ΑΝΑΚΤΗΣΗ ΠΛΗΡΟΦΟΡΙΩΝ ΚΑΙ ΑΝΑΖΗΤΗΣΗ ΣΤΟΝ ΠΑΓΚΟΣΜΙΟ ΙΣΤΟ

Παροράματα από το Πανεπιστήμιο της Στουγκάρδης

Introduction to

Information Retrieval

Hinrich Schütze and Christina Lioma

Lecture 20: Crawling

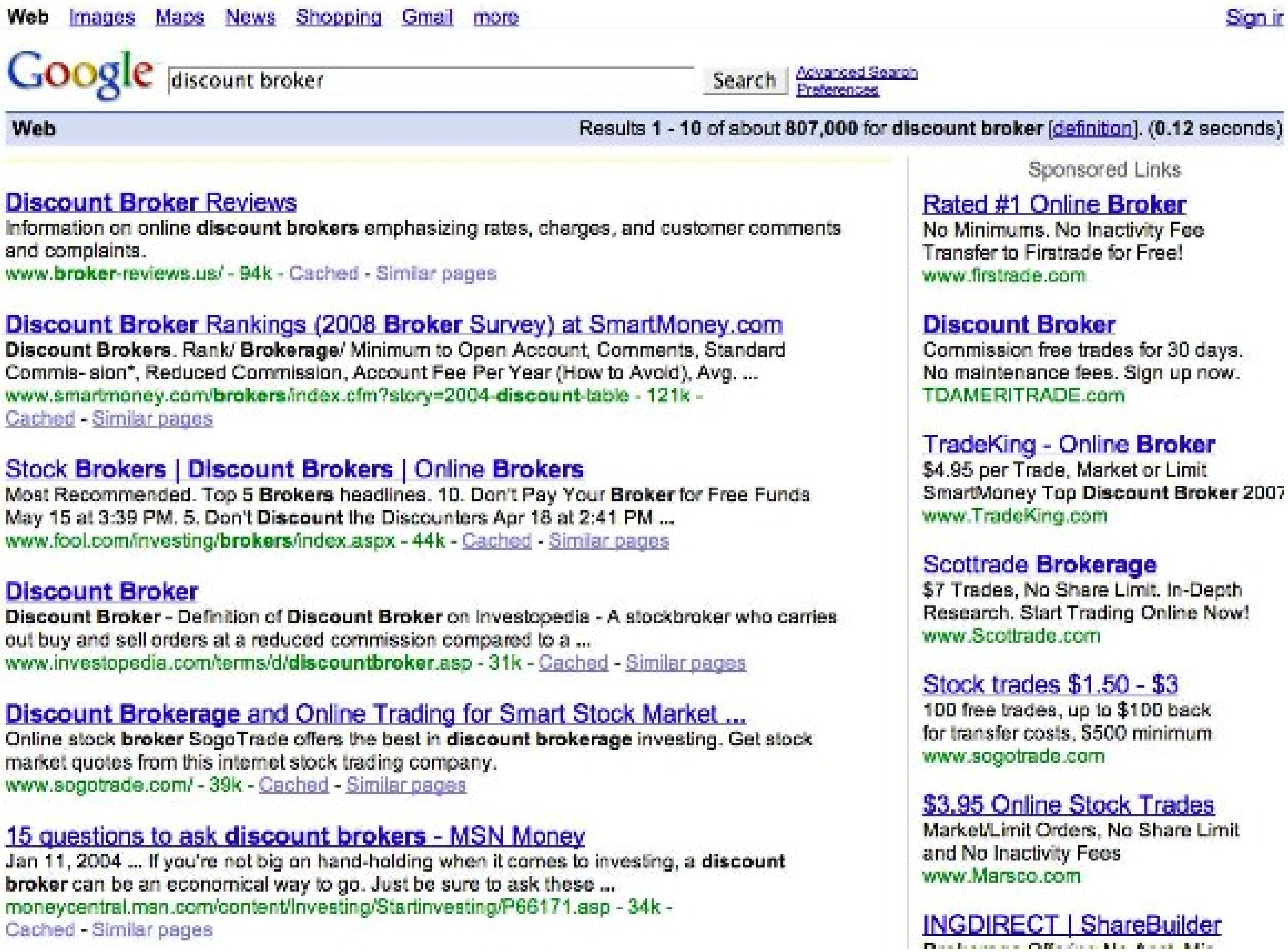
Overview

1. Recap
2. A simple crawler
3. A real crawler

Outline

1. Recap
2. A simple crawler
3. A real crawler

Search engines rank content pages *and* ads



Google's second price auction

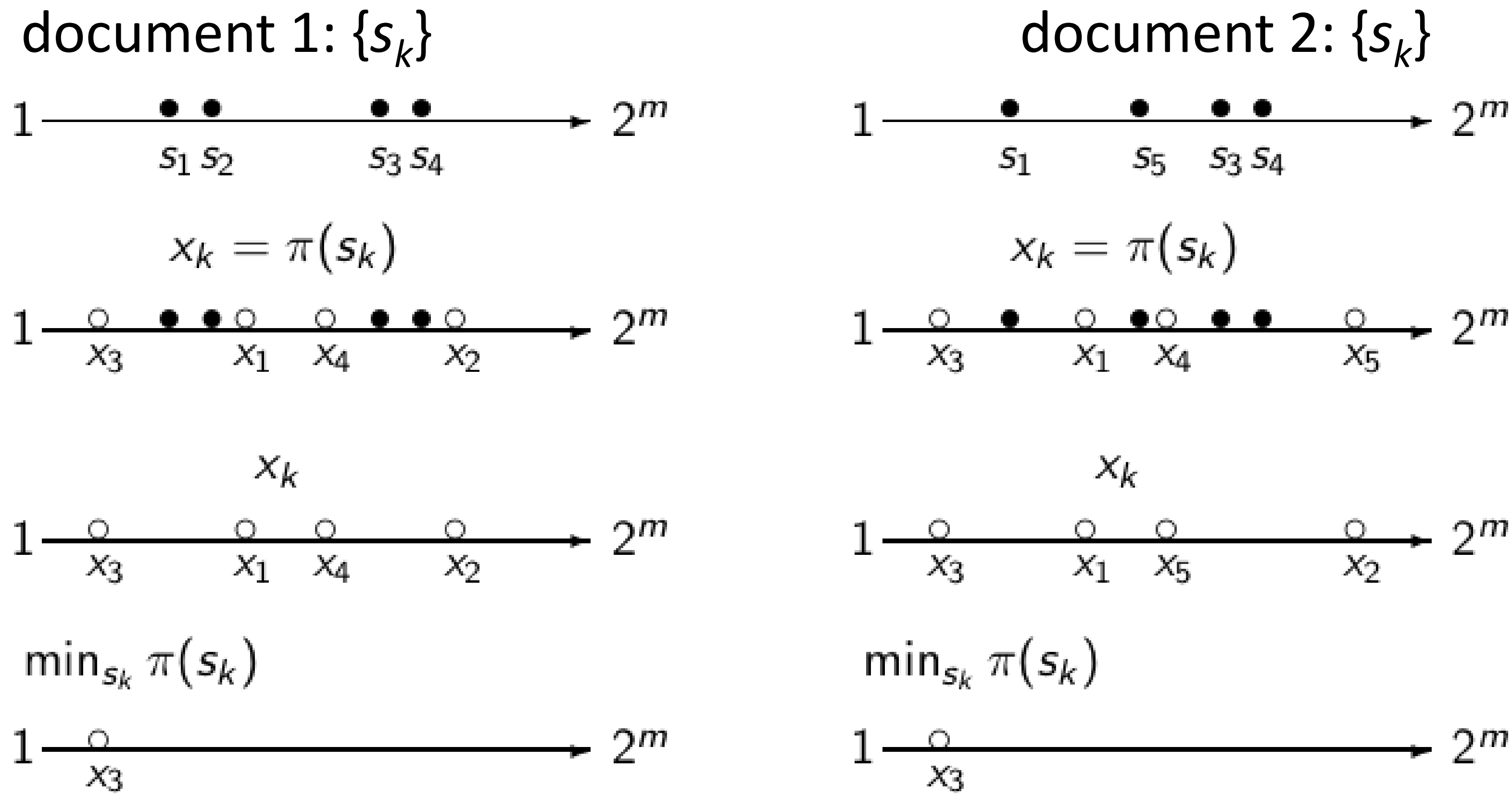
advertiser	bid	CTR	ad rank	rank	paid
A	\$4.00	0.01	0.04	4	(minimum)
B	\$3.00	0.03	0.09	2	\$2.68
C	\$2.00	0.06	0.12	1	\$1.51
D	\$1.00	0.08	0.08	3	\$0.51

- bid: maximum bid for a click by advertiser
- CTR: click-through rate: when an ad is displayed, what percentage of time do users click on it? CTR is a measure of relevance.
- ad rank: bid × CTR: this trades off (i) how much money the advertiser is willing to pay against (ii) how relevant the ad is
- paid: Second price auction: The advertiser pays the minimum amount necessary to maintain their position in the auction (plus 1 cent).

