

Web Dynamics

Part 6 – Searching the Past

6.1 Time-travel problems

6.2 Efficient Time-Travel Search

6.3 Temporal measures of page importance

Time Travel Problems on the Web

Search engines index only the *current* Web

But: Many interesting aspects on the *historical* Web:


5.2 → *Search the Web* as of a specific time in the past
(„opinions of major US politicians on the Iraq War in 2002“)

5.3 → *Analyze the Web* as of a specific time in the past
(„most authoritative news page in 2002“)

- Analyze *temporal development* of the Web
(„since when have political blogs been around?“)

Web Archives don't provide these functionalities
(at least not publicly)

Rare example: Google@2001



In honor of our 10th birthday, we've brought back our oldest available index. Take a look back at Google in January 2001.

2001 Web


[Hilton Paris - France](#)
3 prestigious hotels to discover attendees or enjoy typical fren
...
<http://www.hilton-paris.com/> -

[Hotel Discounts : Hotel In](#)
Listing of Discounts of Hotels:
<http://www.vacationweb.com/>

[Travelocity : Message Bo](#)
#2 of 3: **Paris Hilton**. katherin
November of 1997. It is right b
<http://dest.travelocity.com/Cor>

[Paris Las Vegas - A Hilt](#)
Paris Las Vegas - A Hilton C
Las Vegas.
<http://www.lasvegastriphotels>


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Web News Images Video Blogs

Related searches: [paris hilton movie](#) [1 night in paris](#) [paris exposed](#)

News results for **paris hilton**



[Windsor Star](#)
Paris Hilton debuts new single, "My BFF" - 8 hours ago
By Jill Serjeant LOS ANGELES (Reuters) - Leave it to **Paris Hilton** to ratchet up the hype for her new TV show's debut, releasing a new single, ...
[Reuters](#) - [30 related articles »](#)
Paris Hilton finds new BFF Ellen - [Oneindia](#) - [9 related articles »](#)
Paris Hilton porno art goes on display - [Stuff.co.nz](#) - [4 related articles »](#)

[Paris Hilton](#) - Wikipedia, the free encyclopedia
[19] In March 2008, it was reported that **Hilton** would star in a new MTV reality series tentatively titled **Paris Hilton's My New BFF**, about her looking for a ...
en.wikipedia.org/wiki/Paris_Hilton - 141k - [Cached](#) - [Similar pages](#)

[Paris Hilton](#) | The Official Website
ParisHilton.com Paris Hilton, Nicky **Hilton** Fashion, Pictures, Apparel, Jewellery , Film, and Fun.
www.parishilton.com/ - 8k - [Cached](#) - [Similar pages](#)

[Paris Hilton](#) Zone | [Paris Hilton](#) Pictures, Pics, Photos
4000+ new **Paris Hilton** pictures, **Paris** wallpaper, sex tape, lyrics, audio, video , daily **Paris** pics & news.
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Result

Web Dynamics

Part 6 – Searching the Past

6.1 Time-travel problems

6.2 Efficient Time-Travel Search

6.3 Temporal measures of page importance

(Some of the slides were contributed by Klaus Berberich)

The Need for Time-Travel Search

- Historical information needs, e.g.,
 - Contemporary (~2001) articles about the movie “Harry Potter and the Sorcerer’s Stone”
 - Search for prior art for a patent submitted 2005
 - Links to some illegal content before Feb 2009
- Relevant pages disappeared in the current Web, but preserved by Web archives (e.g., archive.org)
- Search in existing Web archives limited and ignores the time-axis

The Need for Time-Travel Search

Result on current Web

Google

Relevant (but unfound) result

http://web.archive.org/web/20020209030855/www.nytimes.com/2001/11/16/movies/16POTT.html

Web

Harry Potter and t

Directed by Chris Colur
from the outrageous ne
[Full cast and crew - Pl](#)
[www.imdb.com/title/tt0](#)

Harry Potter

Harry Potter an
information for H
[www.imdb.com/](#)
[Weitere Ergebni](#)

Harry Potter and t

Harry Potter and the F
and the Sorcerer's St
[en.wikipedia.org/.../Har](#)

Harry Potter and t

Harry Potter and the
bullying Uncle Vernon,
[movies.yahoo.com/mov](#)

Harry Potter & The

Alles zum Film "Harry
Kinoprogramm, Wallpa
[outnow.ch/Movies/2001](#)

Harry Potter und d

(Harry Potter and the
Romane bin ich mit die
[www.moviemaze.de/...](#)

Amazon.com: Harr

Harry Potter and the
magical thrill ride - Fan
[www.amazon.com/Har](#)

Harry Potter and t

Harry Potter and the
information and related
[www.boxofficemojo.com](#)

Summer Ter

Movies

HOME
JOB MARKET
REAL ESTATE
AUTOMOBILES

NEWS
International
National
Nation Challenged
Politics
Business
Technology
Science
Health
Sports
New York Region
Education
Weather
Obituaries
NYT Front Page
Corrections
Special: Winter
Olympics

OPINION
Editorials/Op-Ed
Readers' Opinions

Scotland
PA
Opens
Today

FEATURES
Arts
Books
Movies
Travel
Dining & Wine
Home & Garden
Fashion & Style
New York Today
Crossword/Games
Cartoons
Magazine
Week in Review
Photos
Columns
Learning Network

SERVICES
Archive
Classifieds
Help Center
NYT Mobile
NYT Store
E-Cards & More
About NYTDigital
Jobs at NYTDigital
Online Media Kit
Our Advertisers

NEWSPAPER
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Customer Service
Electronic Edition

Search Past 30 Days

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☐ E-Mail This Article ☐ Printer-Friendly Format
☐ Most E-Mailed Articles ☐ Single-Page View

November 16, 2001

MOVIE REVIEW / 'HARRY POTTER AND THE SORCERER'S STONE'

Wizard School Without the Magic

By ELVIS MITCHELL

THE world may not be ready yet for the film equivalent of books on tape, but this peculiar phenomenon has arrived in the form of the film adaptation of J. K. Rowling's "Harry Potter and the Sorcerer's Stone." The most highly awaited movie of the year has a dreary, literal-minded competence, following the letter of the law as laid down by the author. But it's all muted flourish, with momentary pleasures, like Gringott's, the bank staffed by trolls that looks like a Gaudí throwaway. The picture is so careful that even the tape wrapped around the bridge of Harry's glasses seems to have come out of the set design. (It never occurred to anyone to show him taping the frame together.)

The movie comes across as a covers act by an extremely competent tribute band not the real thing but an incredible simulation and there's an audience for this sort of thing. But watching "Harry Potter" is like seeing "Beetlemania" staged in the Hollywood Bowl, where the cheers and screams



on current Web

er's stone december 2001 [Erweiterte Suche](#)
[Einstellungen](#)

eiten auf Deutsch ☐ Seiten aus Deutschland

nen Ihre bevorzugten Spracheinstellungen in [Einstellungen](#) angeben.

