

# Understand and Supporting People in Dynamic Information Environments

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*In collaboration with:*

Jaime Teevan, Eytan Adar, Jon Elsas, Dan Liebling, Richard Hughes



# Overview



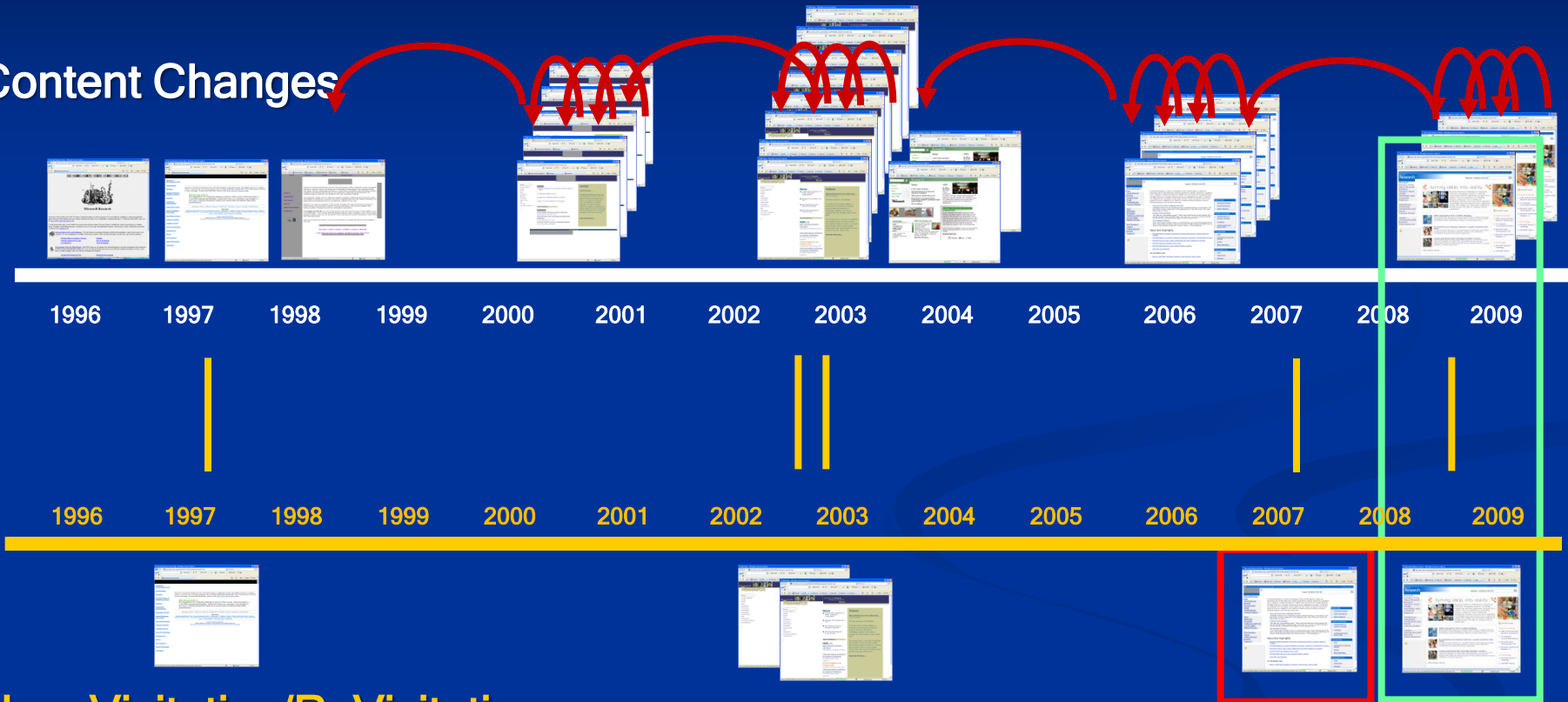
- Many differences between physical & digital libraries
- **Temporal dynamics of digital information**
  - Characterizing change
    - Content changes over time
    - People re-visit and re-find over time
    - Relationships between change and re-access
  - Improving retrieval and understanding
    - Building tools for understanding change
    - Building models and systems that leverage dynamics
  - Web search and browser support as examples

❖ 35% of Web pages change in 11 wks

❖ 66% of visited Web pages change in 5 wks  
... of these, 63% change every hour

# Information Dynamics

## Content Changes



## User Visitation/ReVisitation

## Today's Browse and Search Experiences

But, ignores ...

# Digital Dynamics Easy to Capture

- Easy to capture
- But ... few tools support dynamics



# Information Dynamics

- Characterizing change
  - Content changes over time
  - People re-visit and re-find
  - Relationships between change and re-access
- Improving retrieval and understanding
  - Building support for understanding change (e.g., DiffIE)
  - Building models and systems that can leverage dynamics (e.g., temporal IR models)

# Characterizing Change

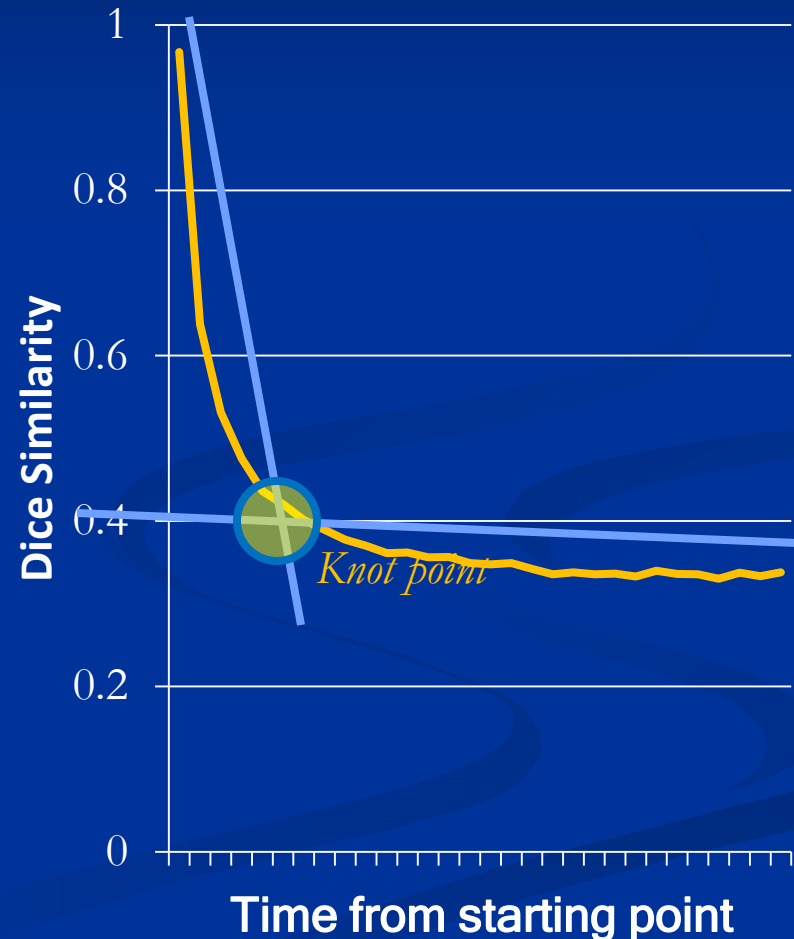
## Content Changes



- Large-scale Web crawls, over time
  - Revisited pages
    - 55,000 pages crawled hourly for 18+ months
    - Unique users, visits/user, time between visits
  - Pages returned by search engine (for ~100k queries)
    - 6 million pages crawled every two days for 6 months

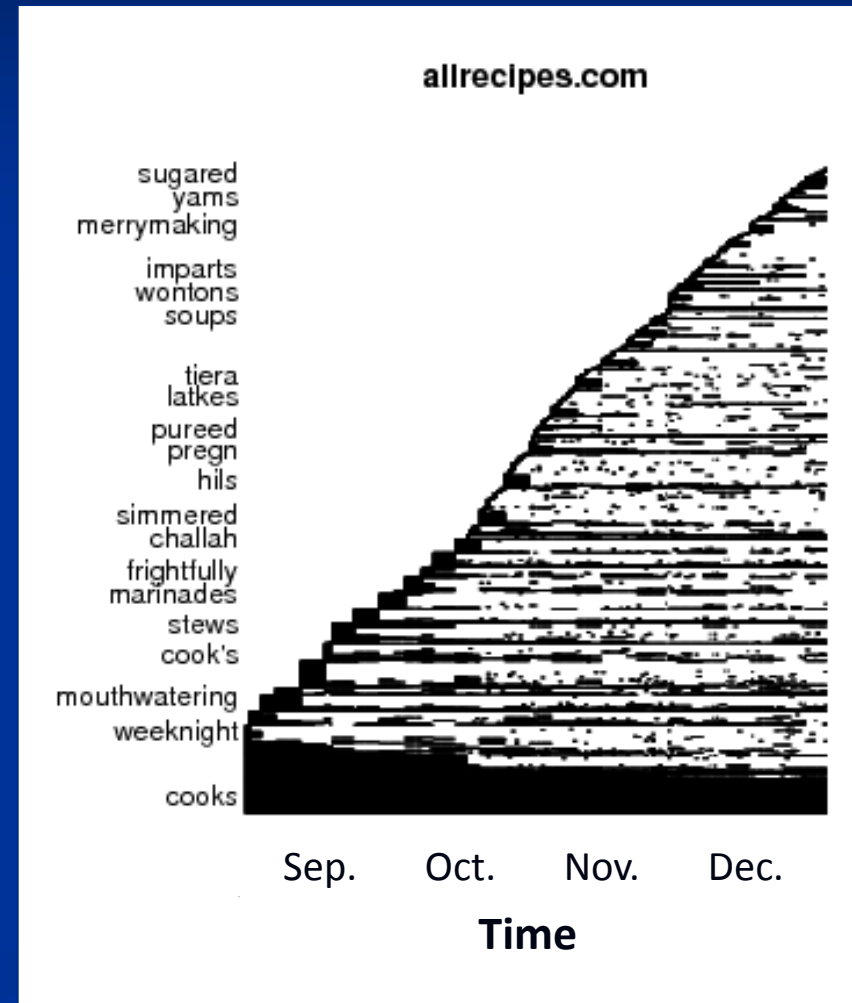
# Measuring Web Page Change

- Summary metrics
  - Number of changes
  - Amount of change
  - Time between changes
- Change curves
  - Fixed starting point
  - Measure similarity over different time intervals



