CSC2231: Caching + Zipf

http://www.cs.toronto.edu/~stefan/courses/csc2231/05au

Stefan Saroiu

Department of Computer Science

University of Toronto

Administrivia

- **No lecture on Monday because of Cascon**
- **Research reports due next Wednesday**
  - In less than 1 week!!

Cache Hit Rates

- **Two ways to measure cache hit rates:**
  - Object hit rate
    - Reduces latency
    - Reflects caching benefits to users
  - Byte hit rate -- reduced bandwidth
    - Reduces bandwidth
    - Reflects caching benefits to network

- **Typically for the Web:**
  - Byte HR < Object HR
  - What does this mean?

What drives cache hit rates?

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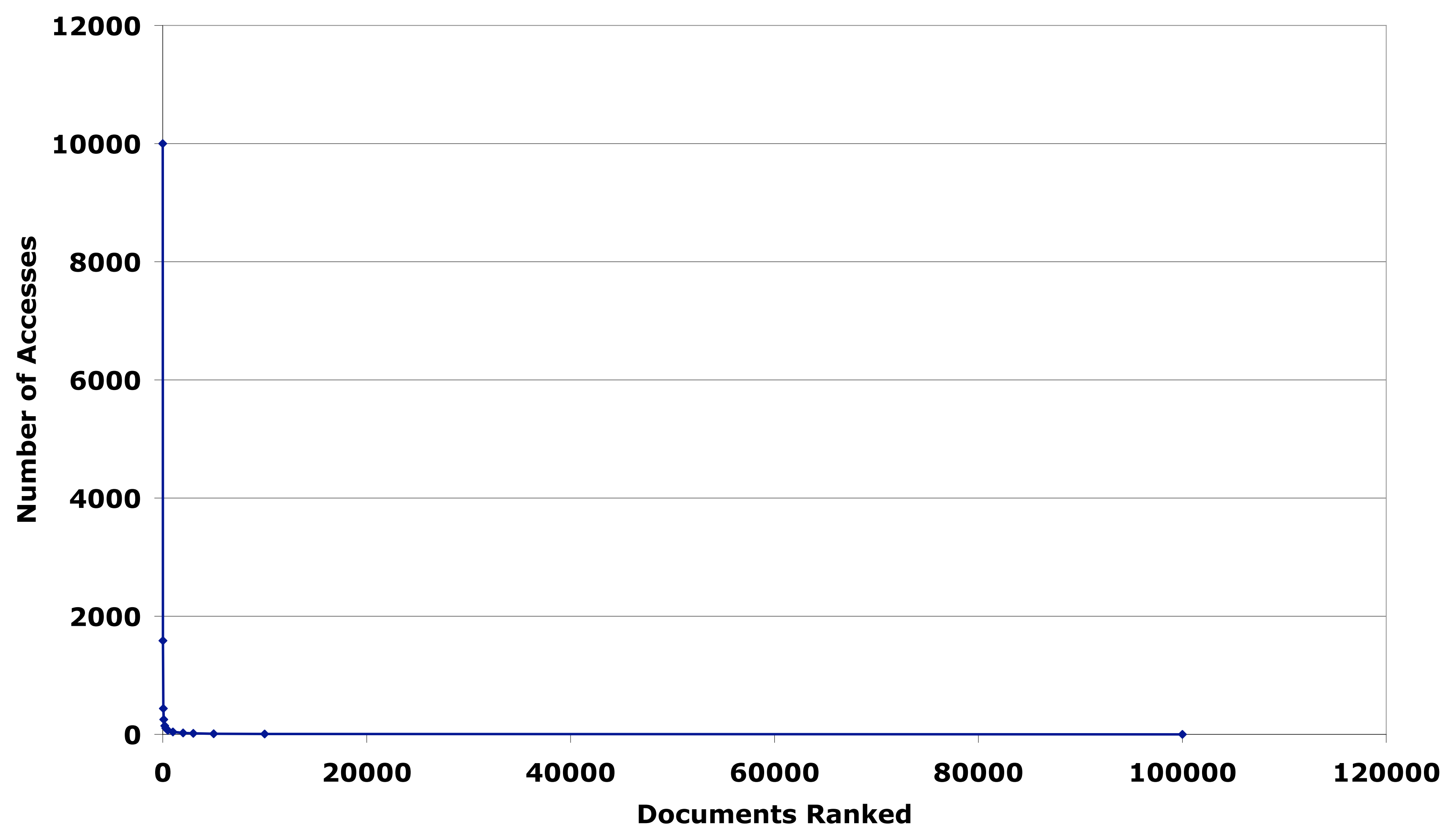
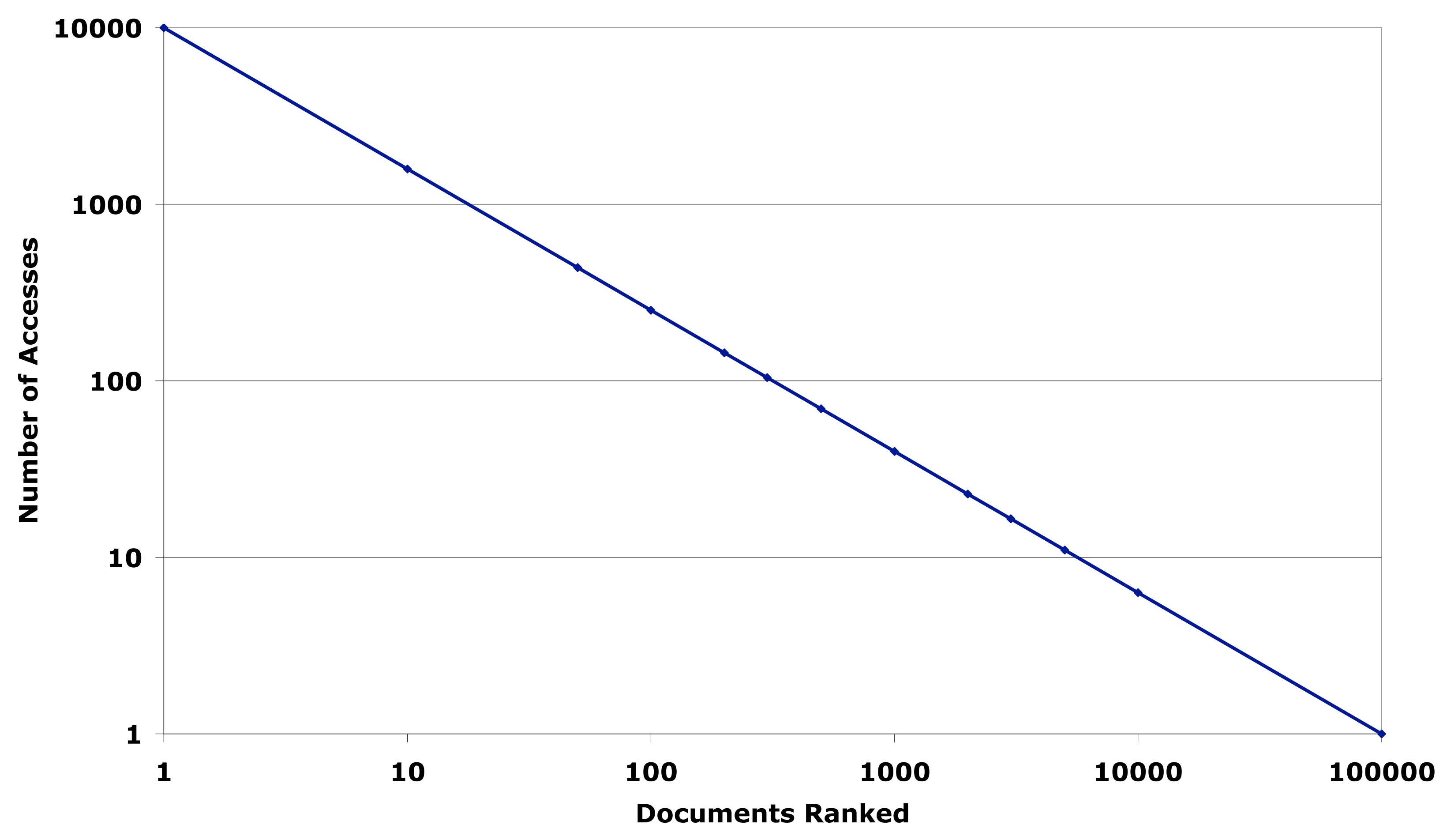
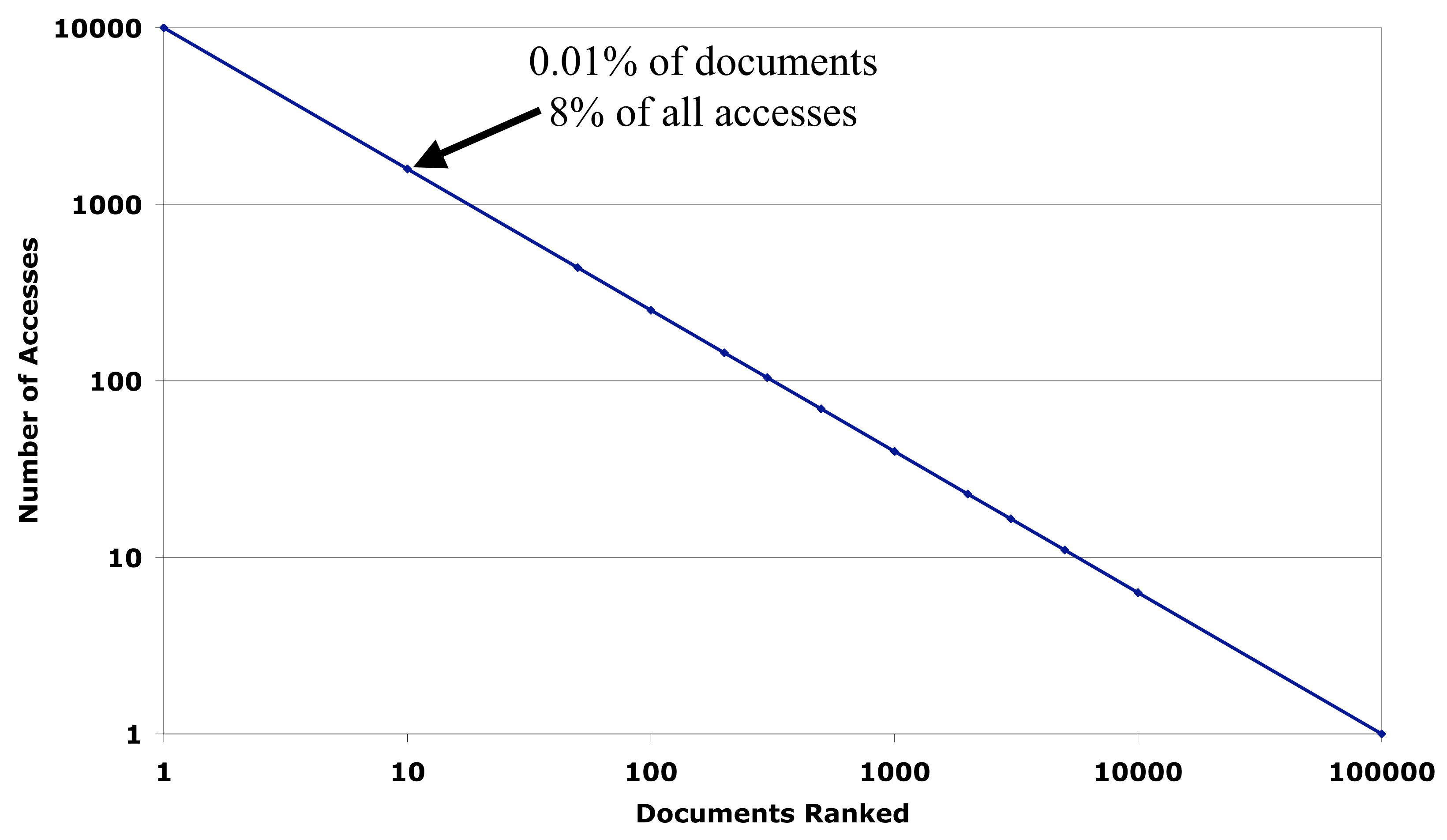
- **Popularity distribution**
- **Number of clients**
- **Rate of updates to the documents**
- **Cacheability of data**
- **Cache sizes vs. object sizes**

