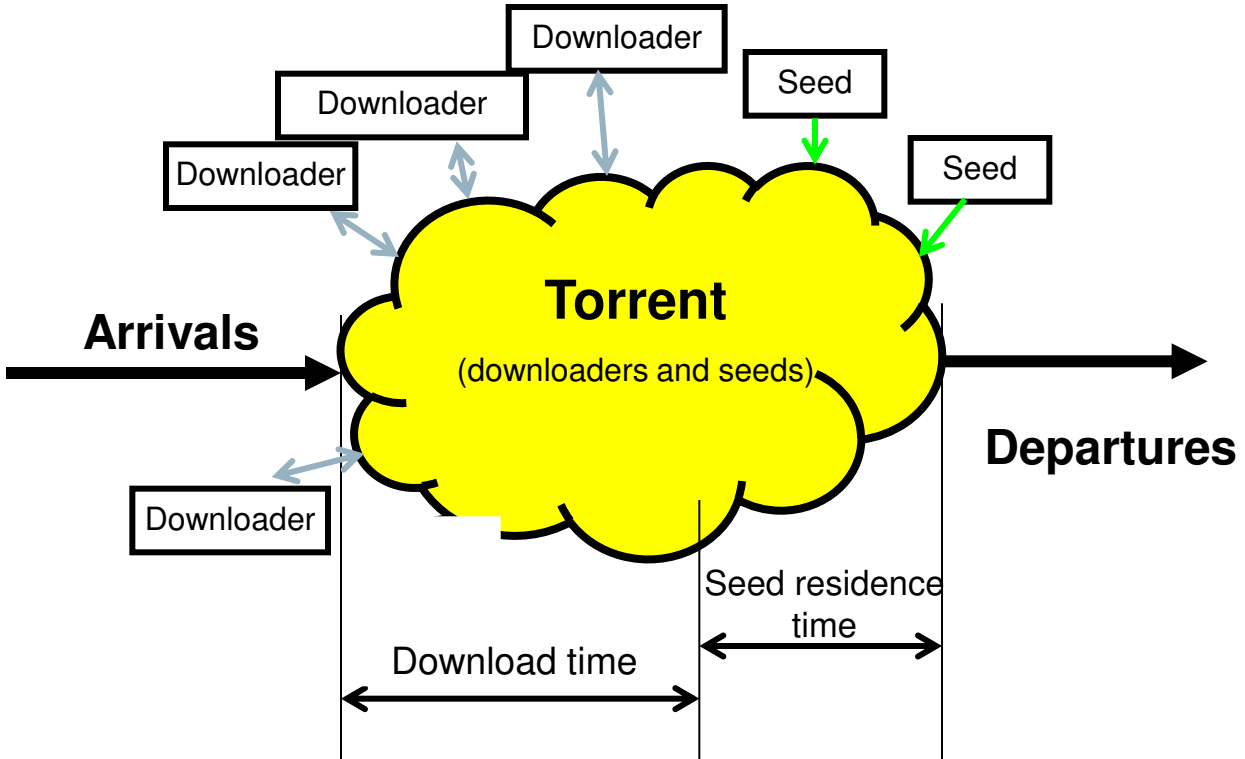
Motivation

- 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

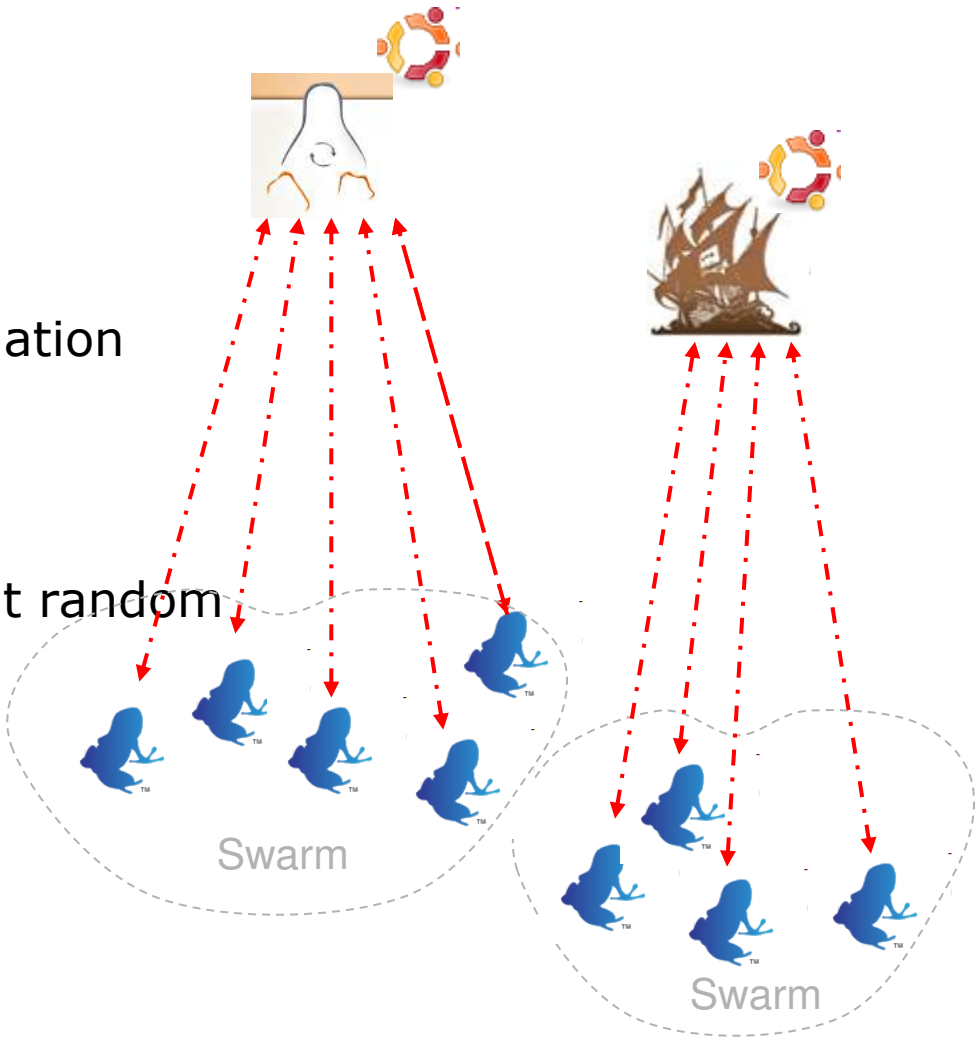
- File split into many smaller chunks
- Downloaded from both seeds and downloaders
- Distribution paths are dynamically determined
  - Based on data availability



Background: BitTorrent

Multi-tracked torrents

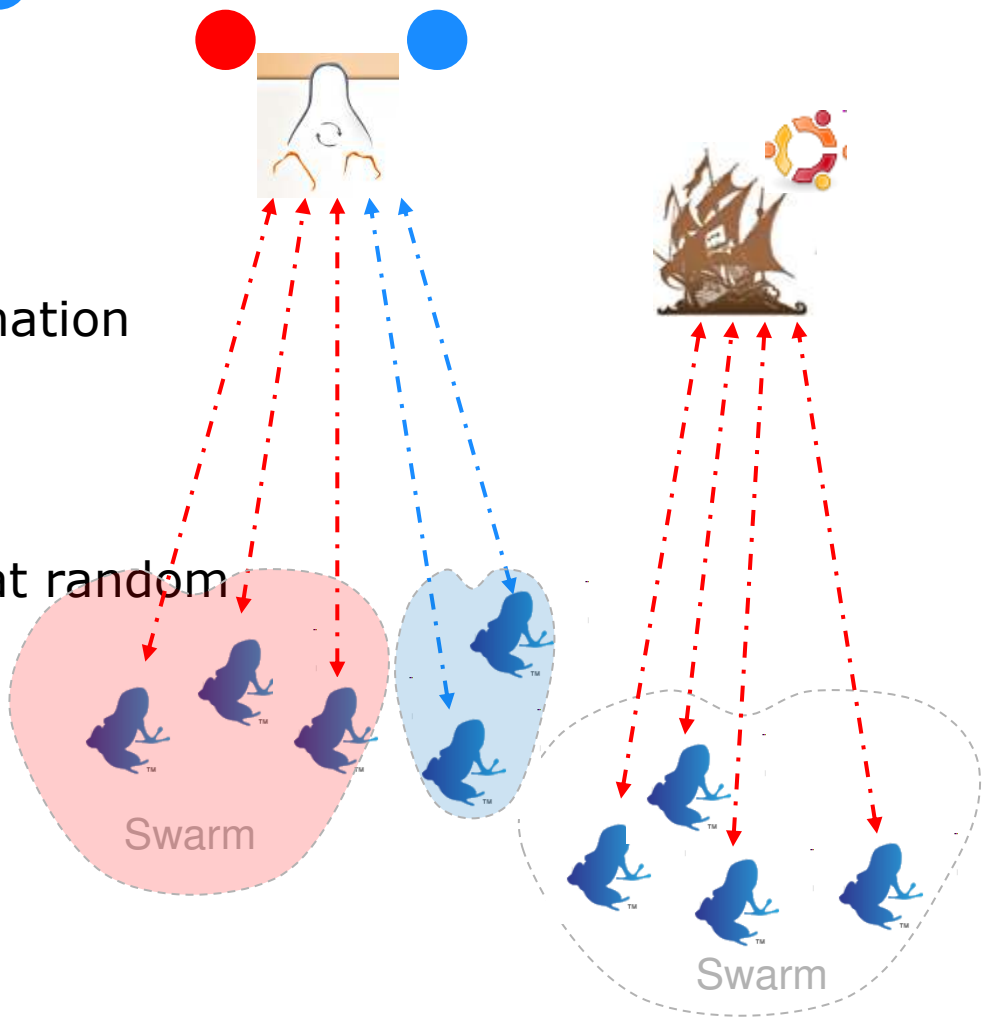
- Torrent file
  - "announce-list" URLs
- Trackers
  - Register torrent file
  - Maintain state information
- Peers
  - Obtain torrent file
  - Choose one tracker at random
  - Announce
  - Report status
  - Peer exchange (PEX)

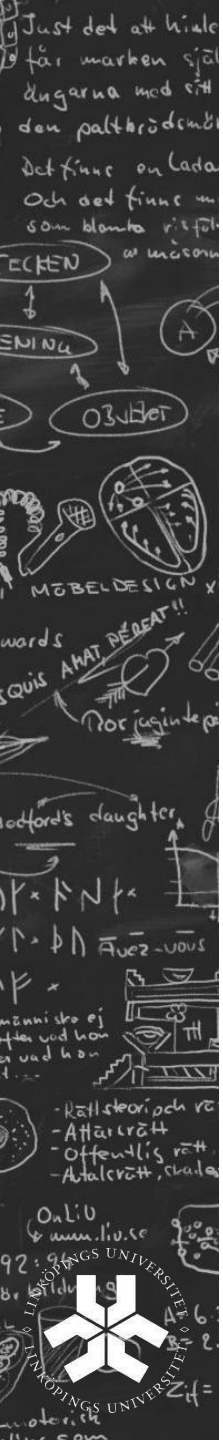


Background: BitTorrent

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)