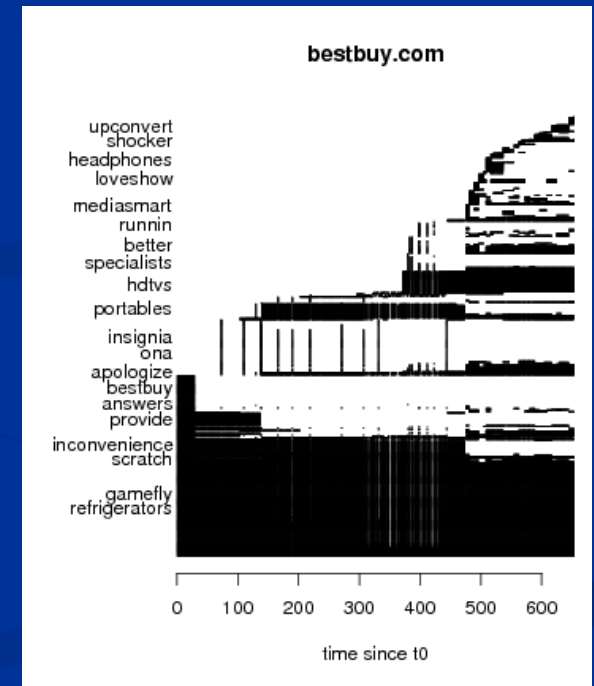
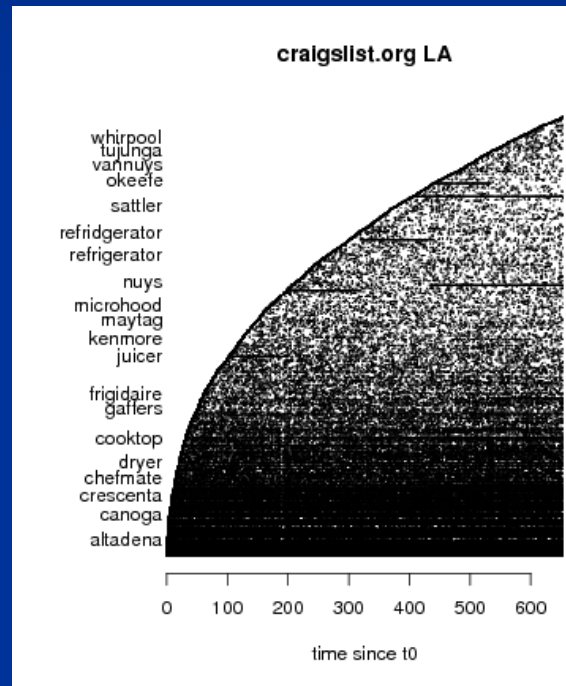
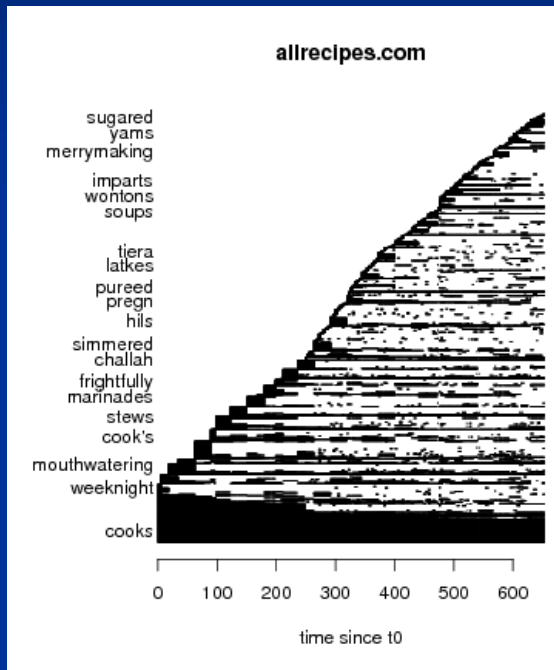
# Measuring Within-Page Change

- DOM structure changes
- Term use changes
  - Divergence from norm
    - cookbooks
    - salads
    - cheese
    - ingredient
    - bbq
  - “Staying power” in page





# Example Term Longevity Graphs



# Revisitation on the Web

- Revisitation patterns
  - Log analyses
    - Toolbar logs for *revisitation*
    - Query logs for *re-finding*
  - User survey to understand intent in revisitations

1996

1997

1998

1999

2000

2001

2002

2003

2004

2005

2006

2007

2008

2009

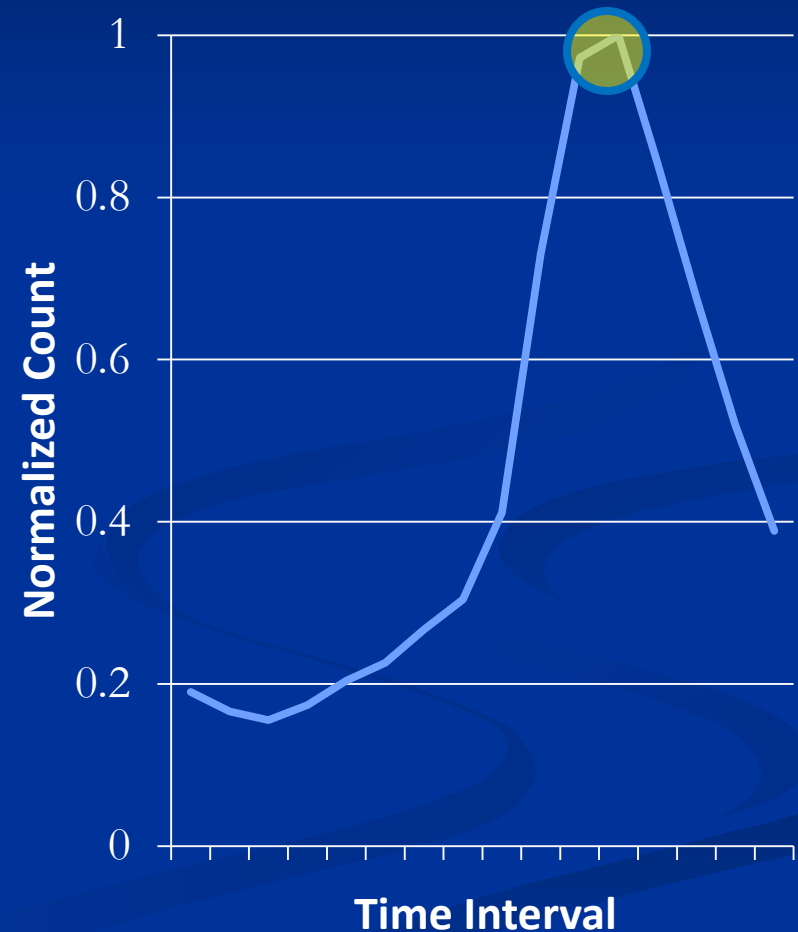


User Visitation/ReVisitation

What was the last Web page you visited?

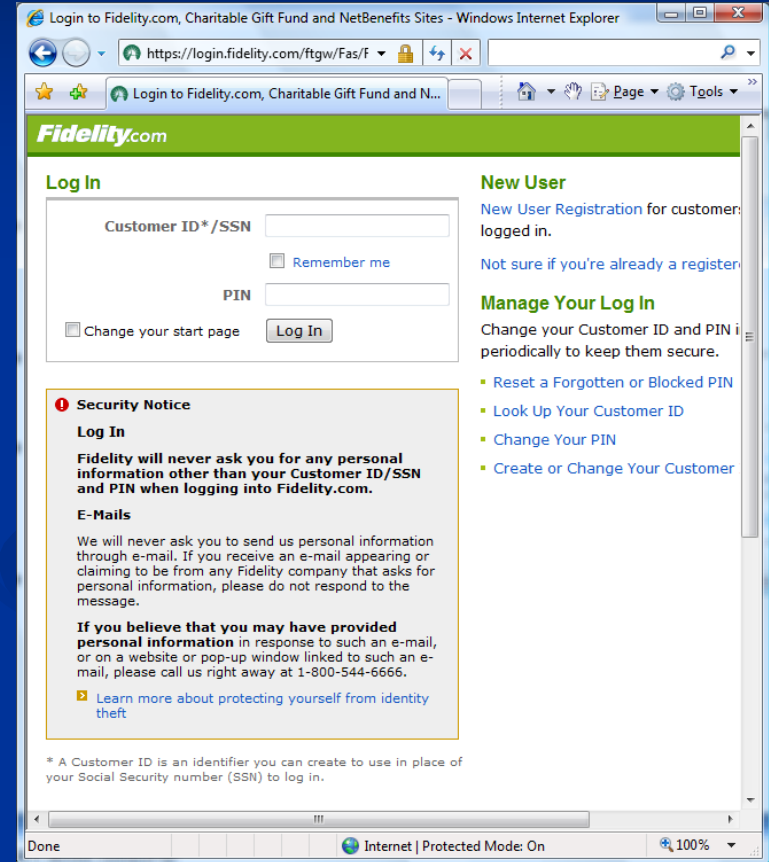
# Measuring Revisitation

- Summary metrics
  - Unique visitors
  - Visits/user
  - Time between visits
- Revisitation curves
  - Histogram of revisit intervals
  - Normalized