What’s great about search ads

- Users only click if they are interested.
- The advertiser only pays when a user clicks on an ad.
- Searching for something indicates that you are more likely to buy it . . .
- . . . in contrast to radio and newpaper ads.

Near duplicate detection: Minimum of permutation



Roughly: We use $\min_{s \in d_1} \pi(s) = \min_{s \in d_2} \pi(s)$ as a test for: are d_1 and d_2 near-duplicates?

Example

	d_1	d_2
s_1	1	0
s_2	0	1
s_3	1	1
s_4	1	0
s_5	0	1

$h(x) = x \bmod 5$

$g(x) = (2x + 1) \bmod 5$

$\min(h(d_1)) = 1 \neq 0 = \min(h(d_2))$ $\min(g(d_1)) = 2 \neq 0 = \min(g(d_2))$

$\hat{J}(d_1, d_2) = \frac{0+0}{2} = 0$

	d_1 slot		d_2 slot	
		∞		∞
		∞		∞
$h(1) = 1$	1	1	–	∞
$g(1) = 3$	3	3	–	∞
$h(2) = 2$	–	1	2	2
$g(2) = 0$	–	3	0	0
$h(3) = 3$	3	1	3	2
$g(3) = 2$	2	2	2	0
$h(4) = 4$	4	1	–	2
$g(4) = 4$	4	2	–	0
$h(5) = 0$	–	1	0	0
$g(5) = 1$	–	2	1	0

final sketches

Outline

1. Recap
2. A simple crawler
3. A real crawler

How hard can crawling be?

- Web search engines must crawl their documents.
- Getting the content of the documents is easier for many other IR systems.
  - E.g., indexing all files on your hard disk: just do a recursive descent on your file system
- Ok: for web IR, getting the content of the documents takes longer . . .
- . . . because of latency.
- But is that really a design/systems challenge?

Basic crawler operation

- Initialize queue with URLs of known seed pages
- Repeat
  - Take URL from queue
  - Fetch and parse page
  - Extract URLs from page
  - Add URLs to queue
- Fundamental assumption: The web is well linked.

Exercise: What's wrong with this crawler?

```
urlqueue := (some carefully selected set of seed urls)
while urlqueue is not empty:
myurl := urlqueue.getlastanddelete()
mypage := myurl.fetch()
fetchedurls.add(myurl)
newurls := mypage.extracturls()
for myurl in newurls:
if myurl not in fetchedurls and not in urlqueue:
urlqueue.add(myurl)
addtoinvertedindex(mypage)
```

What's wrong with the simple crawler

- Scale: we need to distribute.
- We can't index everything: we need to subselect. How?
- Duplicates: need to integrate duplicate detection
- Spam and spider traps: need to integrate spam detection
- Politeness: we need to be "nice" and space out all requests for a site over a longer period (hours, days)
- Freshness: we need to recrawl periodically.
  - Because of the size of the web, we can do frequent recrawls only for a small subset.
  - Again, subselection problem or prioritization

Magnitude of the crawling problem

- To fetch 20,000,000,000 pages in one month . . .
- . . . we need to fetch almost 8000 pages per second!
- Actually: many more since many of the pages we attempt to crawl will be duplicates, unfetchable, spam etc.

What a crawler must do

Be polite

- Don’t hit a site too often
- Only crawl pages you are allowed to crawl: robots.txt

Be robust

- Be immune to spider traps, duplicates, very large pages, very large websites, dynamic pages etc

Robots.txt

- Protocol for giving crawlers (“robots”) limited access to a website, originally from 1994
- Examples:
  - User-agent: *

    Disallow: /yoursite/temp/
  - User-agent: searchengine

    Disallow: /
- Important: cache the robots.txt file of each site we are crawling

Example of a robots.txt (nih.gov)

```
User-agent: PicoSearch/1.0
Disallow: /news/information/knight/
Disallow: /nidcd/
...
Disallow: /news/research_matters/secure/
Disallow: /od/ocpl/wag/
User-agent: *
Disallow: /news/information/knight/
Disallow: /nidcd/
...
Disallow: /news/research_matters/secure/
Disallow: /od/ocpl/wag/
Disallow: /ddir/
Disallow: /sdminutes/
```

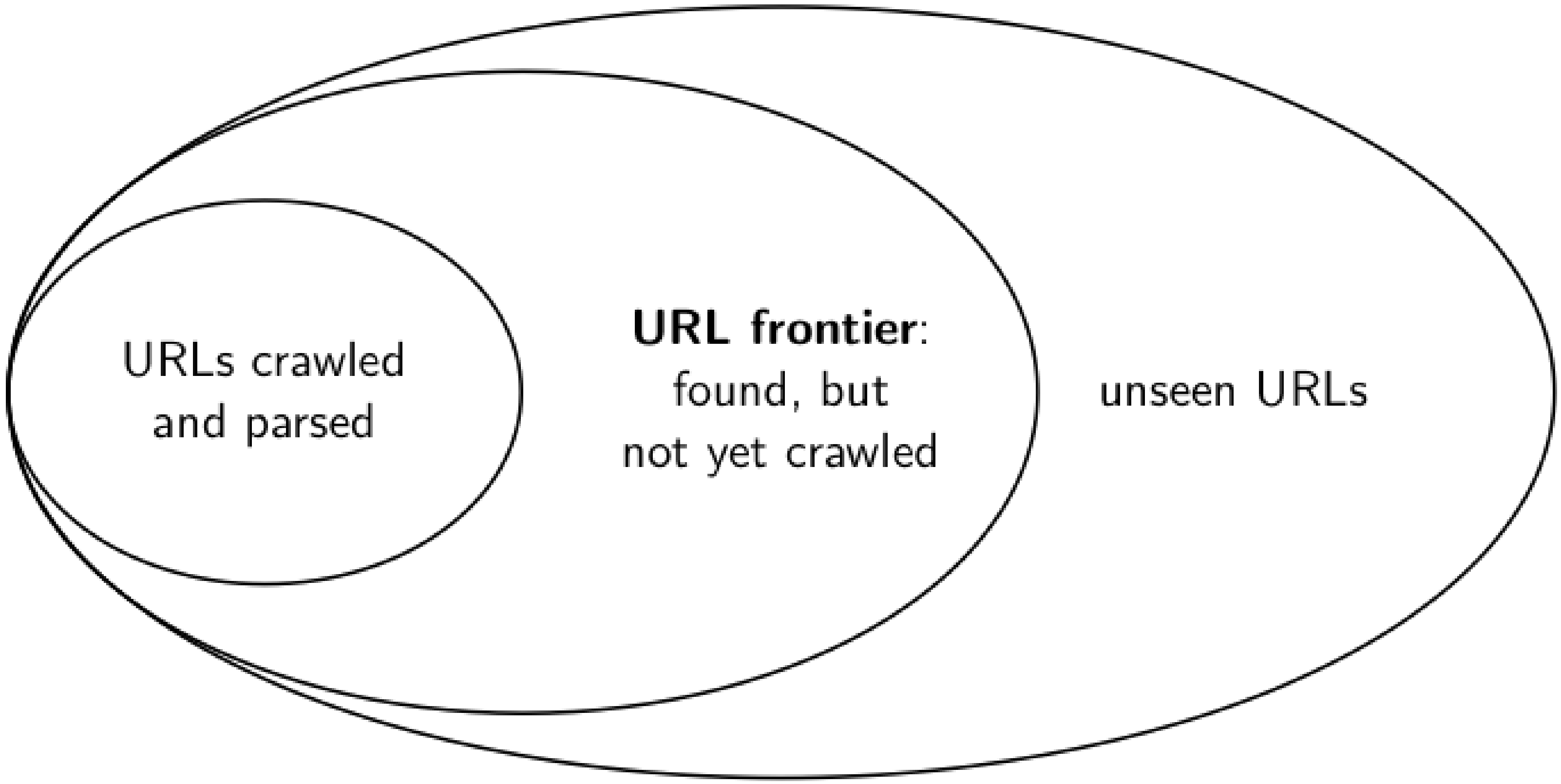
What any crawler should do

- Be capable of distributed operation
- Be scalable: need to be able to increase crawl rate by adding more machines
- Fetch pages of higher quality first
- Continuous operation: get fresh version of already crawled pages