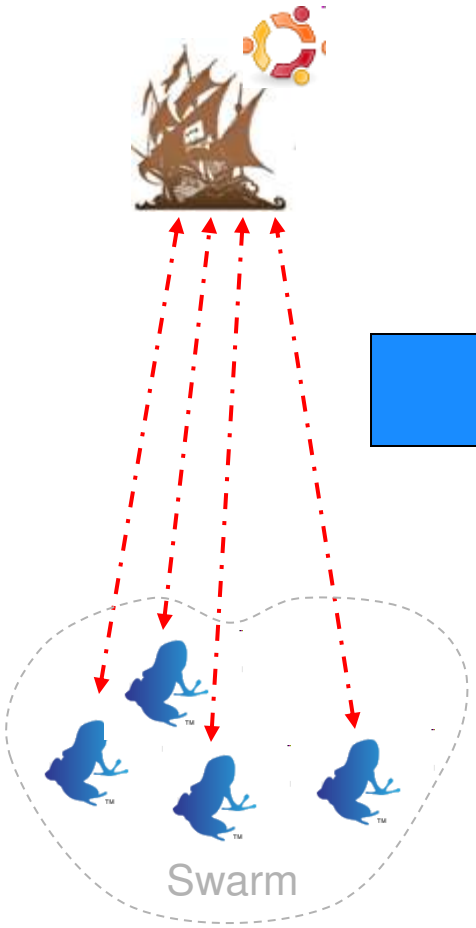




Contributions

- 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

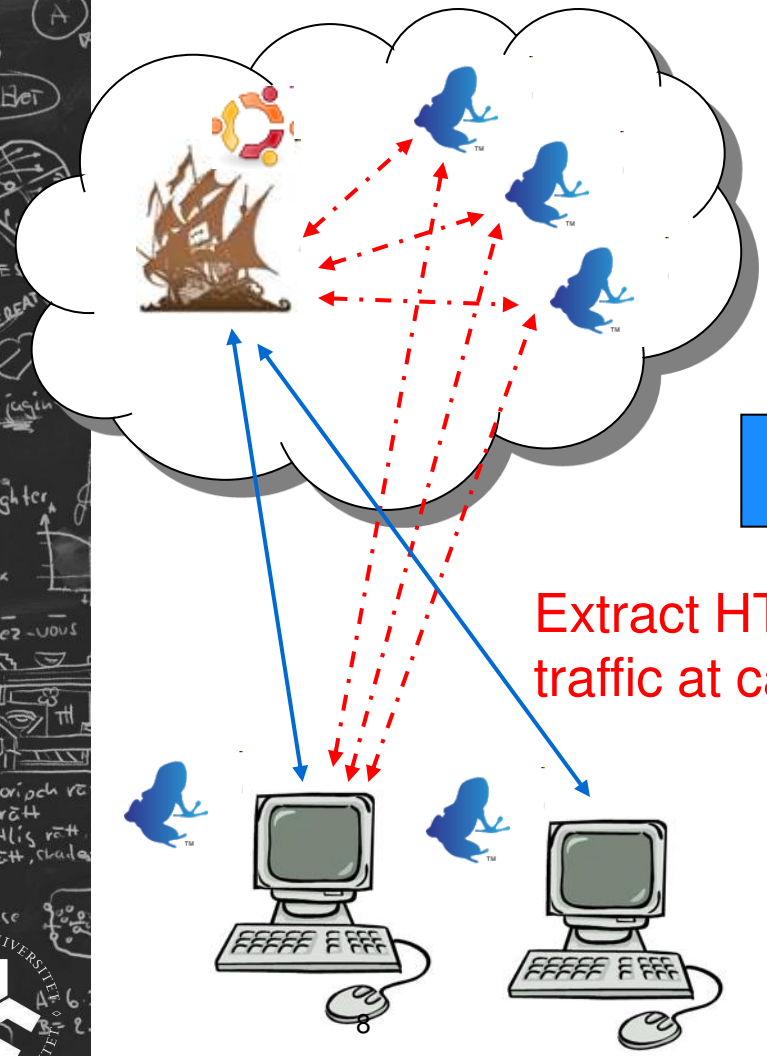


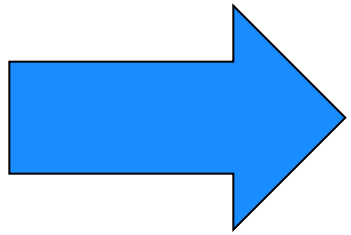
Popularity dynamics

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

University: tracker communication

Passive measurements

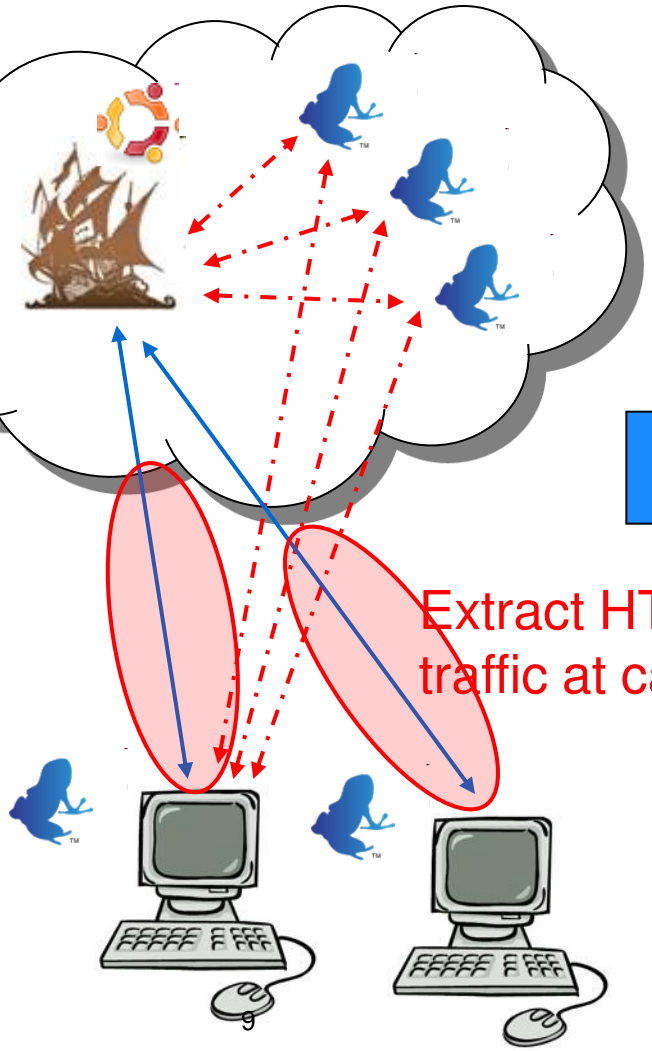


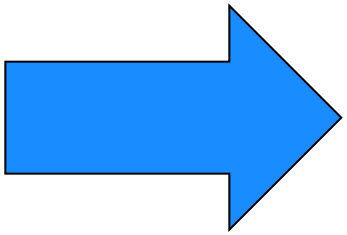


Extract HTTP peer-to-tracker traffic at campus ingress/egress

University: tracker communication

Passive measurements

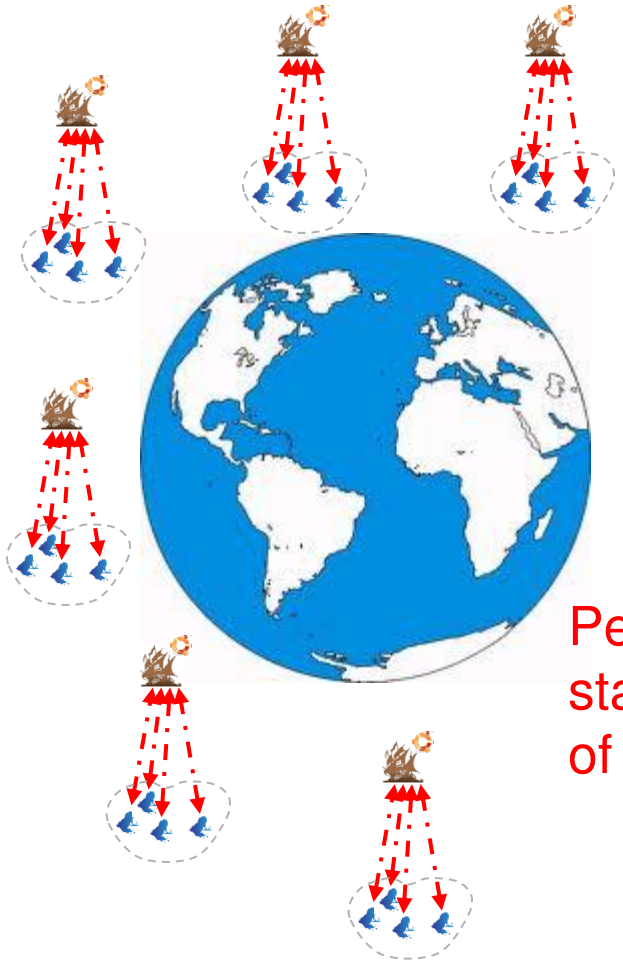


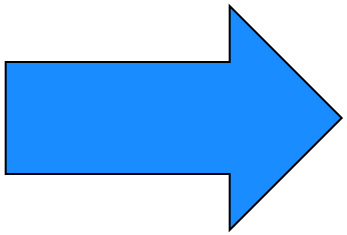


Extract HTTP peer-to-tracker traffic at campus ingress/egress

Global: Tracker scrapes

Active measurements

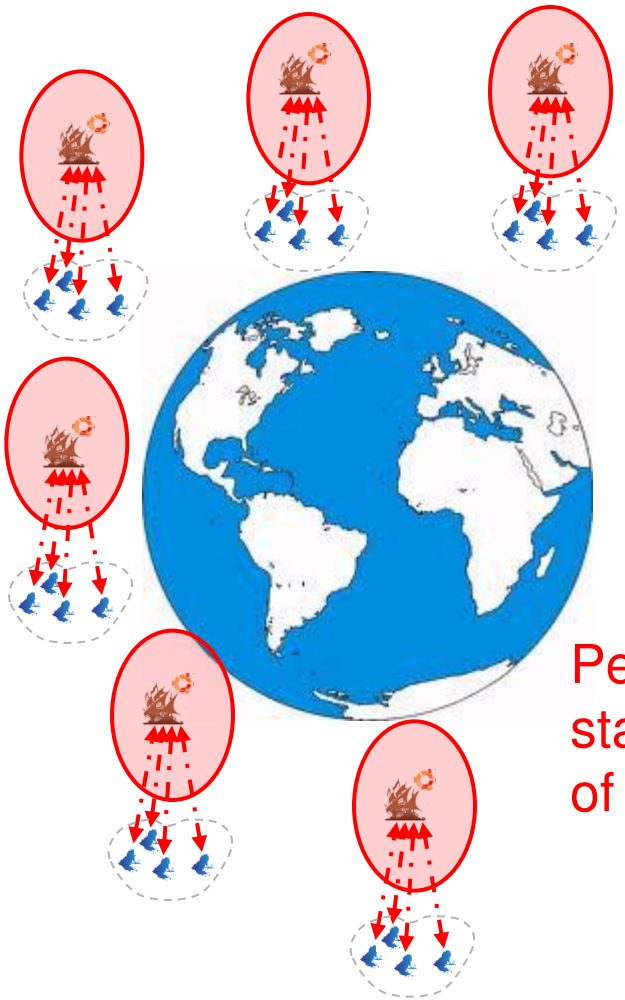


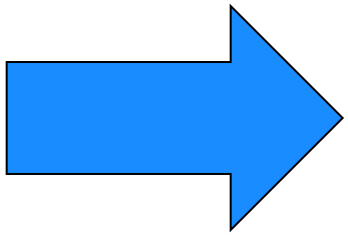


Periodically request the current state as observed at a large set of trackers

Global: Tracker scrapes

Active measurements

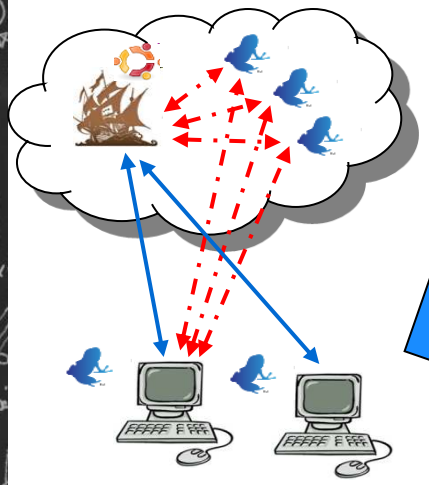


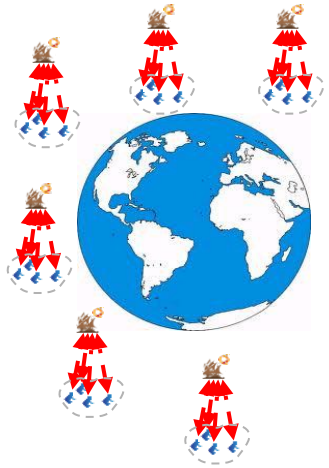


Periodically request the current state as observed at a large set of trackers

Measurement overview

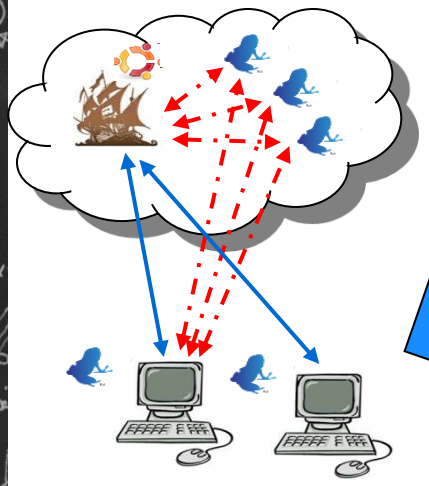
Active + passive measurements

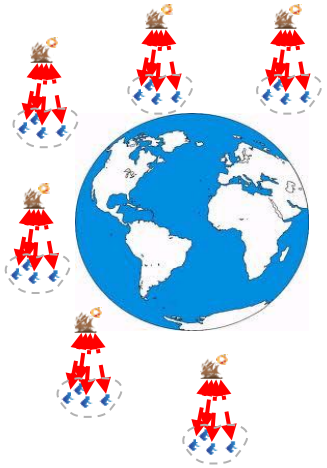


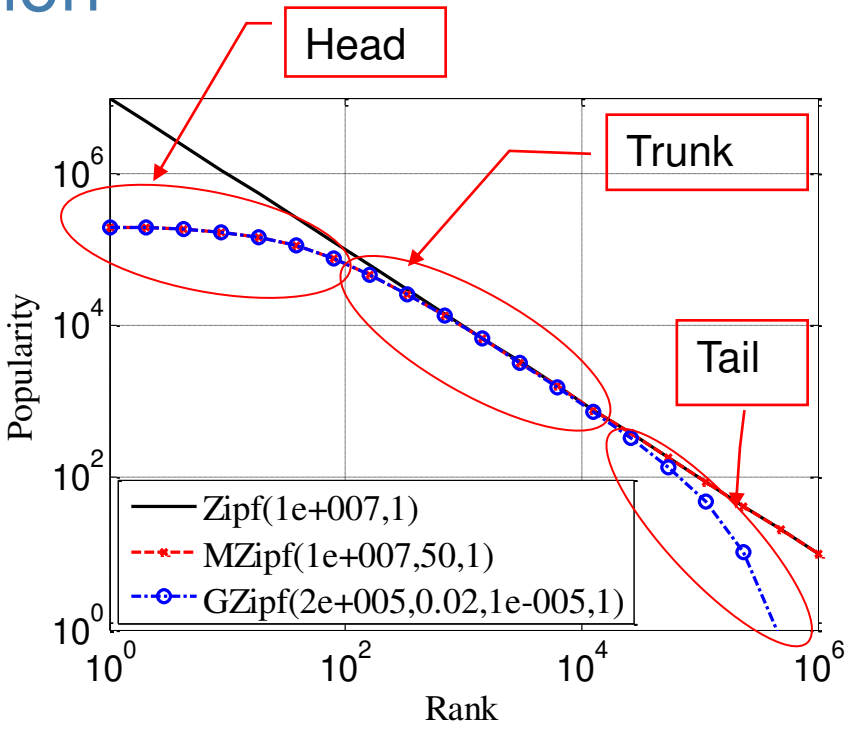


Popularity dynamics

Previous work
Popularity distribution







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

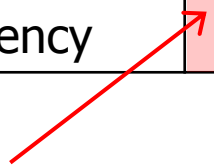
- Popularity distribution statistics
  - Over lifetime
  - Over different time period
  - Different sampling methods

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
End date	Aug. 17, 2009	Aug. 17, 2009	Aug., 2009
Frequency	All requests	Weekly scrapes	Twice

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
End date	Aug. 17, 2009	Aug. 17, 2009	Aug., 2009
Frequency	All requests	Weekly scrapes	Twice



- 48 weeks of overlapping longitudinal data

Summary of datasets

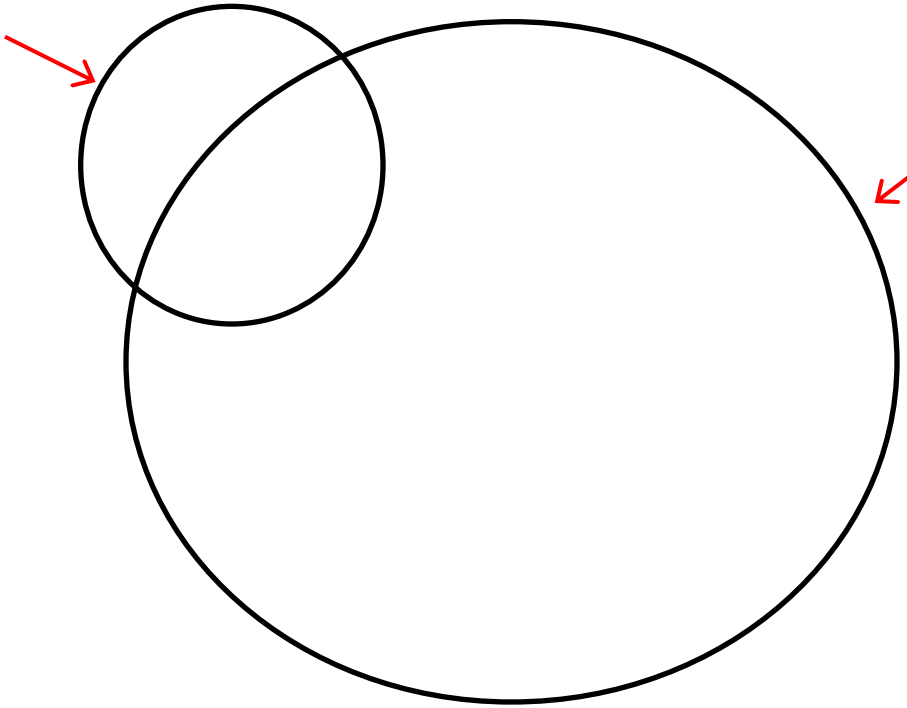
Property	University	Global	Mininova
Trackers	2,371	721	1,690
Torrents	56,963	11.2 M	911,687
Downloads	1.73 M	37.0 B	--
HTTP requests	249 M	--	--
Start date	Sep. 15, 2008	Sep. 15, 2008	Sep., 2008
End date	Aug. 17, 2009	Aug. 17, 2009	Aug., 2009
Frequency	All requests	Weekly scrapes	Twice

