Web Science

5 February 2019

Christina Lioma
c.lioma@di.ku.dk

Lecture 1 plan

- General course information
- Introduction to the WWW

Teaching Team

Lectures (Tuesday 13h00-15h00) @ UP1

- Isabelle Augenstein
- Christina Lioma (course responsible)

Labs (Tuesday 15h00-17h00) @ bib 4-0-17

- Casper Hansen
- Christian Hansen
- Lucas Chaves

Course Info Resources

Absalon:

- Lecture plan, projects, readings, slides, latest news and other **important** information
- Keep an eye on the course homepage **throughout** the block for information updates
- **Familiarise** yourselves with Absalon

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Also:

https://kurser.ku.dk/course/ndak14004u/2018-2019

Readings:

- On Absalon course page (no single textbook)
- Provide important context to **supplement** lectures; they do not replace lectures

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Lectures:

- Slides supplement the oral lectures; they do not replace them
- Pointers to more readings and sources

Labs:

- Help with the projects; not solve them for you
- Answer questions about the project or lectures

Attendance:

- Your responsibility to attend; if not, no *formal* way of catching up

Plagiarism:

- automatic fail on project
- referral to head of students

Prerequisites:

- Programming
- Machine Learning

To pass the course

1) Continuous project (throughout the course):

- Individual
- Includes oral presentation & QA
- 40% of final grade

2) Take home assignment:

- Individual
- 1-5 April 2019
- 60% of final grade

Re-exam

New projects AND oral exam on the full course syllabus without preparation

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New projects AND oral exam on the full course syllabus without preparation

Both are compulsory:

- If you do not submit the new projects, you cannot take the oral exam → automatic fail
- If you do not show up at the oral → automatic fail

Final grade is based on the overall assessment of both (not average)

Today’s lecture

- What is Web Science
- What is the Web
- What is the Internet
- Web graph
- Main challenges of web data processing
- Web crawling

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Comprises elements of: machine learning, information retrieval, natural language processing, data mining, databases, statistics...

Spans from back-end (algorithms) to front-end (visualisation)

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- *Visualisation*: focus on user-intuitive data overviewing
- *Data cleaning*: focus on detecting bogus data, e.g. age=150

Web

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The Web is part of the Internet

Web as a graph

- A graph $G = (V, E)$ is defined by
  - a set V of vertices (nodes)
  - a set E of edges (links) connecting pairs of nodes

- The **Web page graph**
  - V is the set of pages
  - E is the set of hyperlinks

Web as a graph (directed)

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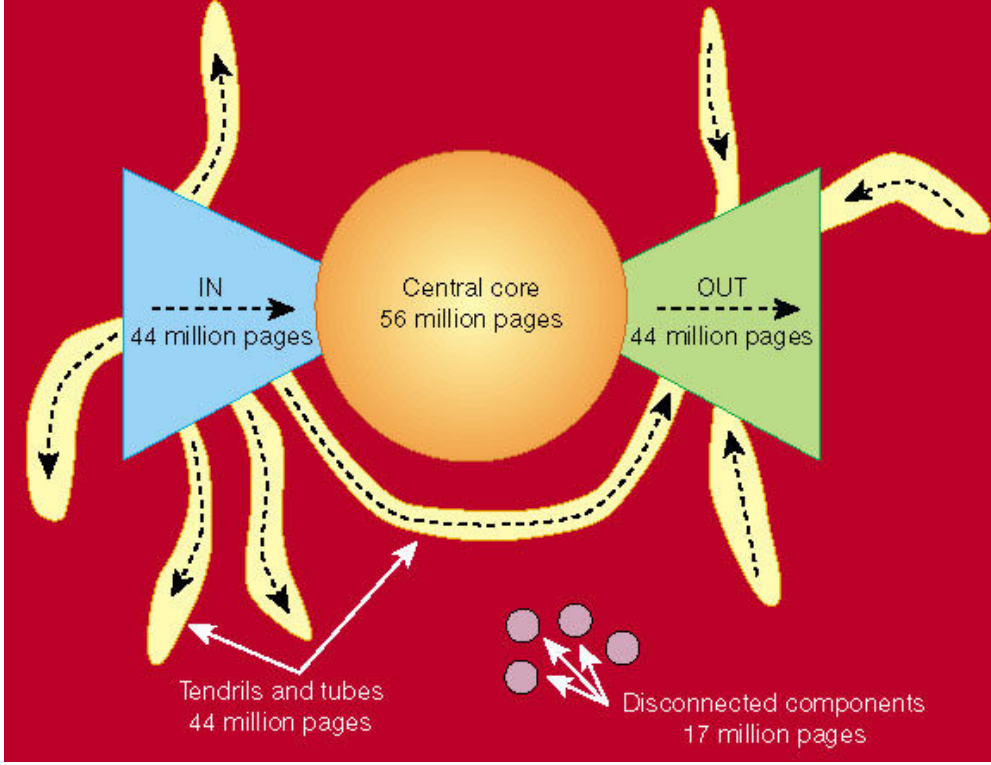
Power law distribution of hyperlinks:

- very few pages have the most hyperlinks
- vast majority of pages have very few hyperlinks

Bow-Tie Structure of the Web

(Broder et al, 1999)



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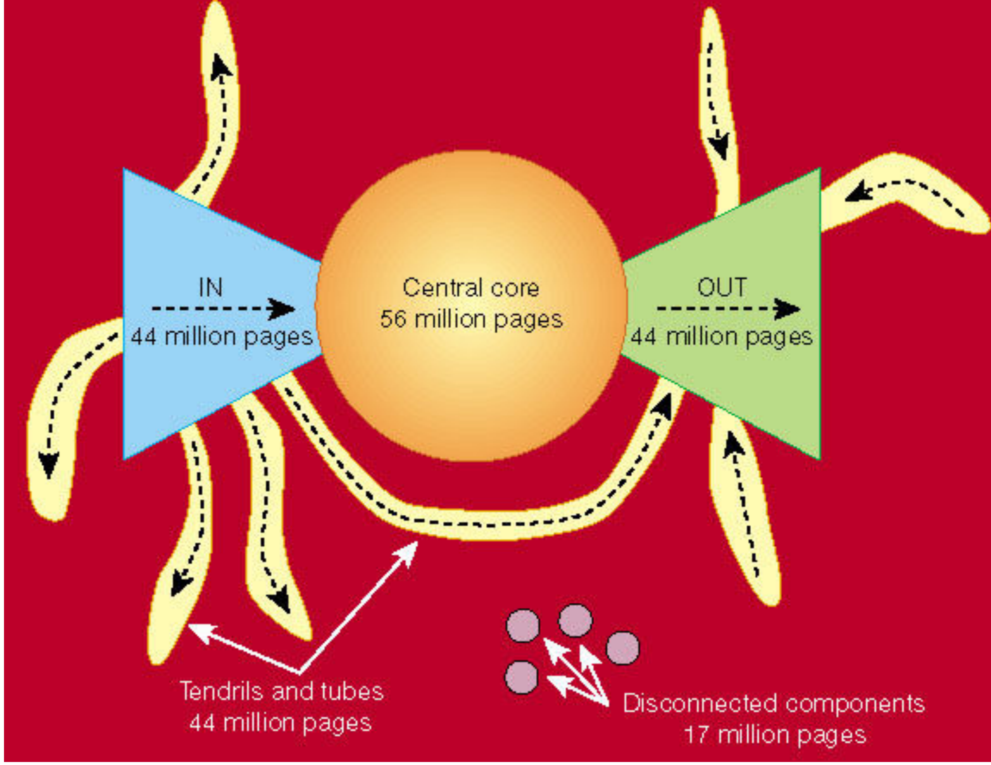

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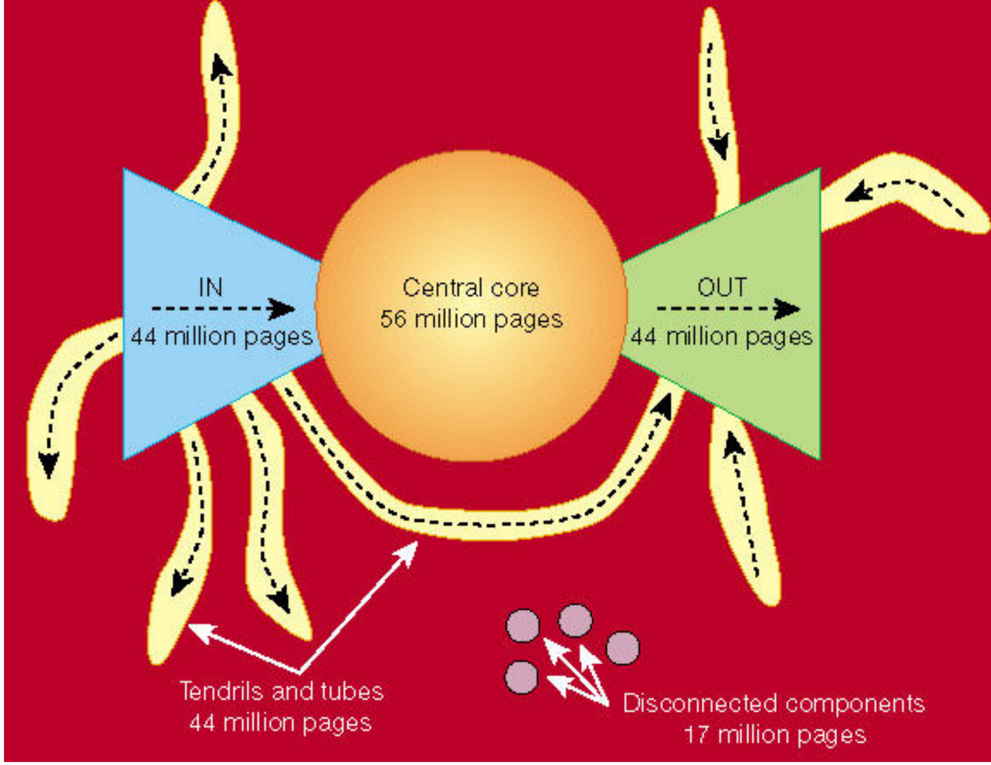