[- Box office / business](#) - [[Diese Seite übersetzen](#)]
Box office / business

[ich](#)

[pedia, the free ...](#) - [[Diese Seite übersetzen](#)]
tive sales of children's fiction placed
backs ...
[s_Stone](#) - [Im Cache](#) - [Ähnlich](#)

[\(film\) - Wikipedia, the ...](#) - [[Diese Seite übersetzen](#)]
December 2000, Richard Corliss
tone: Movie ...
[opher's_Stone_\(film\)](#) - [Im Cache](#) - [Ähnlich](#)

[er Trailer](#)

★
2001 Ireland 16 November 2001
ber 2001 UK 16 November ...

[\[VHS\]: Daniel ...](#) - [[Diese Seite übersetzen](#)]
tone, of 5 stars A magical thrill
e any of the Harry Potter DVD's

[003CX10](#) - [Im Cache](#) - [Ähnlich](#)

[xX Hamburg-Dammtor ...](#)
POTTER AND THE SORCERER'S
stag erfährt Harry Potter ...
[he](#) - [Ähnlich](#)

[ailer, Wallpaper ...](#) - [[Diese Seite übersetzen](#)]
, 2001. Steven Soderbergh's
the Sorcerer's Stone ...

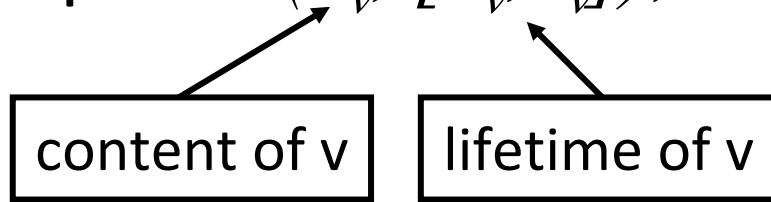
Time-Travel Search Beyond the Web

More versioned document collections:

- Wikis (like Wikipedia)
- Repositories (e.g., controlled by CVS, Subversion)
- Your Desktop

Formal Model: Document Versions

Assume continuous time dimension $T=[0...\infty($.
For each document (=url) d , maintain set of different **versions** $V(d)$, where each $v \in V(d)$ is a tuple $v=(c_v, [s_v, e_v])$, with $e_v=\infty$ for current versions.



Different versions of the same document have **disjoint lifetimes** $\Rightarrow (d, s_v)$ identifies version

Archive can only estimate versions of a document

Time-Travel Keyword Queries

Time-travel keyword query $q=(k,I)$ combination of

- standard keyword query $k=(k_1, \dots k_n)$
- time-of-interest interval $I=(s_I, e_I)$

Two important subclasses:

- **Point-in-time** queries: $s_I=e_I$
- **Interval** queries: $e_I>s_I$



Example:

“harry potter” @ 2001/11/14

This is a point-in-time query if the granularity of time is 1 day!

Scoring Point-in-Time Time-Travel Queries

Reminder: score in standard text retrieval:

$$s(d, q) \propto \sum_{k \in q} tf(d, k) \cdot idf(k)$$

frequency of k in d

importance of k

$$idf(k) \propto \frac{N}{df(k)}$$

score of version $v = (c_v, [s_v, e_v])$ for $q = (\{k_1 \dots k_n\}, t)$

$$s_T(v, q) \propto \begin{cases} 0 & \text{if } t \notin [s_v, e_v] \\ \sum_{k_i} tf(c_v, k_i) \cdot idf(k_i, t) & \text{if } t \in [s_v, e_v] \end{cases}$$

frequency of k_i in c_v

importance of k_i at query time t

$$idf(k, t) \propto \frac{N(t)}{df(k, t)}$$

N : # docs; $N(t)$: #docs at time t
 $df(k)$: # docs with term k
 $df(k, t)$: # docs with term k at time t

Inverted Lists in Text IR

Reminder: Inverted Lists in text retrieval

For each term t , keep list $(d, score(d, t))$ of documents containing term t and their score, in some order

List for term t
in score order


d1,0.9
d7,0.85
d2,0.84763
d119,0.79
...

List for term t
in document order

d1,0.9
d2,0.84763
d4, 0.27
d7,0.85
...

Query processing using merge joins of these lists
(plus optional top-k for efficiency)

Extension for time-travel: SOPT

1. Split score in tf and idf component
(idf is query-dependent!)  store this somewhere else
2. For each term k , keep list $(v, tf(v, k), (s_v, e_v))$ of document versions containing term k , their tf value, and their lifetime, in some order

List for term k in score order

~~d1,90,(2001/jan/01,2001/jan/15)~~

~~d1,90,(2001/jan/16,2001/feb/28)~~

d7,85,(2004/aug/14,2004/aug/16) ✓

d1,84,(2001/mar/01,∞) ✓

...

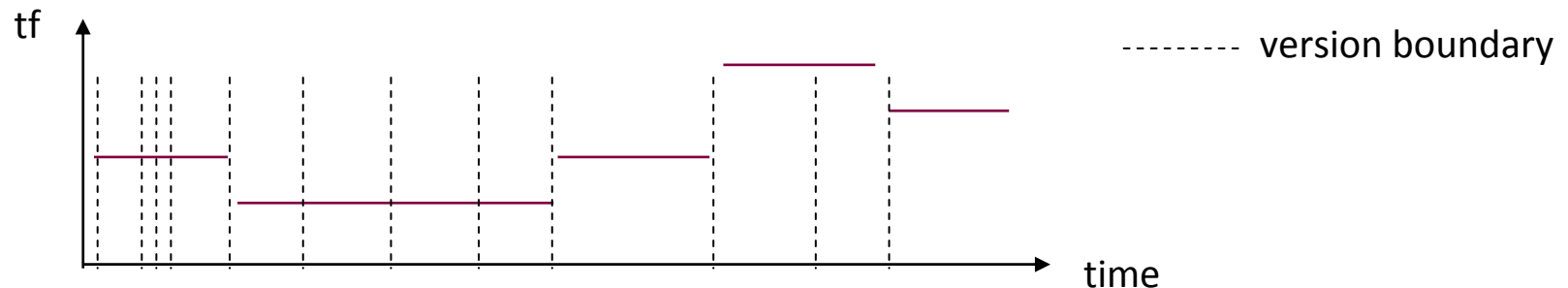
Example:
 $k@2004/\text{aug}/15$

Query processing using merge joins of these lists
plus ignoring versions where lifetime does not match query

This is not good enough

Major problems of this simple approach:

