

Web Dynamics

Part 1 - Introduction

1.1 Dimensions of dynamics in the Web

1.2 Application examples

Why Web Dynamics?

From Wikipedia:

*In physics the term **dynamics** customarily refers to the time evolution of physical processes.*

Which aspects of the Web are dynamic?

- **Size:** sites/pages added and deleted all the time

Number of sites on the Web

- 1998: 2,636,000 (IP addresses with HTTP server)
- 1999: 4,662,000
- 2000: 7,128,000, ~40% public, 40% dead
- 2001: 8,443,000
- 2002: 8,712,000

- 2007: 109 million sites (Netcraft)
- 2007: 433 million hosts on Internet (ISC)

1998 – 2002: <http://www.oclc.org/research/projects/archive/wcp/stats/size.htm>

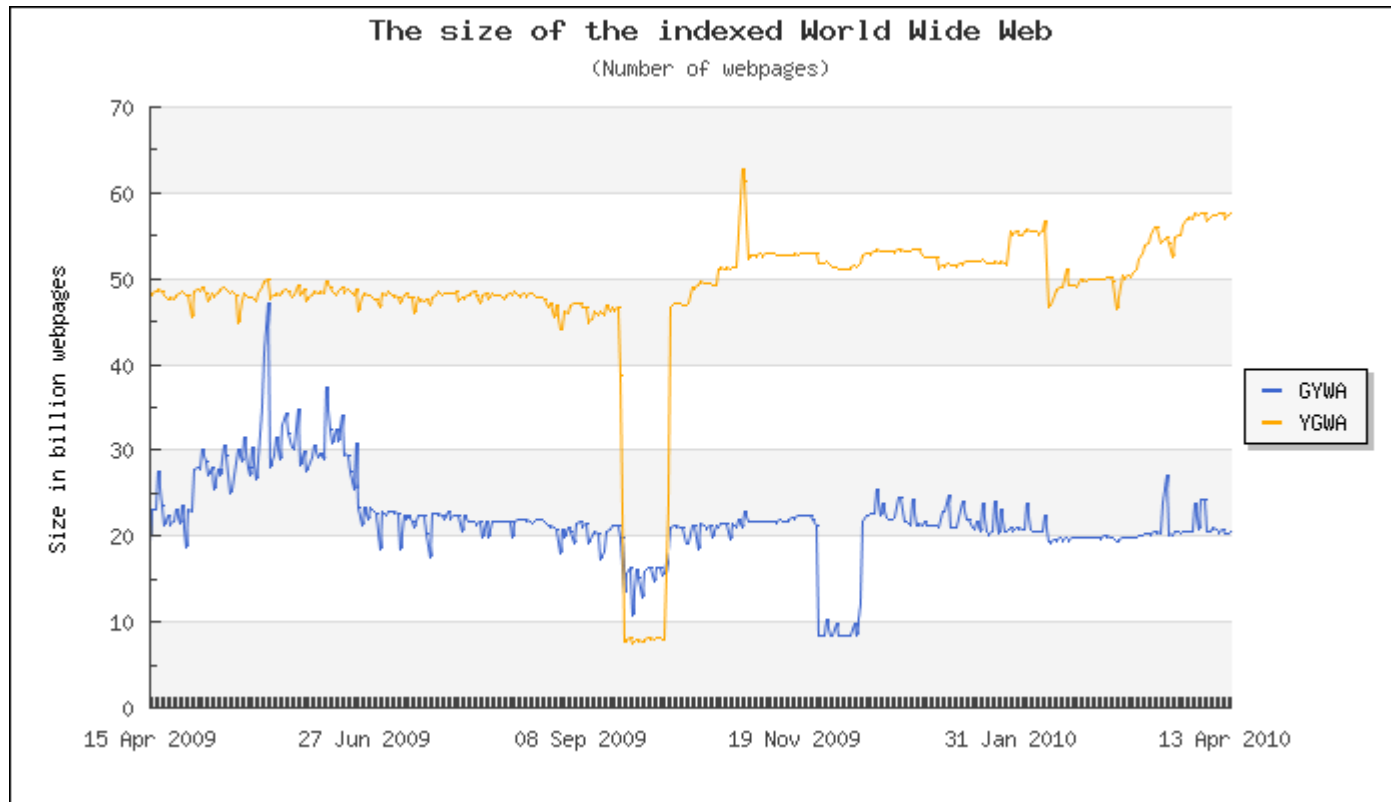
Size estimates for the (indexable) Web

- 1995: ~11.4 million docs (Bray)
- 1997: ~200 million docs (Bharat&Broder)
(sampling based on Hotbot, Altavista, Excite and Infoseek, overlap ~2%)
- 1998: >800 million docs (Lawrence&Giles)
- January 2005: 11.5 billion docs (Gulli&Signorini)
(sampling based on Google, MSN, Yahoo! and Ask/Teoma)
- 2005: 19.2 billion documents in Yahoo! index
- 2008: >1 trillion documents counted by Google

<http://googleblog.blogspot.com/2008/07/we-knew-web-was-big.html>



More size estimates



Estimates based on overlap of search engine results

(from <http://www.worldwidewebsite.com/>)

[We will discuss this technique later in the course]

The Web is infinite – and growing

- Non-indexable Web not seen by search engines („**Deep Web**“ behind forms):
 - est. 550 billion docs,
 - est. 7.5 petabytes in 2000 (Bright Planet)
- **User-generated content** (social networks, communities, wikis, blogs, ...)
- **Pages created on demand** („next week“ link in online calendars)

Some social networks

Flickr: (as of Oct 2009)

- 4+ billion photos (3 billion in Nov 2008, 2 billion in Nov 2007)
- 3 million new photos per day

Facebook: (as of Apr 2010) [<http://www.facebook.com/press/info.php?statistics>]

- 3+ billion new photos per month, 60 million status updates per day
- 400 million active users (120 million in Nov 2008, 31 million in Apr 2007)
- 150,000 new users per day in Nov 2008 (100,000/day in April 2007)

Myspace: (as of Apr 2007)

- 135 million users (6th largest country on Earth)
- 2+ billion images (150,000 req/s), millions added daily
- 25 million songs
- 60TB videos

StudiVZ.net: (as of Nov 2008)

- 11 million users
- 300 million images, 1 million added daily

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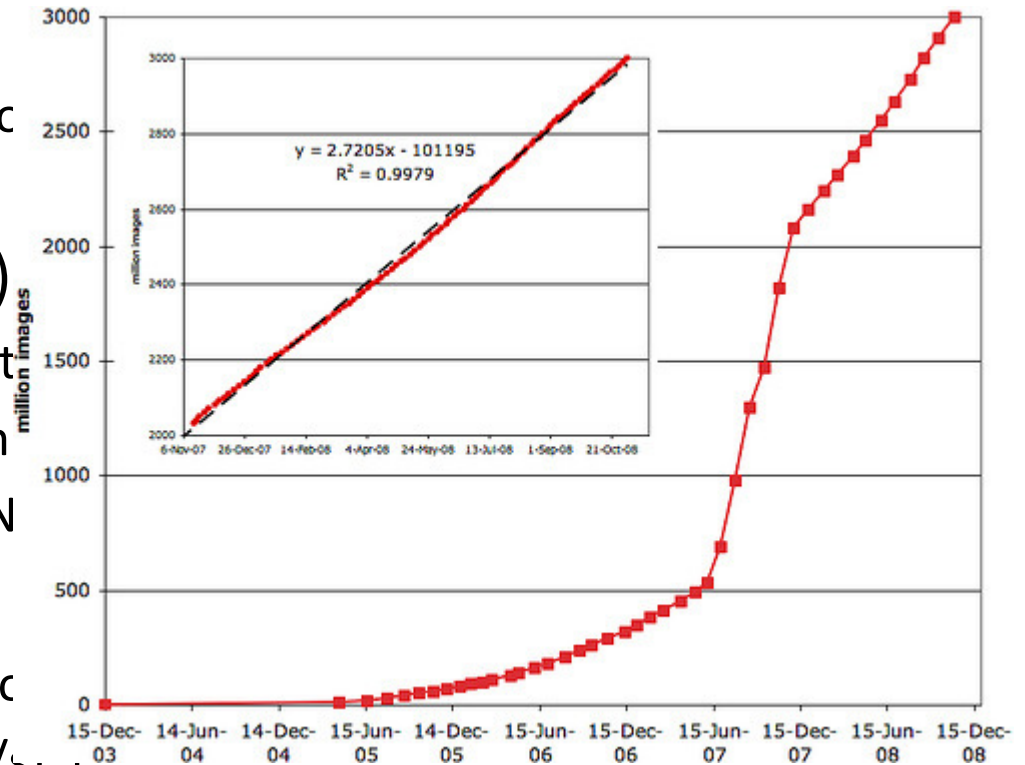
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Flickr growth rate 2004-2008,
from <http://www.flickr.com/photos/gustavog/3000686815/>

