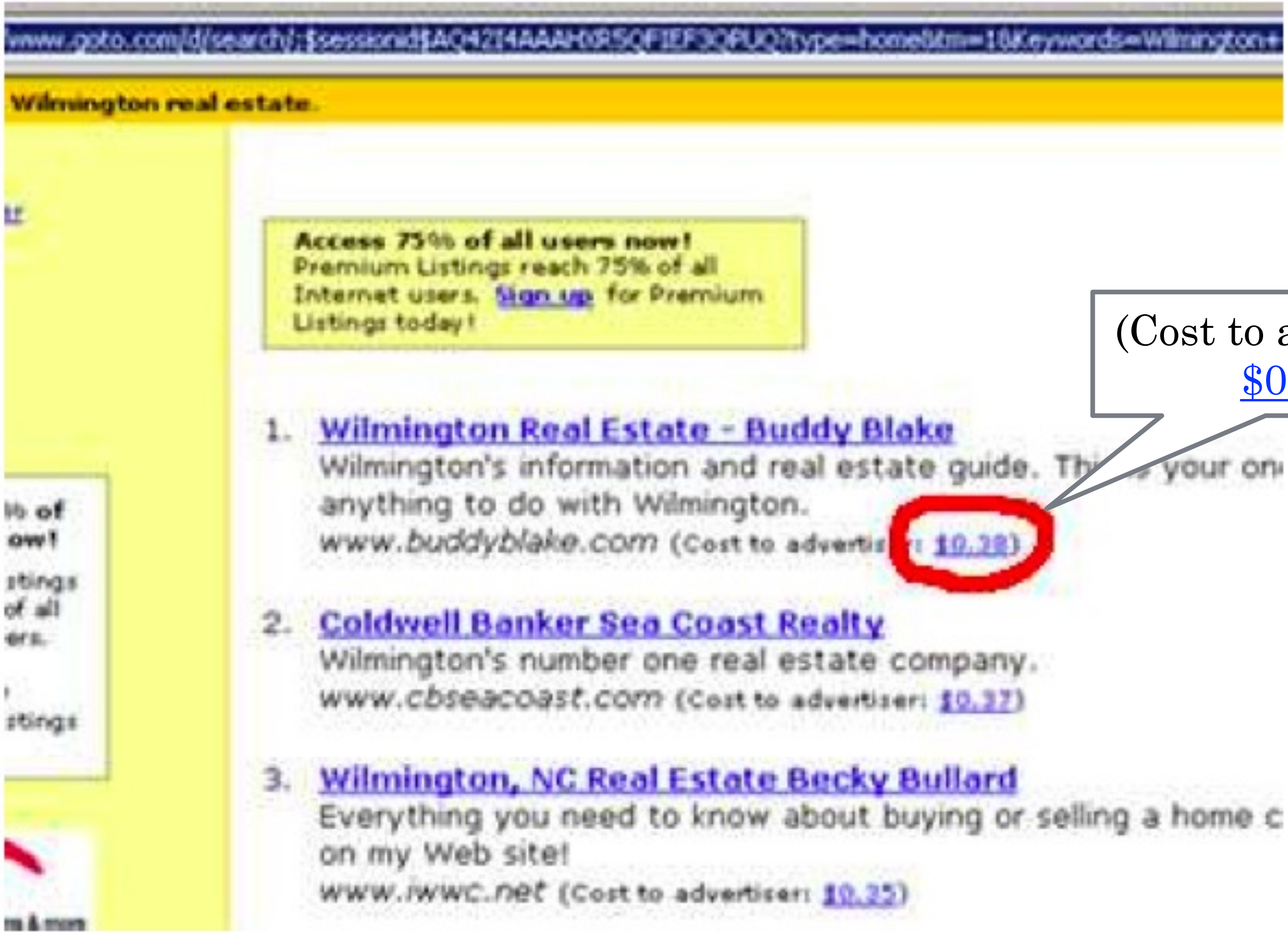
Search Ads

First generation of search ads: Goto (1996)



www.goto.com/d/search/;$sessionid$AQ42I4AAAHXRSQFIEF3QPUQ?type=home&tm=1&Keywords=Wilmington+

Wilmington real estate.

% of
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stings
of all
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stings

Access 75% of all users now!
Premium Listings reach 75% of all Internet users. Sign up for Premium Listings today!

1. Wilmington Real Estate - Buddy Blake
   Wilmington's information and real estate guide. Th[illegible] your on
   anything to do with Wilmington.
   www.buddyblake.com (Cost to advertis[illegible]: $0.38)
2. Coldwell Banker Sea Coast Realty
   Wilmington's number one real estate company.
   www.cbseacoast.com (Cost to advertiser: $0.37)
3. Wilmington, NC Real Estate Becky Bullard
   Everything you need to know about buying or selling a home c
   on my Web site!
   www.iwwc.net (Cost to advertiser: $0.25)

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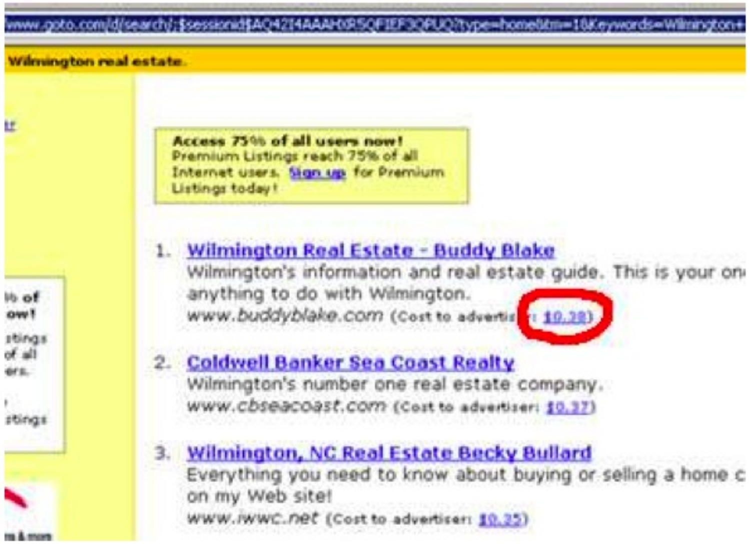