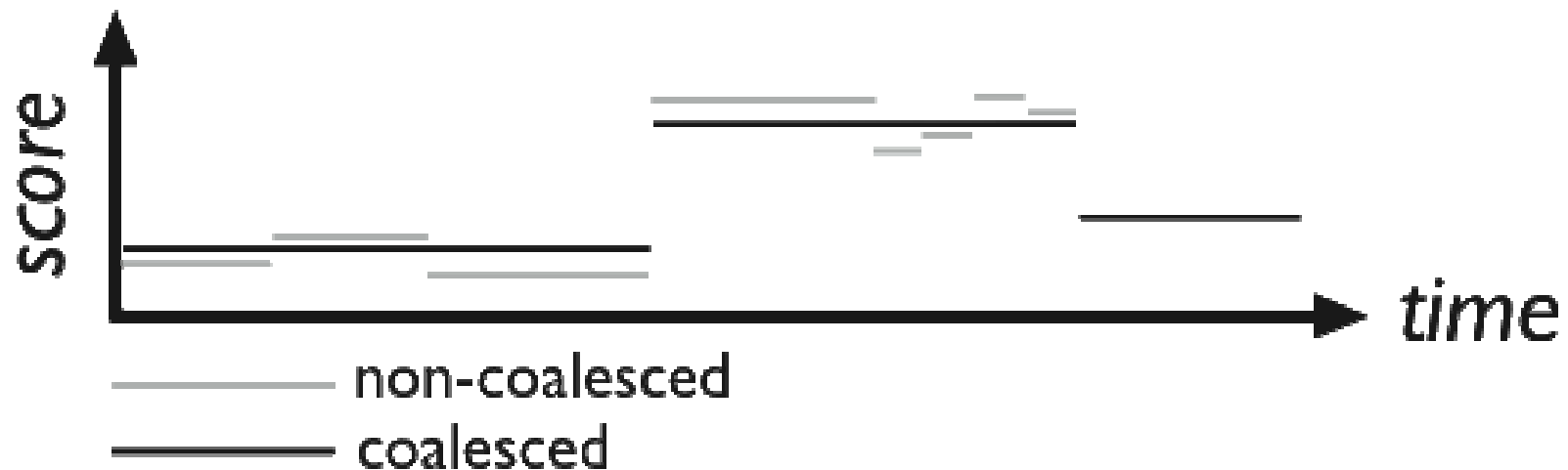
- index size explodes (*one index entry per version per term*)
⇒ for Wikipedia alone: $9 \cdot 10^9$ entries!
- Many entries
 - differ only in their lifetimes
 - have almost identical tf values (hardly matters for ranking)



Reducing Index Size: Coalescing

Idea:

Coalesce sequences of temporally adjacent postings having similar scores

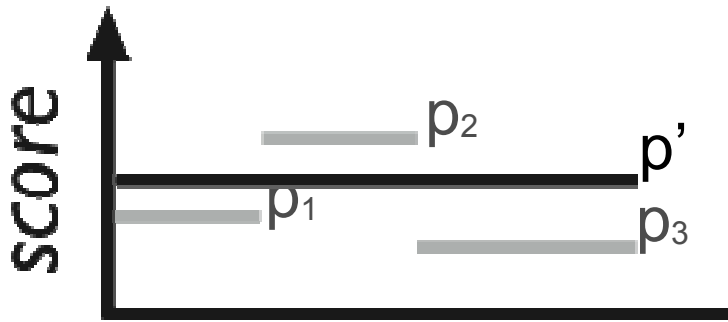


Can drastically reduce index size
But: what happens to result quality?

Formal Optimization Problem

Problem Statement:

Given input sequence I find a *minimal length output sequence* O with approximation errors bounded by a threshold ε



Guarantee:

$$|p' - p_i| / |p_i| \leq \varepsilon$$

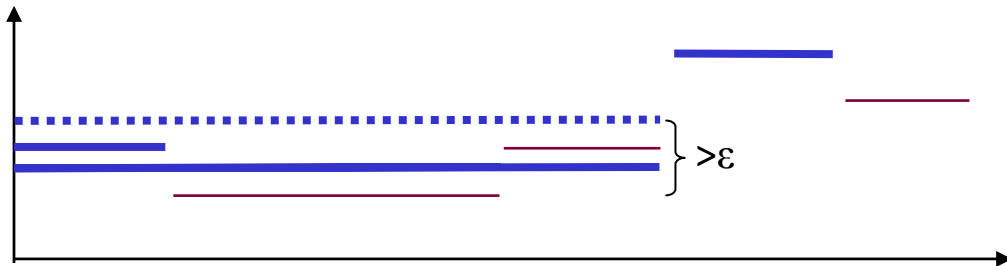
Approximate Temporal Coalescing (ATC):

finds an optimal output sequence using a greedy linear time algorithm

Approximate Temporal Coalescing (ATC)

General approach:

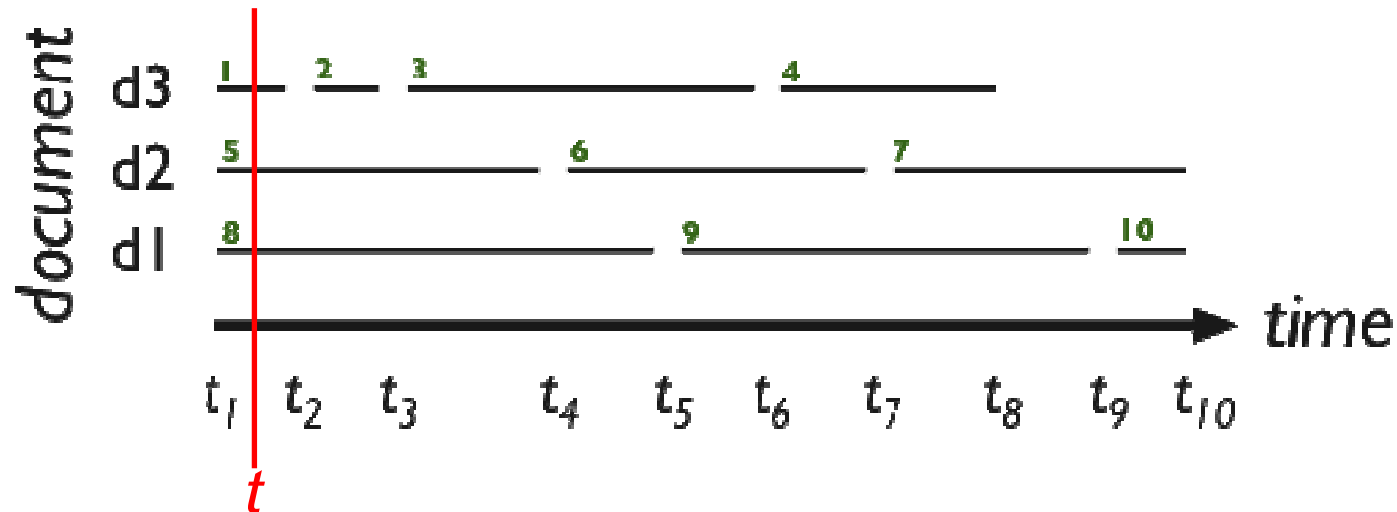
- Scan from left to right
- Maintain current estimate for representative p'
- When next value is encountered, check if it can be represented within the error margin
 - If not, close current subsequence



