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Charting SearchLand:
search quality for beginners

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Cuil, Inc.
Aug 2010

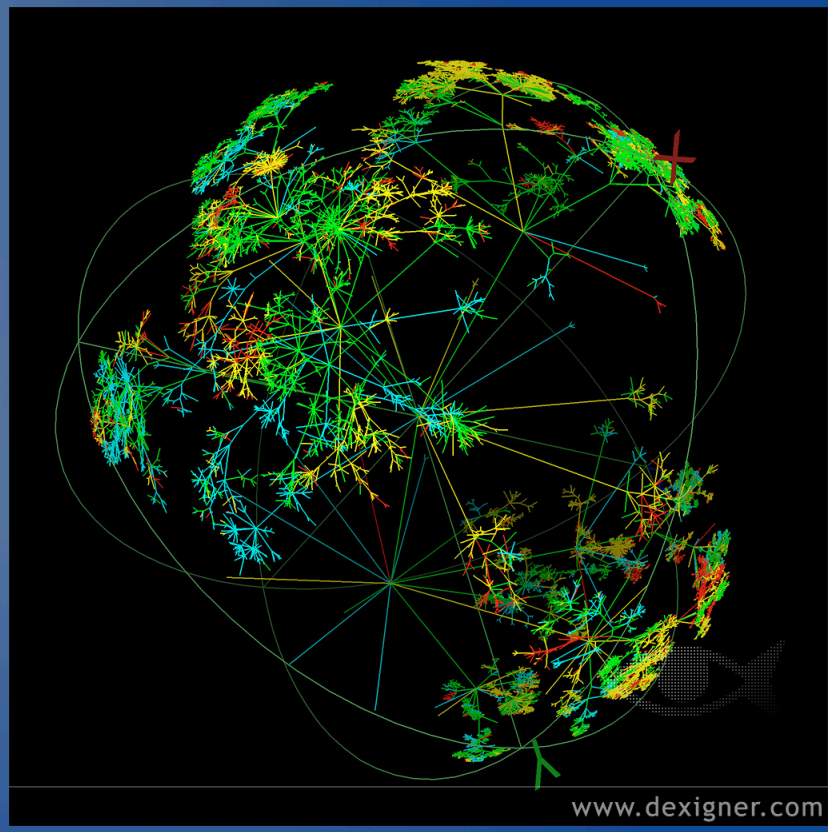
Check http://www.parc.com/event/934/adventures-in-searchland.html

Charting SearchLand

- SearchLand? codename for search in start-up culture
- Academic research is a landscape I understand and can travel in (if you change the field you do research, you keep the tools and the methods)
- Searchland feels very foreign and it needs charting
- Even a primitive map is better than no map at all…

Outline

- SearchLand
- Search engine basics
- Measuring IR systems
- Measuring search quality
- Conclusions...
- and Opportunities



SearchLand?

"Up until now most search engine development has gone on at companies with little publication of technical details. This causes search engine technology to remain largely a black art and to be advertising oriented.'' Brin and Page, "The anatomy of a search engine", 1998

Disclaimer: This talk presents the guesswork of the author.
It does not reflect the views of my employers or practices at work.

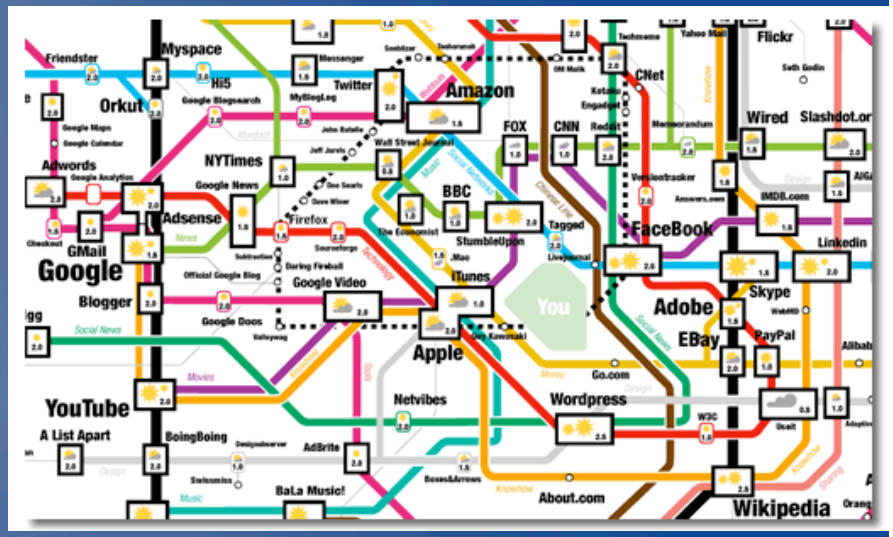
Thanks kxdc2007!

SearchLand

- Twelve years later the complaint remains…
- Gap between research and practice widened
- Measuring SE quality is `adversarial computing’
- Many dimensions of quality: pictures, snippets, categories, suggestions, etc

SearchLand: Draft Map

Based on slides for Croft, Metzler and Strohman's "Search Engines: Information Retrieval in Practice", 2009 the tutorial **`Web Search Engine Metrics'** by Dasdan, Tsioutsiouliklis and Velipasaoglu for WWW09/10 and Hugh Williams slides!



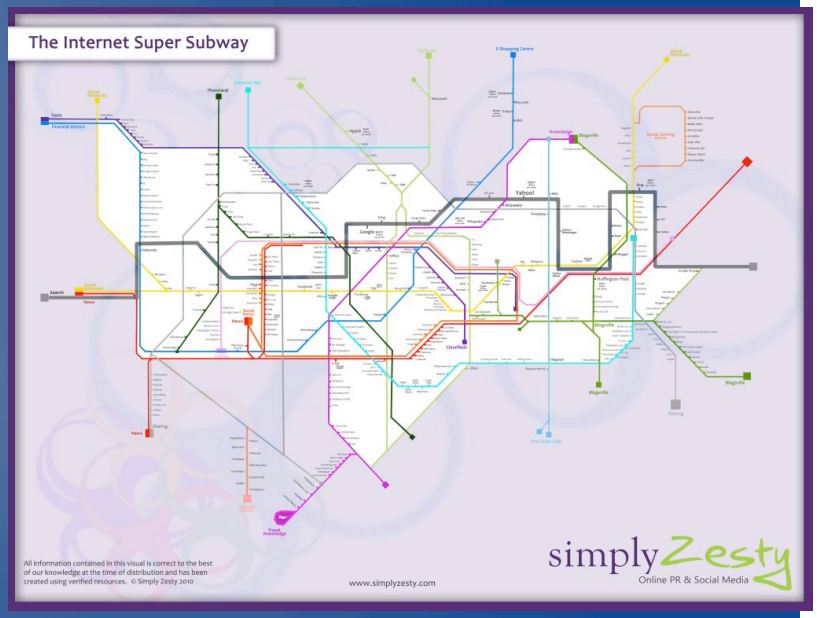
THANKS GUYS!!…

Search engines…

My understanding of search engines is very basic: I know when I like results and when I don't. (yes, you'll get the user perspective here…)

Assuming you're like this too, some basics, from folks that know more.

Basic metaphor: search engine as a librarian in super-hyped library…



Search Engine Basics...