Some social networks

MySpace Infrastructure: (as of 2008)

- sending 100 gigabits of data per second to the Internet
 - 10 gigabits HTML content
 - 90 gigabits media (videos, pictures)
- 4500 web servers
- 1200 cache servers
- 500 database servers
- custom distributed file system

(from <http://en.wikipedia.org/wiki/MySpace> and <http://www.infoq.com/presentations/MySpace-Dan-Farino>)

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Challenges: Size dynamics

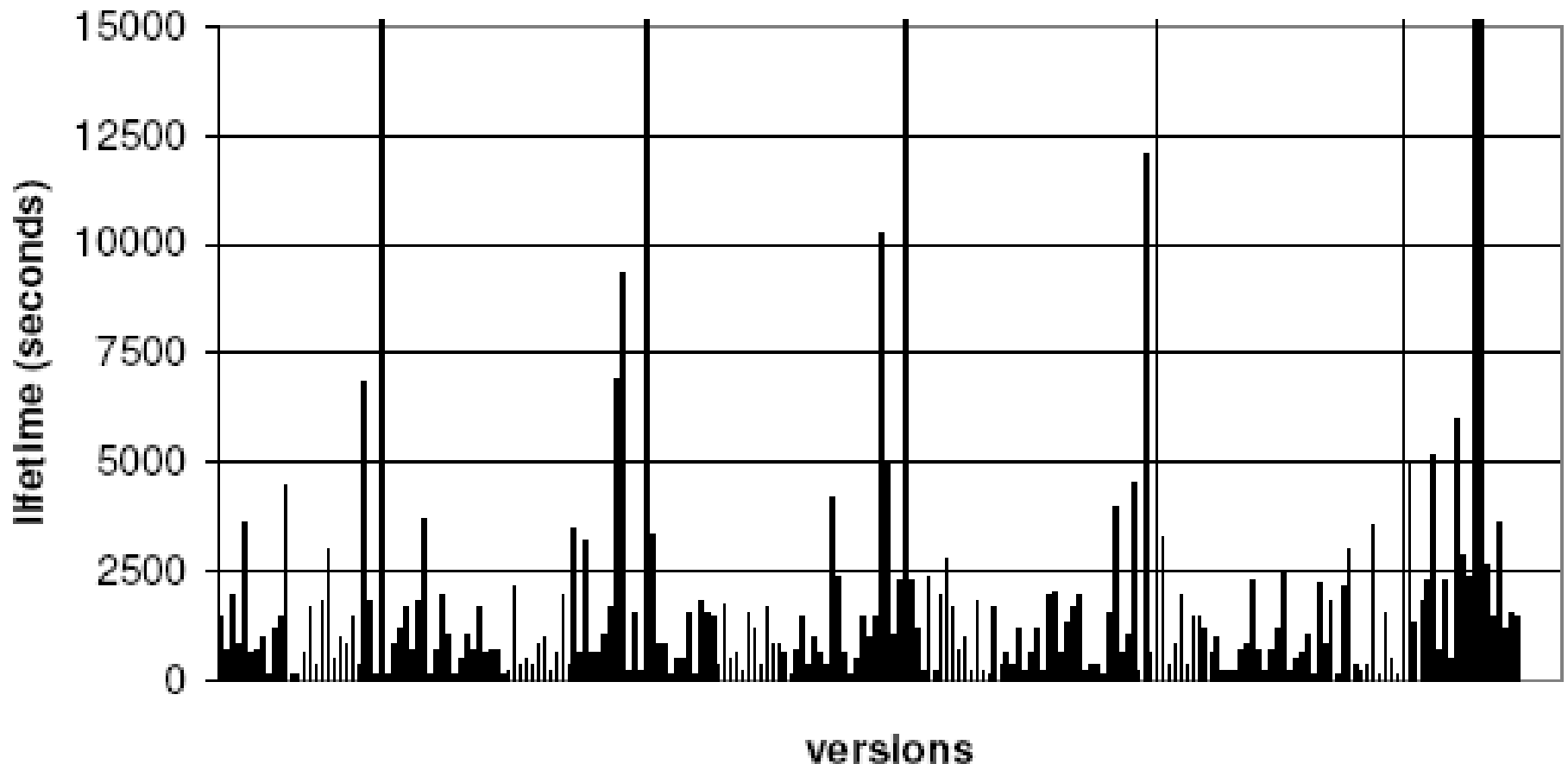
How can a search engine deal with „infinite“ Web?

- Massively parallel, distributed architecture (MapReduce, Hadoop, etc.)
- Detect and remove noise (duplicates, spam etc.)

Which aspects of the Web are dynamic?

- **Size:** pages added and deleted all the time
- **Content:** pages change all the time

Lifetime of versions on heise.de



High-frequency crawl of heise.de over one week in January 2009
new version when news item added or removed

[R. Schenkel, ECIR 2010]

Evolution of the Web (Ntoulas et al., 2004)

Large-scale study:

- October 2002 – October 2003
- Weekly crawls of 154 large Web sites (up to 200,000 pages per site)

Average page creation per week

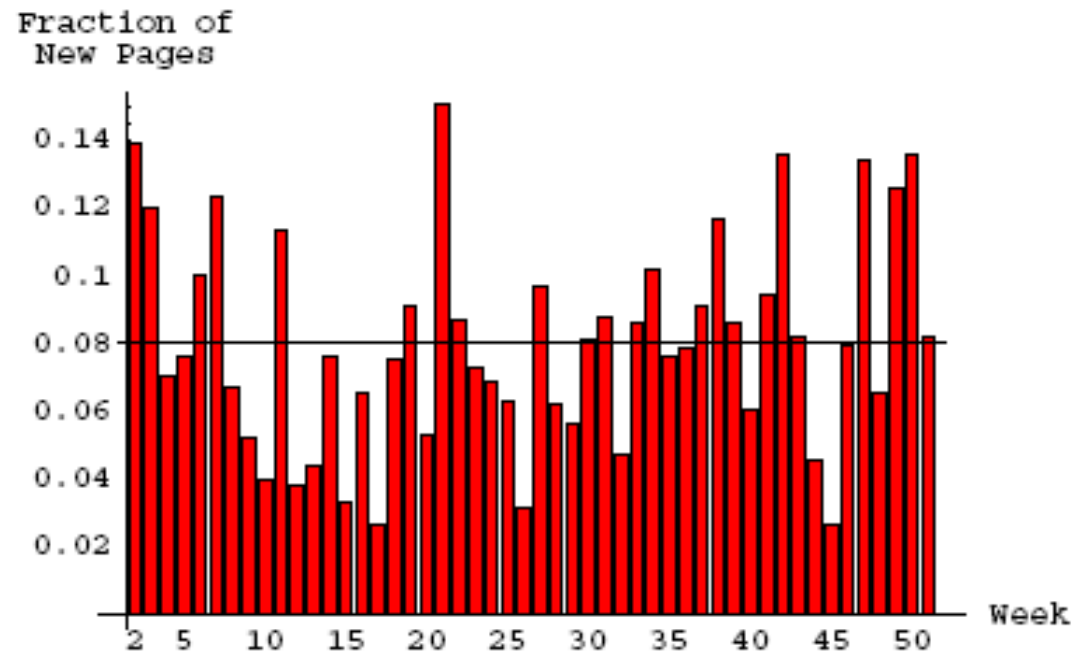


Figure 1: Fraction of new pages between successive snapshots.