Outline

1. Recap
2. A simple crawler
3. A real crawler

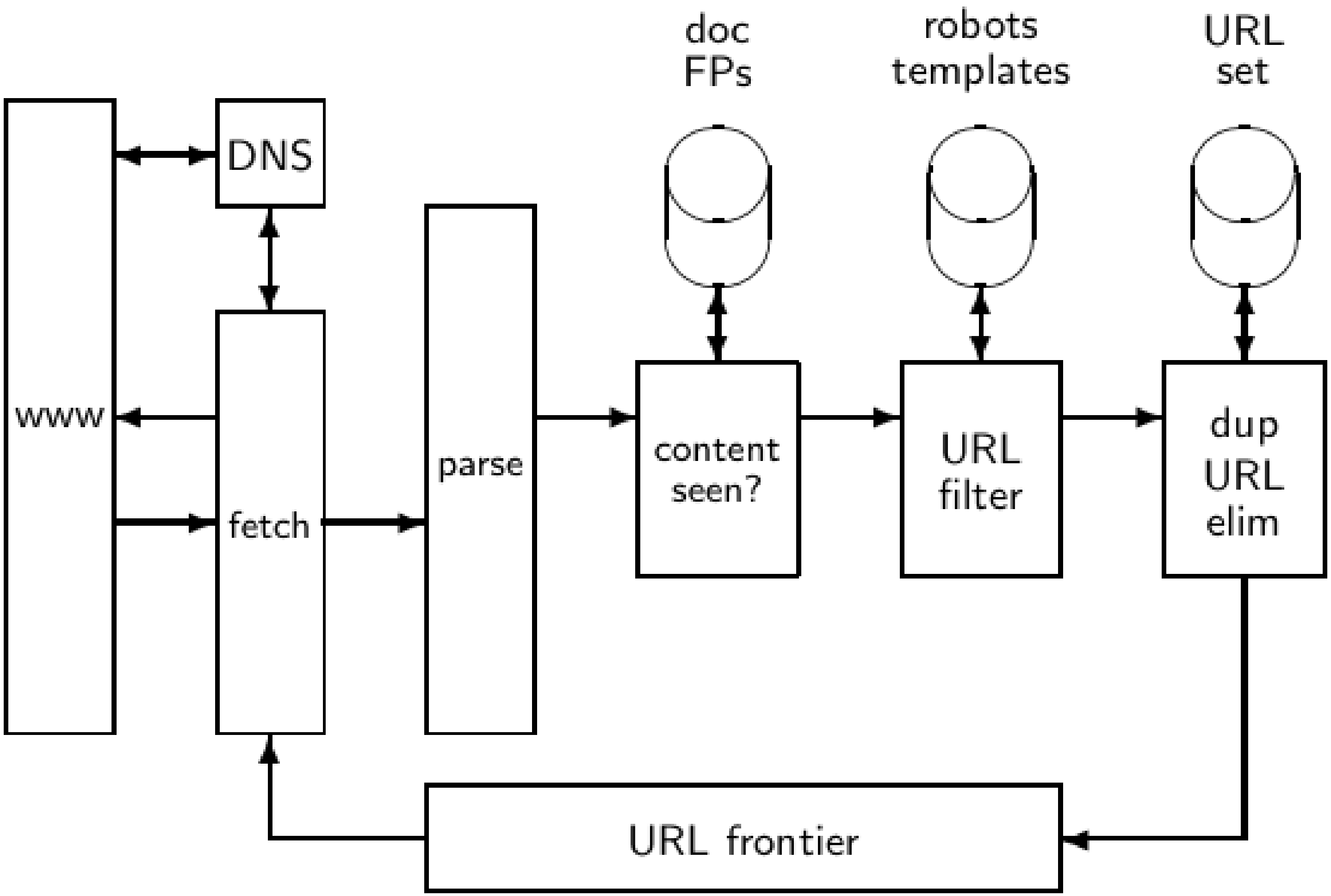
URL frontier



URL frontier

- The URL frontier is the data structure that holds and manages URLs we've seen, but that have not been crawled yet.
- Can include multiple pages from the same host
- Must avoid trying to fetch them all at the same time
- Must keep all crawling threads busy

Basic crawl architecture



URL normalization

- Some URLs extracted from a document are relative URLs.
- E.g., at http://mit.edu, we may have aboutsite.html
  - This is the same as: http://mit.edu/aboutsite.html
- During parsing, we must normalize (expand) all relative URLs.

Content seen

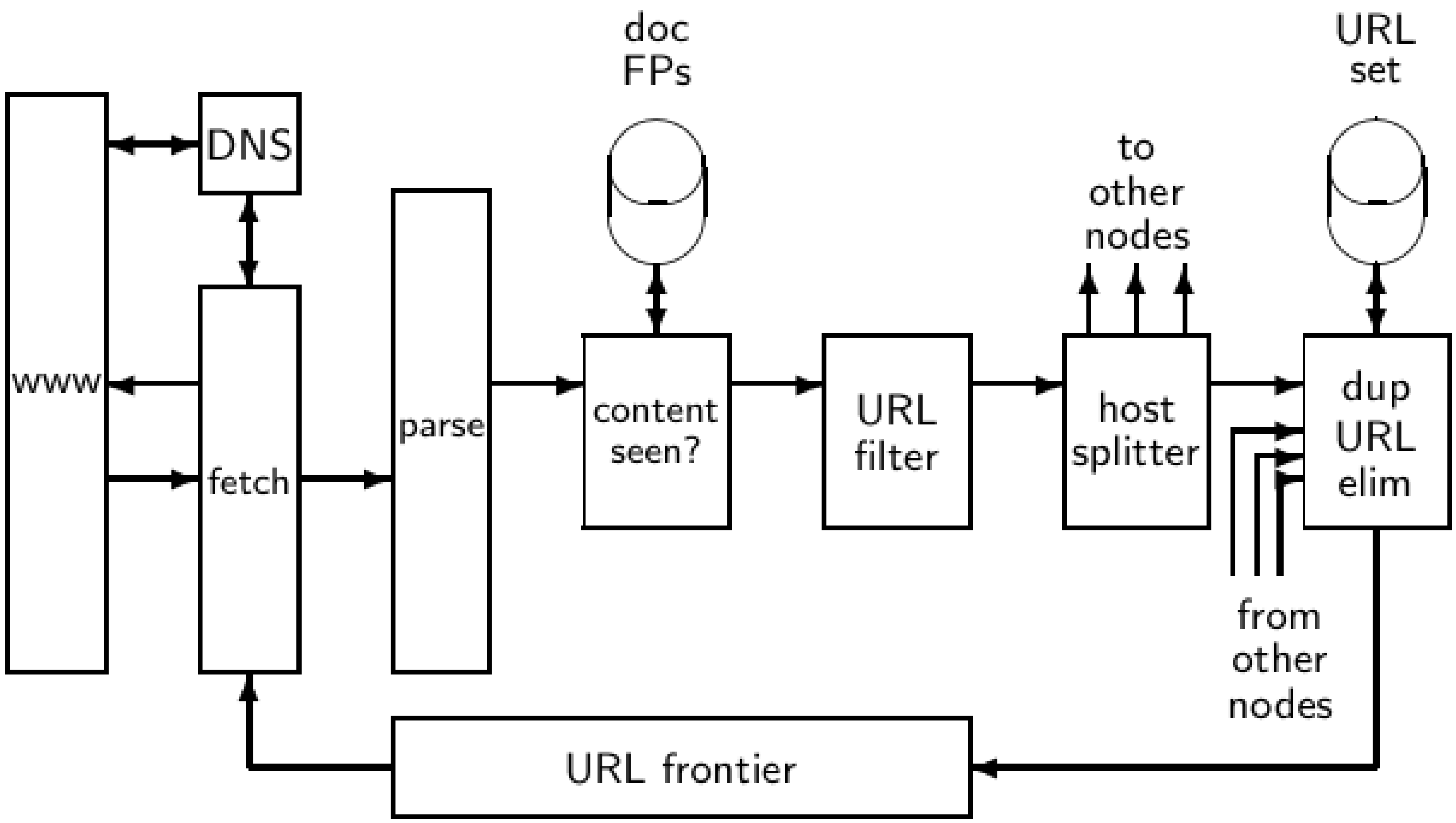
- For each page fetched: check if the content is already in the index
- Check this using document fingerprints or shingles
- Skip documents whose content has already been indexed