Web search engines don't search the web:

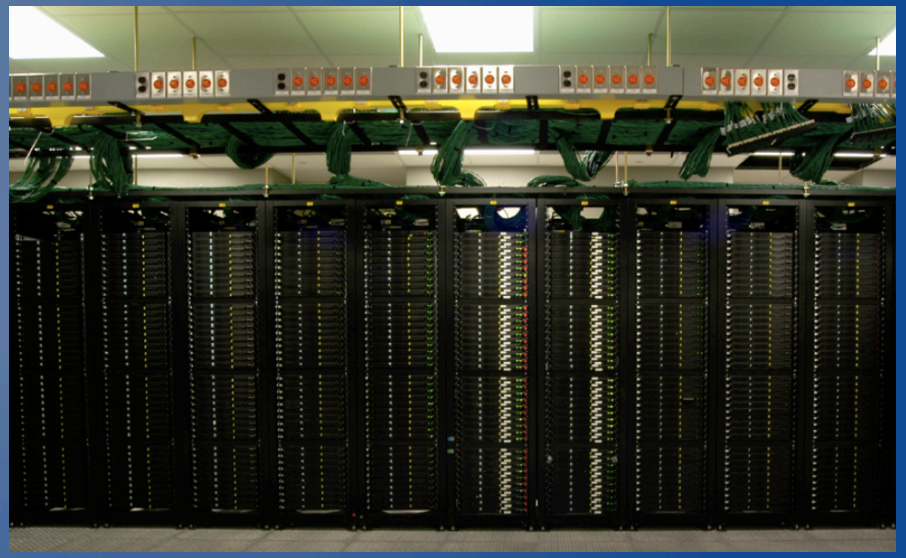
- They search a *copy* of the web
- They *crawl* documents from the web
- They *index* the documents, and provide a search interface based on that index
- They present short *snippets* that allow users to judge relevance
- Users click on links to visit the actual web document

(thanks ACMSIG May 2010)

Search Engine Basics

Modules: Crawler

- Indexer
- [content mining]*
- Query analyzer
- Query server
- Index server
- Snippeter
- Ranking
- Webserver, etc…

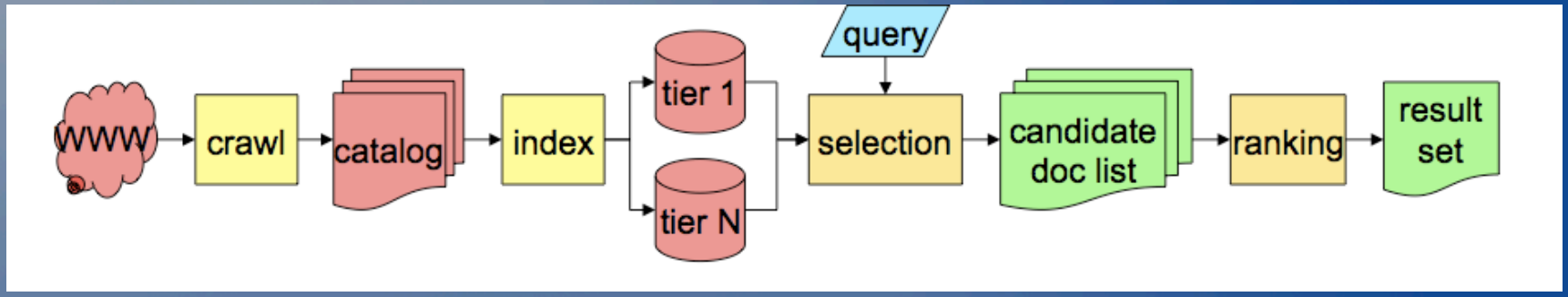


Why writing your own search engine is hard, Patterson, ACM Q, 2004
Search Engines: Information Retrieval in Practice, Croft, Metzler and Strohman*, Addison Wesley, 2009*

picture: Trevor S.

Search Engines

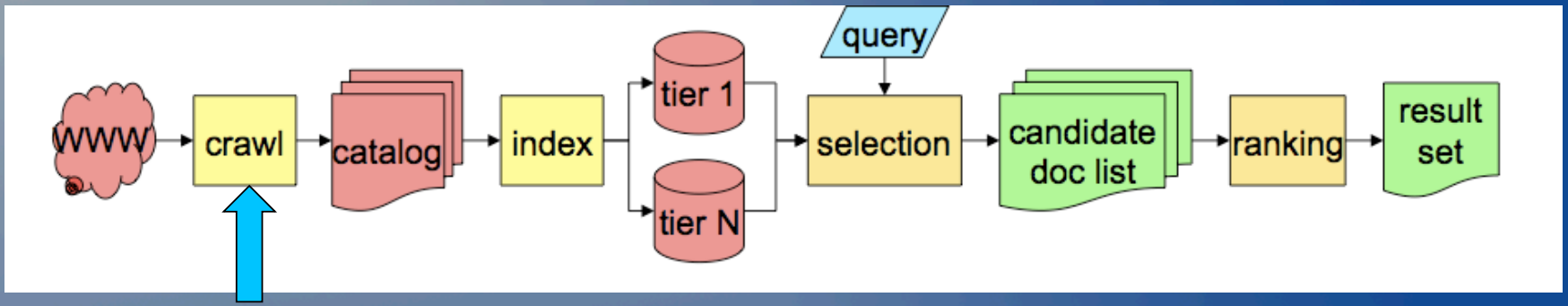
Basic architecture



From **Web Search Engine Metrics for Measuring User Satisfaction**
Tutorial at WWW conference, by Dasdan et al 2009,2010

Crawlers

First one needs to crawl the pages.



"you don't need a lot of thinking to do crawling; you need bandwidth, so any old CPU will do". Patterson, 2004

BUT Writing a crawler isn't straightforward…

Crawlers

writing/running a crawler

isn't straightforward…

- Must respect robots.txt exclusion standard to limit which pages should be retrieved
- Crawler shouldn't overload or overvisit sites
- Many URLs exist for the same resource
- URLs redirect to other resources (often)
- Dynamic pages can generate loops, unending lists, and other traps
- URLs are difficult to harvest: some are embedded in JavaScript scripts, hidden behind forms, and so on

Crawlers

Crawlers actually need to

- Fetch new resources from new domains or pages
- Fetch new resources from existing domains or pages
- Re-fetch existing resources that have changed

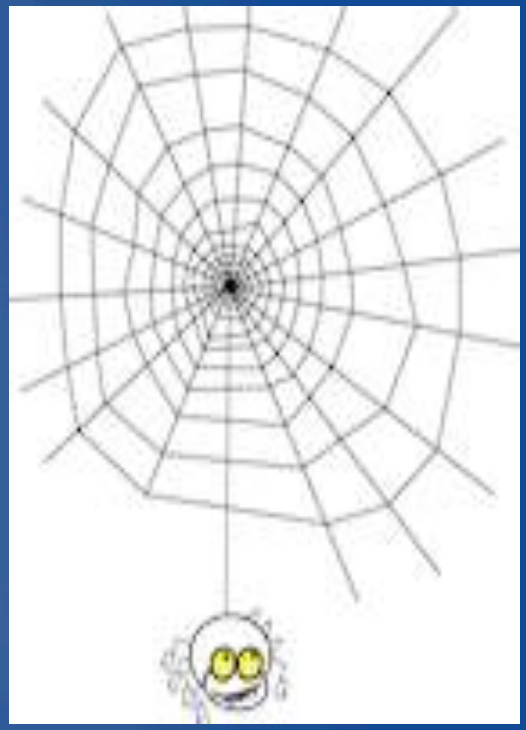
Crawl prioritization is essential:

- There are far more URLs than available fetching bandwidth
- For large sites, it's difficult to fetch all resources
- Essential to balance re-fetch and discovery
- Essential to balance new site exploration with old site exploration
- Snapshot or incremental? How broad? How seeded?

Brin and Page again..

Crawler Challenges

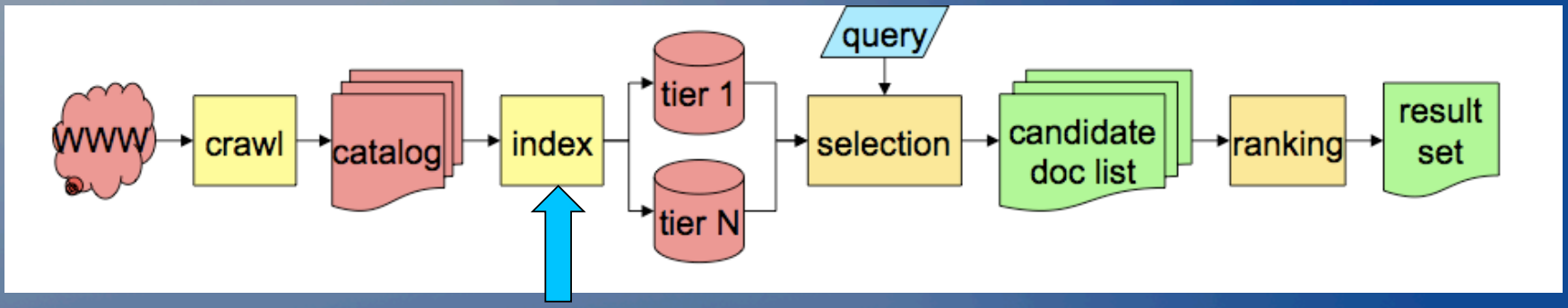
- Not Found pages often return ok HTTP codes
- DNS failures
- A pages can redirect to itself, or into a cycle
- Pages can look different to end-user browsers and crawlers
- Pages can require JavaScript processing
- Pages can require cookies
- Pages can be built in non-HTML environments



Open source solutions exist: Heretrix, Nutch, UbiCrawler, etc..