About 8% new pages created per week

(A. Ntoulas, J. Cho, C. Olston: What's new on the Web? The Evolution of the Web from a search engine perspective, WWW Conference, 2004)

How long do pages live?

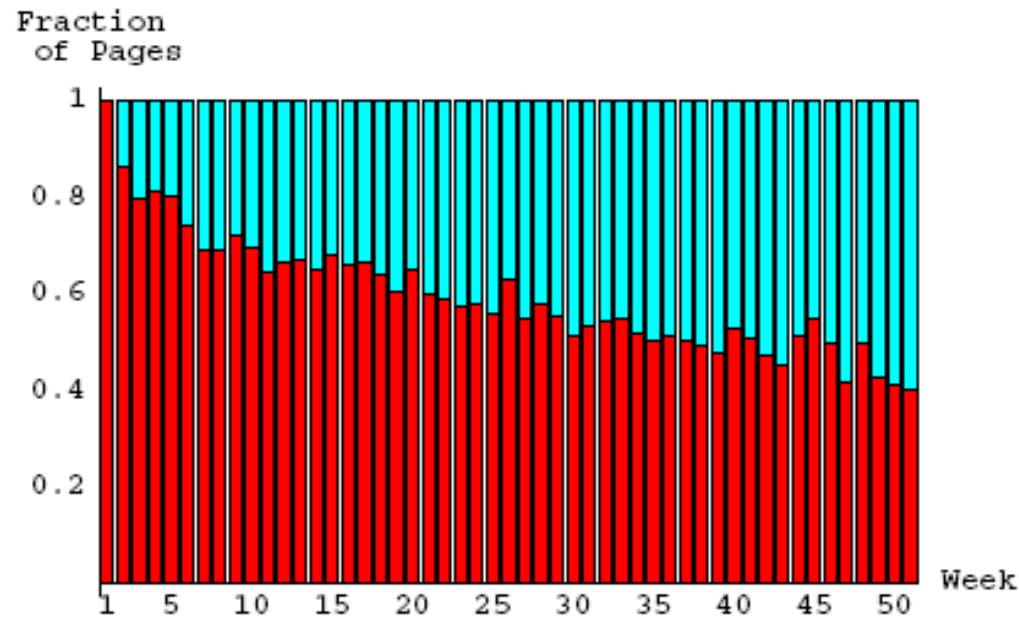


Figure 3: Normalized fraction of pages from the first crawl still existing after n weeks (dark bars) and new pages (light bars).

About 40% of the pages still available after one year

(A. Ntoulas, J. Cho, C. Olston: What's new on the Web? The Evolution of the Web from a search engine perspective, WWW Conference, 2004)

How frequently does a page change?

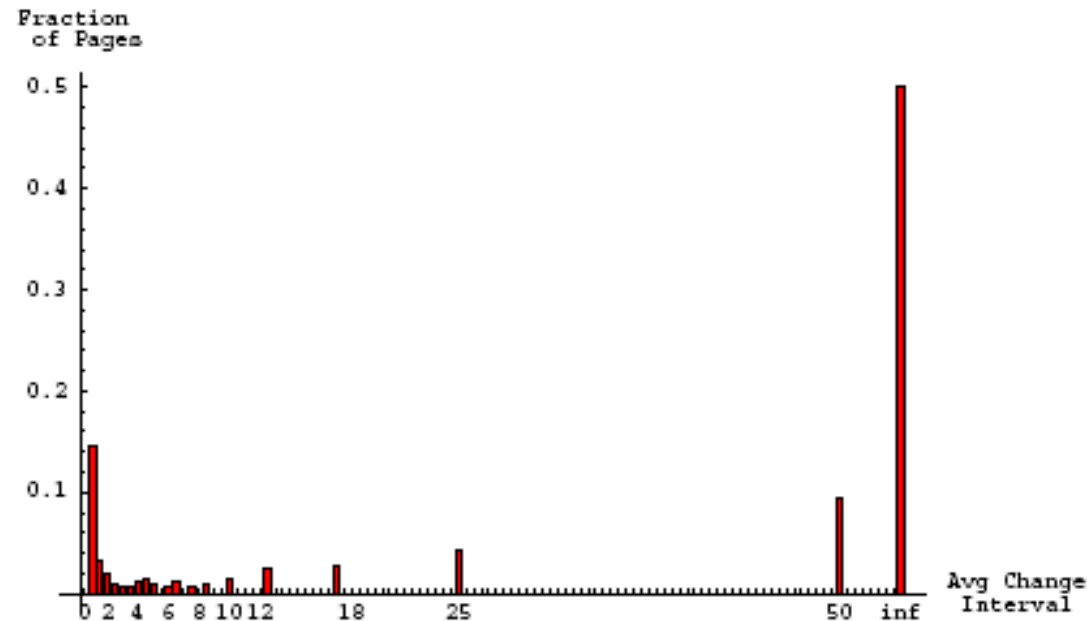


Figure 10: Distribution of the average change intervals of the pages.

Most pages never change, second most change at least weekly

(A. Ntoulas, J. Cho, C. Olston: What's new on the Web? The Evolution of the Web from a search engine perspective, WWW Conference, 2004)

How much do pages change?

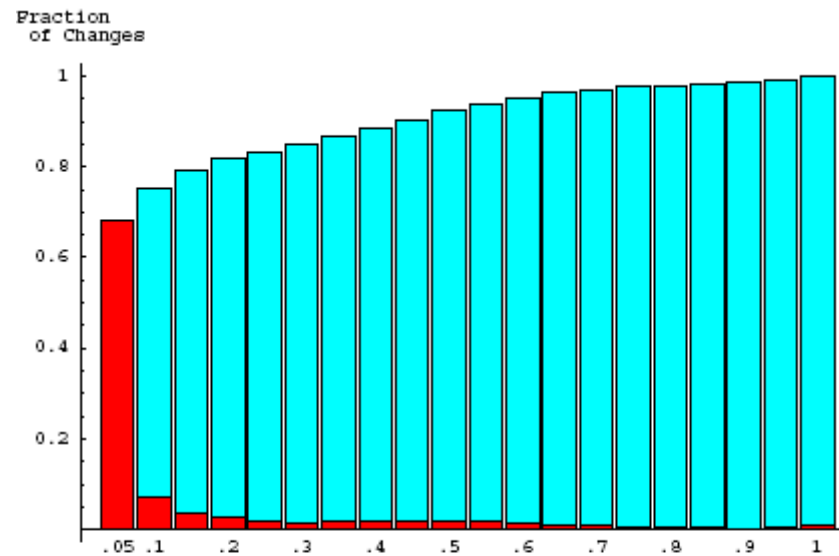


Figure 11: Distribution of cosine distance for all changes. Each dark bar corresponds to changes with cosine distance between the respective x-axis value and the previous one. For example, bin 0.1 corresponds to changes with cosine distance between 0.05 and 0.1. The light bars show the cumulative distribution.