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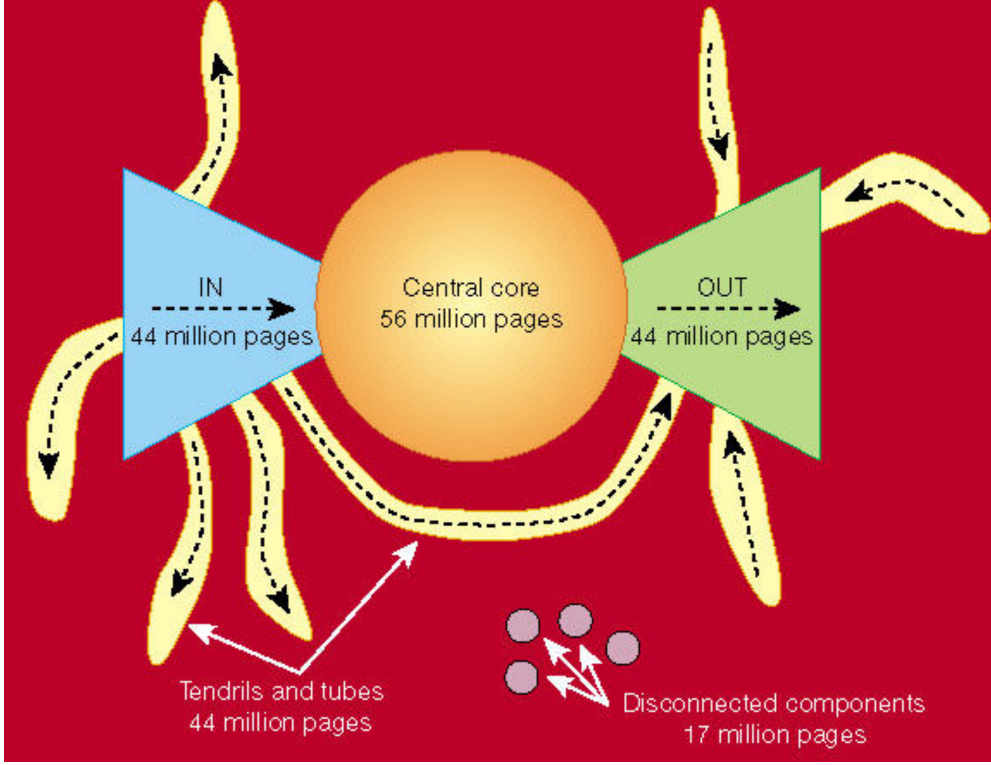
Disconnected: 8%



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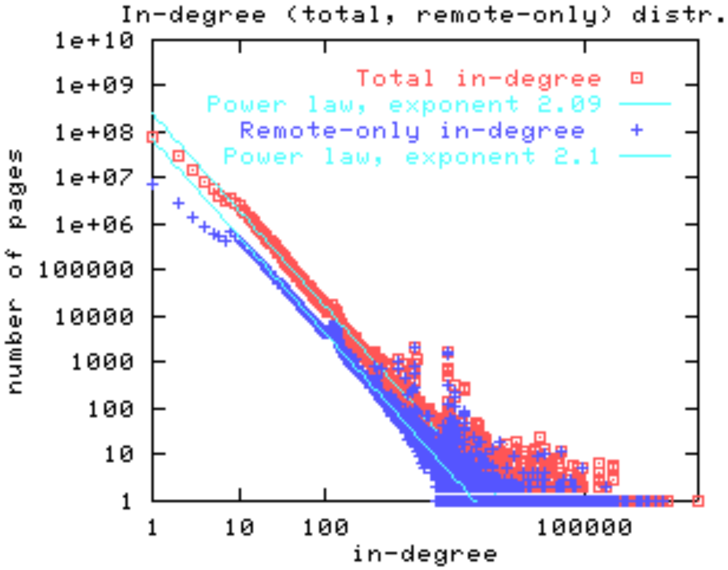
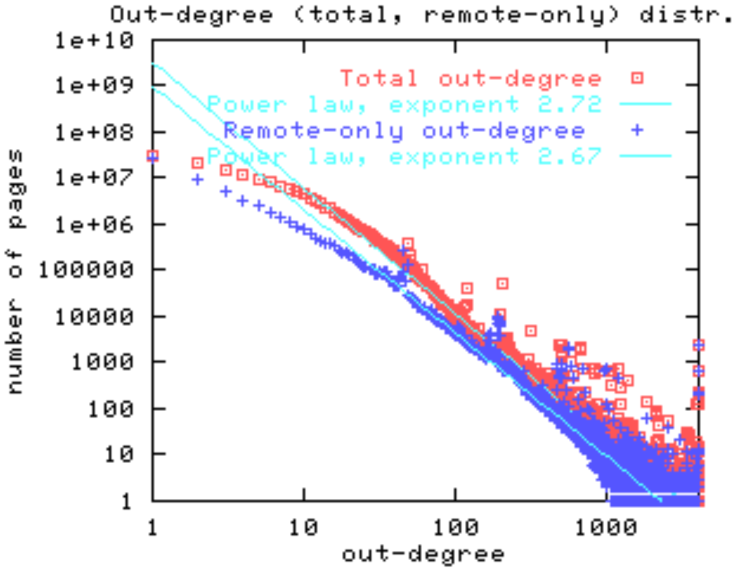
Tendrils: (a) reachable from IN but cannot reach core OR/AND

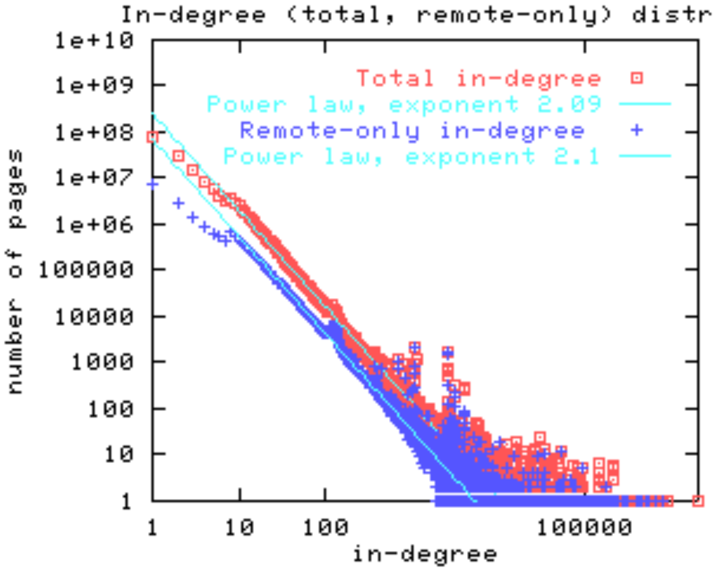
(b) can reach OUT but cannot be reached from it

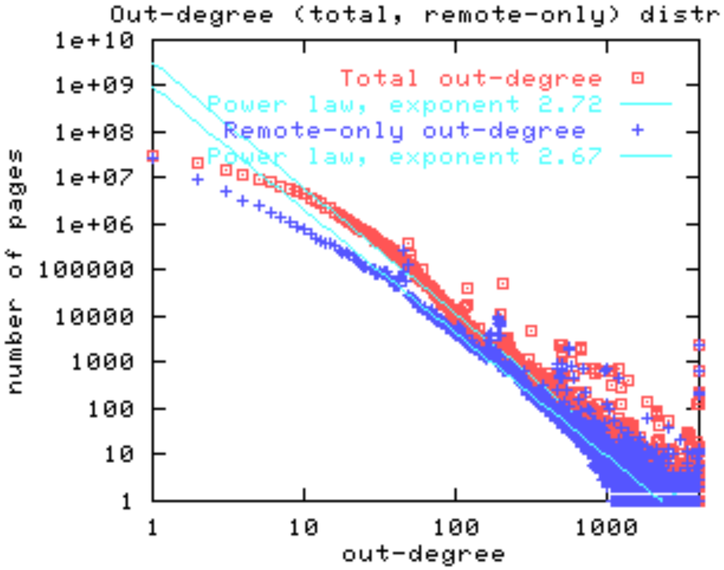
Disconnected: no path to core even if direction is ignored





In & out degree (number of links) distribution: power-law with exponent 2.1 and 2.7