Distributing the crawler

- Run multiple crawl threads, potentially at different nodes
  - Usually geographically distributed nodes
- Partition hosts being crawled into nodes

Google data centers (wazfaring. com)

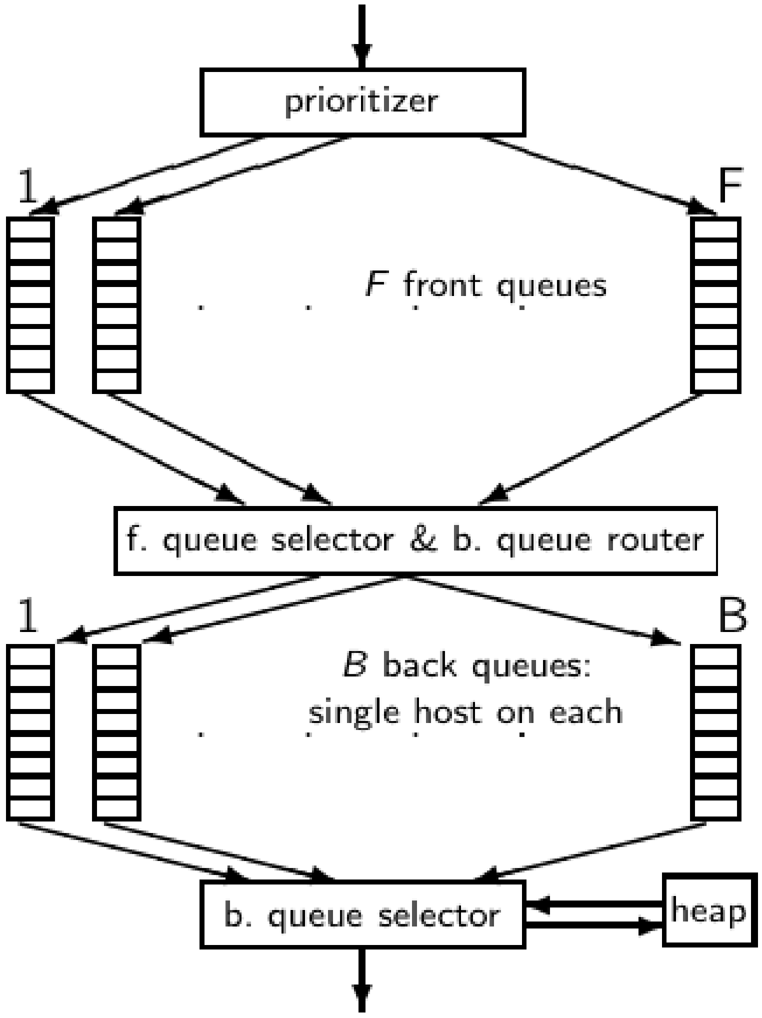
Distributed crawler



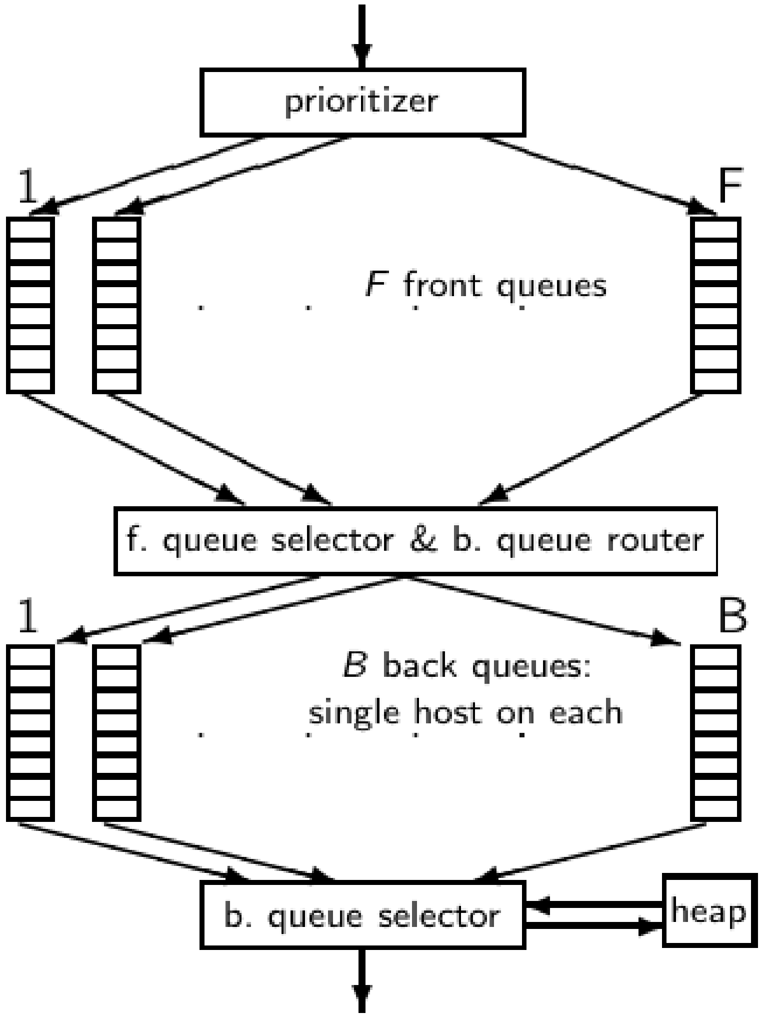
URL frontier: Two main considerations

- Politeness: Don't hit a web server too frequently
  - E.g., insert a time gap between successive requests to the same server
- Freshness: Crawl some pages (e.g., news sites) more often than others
- Not an easy problem: simple priority queue fails.