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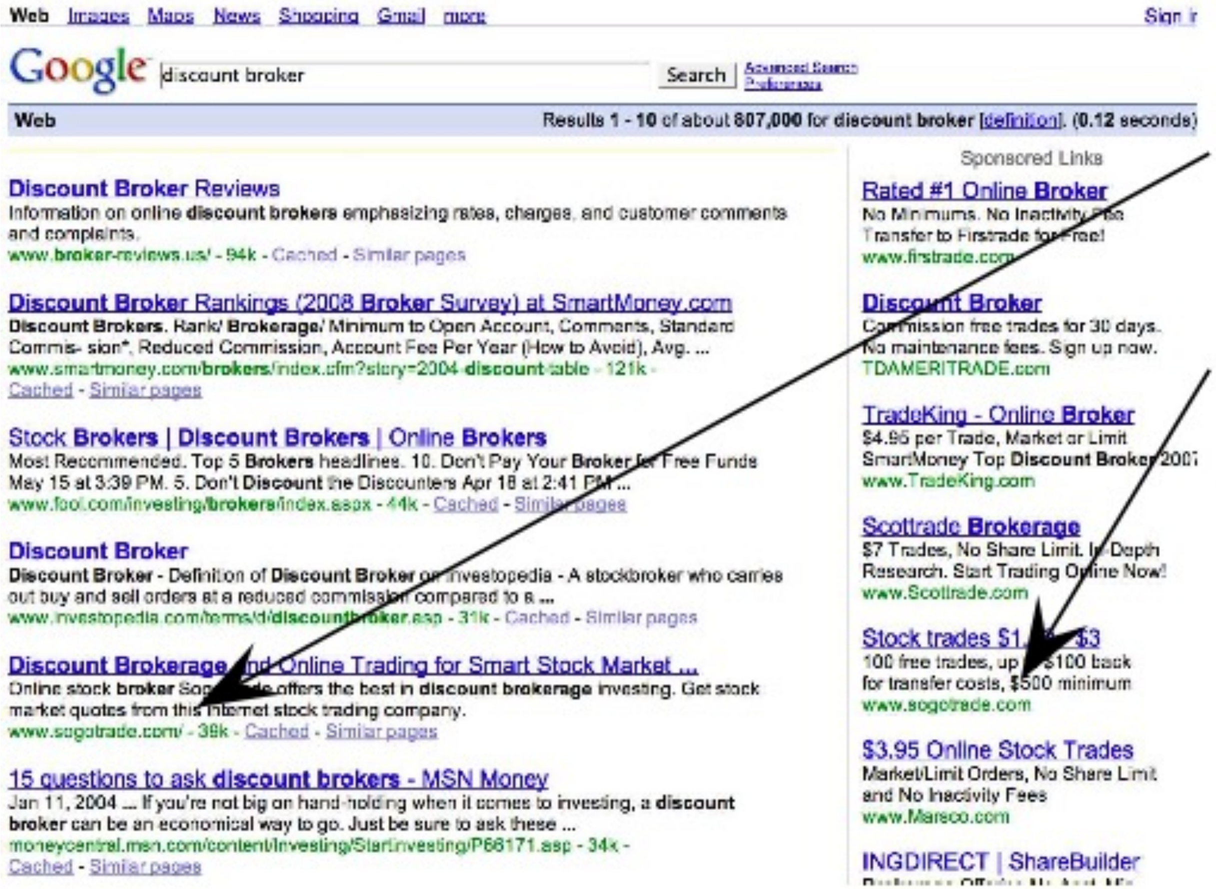
- Buddy Blake bid the maximum ($0.38) for this search.
- He paid $0.38 to Goto every time somebody clicked on the link.
- Pages were simply ranked according to bid – revenue maximization for Goto.
- No separation of ads/docs. Only one result list!
- Upfront and honest. No relevance ranking, . . .
- . . . but Goto did not pretend there was any.

Second generation of search ads: Google (2000/2001)

Strict separation of search results and search ads

Two ranked lists: web pages (left) and ads (right)



Web Images Maps News Shopping Gmail more Sign in

Google discount broker Search Advanced Search Preferences

Web Results 1 - 10 of about 807,000 for discount broker [definition]. (0.12 seconds)

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. ...
www.smartmoney.com/brokers/index.cfm?story=2004-discount-table - 121k - Cached - Similar pages

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 ...
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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/P68171.asp - 34k - Cached - Similar pages

Sponsored Links

Rated #1 Online Broker
No Minimums. No Inactivity Fee
Transfer to Firstrade for Free!
www.firstrade.com

Discount Broker
Commission free trades for 30 days.
No maintenance fees. Sign up now.
TDAMERITRADE.com

TradeKing - Online Broker
$4.95 per Trade, Market or Limit
SmartMoney Top **Discount Broker** 2007
www.TradeKing.com

Scottrade Brokerage
$7 Trades, No Share Limit. In-Depth
Research. Start Trading Online Now!
www.Scottrade.com

Stock trades $1 [illegible] $3
100 free trades, up to $100 back
for transfer costs, $500 minimum
www.sogotrade.com

$3.95 Online Stock Trades
Market/Limit Orders, No Share Limit
and No Inactivity Fees
www.Mareco.com

INGDIRECT | ShareBuilder

SogoTrade appears in search results.

SogoTrade appears in ads.

Do search engines rank advertisers higher than non-advertisers?

All major search engines claim no.