Tuning query performance

Problem:

Many postings are *ignored* during query processing

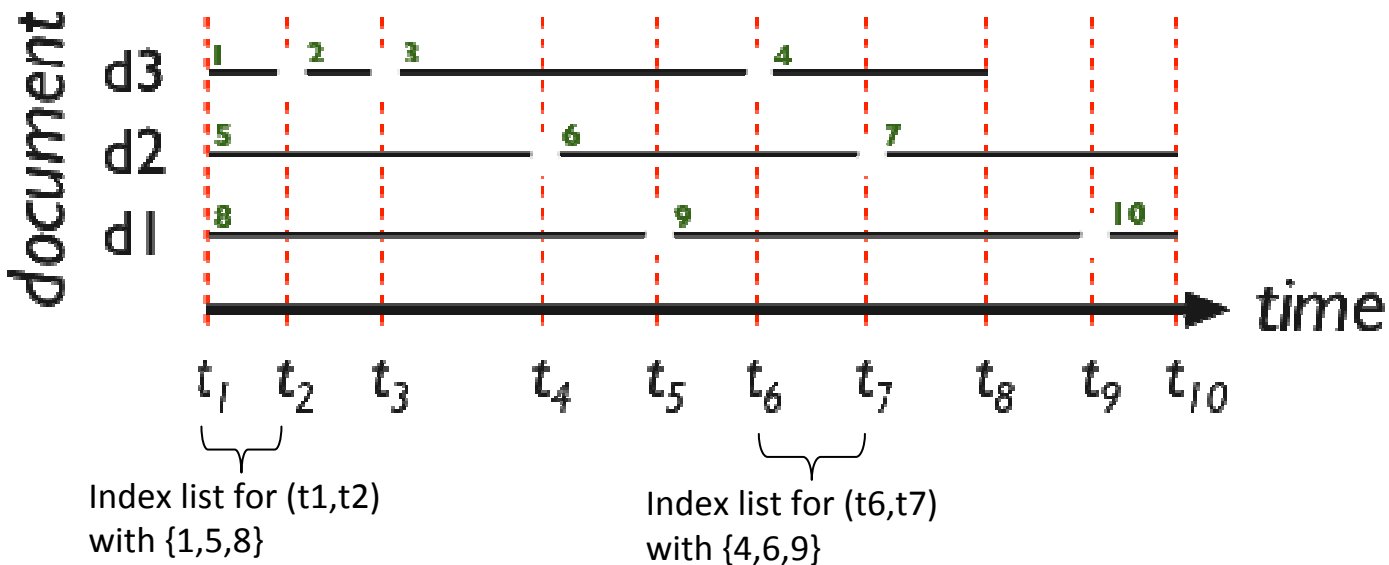


We read 10 postings,
but only {1, 5, 8} are needed

Tuning Query Performance: POPT

Idea:

Materialize smaller sublists containing only postings that **overlap** with a smaller interval



Maintaining a sublist for each elementary interval yields optimal query performance

Tuning Index Performance

Two extreme solutions up to now:

- ***space-optimal***: keep only a single list (SOPT)
- ***performance-optimal***: keep one list per elementary time-interval (POPT)

Now: two systematic techniques to trade-off space and performance

- ***performance-guarantee***: consumes minimal space while retaining a performance guarantee (PG)
- ***space-bound***: achieves best performance while not exceeding a space limit (SB)

Performance Guarantee (PG)

- consumes *minimal* space
- *guarantees* that for any t *at most $\gamma \cdot n_t$ postings are read* where n_t is the number of postings that exist at time t

Optimal solution computable for discrete time by means of induction (on the number of time points) *in $O(T^2)$ time and $O(T^2)$ space* (where T is the number of distinct timestamps in the list)

- start with elementary intervals (length 1)
- compute optimal solution for intervals of length $k+1$ from solutions for intervals of length $\leq k$

Space Bound (SB)

- achieves *minimal expected processing cost* (i.e., expected length of the list that is scanned)
- consumes *at most $\kappa \cdot n$ space* where n is the length of the original list

Optimal solution computable using dynamic programming in *$O(n^4)$ time* and $O(n^3)$ space

Approximate solution computable in *$O(T^2)$ time* and $O(T)$ space using simulated annealing

Experimental Evaluation: Setup

Implementation:

Java, Oracle 10g

Datasets:

- WIKI: Revision history of English Wikipedia (2001-2005)
892K documents / 13,976K versions / 0.7 TBytes
- UKGOV: Weekly crawls of 11 .gov.uk sites (2004-2005)
502K documents / 8,687K versions / 0.4 TBytes

Queries:

- 300 keyword queries from AOL query log that most frequently produced a result click on en.wikipedia.org / .gov.uk
- Each keyword query is assigned one time point per month in the collection's lifespan (18K / 7.2K time-travel queries in total)

Experimental Evaluation: Setup

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892K documents / 13,976K versions / 0.7 TBytes
- UKGOV: Weekly crawls of 11 .gov.uk sites (2004-2005)

WIKI:

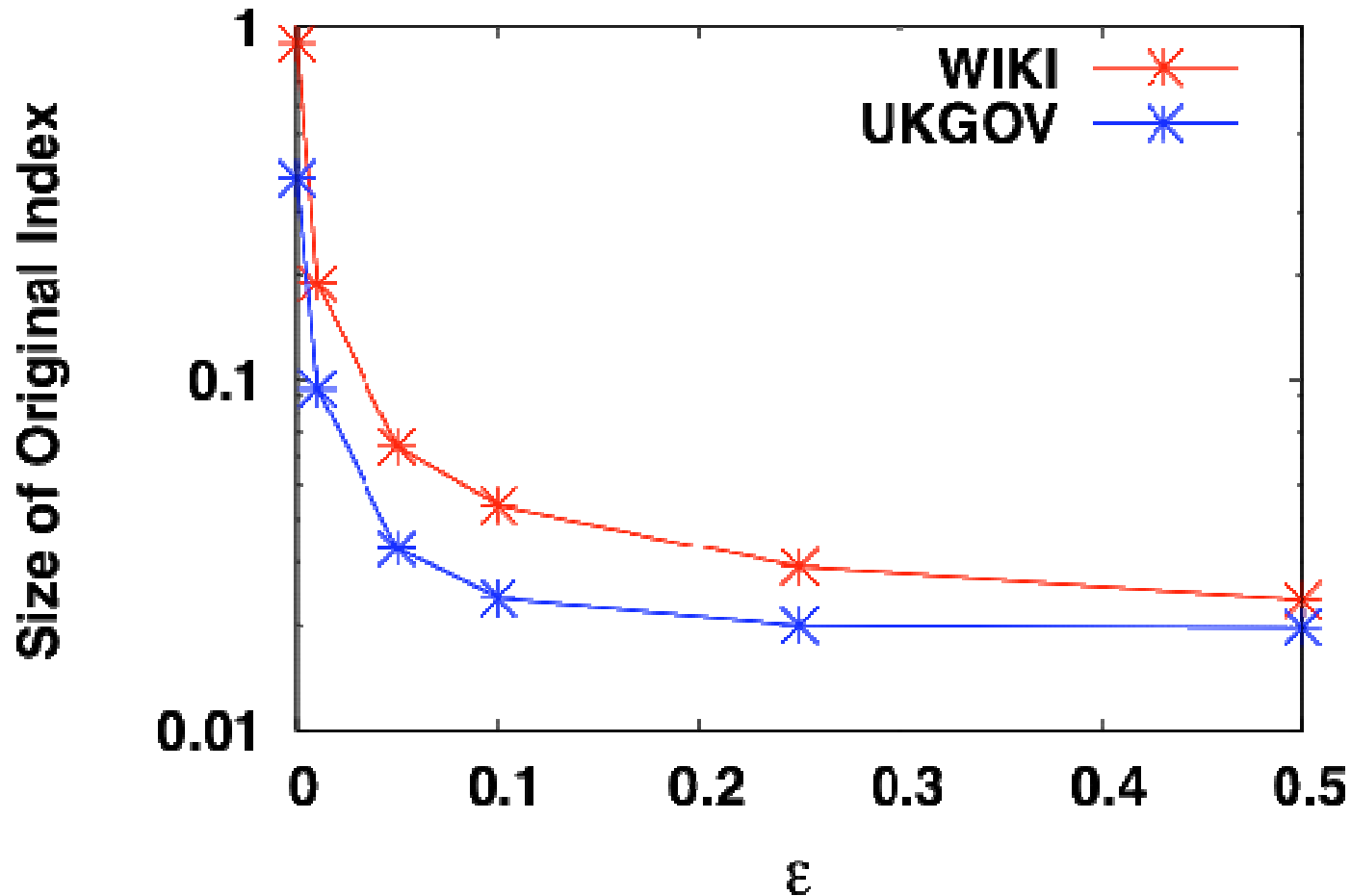
ten commandments, abraham lincoln, da vinci code, harlem renaissance...

UKGOV:

1901 uk census, british royal family, migrant worker statistics, witness intimidation...

Approximate Temporal Coalescing

Indexes computed for different values of threshold ε



At the same time provides excellent result quality

Sublist Materialization - Setup

Start with index created by ATC for $\varepsilon = 0.10$

For terms in query workloads (422/522) apply

- SOPT and POPT
- PG for γ varying between 1.10 and 3.00
- SB for κ varying between 1.10 and 3.00

Report

- Space, i.e., total number of postings in materialized sublists
- Expected Processing Cost (EPC), i.e., expected length of scanned list for random term and time

Performance Guarantee

	WIKI		UKGOV	
	Space	EPC	Space	EPC
P_{OPT}	14,428%	100%	11,406%	100%
S_{OPT}	100%	963%	100%	147%

Performance Guarantee

	WIKI		UKGOV	
	Space	EPC	Space	EPC
$\gamma = 1.10$	1,004%	106%	616%	103%
$\gamma = 1.50$	295%	132%	233%	117%
$\gamma = 2.00$	195%	160%	163%	125%
$\gamma = 3.00$	145%	207%	132%	133%

EPC = Expected Processing Cost

Space Bound

	WIKI		UKGOV	
	Space	EPC	Space	EPC
P_{OPT}	14,428%	100%	11,406%	100%
S_{OPT}	100%	963%	100%	147%

Space Bound

	WIKI		UKGOV	
	Space	EPC	Space	EPC
$\kappa = 3.00$	288%	139%	273%	107%
$\kappa = 2.00$	194%	171%	180%	119%
$\kappa = 1.50$	146%	214%	131%	131%
$\kappa = 1.10$	109%	406%	104%	145%

EPC = Expected Processing Cost

Web Dynamics

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6.1 Time-travel problems

6.2 Efficient Time-Travel Search

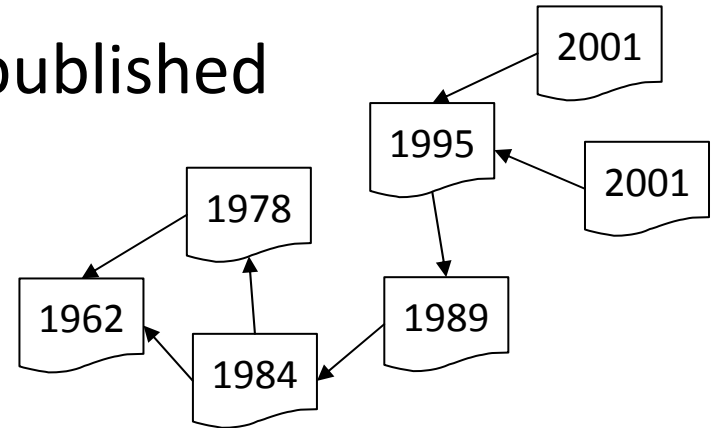
6.3 Temporal measures of page importance

Differences between Citations and Links

- Citations in printed documents (papers)

- never change once paper is published
- mostly to recent documents

⇒ Old papers hardly cited,
negative authority bias

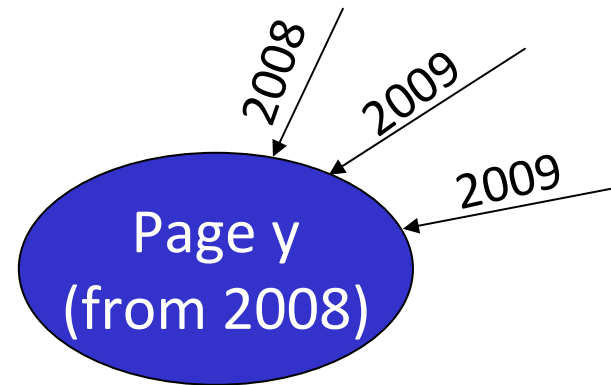
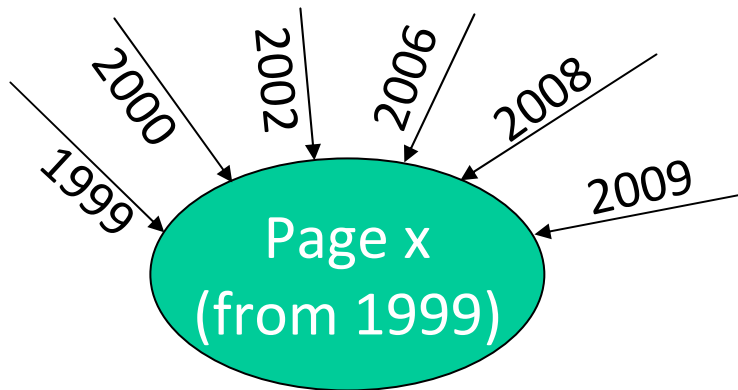