Web popularity distribution

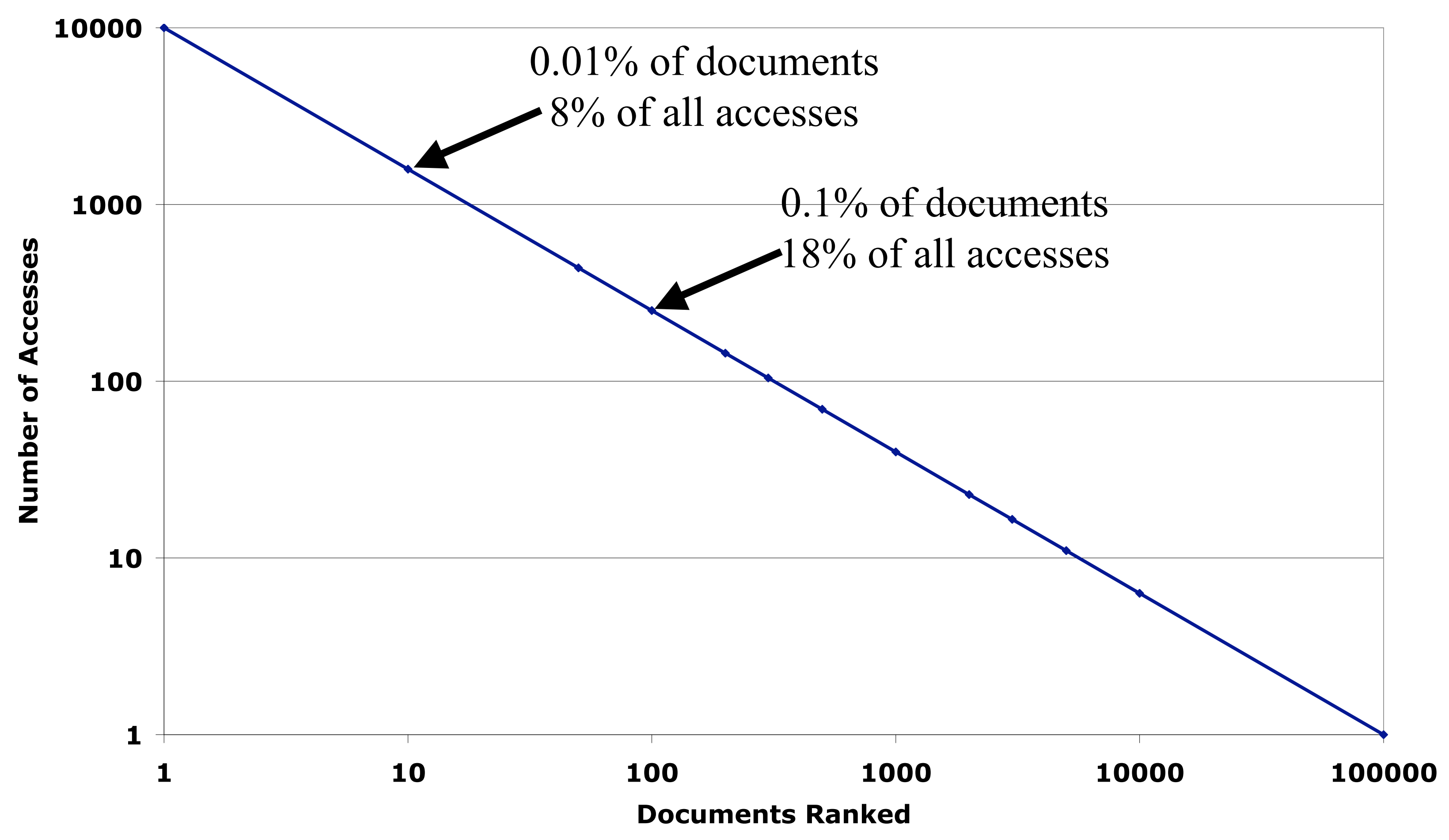


Artificial Zipf distribution with α=0.8


10000
1000
100
10
1
Number of Accesses
1
10
100
1000
10000
100000
Documents Ranked