# Four Revisitation Patterns

- *Fast*
  - Hub-and-spoke
  - Navigation within site
- *Hybrid*
  - High quality *fast* pages
- *Medium*
  - Popular homepages
  - Mail and Web applications
- *Slow*
  - Entry pages, bank pages
  - Accessed via search engine

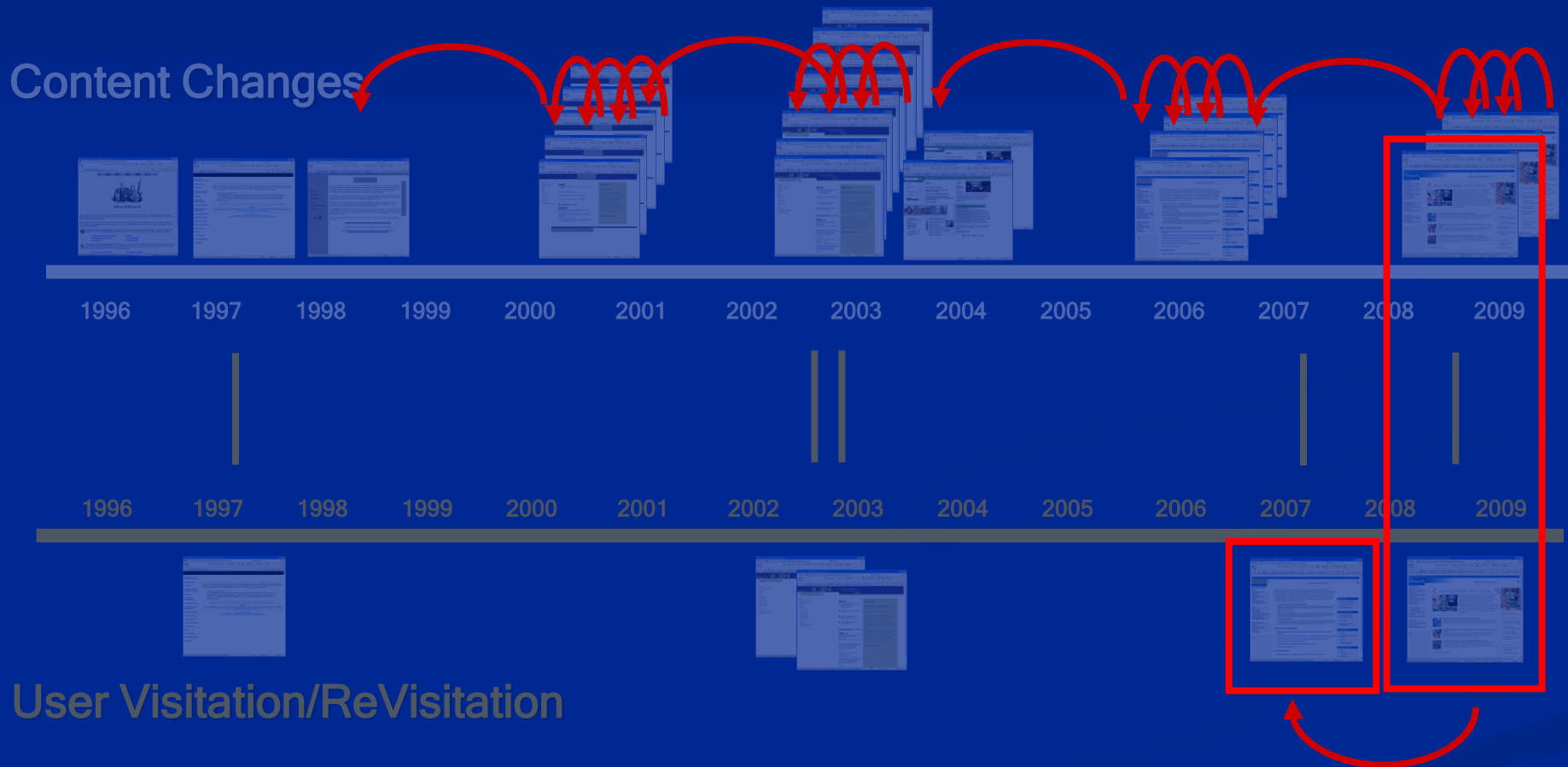


# Revisitation and Search

- Repeat query (33%)
  - *microsoft research*
- Repeat click (39%)
  - <http://research.microsoft.com>
  - Q: *microsoft research, msr ...*
- Big opportunity (43%)
  - 24% “navigational revisits”

		Repeat Click	New Click
Repeat Query	33%	29%	4%
New Query	67%	10%	57%
		39%	61%

# Relationships Between Revisitation and Change



***Why did you revisit the last Web page you revisited?***

# Possible Relationships

The screenshot shows the website for the 14th European Conference on Research and Advanced Technology for Digital Libraries (ECDL) in Glasgow, held from September 6-10. The page features a navigation menu with sections for 'GENERAL' (Home, Venue, History, Travel, Accommodation, General Information) and 'PROGRAMME' (Overview, Keynote Talks, Papers, Posters, Tutorials, Workshops, Demos, Panel, Doctorial Consortium, Social Programme). The main content area includes a 'Welcome to ECDL 2010' message and a 'Conference brochure: Changes after press date' notice dated September 3, 2010. The notice lists changes to the welcome reception, Workshop 1, and Workshop 2. A sidebar on the right contains a 'WELCOME TO ECDL 2010!' message, a schedule of events (Main conference: Sept 7-9, Tutorials: Sept 6, Doctorial Consortium: Sept 6, Workshops: Sept 9 & 10), and a 'ECDL2010 on Twitter' section.

- Interested in change
  - Monitor
- Effect change
  - Transact
- Change unimportant
  - Re-find old
  - Change can interfere with re-finding

# Understanding the Relationship

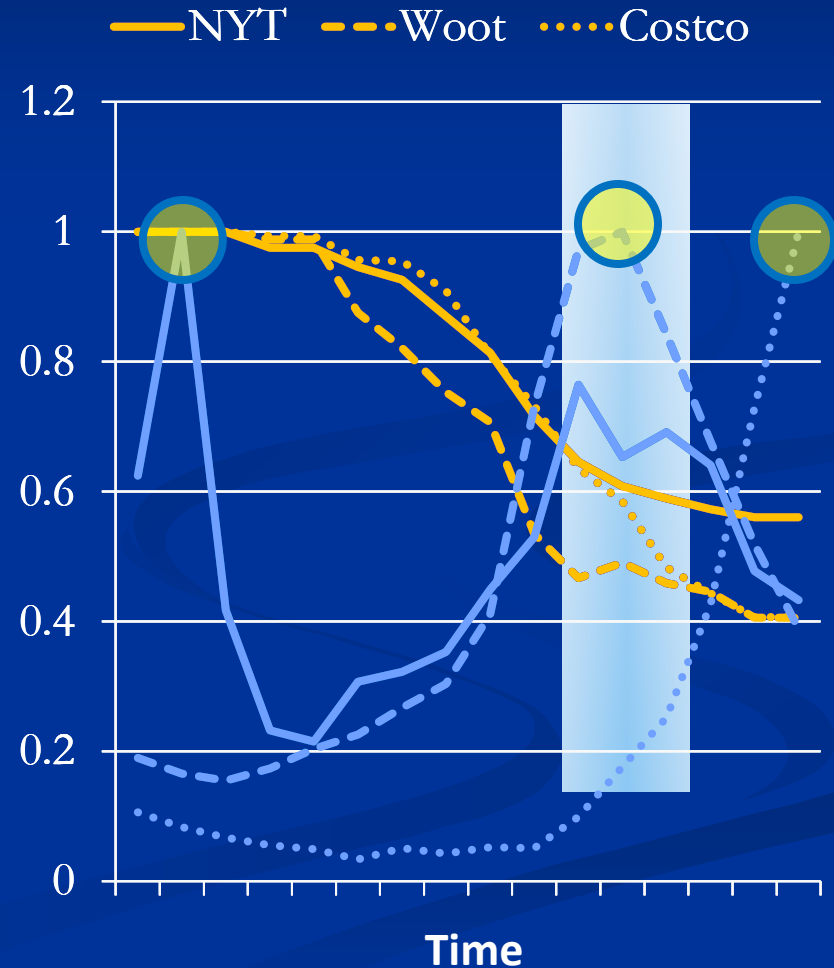
- Compare summary metrics
  - Revisits: Unique visitors, visits/user, interval
  - Change: Number of, interval between, Dice coeff.