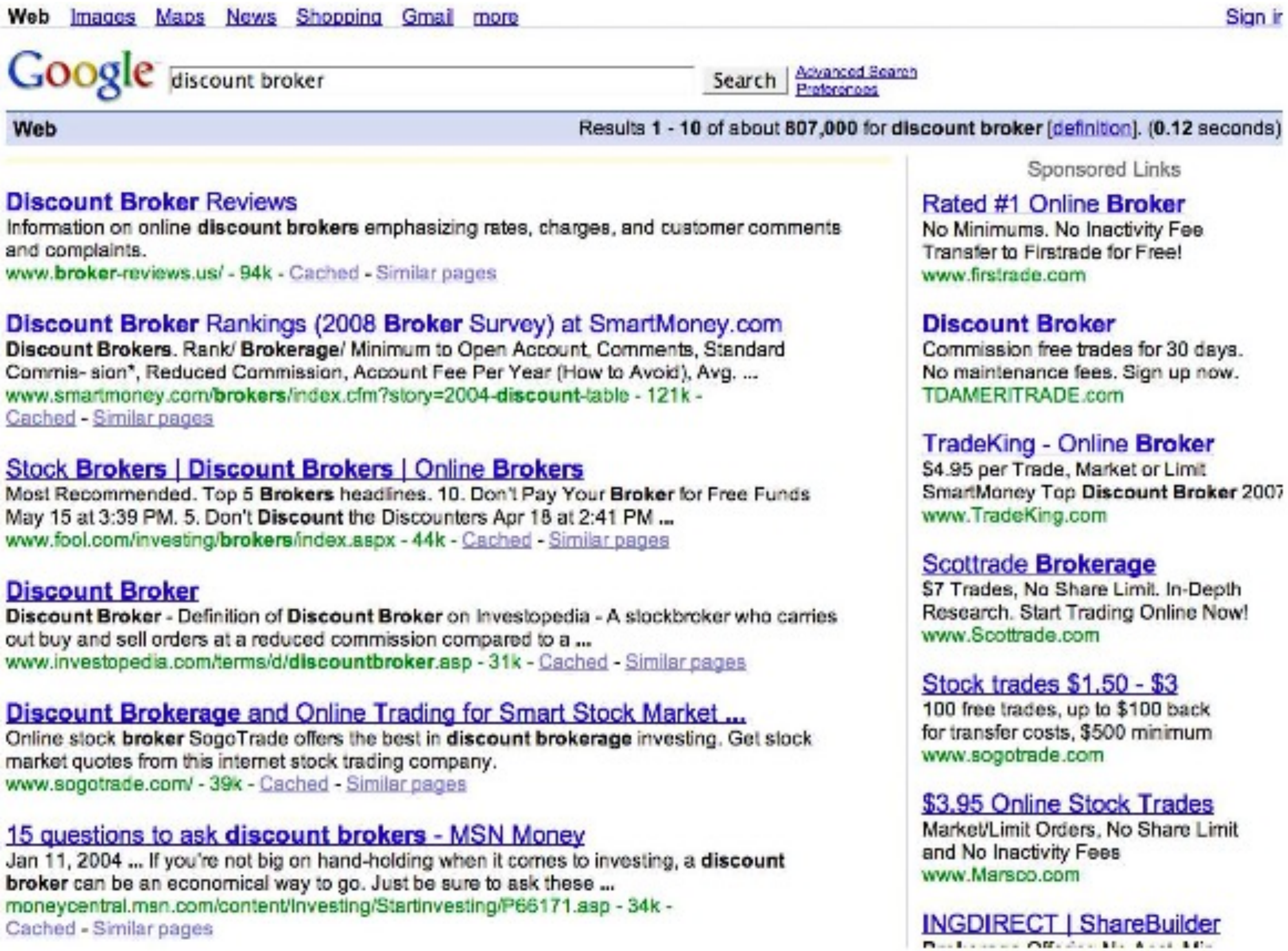
Quiz: Paid Ranking

- Why is it not a good idea for Goto.com to show the amount successfully bid by the advertiser? (name just one good reason.)

Do ads influence editorial content?

- Similar problem at newspapers / TV channels
- A newspaper is reluctant to publish harsh criticism of its major advertisers.
- The line often gets blurred at newspapers / on TV.
- No known case of this happening with search engines yet?

How are the ads on the right ranked?



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and No Inactivity Fees
www.Marsco.com

INGDIRECT | ShareBuilder

How are ads ranked?

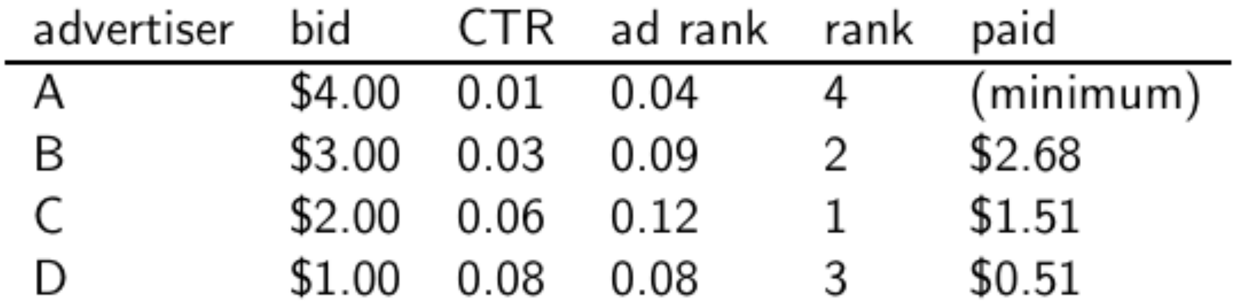
- Advertisers bid for keywords – sale by auction.
- Open system: Anybody can participate and bid on keywords.
- Advertisers are only charged when somebody clicks on your ad.
- How does the auction determine an ad's rank and the price paid for the ad?
- Basis is a second price auction, but with twists
- For the bottom line, this is perhaps the most important research area for search engines – computational advertising.
    - Squeezing an additional fraction of a cent from each ad means billions in additional revenue for the search engine.

How are ads ranked?

- First cut: according to bid price **only** `a la Goto
  - Bad idea: open to abuse
  - Example: query [does my wife cheat?] → ad for divorce lawyer
  - We don't want to show nonrelevant ads.
- Instead: rank based on bid price and relevance
- Key measure of ad relevance: clickthrough rate
  - clickthrough rate = CTR = clicks per impressions
- Result: A nonrelevant ad will be ranked low.
  - Even if this decreases search engine revenue short-term
  - Hope: Overall acceptance of the system and overall revenue is maximized if users get useful information.
- Other ranking factors: location, time of day, quality and loading speed of landing page
- The main ranking factor: the query