Processing pages…

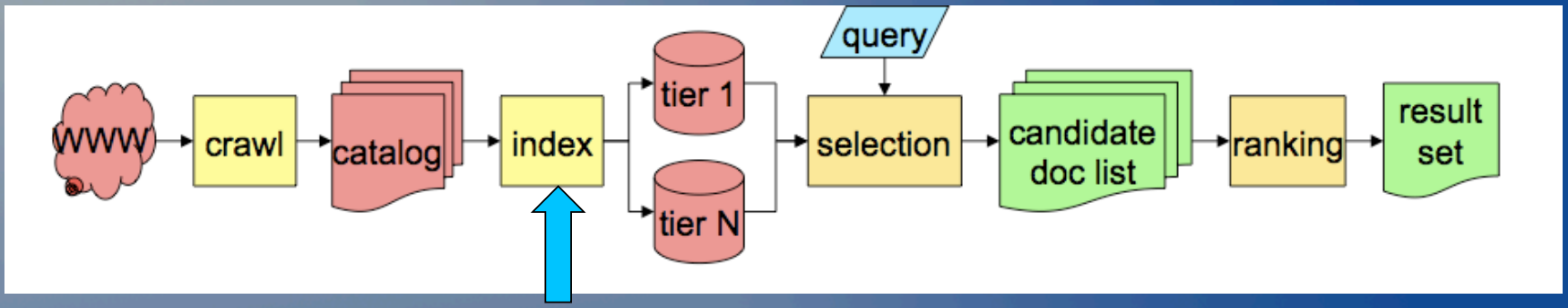
Second one needs to convert documents into index terms… to create an index.



"For indexing, you are doing a lot of I/O and a lot of thinking/analyzing the page, so the bigger (CPU) the better." Patterson, 2004

To index or not to index…

Writing an indexer isn't easy…



You need to decide how much of the page you index and which `features or signals' you care about.

Also which kinds of file to index? Text, sure.

Pdfs, jpegs, audio, torrents, videos, Flash???

Indexing…

There are hundreds of billions of web pages

It is neither practical nor desirable to index all:

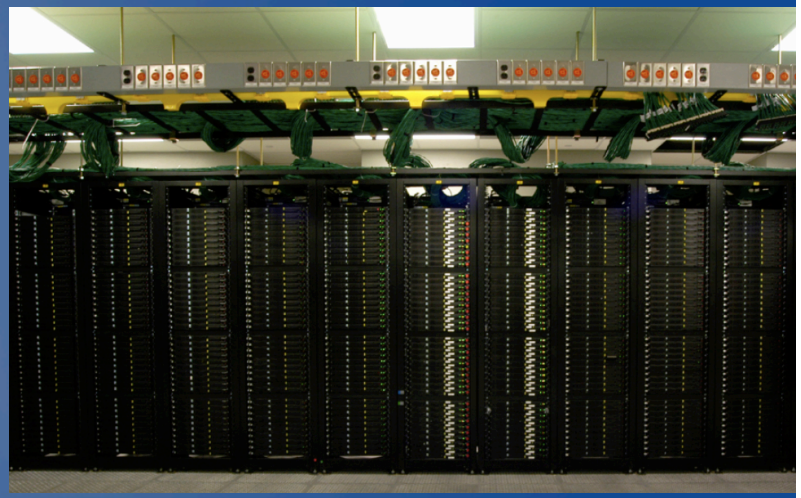
- Should remove spam pages
- Should remove illegal pages
- Should remove malware
- Should remove repetitive or duplicate pages
- Should remove crawler traps
- Should remove pages that no longer exist
- Should remove pages that have substantially changed

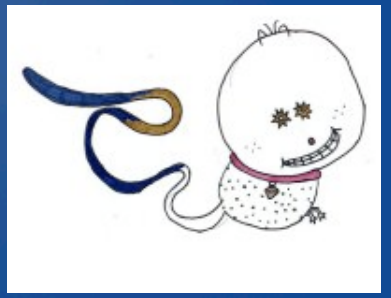
Most search engines index in the range of 20 to 50 billion documents, says Williams

How many pages each engine indexes, and how many pages are on the web are hard research problems

Indexing: which are the right pages?

- pages that users want (duh…)
- pages that are popular in the web link graph
- pages that match queries
- pages from popular sites
- pages that are clicked on in search results
- pages shown by competitors
- pages in the language or market of the users
- pages that are distinct from other pages
- pages that change at a moderate rate





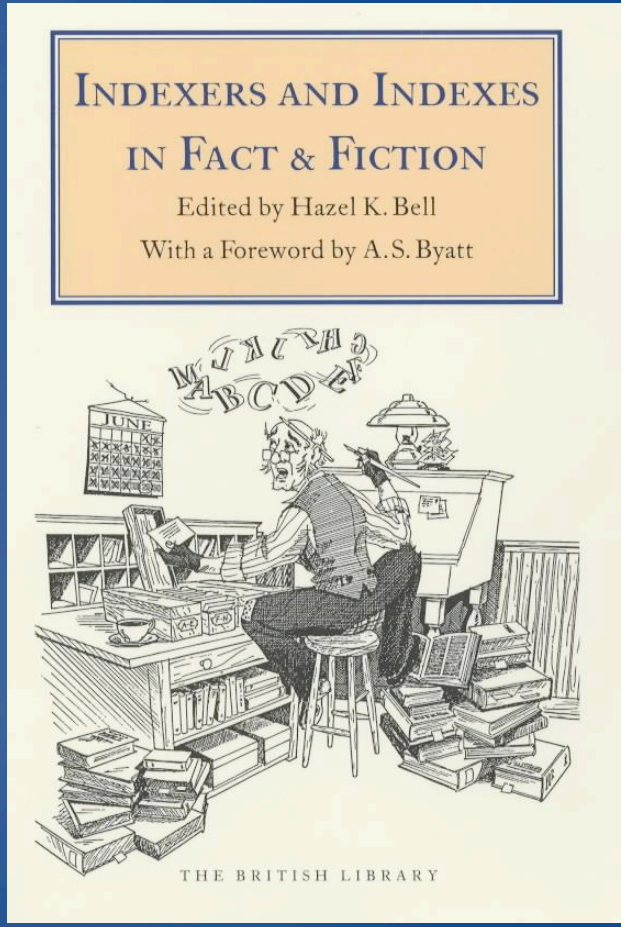
The head is stable, The tail consists of billions of candidate pages with similar scores

Indexing…

- Store (multiple copies of?) the web in a document store
- Iterate over the document store to choose documents
- Create an index, and ship it to the index serving nodes
- Repeat…
- Sounds easy? It isn't!

> [..] build an index. This is tricky. Just don't do anything wrong, as the saying goes. One false step and those billions of pages are going to take too long to process… Patterson, 2004

Three words: scale, parallelism, time



Indexing: features

How to index pages so that we can find them?

A feature (signal) is an attribute of a document that a computer can detect, and that we think may indicate relevance.