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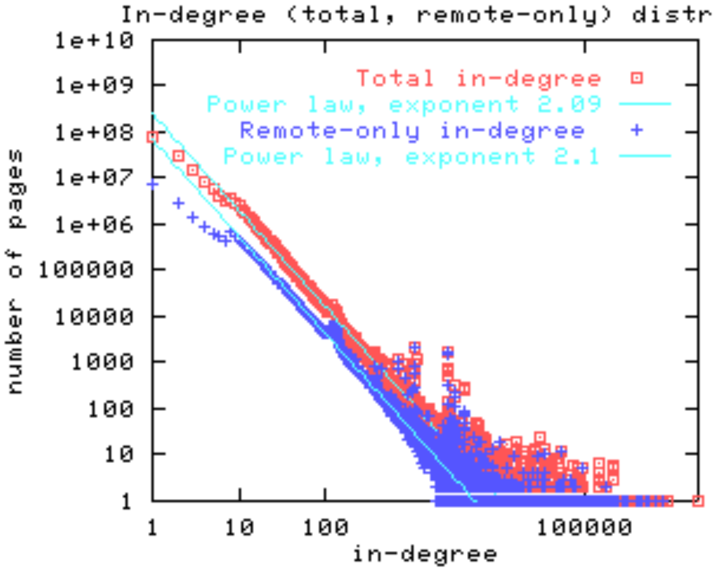

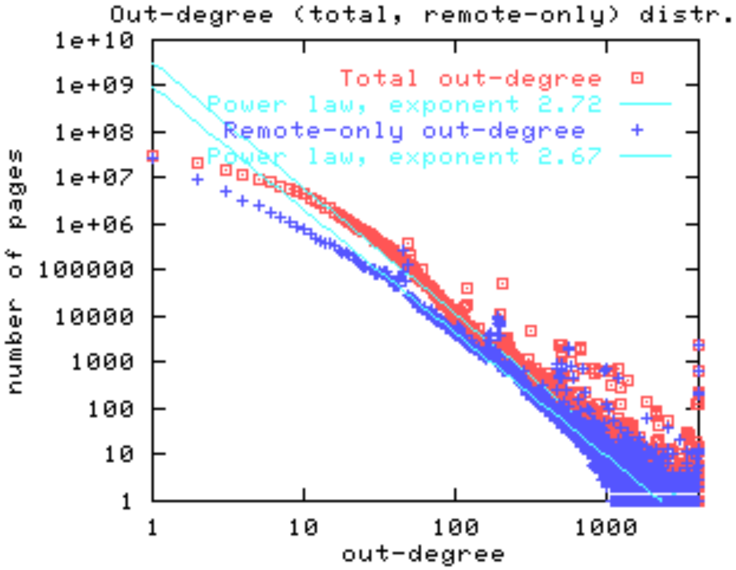

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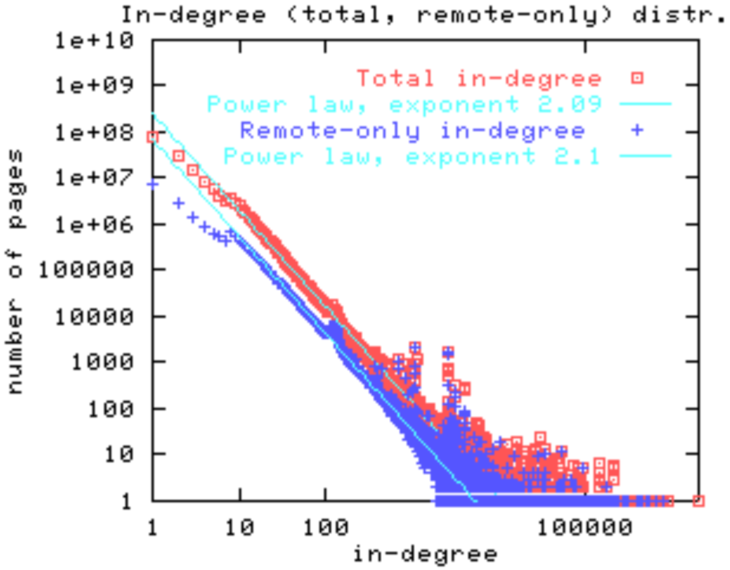

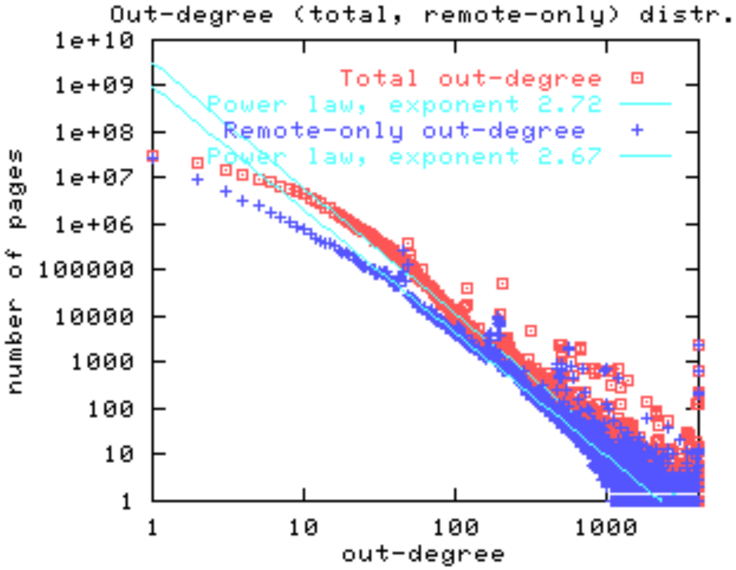

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Good news (because we cannot handle anything more than linear)

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  - crawlers
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  - spam detection
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- Largest human artifact ever created (?)

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Challenges:

- Volume, Variety, Veracity, Velocity (the 4 Vs of data)
- Situation, Scale, Semantics, Sequence (the 4 Ss of data)

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- Data volume in 2020 will be 40ZB (International Data Corporation)

Gigabyte − 1K Megabytes	A movie of TV quality
Terabyte − 1K Gigabytes	All x-ray films in a large hospital
Petabyte − 1K Terabytes	Half of all US academic research libraries
Exabyte − 1K Petabytes	Data generated from SKA telescope per day
Zetabyte − 1K Exabytes	All worldwide data generated by June 2012
Yottabyte − 1K Zetabytes	1YB=1000^8 bytes

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- By 2020, 85% of all data will be in new data types and formats (International Data Corporation)

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Velocity:

- Dynamic: updated at various frequencies, often without warning (e.g. no timestamp on the update)
- Time-series (some): from near real-time (e.g. instant messaging) to periodicity (e.g. web search query logs)

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- **Semantics**: circa 80% of data is unstructured → extracting pertinent terms from unstructured data is a challenge

- **Sequence** (same as Velocity): sequential or time series data

What is the size of the Web?

Surprisingly hard to answer

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  - Spamming, duplicates, mirrors, …
- Simple example of a complication: Soft 404
  - If a page does not exist, the server is supposed to return an error code = “404”
  - Many servers do not return an error code, but keep the visitor on site, or simply send the visitor to the home page

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Estimates:

1999: 800 million pages (Lawrence and Giles)

2008: 1 trillion pages (https://googleblog.blogspot.dk/2008/07/we-knew-web-was-big.html)

The *deep* (or *hidden* or *invisible)* Web contains 400-550 times more information than the known Web [Bergman, 2001: “The deep web: surfacing hidden value”]

Today’s lecture

- ~~What is Web Science~~
- ~~What is the Web~~
- ~~What is the Internet~~
- ~~Web graph~~
- ~~Main challenges of web data processing~~
- Web crawling

Crawler (a.k.a. spider, bot, worm, ant, scutter, harvester …)

- Program that automatically locates, fetches and stores webpages efficiently & methodically

http://www.google.com/support/enterprise/static/gsa/docs/admin/70/gsa_doc_set/admin_crawl/introduction.html

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Aim: gather as many useful webpages as possible