	Number of changes	Time between changes	Dice coefficient
2 visits/user	172.91	133.26	0.82
3 visits/user	200.51	119.24	0.82
4 visits/user	234.32	109.59	0.81
5-6 visits/user	269.63	94.54	0.82
7+ visits/user	341.43	81.80	0.81



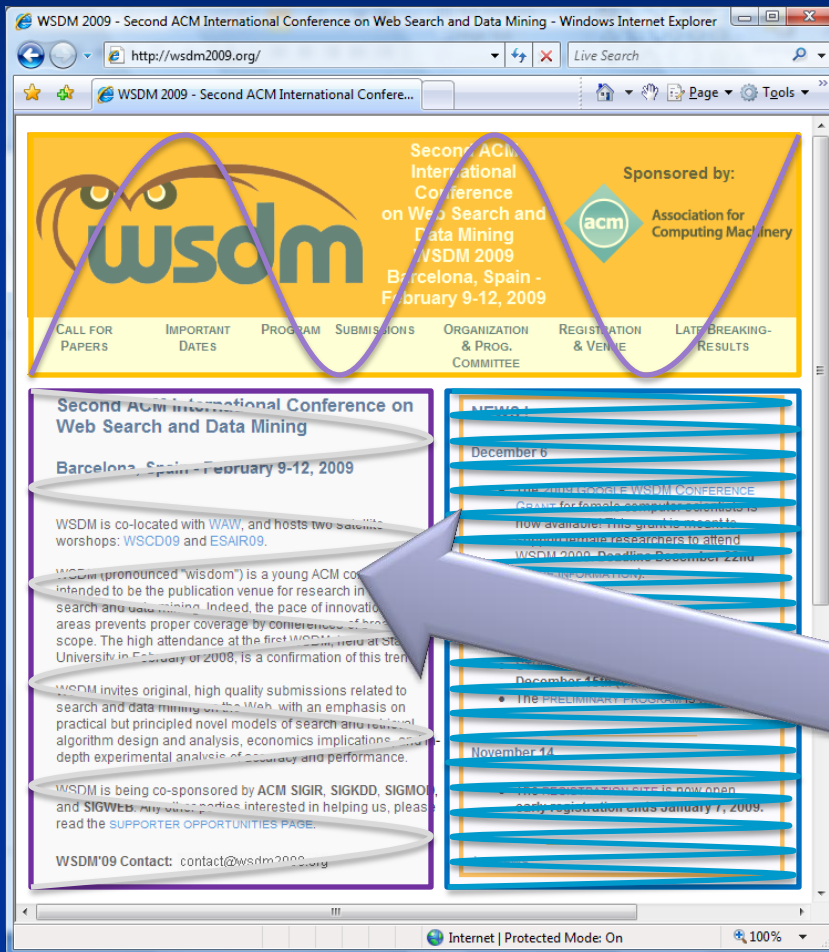
# Comparing Change and Revisit Curves

- Three pages
  - New York Times
  - Woot.com
  - Costco
- Similar change patterns
- Different revisitation
  - NYT: *Fast* (news, forums)
  - Woot: *Medium*
  - Costco: *Slow* (retail)



# Within-Page Relationship

- Page elements change at different rates
- Pages are revisited at different rates



- “*Resonance*” can serve as a filter for identifying interesting content

**Protect and Provide.**  
**HSBC Insurance**

# The New York Times

Thursday, August 7, 2008 Last Update: 3:02 PM ET

**Instant\* Term Life.**  
**HSBC Insurance**

 Search

Get Home Delivery | Personalize Your Weather

- JOBS
- REAL ESTATE
- AUTOS
- ALL CLASSIFIEDS
- WORLD
- U.S.
- Politics
- Washington
- Education
- N.Y./REGION
- BUSINESS
- TECHNOLOGY
- SPORTS
- OLYMPICS
- SCIENCE
- HEALTH
- OPINION
- ARTS
- Books
- Movies
- Music
- Television
- Theater
- STYLE
- Dining & Wine
- Fashion & Style
- Home & Garden
- Weddings/ Celebrations
- TRAVEL
- Blogs
- Cartoons / Humor
- Classifieds
- Corrections
- Crossword/ Games
- First Look
- Learning Network
- Multimedia
- NYC Guide
- Obituaries
- Podcasts

## Coalition in Pakistan Moves to Impeach Musharraf

By JANE PERLEZ 12:19 PM ET  
 Pakistan's usually fractious coalition government moved decisively for the first time on Thursday to impeach President Pervez Musharraf.

• Times Topics: Pervez Musharraf | Pakistan  
[Post a Comment](#) | [Read \(33\)](#)

## E.P.A. Won't Ease Requirements for Ethanol in Gas

By MATTHEW L. WALD 23 minutes ago  
 The agency denied a request to cut the quota for the use of ethanol in cars, concluding that the goal of reducing the nation's reliance on oil trumps any effect on food prices.

## In Anthrax Scientist's E-Mail, Hints of Delusions

By ERIC LIPTON  
 The e-mail messages of Bruce E. Ivins provide a narrative of his paranoid episodes, dating to 2000.

- The Lede: Reactions to the Case 12:22 PM ET
- F.B.I. Presents Anthrax Case, Saying Scientist Acted Alone
- Times Topics: Anthrax

## 2008 BEIJING OLYMPICS



Elizabeth Dalziel/Associated Press

### SPORTS OF THE TIMES

#### Raising the Bar and Raising Elbows

By GEORGE VECSEY 11:07 AM ET  
 Increased physicality in women's basketball will not give a black eye to the entire sport. However, it most certainly gave a black eye to Penny Taylor of Australia on Tuesday.

### INTERACTIVE SCHEDULE

Friday	Saturday	Sunday
1 events	4 events	18 events
1 event	1 event	23 events

### ⚡ Olympics Tracker

Follow the schedules of your favorite sports, day by day and event by event.

### Judge Orders Detroit Mayor Jailed

By NICK BUNKLEY 39 minutes ago

### MORE OLYMPICS NEWS

- Men's Soccer: U.S. 1, Japan 0
- Bush Arrives in Beijing
- Silver Keeps Her Place on U.S. Relay Team
- Federer Arrives, Soon to Lose His No. 1 Status
- Rings Blog
- Complete Coverage »

### OPINION »

#### An Olive Branch From the Dalai Lama

By NICHOLAS D. KRISTOF

For the first time, the Tibetan leader has expressed a willingness to accept Communist Party rule over his homeland.



[Post a Comment](#) | [Read \(104\)](#)

### THEATER »

#### With Echoes of Chekhov

A. R. Gurney's "Buffalo Gal" is about an actress who retreads the boards of her hometown.



• Times Topics: A. R. Gurney

### OPINION »

- Collins: Energy Drill
- Cohen: Spanish Summer
- Egan: Nanny Nation
- Self: Vanishing Cliffs
- Editorial: Hamdan's Trial
- [Comments \(221\)](#)

**AMERITRADE**  
**\$9.99 trades.** [GO](#)  
 No guesswork.

### MARKETS »

At 3:05 PM ET

S.&P.	Dow	Nasdaq
500	11,481.02	2,362.26
1,271.12	-175.05	-16.11
-18.07	-1.50%	-0.68%
-1.40%		

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Hi. Are you new? [Start here.](#)

[GO!](#)  
username password ([I forgot!](#))

## HP Compaq 6820s 2GHz 17" Widescreen Notebook

**\$529.99**  
+ \$5 shipping

CONDITION: **New**

PRODUCT: 1 HP Compaq 6820s Celeron 2.0GHz, 160GB, 17" Widescreen, 2GB DDR2, DL-DVDRW, 802.11a/b/g, Vista

[DISCUSS THIS PRODUCT \(176 COMMENTS\)](#)



[PRODUCT INFO](#) [PRODUCT STATS](#)

### Sometimes The Past Is Hard To Let Go

"-and when she told me, I just couldn't deal. So I left, just like I always did. Just like my father."

*Tom, thank you for sharing all that. Have one of these tissues. Do you feel like you've made a forward step?*

"I do, Jack, I really do. Can I maybe have a second tissue?"

*As many as you like, Tom, you don't even need to ask. Let's hear from someone else now. HP Compaq 2GHz Celeron 17" Widescreen Notebook, tell us more about your loss.*

Well, with me, it was the teasing. See, I'm in the tech industry, which is a really high stress field. And, you know, growing up, everyone in a position of authority says, you know, play the hand you're dealt. But I've got a 2.0GHz Intel Celeron 550 Processor with 1MB L2 cache and 533MHz front side bus, and most people think that's nothing. But, you know, what are they doing? Playing Bejeweled on their lunch break and writing out memos in work? Maybe looking for um... nee... oh... are... en?

WOOTCAST

"Listener Mailbag" (4 comments)

THIS WEEK ON **wine.woot!**

AUG 07 Laura Zahtila Vineyards Napa Valley Chardonnay - Three Pack

TODAY ON **shirt.woot!**

AUG 07 Sweet Dreams Are Made of These...

**SONY**

The new Sony® VAIO® FW notebook with extra-wide screen.



High Definition. It's in our DNA.

LOGIN

Search

in All

GO



SHOP FOR BUSINESS PRODUCTS... [CLICK BUSINESS ABOVE](#)

USA

Sign up to receive offers by e-mail:

your e-mail address  GO

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[CLICK HERE](#) [CLICK HERE](#)



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Up to \$400 OFF



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Select Branded TV Hot Buys  
Up to \$400 OFF

Earn 3% cash back when you buy gas.