0.01% of documents
8% of all accesses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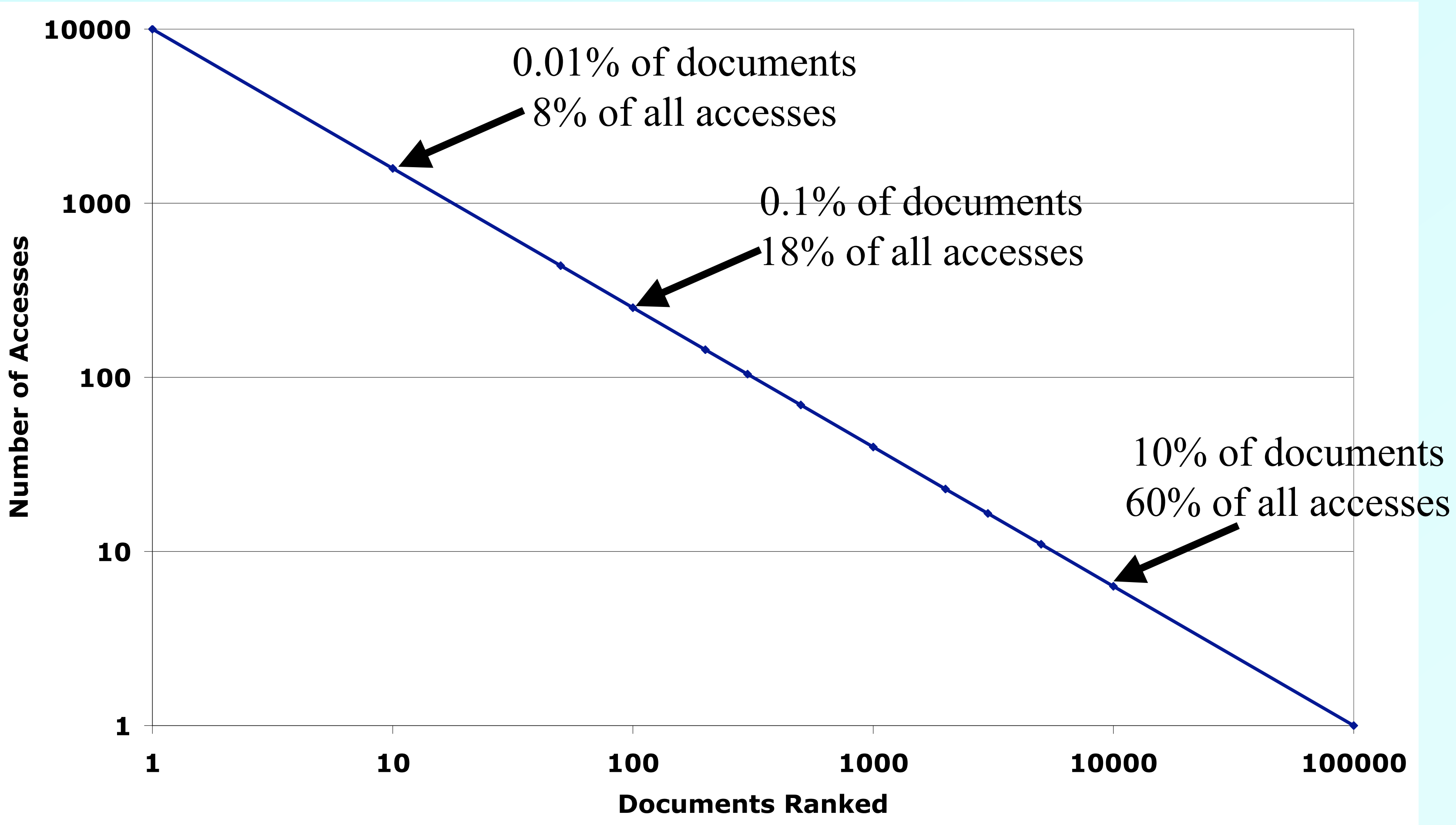