How: following hyperlinks

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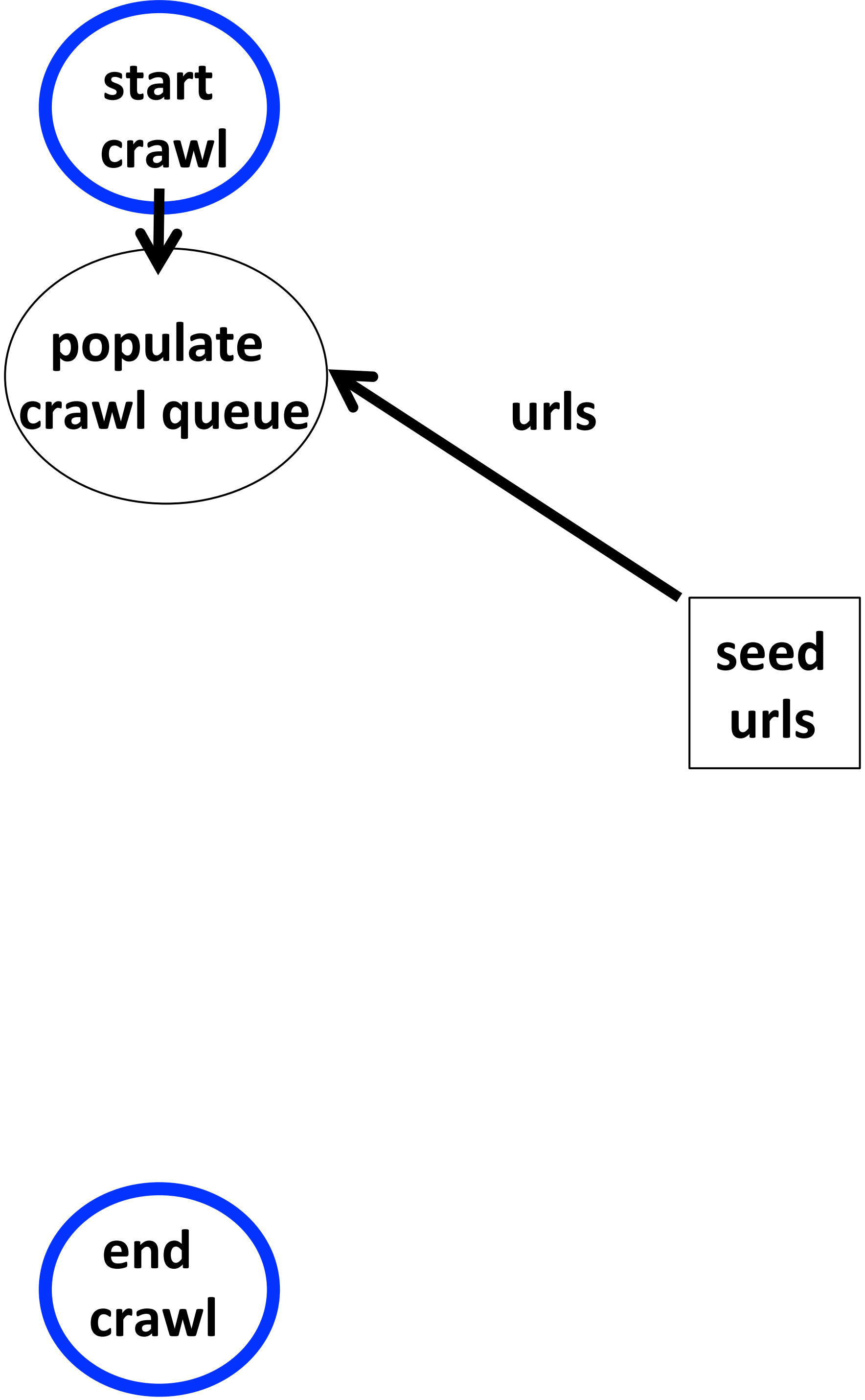
start crawl

