Web search engines

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Two main difficulties

The Web:

Extracting “significant data” is difficult !!

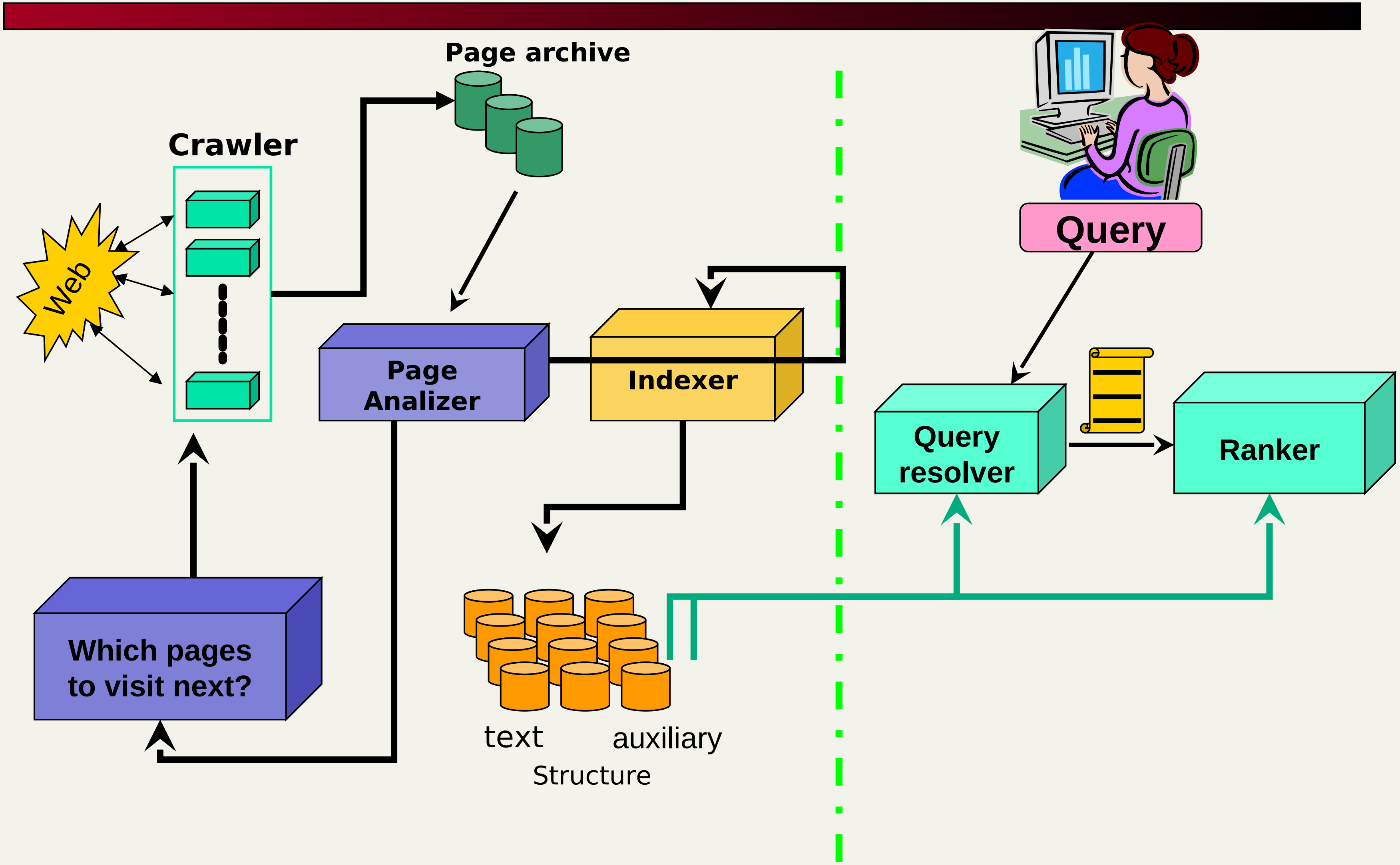
- Size: more than 1 trillion pages
- Language and encodings: hundreds…
- Distributed authorship: SPAM, format-less,…
- Dynamic: in one year 35% survive, 20% untouched

The User:

Matching “user needs” is difficult !!

- Query composition: short (2.5 terms avg) and imprecise
- Query results: 85% users look at just one result-page
- Several needs: Informational, Navigational, Transactional