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Sunsetter Motorized Retractable Patio Awnings 30%



Hoover All Terrain SteamVac  
\$199.99 After \$50 OFF



Emergency Food Kit  
\$74.99 After \$10 OFF



4-pc Hardside Luggage  
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Garmin nuvi 770 4.3" GPS  
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on balances of \$10,000 or more

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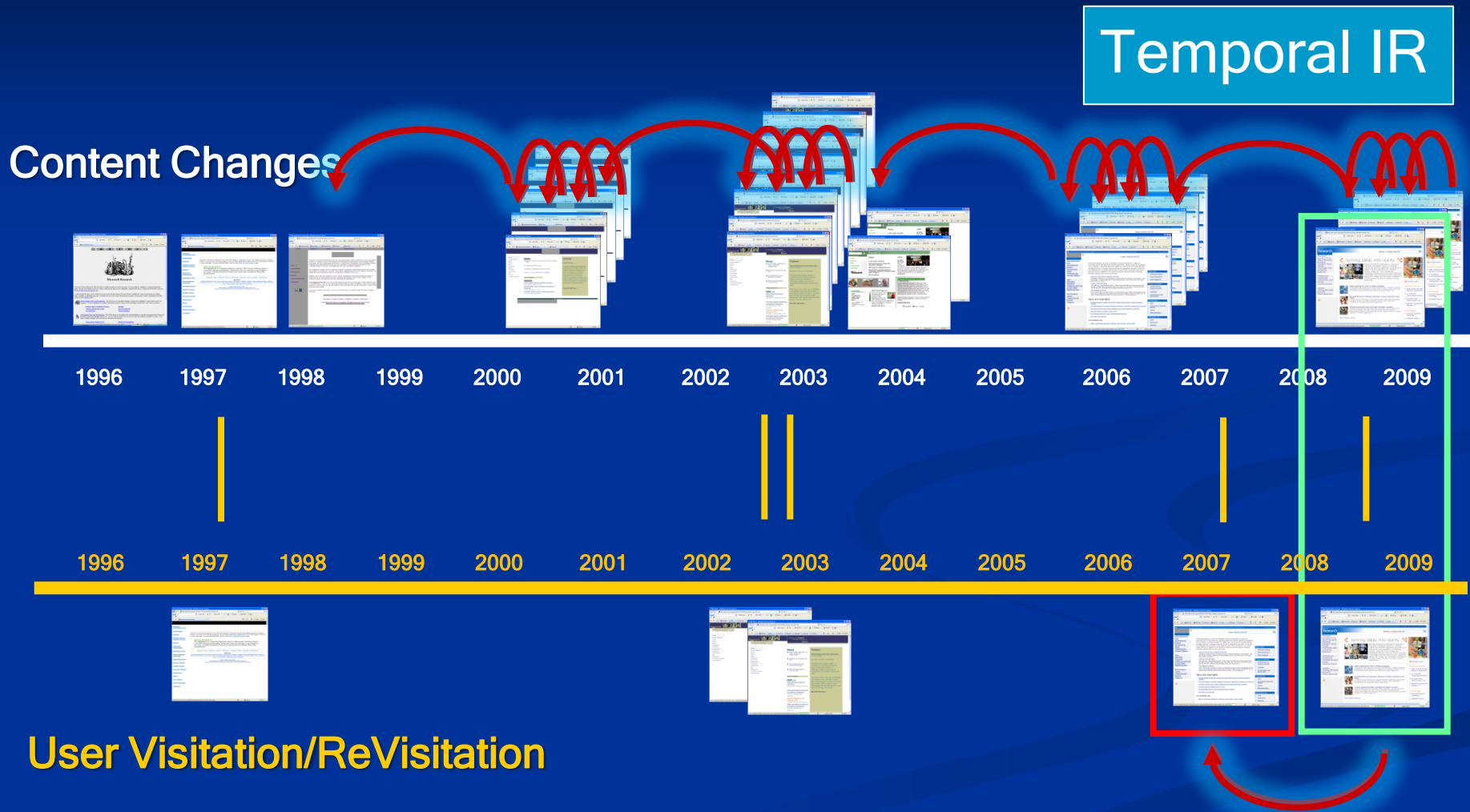
Give us your Best Shot



# Information Dynamics

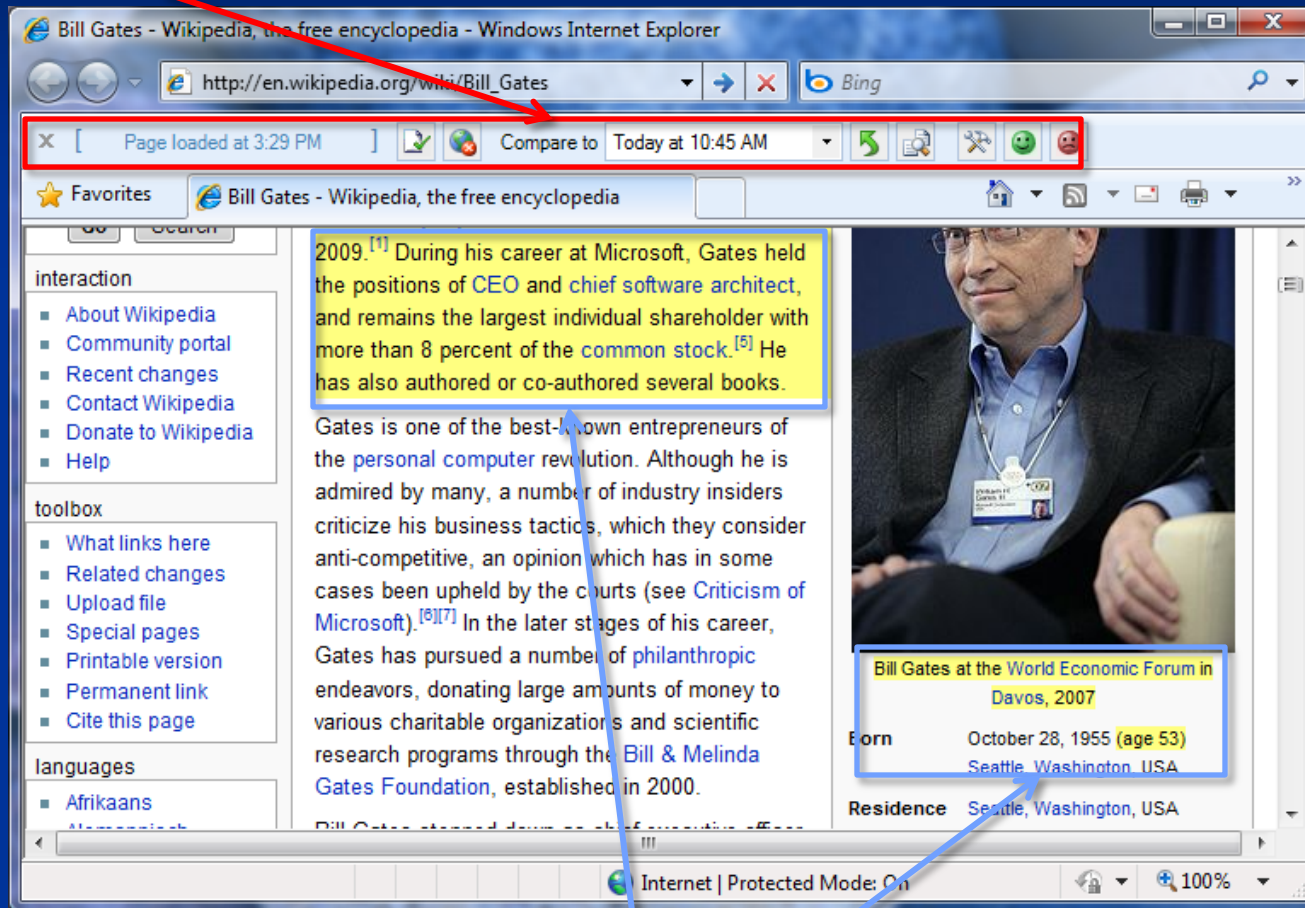
- Characterizing change
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# Building Support for Web Dynamics