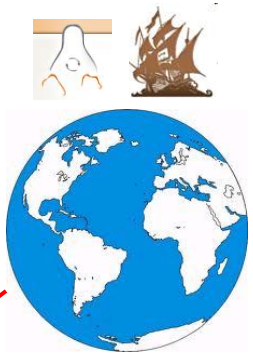
- Many torrents (and downloads) …

Dataset summary

Torrents observed

56,963



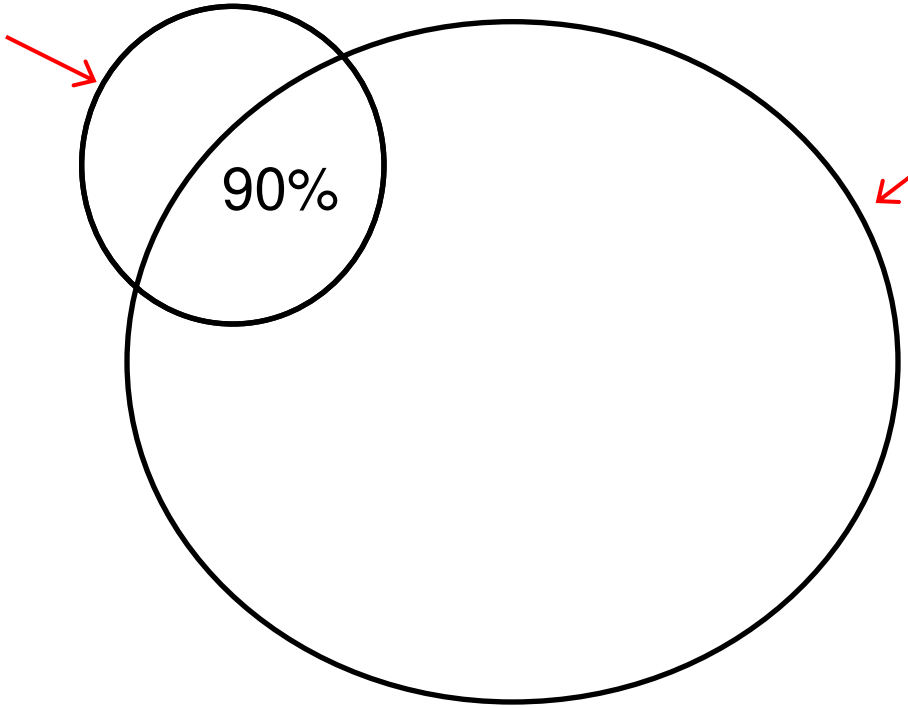


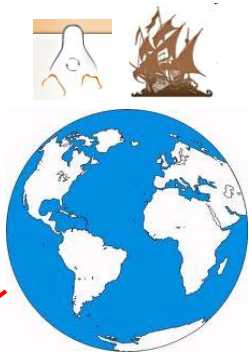
11.2 M

Dataset summary

Torrents observed

56,963

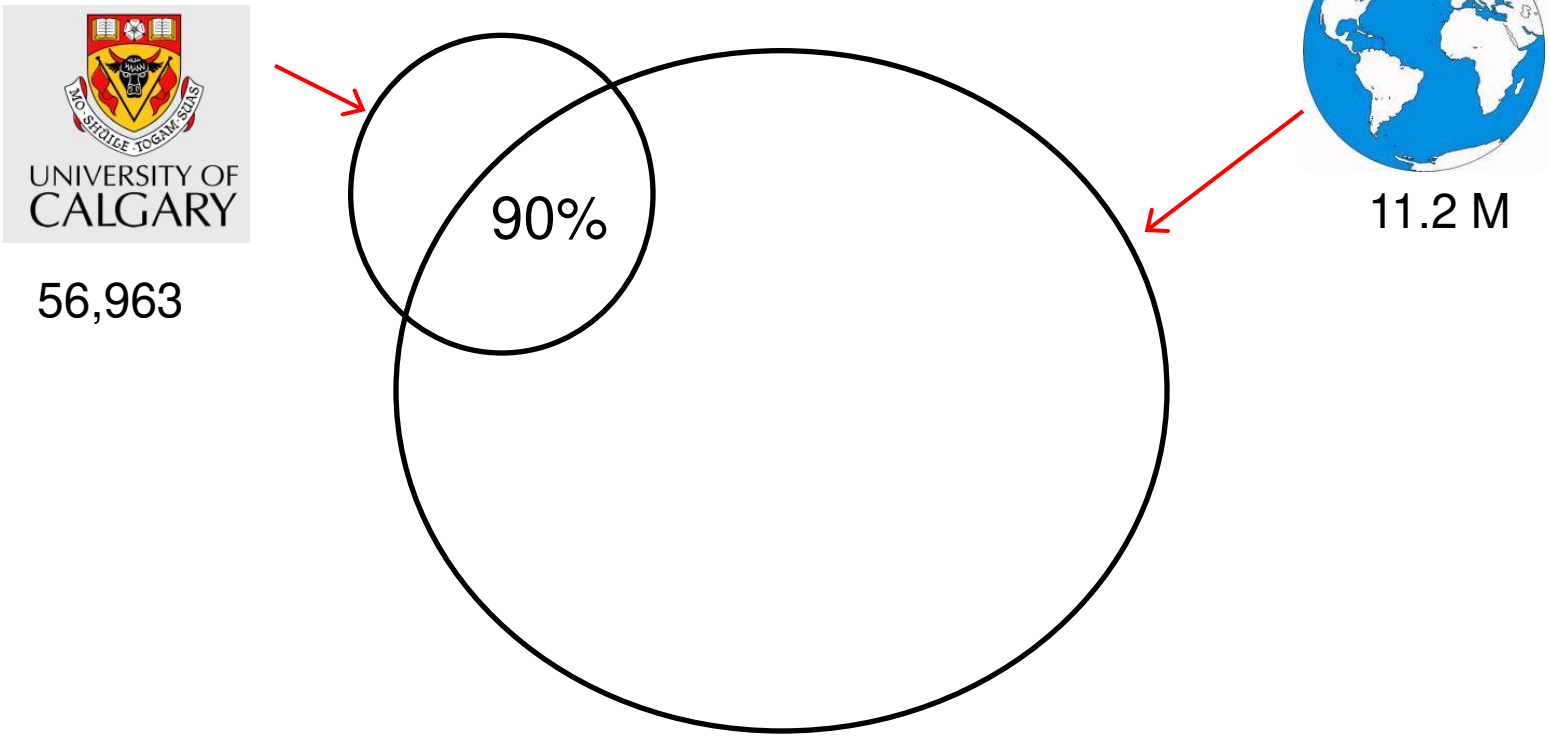




11.2 M

Dataset summary

Torrents observed

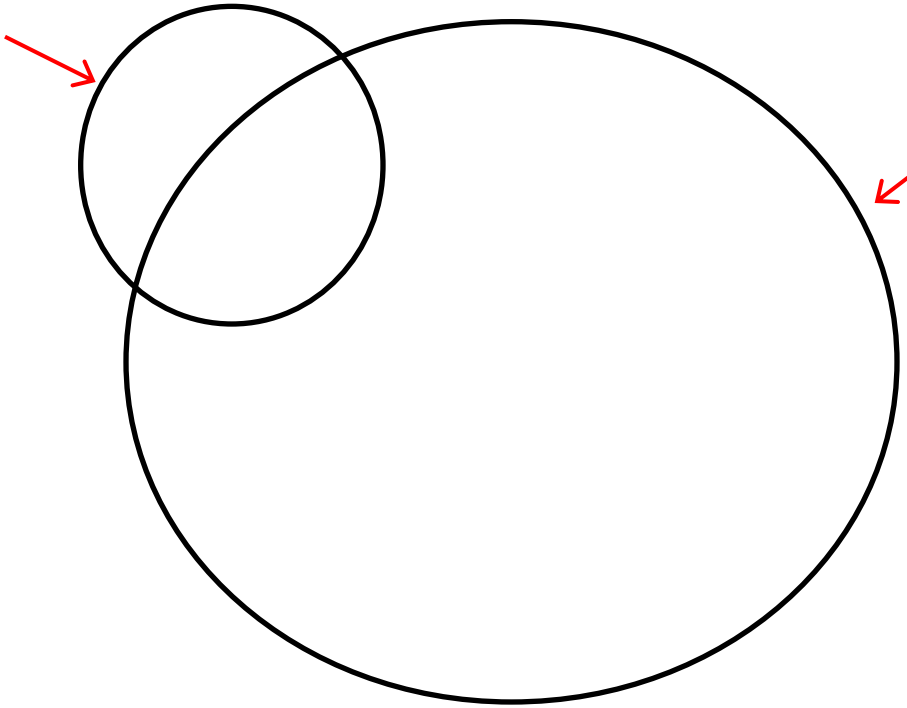


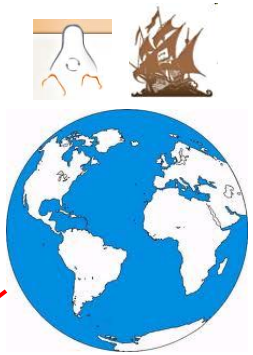
- Most of the files observed locally are also observed in the global dataset