- Links on the Web

- frequently change after page is published
- old (but updated!) pages still get many new links

⇒ Old pages have **positive authority bias**

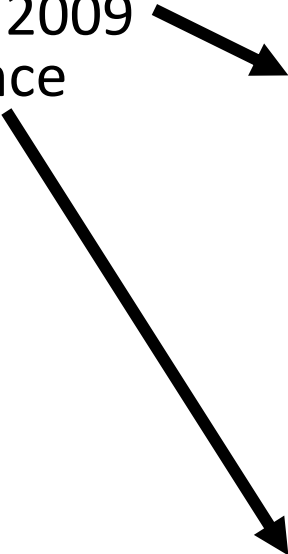
Temporal Development of Links



- PageRank (HITS, ...): **x** more authoritative than **y**
- But:
 - **x** has 6 links in 10 years
 - **y** has 3 links in 2 years
 - ⇒ **y** a lot more dynamic and up-to-date than **x**,
but difficult to beat **x**'s "temporal advantage"
- Why **Temporal notions of authority required!** 999?

Example: Search for SIGMOD conference

Old pages
dominate over
page for 2009
conference



Web Bilder Video Maps News Shopping E-Mail Mehr ▼

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[Einstellungen](#)

Suche: ☒ Das Web ☐ Seiten auf Deutsch ☐ Seiten aus Deutschland

Web

[ACM SIGMOD Conference](#) - [[Diese Seite übersetzen](#)]
Michael Stonebraker (Ed.): Proceedings of the 1992 ACM SIGMOD International Conference on Management of Data, San Diego, California, June 2-5, 1992. ...
www.informatik.uni-trier.de/.../sigmod/index.html - [Im Cache](#) - [Ähnlich](#)

[ACM SIGMOD Conference 1999: Philadelphia, Pennsylvania, USA](#) - [[Diese Seite übersetzen](#)]
Alex Delis, Christos Faloutsos, Shahram Ghandeharizadeh (Eds.): SIGMOD 1999, Proceedings ACM SIGMOD International Conference on Management of Data, ...
www.informatik.uni-trier.de/.../sigmod/sigmod99.html - [Im Cache](#) - [Ähnlich](#)
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[The ACM SIGMOD/PODS Conference: Vancouver, 2008 - Welcome](#) - [[Diese Seite übersetzen](#)]
28th ACM SIGMOD/PODS International Conference on Management of Data / Principles of Database Systems, Vancouver, BC, Canada.
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[ACM SIGMOD Conference 2007: Beijing, China](#) - [[Diese Seite übersetzen](#)]
Chee Yong Chan, Beng Chin Ooi, Aoying Zhou (Eds.): Proceedings of the ACM SIGMOD International Conference on Management of Data, Beijing, China, June 12-14, ...
www.sigmod.org/dblp/.../sigmod/sigmod2007.html - [Im Cache](#) - [Ähnlich](#)

[ACM SIGMOD Conference 1996: Montreal, Canada](#) - [[Diese Seite übersetzen](#)]
@proceedings[DBLP:conf/sigmod/96, editor = {H. V. Jagadish and Inderpal Singh Mumick}, title = {Proceedings of the 1996 ACM SIGMOD International Conference ...
www.sigmod.org/dblp/db/.../sigmod/sigmod96.html - [Im Cache](#) - [Ähnlich](#)
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22th ACM SIGMOD International Conference on Management of Data / Principles of Database Systems, San Diego, California, June 9-12, 2003.
db.ucsd.edu/sigmodpods03/ - [Im Cache](#) - [Ähnlich](#)

Modelling Temporal Changes

For each page p , maintain

- timestamp of **creation** $TS_C(p)$
- timestamp of **deletion** $TS_D(p)$
- set of timestamps of **modifications** $TS_M(p)$

(timestamp: amount of time units since time 0)

Analogous definitions for link (x,y) :

- timestamp of **creation** $TS_C(x,y)$: time when (x,y) added
- timestamp of **deletion** $TS_D(x,y)$: time when (x,y) del'ed
- timestamp $TS(x,y)$: last modification time of page x

Timestamped Link Profile (TLP)

Goal: Measure the „activity“ of a topic on the Web

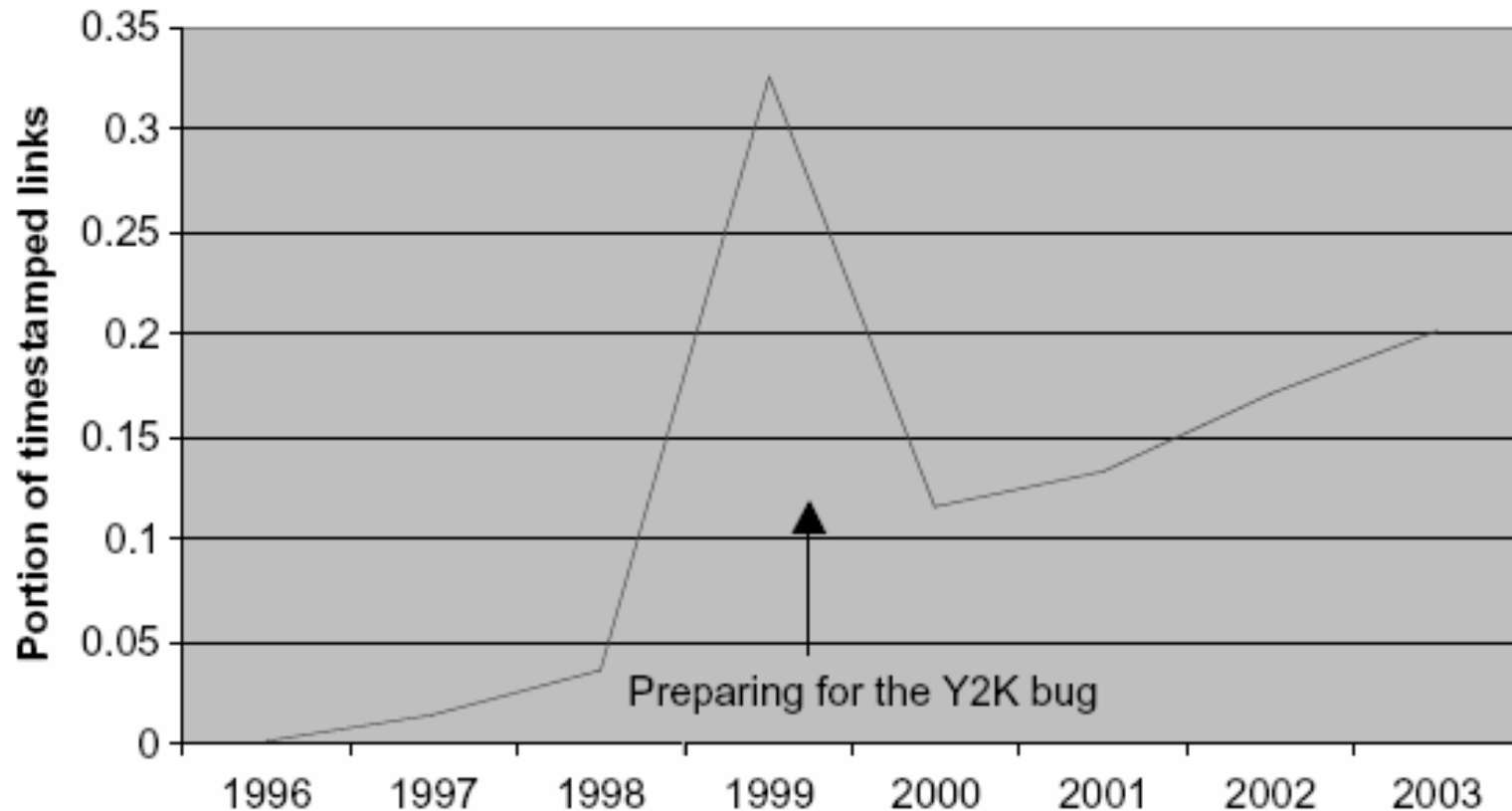
⇒ Construction of *Timestamped Link Profile*:

- Collect set of Web pages for the topic (e.g., by collecting results of keyword queries)
- Collect set of inlinks (x,y) to these pages (provided by search engines: `link:url`)
- Compute temporal distribution of timestamps of inlinks (partitioning time range into intervals)

Based on *limited sample* of the inlinks

Timestamps usually available for some inlinks only (last-modified timestamp of page)

Example TLP



Amitay et al., JASIST 2004

FIG. 2. TLP for the theme “Year 2000 Bug” (~750 timestamped links).

Towards Timely Authorities

Goal: Determine *currently* authoritative pages
(opposed to those authoritative years ago,
but still around)

Intuition of [Amitay et al.]:

- Deviate from uniform link weight in HITS etc
- Give more weight to recent links:

$$\begin{aligned} \textit{weight}(x,y) &\propto 1/\textit{age}(x,y) \\ &= 1/(\textit{currentTime} - \textit{TS}(x,y)) \end{aligned}$$

(with linear or exponential decay)

Authoritative Pages in the Past

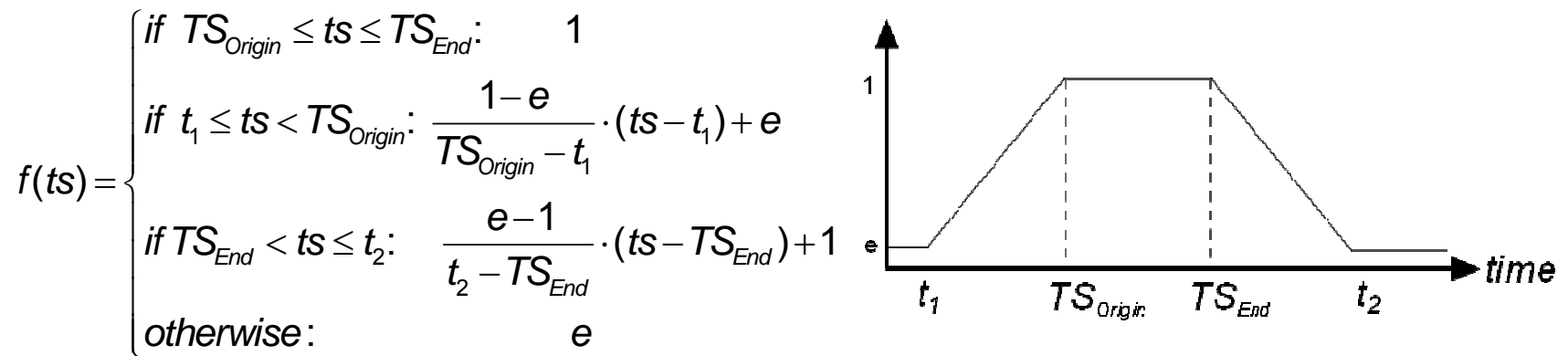
Goal: extend this approach towards

- finding important pages at **any interval** in the past
- including **page activity** as quality measure

Consider **interval of interest** $ti=[TS_{Origin}, TS_{End}]$ with additional **tolerance interval** $[t1, t2]$ where pages are less interesting, but still relevant to user
($t1 \leq TS_{Origin}, t2 \geq TS_{End}$)

Freshness

Freshness measures relevance of timestamp to interval of interest:



Freshness of node x : $f(x) = f(TS(x))$

Freshness of edge (x,y) : $f(x,y) = f(TS(x,y))$

Activity

Activity of set TS of timestamps measures frequency of change with respect to interval of interest:

$$a(TS) = \begin{cases} \text{if } TS \cap [t_1, t_2] \neq \emptyset : & \sum_{t_1}^{t_2} \{f(ts) | ts \in TS\} \\ \text{otherwise:} & e \end{cases}$$

Activity of node x : $a(x) = a(TS_M(x))$

Activity of edge (x,y) : $a(x,y) = a(TS_M(x,y))$

Restricting the Graph to an Interval

For graph G and interval of interest $ti=[ts,te]$ with tolerance interval $[t1,t2]$, consider **time projection**

$G_{ti}=(V_{ti},E_{ti})$ of $G=(V,E)$:

$$V_{ti}=\{v \in V \mid TS_C(v) \leq t_2 \wedge TS_D(v) \geq t_1\}$$

$$E_{ti}=\{(x,y) \in E \mid (x,y) \in V_{ti} \times V_{ti} \wedge TS_C(x,y) \leq t_2 \wedge TS_D(x,y) \geq t_1\}$$

Special case $t_1=t_2$: G_{ti} snapshot of G as of time t_1

Towards Temporal PageRank

Standard definition of PageRank:

$$r(y) = \sum_{(x,y) \in E} (1 - \varepsilon) \cdot \frac{r(x)}{\text{outdegree}(x)} + \frac{\varepsilon}{n}$$

Generalized version allowing for **non-uniform** transition and random jump probabilities:

$$r(y) = \sum_{(x,y) \in E} (1 - \varepsilon) \cdot t(x,y) \cdot r(x) + \varepsilon \cdot s(y)$$

- $t(x,y)$ describes transition probabilities
- $s(y)$ describes random jump probabilities

Temporal Pagerank (T-Rank)