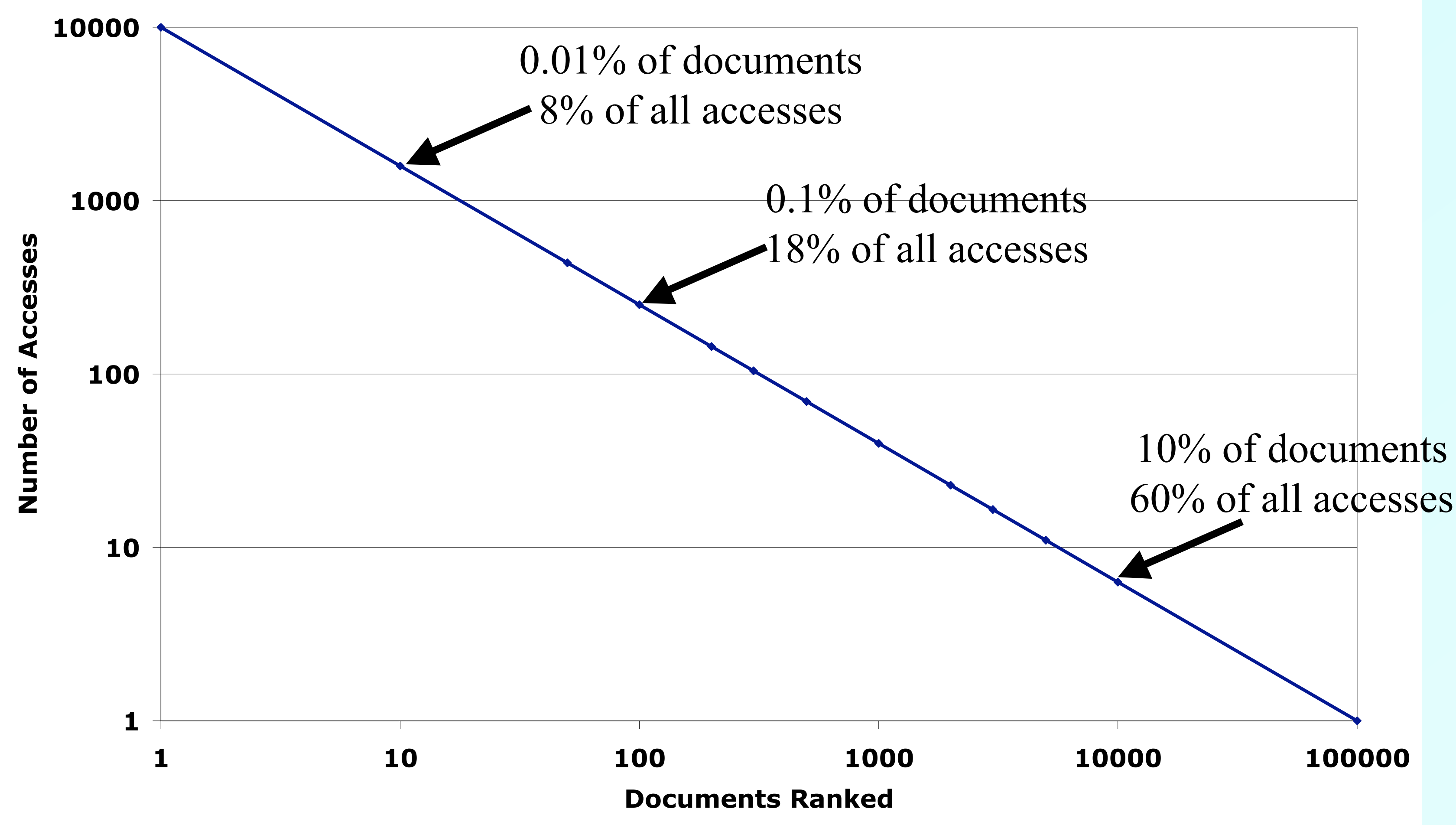
Documents Ranked
0.01% of documents
8% of all accesses
0.1% of documents
18% of all accesses