The structure of a search Engine



The web graph: properties

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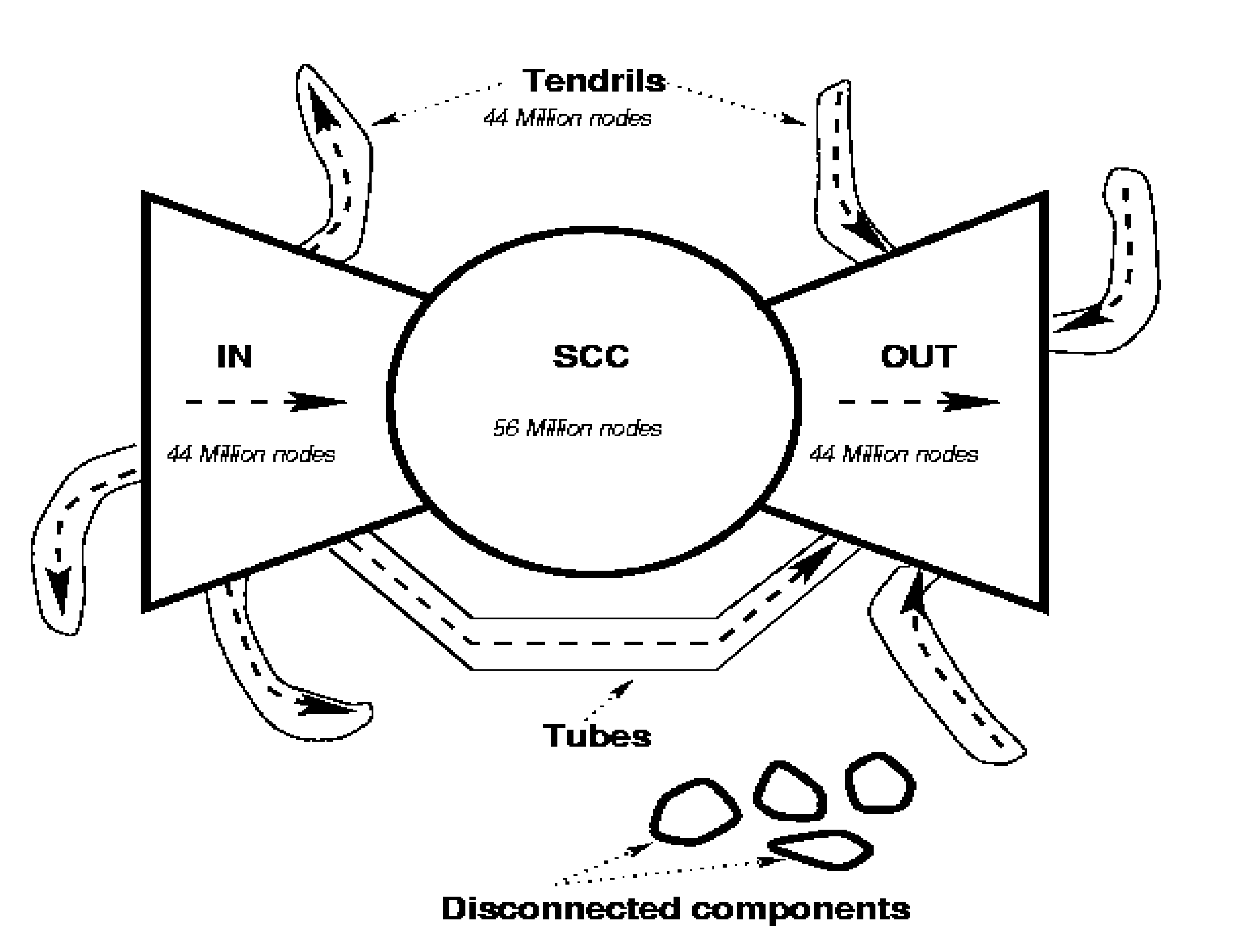
The Web’s Characteristics

- It’s a graph whose size is
  - 1 trillion of pages is available
    - 50 billion pages crawled (09/15)
  - 5-40K per page => terabytes & terabytes
  - Size grows every day!!
  - Actually the web is infinite… Calendars…

- It’s a dynamic graph with
  - 8% new pages, 25% new links change weekly
  - Life time of about 10 days

The Bow Tie


Tendrils
44 Million nodes
IN
44 Million nodes
SCC
56 Million nodes
OUT
44 Million nodes
Tubes
Disconnected components

Crawling

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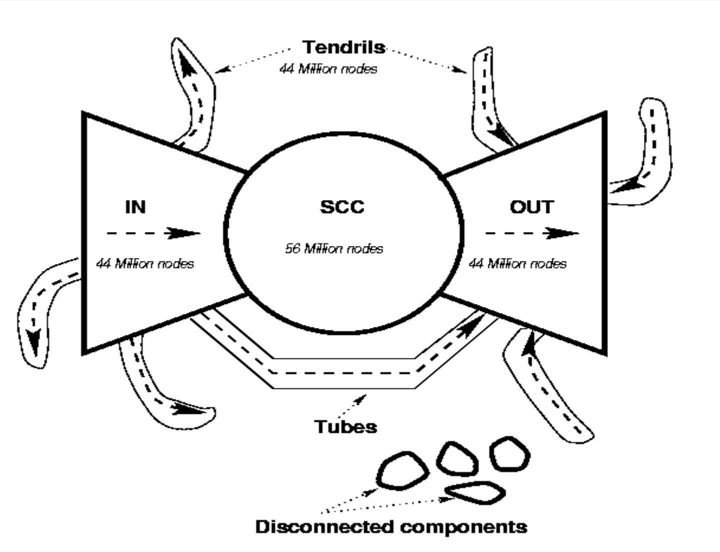
Spidering