Google AdsWords demo

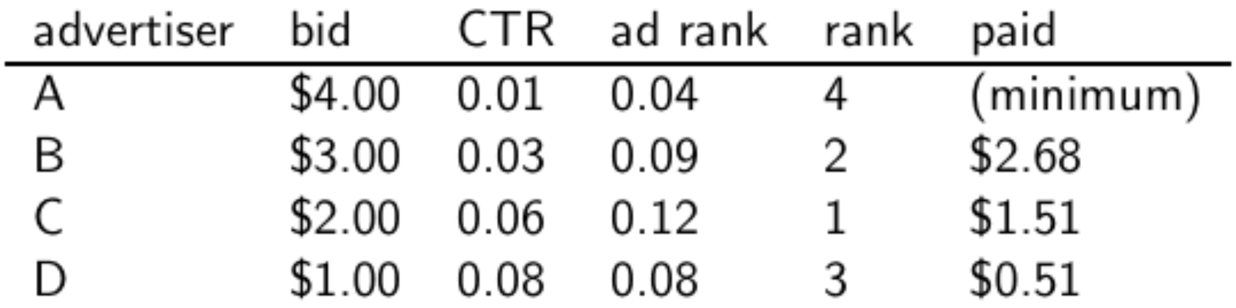
Google's second price auction



advertiser	bid	CTR	ad rank	rank	paid
A	$4.00	0.01	0.04	4	(minimum)
B	$3.00	0.03	0.09	2	$2.68
C	$2.00	0.06	0.12	1	$1.51
D	$1.00	0.08	0.08	3	$0.51

- 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 × CTR: this trades off (i) how much money the advertiser is willing to pay against (ii) how relevant the ad is
- rank: rank in auction
- paid: second price auction price paid by advertiser

Google's second price auction



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Second price auction: The advertiser pays the minimum amount necessary to maintain their position in the auction (plus 1 cent).

$\text{price}_1 \times \text{CTR}_1 = \text{bid}_2 \times \text{CTR}_2$ (this will result in $\text{rank}_1 = \text{rank}_2$)

$\text{price}_1 = \text{bid}_2 \times \text{CTR}_2 / \text{CTR}_1$

$$p_1 = \text{bid}_2 \times \text{CTR}_2/\text{CTR}_1 = 3.00 \times 0.03/0.06 = 1.50$$
$$p_2 = \text{bid}_3 \times \text{CTR}_3/\text{CTR}_2 = 1.00 \times 0.08/0.03 = 2.67$$
$$p_3 = \text{bid}_4 \times \text{CTR}_4/\text{CTR}_3 = 4.00 \times 0.01/0.08 = 0.50$$

Notice 2nd guy pays more than 1st guy

Keywords with high bids

According to http://www.cwire.org/highest-paying-search-terms/

$69.1	mesothelioma treatment options
$65.9	personal injury lawyer michigan
$62.6	student loans consolidation
$61.4	car accident attorney los angeles
$59.4	online car insurance quotes
$59.4	arizona dui lawyer
$46.4	asbestos cancer
$40.1	home equity line of credit
$39.8	life insurance quotes
$39.2	refinancing
$38.7	equity line of credit
$38.0	lasik eye surgery new york city
$37.0	2nd mortgage
$35.9	free car insurance quote

Search ads: A win-win-win?

- The search engine company gets revenue every time somebody clicks on an ad.
- The user only clicks on an ad if they are interested in the ad.
    - Search engines punish misleading and nonrelevant ads.
    - As a result, users are often satisfied with what they find after clicking on an ad.
- The advertiser finds new customers in a cost-effective way.

Quiz: Search Ads

- Why is web search potentially more attractive for advertisers than TV spots, newspaper ads or radio spots? (name just one reason.)

Not a win-win-win: Keyword arbitrage

- Buy a keyword on Google
- Then redirect traffic to a third party that is paying much more than you are paying Google.
  - E.g., redirect to a page full of ads
- This rarely makes sense for the user.
- Ad spammers keep inventing new tricks.
- The search engines need time to catch up with them.

Not a win-win-win: Violation of trademarks

- Example: geico
- During part of 2005: The search term “geico” on Google was bought by competitors.
- Geico lost this case in the United States.
- Louis Vuitton lost similar case in Europe.
- See https://www.cnet.com/news/geico-sues-google-overture-over-trademarks/
- It’s potentially misleading to users to trigger an ad of a trademark if the user can’t buy the product on the site.

SPAM
(SEARCH ENGINE OPTIMIZATION)

The trouble with paid search ads …

- It costs money. What's the alternative?
- *Search Engine Optimization:*
  - "Tuning" your web page to rank highly in the algorithmic search results for select keywords
  - Alternative to paying for placement
  - Thus, intrinsically a marketing function
- Performed by companies, webmasters and consultants ("Search engine optimizers") for their clients
- Some perfectly legitimate, some very shady

SEARCH ENGINE OPTIMIZATION (SPAM)

- Motives
  - Commercial, political, religious, lobbying
  - Promotion funded by advertising budget
- Operators
  - Contractors (Search Engine Optimizers) for lobbies, companies
  - Web masters
  - Hosting services
- Forums
  - E.g., Web master world (www.webmasterworld.com)
    - Search engine specific tricks
    - Discussions about academic papers ☺

Simplest forms

- First generation engines relied heavily on *tf/idf*
  - The top-ranked pages for the query **`maui resort`** were the ones containing the most **`maui`**'s and **`resort`**'s
- SEOs responded with dense repetitions of chosen terms
  - e.g., **`maui resort maui resort maui resort`**
  - Often, the repetitions would be in the same color as the background of the web page
    - Repeated terms got indexed by crawlers
    - But not visible to humans on browsers

Pure word density cannot be trusted as an IR signal

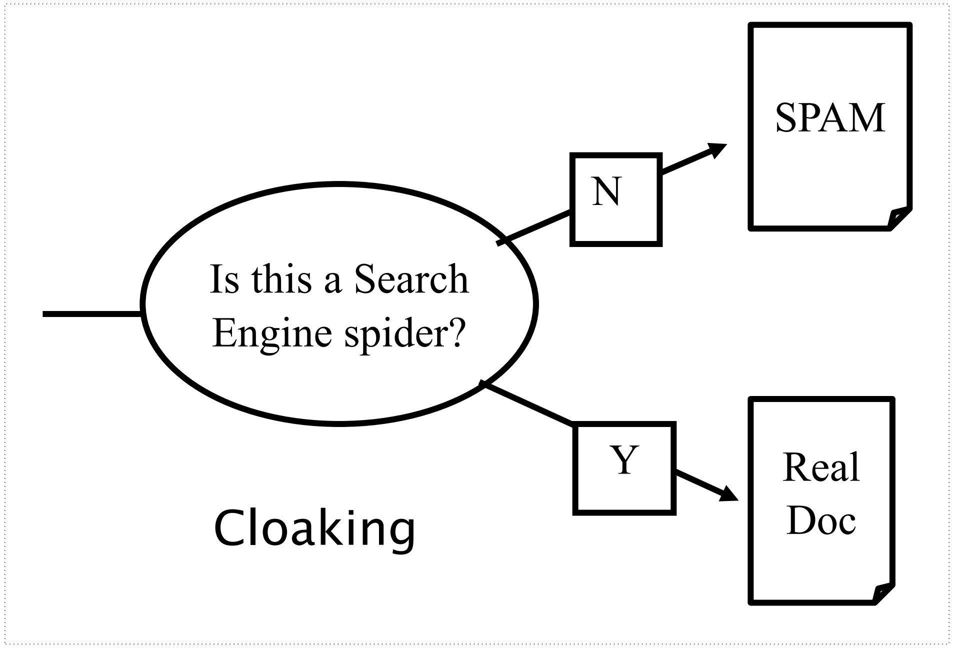
Variants of keyword stuffing

- Misleading meta-tags, excessive repetition
- Hidden text with colors, style sheet tricks, etc.