0.01% of documents
8% of all accesses

0.1% of documents
18% of all accesses

10% of documents
60% of all accesses



0.01% of documents
8% of all accesses

0.1% of documents
18% of all accesses

10% of documents
60% of all accesses

90% of documents:

- have at most 6 accesses
- account for 40% of all accesses

Implications of Object Popularity

- **Implications of object popularity to cache hit rates**
  - Lots of unpopular objects <-- don’t cache
  - Significant very popular objects <-- cache
  - Grey area <-- ?

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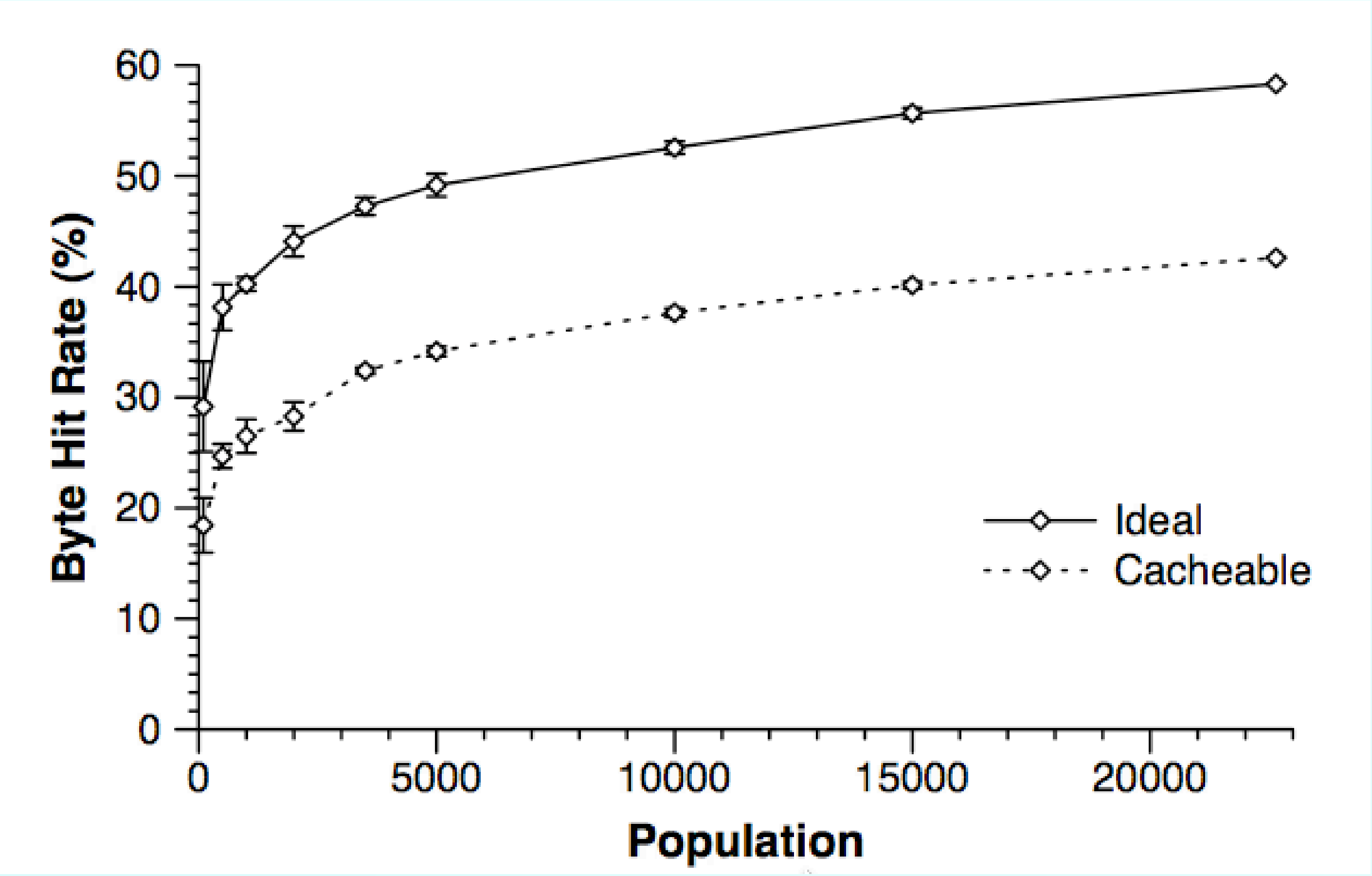
Hit Rate vs. Population