# DiffIE

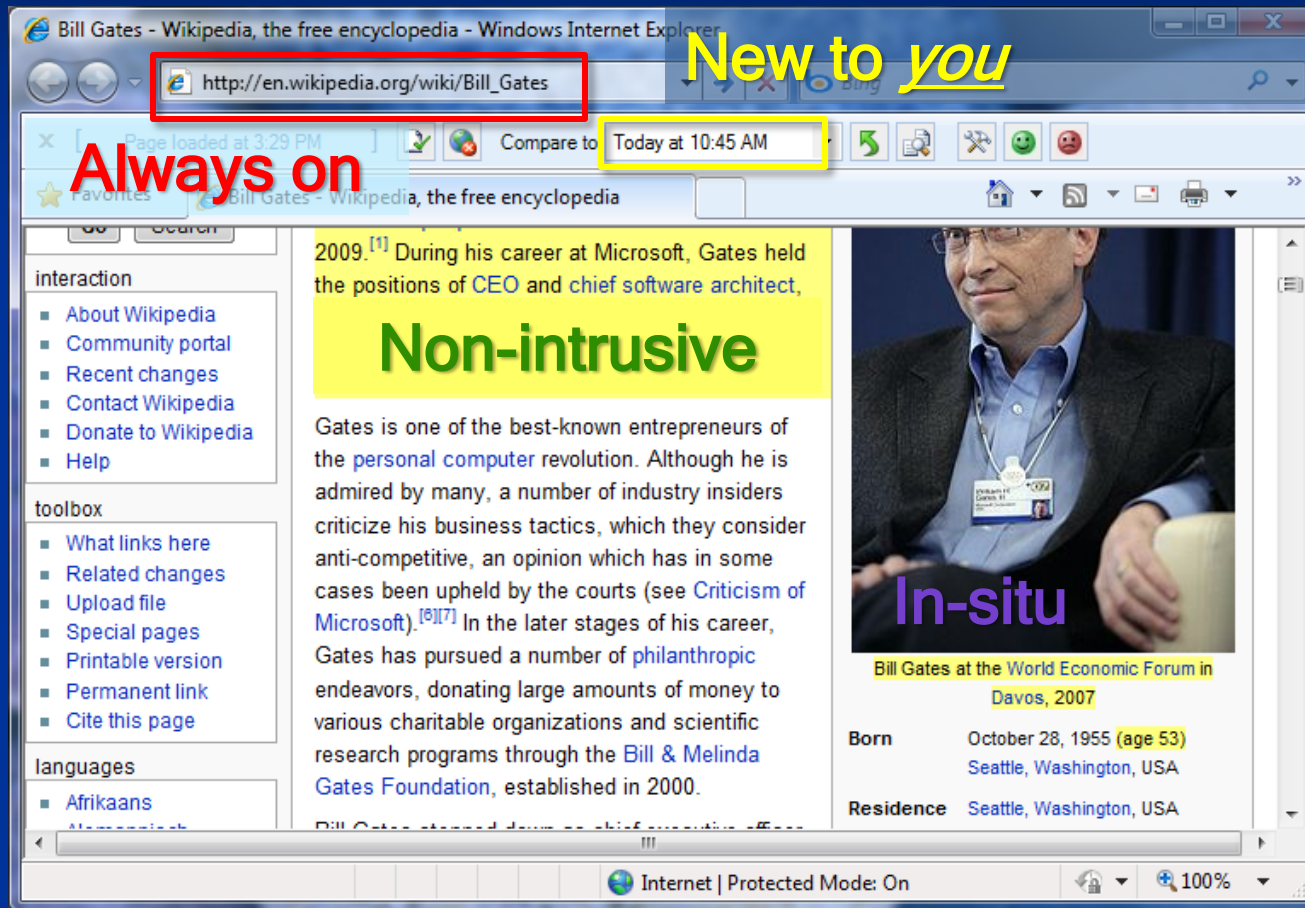
## DiffIE toolbar



Changes to page since  
your last visit



# Interesting Features of *DiffLE*



# Examples of *DiffLE* in Action

# Expected New Content

msnbc  
Powered by Bing  
MSN Home | Mail | More | Sign In  
featuring TODAY | Nightly News | Dateline | Meet the Press | msnbc tv | NBC Sports

Top stories as of 10:14 a.m. Wed., Sept 30, 2009  
New York, NY  
mostly cloudy, 57°F

World news

## Thousands trapped in 2nd Pacific-area quake, official says

**UPDATED** At least 75 people dead as 7.6-magnitude temblor hits Indonesia; hundreds of houses reportedly damaged; panicked residents flee their homes. [Full story](#) | [Video: Western Sumatra struck](#)


### Iraq resonates in claims over Iran nukes

NYT: While similarities between 2002, with its faulty IWMMD estimates, and 2009 are unmistakable, the differences are profound. [Full story](#)

### China stalls action against Iran

Beijing's reluctance stems from oil, ideology. [Story](#)

[Video: World leaders meet on Iran nuclear threat](#)



Damaged boat (John Newton / AFP - Getty Images)

## Samoans count cost after deadly tsunami

Undersea earthquake propels waves onto island nation and U.S. territory; toll expected to rise. [Story](#) | [Video: South Seas terror](#) | [Are you there? Send images, reports](#)

Sports

## Some in Windy City hope 2016 bid is a bust

"I know it's going to cost u money somehow," one Chicago resident says. [Full story](#)

**NEW** Meet the Olympic contestants: Chicago, Tokyo, Rio, Madrid

[Video: Obamas and Winfrey make '16 pitch](#)

U.S. news

## Guns to be allowed in Arizona bars | Vote

[Video: Summit to tackle distracted drivin](#)

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- Swine flu school closings could cost billions
- 1st lady in Europe for Olympics vote | [Video](#)
- GOP candidate: Too busy with family to vote
- Newsweek: What most suicide bombers have in common
- UPDATED** Church ordains sex offender as minister

Only on msnbc.com



Reuters  
Slideshow: China

# Monitor

The screenshot shows a Twitter profile for Susan Dumais. The top navigation bar includes 'Home', 'Profile', 'Find People', 'Settings', 'Help', and 'Sign out'. The profile header shows 'Name Susan Dumais' with statistics: 20 following, 12 followers, and 1 listed. Below this are sections for 'Tweets' (0) and 'Favorites'. The 'Following' section displays a grid of profile pictures for users being followed, including logos for CNN, Huffington Post, and NY Times, as well as individual user avatars. The main content area lists the profiles of the users being followed, each with their name, bio, and a recent tweet. The users listed are pfromthenc, DARPA\_News, huffingtonpost, nytimes, and dm Russell.

**twitter** Home Profile Find People Settings Help Sign out

**You follow 20 people** [add or invite more](#)

Name Susan Dumais  
20 following 12 followers 1 listed

Tweets 0  
Favorites

Following

User / Name	Actions
 <b>pfromthenc</b> Loren Terveen Just had my first Surly Furious... waited until *after* I finished working on the proposal tonight. <a href="#">about 22 hours ago</a>	 
 <b>DARPA_News</b> DARPA   Arlington, VA Team standings from DARPA Network Challenge posted on <a href="http://bit.ly/5kdAZ1">http://bit.ly/5kdAZ1</a> <a href="#">about 4 hours ago</a>	 
 <b>huffingtonpost</b> HuffingtonPost.com GOP Senator: We Will Unanimously Oppose Newest Health Care Compromise <a href="http://bit.ly/5xRBEi">http://bit.ly/5xRBEi</a> <a href="#">about 1 hour ago</a>	 
 <b>nytimes</b> The New York Times   New York, NY Citi Races to Pay Back Bailout Aid <a href="http://bit.ly/87E9Ry">http://bit.ly/87E9Ry</a> <a href="#">5 minutes ago</a>	 
 <b>dm Russell</b> CA, USA @roblyons Google Office is at 1101 New York Ave (although the entrance is on I) #gtadc <a href="#">about 13 hours ago</a>	 

# Unexpected Important Content

## Social Programme

### CALL FOR CONTRIBUTIONS

- Call for Research Papers
- Call for Posters and Demos
- Call for Panels
- Call for Tutorials
- Call for Workshops
- Doctoral Consortium
- Submissions
- Important Dates
- Sponsorship Programme

### ORGANISATION

- Programme Committee
- Organising Committee
- Contact
- Sponsors

### RELATED CONFERENCES

- ACM/IEEE Joint Conference on Digital Libraries
- International Conference on Asia-Pacific Digital Libraries
- International Conference on Digital Libraries
- Russian Conference on Digital Libraries

All changes will be announced here so please check for updates regularly. Thanks!

## Invitation: Excursion to Auchentoshan distillery

SEPTEMBER 2, 2010



On Monday afternoon you are invited to join the tour to Auchentoshan distillery for a discovery of the famous Scottish Single Malt Whisky. This is something not to be missed! Free tickets will be available on a first-come first-served basis at the conference registration desk in Boyd Orr building on Monday from 8am onwards.

The coach to Auchentoshan departs from Hilton City Centre at 3.30pm and from the University at 3.50pm. If you – due to flight times etc – can't make it to the registration desk before the coach leaves please drop us an email to [info@ecdl2010.org](mailto:info@ecdl2010.org) before Sunday evening. We might then be able to allocate some tickets.

For tutorials and doctoral consortium delegates there will be a later departure. Please refer to the [social programme page](#) for additional information.


## Shuttle service to Uni Campus

SEPTEMBER 1, 2010

Delegates staying at either Wolfson Hall or Hilton City Centre can use the following complimentary shuttle service to Uni Campus in the mornings:

	Departure	Monday, Sept 6	Tuesday, Sept 7	Wednesday, Sept 8	Thursday, Sept 9	Friday, Sept 10

## ECDL2010 on Twitter

 [hvdsonp](#) Bumped by ongoing data modeling issues with open annotation. Also because I need to present a tutorial on it, Monday at #ecdl10 4 days ago

 [ECDL2010](#) We are happy to announce a free shuttle service from the main accommodation of #ECDL2010 to Uni campus in the mornings. <http://www.ecdl.org> 4 days ago

 [ECDL2010](#) Explore the world famous Scottish Whisky! #ECDL2010 invites all delegates to Auchentoshan Distillery

 Join the conversation

## NEED HELP?

Our ECDL volunteers are here to help:




# Serendipitous Encounters



Jaime Teevan, Ph.D.  
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Redmond, WA 98052  
(425) 421-9299  
[Home](#) \* [Work](#) \* [Publications](#)

Organized by [Type](#) \* [Subject](#) \* [Date](#) \* [Internal](#)

## REFEREED JOURNAL ARTICLES:


 Jaime Teevan, Susan T. Dumais and Eric Horvitz. *Potential for Personalization*. To appear in the ACM Transactions on Computer-Human Interaction ([TOCHI](#)) special issue on Data Mining for Understanding User Needs, 2009. [[pdf](#)]

Jaime Teevan. *How People Recall, Recognize and Reuse Search Results*. ACM Transactions on Information Systems ([TOIS](#)) special issue on Keeping, Refinding, and Sharing Personal Information, 26(4), September 2008. [[pdf](#)]

Edward Cutrell, Susan T. Dumais and Jaime Teevan. *Searching to Eliminate Personal Information Management*. Communications of the ACM ([CACM](#)), Special Issue on Personal Information Management, 49(1), January 2006.