Mercator URL frontier

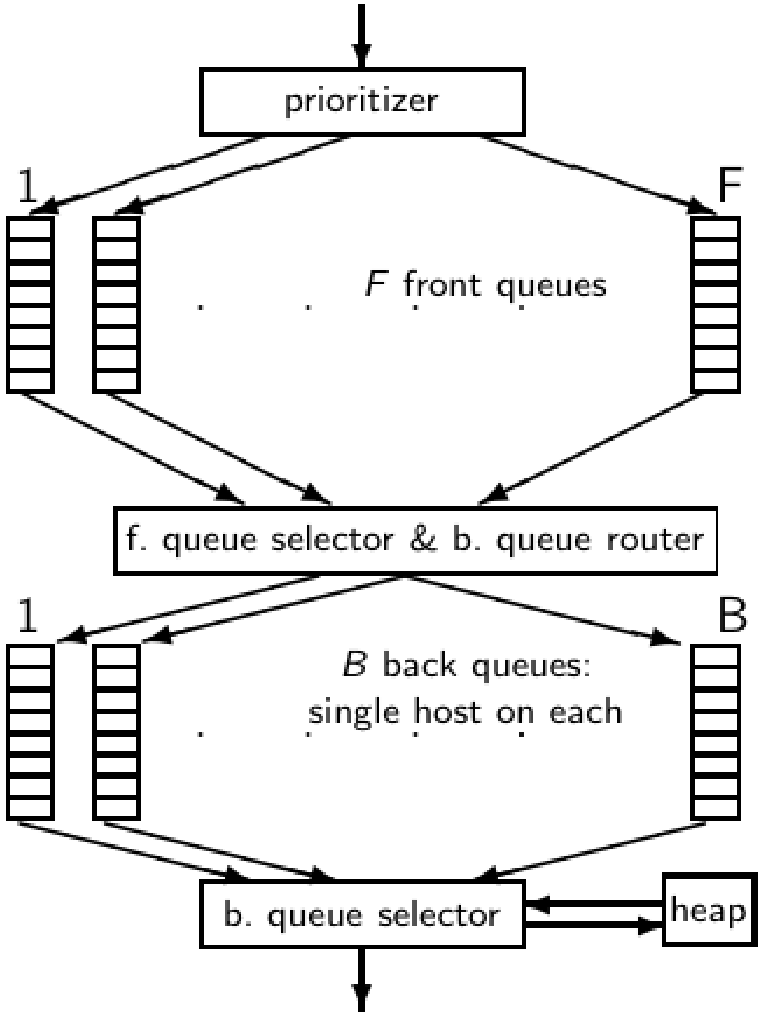


Mercator URL frontier



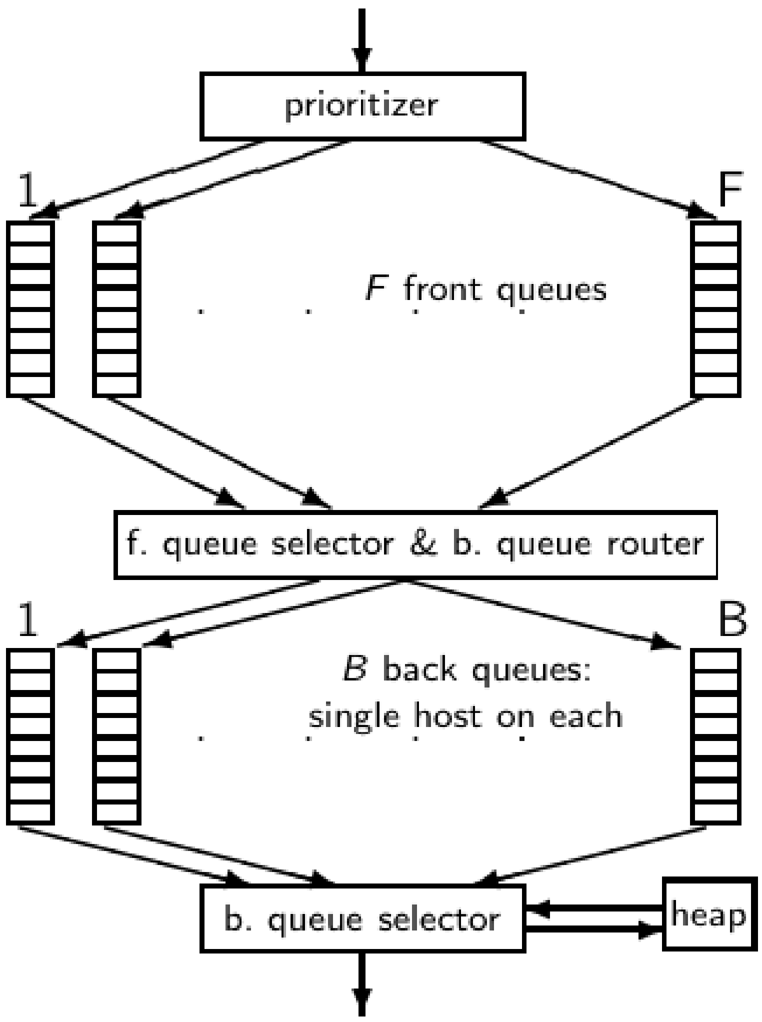
- URLs flow in from the top into the frontier.

Mercator URL frontier



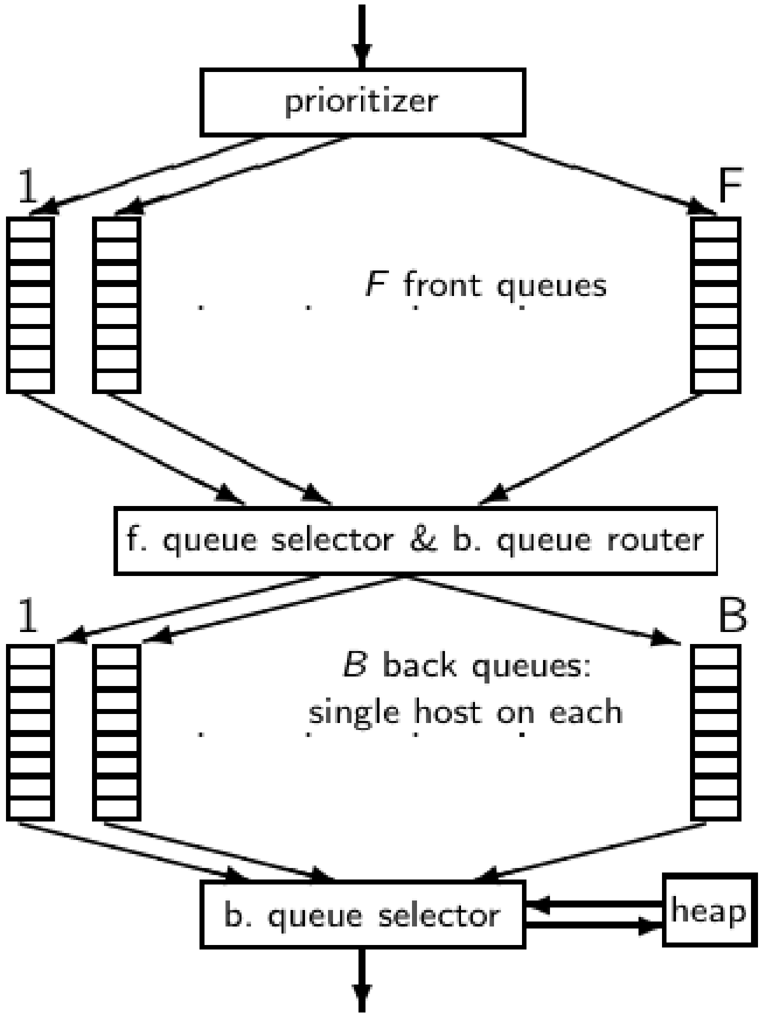
- URLs flow in from the top into the frontier.
- Front queues manage prioritization.

Mercator URL frontier



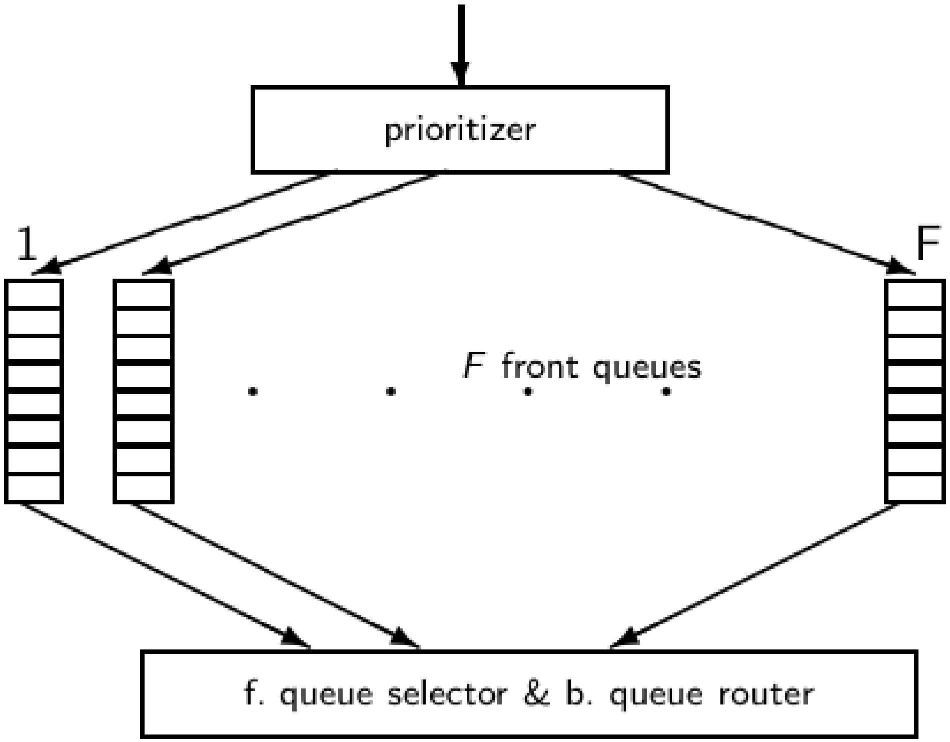
- URLs flow in from the top into the frontier.
- Front queues manage prioritization.
- Back queues enforce politeness.