Meta-Tags =
"… London hotels, hotel, holiday inn, hilton, discount, booking, reservation, sex, mp3, britney spears, viagra, …"

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
- **Link spamming**
  - Mutual admiration societies, hidden links, awards – more on these later
  - *Domain flooding:* numerous domains that point or re-direct to a target page
- **Robots**
  - Fake query stream – rank checking programs
    - "Curve-fit" ranking programs of search engines
  - Millions of submissions via Add-Url

The war against spam

- Quality signals - Prefer authoritative pages based on:
  - Votes from authors (linkage signals)
  - Votes from users (usage signals)
- Policing of URL submissions
  - Anti robot test
- Limits on meta-keywords
- Robust link analysis
  - Ignore statistically implausible linkage (or text)
  - Use link analysis to detect spammers (guilt by association)
- Spam recognition by machine learning
  - Training set based on known spam
- Family friendly filters
  - Linguistic analysis, general classification techniques, etc.
  - For images: flesh tone detectors, source text analysis, etc.
- Editorial intervention
  - Blacklists
  - Top queries audited
  - Complaints addressed
  - Suspect pattern detection

More on spam

- Web search engines have policies on SEO practices they tolerate/block
  - https://www.bing.com/toolbox/webmaster/
  - http://www.google.com/intl/en/webmasters/
- Adversarial IR: the unending (technical) battle between SEO's and web search engines
- Research http://airweb.cse.lehigh.edu/

SIZE OF THE WEB

WHAT IS THE SIZE OF THE WEB ?

- Issues
  - The web is really infinite
    - Dynamic content, e.g., calendars
    - Soft 404: www.yahoo.com/<anything> is a valid page
  - Static web contains syntactic duplication, mostly due to mirroring (~30%)
  - Some servers are seldom connected
- Who cares?
  - Media, and consequently the user
  - Engine design
  - Engine crawl policy. Impact on recall.

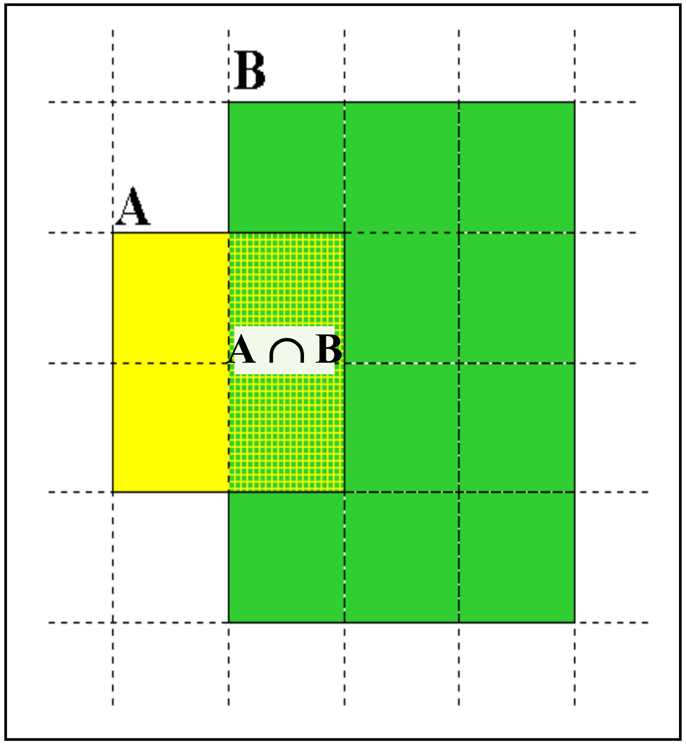
What can we attempt to measure?

- The relative sizes of search engines
  - The notion of a page being indexed is still *reasonably* well defined.
  - Already there are problems
    - Document extension: e.g., engines index pages not yet crawled, by indexing anchor text.
    - Document restriction: All engines restrict what is indexed (first *n* words, only relevant words, etc.)

New definition?

- The statically indexable web is whatever search engines index.
  - IQ is whatever the IQ tests measure.
- Different engines have different preferences
  - max url depth, max count/host, anti-spam rules, priority rules, etc.
- Different engines index different things under the same URL:
  - frames, meta-keywords, document restrictions, document extensions, ...

Relative Size from Overlap Given two engines A and B



Sample URLs randomly from A

Check if contained in B and vice versa

$A \cap B = (1/2) * \text{Size } A$

$A \cap B = (1/6) * \text{Size } B$

$(1/2) * \text{Size } A = (1/6) * \text{Size } B$

$\therefore \text{ Size } A / \text{Size } B =$

$(1/6)/(1/2) = 1/3$

Each test involves: (i) Sampling (ii) Checking

Sampling URLs

- Ideal strategy: Generate a random URL and check for containment in each index.
- Problem: Random URLs are hard to find! Enough to generate a random URL contained in a given Engine.
- Approach 1: Pick a random URL contained in a given engine
  - Suffices for the estimation of relative size
- Approach 2: Random walks / IP addresses
  - In theory: might give us a true estimate of the size of the web (as opposed to just relative sizes of indexes)

Statistical methods

- Approach 1
  - Random queries
  - Random searches
- Approach 2
  - Random IP addresses
  - Random walks

Random URLs from random queries

- Generate random query: how?
  - **Lexicon:** 400,000+ words from a web crawl
  - **Conjunctive Queries:** w_1 and w_2

    e.g., vocalists AND rsi

Not an English dictionary

- Get 100 result URLs from engine A
- Choose a random URL as the candidate to check for presence in engine B
- This distribution induces a probability weight W(p) for each page.