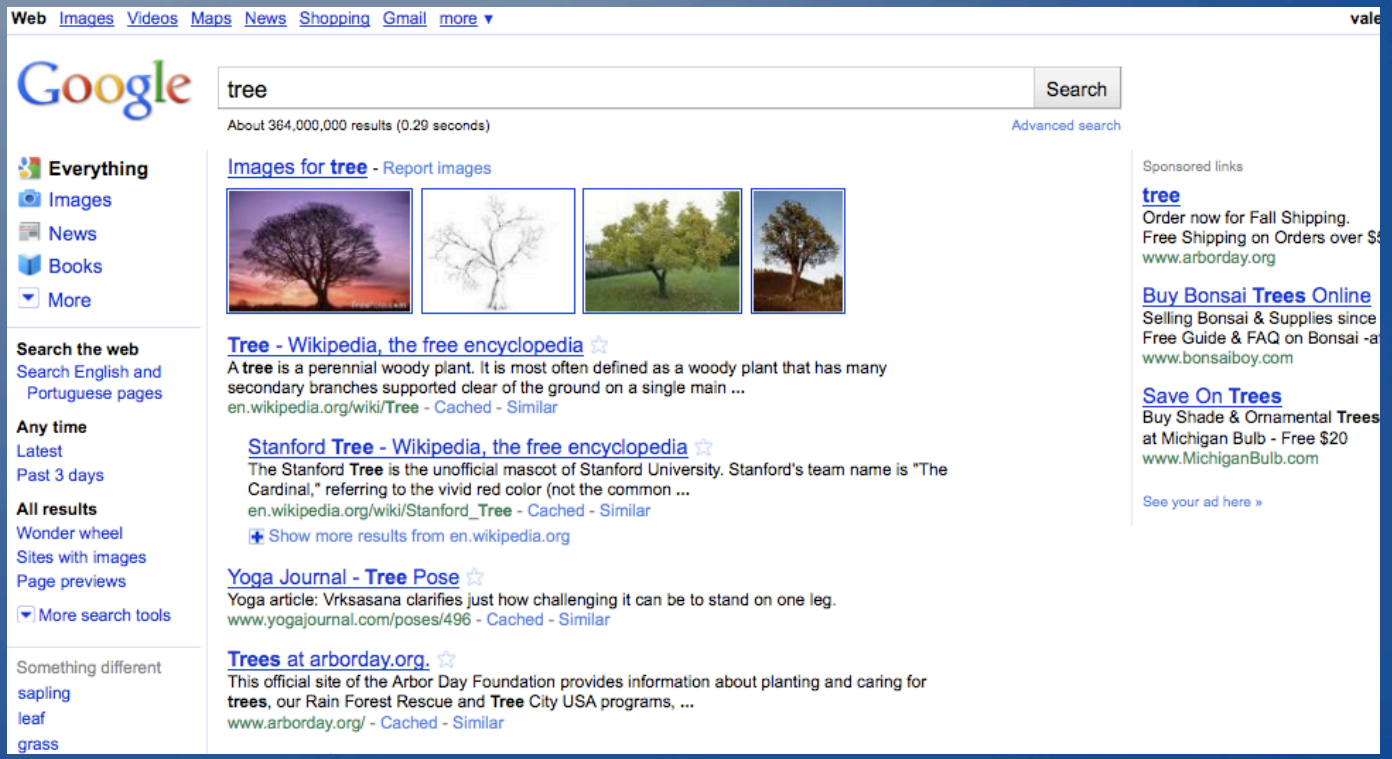
Some features are obvious, some are secret sauce and how to use them is definitely a trade secret for each engine.


INDEX LIBRORVM
PROHIBITORVM,
CVM REGVLIS CONFECTIS
per Patres a Tridentina Synodo delectos,
auctoritate Sanctiſs. D.N. Pij IIII,
Pont. Max. comprobatus.
VENETIIS, M. D. LXIIII.

Features: the obvious…

Term matching

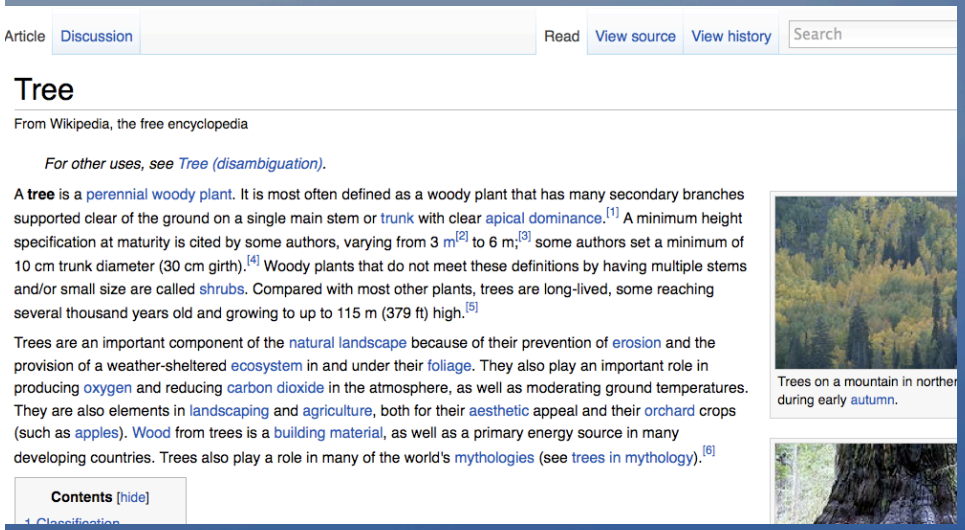
The system should prefer documents that contain the query terms.

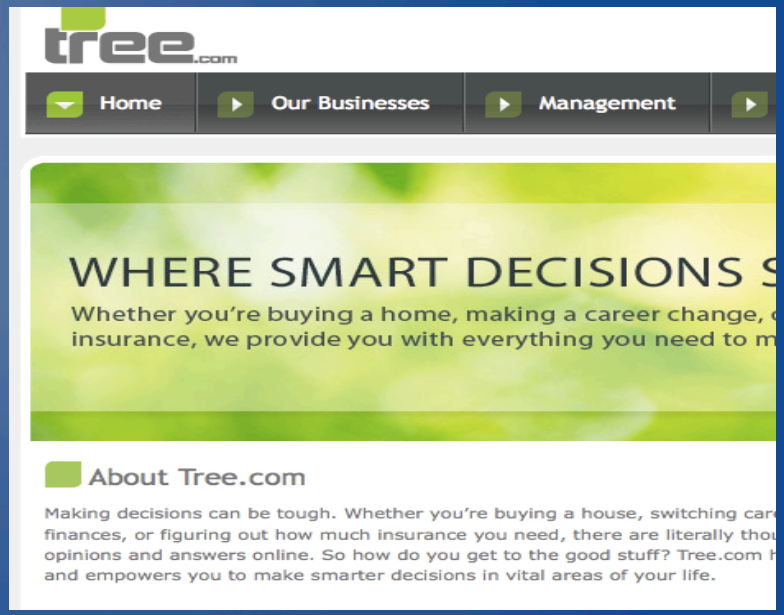


Features: the obvious…

Term frequency

The system should prefer documents that contain the query terms many times.





Features: the obvious…

Inverse document frequency

Rare words are more important than frequent words

Article Discussion Read Edit View history Search

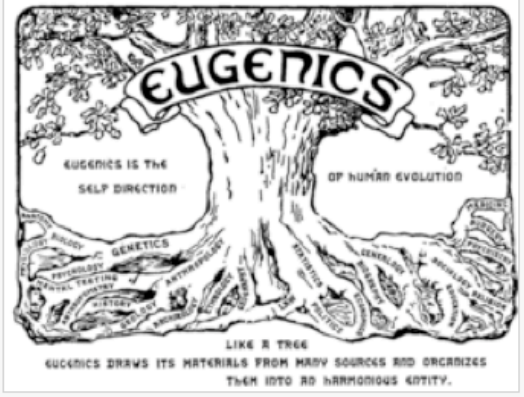
Eugenics

From Wikipedia, the free encyclopedia

Eugenics is the study and practice of selective breeding applied to humans, with the aim of improving the species. In a historical and broader sense, eugenics can also be a study of "improving human genetic qualities." Eugenics was widely popular in the early decades of the 20th century, but has fallen into disrepute after having become associated with Nazi Germany. Since the postwar period, both the public and the scientific communities have associated eugenics with Nazi abuses, such as enforced racial hygiene, human experimentation, and the extermination of "undesired" population groups. However, developments in genetic, genomic, and reproductive technologies at the end of the 20th century have raised many new questions and concerns about the meaning of *eugenics* and its ethical and moral status in the modern era.

Contents [hide]

1 Overview
2 Meanings and types
2.1 Implementation methods
3 Notable proponents
4 History



"Eugenics is the self-direction of human evolution": Logo from the Second International Eugenics Conference, 1921, depicting it as a tree which unites a variety of different fields.[1]