end crawl



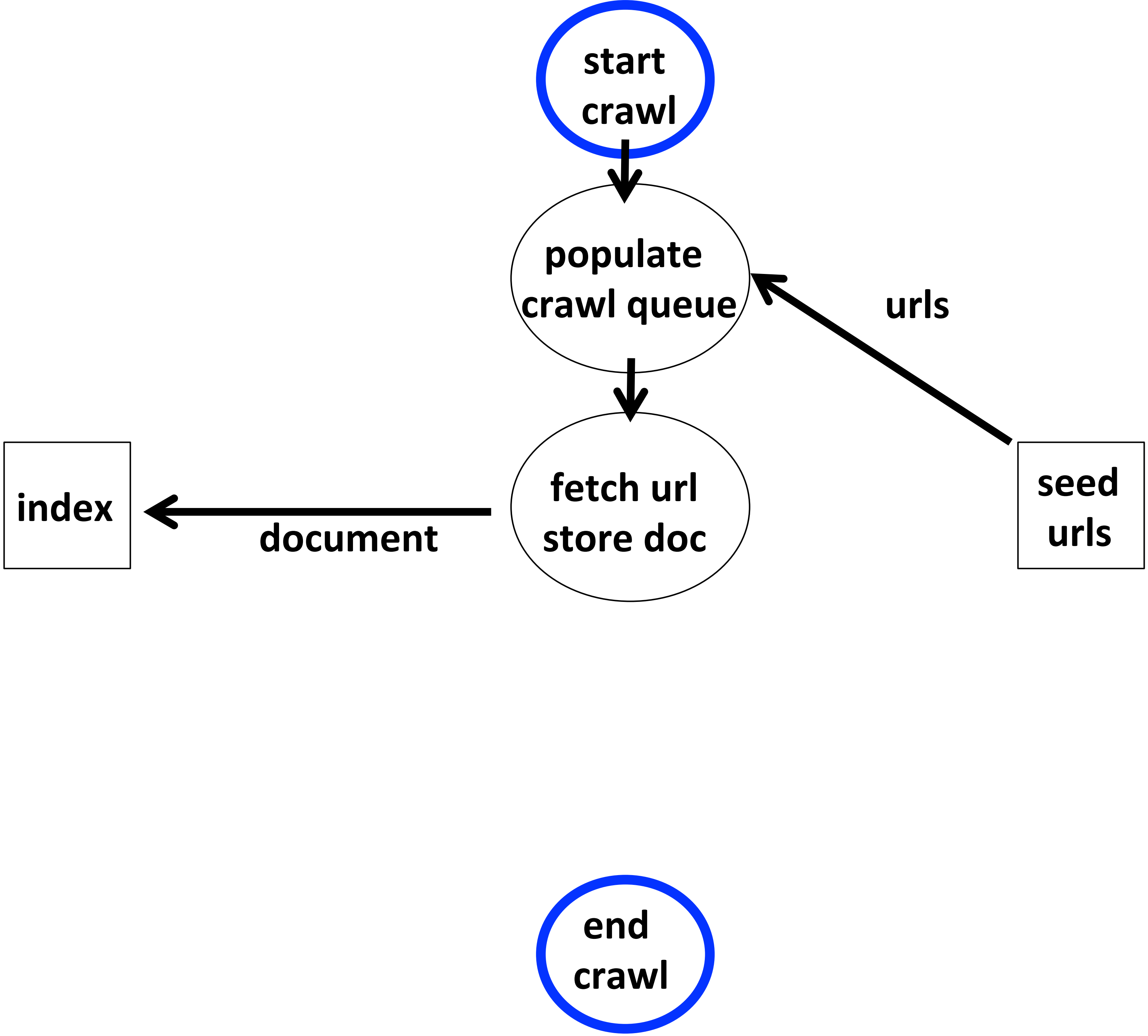
start crawl

populate crawl queue

urls

seed urls

end crawl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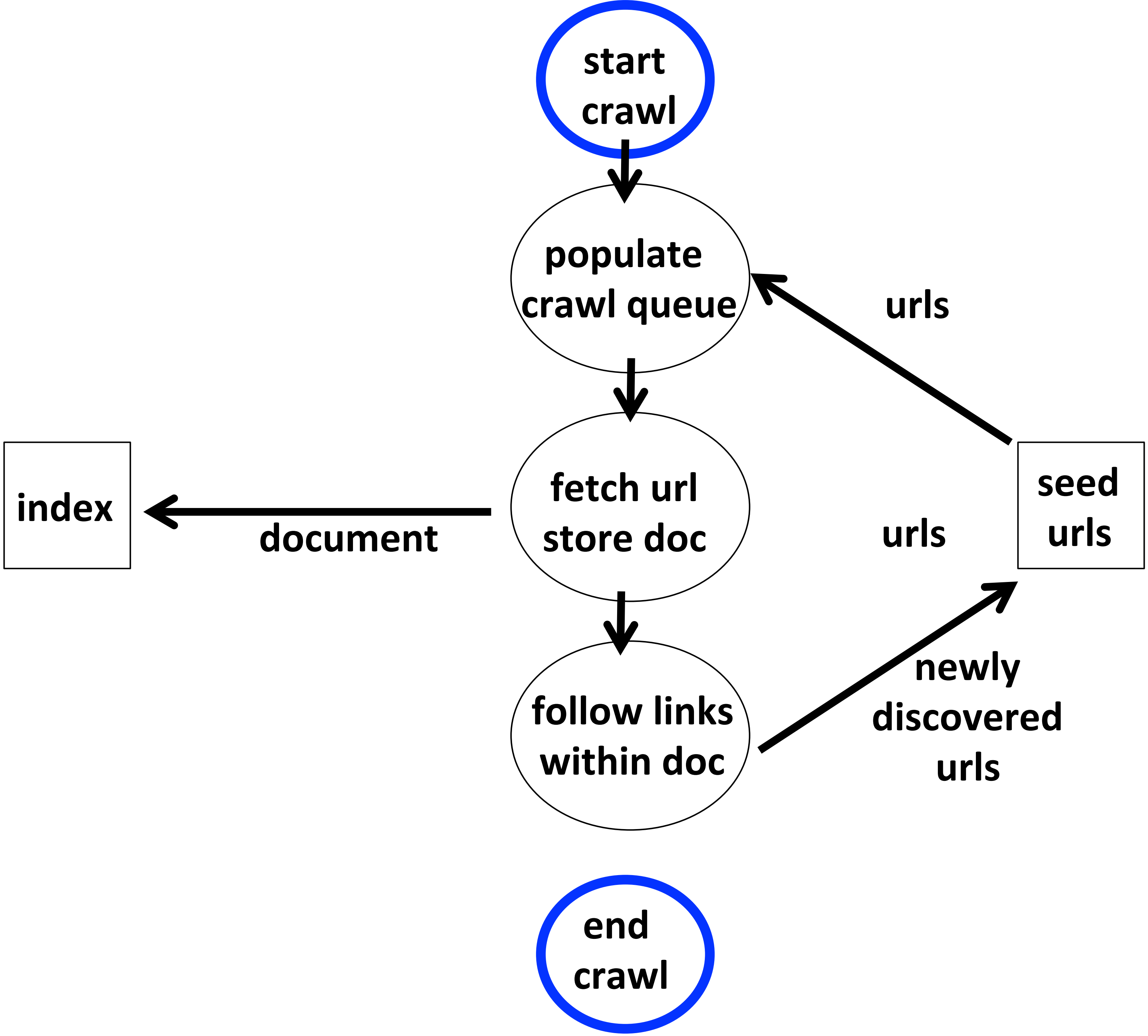
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seed urls
follow links within doc
newly discovered urls
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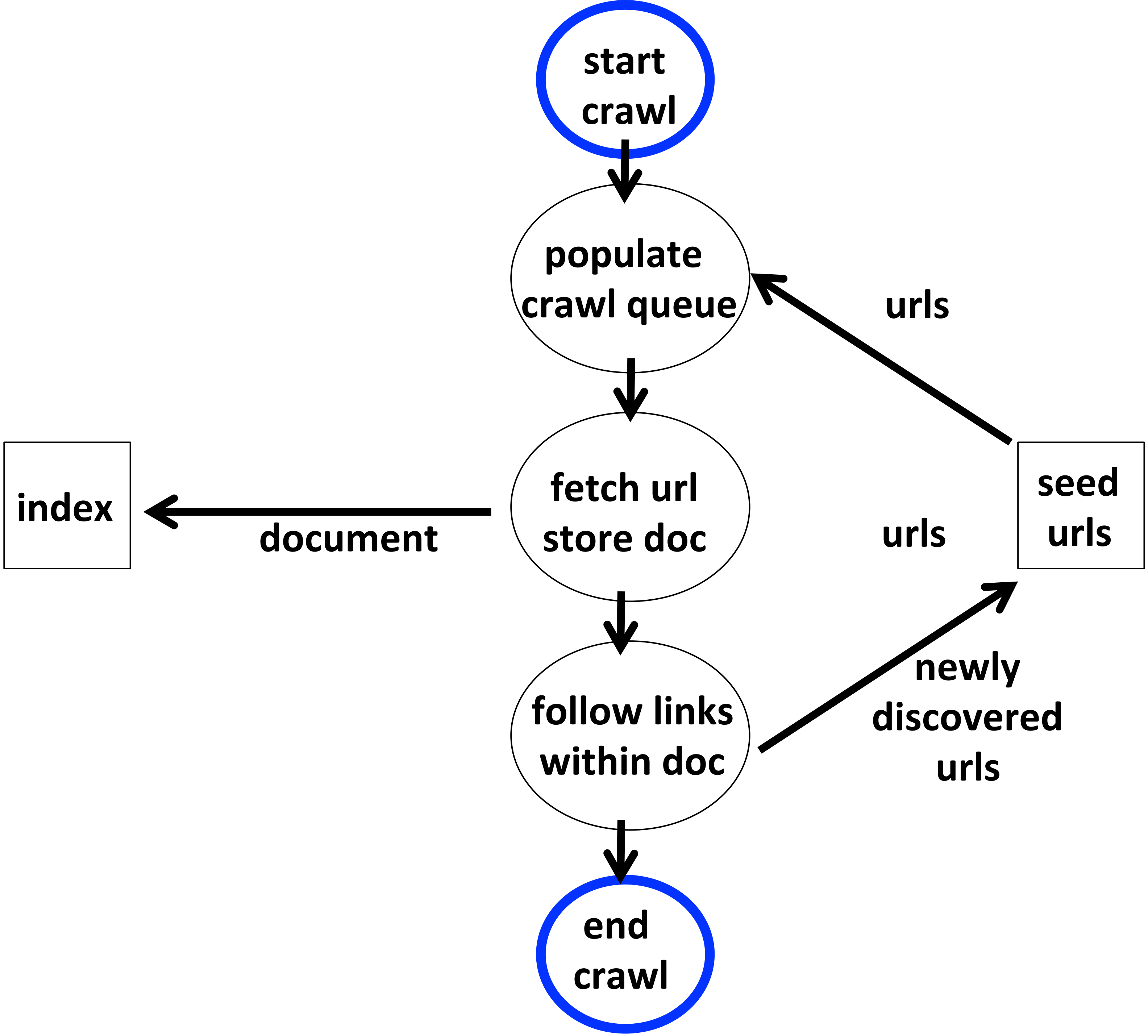

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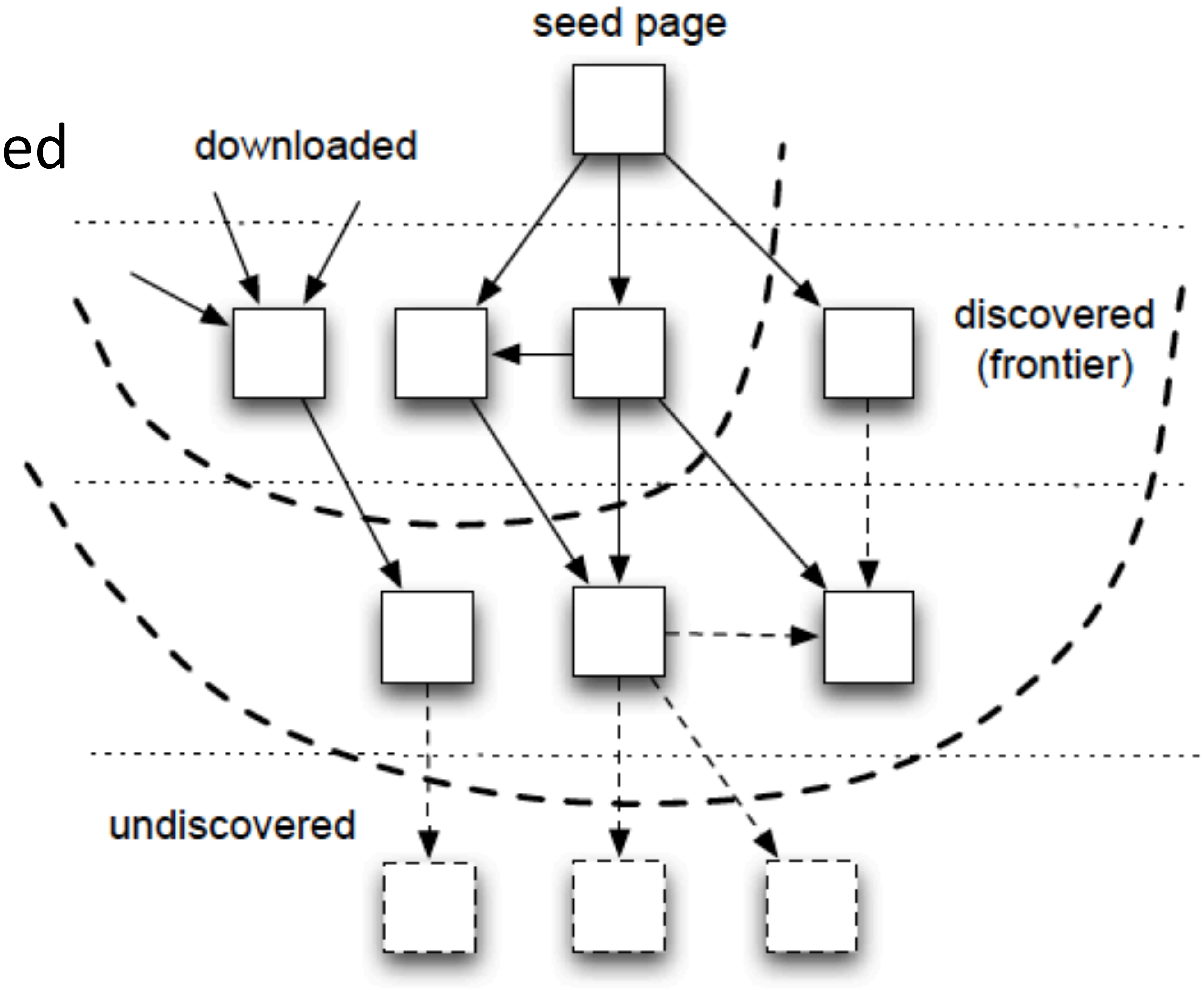
Crawling divides the web into 3 sets:

1. Downloaded
2. Discovered
3. Undiscovered



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Crawl stops when crawl queue is exhausted & ***subject to policies***

Crawling policies:

1. **Selection policy**: which urls to crawl
2. **Re-visit policy**: when to re-crawl the same url
3. **Politeness policy**: how aggressive the crawl is

