CS276

Lecture 15

Recap

- In the last lecture we introduced web search
- Paid placement
- SEO/Spam

Plan for today

- Wrap up spam
- Crawling
- Connectivity servers

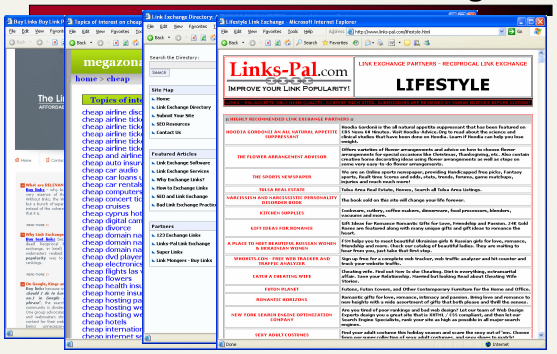
Link-based ranking

- Most search engines use hyperlink information for ranking
- Basic idea: Peer endorsement
  - Web page authors endorse their peers by linking to them
- Prototypical link-based ranking algorithm: PageRank
  - Page is important if linked to (endorsed) by many other pages
  - More so if other pages are themselves important
  - More later …

Link spam

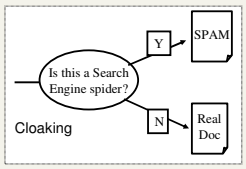
- Link spam: Inflating the rank of a page by creating nepotistic links to it
  - From own sites: Link farms
  - From partner sites: Link exchanges
  - From unaffiliated sites (e.g. blogs, web forums, etc.)
- The more links, the better
  - Generate links automatically
  - Use scripts to post to blogs
  - Synthesize entire web sites (often infinite number of pages)
  - Synthesize *many* web sites (DNS spam; e.g. *.thrillingpage.info)
- The more important the linking page, the better
  - Buy expired highly-ranked domains
  - Post to high-quality blogs

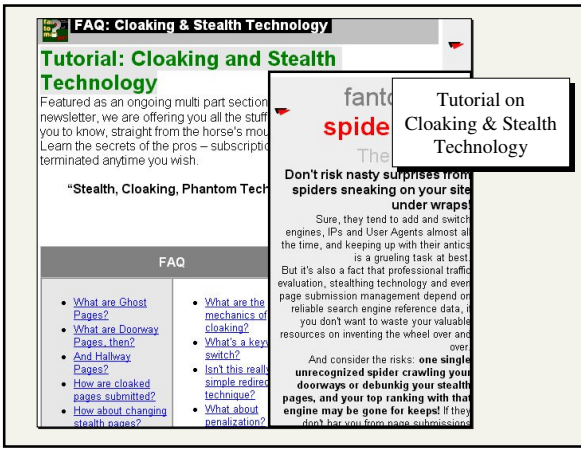
Link farms and link exchanges



More spam techniques

- **Cloaking**
  - Serve fake content to search engine spider
  - *DNS cloaking:* Switch IP address. Impersonate





More spam techniques

- **Doorway pages**
  - Pages optimized for a single keyword that re-direct to the real target page
- **Robots**
  - Fake query stream – rank checking programs
    - "Curve-fit" ranking programs of search engines
  - Millions of submissions via Add-Url

Acid test

- Which SEO's rank highly on the query ***seo***?
- Web search engines have policies on SEO practices they tolerate/block
  - See pointers in Resources
- Adversarial IR: the unending (technical) battle between SEO's and web search engines
- See for instance http://airweb.cse.lehigh.edu/

Crawling

Crawling Issues

- How to crawl?
  - *Quality*: "Best" pages first
  - *Efficiency*: Avoid duplication (or near duplication)
  - *Etiquette*: Robots.txt, Server load concerns
- How much to crawl? How much to 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?
  - How much has really changed? (why is this a different question?)

Basic crawler operation

- Begin with known "seed" pages
- Fetch and parse them
  - Extract URLs they point to
  - Place the extracted URLs on a queue
- Fetch each URL on the queue and repeat

Simple picture – complications

- Web crawling isn't feasible with one machine
  - All of the above steps distributed
- Even non-malicious pages pose challenges
  - Latency/bandwidth to remote servers vary
  - Robots.txt stipulations
    - How "deep" should you crawl a site's URL hierarchy?
  - Site mirrors and duplicate pages
- Malicious pages
  - Spam pages (Lecture 1, plus others to be discussed)
  - Spider traps – incl dynamically generated
- Politeness – don't hit a server too often

Robots.txt

- Protocol for giving spiders ("robots") limited access to a website, originally from 1994
  - www.robotstxt.org/wc/norobots.html
- Website announces its request on what can(not) be crawled
  - For a URL, create a file `URL/robots.txt`
  - This file specifies access restrictions

