Web Search

Spidering

1

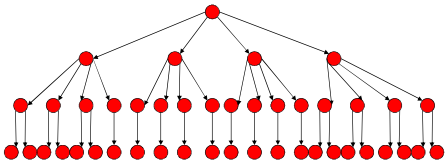
Spiders (Robots/Bots/Crawlers)

- Start with a comprehensive set of root URL's from which to start the search.
- Follow all links on these pages recursively to find additional pages.
- Index all **novel** found pages in an inverted index as they are encountered.
- May allow users to directly submit pages to be indexed (and crawled from).

2

Search Strategies

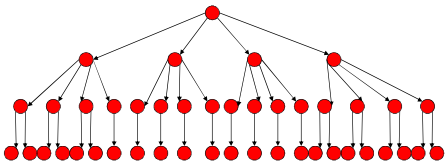
Breadth-first Search



3

Search Strategies (cont)

Depth-first Search



4

Search Strategy Trade-Off's

- Breadth-first explores uniformly outward from the root page but requires memory of all nodes on the previous level (exponential in depth). Standard spidering method.
- Depth-first requires memory of only depth times branching-factor (linear in depth) but gets "lost" pursuing a single thread.
- Both strategies implementable using a queue of links (URL's).

5

Avoiding Page Duplication

- Must detect when revisiting a page that has already been spidered (web is a graph not a tree).
- Must efficiently index visited pages to allow rapid recognition test.
  - Tree indexing (e.g. trie)
  - Hashtable
- Index page using URL as a key.
  - Canonicalize URL by using "redirected" URL from URLConnection
  - Not detect duplicated or mirrored pages.
- Index page using textual content as a key.
  - Requires first downloading page.

6

Spidering Algorithm

```
Initialize queue (Q) with initial set of known URL's.
Until Q empty or page or time limit exhausted:
    Pop URL, L, from front of Q.
    If L is not to an HTML page (.gif, .jpeg, .ps, .pdf, .ppt…)
        continue loop.
    If already visited L, continue loop.
    Download page, P, for L.
    If cannot download P (e.g. 404 error, robot excluded)
        continue loop.
    Index P (e.g. add to inverted index or store cached copy).
    Parse P to obtain list of new links N.
    Append N to the end of Q.
```

7

Queueing Strategy

- How new links added to the queue determines search strategy.
- FIFO (append to end of Q) gives breadth-first search.
- LIFO (add to front of Q) gives depth-first search.
- Heuristically ordering the Q gives a "focused crawler" that directs its search towards "interesting" pages.

8

Restricting Spidering

- Restrict spider to a particular site.
  - Remove links to other sites from Q.
- Restrict spider to a particular directory.
  - Remove links not in the specified directory.
- Obey page-owner restrictions (robot exclusion).

9

Link Extraction

- Must find all links in a page and extract URLs.
  - <a href="http://www.cs.utexas.edu/users/mooney/ir-course">
  - <frame src="site-index.html">
- Must complete relative URL's using current page URL:
  - <a href="proj3"> to http://www.cs.utexas.edu/users/mooney/ir-course/proj3
  - <a href="../cs343/syllabus.html"> to http://www.cs.utexas.edu/users/mooney/cs343/syllabus.html

10

URL Syntax

- A URL has the following syntax:
  - <scheme>://<authority><path>?<query>#<fragment>
- An *authority* has the syntax:
  - <host>:<port-number>
- A *query* passes variable values from an HTML form and has the syntax:
  - <variable>=<value>&<variable>=<value>…
- A *fragment* is also called a *reference* or a *ref* and is a pointer within the document to a point specified by an anchor tag of the form:
  - <A NAME="<fragment>">

11

Java Spider

- Spidering code in ir.webutils package.
- Generic spider in Spider class.
- Does breadth-first crawl from a start URL and saves copy of each page in a local directory.
- This directory can then be indexed and searched using VSR InvertedIndex.
- Main method parameters:
  - -u <start-URL>
  - -d <save-directory>
  - -c <page-count-limit>

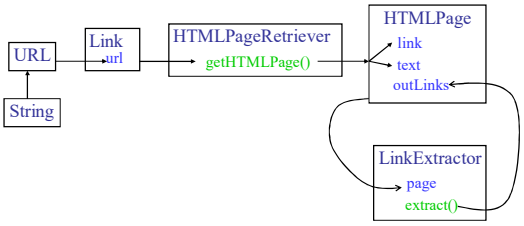
12

Java Spider (cont.)

- Robot Exclusion can be invoked to prevent crawling restricted sites/pages.
  - -safe
- Specialized classes also restrict search:
  - SiteSpider: Restrict to initial URL host.
  - DirectorySpider: Restrict to below initial URL directory.

13

Spider Java Classes



14

Link Canonicalization

- Canonicalize URL by using "redirected" URL returned by an established Java URLConnection.
- Internal page fragments (ref's) removed:
  - http://www.cs.utexas.edu/users/mooney/welcome.html#courses
  - http://www.cs.utexas.edu/users/mooney/welcome.html

15

Link Extraction in Java

- Java Swing contains an HTML parser.
- Parser uses "call-back" methods.
- Pass parser an object that has these methods:
  - HandleText(char[] text, int position)
  - HandleStartTag(HTML.Tag tag, MutableAttributeSet attributes, int position)
  - HandleEndTag(HTML.Tag tag, int position)
  - HandleSimpleTag (HTML.Tag tag, MutableAttributeSet attributes, int position)
- When parser encounters a tag or intervening text, it calls the appropriate method of this object.