Query Based Checking

- *Strong Query* to check whether an engine *B* has a document *D*:
  - Download *D*. Get list of words.
  - Use 8 low frequency words as AND query to *B*
  - Check if *D* is present in result set.
- Problems:
  - Near duplicates
  - Frames
  - Redirects (to docs not on engine *B*)
  - Engine time-outs
  - Is 8-word query good enough?

ADVANTAGES & DISADVANTAGES

- Statistically sound under the "induced weight".
- Biases induced by random query
  - Query Bias: Favors content-rich pages in the language(s) of the lexicon
  - Ranking Bias: *Solution:* Use conjunctive queries & fetch all
  - Checking Bias: Duplicates, impoverished pages omitted
  - Document or query restriction bias: engine might not deal properly with 8 words conjunctive query
  - Malicious Bias: Sabotage by engine
  - Operational Problems: Time-outs, failures, engine inconsistencies, index modification.

Random searches

- Choose random searches extracted from a local log [Lawrence & Giles 97] or build "random searches" [Notess]
  - Use only queries with small result sets.
  - Count normalized URLs in result sets.
  - Use ratio statistics

ADVANTAGES & DISADVANTAGES

- Advantage
  - Might be a better reflection of the human perception of coverage (because it covers all the human searches)
- Issues
  - Samples are correlated with source of log
  - Duplicates
  - Technical statistical problems (must have non-zero results, ratio average not statistically sound)

RANDOM SEARCHES

- 575 & 1050 queries from the NEC RI employee logs
- 6 Engines in 1998, 11 in 1999
- Implementation:
  - Restricted to queries with < 600 results in total
  - Counted URLs from each engine after verifying query match
  - Computed size ratio & overlap for individual queries
  - Estimated index size ratio & overlap by averaging over all queries

Quiz: Queries from NEC study

- *adaptive access control*
- *neighborhood preservation topographic*
- *hamiltonian structures*
- *right linear grammar*
- *pulse width modulation neural*
- *unbalanced prior probabilities*
- *ranked assignment method*
- *internet explorer favourites importing*
- *karvel thornber*
- *zili liu*
- *softmax activation function*
- *bose multidimensional system theory*
- *gamma mlp*
- *dvi2pdf*
- *john oliensis*
- *rieke spikes exploring neural*
- *video watermarking*
- *counterpropagation network*
- *fat shattering dimension*
- *abelson amorphous computing*

What's the problem with these queries?

Random IP addresses

- Generate random IP addresses
- Find a web server at the given address
  - If there's one
- Collect all pages from server
  - From this, choose a page at random

RANDOM IP ADDRESSES

- HTTP requests to random IP addresses
  - Ignored: empty or authorization required or excluded
  - [Lawr99] Estimated 2.8 million IP addresses running crawlable web servers (16 million total) from observing 2500 servers.
  - OCLC using IP sampling found 8.7 M hosts in 2001
    - Netcraft [Netc02] accessed 37.2 million hosts in July 2002
- [Lawr99] exhaustively crawled 2500 servers and extrapolated
  - Estimated size of the web to be 800 million pages
  - Estimated use of metadata descriptors:
    - Meta tags (keywords, description) in 34% of home pages, Dublin core metadata in 0.3%

ADVANTAGES & DISADVANTAGES

- Advantages
  - Clean statistics
  - Independent of crawling strategies
- Disadvantages
  - Doesn't deal with duplication
  - Many hosts might share one IP, or not accept requests
  - No guarantee all pages are linked to root page.
    - E.g.: employee home pages
  - Power law for # pages/hosts generates bias towards sites with few pages.
    - But bias can be accurately quantified IF underlying distribution understood
  - Potentially influenced by spamming (multiple IP's for same server to avoid IP block)

Random walks

- View the Web as a directed graph
- Build a random walk on this graph
  - Includes various “jump” rules back to visited sites
    - Does not get stuck in spider traps!
    - Can follow all links!
  - Converges to a stationary distribution
    - Must assume graph is finite and independent of the walk.
    - Conditions are not satisfied (cookie crumbs, flooding)
    - Time to convergence not really known
  - Sample from stationary distribution of walk
  - Use the “strong query” method to check coverage by search engine

ADVANTAGES & DISADVANTAGES

- Advantages
  - "Statistically clean" method, at least in theory!
  - Could work even for infinite web (assuming convergence) under certain metrics.
- Disadvantages
  - List of seeds is a problem.
  - Practical approximation might not be valid.
  - Non-uniform distribution
    - Subject to link spamming

Conclusions

- No sampling solution is perfect.
- Lots of new ideas ...
- ....but the problem is getting harder
- Quantitative studies are fascinating and a good research problem

DUPLICATE DETECTION

Duplicate documents

- The web is full of duplicated content
- Strict duplicate detection = exact match
  - Not as common
- But many, many cases of near duplicates
  - E.g., last-modified date the only difference between two copies of a page

Duplicate/Near-Duplicate Detection

- *Duplication*: Exact match can be detected with fingerprints
- *Near-Duplication*: Approximate match
  - Overview
    - Compute syntactic similarity with an edit-distance measure
    - Use similarity threshold to detect near-duplicates
      - E.g., Similarity > 80% => Documents are “near duplicates”
      - Not transitive though sometimes used transitively

COMPUTING SIMILARITY

- Features:
  - Segments of a document (natural or artificial breakpoints)
  - **Shingles** (Word N-Grams)
  - ***a rose is a rose is a rose*** →