Selection & Revisit are *URL Prioritisation Policies*

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- **Discovery queue** (selection policy):
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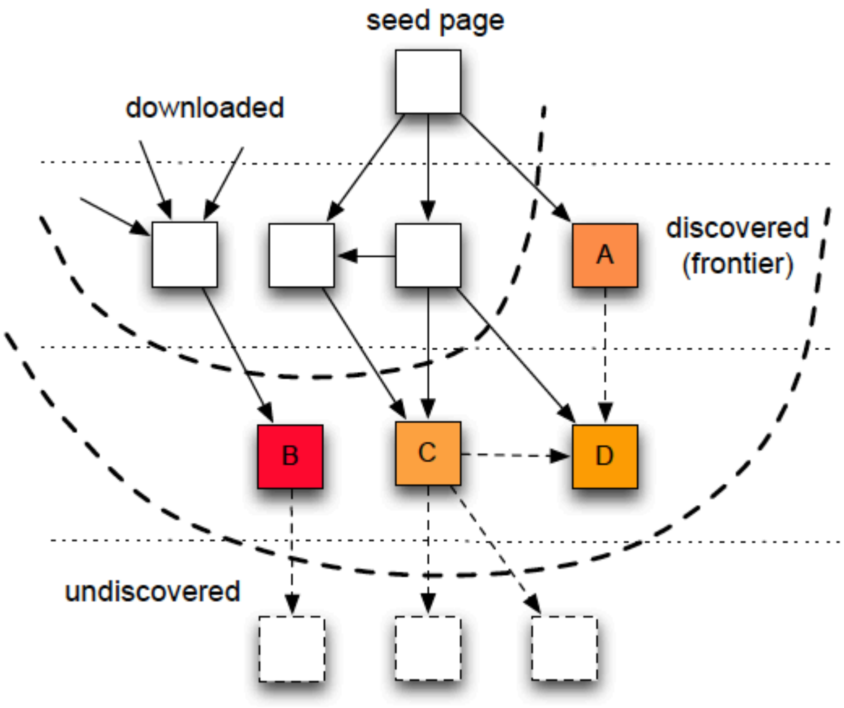
- **Refreshing queue** (re-visit policy)
  - Re-downloads already downloaded pages
  - Tries to increase ***freshness***

URL prioritization (Discovery):

- Random (A,B,C,D)
- Breadth-first (A)
- In-degree (C)
- PageRank (B)



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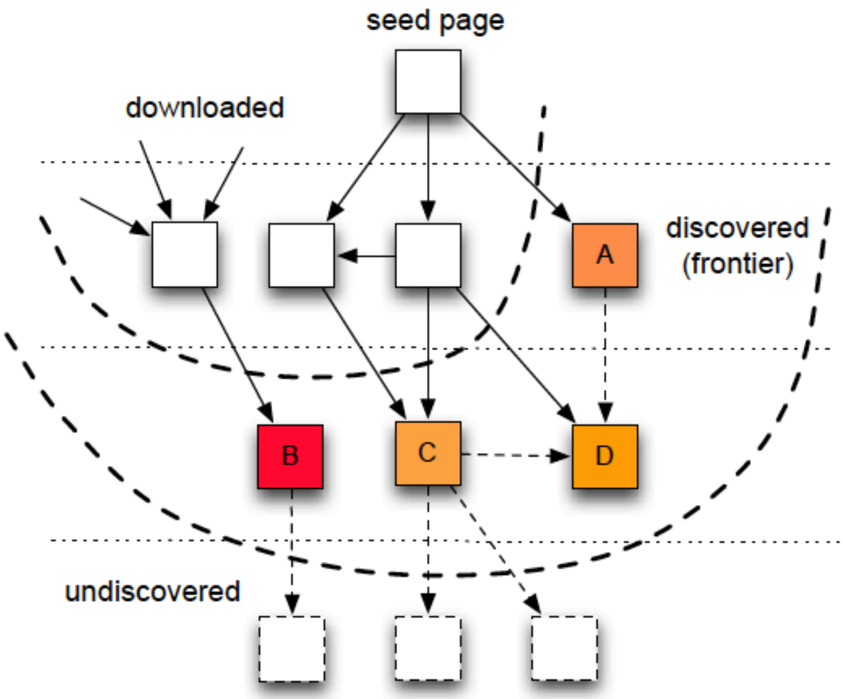

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URL prioritization (Refreshing):

- Random
- PageRank
- User feedback/interest
- Age
- Longevity

Why focus on ***discovery*** and ***refreshing***?

- Because the web is ***dynamic***: crawling tiny fraction can take months. By the time crawling is done, new information has been added, updated or deleted. Need to re-crawl.

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  – Crawling metrics measure this cost

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Quality metrics:

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Performance metric:

- Throughput: content download rate in bytes per unit of time

Example of Freshness

Freshness *F* of a webpage *p* stored in the index at time *t* (binary measure)

$$F_p(t) = \begin{cases} 1, \text{ if } p \text{ is equal to the stored copy at time } t \\ 0, \text{ otherwise} \end{cases}$$

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Age *A* of a webpage *p* stored in the index at time *t*

$$A_p(t) = \begin{cases} 0, \text{ if } p \text{ is not modified} \\ t - \text{modification time of } p\text{, otherwise} \end{cases}$$

Example of Freshness

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Age *A* of a webpage *p* stored in the index at time *t* **(0 is best)**

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- **Server overload**: if frequency of accesses to server is high

Poorly written crawlers may crash servers or routers or may download webpages they cannot handle

Partial solutions:

- A polite crawler puts a delay between two consecutive downloads from the same server (common: 20 seconds)

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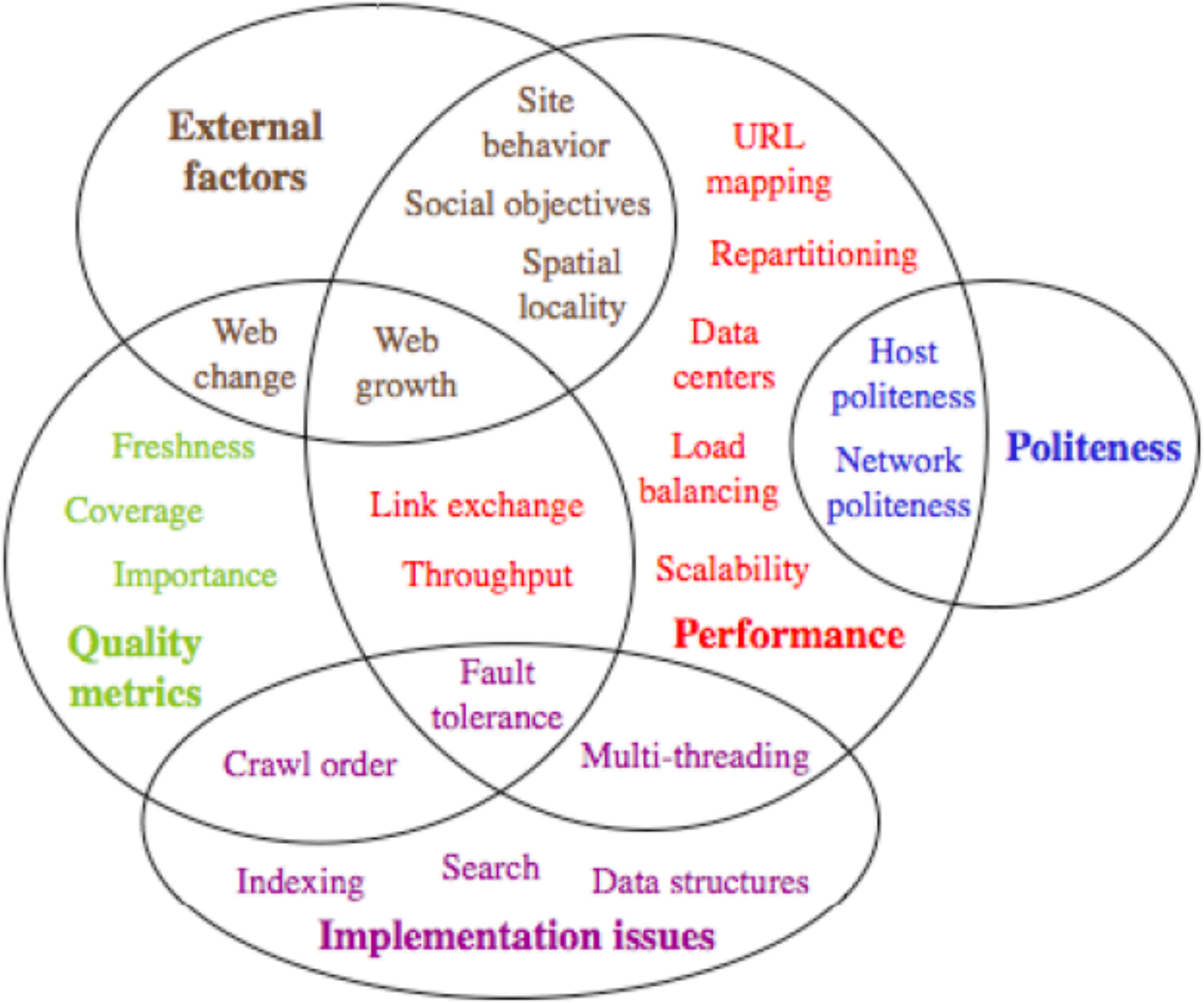
  - Created by webpage administrators to indicate which parts of their servers should and/or should not be crawled
  - robots.txt: standard from the early days of the web
  - Crawlers often cache robots.txt files for efficiency

How Google handles such exclusion protocols (in BNF):

https://developers.google.com/webmasters/control-crawl-index/docs/robots_txt

Concepts related to web crawling



Crawlers: central part of search engines

- Details of their algorithms & architecture are kept as **business secrets** (lack of detail in published designs)

Why?