16

Link Extraction in Java (cont.)

- In HandleStartTag, if it is an "A" tag, take the HREF attribute value as an initial URL.
- Complete the URL using the base URL:
  - new URL(URL baseURL, String relativeURL)
  - Fails if baseURL ends in a directory name but this is not indicated by a final "/"
  - Append a "/" to baseURL if it does not end in a file name with an extension (and therefore presumably is a directory).

17

Cached File with Base URL

- Store copy of page in a local directory for eventual indexing for retrieval.
- BASE tag in the header section of an HTML file changes the base URL for all relative pointers:
  - <BASE HREF="<base-URL>">
- This is specifically included in HTML for use in documents that were moved from their original location.

18

Java Spider Trace

- As a simple demo, SiteSpider was used to collect 100 pages starting at: UT CS Faculty Page
- See trace at: http://www.cs.utexas.edu/users/mooney/ir-course/spider-trace.txt
- A larger crawl from the same page was used to assemble 800 pages that are cached at:
  - /u/mooney/ir-code/corpora/cs-faculty/

19

Servlet Web Interface Demo

- Web interface to using VSR to search directories of cached HTML files is at:
  - http://www.cs.utexas.edu/users/mooney/ir-course/search.html
- The Java Servlet code supporting this demo is at:
  - /u/ml/servlets/irs/Search.java

20

Anchor Text Indexing

- Extract anchor text (between <a> and) of each link followed.
- Anchor text is usually descriptive of the document to which it points.
- Add anchor text to the content of the destination page to provide additional relevant keyword indices.
- Used by Google:
  - Evil Empire
  - IBM

21

Anchor Text Indexing (cont)

- Helps when descriptive text in destination page is embedded in image logos rather than in accessible text.
- Many times anchor text is not useful:
  - "click here"
- Increases content more for popular pages with many in-coming links, increasing recall of these pages.
- May even give higher weights to tokens from anchor text.

22

Robot Exclusion

- Web sites and pages can specify that robots should not crawl/index certain areas.
- Two components:
  - Robots Exclusion Protocol: Site wide specification of excluded directories.
  - Robots META Tag: Individual document tag to exclude indexing or following links.

23

Robots Exclusion Protocol

- Site administrator puts a "robots.txt" file at the root of the host's web directory.
  - http://www.ebay.com/robots.txt
  - http://www.cnn.com/robots.txt
- File is a list of excluded directories for a given robot (user-agent).
  - Exclude all robots from the entire site:

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

24

Robot Exclusion Protocol Examples

- Exclude specific directories:

```
User-agent: *
Disallow: /tmp/
Disallow: /cgi-bin/
Disallow: /users/paranoid/
```

- Exclude a specific robot:

```
User-agent: GoogleBot
Disallow: /
```

- Allow a specific robot:

```
User-agent: GoogleBot
Disallow:

User-agent: *
Disallow: /
```

25

Robot Exclusion Protocol Details

- Only use blank lines to separate different User-agent disallowed directories.
- One directory per "Disallow" line.
- No regex patterns in directories.

26

Robots META Tag

- Include META tag in HEAD section of a specific HTML document.
  - <meta name="robots" content="none">
- Content value is a pair of values for two aspects:
  - index | noindex: Allow/disallow indexing of this page.
  - follow | nofollow: Allow/disallow following links on this page.

27

Robots META Tag (cont)

- Special values:
  - all = index,follow
  - none = noindex,nofollow
- Examples:

```
<meta name="robots" content="noindex,follow">
<meta name="robots" content="index,nofollow">
<meta name="robots" content="none">
```

28

Robot Exclusion Issues

- META tag is newer and less well-adopted than "robots.txt".
- Standards are conventions to be followed by "good robots."
- Companies have been prosecuted for "disobeying" these conventions and "trespassing" on private cyberspace.
- "Good robots" also try not to "hammer" individual sites with lots of rapid requests.
  - "Denial of service" attack.

29

Multi-Threaded Spidering

- Bottleneck is network delay in downloading individual pages.
- Best to have multiple threads running in parallel each requesting a page from a different host.
- Distribute URL's to threads to guarantee equitable distribution of requests across different hosts to maximize through-put and avoid overloading any single server.
- Early Google spider had multiple co-ordinated crawlers with about 300 threads each, together able to download over 100 pages per second.

30

Directed/Focused Spidering

- Sort queue to explore more "interesting" pages first.
- Two styles of focus:
  - Topic-Directed
  - Link-Directed

31

Topic-Directed Spidering

- Assume desired topic description or sample pages of interest are given.
- Sort queue of links by the similarity (e.g. cosine metric) of their source pages and/or anchor text to this topic description.
- Preferentially explores pages related to a specific topic.
- Robosurfer assignment in AI course.

32

Link-Directed Spidering

- Monitor links and keep track of in-degree and out-degree of each page encountered.
- Sort queue to prefer popular pages with many in-coming links (*authorities*).
- Sort queue to prefer summary pages with many out-going links (*hubs*).

33

Keeping Spidered Pages Up to Date

- Web is very dynamic: many new pages, updated pages, deleted pages, etc.
- Periodically check spidered pages for updates and deletions:
  - Just look at header info (e.g. META tags on last update) to determine if page has changed, only reload entire page if needed.
- Track how often each page is updated and preferentially return to pages which are historically more dynamic.
- Preferentially update pages that are accessed more often to optimize freshness of more popular pages.

34