Dataset summary

Torrents observed

56,963

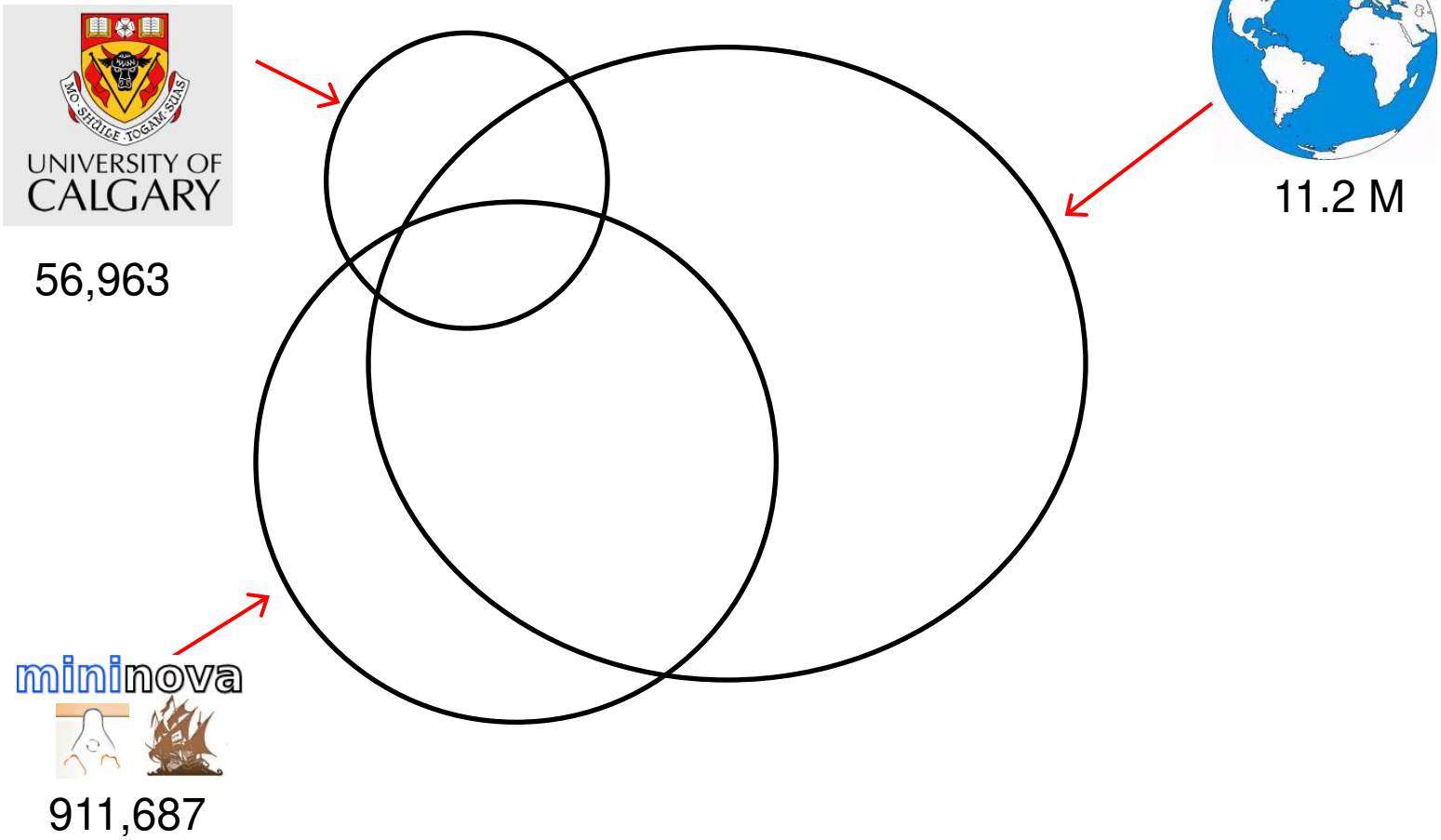




11.2 M

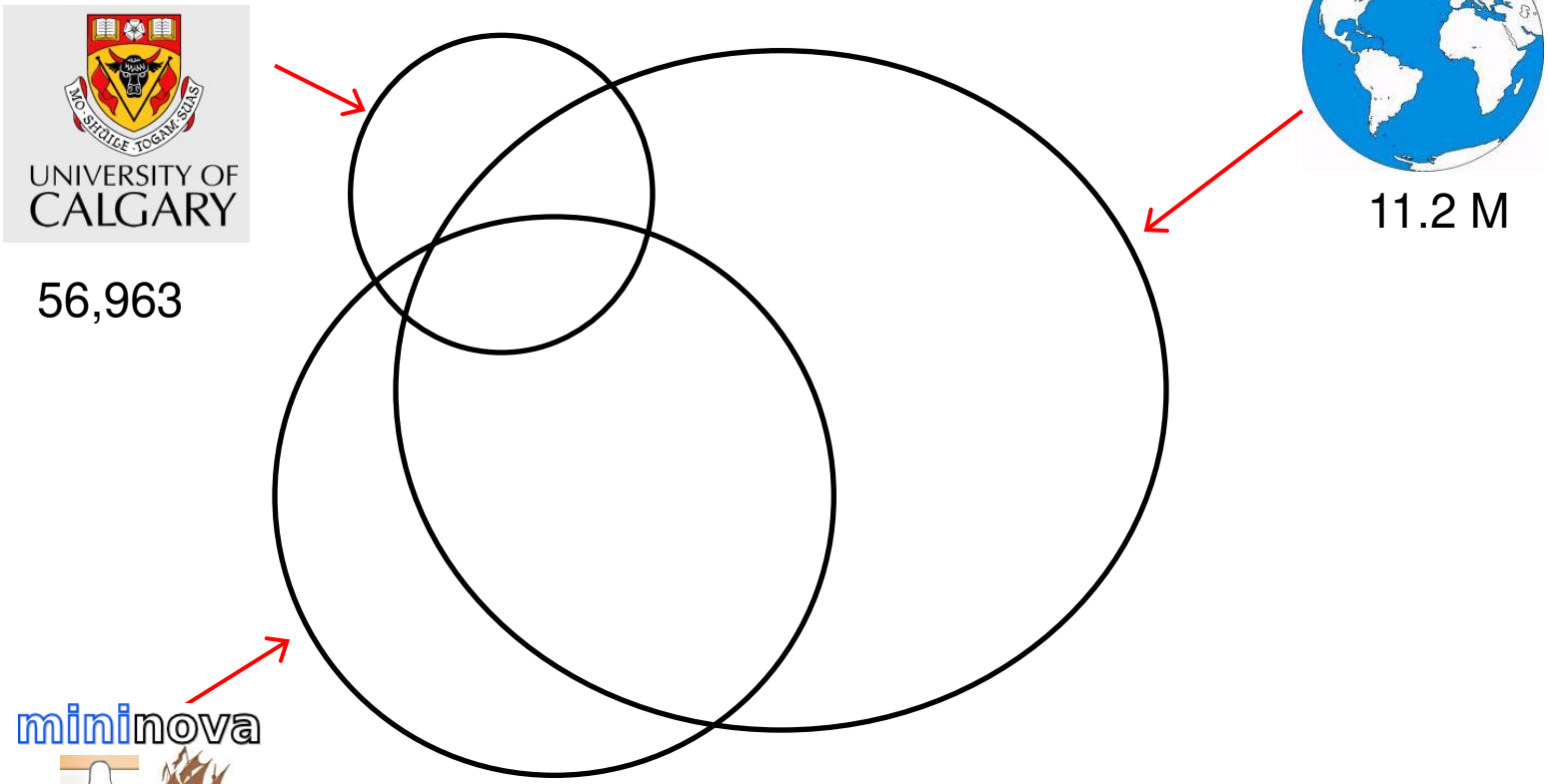
Dataset summary

Torrents observed



Dataset summary

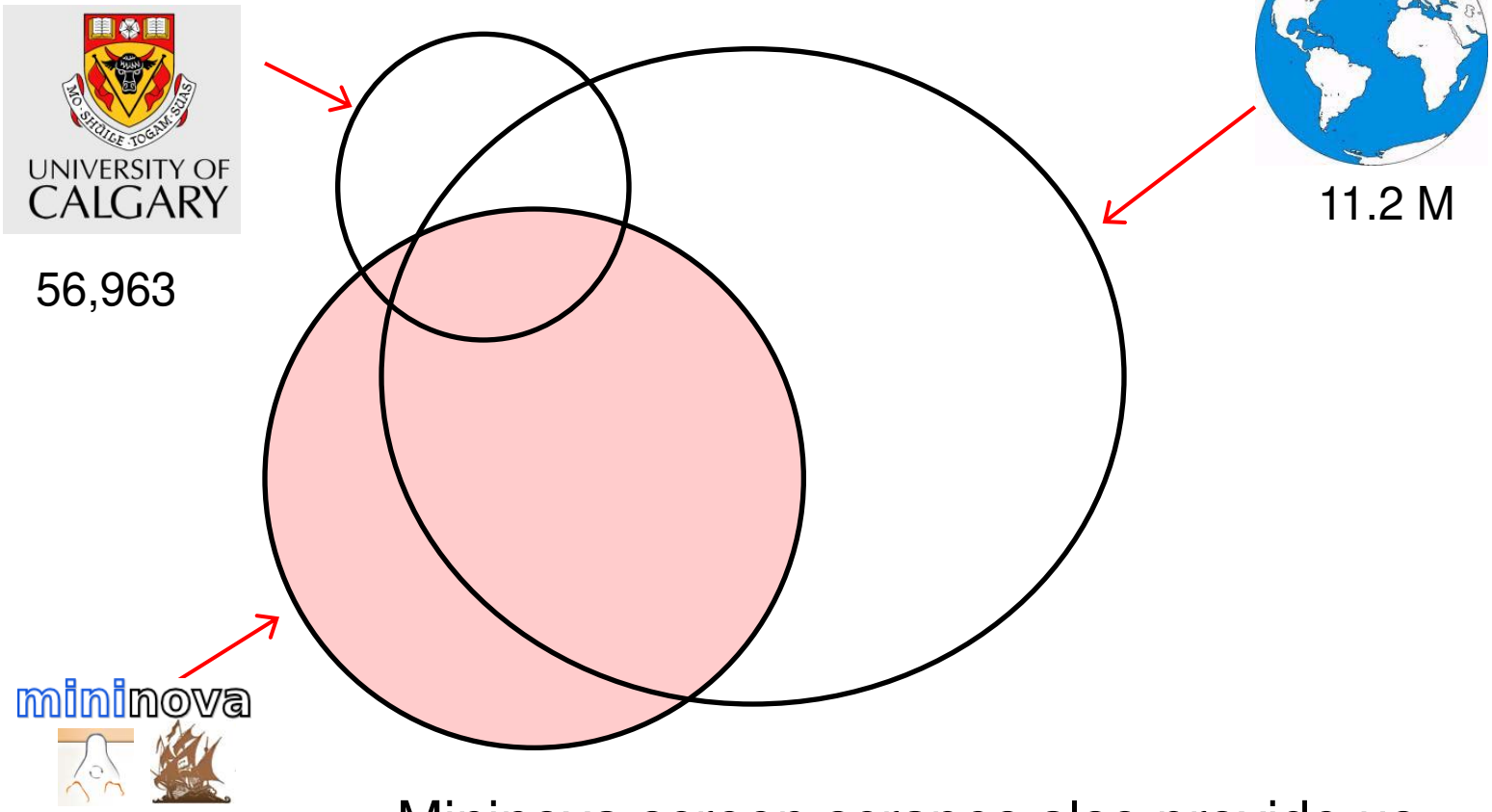
Torrents observed



- Mininova screen scrapes also provide us with ***size*** and ***category*** information for some of these files

Dataset summary

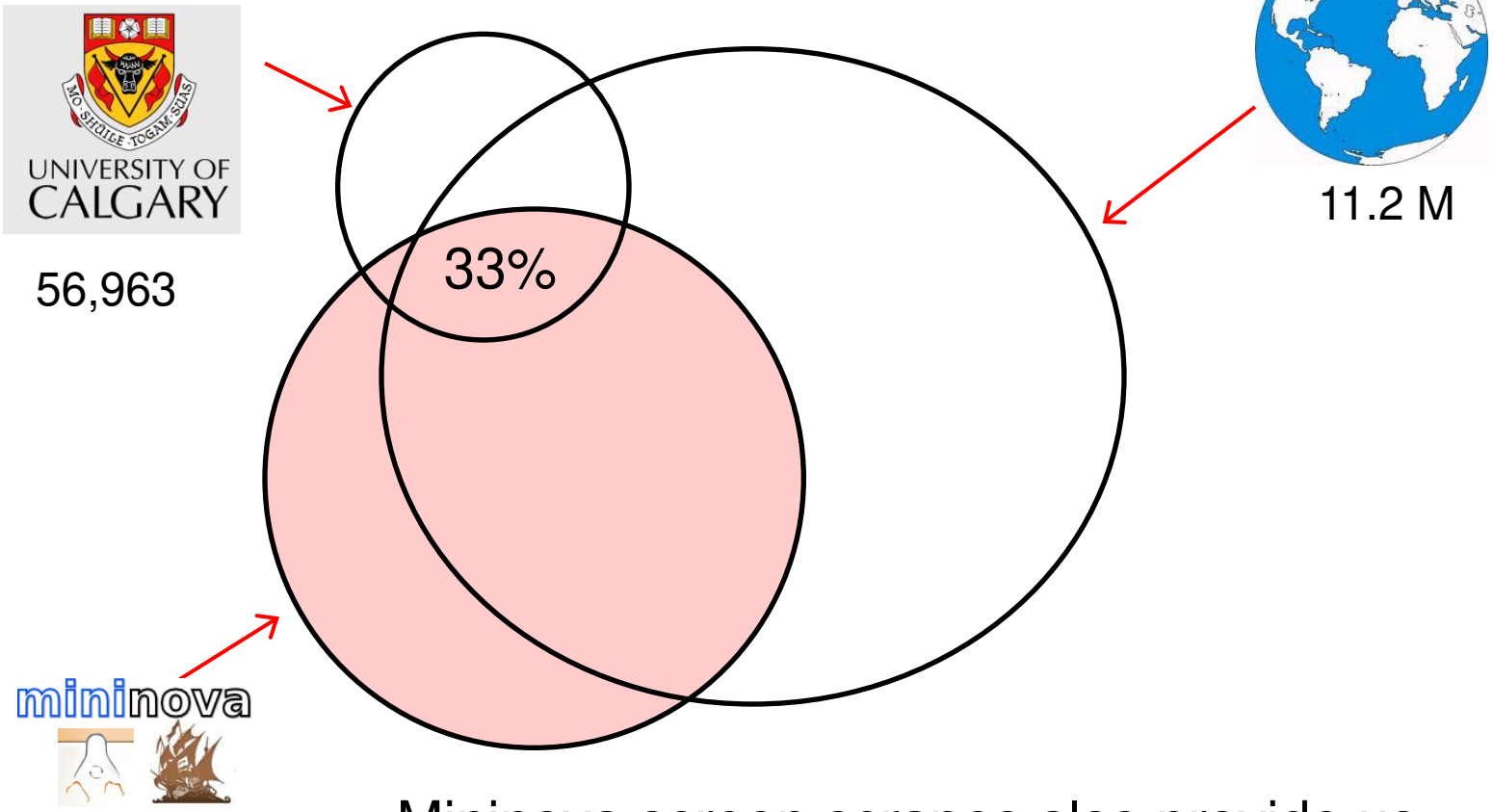
Torrents observed



- Mininova screen scrapes also provide us with ***size*** and ***category*** information for some of these files

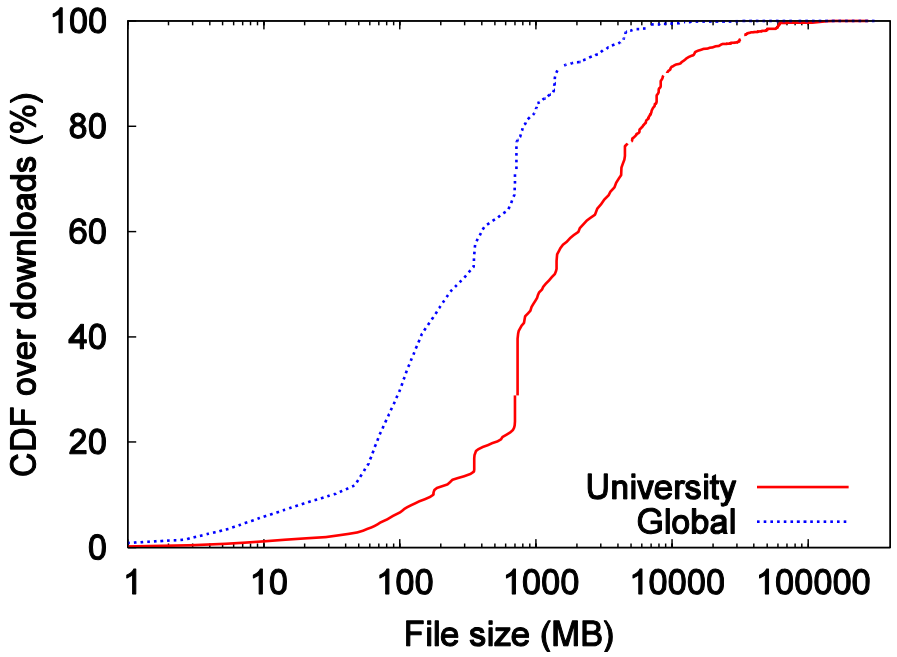
Dataset summary

Torrents observed



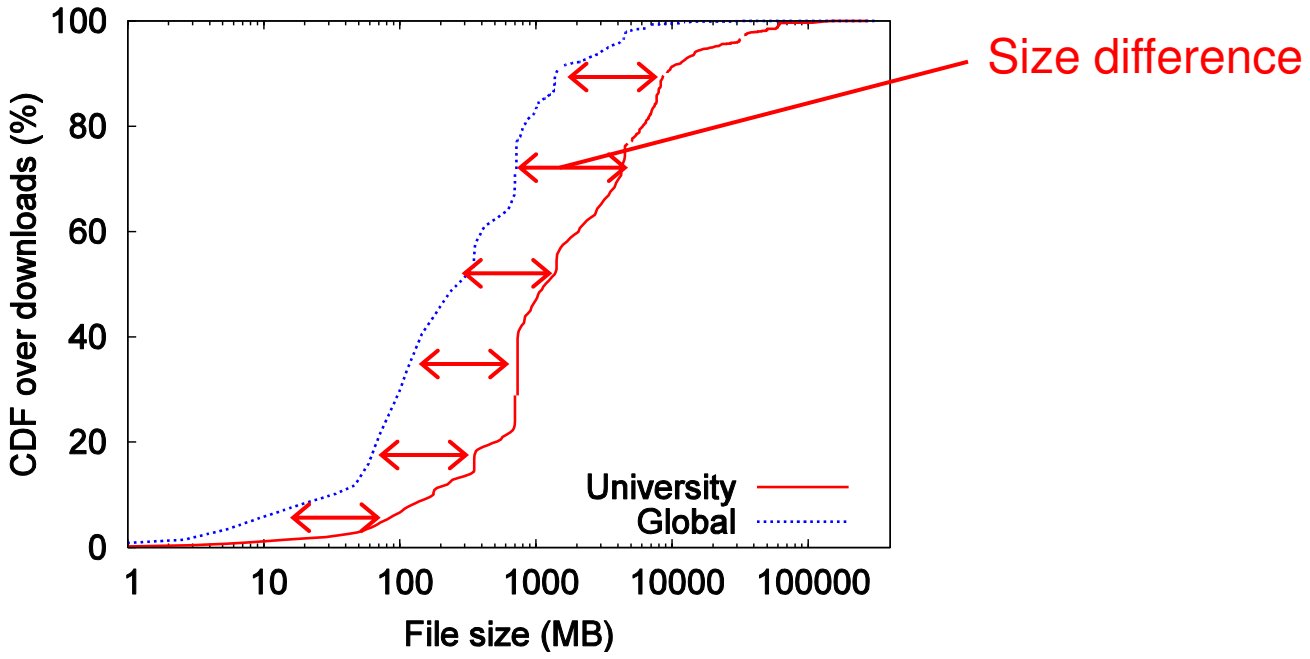
- Mininova screen scrapes also provide us with ***size*** and ***category*** information for some of these files