Indexing: More features

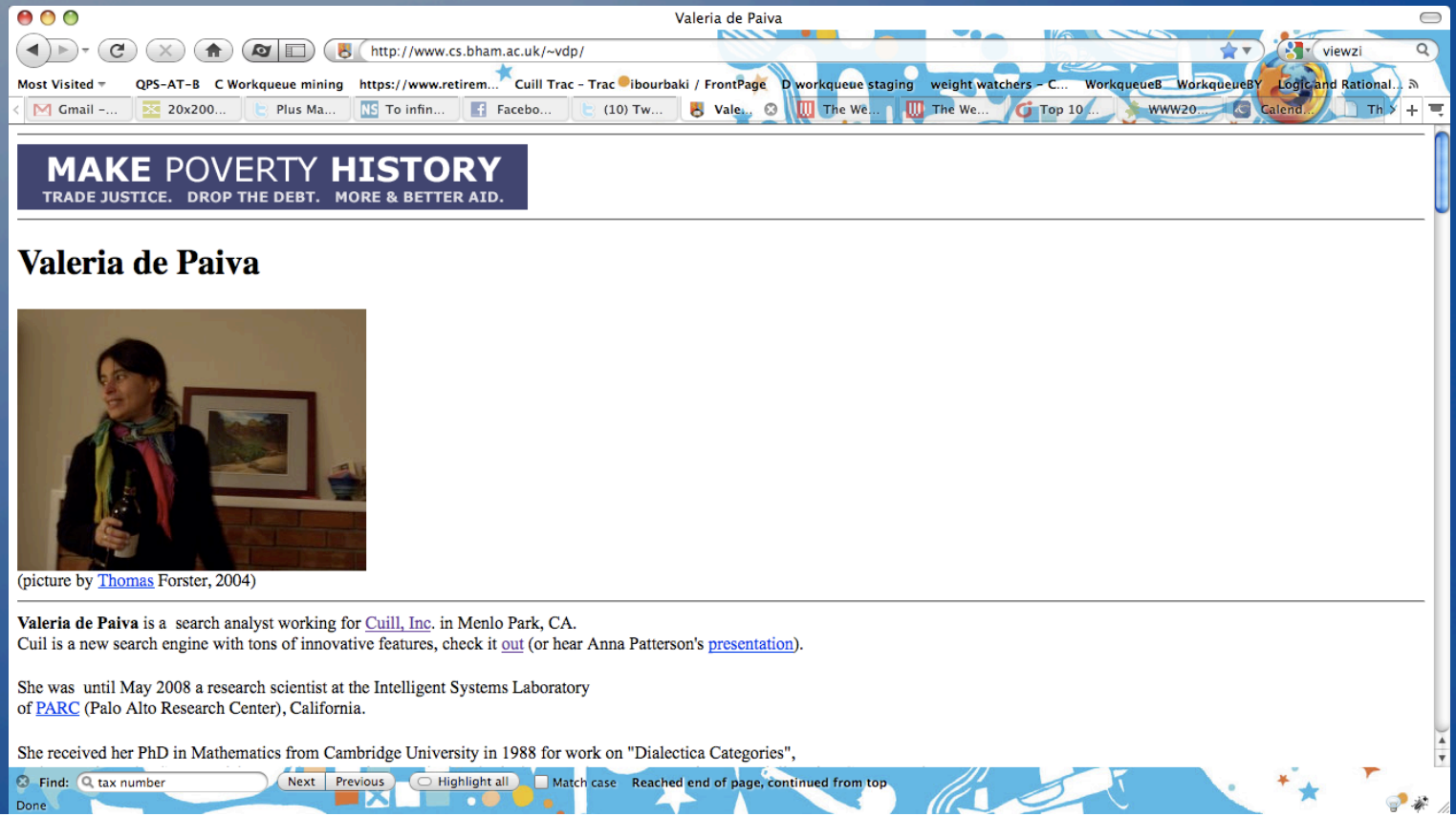
Term proximity

Words that are close together in the query should be close together in relevant documents.

Indexing: more features

Term location

Prefer documents that contain query words in the title or headings.



Indexing: web features

URL text

Prefer documents that contain query words in the URL.

www.**whitehouse**.gov

www.linkedin.com/in/valeriadepaiva

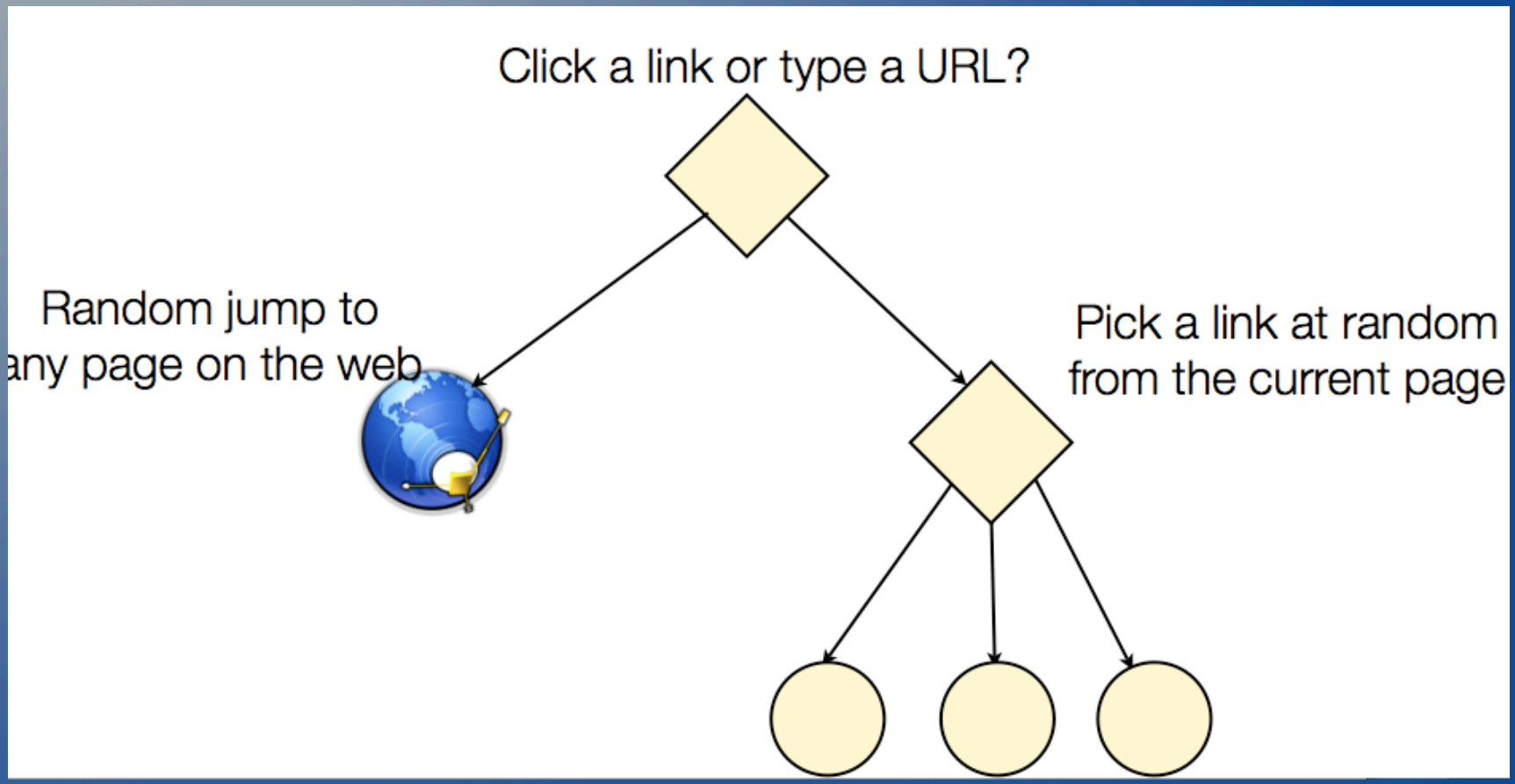
Indexing: which features?

Prefer documents that are authoritative and popular.