- **Competition**: prevent others to reproduce the work
- **Spamming risks**: emerging concerns about spammers taking advantage of the crawling process to spread spam

http://www.google.com/insidesearch/howsearchworks/crawling-indexing.html

Crawling architectures

- **Single computer**

- **Parallel**

- **Geographically distributed**

Crawling architectures

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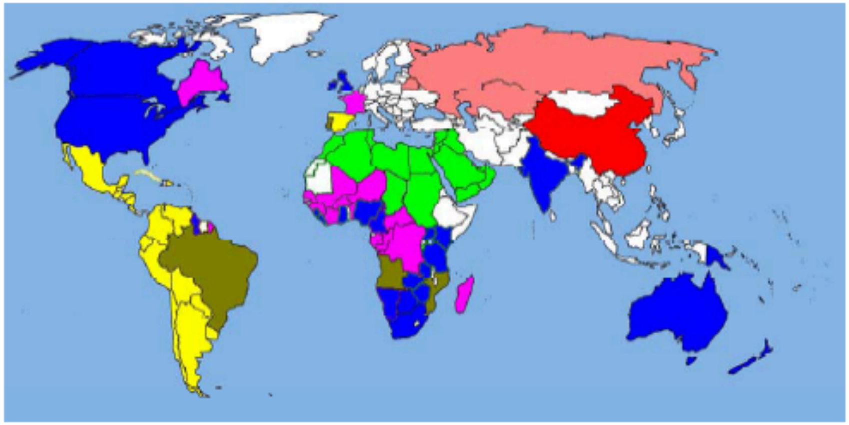
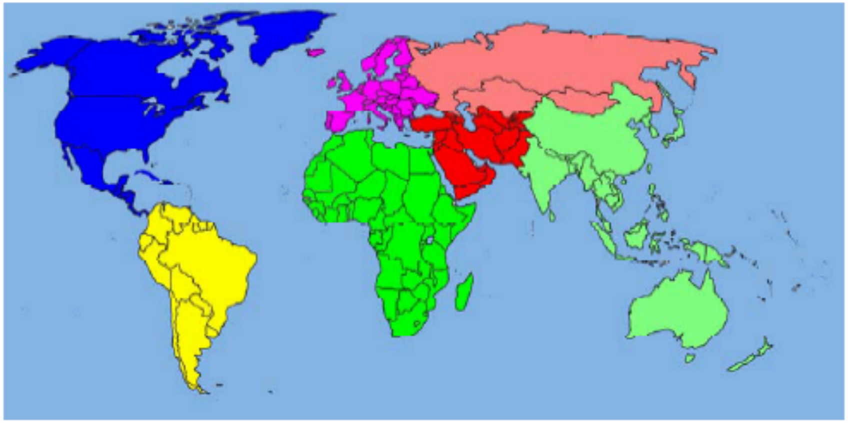
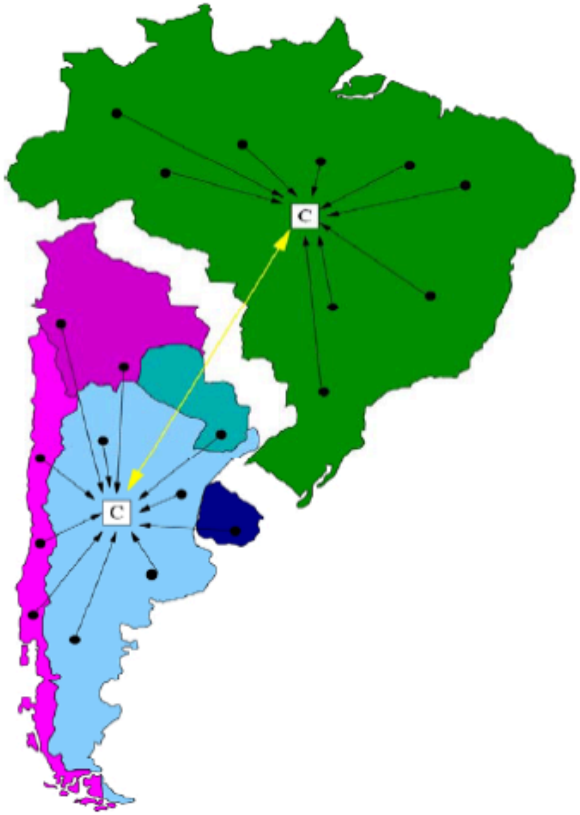
  - Multiple computers, multiple data centres
  - Scalable
  - Reduces network latency

Geographically distributed Web crawling







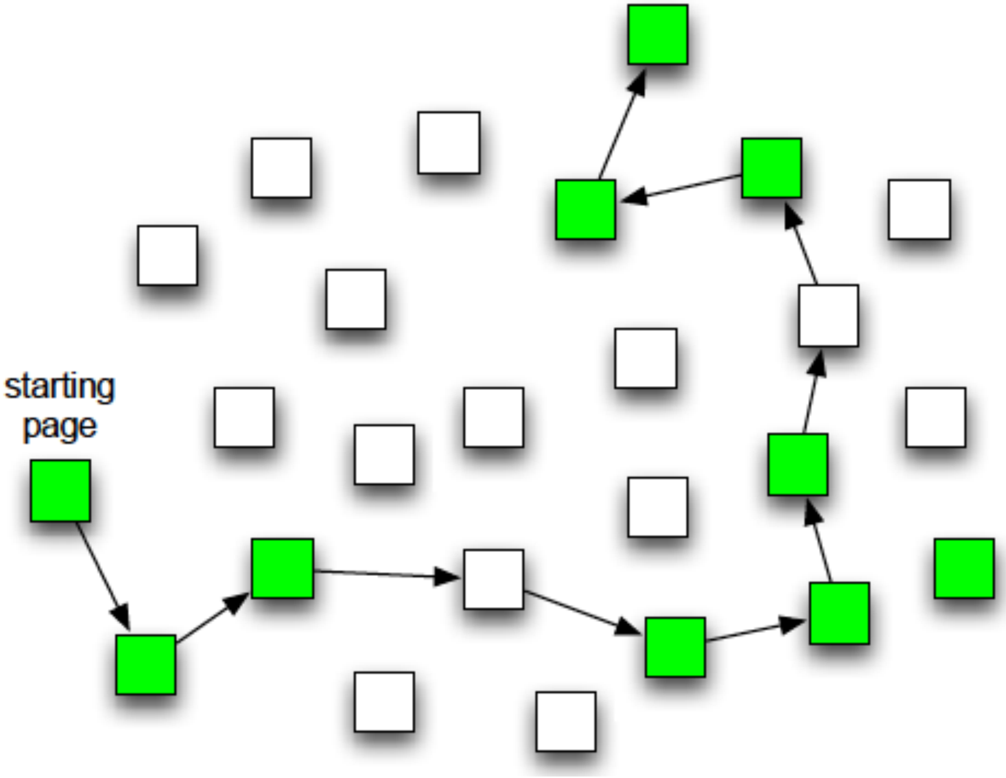
Geographically distributed Web crawling

Benefits:

- Higher crawling throughput
  - Geographical proximity
  - Lower crawling latency
- Increased availability
  - Continuity of business
- Better coupling with distributed indexing/search
  - Reduced data migration

Focused Web Crawling

Goal: locate and download a large proportion of web pages that match a given target theme as early as possible



Focused Web Crawling

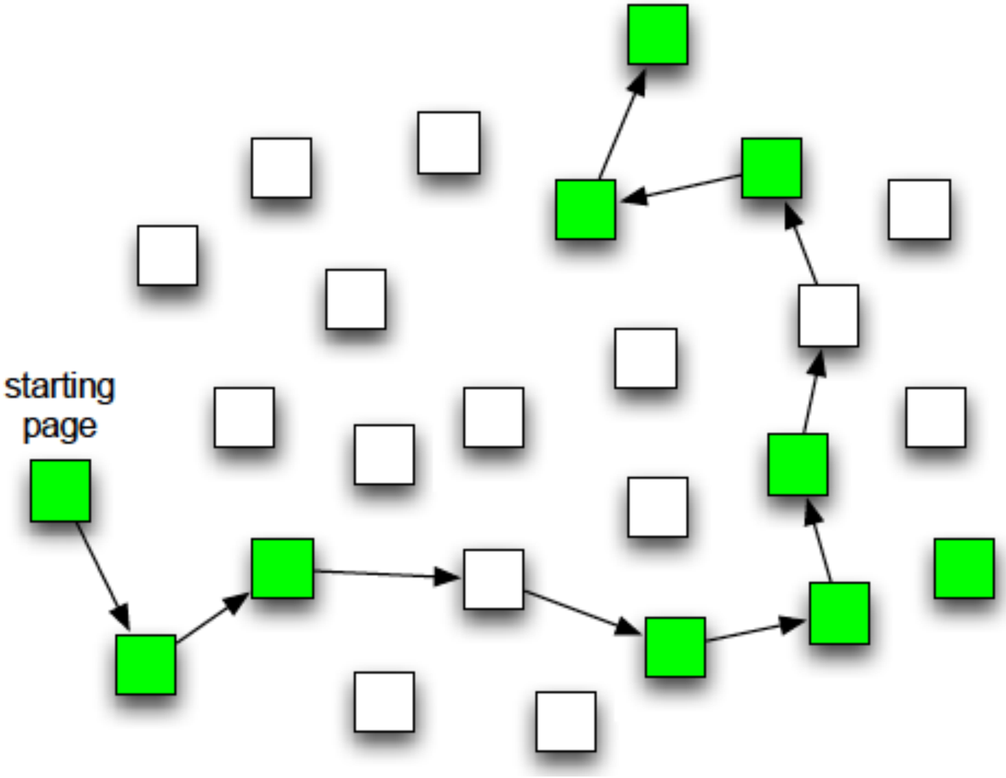
Goal: locate and download a large proportion of web pages that match a given target theme as early as possible

