SEARCHING: FAST AND SLOW

Susan Dumais

http://research.microsoft.com/~sdumais
Searching: Fast and Slow

- Tremendous engineering effort aimed at making search fast
  - ... and for good reason
  - But, many compromises made to achieve speed

- Not all searches need to be fast
- How can we use additional time to improve search quality?
Speed Focus in Search Important

- Schurman & Brutlag, Velocity 2009
  (Arapakis, Bai & Cambazoglu, SIGIR 2014)

- A/B tests increasing page load time (at server)

- Increasing page load time by as little 100 msecs influences search experience substantially
  - Decreased searches per user, clicks, and revenue
  - Increased abandonment, and time to click

- Effects are larger with longer latency and persist after delays are removed
**Server Delays Experiment: Results**

<table>
<thead>
<tr>
<th>Delay (ms)</th>
<th>Distinct Queries/User</th>
<th>Query</th>
<th>Refinement</th>
<th>Revenue/User</th>
<th>Any Clicks</th>
<th>Satisfaction</th>
<th>Time to Click (increase in ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50ms</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>200ms</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-0.3%</td>
<td>-0.4%</td>
<td>500</td>
</tr>
<tr>
<td>500ms</td>
<td>-</td>
<td>-0.6%</td>
<td>-1.2%</td>
<td>-1.0%</td>
<td>-0.9%</td>
<td>-</td>
<td>1200</td>
</tr>
<tr>
<td>1000ms</td>
<td>-0.7%</td>
<td>-0.9%</td>
<td>-2.8%</td>
<td>-1.9%</td>
<td>-1.6%</td>
<td>-</td>
<td>1900</td>
</tr>
<tr>
<td>2000ms</td>
<td>-1.8%</td>
<td>-2.1%</td>
<td>-4.3%</td>
<td>-4.4%</td>
<td>-3.8%</td>
<td>-</td>
<td>3100</td>
</tr>
</tbody>
</table>

- Means no statistically significant change

- Strong negative impacts
- Roughly linear changes with increasing delay
- Time to Click changed by roughly double the delay
Brutlag (Google)

Impact of Post-header Delays Over Time

- 200 ms delay
- 400 ms delay

-0.22%
-0.44%
-0.36%
-0.74%
Brutlag (Google)

Persistent Impact of Post-header Delay

- 0.08%
- 0.21%

daily searches per user relative to control

wk3  wk4  wk5  wk6  wk7  wk8  wk9  wk10  wk11
Teevan et al., HCIR 2013

Examined naturally occurring variation in page load time (for same query), from 500-1500 msec

- Longer load time associated with increases in
  - Abandonment rate increased (from 20% to 25%)
  - Time first to click increased (from 1.2 to 1.6 secs)
- Larger effects on navigational (vs. informational) queries
Not All Searches Need to Be Fast

- Complex information needs
  - Long search sessions
  - Cross-session tasks
- Social search
  - Question asking
- Technology limits
  - Mobile devices
  - Limited connectivity
  - Search from Mars
Improving Search with More Time

- **By the second**
  - Use richer query and document analysis
  - Issue additional queries

- **By the minute**
  - Include humans in the loop, e.g., to generate “answers”

- **By the hour**
  - Create new search artifacts
  - Enable new search experiences

- Relaxing time constraints creates interesting new opportunities for “search”
By the Second

- Use richer query and document analysis
- Issue additional queries
- Find additional answers on “quick back”
- ...

- Especially helpful for
  - Difficult queries
  - Long sessions, whether struggling or exploring
Question Answering

- AskMSR question answering system
- Re-write query in declarative form
  - E.g., “Who is Bill Gates married to?”
    - “Bill Gates +is married +to” <>
    - <> “+is married +to Bill Gates”
    - “Bill Gates” AND “married to”
    - “Bill” AND “Gates” AND “married”
- Mine n-grams from snippets, exploiting redundancy
- Are multiple queries worth the cost?

1. Melinda French 53%
2. Microsoft Corp 16%
3. Mimi Gardner 8%
Decision-Theoretic QA

- Order query rewrites by their importance
- Assess cost and benefit of additional queries
- Aggregate results

<table>
<thead>
<tr>
<th>Rewrite Policy</th>
<th>Cost</th>
<th>Correct Answers (out of 499)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conjunctural rewrites only</td>
<td>499</td>
<td>247</td>
</tr>
</tbody>
</table>
| Cost-benefit  
k=10, c=1         | 1179 | 277                           |
| All rewrites                   | 3426 | 283                           |
By the Minute

- Use slower resources (like people)
- Can be used to augment many components of the search process
  - Understanding the query
  - Finding (or generating) better results
  - Understanding (or organizing) results
People Can Provide Rich Input

- Study: Complex restaurant queries to Yelp

- People used to
  - Support deeper understand of the query
  - Organize results in a new way
Search engines do poorly with long, complex queries.