Most of the changes are minor

(A. Ntoulas, J. Cho, C. Olston: What's new on the Web? The Evolution of the Web from a search engine perspective, WWW Conference, 2004)

How large are pages?

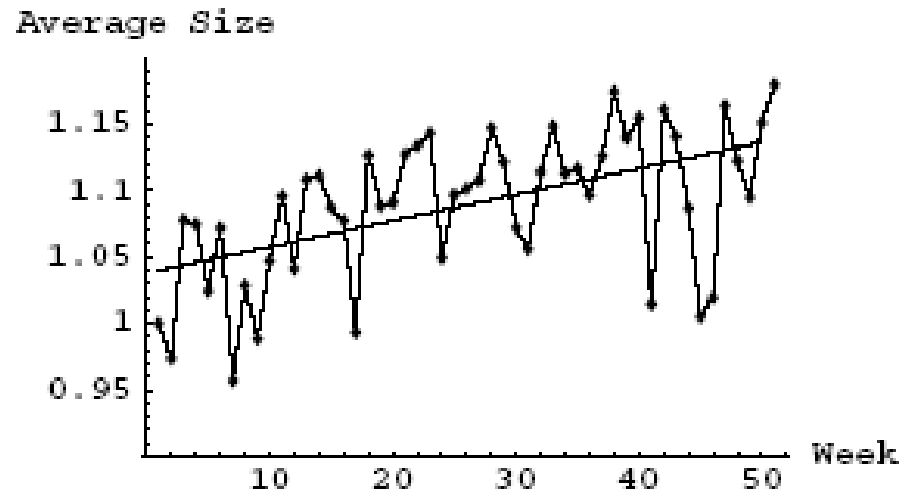


Figure 5: Average page sizes in our snapshots over time.

Average size raised by about 15% in one year

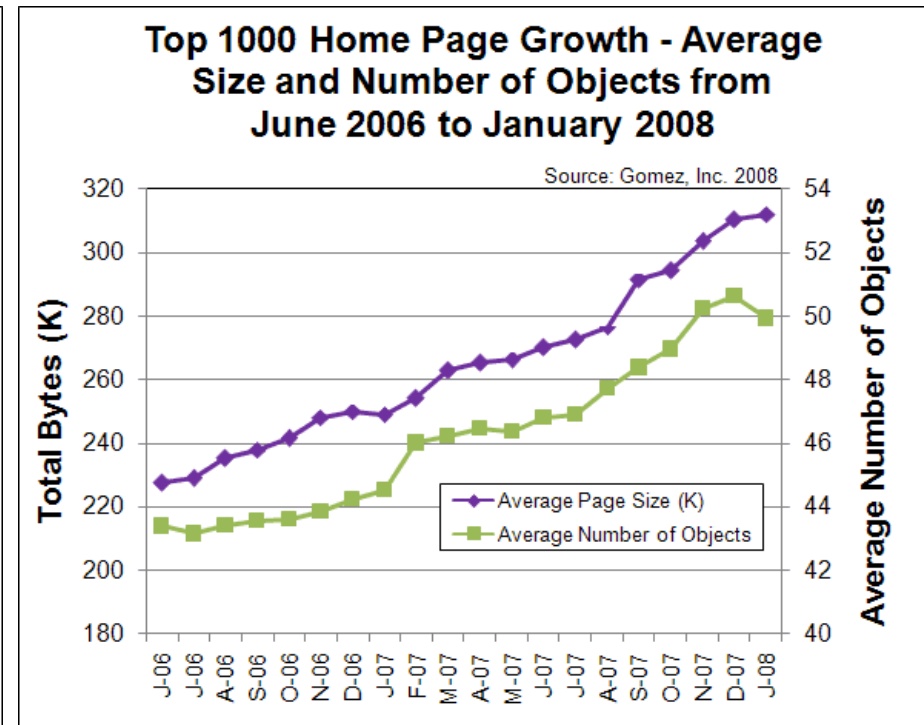
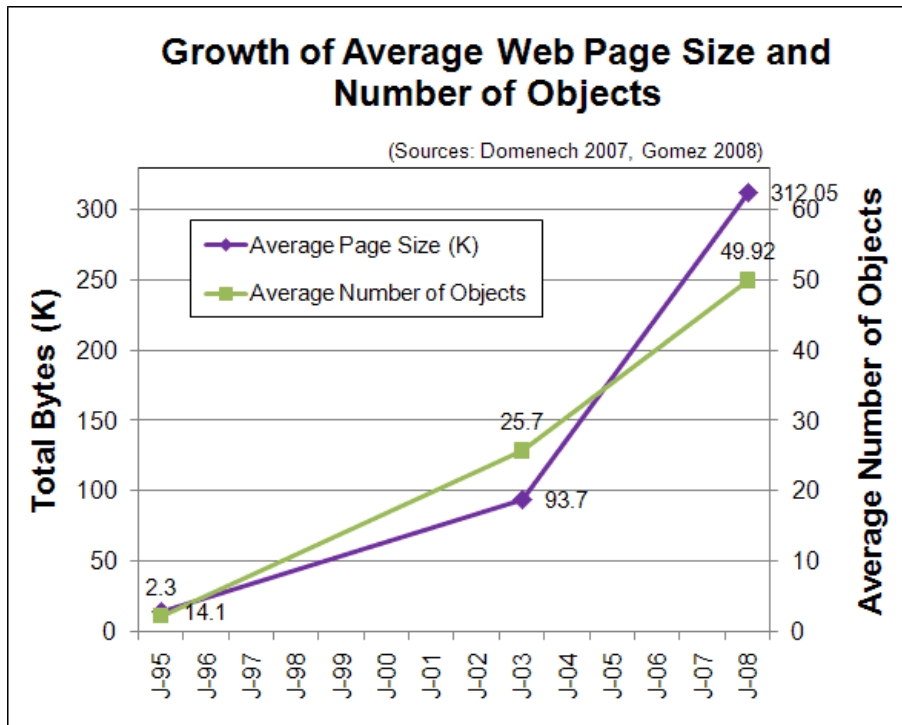
(A. Ntoulas, J. Cho, C. Olston: What's new on the Web? The Evolution of the Web from a search engine perspective, WWW Conference, 2004)

More recent numbers...

- Average size of Web pages more than tripled since 2003 from 93.7K to over 312K
- Average number of objects per Web page nearly doubled from 25.7 to 49.9
- Since 1995 average size of Web pages increased by 22 times
- Since 1995 average number of objects per Web page increased by 21.7 times

(from <http://www.websiteoptimization.com/speed/tweak/average-web-page/>)

More recent charts...



(from <http://www.websiteoptimization.com/speed/tweak/average-web-page/>)

Challenges: Content dynamics

How can a search engine maintain a reasonably accurate snapshot of the Web?

- Model how/when documents updated
- Recrawl policy based on expected changes
- Decide if a page's content changed (enough to replace old version in snapshot)

How can we maintain the Web of the past?

- Web archiving

Which aspects of the Web are dynamic?

- **Size:** pages added and deleted all the time
- **Content:** pages change all the time
- **Structure:** links added all the time (and dropped)

How frequently do links change?