Example themes:

- Topic (nuclear energy)
- Media type (forums)
- Demographics (kids)

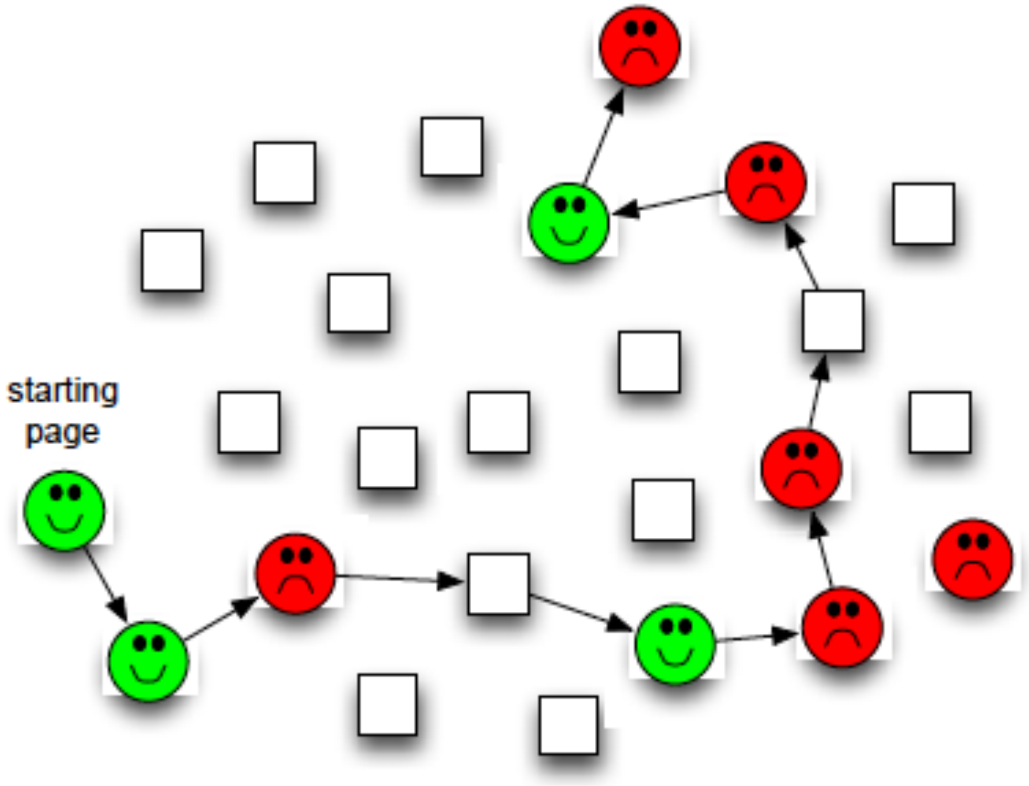
Strategies:

- URL patterns
- Referring page content
- Local graph structure



Sentiment Focused Web Crawling

Goal: locate and download a large proportion of web pages that contain positive or negative sentiments (opinionated content) as early as possible



Research Problem: Hidden Web Crawling

Hidden Web: web pages that a crawler cannot access by simply following link structure

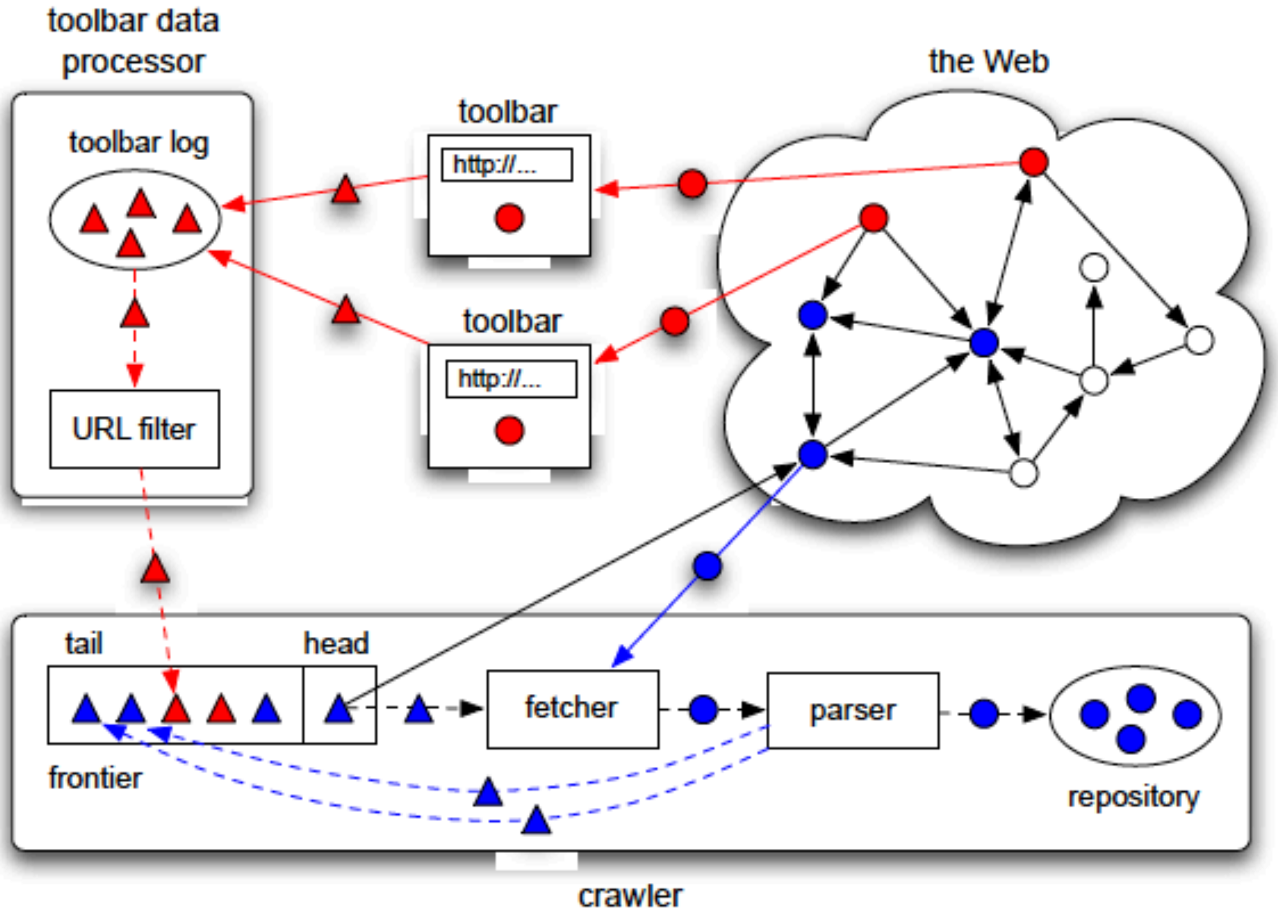
Examples:

- Unlinked pages
- Private sites
- Scripted content
- Dynamic content
- …

Hidden Web Crawling → Passive discovery

URL discovery by external agents: toolbar logs, email messages, tweets, …

Benefits: improved coverage, early discovery



Published web crawler architectures

- Bingbot: Microsoft’s Bing web crawler
- FAST craweler: Used by Fast Search & Transfer
- Googlebot: Web crawler of Google
- PolyBot: a distributed web crawler
- RBSE: The first published web crawler
- WebFountain: A distributed web crawler
- Web RACE: a crawling and caching module
- Yahoo Slurp: web crawler used by Yahoo search

Open source web crawlers

- DataparkSearch: GNU General Public License (GPL)
- GRUB: open source distributed crawler of Wikia Search
- Heritrix: Internet Archives crawler
- ICDL Crawler: cross-platform web crawler
- Norconex HTTP Collector: licensed under GPL
- Nutch: Apache License
- Open Search Server: GPL License
- PHP-Crawler: BSD license
- Scrapy: BSD license
- Seeks: Affero GPL

Today's lecture

- Course administration

- What is Web Science
- What is the Web
- What is the Internet
- Web graph
- Main challenges of web data processing
- Web crawling

References (in addition to Absalon readings) & sources:

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  Complete preprint on-line at http://www.cs.cornell.edu/home/kleinber/networks-book/
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