Mercator URL frontier

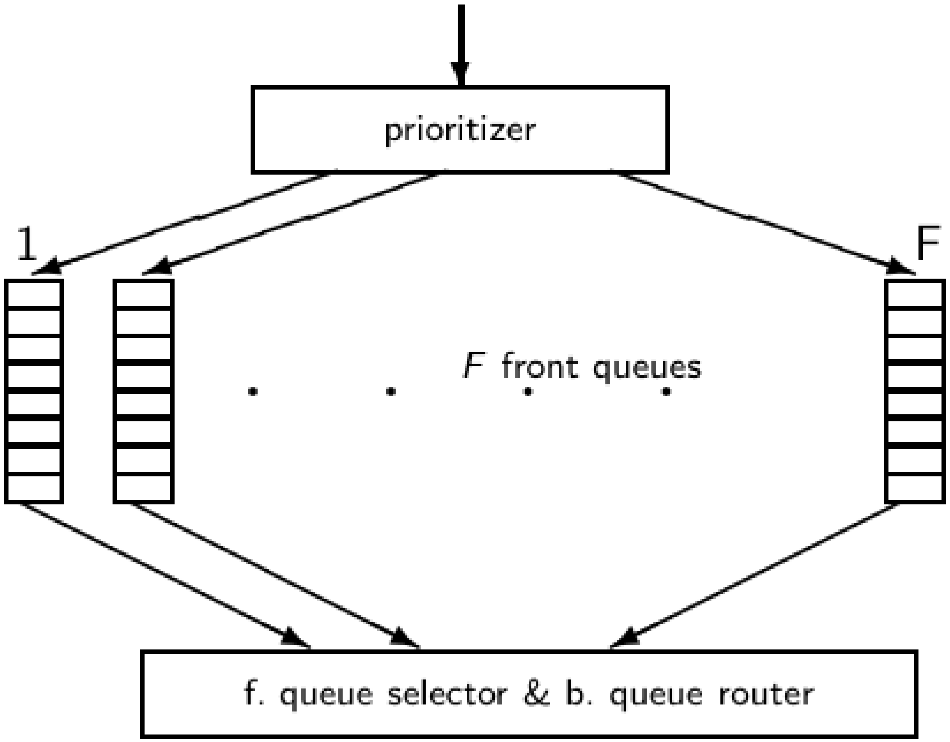


- URLs flow in from the top into the frontier.
- Front queues manage prioritization.
- Back queues enforce politeness.
- Each queue is FIFO.

Mercator URL frontier: Front queues

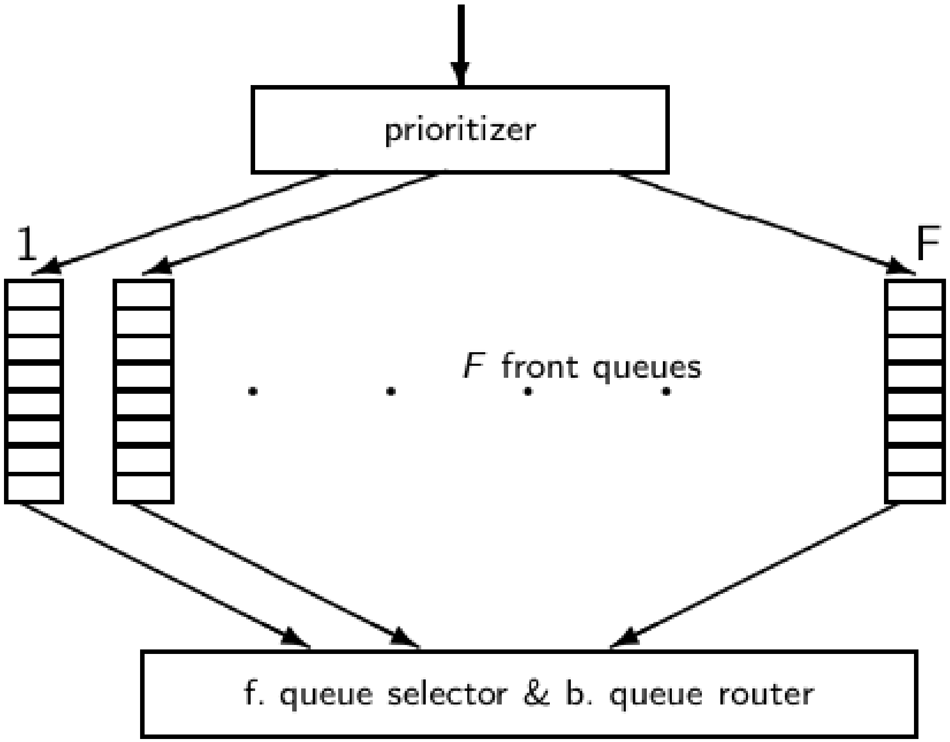


Mercator URL frontier: Front queues



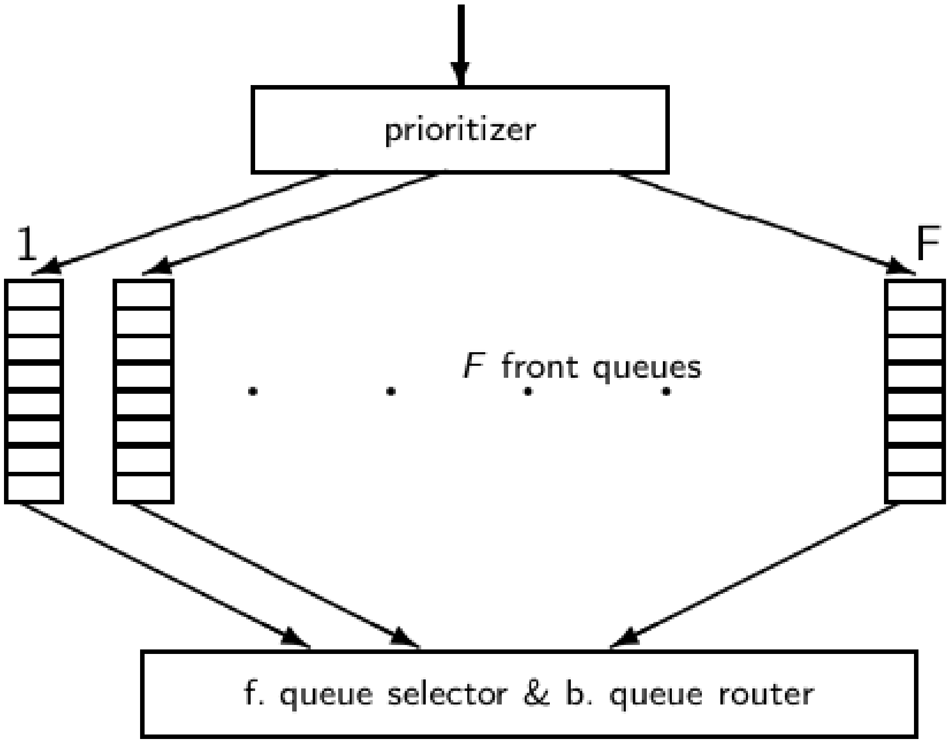
- Prioritizer assigns to URL an integer priority between 1 and *F*.

Mercator URL frontier: Front queues



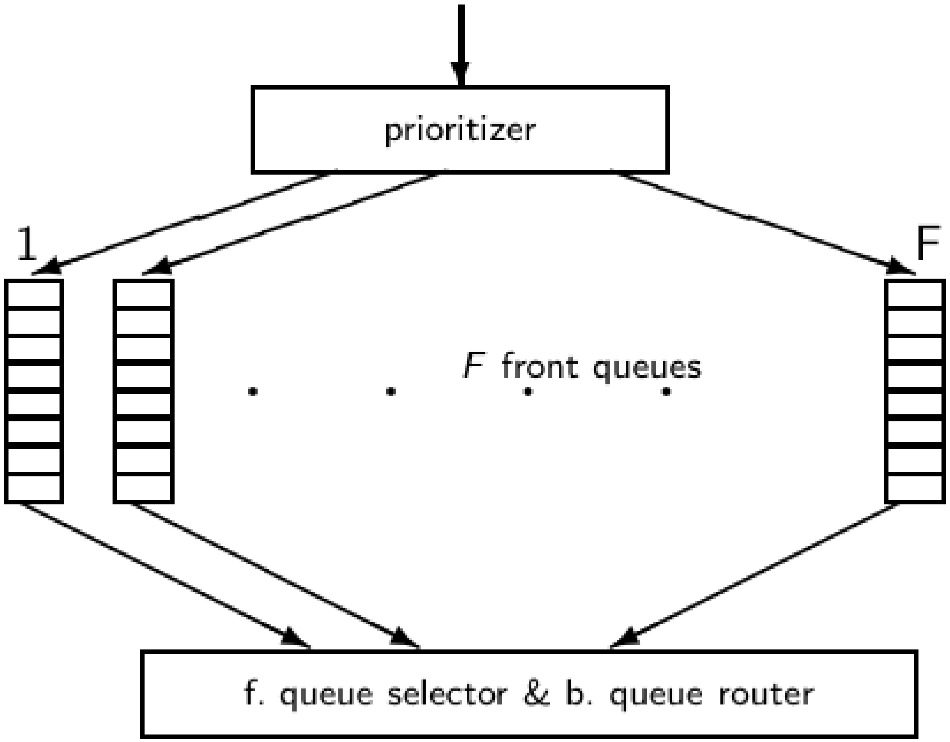
- Prioritizer assigns to URL an integer priority between 1 and *F*.
- Then appends URL to corresponding queue