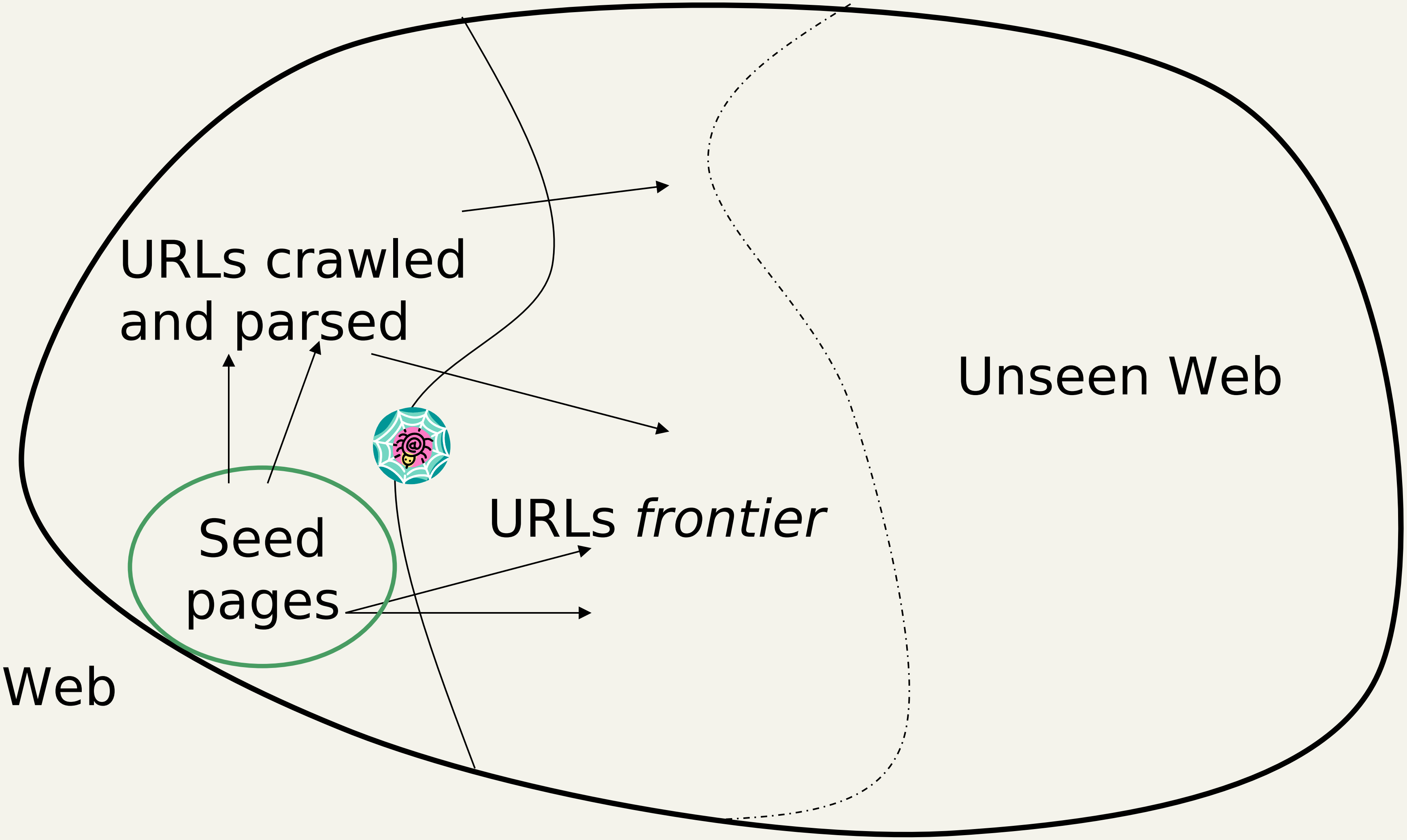
- 24h, 7days "walking" over the web graph
- Recall that:
  - Direct graph G = (N, E)
  - N changes (insert, delete) >> trillion nodes
  - E changes (insert, delete) > 10 links per node
    - Trillion entries in posting lists
    - Many more if we consider also the word positions in every document where it occurs.



Crawling Issues

- How to crawl?
  - *Quality*: “Best” pages first
  - *Efficiency*: Avoid duplication (or near duplication)
  - *Etiquette*: Robots.txt, Server load concerns (Minimize load)
  - *Malicious pages*: Spam pages, Spider traps – incl dynamically generated
- How much to crawl, and thus index?
  - *Coverage*: How big is the Web? How much do we cover?
  - *Relative Coverage:* How much do competitors have?
- How often to crawl?
  - *Freshness*: How much has changed?
  - *Frequency*: Commonly insert time gap btw host requests

