Searching for

Authority on the WWW

(Not just relevance or popularity...)

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Sources of Information on the WWW

- Textual content
- Images, sounds, multimedia content
- Hyperlink digraph (network structure)
  - Pages are vertices, links are arcs
    - Refinement: URLs are nodes

Nature of the WWW

- Local organization may be a priori.
- Global organization "utterly unplanned."
- Billions of agents (users, spiders).
- Millions of publishers.
- Trillions of vertices, at least.
- Too big for simple search.

Searching the WWW

- **Quality** of search method defined by utility of results.
- **Utility** requires human evaluation.
- Utility is closely correlated to **relevance**.
- Algorithmic and storage **efficiency** are a concern: interactivity/response time.

Search: Queries

- Searches are initiated by a user-supplied **query**.
- Three types of queries discussed:
  - **Specific** queries.
  - **Broad-topic** queries.
  - **Similar content** queries.

Search: Problems.

- Specific queries: **Scarcity**.
  - Required information is scarce and pages are hard to find.
- Broad-topic queries: **Abundance**.
  - We only want the **authoritative** pages. (i.e.: Wikipedia itself, not ad-clones.)

Search: Authorities

- Possible measures of authority:
  - **Frequency** of search term on page.
    - Problem: **Self-descriptive**.
  - **Popularity** of page. (rank by links in)
    - Problem: Obfuscation by **hubs**.
  - Analysis of link structure...

Hyperlinks

- Claim:
  Hyperlinks indicate **conferred authority**.
- Claim:
  Hyperlinks solve self-descriptive problem.
- What about navigational links?
- What about paid advertisements?

Popularity

- In some cases, most authoritative pages aren't self-descriptive.
- Universally popular pages would be considered highly authoritative w.r.t any query string, when they are not.

Step 1: Constructing Focused Subgraph

- Obtain root set, **R**, from textual search.
  - Relatively small, rich in relevant pages, but doesn't contain most or many of strongest authorities.
  - Extremely few intra-R links.
- Obtain base set, **S**, from R by adding any pages pointing to or pointed from R.

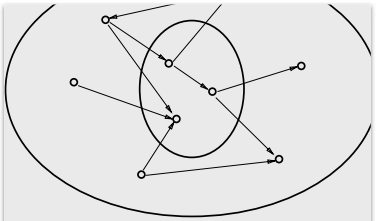


Figure 1: Expanding the root set into a base set.

R → S

- What about navigational links?
  - Transverse vs. intrinsic links.
  - Delete all intrinsic links.
    - Caveats?
- What about "Google Bombing"?
  - Set limitations on in-degree or out-degree on a per-domain basis.

Step 2: Computing Hubs and Authorities

- Given our focused subgraph G, now what?
  - Popularity ranking by in-degree?
    - Popularity ≠ relevance.
  - **Hub**: links to multiple relevant authorities.
  - **Authorities**: high in-degree and overlap.
  - Hubs & Authorities: Mutually reinforcing.

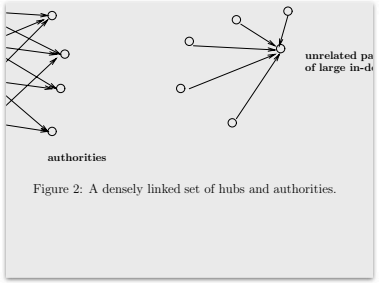


Figure 2: A densely linked set of hubs and authorities.

Iterative Algorithm

- Subgraph G = (V, A).
- Normalized weights, x<p> & y<p>.
- Update operations, I & O.
- Mutually reinforcing:
  - I: $x_{<p>} = \sum y_{<q>} \; \forall \; q : (q, p) \in A$.
  - O: $y_{<p>} = \sum x_{<q>} \; \forall \; q : (p, q) \in A$.

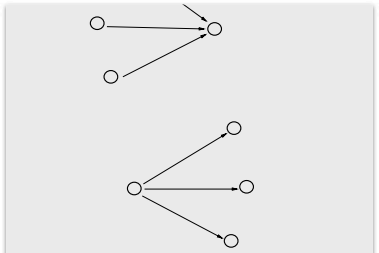
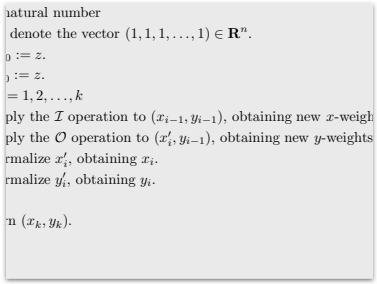


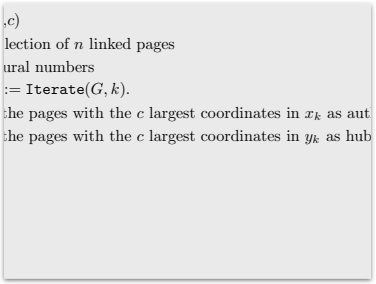
Figure 3: The basic operations.

I & O

- x is a vector containing all x<p>
- y is a vector containing all y<p>
- Iterate(k): apply I & O and normalize.
- Filter(c): obtain c largest coordinates.
- Optimization of k is trivial:
  - x and y converge eventually. (3.1)



Iterate



Filter

Method Quirks

- Textual search as black box.
- Only probabilistically global.
- Does not address scarcity problem.

Similar-Page Queries

- "similar:www.example.com"
- Very little modification necessary!
- Obtain root set from in-pages search.
  - R = t pages pointing to p.
- In-degree still not a good ranking.

Related Work

- Standing in social networks.
- Influence in scientific citation networks.
- PageRank. (i.e.: WWW indices, no hubs)

Multiple Sets of H&A

- What about ambiguous query terms? (Terms with several meanings.)
- What about different contexts?
- What about polarized issues? (Groups that won't link to one another, but are debating the same topic.)
- Clusters exist.

Diffusion and Generalization

- **Diffusion**: pages corresponding to "broader" topics than the query string are returned, or reference page has insufficient in-degree.
  - Was the query string too specific?
- Possible solutions?
  - Non-principal eigenvectors.
  - Textual approaches (i.e.: term-matching)

Conclusions

- **Abundance** problem is harder each day.
  - Calls for search engines to consider more than simple relevance and clustering.
- Growth of WWW makes **indexing** harder.
- WWW search results must be **global**, WWW search process doesn't have to be.
- **Quality** of results is critical, more so as the WWW grows and becomes polluted.

Conclusions

- WWW is social.
  (Social organization is represented.)
- Further avenues:
  - User traffic pattern analysis.
  - Eigenvector-based heuristics. (LSA)
  - Link-based methods for other queries.