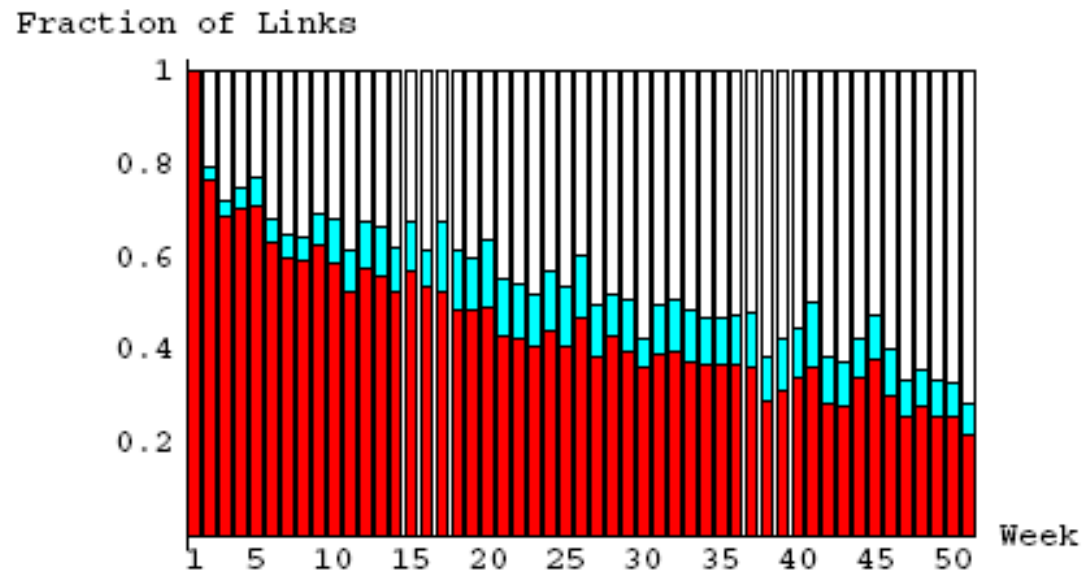


Figure 9: Normalized fraction of links from the first weekly snapshot still existing after n weeks (dark/bottom portion of the bars), new links from existing pages (grey/middle) and new links from new pages (white/top).

25% new links created per week, 80% of links replaced within a year

(A. Ntoulas, J. Cho, C. Olston: What's new on the Web? The Evolution of the Web from a search engine perspective, WWW Conference, 2004)

Challenges: Structure dynamics

How can a search engine maintain a reasonably accurate snapshot of the Web graph?

- Massively parallel, distributed architecture (MapReduce, Hadoop, etc.)
- Distributed approximation algorithms for computing authority measures (PageRank)

Which aspects of the Web are dynamic?

- **Size:** pages added and deleted all the time
- **Content:** pages change all the time
- **Structure:** links added all the time (and dropped)
- **Usage:** Behaviour of users changes all the time

Reasons why user behaviour changes

- Global trends and changes, Web 2.0
(Flickr, Youtube, social networks, twitter, ...)
 - Different situation/context
 - Roles (private vs. professional)
 - Locations (home vs. office vs. travelling)
 - Date & Time
 - Tasks (ordering a book, booking a flight, ...)
- ⇒ **influence browsing and search behaviour**

Challenges: User dynamics

How can a search engine adapt to changing users?

- Identify user (e.g., Google's cookie)
- Collect user behaviour
- Personalize search results based on past actions
- Personalize based on current context

This can be done

- For each user
- For groups of users
- For all users („global user model“)

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1.2 Application examples

Live Search in News Streams

angela merkel - Google Search - Windows Internet Explorer


http://www.google.com/#q=angela%20merkel&hl=en&tbo=1&tbs=mbl:1&ei=bvXG5958D8v_-QbN5I3wDw&sa=X&oi=tool&resnum=1&ct=tlink&ved=0CCcQpwU&fp=1a63c761c82b7fcd

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angela merkel - Google Search

Web [Images](#) [Videos](#) [Maps](#) [News](#) [Shopping](#) [Mail](#) [more](#) ▼ ralf.sch

 [Advanced Search](#)

[Web](#) > **Updates** [Hide options](#) Results 1

[All results](#)
[Images](#)
[Videos](#)
[News](#)
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› **Updates**
[Books](#)
[Discussions](#)

[Any time](#)
› **Latest**


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New results will appear below as they become available. [Pause](#)


A Visit to Hollywood: **Angela Merkel** Discovers Glitz and Glamour... - tinyurl.com/y324p93

 [SPIEGEL English](#) - [Twitter](#) - seconds ago


Angela Merkel's day in Hollywood with the stars - Bild.com ... - [More »](#)

 [terminator](#) - [FriendFeed](#) - 40 minutes ago

Als die Mauer fiel saß **Angela Merkel** in der Sauna. Aber wo war David Hasselhoff???

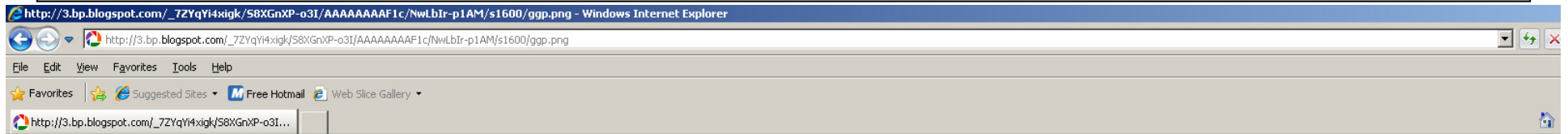
 [RealLifeOfBiene](#) - [Twitter](#) - 1 hour ago

Angela Merkel is in LA to support the German film making industry? Way to go.
facepalm

 [SunnyAnnie94](#) - [Twitter](#) - 1 hour ago

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April 1

Search in Past News Streams



golden gate park

Search

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Web > Updates [Hide options](#)

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[Videos](#)

[News](#)

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> Updates

[Books](#)

[Discussions](#)

[Any time](#)

> Latest

[Reset options](#)

[2010](#) > March

[Now](#)



SF counts its parking spaces. Finds that parking uses up space as big as **Golden Gate Park** (bigger than Central Park)

[Streetsblog San Francisco » San Francisco First City in the ...](#) - streetsblog.org



[JohnPetroDMI](#) - [Twitter](#) - Mar 30, 2010 8:27:07 am

Japanese Tea Garden, San Francisco, **Golden Gate Park** ... Photography.alltop

[Japanese Tea Garden, San Francisco, Golden Gate Park « California ...](#) -

myphotoscout.com



[Alltop Photo](#) - [Twitter](#) - Mar 25, 2010 2:24:49 pm

Google Trends: Hot Searches

Google Trends: volcanic eruptions, Apr 15, 2010 - Windows Internet Explorer
http://www.google.com/trends/hottrends?q=volcanic+eruptions&date=2010-4-15&sa=X

File Edit View Favorites Tools Help
Favorites Suggested Sites Free Hotmail Web Slice Gallery
Google Trends: volcanic eruptions, Apr 15, 2010

Google trends Search Trends
Tip: Use commas to compare multiple search terms.

Hot Searches (USA)

Apr 15, 2010 - [change date](#)
Updated 28 minutes ago

Hot Searches

11. [tim chapman divorce](#)
12. [meteor in wisconsin](#)
13. [oksana grigorieva](#)
14. [brooke white america...](#)
15. [ugly betty finale](#)
16. **volcanic eruptions**
17. [lebron flocka james ...](#)
18. [kaki king](#)
19. [south park 200th epi...](#)
20. [billie holiday](#)

Showing 11 - 20
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Hot Topics (USA)

1. [volcano in iceland](#)
2. [tea party](#)
3. [katie stevens](#)
4. [uk airports](#)
5. [obama nasa](#)

volcanic eruptions

Hotness: **Mild**

Related searches:
bbc news, volcanic eruption, volcanic eruption in iceland, volcanic eruption iceland, iceland volcanic activity

Peak:
3 hours ago

Time	Search Volume index
PDT 6AM	Low
12PM	Low
6PM	Low
Apr 15	High

News articles

[Iceland volcano: volcanic eruptions and activity around the world - right](#)
The Guardian (blog) - 24 minutes ago
The best source is the Global Volcanism Program, which compiles a rolling tally of volcanic activity across the globe. This is the list of what's happening ...