Crawling picture



URLs crawled
and parsed

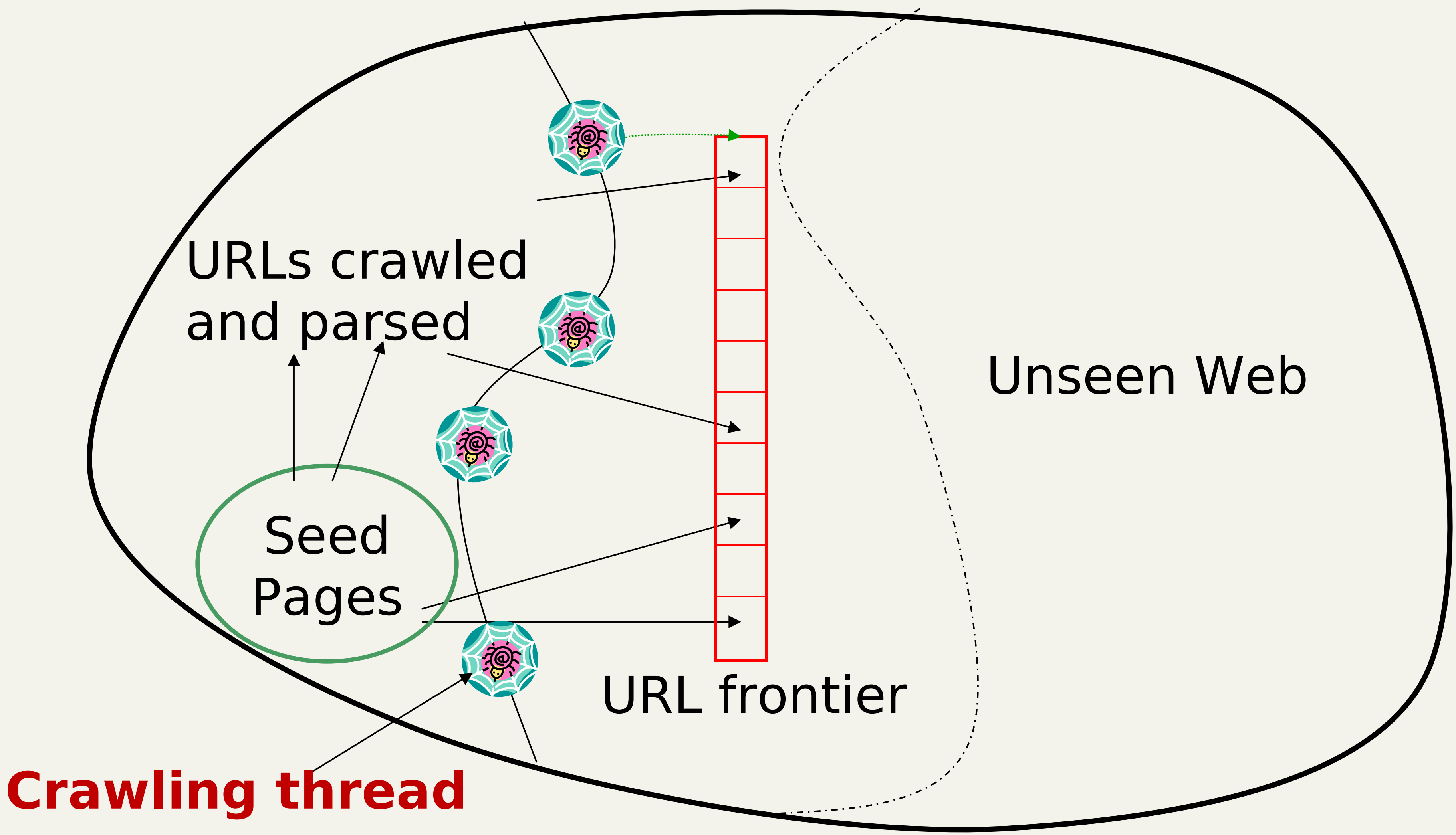
Unseen Web

Seed
pages

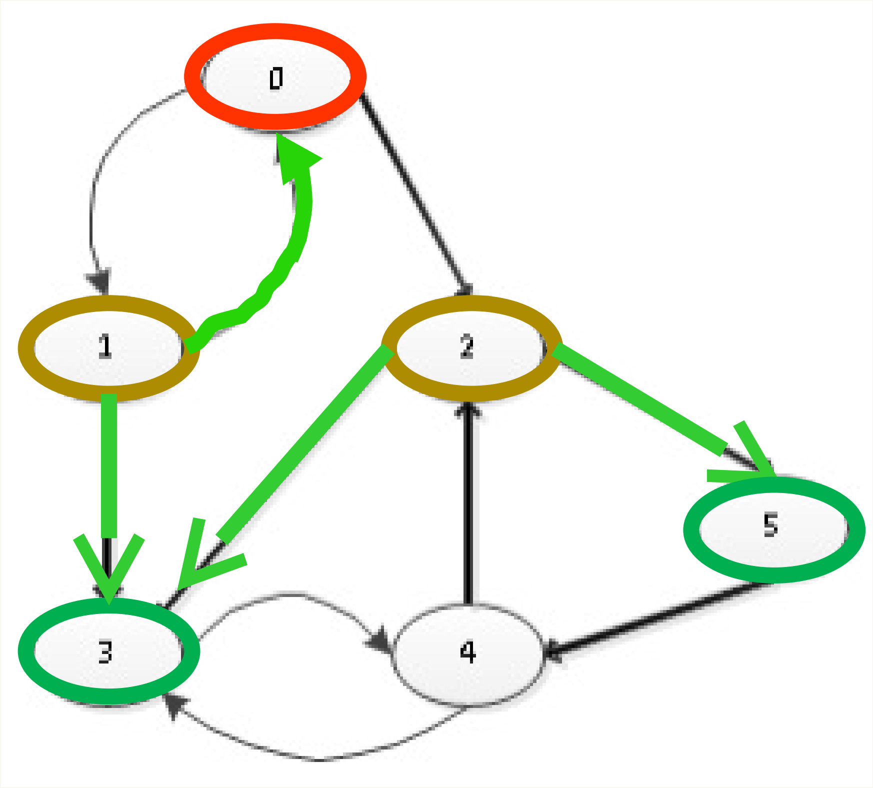
URLs *frontier*

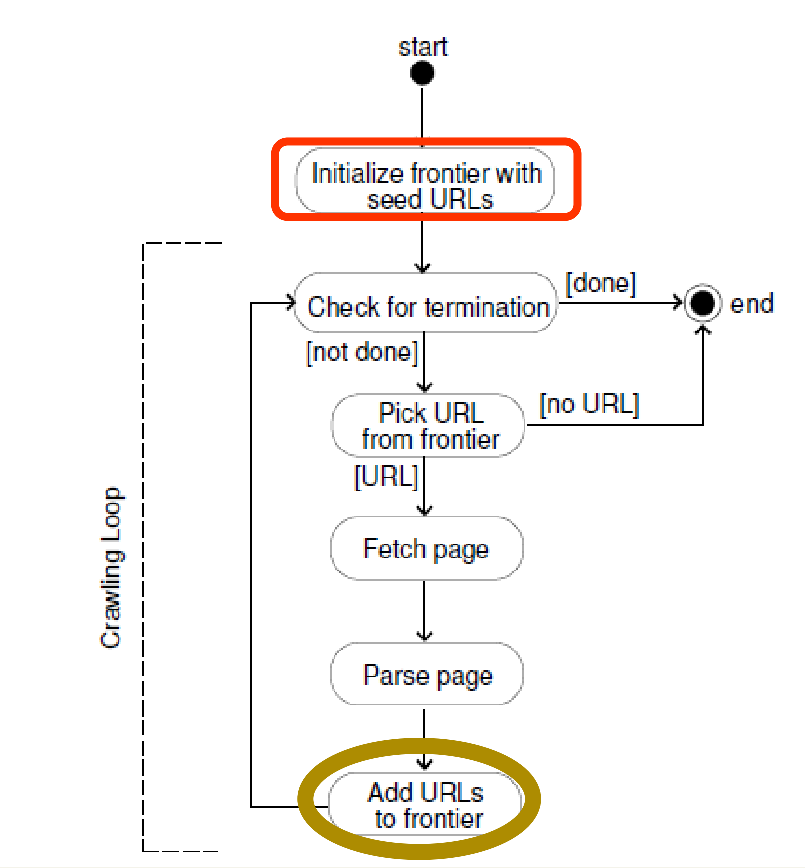
Web

Updated crawling picture

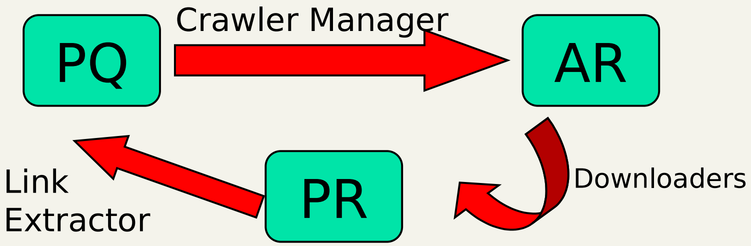


A small example





Crawler “life cycle”



One Link Extractor per page:

```
while(<Page Repository is not empty>){
   <take a page p (check if it is new)>
   <extract links contained in p within href>
   <extract links contained in javascript>
   <extract                 .....
   <insert these links into the Priority Queue>
}
```

One Downloader per page:

```
while(<Assigned Repository is not empty>){
   <extract url u>
   <download page(u)>
   <send page(u) to the Page Repository>
   <store page(u) in a proper archive,
               possibly compressed>
}
```

One single Crawler Manager:

```
while(<Priority Queue is not empty>){
   <extract some URL u having the highest priority>
   foreach u extracted {
                if ( (u ∉ “Already Seen Page” ) ||
                     ( u ∈ “Already Seen Page”  && <u’s version on the Web is more recent> )
                    ) {
                  <resolve u wrt DNS>
                  <send u to the Assigned Repository>
                  }
   }
}
```