Implications of Client Population

- **What are the implications of client population size to caching hit rates?**
  - Cache location:
    - Trade-off:
      - Closer to the user, higher benefit
      - Closer to the user, fewer clients
    - Place it at the “sweet-spot”
  - Cache hierarchies:
    - Hit rate grows slowly above a few 1000 users
    - Each layer adds latency (and bandwidth)

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Rate of Updates

- **Old studies ‘94 - ‘00**
  - Average lifetime of an HTML object: 40-50 days
  - Average lifetime of an image: ~100 days
  - More popular the object, the more often it is updated
  - Hard to predict
    - More popular the object, easier it is to predict
- **Implications:**
  - Content expiration:
    - Hard to get right; unclear if worth doing it

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Active-Caching

- **Java CacheApplet cached with each object**
- **On each request, cache invokes applet to:**
  - Generate reply, use cached copy, trigger revalidation
  - Maintains on-cache persistent state

- **Problems in practice:**
  - Cache monitors applet CPU and storage use
    - Can “evict” applet and revert to “Expires” consistency
  - Does this solve any real problems?
    - Advertising? Commerce? Personalization?

Advertising: Cache-Busting

- **Advertisers want to** track **and** target
  - Per-user cookies
  - Per-user, per-pageview ad selection
  - Caches **defeat** these goals
  - Caches **help** deliver ad content quickly
- **Real-world solution:**
  - Redirect for ad selection/logging
  - Cacheable ad image files

Commerce Databases

Selling

- **Product DB**
  - Inventory, descriptions, promotions, $, cross-selling info, …
- **User DB**
  - Purchase history, recent browsing, …
- **Business rules**

Purchasing

- **User DB**
  - Credit card, shipping address, …
- **Transaction system**
  - Credit card clearance, integration to shipping, …

Distributed databases for this?
Privacy, proprietary concerns?

Advertising Databases

- **Ad information:**
  - “Inventory”, $, targeting criteria (eligible content types, desired user types, time of day), …
- **Placement information:**
  - Stats about the traffic to different pages, $, content topic, expected mix of users with different criteria, …
- **Per-user information:**
  - Topics of interest, links to registration/marketing profiles, detailed recent ad viewing history, …
- **Business rules for combining the above in real-time**
- **How to distribute these databases to caches?**

Personalized Publishing

- **my.yahoo.com, slashdot.org**
  - Personalized pages from sharable/cacheable components
  - Different layouts/subsets/orders/sorts
- **Seems more tractable**
  - Per-user preferences database must be distributed
- **Active-caching? Other cache-side method? Better done at the client w/XML?**

Delta-Coding

- **Server sends “diffs” against cached copy of page**
  - Can reduce bandwidth for dynamic content
  - Still requires round-trip latency to server
    - For most WWW objects probably not worth saving bw
- **Exploits redundant data already in cache to compress updated object**
  - Straight compression (orthogonal)
  - Spring/Wetherall use of Manber fingerprints?

Dynamic Content vs Cache Deployments

	Dynamic: Advertising	Dynamic: Commerce	Dynamic: Publishing	Static
Client Cache				
Proxy Cache				
CDN				
Accelerator				

Dynamic Content vs Cache Deployments

	Dynamic: Advertising	Dynamic: Commerce	Dynamic: Publishing	Static
Client Cache	Delta-coding	Delta-coding	Delta-coding	Delta-coding
Proxy Cache	Delta-coding	Delta-coding	Active-caching / Delta-coding	Delta-coding
CDN	Custom (DoubleClick)	Custom (Amazon?, Yahoo Merchants)	Active-caching, Delta-coding, Custom (Akamai)	Custom (Akamai)
Accelerator	Webserver / DUP	Webserver / DUP	Webserver / DUP	Expires

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Cache Sizes

- **Google can cache the entire Internet**
- **Disks are infinite**

- **Do we care about Web cache sizes anymore?**

Discussion

- **RSS feeds:**
  - Should we cache these?