[How volcanic eruptions affect weather plans](#)
Independent - 3 hours ago
Volcanic eruptions sending ash and gas into the atmosphere can have a massive effect on the weather. In 1815 a huge eruption on the Indonesian island of ...

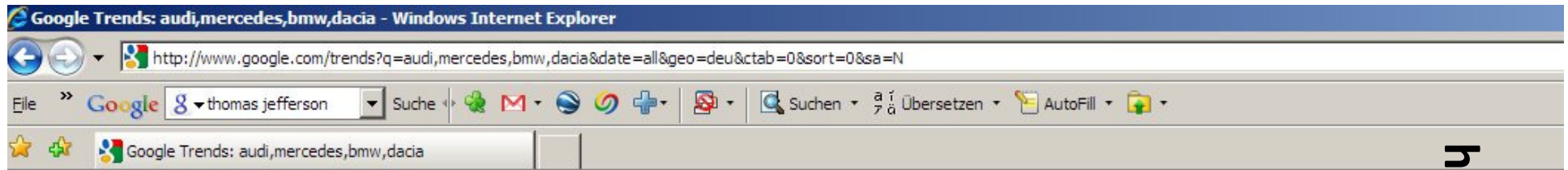
[Volcanic ash sees all Dublin flights grounded](#)

Blog posts

[How volcanic eruptions affect weather plans : HMS Weather](#)
3 hours ago
How **volcanic eruptions** affect weather plans. April 15, 2010 by adm
Leave a Comment. **Volcanic eruptions** sending ash and gas into the atmosphere can have a massive effect on the weather. Go here to see the rest: ...
<http://www.hmsweather.com/>

[Volcanic eruptions UK Flights - MotorhomeFun](#)
1 hour ago
Hi, This sounds a bit worrying as I assume this cloud has got to come down somewhere, and knowing my luck it will be over Norfolk as the where we

Google Trends: Search stats



audi,mercedes,bmw,dacia

Search Trends

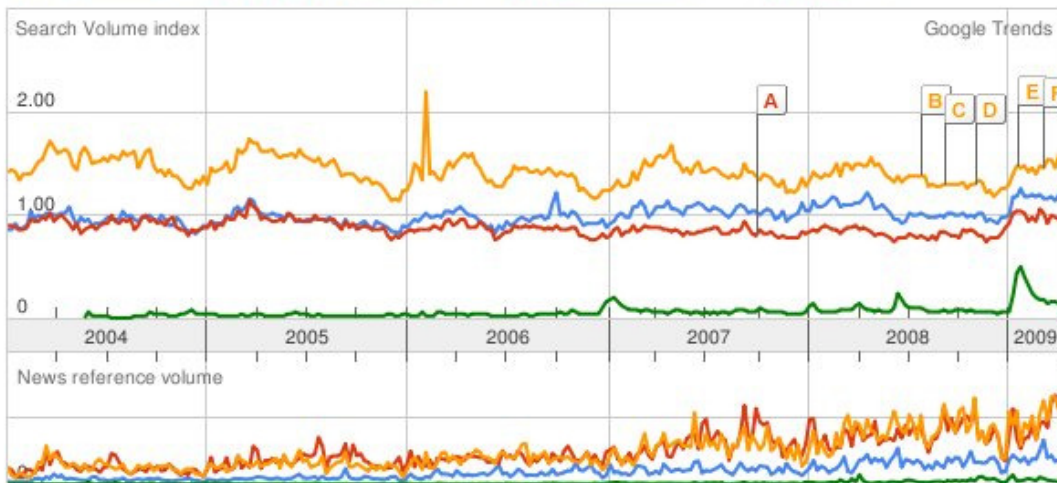
Tip: Use commas to compare multiple search terms.

Searches [Websites](#)

Germany

Scale is based on the average traffic of **audi** from Germany in all years. [Learn more](#)

audi 1.00 mercedes 0.88 bmw 1.42 dacia 0.06



- A** [Daimler revives the Mercedes-Benz brand](#)
Euronews.net - Oct 4 2007
- B** [BMW's 2Q profit slides, dumps profit forecast](#)
Boston Herald - Aug 1 2008
- C** [Villegas wins BMW Championship](#)
cbs4qc.com - Sep 7 2008
- D** [BMW 3Q net profit falls 63 percent](#)
Washington Times - Nov 4 2008
- E** [BMW, Volkswagen reduce work hours](#)
The Oregonian - OregonLive.com - Jan 20 2009
- F** ['Swiss Gigolo' admits to defrauding BMW heiress](#)
The Flint Journal - MLive.com - Mar 9 2009

[More news results »](#)

Rank by

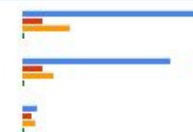
Subregions

- [Bayern](#), Germany
- [Baden-Württemberg](#), Germany
- [Niedersachsen](#), Germany



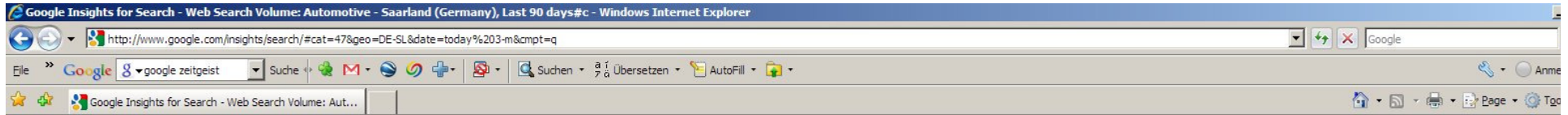
Cities

- Ingolstadt, Germany
- Isernhagen, Germany
- Heilbronn, Germany



http://www.google.com/trends

Google insights: Trends in searches



raif.schenkel@gmail.com | [My Account](#) | [Help](#) | [Sign out](#) | [Download as CSV](#)

Compare by

- Search terms
- Locations
- Time Ranges

Search terms

Tip: Use quotation marks to match an exact phrase. ("table tennis")

- All search terms
- [+ Add search term](#)

Filter

Web Search

Germany Saarland

Last 90 days

Automotive

Web Search Volume: Automotive

Saarland (Germany), Last 90 days

[All Categories](#) > Automotive

Interest over time

News is unavailable for specific categories.