Content download characteristics
File size distribution, per download



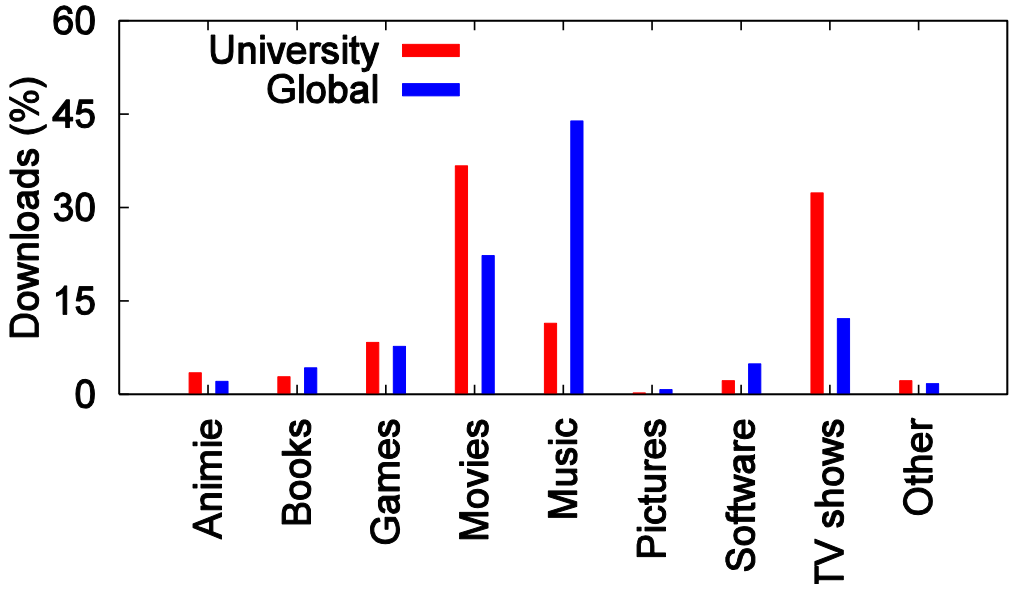
- Campus users download larger files

Content download characteristics
File size distribution, per download



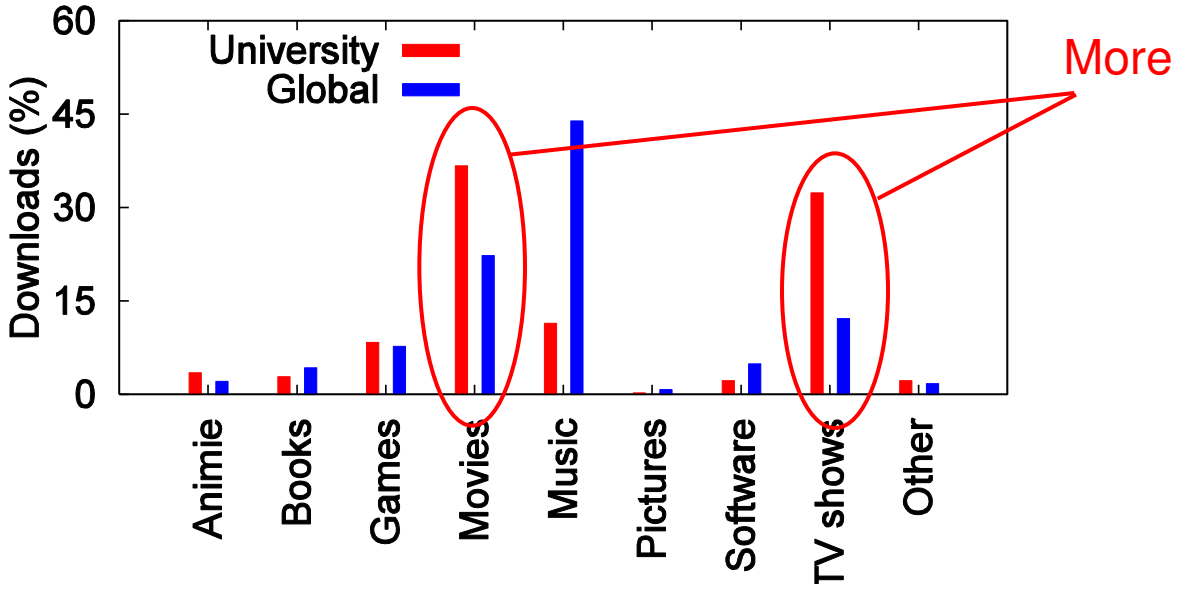
- Campus users download larger files

Content download characteristics
Breakdown per category



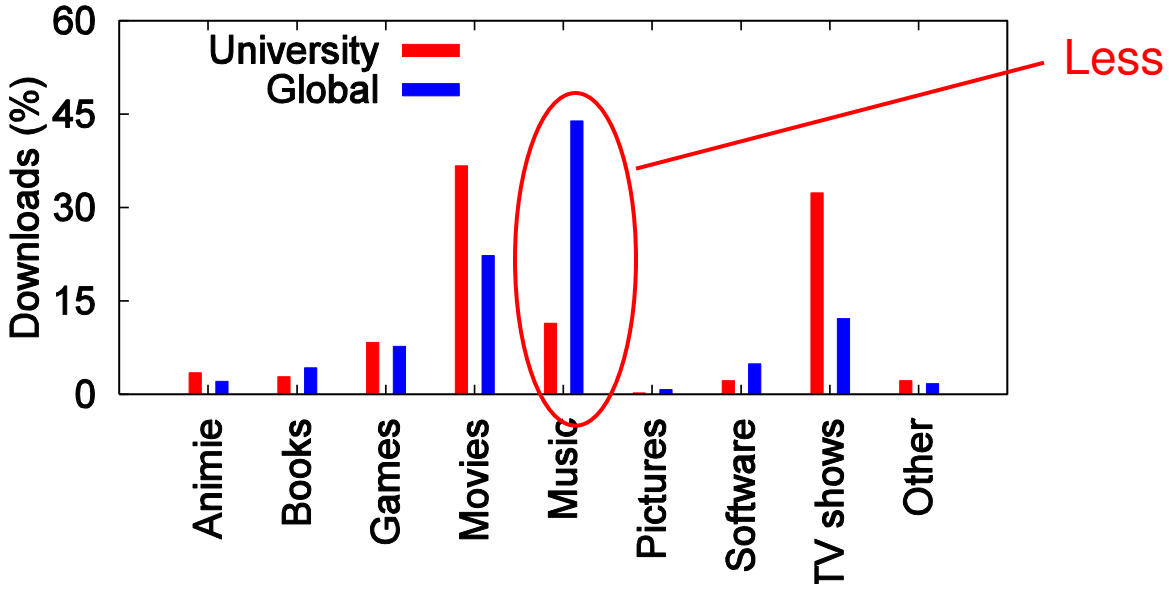
- Campus users download
  - More movies and TV shows
  - Less music

Content download characteristics
Breakdown per category



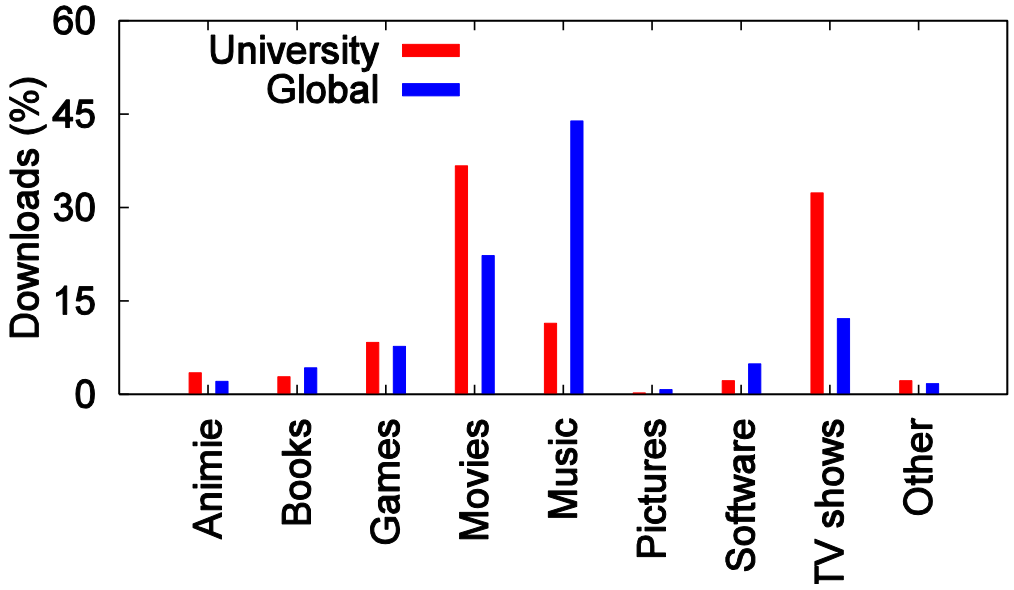
- Campus users download
  - More movies and TV shows
  - Less music

Content download characteristics
Breakdown per category

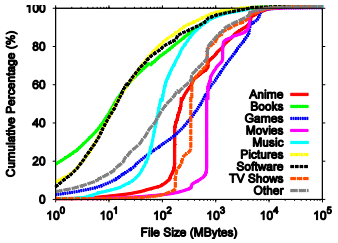


- Campus users download
  - More movies and TV shows
  - Less music

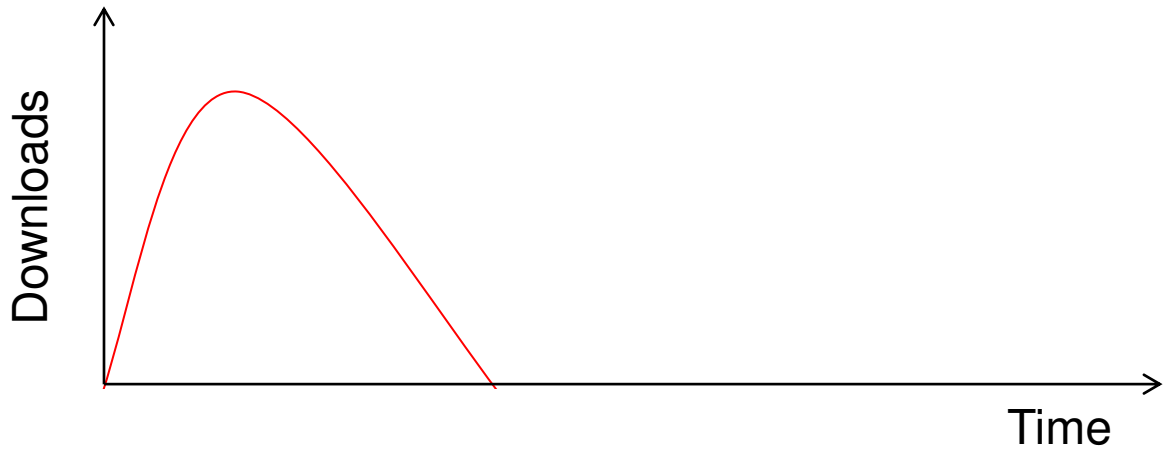
Content download characteristics
Breakdown per category



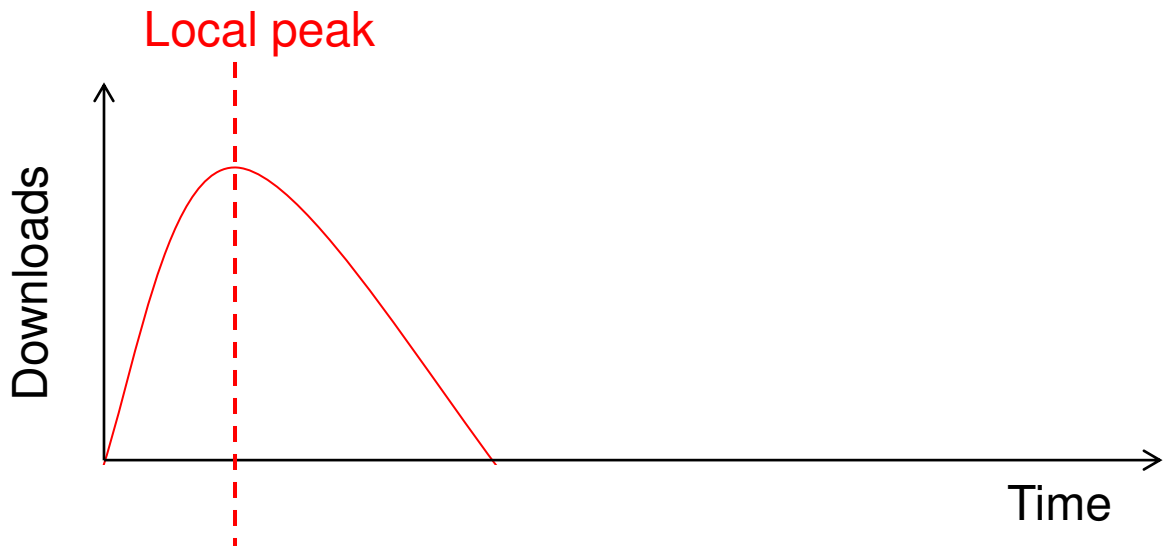
- Campus users download
  - More movies and TV shows
  - Less music
- Again, biased towards larger contents ...