Query: **Italian** restaurant in **Squirrel Hill or Greenfield** with a **gluten-free** menu and a **fairly sophisticated atmosphere**.

Crowd workers identify important attributes:
- Given list of potential attributes
- Option add new attributes
- Example: **cuisine**, **location**, **special diet**, **atmosphere**

Crowd workers match attributes to query:

Attributes used to issue a structured search (to Yelp)
Crowd workers tabulate search results

- Given a query, result, attribute, and value
- Does the result meet the attribute?

<table>
<thead>
<tr>
<th>Restaurant</th>
<th>Takes Reservations</th>
<th>Type of Cuisine</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azul Bistro - New York, NY</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>El Gauchito - Elmhurst, NY</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>El Almacen - Brooklyn, NY</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Pampas Argentinas - Forest Hills, NY</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Sosa Borella - New York, NY</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Libertador - New York, NY</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Mexico Lindo Restaurant - New York, NY</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>El Mariachi Restaurant - Astoria, NY</td>
<td>?</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Nuchas - New York, NY</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Empanadas Bar NYC - New York, NY</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
People Can Generate New Content

- Bing Answers
- “Tail” Answers

- molasses substitute
- dissolvable stitches speed
- increase sound volume windows
- temperature for frying fish
- calories green apple
- dog normal body temperature
The Long Tail of Answers

Information needs

# occurrences

weather
movies

Tail Answers

Hard to find structured information
Not enough query volume for dedicated teams
Tail Answers Pipeline

1. Identify Answer Candidates (logs)
Search trails that lead to same URL

\[ \text{query}_1 \ldots \text{query}_n \rightarrow \text{URL} \]

2. Filter Candidates (crowd-powered)
Navigational behavior    Unambiguous needs    Succinct answers

3. Generate Answers (crowd-powered)
Extract
Proofread
Title

Vote

\[ 101.5 \text{ deg }^\circ \]

Vote

Average Dog Temp.

Vote

Dog Temp
Tail Answers Results

- Quality: 87% had no errors
- Time: minutes
- Cost: 44¢ to create answer
- Expt: result quality \times \text{presence of “tail answer”}

Tail Answers
- Change subjective ratings half as much as good ranking
- Fully compensate for poor rankings

<table>
<thead>
<tr>
<th>IRS Milage</th>
</tr>
</thead>
<tbody>
<tr>
<td>The IRS allows reimbursement for business miles driven at a rate of for 51 cents per mile.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How to Turn Up Volume on Your Computer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start&gt; All Programs&gt; Accessories&gt; Entertainment&gt; Volume Control&gt; Wave Setting. Increase it and the volume should go higher.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fish Frying Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>350 degrees for 3 minutes is the ticket! Also, make sure to put just enough fillets in the basket to cover the bottom of it.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Area Code 407</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area code 407 is the area code for the Orlando metro area including all of Orange, Osceola, and Seminole counties, as well as small portions of Volusia and Lake counties.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ireland Currency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euro (EUR)</td>
</tr>
<tr>
<td>Source: <a href="http://www.greenwichmeantime.com/time-zone/europe/european-">http://www.greenwichmeantime.com/time-zone/europe/european-</a></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>New York City Sales Tax 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York City sales tax rate is 8.875%</td>
</tr>
<tr>
<td>Source: <a href="http://ny.rand.org/stats/govtfin/salestax.html">http://ny.rand.org/stats/govtfin/salestax.html</a></td>
</tr>
</tbody>
</table>
By the Hour

☐ We can create new “search” experiences

☐ Support ongoing tasks
  ✤ Task resumption, across sessions or devices
  ✤ Reinstate context, generate summaries, highlight change

☐ Proactively retrieve information of interest

☐ Asynchronously answer search requests
  ✤ Dinner reservations for tonight
  ✤ Background material by morning
Support Task Resumption

- 10-15% of tasks continue across sessions
- Predict which tasks will be resumed at a later time
- Reinstates and enrich context

In Office (on PC) -> Stops Task -> Walking to bus stop -> Resumes Task -> On Bus (on Smartphone)

~20 minutes

Task Continuation Predictor

Resume task »
New info found!!
Better results found!
Searching: Fast and Slow

- Relaxing time constraints creates interesting opportunities to change “search” as we know it.

- Especially useful for:
  - complex information needs that extend over time
  - richer understanding and presentation of information

- Allows us to think about solutions that:
  - support differential computation (e.g., CiteSight)
  - combine human and algorithmic components (e.g., TailAnswers, VizWiz)

- Requires that we break out of the search box.
Thank You!

- Questions/Comments ???

Further Reading

- **The need for speed**
  - Schurman, E. and Brutlag, J. *Performance related changes and their user impact.* Velocity 2009 Conference.

- **Slow search**
  - Lee, C-J., Teevan, J. and de la Chica, S. *Characterizing multi-click search behavior and the risks and opportunities of changing results during use.* SIGIR 2014.