[Learn what these numbers mean](#)



Search terms in Automotive Saarland, Last 90 days

Top searches

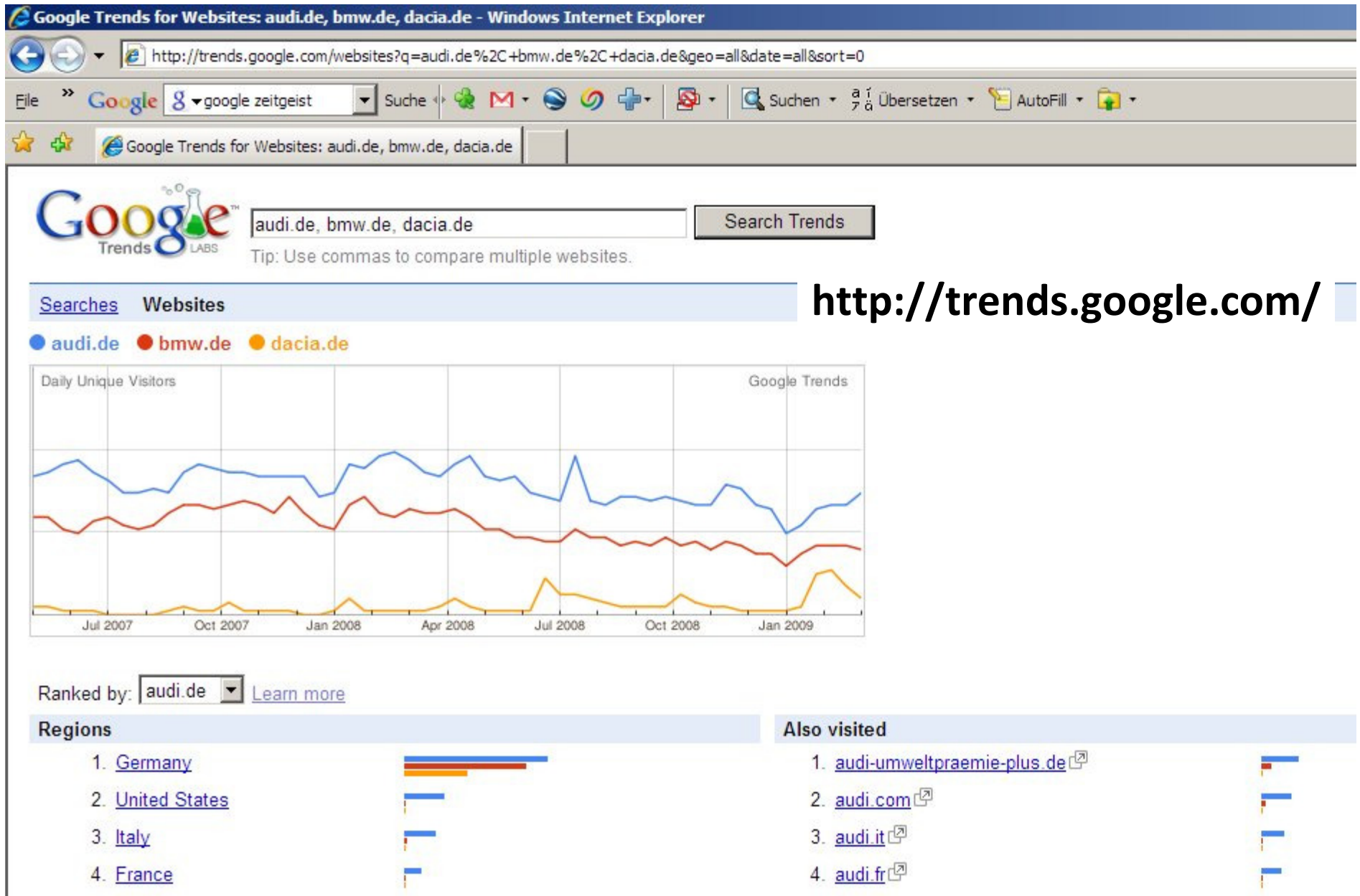
1.	bmw	100
2.	auto	95
3.	vw	90
4.	ford	90
5.	audi	85
6.	peugeot	70
7.	opel	65
8.	mercedes	65

Rising searches

1.	hyundai	+140%
2.	jahreswagen	+110%
3.	felgen	+90%
4.	dacia	+90%
5.	polo	+70%
6.	fiat	+70%
7.	skoda	+60%
8.	seat	+60%

<http://www.google.com/insights>

Google Website trends: access stats



Google News Timeline: News trends

Google News Timeline - Windows Internet Explorer

http://newstimeline.googlelabs.com/?q=financial+crisis&corpus=news

Google News Timeline

Google News Timeline Labs

News climate change

Example: financial crisis

http://newstimeline.googlelabs.com/

Climate Change News Time Magazine Wikipedia Events Add More Queries

Show: Decade Size: Medium Date: Go

1930s	1940s	1950s	1960s	1970s	1980s	1990s	2000s	2010s
<p>February 23rd, 1931 COOL CHANGE AFTER THE HOT SPELL A Storm Study Canberra Times: COOL CHANGE AFTER THE HOT SPELL. <A Stfmm Study>... i Thei capicious nature of the climate in Canberra Was demostiated pn Sat- ...</p> <p>January 30th, 1932 PHAR LAP IN MEXICO. THE PROBLEM OF REVERSED SEASONS. The Argus: phantom climate. Change of hemisphere in the South African ovar led to frightful mortality among English horses, for the poor beasts had to face the ?wind- ...</p> <p>February 23rd, 1934 Display Advertising Canberra Times: how unsuited it is to our., life and climate! Change to the 1934 breakfast crisp, ready-to-eat, nour- ishing Kellogg's Corn Flakes. You'll enjoy a ...</p> <p>April 13th, 1934 Display Advertising Canberra Times: life and climate! Change to the 1934 breakfast crisp, ready-to-eat, nour- ishing Kellogg's Corn Flakes. You'll enjoy a new feeling of energy! ...</p> <p>October 19th, 1934 Display Advertising Canberra Times: life and climate! Change to the 1934 breakfast crisp, ready-to-eat, nour- ishing Kellogg's Corn Flakes. You'll enjoy a new feeling of energy! ...</p> <p>December 7th, 1934 Display Advertising</p>	<p>August 4th, 1940 Season Change Held To Raise Quake Dangers . St. Petersburg Times: St. Petersburg Times: ... he said, when changing climate conditions produce a transport of Urge sir masses from one hem I to another A change in mass distribution on the earth re ...</p> <p>December 21st, 1942 Worm Weather Greets Eagles . St. Petersburg Times: Why, they had to shovel snow off the field so we could run signals He expects no particular difficulty from the change in climate. can handle heat in two ...</p> <p>November 15th, 1943 Background and Results Time Magazine: Change of Climate. The first tangible result of Moscow was a fundamental change in the diplomatic climate of Europe. Areas of disagreement, acts that ...</p> <p>January 22nd, 1945 South Wind A Political Change In The South . St. Petersburg Times: Times: A more benign voting climate is in the making. The effects of the Atlanta conference may not be visible for some time, but I will hazard this forecast ...</p> <p>October 25th, 1945 BEAUTIFICATION OF CANBERRA STREETS Change-Over to Permanent Trees Canberra Times: Times: A more benign voting climate is in the making. The effects of the Atlanta conference may not be visible for some time, but I will hazard this forecast ...</p>	<p>February 16th, 1950 Weather Changes Abruptly . St. Petersburg Times: JT Drip of The Times, who has been demanding a change in climate for days, was not available for comment last night. Weathermen explained that a cold air ...</p> <p>September 1st, 1951 Ginkgo Logs Exceptional In Forest. More Familiar American Trees Outnumber Them . Ellensburg Daily Record: tropical climate withdrew southward. The countless kinds of new virile ... Series of raft Evolution naturally advances most where conditions change the most ...</p> <p>November 25th, 1952 No Place To Hide David Lawrence A Change In The Washington Climate . Rome News-Tribune: in the Washington climate The cabinet appointments already announced by President-elect Eisen hower indicate it. No longer will the political class ...</p> <p>February 2nd, 1954 Ike Puts Tremendous Job In Hands Of Businessmen . St. Petersburg Times: St. Petersburg Times: We're set to do s lot more to help. we're going to change the tax laws to you ... favorable climate here then is your favorable climate Mr. Businessman. the ...</p>	<p>October 5th, 1961 The World BA Warmer Place To Live . St. Petersburg Times: What's wrong is the people who live in the climate don't change enough Yesterday's High Law. JT Drip. Times meteorologist who was not invited to the an ...</p> <p>September 15th, 1962 Forecaster Predicts Milder Winter Here. Science And You . Pittsburgh Post-Gazette: He says we're about at the point where the climate will change from warm and dry. ... One reason for their skepticism was their bell'he that climate change ...</p> <p>March 4th, 1965 Change Of Climate Lent Needed In Capital, Too James J. Kilpatrick . The Evening Independent: time, here in our own country, when priests and ministers exhort their flocks to get back to fundamentals. In every town of any size, these next six weeks ...</p> <p>October 26th, 1966 Climate May Not Help Lung Case . Pittsburgh Post-Gazette: There is this one thing to be said for change in climate. ... That is why I am always reluctant to recommend a change in climate. Too often it doesn't help. ...</p> <p>December 4th, 1966 For A fair climate . St. Petersburg Times: Times: A more benign voting climate is in the making. The effects of the Atlanta conference may not be visible for some time, but I will hazard this forecast ...</p>	<p>August 2nd, 1970 Supersonic Transport. Abruptly . St. Petersburg Times: Times: increasing quantities of carbon dioxide in the atmosphere believed to raise temperatures by the greenhouse effect has resulted in little climate change in ...</p> <p>May 1st, 1972 Ling2 and Hsing2 Time Magazine: ... two woebegone musk oxen that arrived with scraggly coats and postnasal drip brought on by the climate change and general cultural shock. ...</p> <p>May 26th, 1972 Summit Creating A Change In International Climate . The Evening Independent: summit already has accomplished much toward creating a different sort of international climate. Is the Kremlin changing Is the So viet leadership mellowing ...</p> <p>June 6th, 1972 Reports Global Climate Change . The Virgin Islands Daily News: George former wildlife biologist for the Virgin Islands, suggested recently that Virgin Islanders would have to decide whether they would rather have the ...</p> <p>June 21st, 1974 The Ominous Change In Britain's Climate . St. Petersburg Times: Times: A more benign voting climate is in the making. The effects of the Atlanta conference may not be visible for some time, but I will hazard this forecast ...</p>	<p>November 26th, 1981 Mars climate change: where are the petroglphs? Nature.com: El-Baz, F. in J. geophys. Res. 3rd int. Colloq. on Mars Spec. Issue (in the press). Sharp, RP & Malin, MC Bull. geol. Soc. Am. 86, 593 (1975). ...</p> <p>February 25th, 1983 Global Mean Sea Level: Indicator of Climate Change? Science Magazine: CESS, RD, THE EFFECT OF OCEAN HEAT-CAPACITY UPON GLOBAL WARMING DUE TO INCREASING ATMOSPHERIC CARBON-DIOXIDE, JOURNAL OF GEOPHYSICAL RESEARCH-OCEANS AND ...</p> <p>July 17th, 1987 01:23 InfoWorld: Product Guide: pktstat : Company infoworld.com: "Climate change is a very real danger facing the world today," said Dr. Zhongrong Shi ... 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The Bush administration's unwillingness to seriously confront global warming was increasingly at odds with the rest of the ...</p> <p>October 29th, 2006 £3.68 trillion: The price of failing to act on climate change guardian.co.uk: Britons face the prospect of a welter of new green taxes to tackle climate change, as the most authoritative report on global warming warns it will cost the ...</p> <p>November 15th, 2006 UN's Annan warns of 'frightening lack of leadership' over climate change</p>	