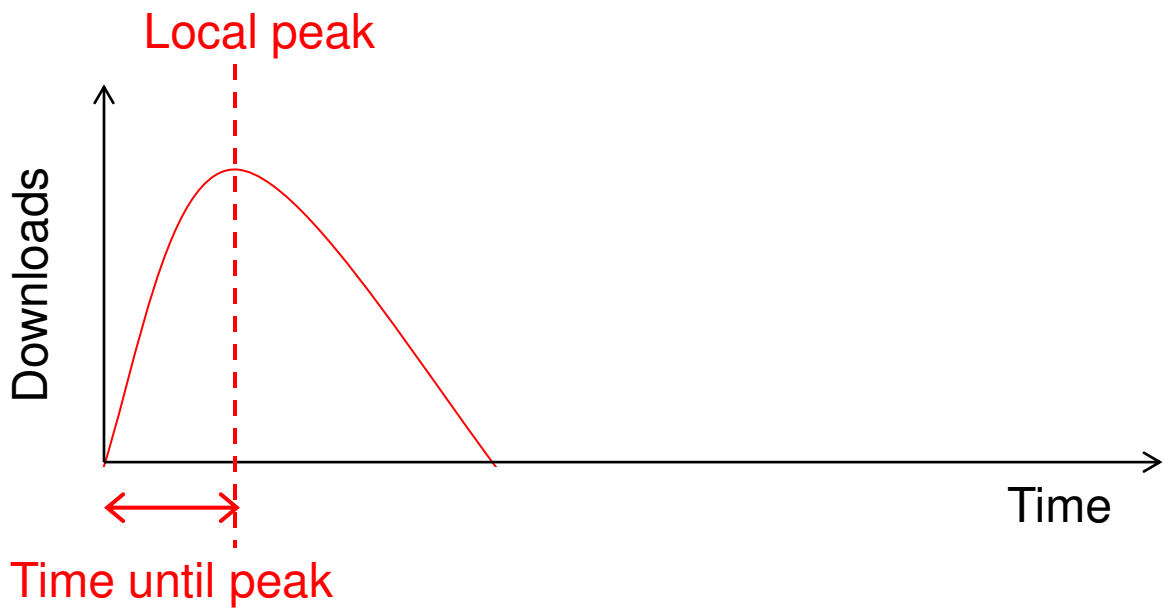
Early adopters
Terminology



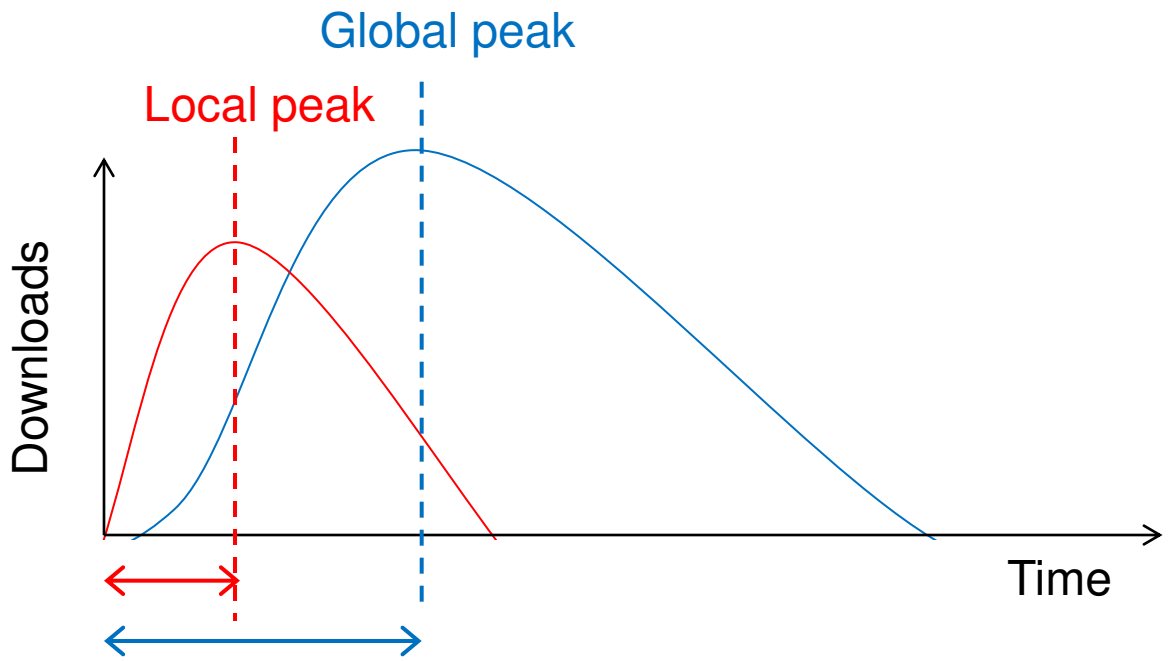
Early adopters
Terminology



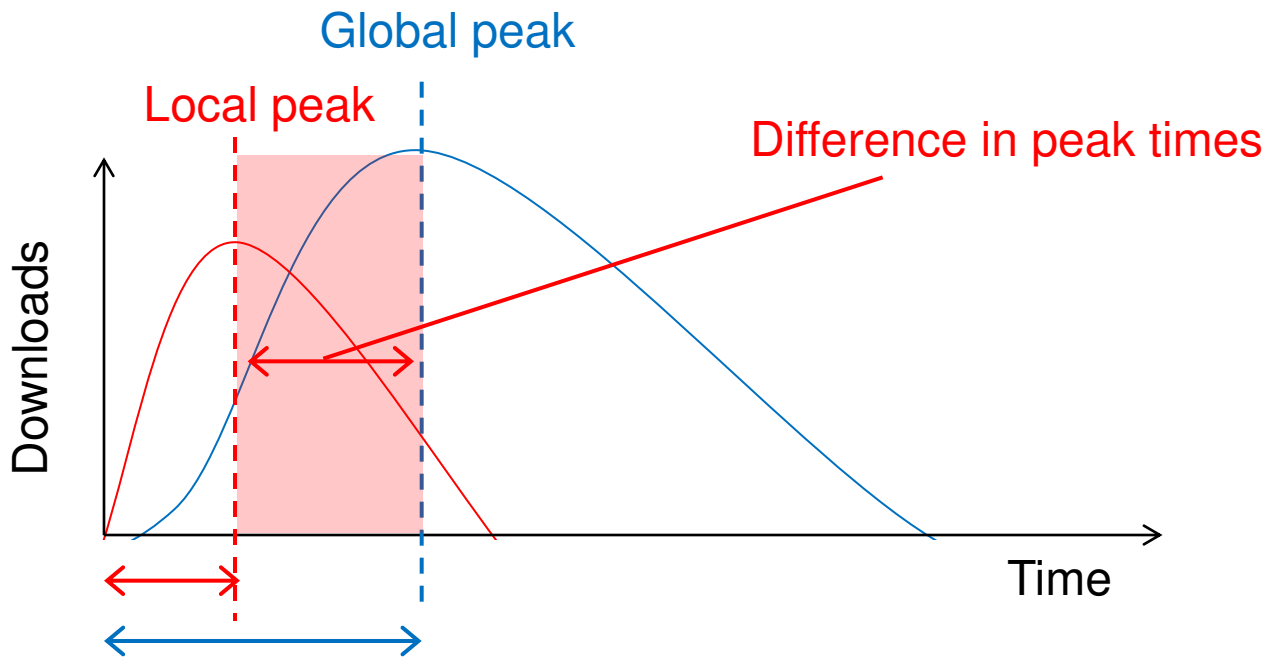
Early adopters
Terminology



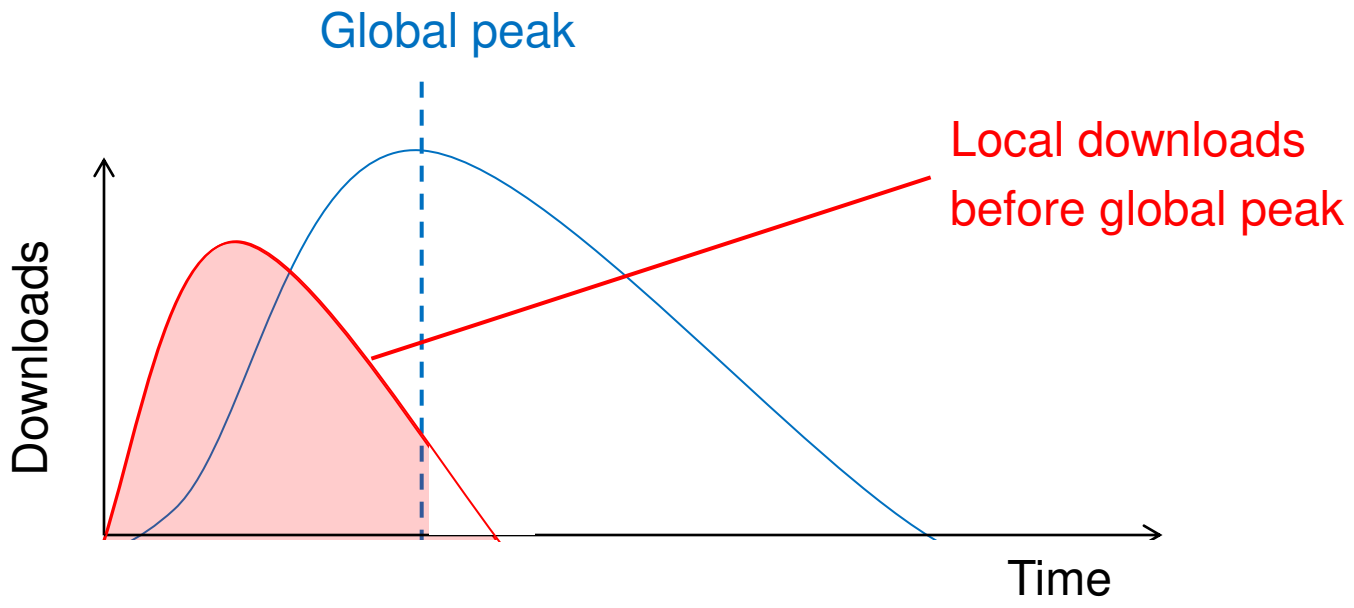
Early adopters
Terminology



Early adopters
Terminology

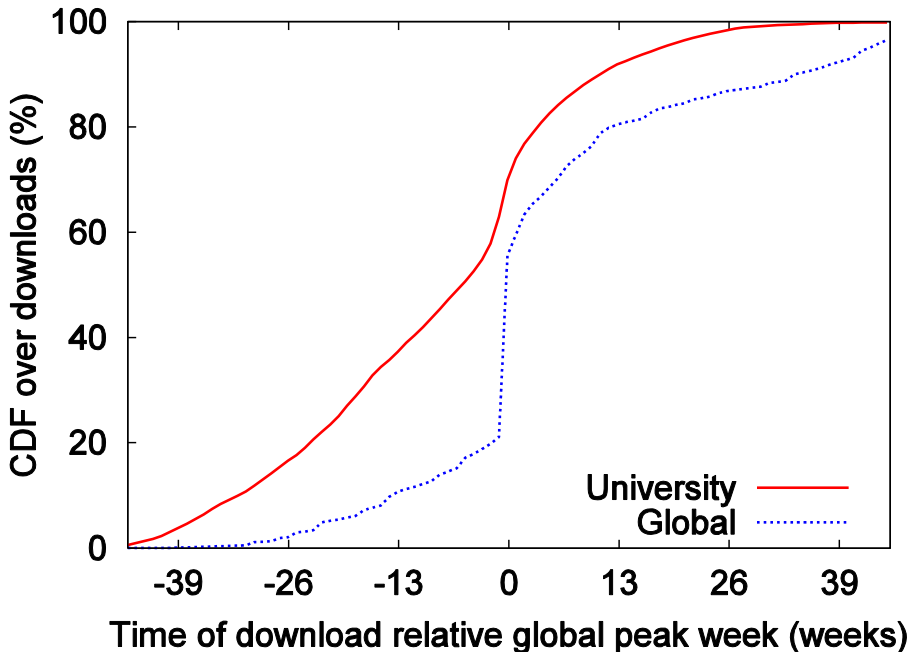


Early adopters
Terminology



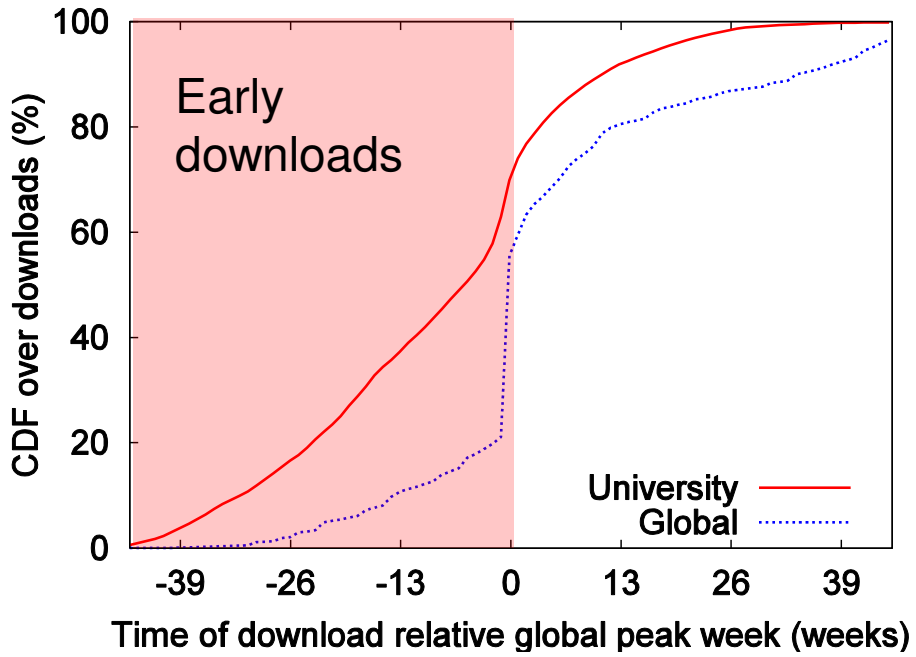
Early adopters

Downloads relative to global peak



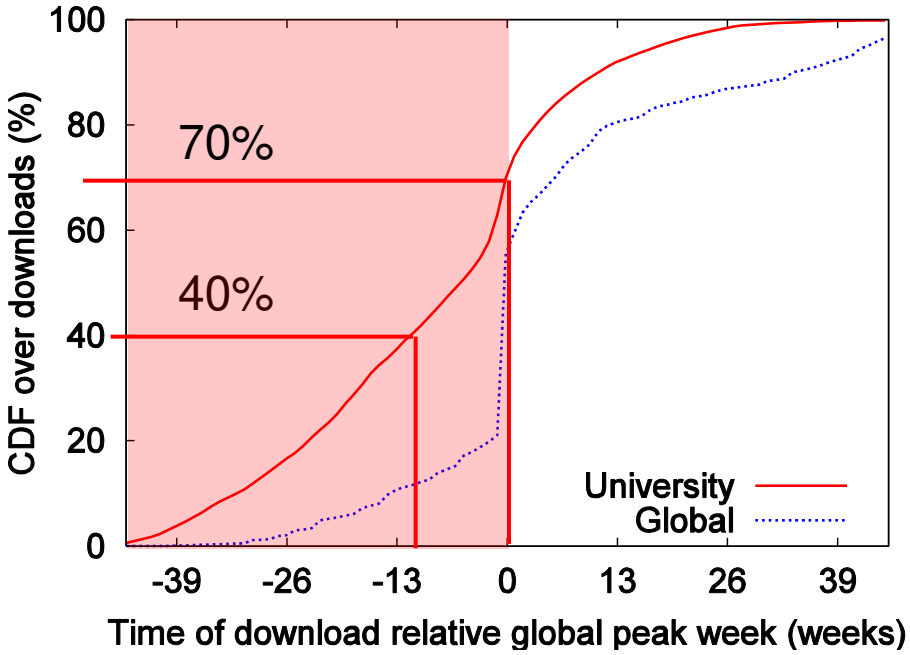
- Campus users are generally early adopters of content
  - 70% of downloads before global peak
  - 40% of downloads at least 10 weeks before global peak