Robots.txt example

- No robot should visit any URL starting with "/yoursite/temp/", except the robot called "searchengine":

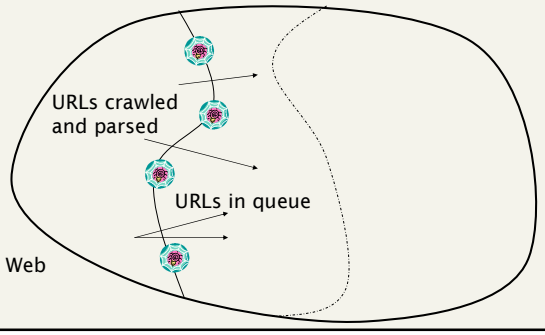
```
User-agent: *
Disallow: /yoursite/temp/

User-agent: searchengine
Disallow:
```

Crawling and Corpus Construction

- Crawl order
- Distributed crawling
- Filtering duplicates
- Mirror detection

Where do we spider next?



Crawl Order

- Want best pages first
- Potential quality measures:
  - Final In-degree
  - Final Pagerank

What's this?

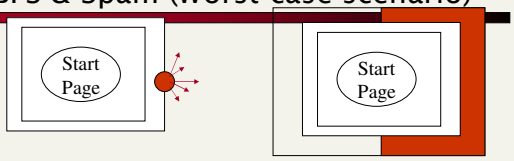
Crawl Order

- Want best pages first
- Potential quality measures:
  - Final In-degree
  - Final Pagerank

Measure of page quality we'll define later in the course.

- Crawl heuristic:
  - Breadth First Search (BFS)
  - Partial Indegree
  - Partial Pagerank
  - Random walk

BFS & Spam (Worst case scenario)



BFS depth = 2

Normal avg outdegree = 10

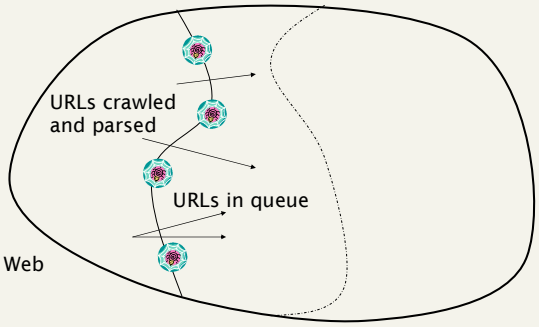
100 URLs on the queue including a spam page.

Assume the spammer is able to generate dynamic pages with 1000 outlinks

BFS depth = 3
2000 URLs on the queue
50% belong to the spammer

BFS depth = 4
1.01 million URLs on the queue
99% belong to the spammer

Where do we spider next?



Where do we spider next?

- Keep all spiders busy
- Keep spiders from treading on each others' toes
  - Avoid fetching duplicates repeatedly
- Respect politeness/robots.txt
- Avoid getting stuck in traps
- Detect/minimize spam
- Get the "best" pages
  - What's best?
  - Best for answering search queries

Where do we spider next?

- Complex scheduling optimization problem, subject to all the constraints listed
  - Plus operational constraints (e.g., keeping all machines load-balanced)
- Scientific study – limited to specific aspects
  - Which ones?
  - What do we measure?
- What are the compromises in distributed crawling?

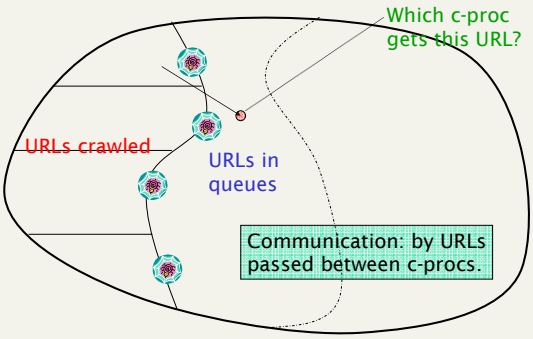
Parallel Crawlers

- We follow the treatment of Cho and Garcia-Molina:
  - http://www2002.org/CDROM/refereed/108/index.html
- Raises a number of questions in a clean setting, for further study
- Setting: we have a number of *c-proc*'s
  - c-proc = crawling process
- Goal: we wish to spider the *best* pages with minimum *overhead*
  - What do these mean?