- **Modified *PageRank*** on G_{ti}
- Transition probabilities $t(x,y)$ depend on **freshness** of nodes and edges
- Random jump probabilities depend on **freshness and activity** of nodes and edges

T-Rank – Transitions

- Transitions favor *fresh* nodes/edges
- Coefficients w_{ti} : probabilities that random surfer follows (x,y) with probabilities proportional to
 - freshness of node y
 - freshness of edge (x,y)
 - average (mean) freshness of incoming edges of node y

$$t(x, y) = w_{t1} \cdot \frac{f(y)}{\sum_{(x,z) \in E} f(z)} + w_{t2} \cdot \frac{f(x, y)}{\sum_{(x,z) \in E} f(x, z)} + w_{t3} \cdot \frac{\text{avg}\{f(v, y) \mid (v, y) \in E\}}{\sum_{(x,w) \in E} \text{avg}\{f(v, w) \mid (v, w) \in E\}}$$

T-Rank – Random Jumps

- Random jumps favor *fresh and active* nodes/edges
- Coefficients w_{s_i} probabilities that random surfer jumps to node y with probabilities proportional to
 - freshness and activity of node y
 - average (mean) freshness and activity of incoming edges of node y

$$s(y) = w_{s_1} \cdot \frac{f(y)}{\sum_{z \in V} f(z)} + w_{s_2} \cdot \frac{a(y)}{\sum_{z \in V} a(z)} +$$
$$w_{s_3} \cdot \frac{\text{avg}\{f(v, y) \mid (v, y) \in E\}}{\sum_{z \in V} \text{avg}\{f(w, z) \mid (w, z) \in E\}} + w_{s_4} \cdot \frac{\text{avg}\{a(v, y) \mid (v, y) \in E\}}{\sum_{z \in V} \text{avg}\{a(w, z) \mid (w, z) \in E\}}$$

T-Rank Experiment: DBLP

Digital Bibliography & Library Project (DBLP) freely available
bibliographic dataset (as XML)

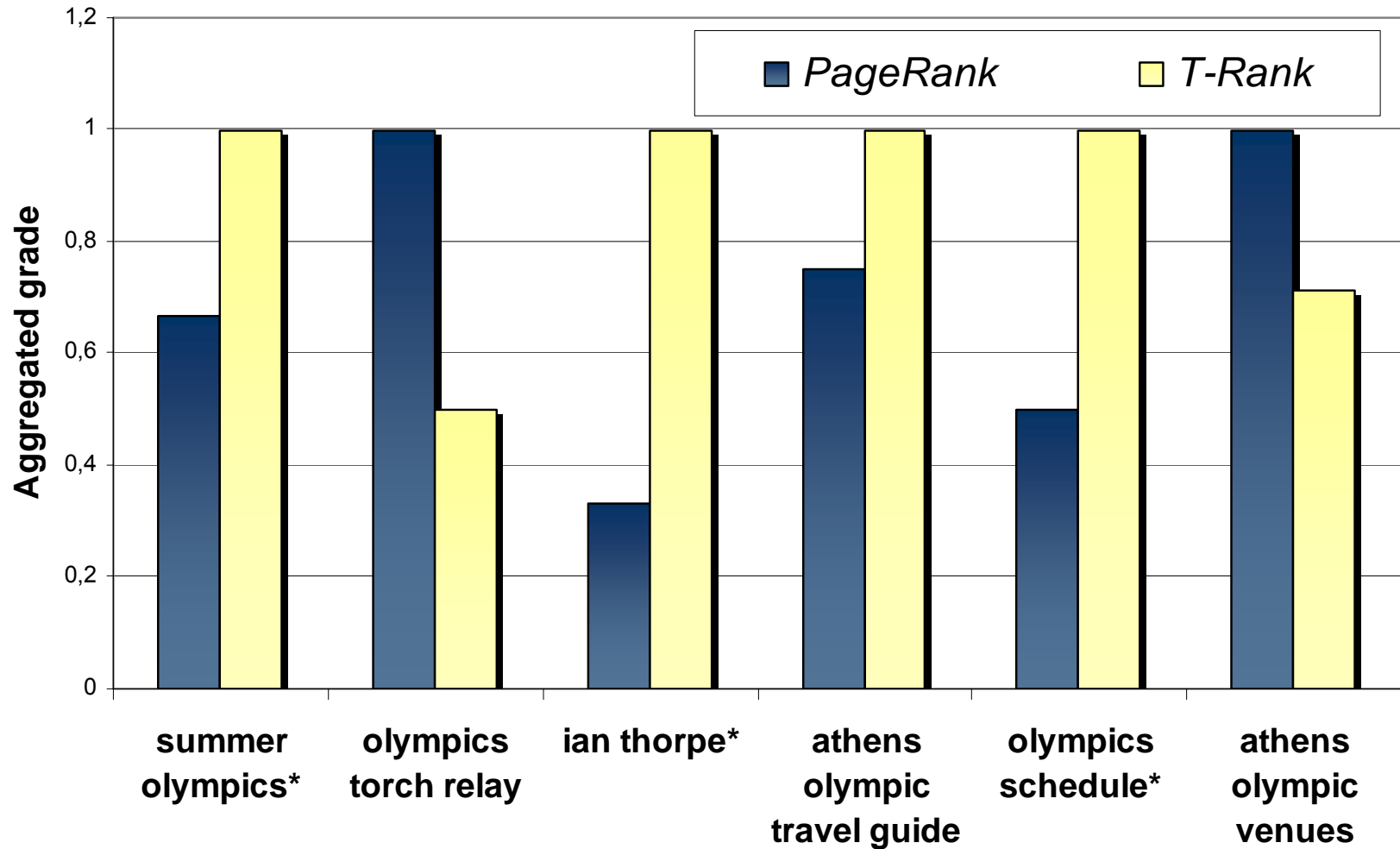
Evolving graph derived from DBLP: Authors as nodes, citations as edges

	<i>PageRank 2000s</i>	<i>T-Rank 2000s</i>
1	E. F. Codd	Jim Gray
2	Michael Stonebraker	Michael Stonebraker
3	Jim Gray	Jeffrey D. Ullman
4	Donald D. Chamberlin	Philip A. Bernstein
5	Jeffrey D. Ullman	Hector Garcia-Molina
6	Philip A. Bernstein	Jeffrey F. Naughton
7	Raymond A. Lorie	Donald D. Chamberlin
8	Morton M. Astrahan	David J. DeWitt
9	Kapali P. Eswaran	Jennifer Widom
10	John Miles Smith	Rakesh Agrawal

T-Rank Experiment: Web

- **Theme: Olympic Games 2004**
 - ~200K thematically related Web pages
 - 9 crawls in period July 26th to September 1st
- **Blind test** comparing *PageRank* and *T-Rank*
 - Users asked to **grade quality** of given top-10 lists
 - Half of the queries drawn from Google Zeitgeist

T-Rank Experiment: Web



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