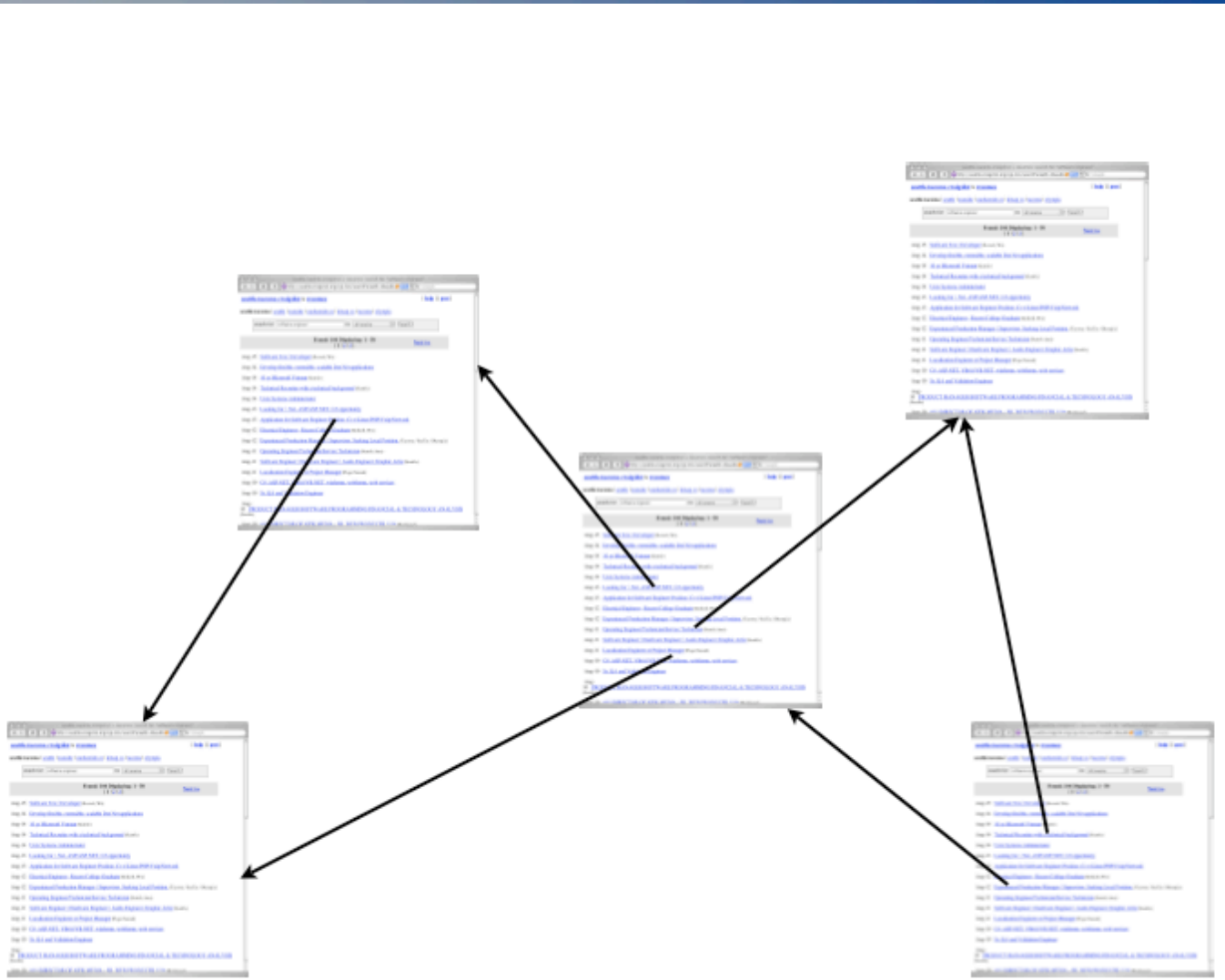
HOW?

The **random surfer** is a hypothetical user that clicks on web links at random.

Random surfer?



PageRank: Popular Pages connect

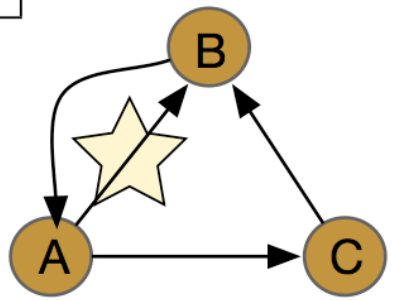


PageRank: how can we leverage the connections?

- Think of a gigantic graph and its transition matrix
- Make the matrix probabilistic
- Those correspond to the random surfer choices
- Find its principal eigen-vector= pagerank

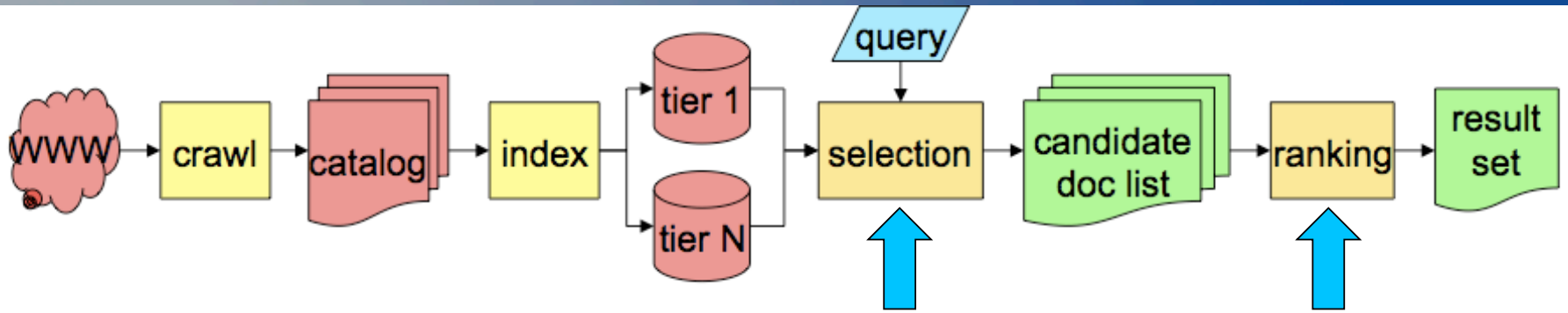
Graphs: Matrix Representation

	A	B	C
A	0	1	1
B	1	0	0
C	0	1	0



PageRank is the proportion of time that a random surfer would jump to a particular page.

Selection and Ranking



Whatever features you will want for RANKING and SELECTION you should consider when indexing…

Patterson's advice "The hallowed `index format' is not the end of the search engine, it is just the beginning. It is a tool to see results, so change it and change it often." ACM Q, 2004

Quality: what do we want to do?

- **Measure user satisfaction**
- **Optimize for user satisfaction in each component of the pipeline**
- **Automate all metrics**
- **Discover anomalies**
- **Visualize, mine, and summarize metrics data**
- **Debug problems automatically**
- **Compare different search engines?**

User satisfaction?

- User issues a query to Search Engine: Receives a list of results
- How relevant are these results? How do we measure relevance of results? How effectively was the information need of the user met?
- How many of the results retrieved were useful?
- Were there useful pages not retrieved?

Evaluating Relevance…

- is HARD!
- Evaluation is key to *effective and efficient* search engines
- Effectiveness, efficiency and

cost are related - difficult trade-off

- Two main kinds of approach:

  IR traditional evaluations,

  click data evaluation & log analysis

- Many books on IR, many patents/trade secrets from search engines…

Traditional IR evaluation

- TREC competitions (NIST and U.S. Department of Defense), since 1992
- Goal: provide the infrastructure necessary for large-scale evaluation of text retrieval methodologies
- several tracks, including a Web track, using ClueWeb09, one billion webpages
- TREC results are baseline, do they work for search engines?

Evaluating Relevance in IR…

if universe small you can check easily precision and recall

$$\text{Precision} = \frac{\#(\text{relevant items retrieved})}{\#(\text{retrieved items})}$$

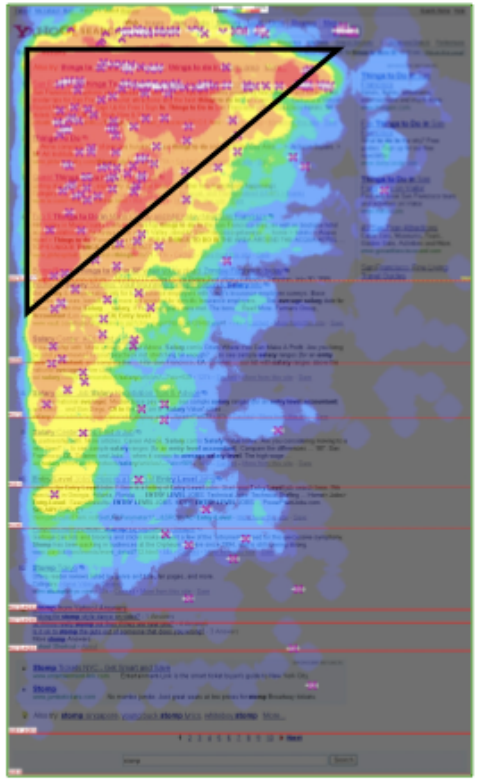
$$\text{Recall} = \frac{\#(\text{relevant items retrieved})}{\#(\text{relevant items})}$$

- **F-measure: Harmonic mean of precision and recall**
  - related to van Rijsbergen's effectiveness measure
  - reflects user's willingness to trade precision for recall controlled by a parameter selected by the system designer

$$F = \frac{1}{\alpha\frac{1}{P} + (1-\alpha)\frac{1}{R}} = \frac{(\beta^2+1)PR}{\beta^2 P + R} \qquad \alpha = \frac{1}{(\beta^2+1)}$$