Diane Kelly and Jaime Teevan. *Implicit Feedback for Inferring User Preference: A Bibliography*. [SIGIR Forum](#), 37(2), 2003. [[pdf](#)]

## REFEREED CONFERENCE PAPERS:

 Paul André, m. c. schraefel, Jaime Teevan and Susan T. Dumais. *Discovery is Never by Chance: Designing for (Un)Serendipity*. To appear in Proceedings of the 7th ACM Creativity and Cognition Conference ([CC '09](#)), Berkeley, CA, October 2009.

Jaime Teevan, Susan T. Dumais, Daniel J. Liebling and Richard Hughes. *Changing the Way People View Changes on the Web*. To appear in Proceedings of the 22nd Annual ACM Symposium on User Interface Software and Technology ([UIST '09](#)), Victoria, BC, October 2009. [[pdf](#)]

Eytan Adar, Jaime Teevan and Susan T. Dumais. *Resonance on the Web: Web Dynamics and Revisitation Patterns*. In Proceedings of ACM Conference on Human Factors in Computing Systems ([CHI '09](#)), Boston, MA, April 2009. [[pdf](#)]

Jaime Teevan, Edward Cutrell, Daniel Fisher, Steven M. Drucker, Gonzalo Ramos, Paul André and Chang-Hy. *Visual Snippets:*

# Understand Page Dynamics

The image shows a screenshot of a Bing search results page for the query "weather 98005". The page layout includes a navigation bar at the top with links for Web, Images, Videos, Shopping, News, Maps, More, MSN, and Hotmail. The Bing logo is on the left, and the search bar contains the text "weather 98005". Below the search bar, there are navigation tabs for "ALL RESULTS" and "Weather". The main content area displays the current weather for "98005" as 54°F (13°C) with a wind speed of 6 mph and 71% humidity. It also shows a 5-day forecast for Wednesday through Saturday. On the left side, there are sections for "RELATED SEARCHES" (Weather 98052, Movies 98005) and "SEARCH HISTORY" (weather 98005, xoost.com, fox news, msn). The search results list includes a "10 Day Weather Forecast for Bellevue, WA (98005) - weather.com" and a "Bellevue, WA (98006) Weather Forecast - Weatherlet.com".

Web Images Videos Shopping News Maps More MSN Hotmail

bing weather 98005

ALL RESULTS 1-10 of 22,100 results - [Advanced](#)

Weather

RELATED SEARCHES  
Weather 98052  
Movies 98005

SEARCH HISTORY  
weather 98005  
xoost.com  
fox news  
msn  
[See all](#)  
[Clear all](#) | [Turn off](#)

ALL RESULTS: **Weather in 98005**

Today **54°F · (°C)**  
Wind: 6 mph  
Humidity: 71%  
61° / 50°

Wed 59° / 51°

Thu 61° / 50°

Fri 58° / 39°

Sat 60° / 37°

[10 Day Forecast](#) · [Hourly Forecast](#) · [Weather Maps](#) · Data provided by WDT

[10 Day Weather Forecast for Bellevue, WA \(98005\) - weather.com](#)  
10 day **weather** forecast for Bellevue, WA (98005) with **weather** conditions, high and low temperatures, and precipitation.  
[www.weather.com/weather/tenday/98005?day=0&vert=WeatherCity](#) - [Cached page](#)

[Bellevue, WA \(98006\) Weather Forecast - Weatherlet.com](#)  
Bellevue, WA (98006) **Weather** Forecast - Weatherlet ... Auburn, WA (98002)  
**Weather** Forecast Federal Way, WA (98003) **Weather** Forecast Bellevue, WA (98005) **Weather** Forecast  
[www.weatherlet.com/?locid=98006&cityname=Bellevue%2C+today...](#) - [Cached page](#)

[Bellevue, Washington \(98005\) Conditions & Forecast : Weather ...](#)  
**Weather** Underground provides **weather** information for worldwide locations, including current conditions, hourly forecasts, radar and satellite maps. Specialized **weather** products ...

Expected



Expected New Content



Monitor



Unexpected Important Content

33 | Estimate Members & More Exps... Use Chapter News and Events for more information. Yeah, baby!

Subject	Replies	Views	Last post
Small Business + ...	21	206	10/10/2009
Confusing Invoicing	10	83	10/10/2009
Back to work Part II	8	43	10/10/2009
Aldergate Christian Preschool - HIKING	0	17	10/10/2009
do you know anyone in Italy or Sweden?	3	30	10/10/2009
Call an Interview and its Recalling ...	94	562	10/10/2009
Accounting or Industry? Finding the Right Fit	7	105	10/10/2009
Any members work at Amazon.com?	10	118	10/10/2009
Time Magazine on SAHRA - getting back into work	1	75	10/10/2009
Freemasonry Resurgence	12	41	10/10/2009
Congrat designer or Admin?	0	45	10/10/2009

Attend to Activity



Serendipitous Encounter

Unexpected



Edit



Understand Page Dynamics



Unexpected Unimportant Content



# Studying *DiffLE*

## ■ Feedback buttons



## ■ Survey

- Prior to installation
- After a month of use

6. How often do you find the following types of pages change?	Always	Often	Sometimes	Rarely	Never
News pages	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Software, books, forums, on-line groups	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Company homepages	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Personal homepages of people you know	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pages with product information	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Reference pages (dictionaries, "how-to" pages)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Weblogs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Blog you read	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Search engine results	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

*In situ*  
*Representative*

## ■ Logging

- URLs visited
- Amount of change when revisited






*Experience*  
*Longitudinal*




## ■ Experience interview



# People Revisit More

- Perception of revisitation remains constant
  - How often do you revisit? 
  - How often are revisits to view new content? 
- Actual revisitation increases
  - First week: 39.4% of visits are revisits
  - Last week: 45.0% of visits are revisits 
- Why are people revisiting more with *DiffIE*?

# Revisited Pages Change More

- Perception of change increases
  - What proportion of pages change regularly?  8%
  - How often do you notice unexpected change?  17%
- Amount of change seen increases
  - First week: 21.5% revisits, changed by 6.2%
  - Last week: 32.4% revisits, changed by 9.5%  51+%
- *DiffIE* is driving visits to changed pages
  - It supports people in understanding change

# More Implications of Dynamics for User Experience

## ■ Content changes

### ■ DiffIE

### ■ Zoetrope (Adar et al., 2008)

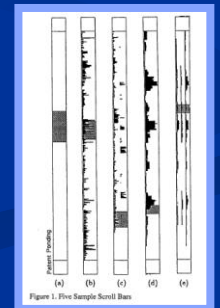
### ■ Temporal summaries and snippets ...

## ■ Interaction changes

### ■ Explicit annotations, ratings, wikis etc.

### ■ Implicit interest via interaction patterns

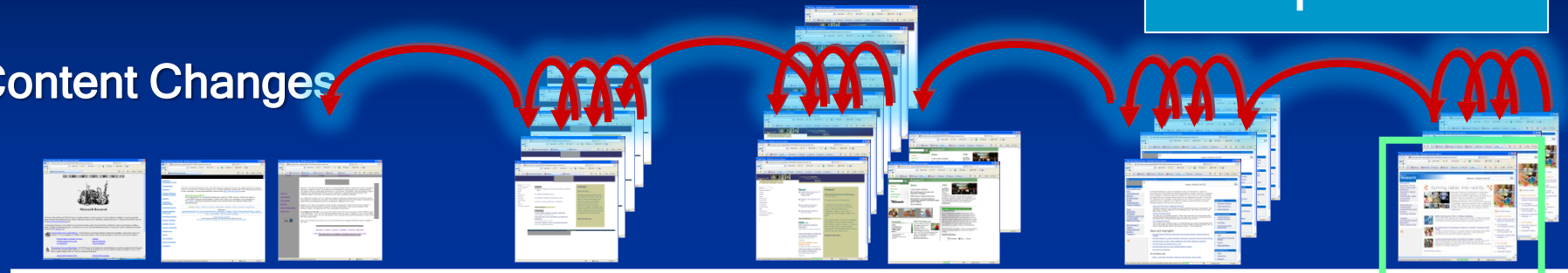
#### ■ Edit wear and read wear (Hill et al., 1992)



# Leveraging Dynamics for Retrieval

Temporal IR

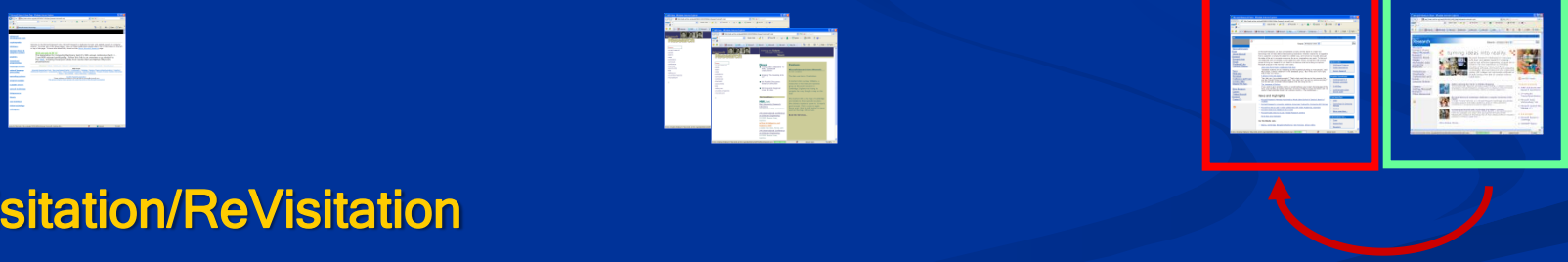
Content Changes



1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009

1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009

User Visitation/ReVisitation



# Temporal Retrieval Models

- Current IR algorithms look only at a single snapshot of a page
- But, Web pages change over time
- Can we can leverage this to improved retrieval?
  - Pages have different *rates of change*
    - Different priors (using change vs. link structure)
  - Terms have *different longevity (staying power)*
    - Some are always on the page; some transient
  - Language modeling approach to ranking