Distributed model

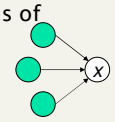
- Crawlers may be running in diverse geographies – Europe, Asia, etc.
  - Periodically update a master index
  - Incremental update so this is "cheap"
    - Compression, differential update etc.
  - Focus on communication overhead during the crawl
- Also results in dispersed WAN load

c-proc's crawling the web



Measurements

- Overlap = *(N-I)/I* where
  - *N* = number of pages fetched
  - *I* = number of distinct pages fetched
- Coverage = *I/U* where
  - *U* = Total number of web pages
- Quality = sum over downloaded pages of their *importance*
  - Importance of a page = its in-degree
- Communication overhead =
  - Number of URLs c-proc's exchange

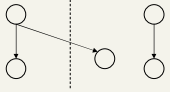


Crawler variations

- c-procs are independent
  - Fetch pages oblivious to each other.
- Static assignment
  - Web pages partitioned statically a priori, e.g., by URL hash … more to follow
- Dynamic assignment
  - Central co-ordinator splits URLs among c-procs

Static assignment

- Firewall mode: each c-proc only fetches URL within its partition – typically a domain
  - inter-partition links not followed
- Crossover mode: c-proc may following inter-partition links into another partition
  - possibility of duplicate fetching
- Exchange mode: c-procs periodically exchange URLs they discover in another partition



Experiments

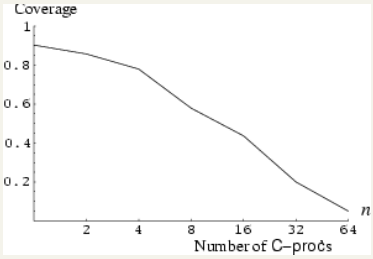
- 40M URL graph – Stanford Webbase
  - Open Directory (dmoz.org) URLs as seeds
- Should be considered a small Web

Summary of findings

- Cho/Garcia-Molina detail many findings
  - We will review some here, both qualitatively and quantitatively
  - You are expected to understand the reason behind each qualitative finding in the paper
  - You are not expected to remember quantities in their plots/studies

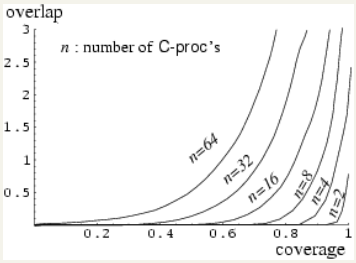
Firewall mode coverage

- The price of crawling in firewall mode



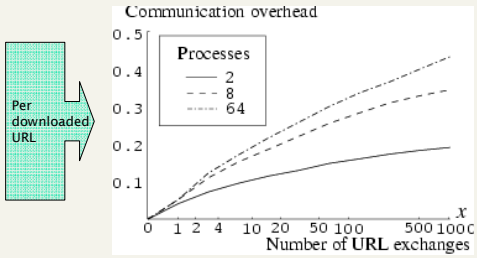
Crossover mode overlap

- Demanding coverage drives up overlap



Exchange mode communication

- Communication overhead sublinear



Connectivity servers

Connectivity Server
[*CS1:* Bhar98b, *CS2 & 3:* Rand01]

- Support for fast queries on the web graph
  - Which URLs point to a given URL?
  - Which URLs does a given URL point to?

  Stores mappings in memory from
  - URL to outlinks, URL to inlinks
- Applications
  - Crawl control
  - Web graph analysis
    - Connectivity, crawl optimization
  - Link analysis
    - More on this later

Most recent published work

- Boldi and Vigna
  - http://www2004.org/proceedings/docs/1p595.pdf
- Webgraph – set of algorithms and a java implementation
- Fundamental goal – maintain node adjacency lists in memory
  - For this, compressing the adjacency lists is the critical component

Adjacency lists

- The set of neighbors of a node
- Assume each URL represented by an integer
- Properties exploited in compression:
  - Similarity (between lists)
  - Locality (many links from a page go to "nearby" pages)
  - Use gap encodings in sorted lists
  - Distribution of gap values

Storage

- Boldi/Vigna get down to an average of ~3 bits/link
  - (URL to URL edge)
  - For a 118M node web graph
- How?

Why is this remarkable?

Main ideas of Boldi/Vigna

- Consider lexicographically ordered list of all URLs, e.g.,
  - www.stanford.edu/alchemy
  - www.stanford.edu/biology
  - www.stanford.edu/biology/plant
  - www.stanford.edu/biology/plant/copyright
  - www.stanford.edu/biology/plant/people
  - www.stanford.edu/chemistry

Boldi/Vigna

- Each of these URLs has an adjacency list
- Main thesis: because of templates, the adjacency list of a node is similar to one of the 7 preceding URLs in the lexicographic ordering
- Express adjacency list in terms of one of these
- E.g., consider these adjacency lists
  - 1, 2, 4, 8, 16, 32, 64
  - 1, 4, 9, 16, 25, 36, 49, 64
  - 1, 2, 3, 5, [illegible] 34, 55, 89, 144

Why 7?

Encode as (-2), remove 9, add 8

Resources

- www.robotstxt.org/wc/norobots.html
- www2002.org/CDROM/refereed/108/index.html
- www2004.org/proceedings/docs/1p595.pdf