Outline

1 Recap

2 A simple crawler

3 A real crawler
Search engines rank content pages and ads

Discount Broker Reviews
Information on online discount brokers emphasizing rates, charges, and customer comments and complaints.
www.broker-reviews.us/ - 94k - Cached - Similar pages

Discount Broker Rankings (2008 Broker Survey) at SmartMoney.com
Discount Brokers. Rank/ Brokerage/ Minimum to Open Account, Comments, Standard Commis- sion*, Reduced Commission, Account Fee Per Year (How to Avoid), Avg. ...

Stock Brokers | Discount Brokers | Online Brokers
Most Recommended. Top 5 Brokers headlines. 10. Don’t Pay Your Broker for Free Funds May 15 at 3:39 PM. 5. Don’t Discount the Discounters Apr 18 at 2:41 PM ...
www.fool.com/investing/brokers/index.aspx - 44k - Cached - Similar pages

Discount Broker
Discount Broker - Definition of Discount Broker on Investopedia - A stockbroker who carries out buy and sell orders at a reduced commission compared to a ...
www.investopedia.com/terms/d/discountbroker.asp - 31k - Cached - Similar pages

Discount Brokerage and Online Trading for Smart Stock Market ...
Online stock broker SogoTrade offers the best in discount brokerage investing. Get stock market quotes from this internet stock trading company.
www.sogotrade.com/ - 39k - Cached - Similar pages

15 questions to ask discount brokers - MSN Money
Jan 11, 2004 ... If you're not big on hand-holding when it comes to investing, a discount broker can be an economical way to go. Just be sure to ask these ...
moneycentral.msn.com/content/Investing/StartInvesting/P66171.asp - 34k - Cached - Similar pages
### Google’s second price auction

<table>
<thead>
<tr>
<th>advertiser</th>
<th>bid</th>
<th>CTR</th>
<th>ad rank</th>
<th>rank</th>
<th>paid</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$4.00</td>
<td>0.01</td>
<td>0.04</td>
<td>4</td>
<td>(minimum)</td>
</tr>
<tr>
<td>B</td>
<td>$3.00</td>
<td>0.03</td>
<td>0.09</td>
<td>2</td>
<td>$2.68</td>
</tr>
<tr>
<td>C</td>
<td>$2.00</td>
<td>0.06</td>
<td>0.12</td>
<td>1</td>
<td>$1.51</td>
</tr>
<tr>
<td>D</td>
<td>$1.00</td>
<td>0.08</td>
<td>0.08</td>
<td>3</td>
<td>$0.51</td>
</tr>
</tbody>
</table>

- **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 $\times$ 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 newspaper ads.
Near duplicate detection: Minimum of permutation

document 1: \( \{s_k\} \)

\[
1 \quad s_1 \quad s_2 \quad s_3 \quad s_4
\]

\[
x_k = \pi(s_k)
\]

\[
1 \quad x_3 \quad x_1 \quad x_4 \quad x_2
\]

\[
\min_{s_k} \pi(s_k)
\]

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?


document 2: \( \{s_k\} \)

\[
1 \quad s_1 \quad s_5 \quad s_3 \quad s_4
\]

\[
x_k = \pi(s_k)
\]

\[
1 \quad x_3 \quad x_1 \quad x_4 \quad x_5 \quad x_2
\]
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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

<table>
<thead>
<tr>
<th>Be polite</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Don’t hit a site too often</td>
</tr>
<tr>
<td>- Only crawl pages you are allowed to crawl: robots.txt</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Be robust</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Be immune to spider traps, duplicates, very large pages, very large websites, dynamic pages etc</td>
</tr>
</tbody>
</table>
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
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
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URL frontier

URLs crawled and parsed

URL frontier: found, but not yet crawled

unseen URLs
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

- DNS
- Fetch
- Parse
- URL frontier
- Content seen?
- URL filter
- Robots templates
- URL set
- Doc FPs
- URL elim
- URL set
- URL frontier
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 (wayfaring.com)
Distributed crawler

www → fetch → parse → content seen? → URL filter → host splitter → URL set

DNS

dup URL elim

from other nodes

to other nodes

FPs

doc
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

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

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

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.

Selection from front queues is initiated by back queues.

Pick a front queue.
Mercator URL frontier: Back queues

f. queue selector & b. queue router

$B$ back queues
Single host on each

b. queue selector

heap
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.

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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 $q$)
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.
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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://cis1mu.org
  - Paper on Mercator by Heydon et al.
  - Robot exclusion standard