Early adopters
Downloads relative to global peak



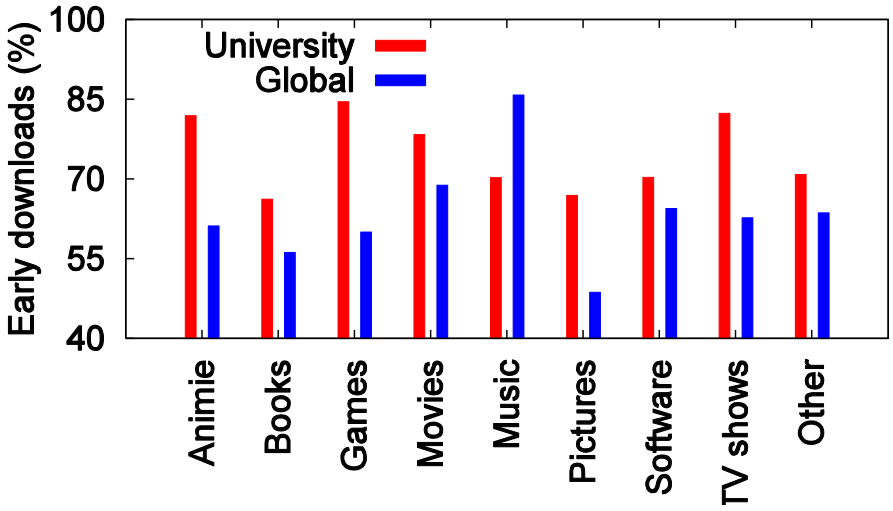
- Campus users are generally early adopters of content
  - 70% of downloads before global peak
  - 40% of downloads at least 10 weeks before global peak

Early adopters
Downloads relative to global peak



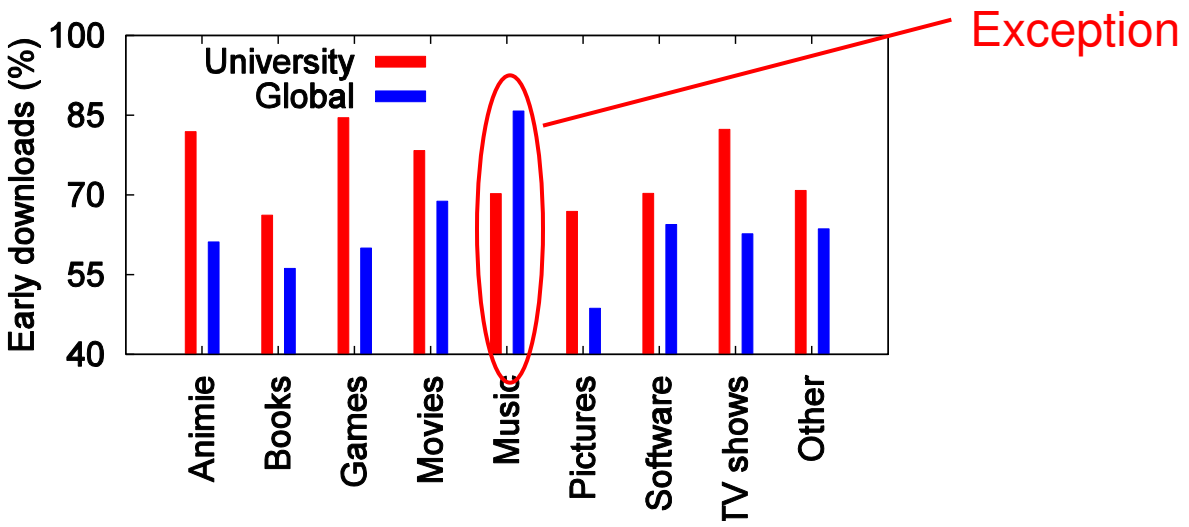
- Campus users are generally early adopters of content
  - 70% of downloads before global peak
  - 40% of downloads at least 10 weeks before global peak

Early adopters
Downloads relative to global peak



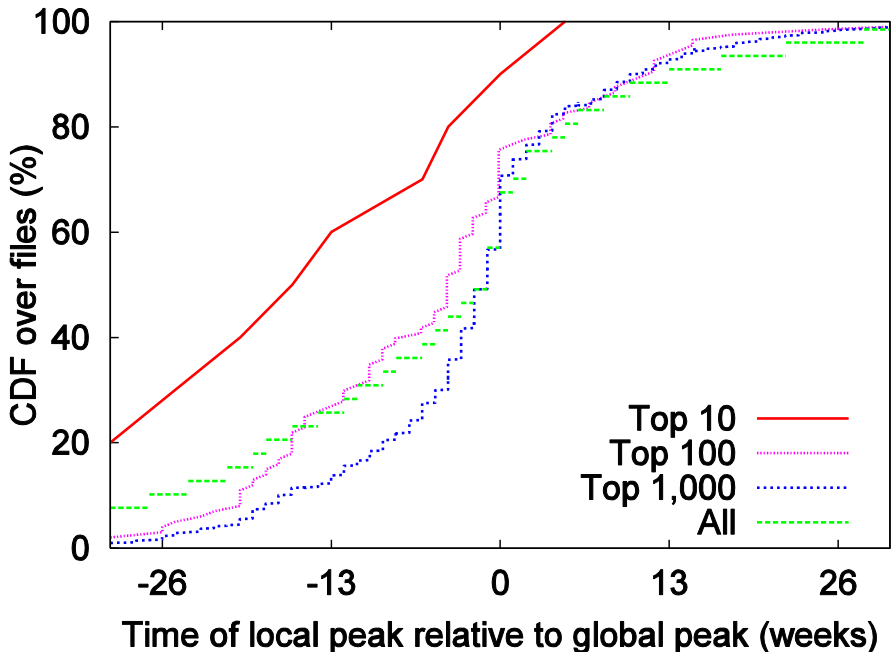
- Campus users are generally early adopters of content
  - Except for music
- Perhaps campus users can be used to predict some future popularity ...
  - And used for seeding such content

Early adopters
Downloads relative to global peak



- Campus users are generally early adopters of content
  - Except for music
- Perhaps campus users can be used to predict some future popularity ...
  - And used for seeding such content

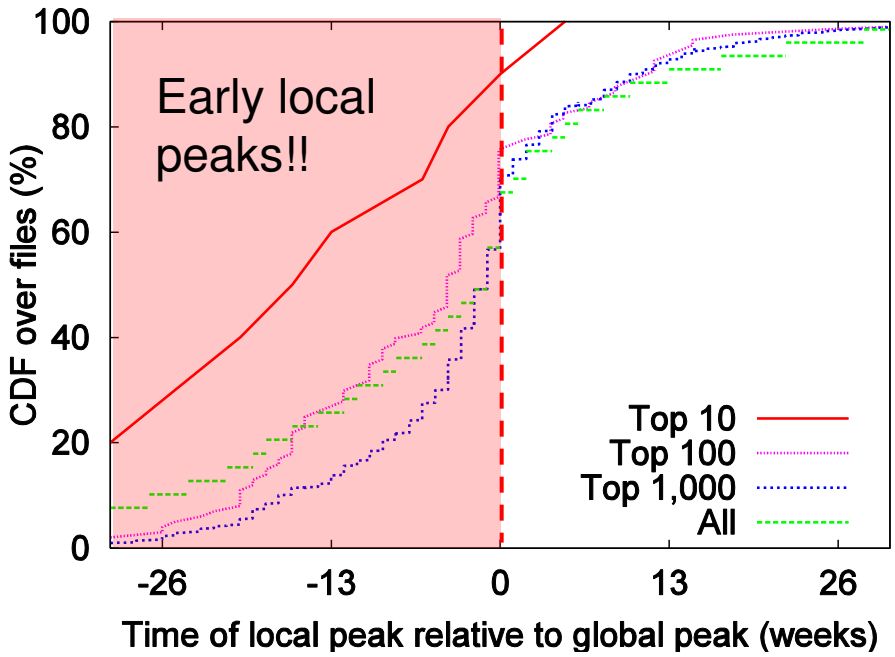
Early adopters
Downloads relative to global peak



- Better predictor the more popular the content becomes
  - As well as for some niche content ...

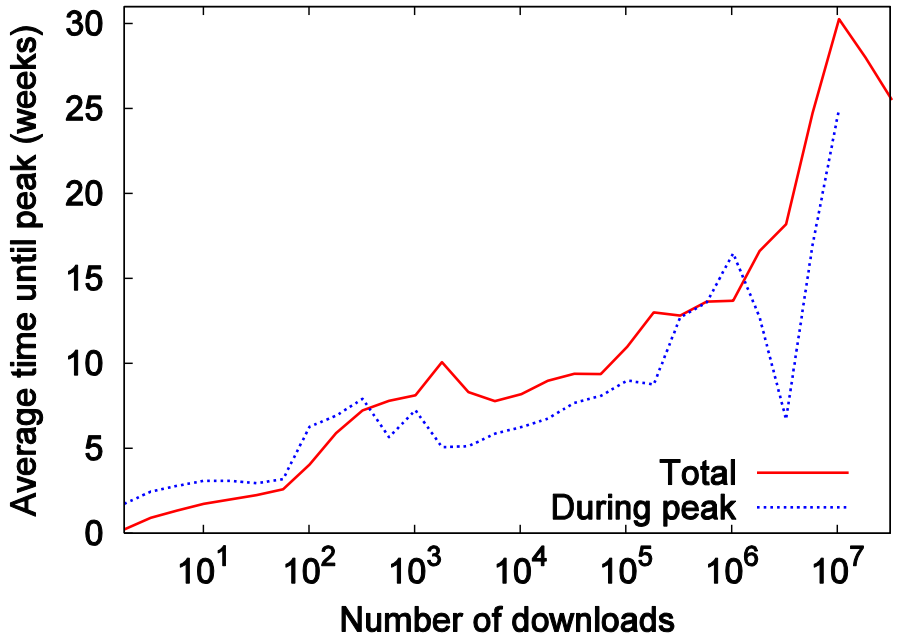
Early adopters

Downloads relative to global peak



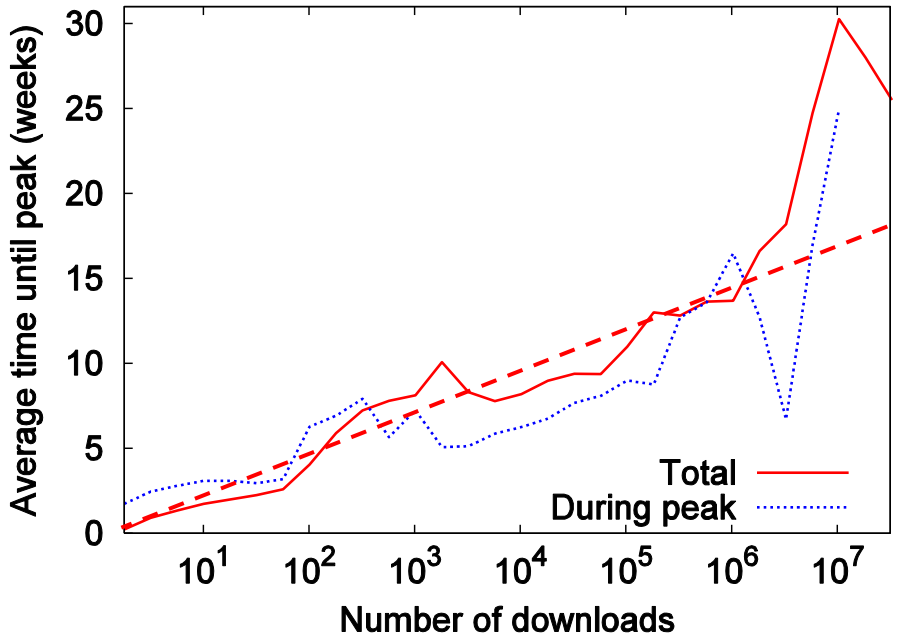
- Better predictor the more popular the content becomes
  - As well as for some niche content ...

Time until peak
Global popularity peaks ...



- The global popularity often peak late for popular content
  - Early flash crowds do not dominate the popularity
  - Perhaps a sign that rich-gets-richer a better model ...

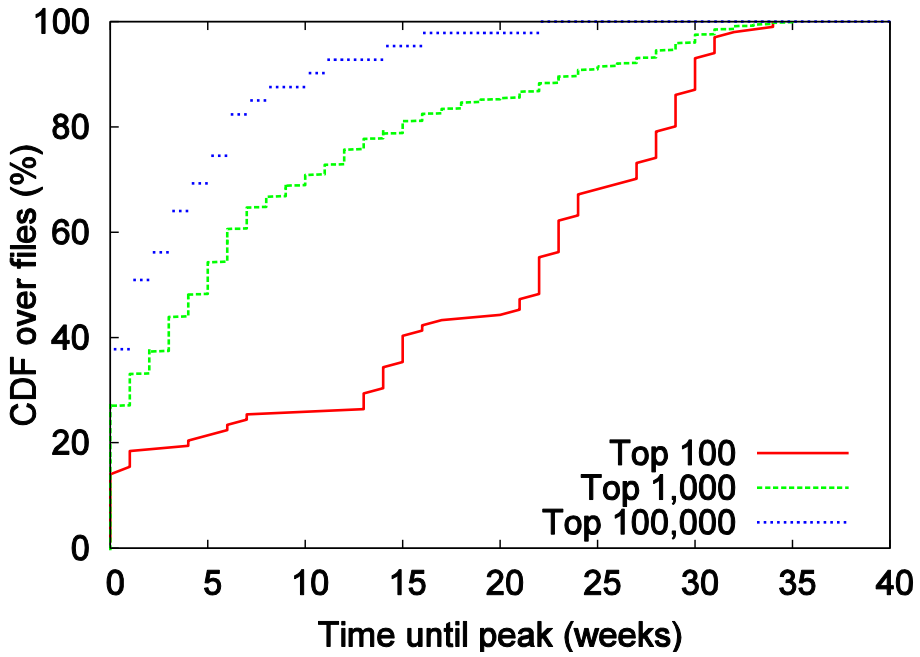
Time until peak
Global popularity peaks ...