    a_rose_is_a

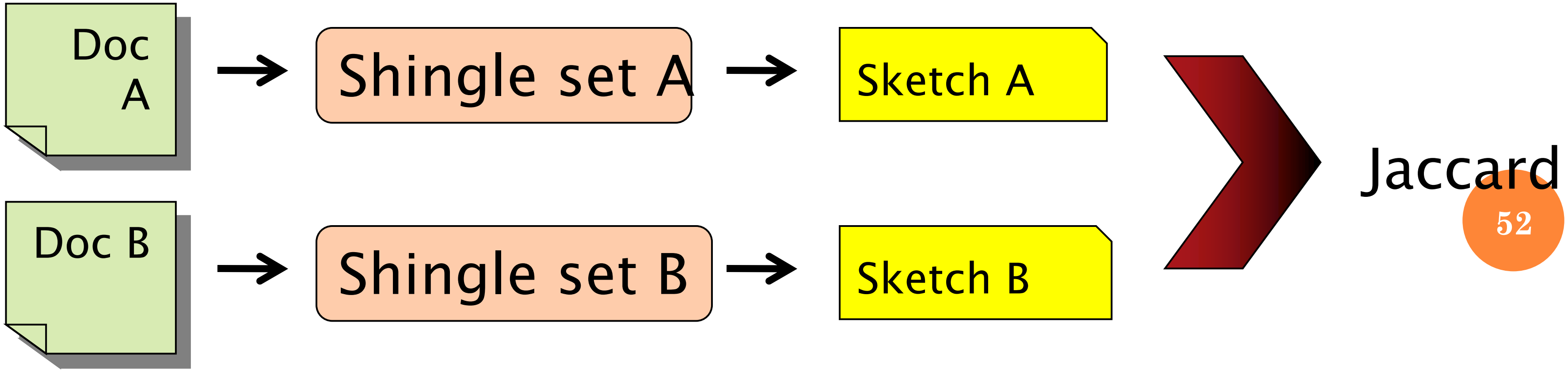
    rose_is_a_rose

    is_a_rose_is

    a_rose_is_a
- Similarity Measure between two docs (= sets of shingles)
  - Jaccard coefficient: Size_of_Intersection / Size_of_Union

Shingles + Set Intersection

- Computing exact set intersection of shingles between all pairs of documents is expensive/intractable
  - Approximate using a cleverly chosen subset of shingles from each (a *sketch*)
- Estimate (size_of_intersection / size_of_union) based on a short sketch

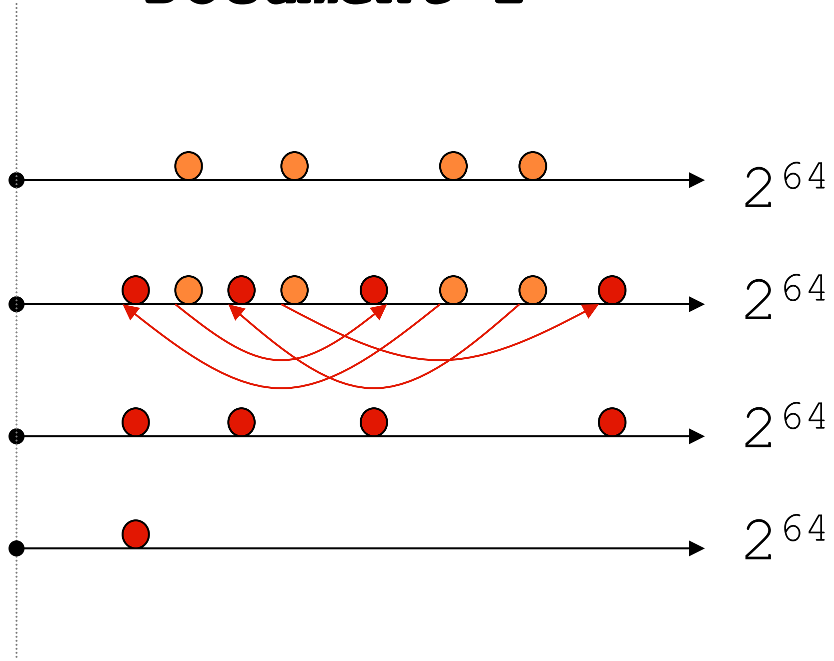


Sketch of a document

- Create a "sketch vector" (of size ~200) for each document
  - Documents that share $\geq t$ (say 80%) corresponding vector elements are near duplicates
  - For doc D, sketch$_D[\, i \,]$ is as follows:
    - Let f map all shingles in the universe to $0..2^m-1$ (e.g., f = fingerprinting)
    - Let π_i be a *random permutation* on $0..2^m-1$
    - Pick MIN $\{\pi_i(f(s))\}$ over all shingles s in D