URL frontier visiting

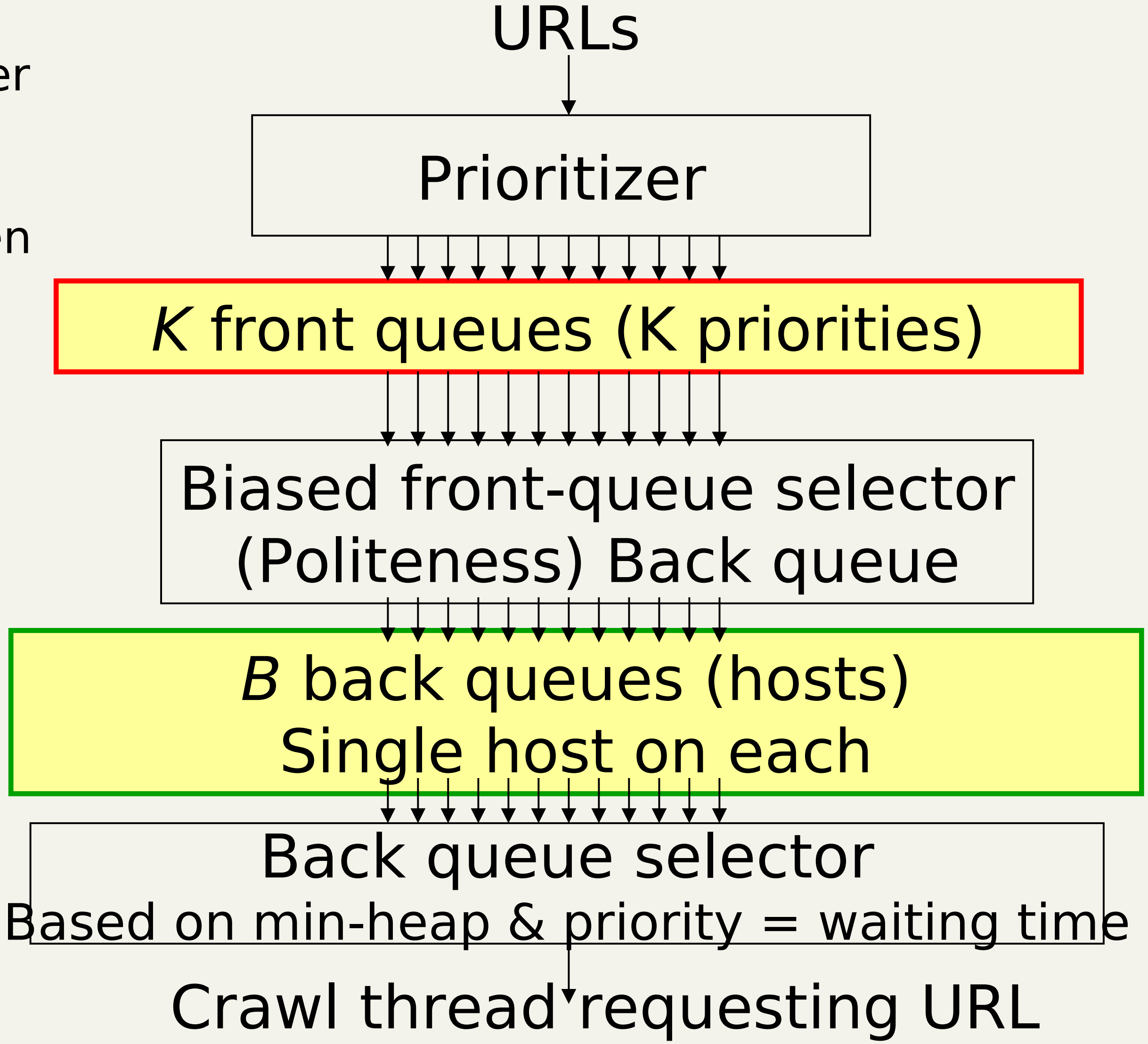
- Given a page P, define how “good” P is.

- Several *metrics* (via priority assignment):
  - BFS, DFS, Random
  - Popularity driven (*PageRank*, full vs partial)
  - Topic driven or focused crawling
  - Combined

- How to fast check whether the URL is new ?

Mercator

1. Only one connection per host is open at a time;
2. a waiting time of a few seconds occurs between successive requests to the same host;
3. high-priority pages are crawled preferentially.



URLs

Prioritizer

K front queues (K priorities)

Biased front-queue selector (Politeness) Back queue

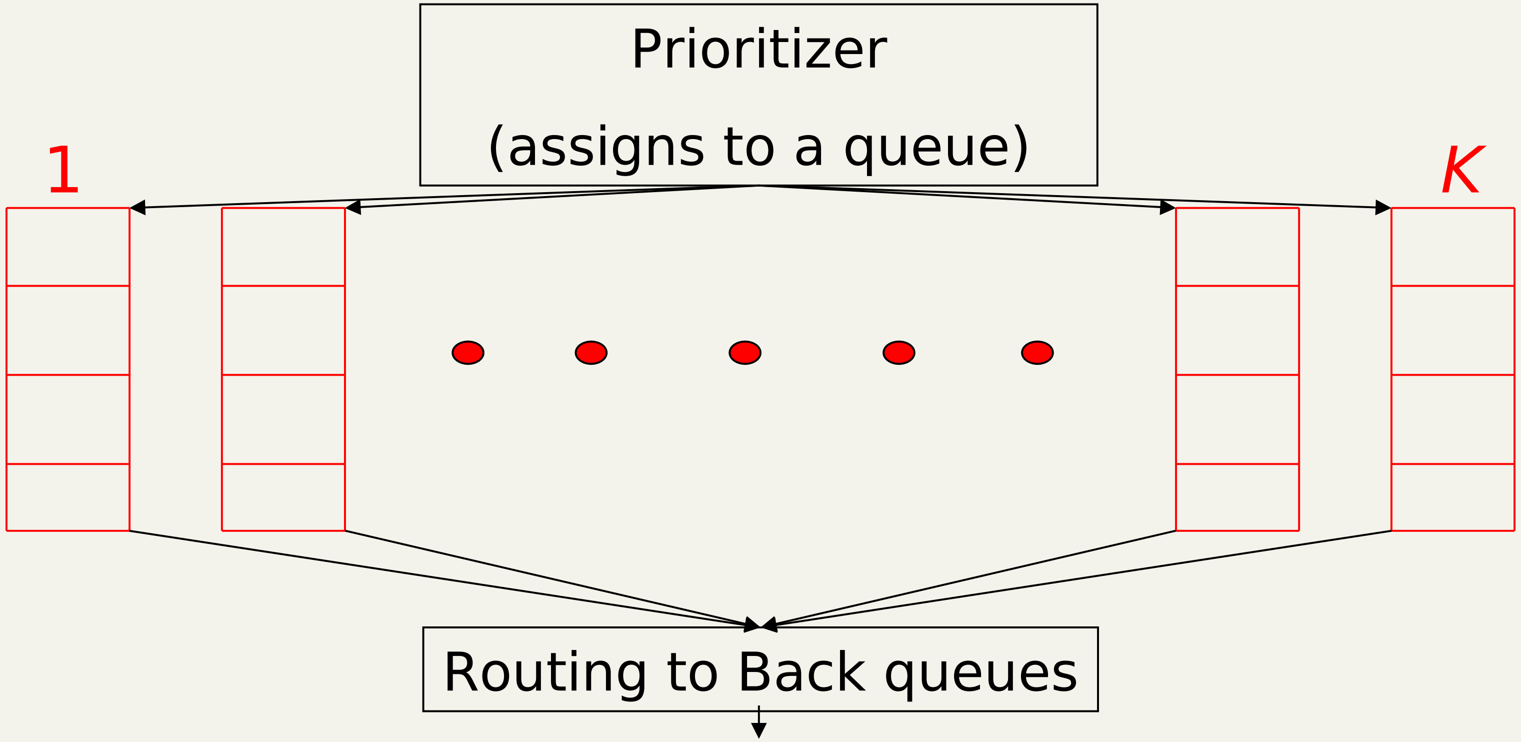
B back queues (hosts)
Single host on each