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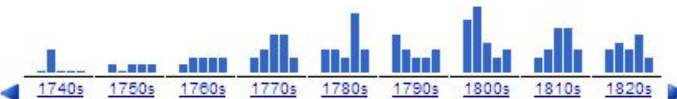
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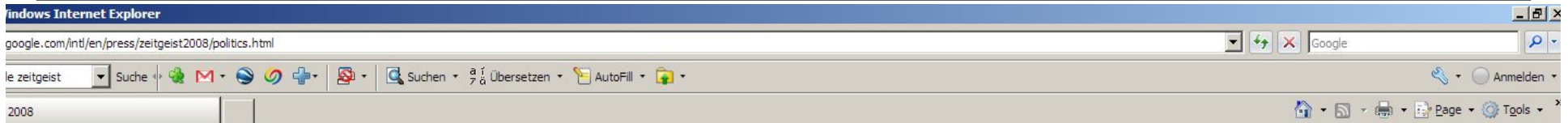
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Apr. 13, 1743 - **Jefferson** was born at Shadwell in what is now Albemarle County, Va., on Apr. 13, 1743. He treated his pedigree lightly, but his mother, Jane Randolph **Jefferson**, ...
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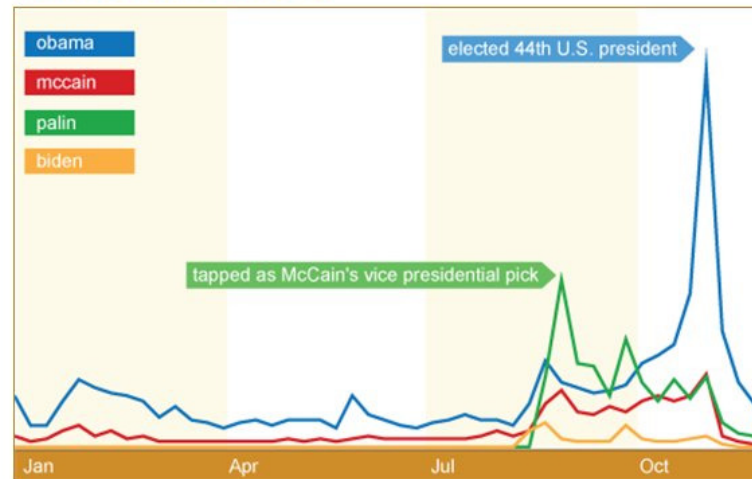
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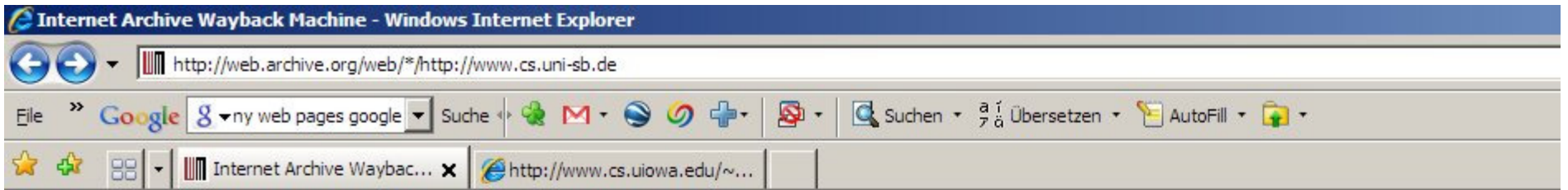
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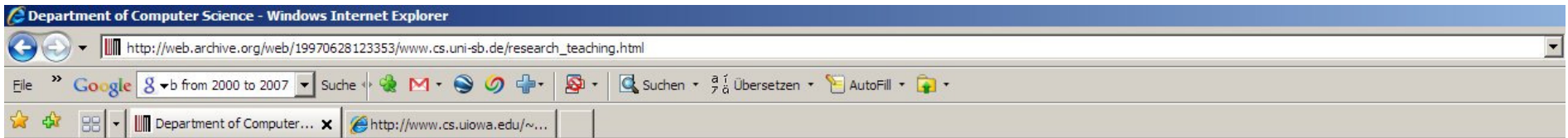
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