- The global popularity often peak later for popular content
  - Early flash crowds do not dominate the popularity
  - Perhaps a sign that rich-gets-richer a better model ...

Time until peak

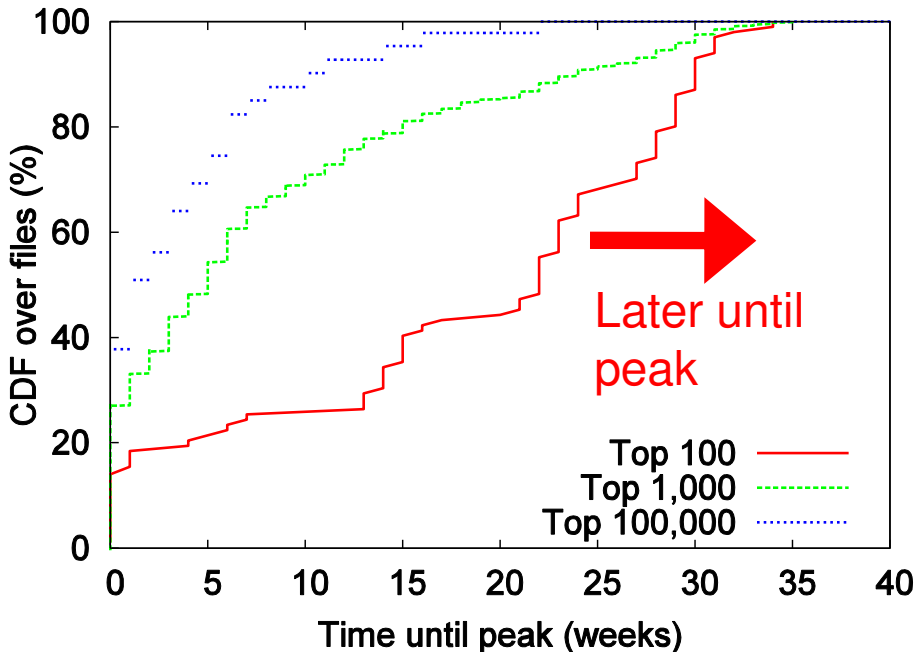
Global popularity peaks ...



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

Time until peak

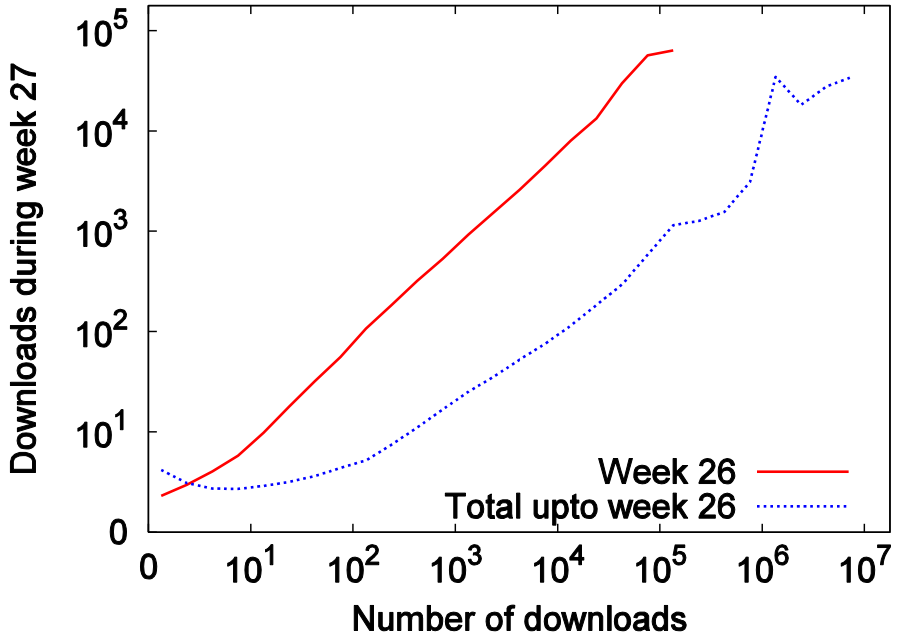
Global popularity peaks ...



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

Time until peak

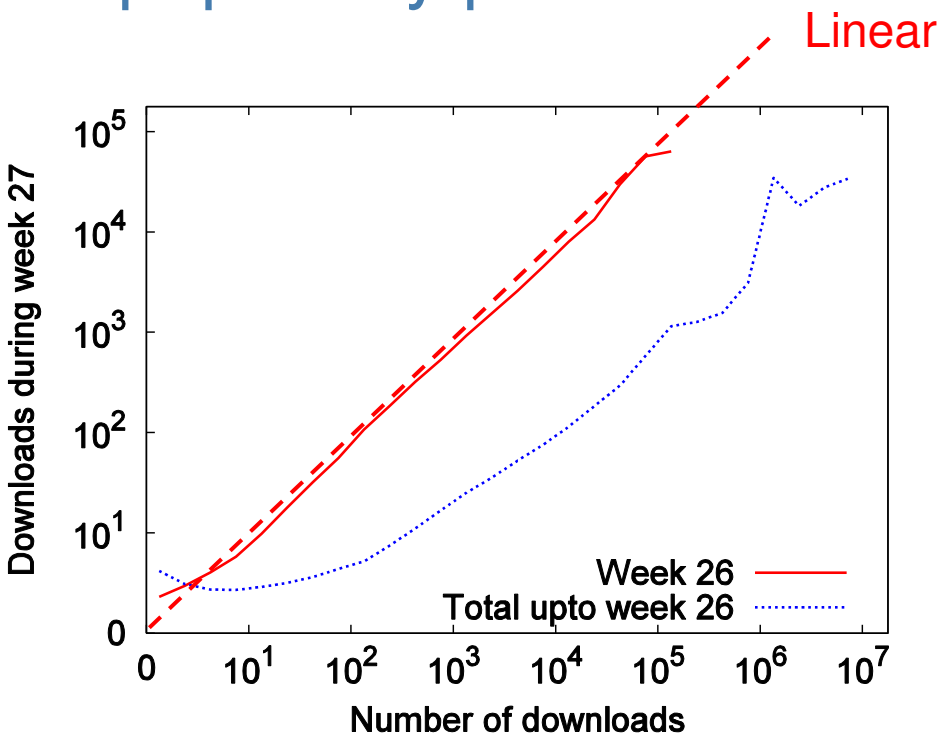
Global popularity peaks ...



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

Time until peak

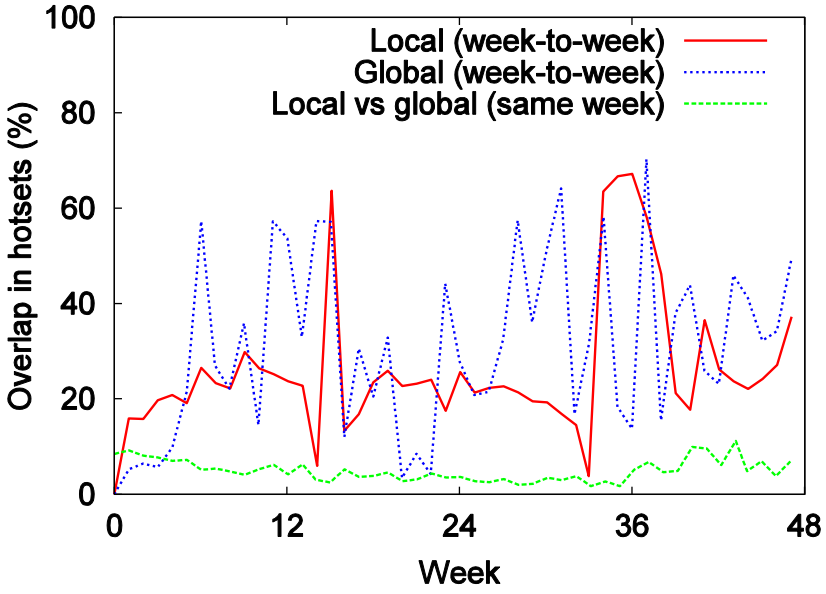
Global popularity peaks ...



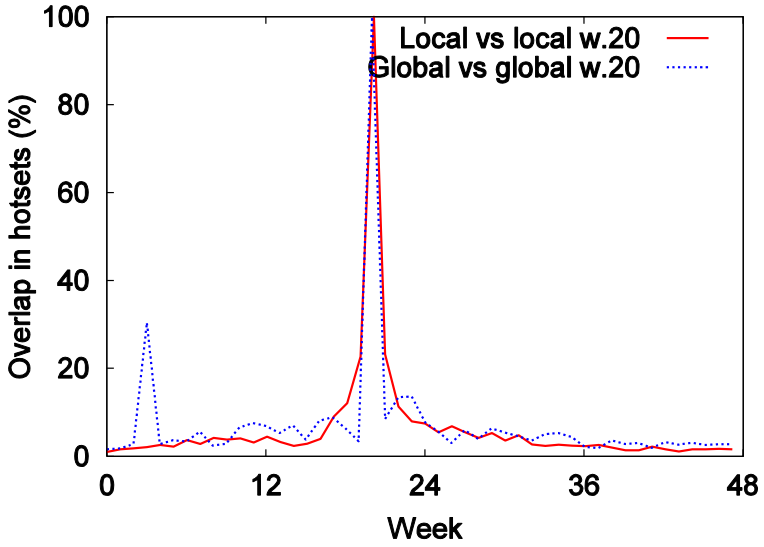
- Rich-gets-richer
  - Close to linear from week-to-week
  - Cumulative total downloads show weaker (sub-linear) rich-gets-richer behavior

Hotset analysis

Popularity churn

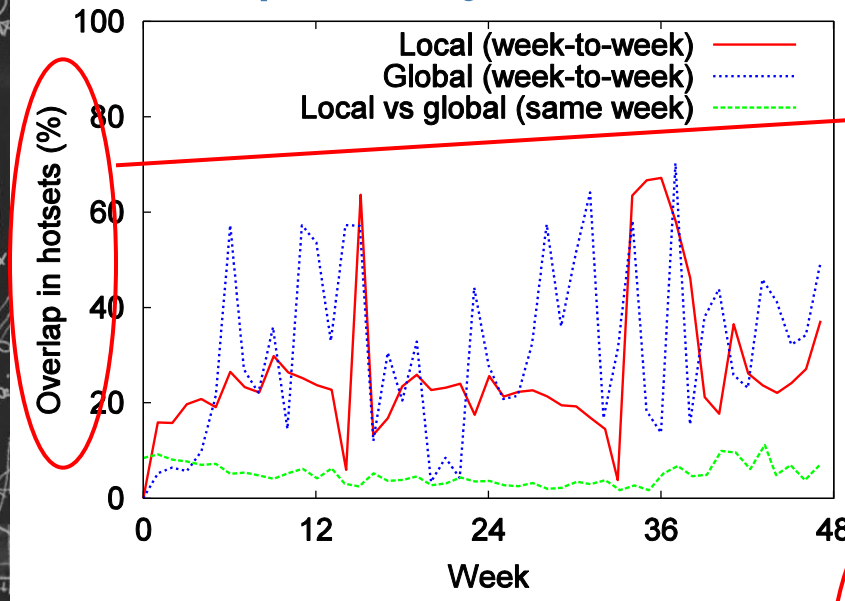


- High popularity churn
  - Roughly 50-60% new videos each week
  - Some files reoccur
- Some video reoccur in hotset



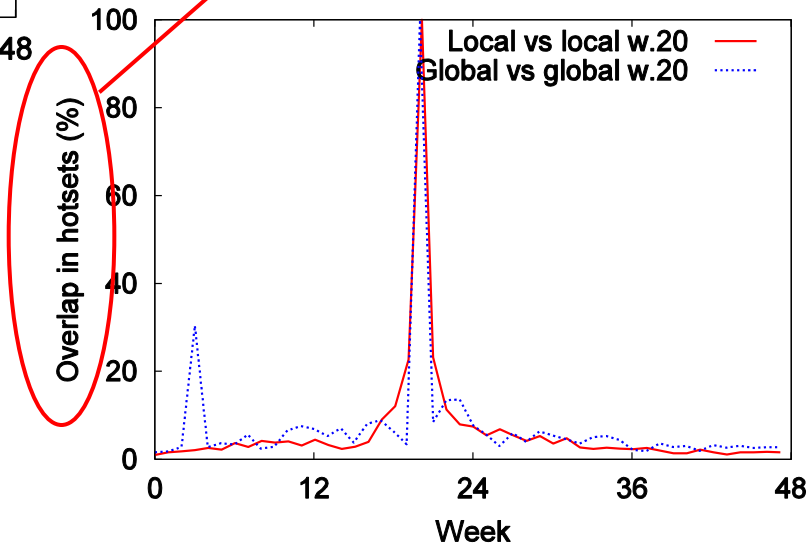
Hotset analysis

Popularity churn



Similarity between weeks

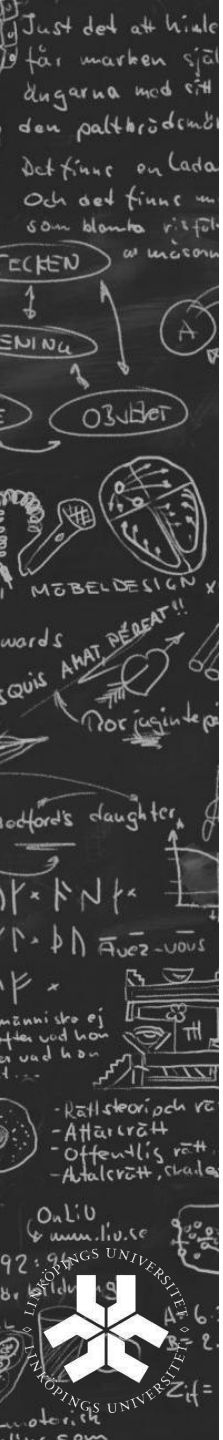
Similarity with week 20



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

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