Evaluating Relevance in IR…

- Many other measures in literature, e.g precision-recall curves, MAP (mean of average precision over all queries), etc..
- For search engines the first results are much more important than later ones
- A natural alternative is to report at top 5, etc
- Instead of binary judgments (relevant or not) graded: very relevant, somewhat relevant, not relevant…



Evaluating Relevance: DCG

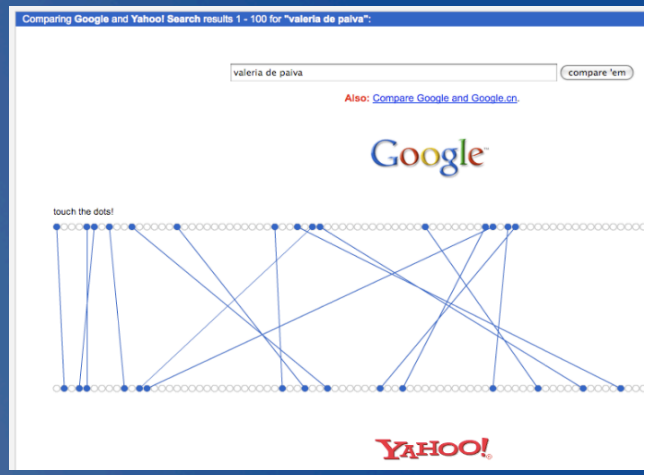
Very used measure: DCG (discounted cumulative gain)

Very good=3, somewhat good=1 and not good=0 penalize good results in bad positions by using the discounted measure. Discounts geometric or log..

If url1=3, url2=1 and url3=0 then

DCG= 3/ 1 + 1/2 + 0/4= 3.5

same urls in opposite order DCG=0/1+ ½ +3/4= 1.25



Evaluating Relevance in IR

Other measures:

Kendall tau coefficient (counts of preferences..)

Bpref (Buckley and Voorhees, 2004)

Rpref (De Beer and Moens, 2006 graded bpref)

Q-measure (Sakai, 2007)

….

Information Retrieval

Relevance

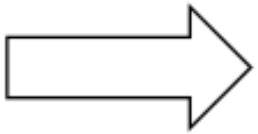
-Effective ranking

Evaluation

-Testing and measuring

Information needs

-User interaction



Search Engines

Performance

-Efficient search and indexing

Incorporating new data

-Coverage and freshness

Scalability

-Growing with data and users

Adaptability

-Tuning for applications

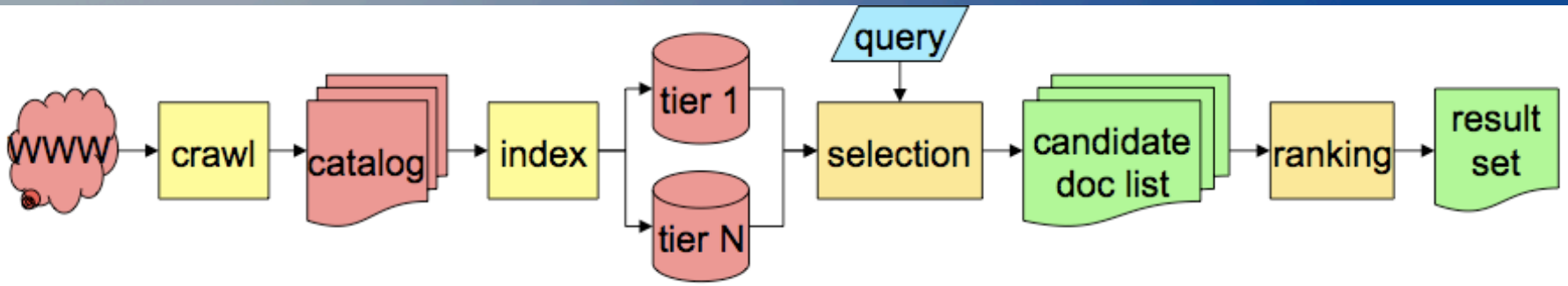
Specific problems

-e.g. Spam

Evaluating User Satisfaction…

- Salient aspects of user satisfaction are hard for IR metrics
- Relevance metrics not based on users experiences or tasks
- Some attempts:
- Huffman and Hochster (2007)
- SIGIR 2009 Workshop on The Future of IR Evaluation (2009)
- Markov models of user frustration and satisfaction (Hassan et al 2010)

Evaluating the whole system…



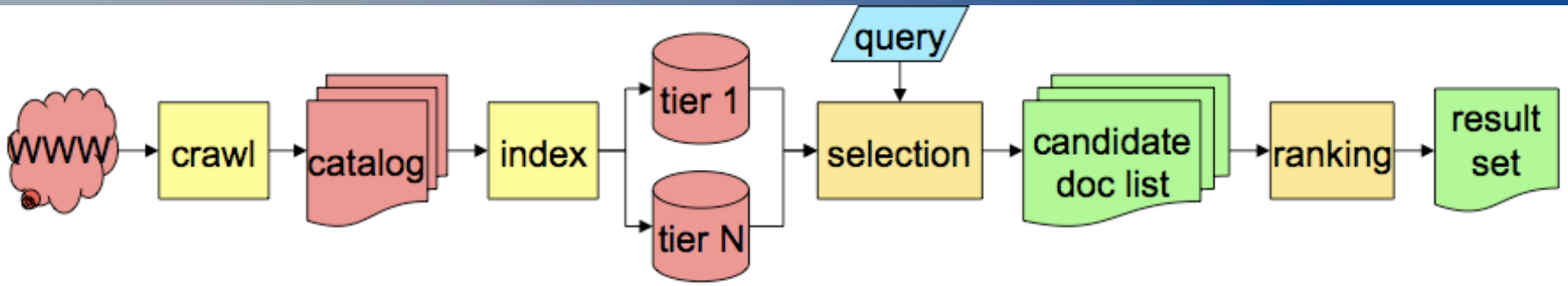
Coverage metrics

Query by URL
Query by content (strong queries)
Compute coverage ratio
Issues: URL normalization/ Page template

Problems:
Web growth in general and in dimensions???
Improve copy detection methods quality and performance

Bar-Yossef and Gurevich: Efficient Search Engine Measurements WWW2007
Olston and Najork: Web Crawling, 2010

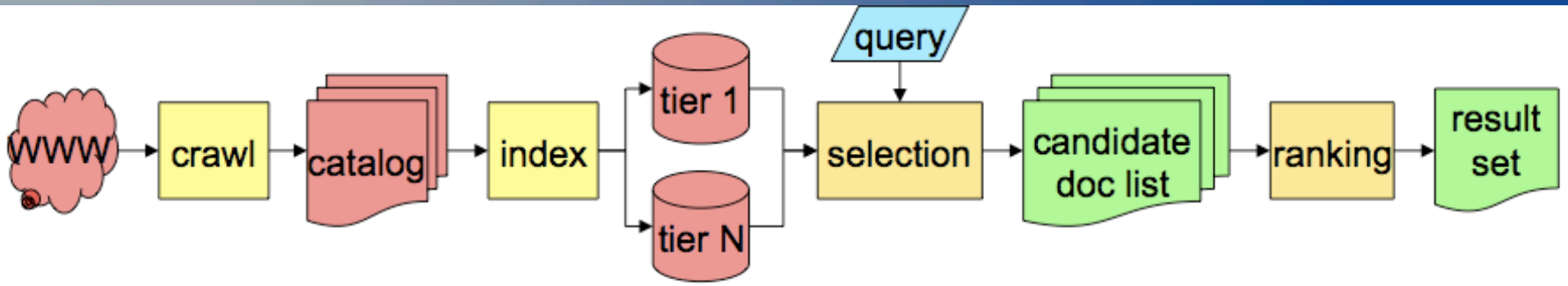
Evaluating the whole system…



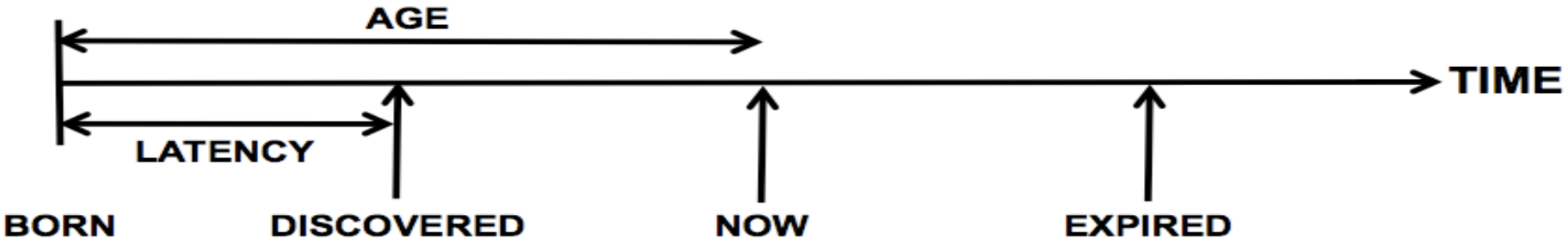
Diversity metrics

Some queries have a single news result, reported by many
Some queries are ambiguous e.g [Stanford]:
Do you want to optimize for the dominant concept or all facets: [jaguar] ?
Implications for interfaces/visualization…
Exclusion of near-duplicates
Problems: measure and summarize diversity
Measure tradeoffs between diversity and relevance [beata keller]
Best presentation of diversity?
Agrawal et al 2009