Back queue selector
Based on min-heap & priority = waiting time

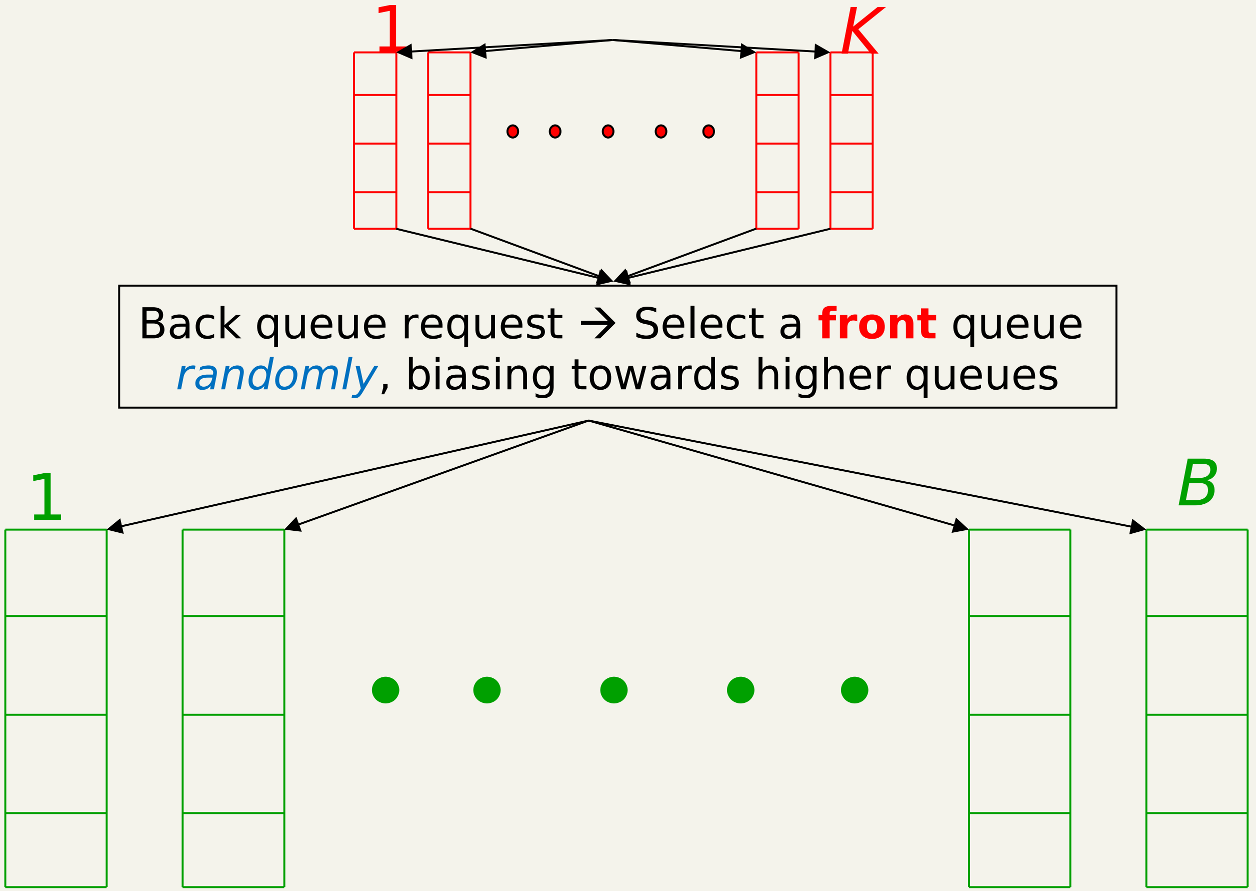
Crawl thread requesting URL

Front queues

- Front queues manage **prioritization**:
  - Prioritizer assigns to an URL an integer priority (refresh, quality, application specific) between 1 and *K*
  - Appends URL to corresponding queue, according to priority