Mercator URL frontier: Front queues



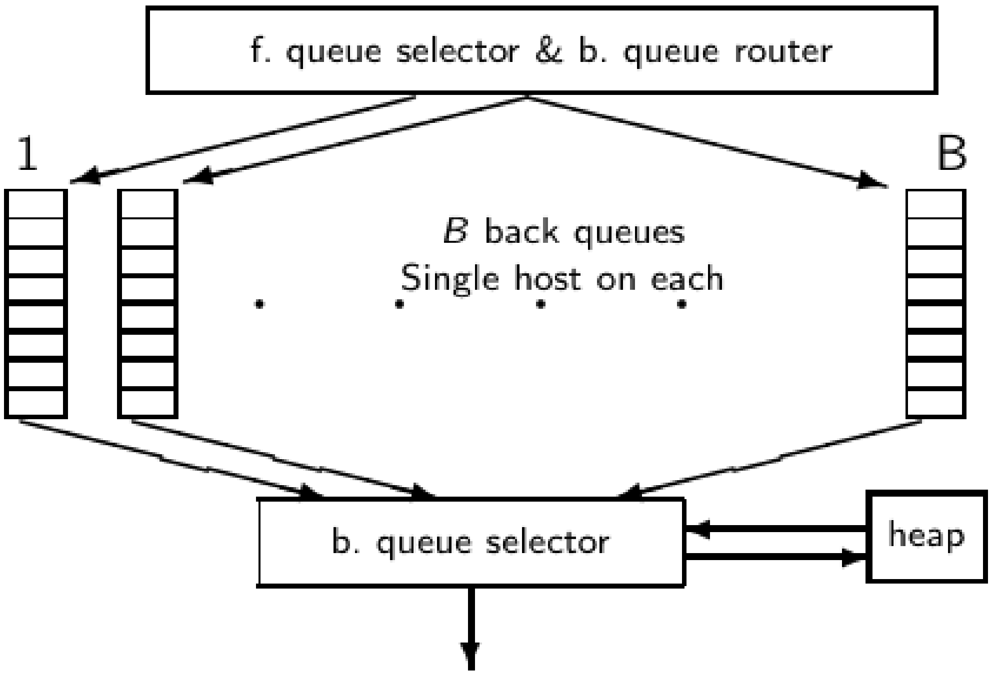
- Prioritizer assigns to URL an integer priority between 1 and *F*.
- Then appends URL to corresponding queue
- Heuristics for assigning priority: refresh rate, PageRank etc

Mercator URL frontier: Front queues

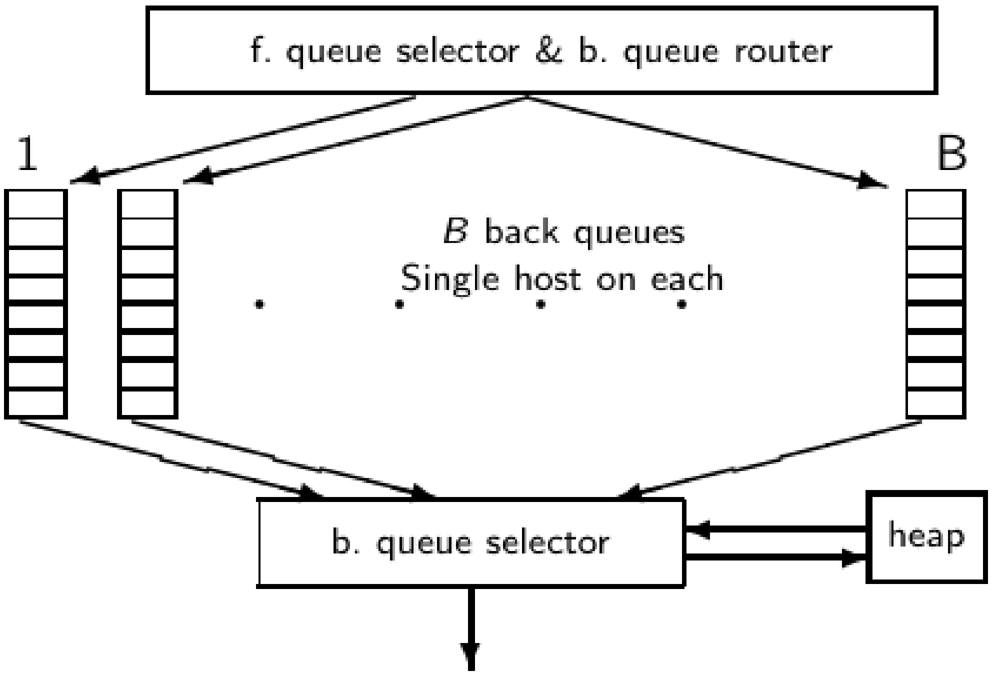


- Selection from front queues is initiated by back queues
- Pick a front queue from which to select next URL: Round robin, randomly, or more sophisticated variant
- But with a bias in favor of high-priority front queues