Evaluating the whole system…

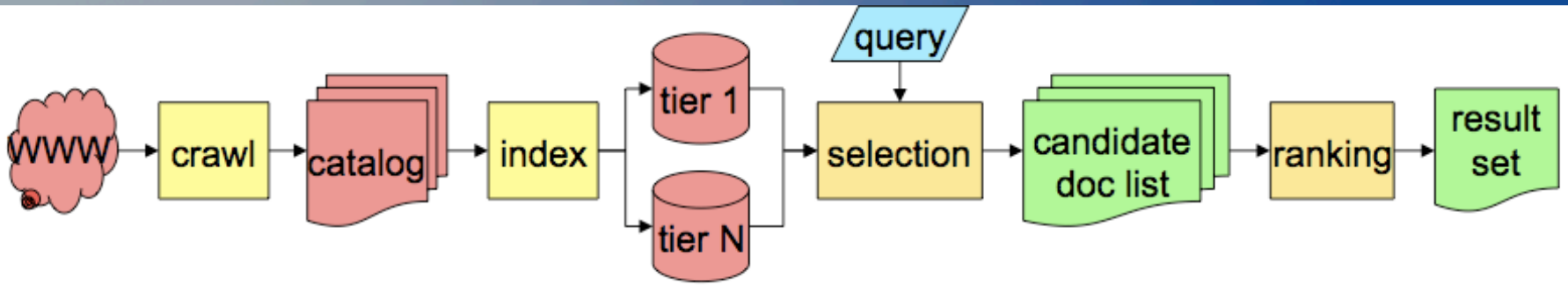


Latency and discovery metrics



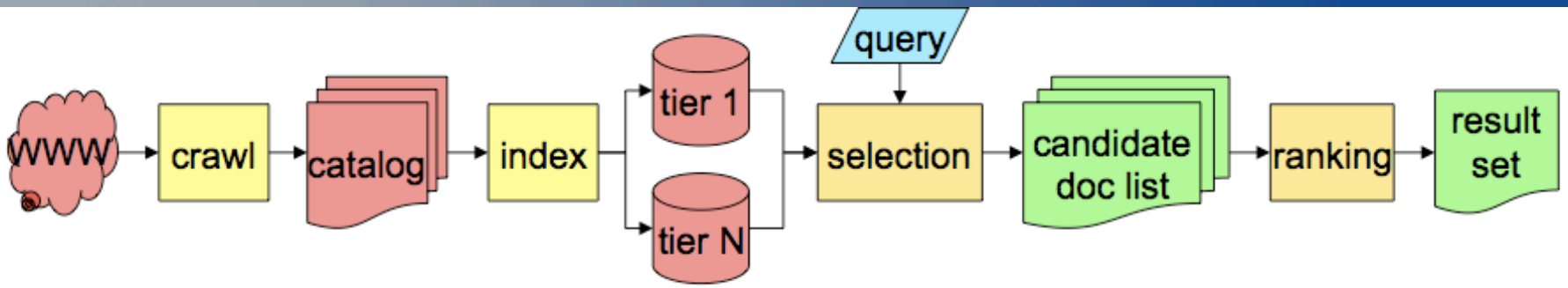
Given a set of new pages, how long does it take for them to be served? How many of them become part of the results?

Evaluating the whole system…



Freshness metrics
Freshness of snippets?
Measuring change of all internet?

Evaluating the system: presentation metrics



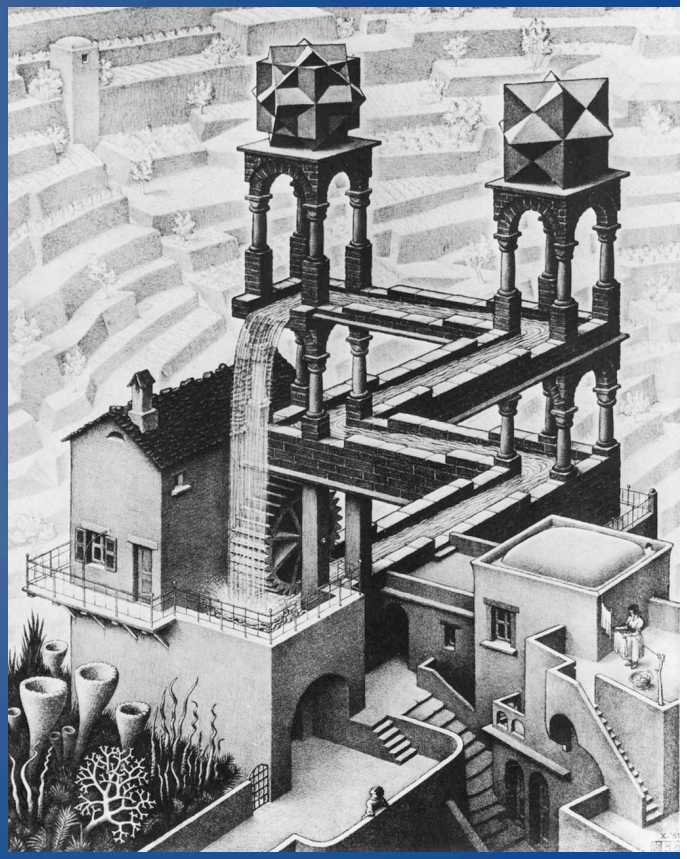
User studies. Eye-tracking studies?
Presentation modules: suggestions, spelling corrections, snippets, tabs, categories, definitions, images, videos, timelines, maplines, streaming results, social results, …
How to measure success? How to optimize relevance? How much is too much? International differences? How to change interfaces?

Conclusions

- Relevance is elusive, but essential.
- Improvement requires metrics and analysis, continuously
- Gone over a rough map of the issues and some proposed solutions
- Many thanks to Dasdan, Tsioutsiouliklis and Velipasaoglu, Croft, Metzler and Strohman, (especially Strohman!) and Hugh Williams for slides/pictures.

Coda

- There are many search engines. Their results tend to be very similar. (how similar?)
- Are we seeing everything? Reports estimate we can see only 15% of the existing web.
- Probing the web is mostly popularity based. You're likely to see what others have seen before. But your seeing increases the popularity of what you saw, thereby reducing the pool of available stuff. Vicious or virtuous circle? How to measure?



Summing up

- Life in Searchland is very different. And lots of fun!

"[...] once the search bug gets you, you'll be back. The problem isn't getting any easier, and it needs all the experience anyone can muster." Patterson, 2004

Thank You!

References

Croft, Metzler and Strohman's "Search Engines: Information Retrieval in Practice", 2009, Addison-Wesley

the tutorial `**Web Search Engine Metrics'** by Dasdan, Tsioutsiouliklis and Velipasaoglu for WWW09/10, available from http://www2010.org/www/program/tutorials/

Hugh Williams slides for ACM Data Mining May 2010

Anna Patterson:
Why Writing Your Own Search Engine Is Hard
ACM Q, 2004

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Evaluating Relevance in IR: implicit judgments

Explicit judgments are expensive

A search engine has lots of user interaction data, like which results were viewed for a query, which received clicks..

How can we use this data?

Basic statistics from raw observations: abandonment rate, reformulation rate, number of queries per session, clicks per query, mean reciprocal rank of clicked results, time to first (last) click, etc.… (Joachims 2002, etc)

Evaluating Relevance in IR: direct and indirect clicks

- Direct and indirect evaluation by clicks
- (Radlinski and Joachims, Carterette and Jones, 2007)
- Model based evaluation (Dupret et al, 2007, Dupret (2009)
- ERR(Expected Reciprocal Rank) unlike DCG has non-zero probability that user stops browsing, better correlation with click metrics, etc…
- So far evaluation method rather than USER satisfaction