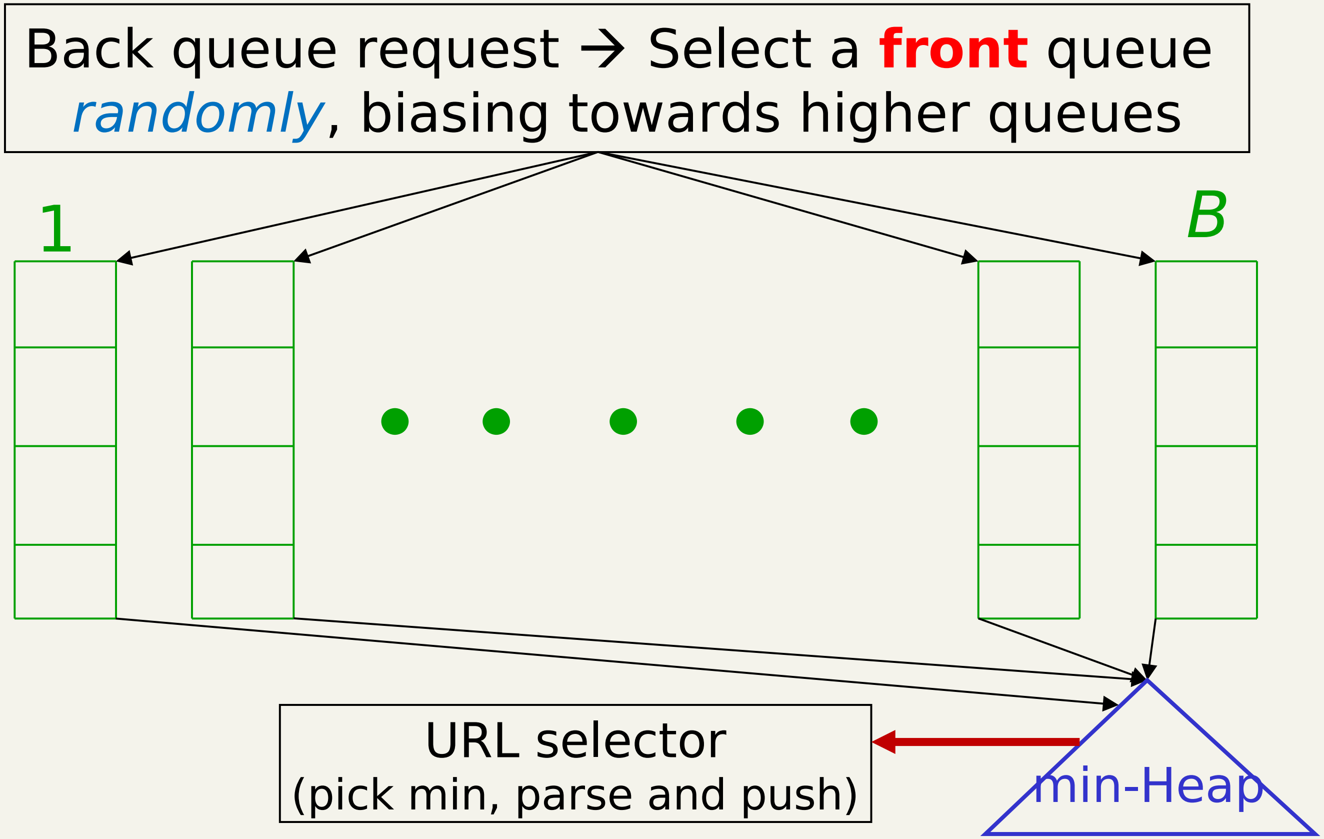
Back queues



Back queue request → Select a **front** queue *randomly*, biasing towards higher queues

Back queues

- Back queues enforce **politeness:**
  - Each back queue is kept non-empty
  - Each back queue contains only URLs from a **single** host



Back queue request → Select a **front** queue *randomly*, biasing towards higher queues

URL selector
(pick min, parse and push)

The **min-heap**

- It contains one entry per back queue

- The entry is the earliest time t_e at which the host corresponding to the back queue can be “hit again”

- This earliest time is determined from
  - Last access to that host
  - Any time buffer heuristic we choose

The crawl thread

- A crawler seeks a URL to crawl:
  - Extracts the root of the heap: So it is an URL at the head of some back queue *q (and then removes it)*
  - Waits the indicated time t_{url}
  - Parses URL and adds its out-links to the Front queues
- If back queue *q* gets empty, pulls a **URL *v*** from some front queue *(more prob for higher queues)*
  - If there's already a back queue for *v*'s host, append *v* to it and repeat until q gets not empty;
  - Else, make *q* the back queue for *v's* host
- If back queue *q* is non-empty, pick URL and add it to the min-heap with priority = waiting time t_{url}

Keep crawl threads busy (B = 3 x threads)