Mercator URL frontier: Back queues

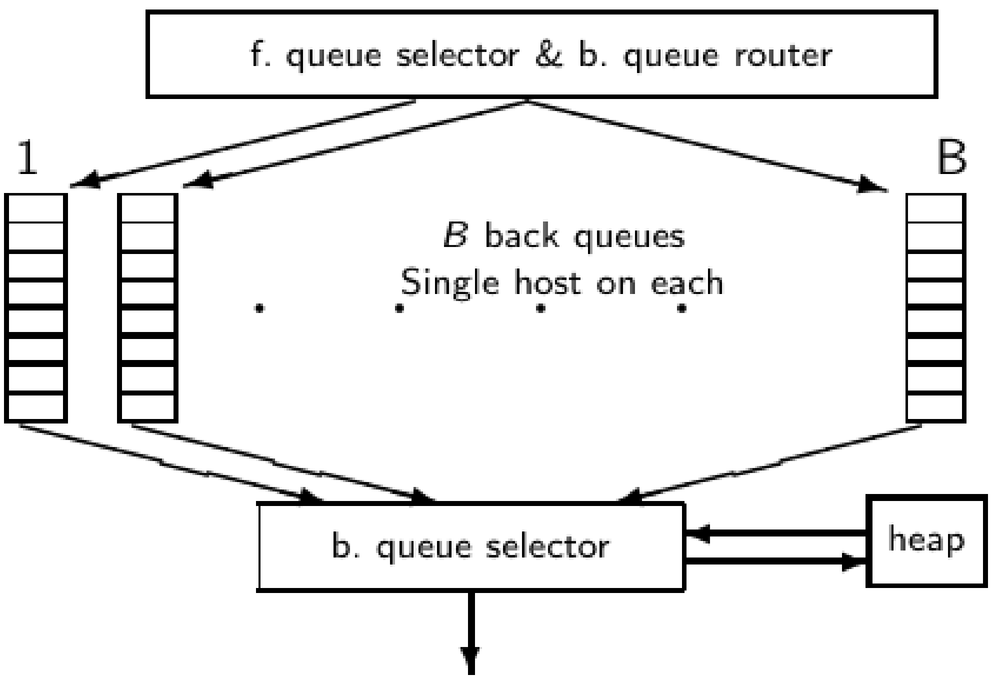


Mercator URL frontier: Back queues



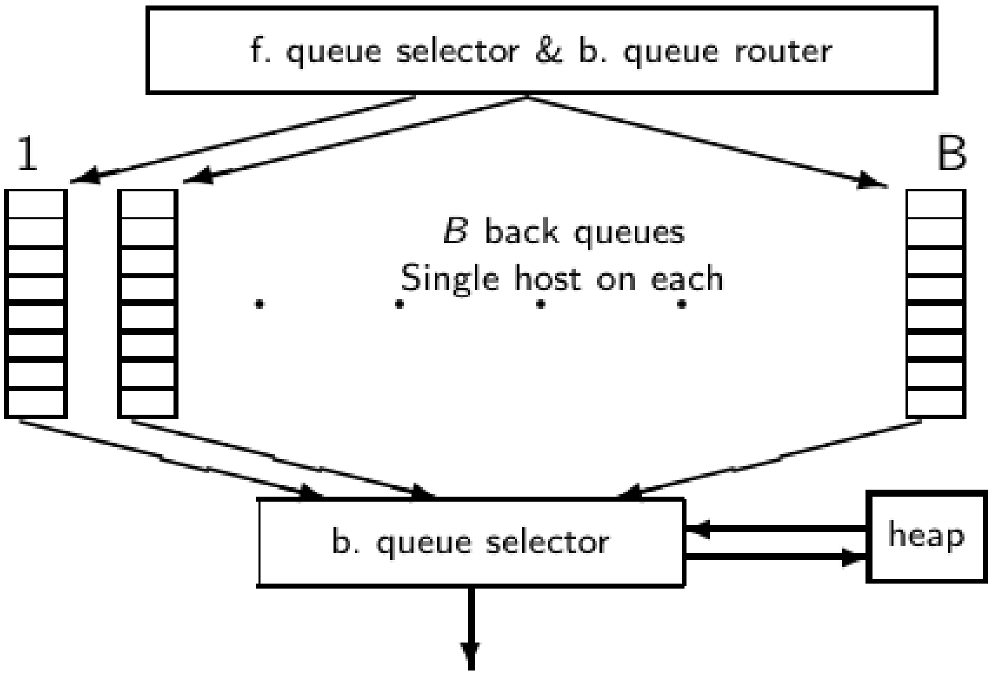
- Invariant 1. Each back queue is kept non-empty while the crawl is in progress.
- Invariant 2. Each back queue only contains URLs from a single host.
- Maintain a table from hosts to back queues.

Mercator URL frontier: Back queues



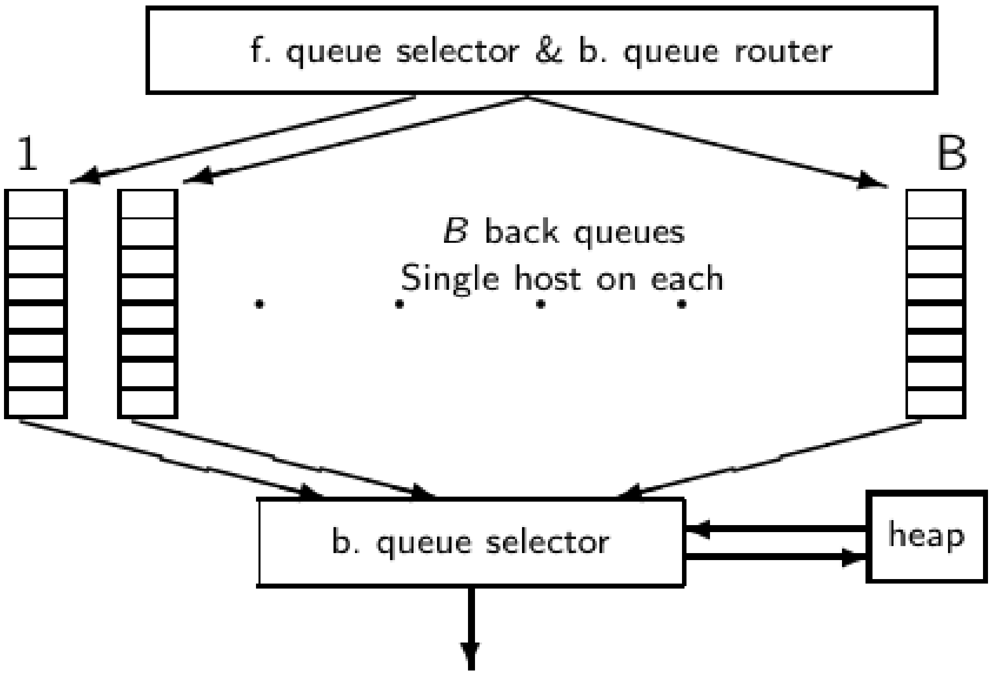
- In the heap:
- One entry for each back queue
- The entry is the earliest time t_e at which the host corresponding to the back queue can be hit again.
- The earliest time t_e is determined by (i) last access to that host (ii) time gap heuristic

Mercator URL frontier: Back queues



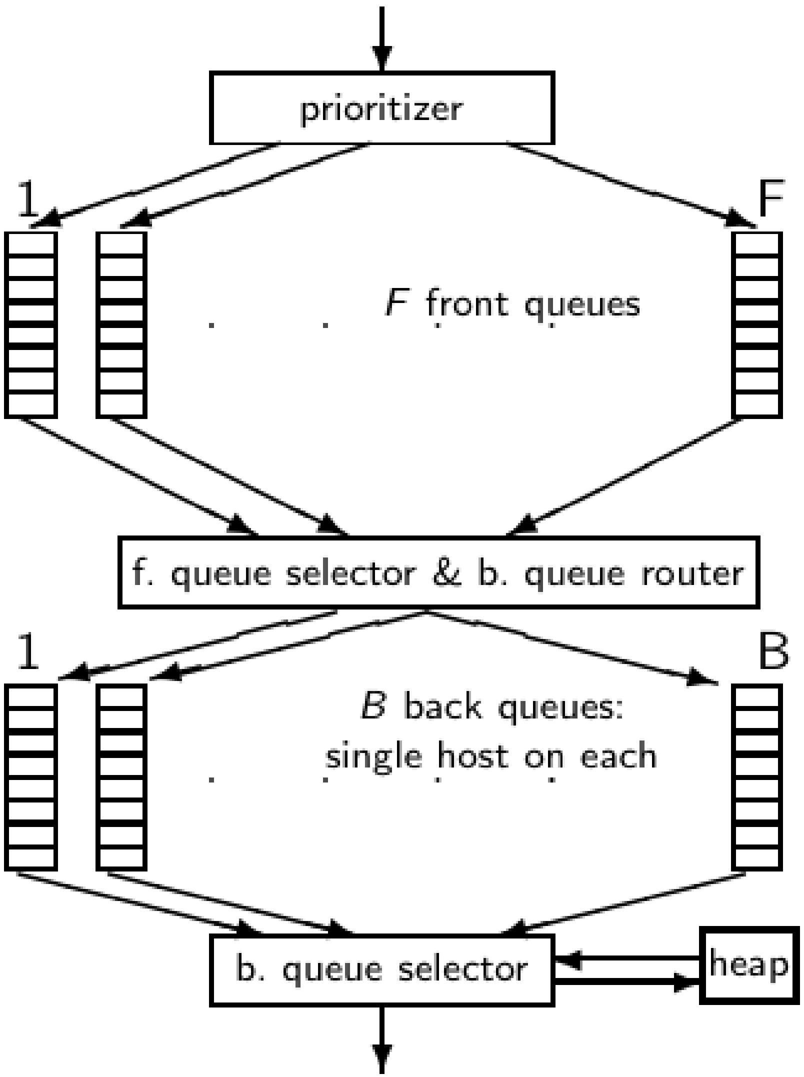
- How fetcher interacts with back queue:
- Repeat (i) extract current root *q* of the heap (*q* is a back queue)
- and (ii) fetch URL *u* at head of *q* . . .
- . . . until we empty the *q* we get.
- (i.e.: *u* was the last URL in *q*)

Mercator URL frontier: Back queues



- When we have emptied a back queue *q*:
- Repeat (i) pull URLs *u* from front queues and (ii) add *u* to its corresponding back queue . . .
- . . . until we get a *u* whose host does not have a back queue.
- Then put *u* in *q* and create heap entry for it.

Mercator URL frontier



- URLs flow in from the top into the frontier.
- Front queues manage prioritization.
- Back queues enforce politeness.

Spider trap

- Malicious server that generates an infinite sequence of linked pages
- Sophisticated spider traps generate pages that are not easily identified as dynamic.

Resources

- Chapter 20 of IIR
- Resources at http://ifnlp.org/ir
  - Paper on Mercator by Heydon et al.
  - Robot exclusion standard