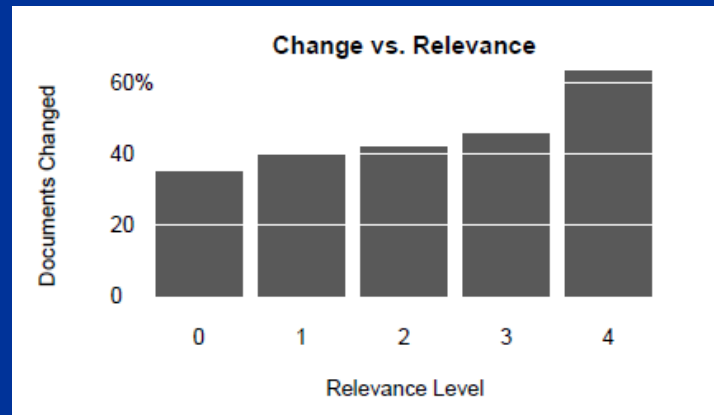
$$P(D|Q) = P(D) \cdot P(Q|D)$$

Change prior

Term longevity

# Relevance and Page Change

- Page change is related to relevance judgments
  - Human relevance judgments
    - 5 point scale - Bad/Fair/Good/Excellent/Perfect
  - Rate of Change -- 30% Bad pages; 60% Perfect pages



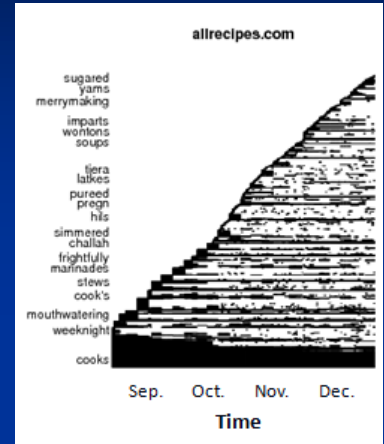
- Use change rate as a document prior (vs. priors based on links like Page Rank)
  - Shingle prints to measure change

$$P(D|Q) = P(D) \cdot P(Q|D)$$

Change prior

# Relevance and Term Change

- Terms patterns vary over time
- Represent a document as a mixture of terms with different “staying power”
  - Long, Medium, Short



$$P(Q | D) = \lambda_L P(Q | D_L) + \lambda_M P(Q | D_M) + \lambda_S P(Q | D_S)$$

$$P(D | Q) = P(D) \cdot P(Q | D)$$

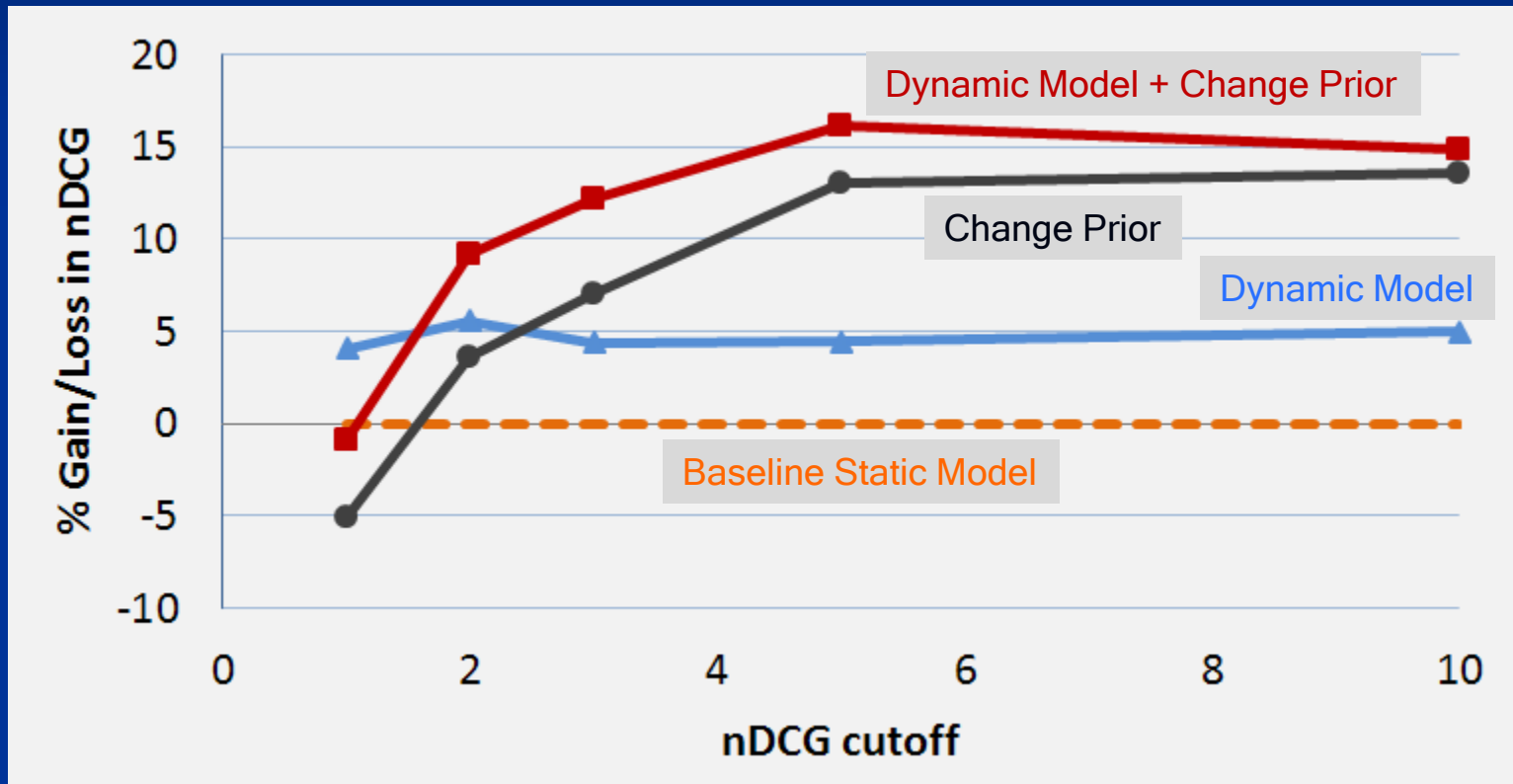
↑  
Term longevity



# Test Setup: Queries & Documents

- 18K Queries, 2.5M Judged Documents
  - 5-level relevance judgment (Perfect ... Bad)
- 2.5M Documents crawled weekly for 10 weeks
- Navigational queries
  - 2k queries identified with a “Perfect” judgment
- 60/40 Training/Test split

# Experimental Results



# Temporal Retrieval, Next Steps

- Initial evaluation/model
  - Focused on navigational queries
  - Assumed their relevance is “static” over time
- But, there are many other cases ...
  - E.g., *World Cup results* (in 2010 vs. 2006)
  - E.g., *US Open 2010* (in June vs. Sept)
- Ongoing evaluation
  - Collecting explicit relevance judgments, interaction data, page content, and query frequency over time

# More Implications of Dynamics for Models/Systems

## ■ Temporal retrieval models

- Elsas & Dumais (WSDM 2010), Efron (JASIST 2010)

## ■ Methods for storing and protocols for retrieving content/versions over time

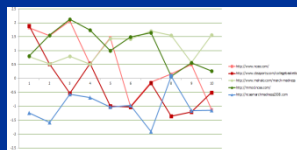


- E.g., Memento (Von de Sompel, Nelson, Sanderson et al.)

## ■ Meta-data generation or info extraction

- E.g., *Who is the president of the U.S.?*

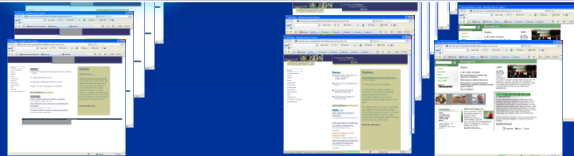
## ■ Evaluation



# Summary

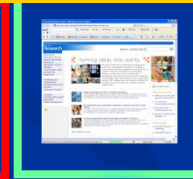
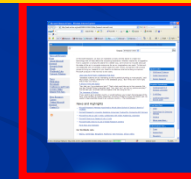
**Temporal IR:**  
Leverages change  
for improved IR

Web content changes: page-level, term-level



Relating revisitation and change allows us to

- Identify pages for which change is important
- Identify interesting components within a page



People revisit and re-find Web content

**DiffIE:** Supports (and influences interaction and understanding)

# Thank You !

- Questions/Comments ...
- More info,  
<http://research.microsoft.com/~sdumais>

# References

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## DiffIE and Temporal IR:

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- Elsas & Dumais. Leveraging temporal dynamics of document content in relevance ranking. WSDM '10.