Computing Sketch[i] for Doc1

Document 1

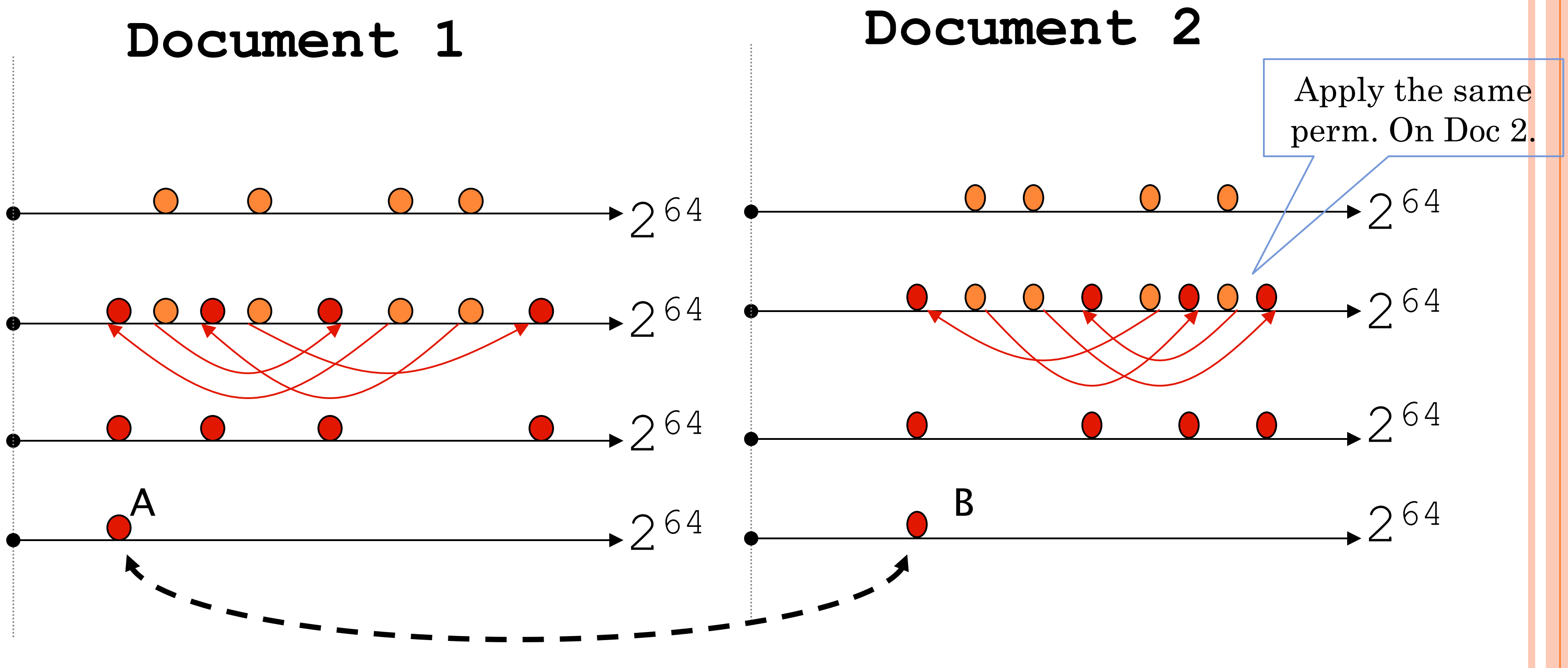


Start with 64-bit *f*(shingles)

Permute on the number line with π_i

Pick the min value

Test if Doc1.Sketch[i] = Doc2.Sketch[i]

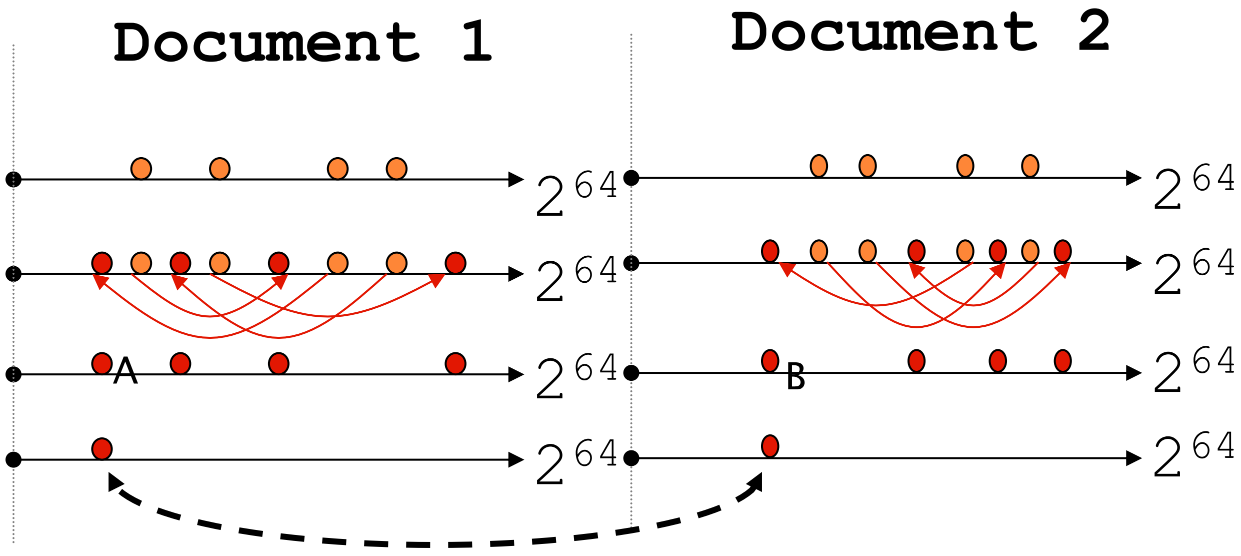


Apply the same perm. On Doc 2.

Are these equal?

Test for 200 random permutations: $\pi_1, \pi_2, \ldots \pi_{200}$

HOWEVER…



Why?

Theorem:

Jaccard (D1, D2) = Prob(A = B)

Set Similarity of sets C_I , C_J

$$\text{Jaccard}(C_i, C_j) = \frac{|C_i \cap C_j|}{|C_i \cup C_j|}$$

- View sets as columns of a matrix A; one row for each element in the universe. $a_{ij} = 1$ indicates presence of item i in set j
- Example

C_1	C_2
0	1
1	0
1	1
0	0
1	1
0	1

Jaccard**(C_1,C_2) = 2/5 = 0.4**

Quiz: Calculate Jaccard

C1	C2	C3
1	0	1
1	0	0
0	0	0
1	1	1
0	1	1
0	0	1
1	1	1
0	1	0
1	0	1

- By Jaccard, which one is more similar to C1: is it C2 or C3? Why?

Key Observation

- For columns C_i, C_j, four types of rows

	C_i	C_j
A	1	1
B	1	0
C	0	1
D	0	0

- Overload notation: A = # of rows of type A
- **Claim**

$$\text{Jaccard}(C_i, C_j) = \frac{A}{A+B+C}$$

"Min" Hashing

- Randomly permute rows
- Hash $h(C_i)$ = index of first row with 1 in column C_i
- Surprising Property

$$P\left(h(C_i) = h(C_j)\right) = \text{Jaccard}\left(C_i, C_j\right)$$

- Why?
  - Both are A/(A+B+C)
  - Look down columns C_i, C_j until first non-Type-D row
  - $h(C_i) = h(C_j)$ ←→ type A row

MIN-HASH SKETCHES

- Pick *P* random row permutations
- MinHash sketch

Sketch$_D$ = list of *P* indexes of first rows with 1 in column C

- Similarity of signatures
  - Let sim[sketch(C_i),sketch(C_j)] = fraction of permutations where MinHash values agree
  - Observe E[sim(sketch(C_i),sketch(C_j))] = Jaccard(C_i,C_j)

Example

	C_1	C_2	C_3
R_1	1	0	1
R_2	0	1	1
R_3	1	0	0
R_4	1	0	1
R_5	0	1	0

Signatures

	S_1	S_2	S_3
Perm 1 = (12345)	1	2	1
Perm 2 = (54321)	4	5	4
Perm 3 = (34512)	3	5	4

Similarities

	1-2	1-3	2-3
Col-Col	0.00	0.50	0.25
Sig-Sig	0.00	0.67	0.00

All signature pairs

- Now we have an extremely efficient method for estimating a Jaccard coefficient for a single pair of documents.
- But we still have to estimate N^2 Jaccard coefficients where N is the number of web pages.
  - Still slow
- One solution: locality sensitive hashing (LSH)
- Another solution: sorting (Henzinger 2006)

More resources

- IIR Chapter 19