User Modeling on the World Wide Web

Andrew Tomkins
Google, Inc
Scope note

• All opinions are mine, not Google’s
• Data described in this presentation is all from the published literature.
Privacy

• This talk could focus entirely on privacy
• …But it won’t
• …But maybe it should
“If I have 3 million customers on the web, I should have 3 million stores on the web.”

Jeff Bezos
Ceo, Amazon.com
Personalization and Queries

• Basic flow
  – User logs onto computer (initial entropy $H_0$)
  – User visits site (destination entropy $H_d$)
  – User expresses intent (intention entropy $H_i$)
  – User selects result (final entropy $H_f = 0$)

• Search vs Display:
  – Display 16x volume
  – Search 2x revenue
  – $H_i$ much smaller for search than display
Taxonomy of Personalization
Profile Personalization

• Idea: User-settable features significantly determine site behavior

• Examples:
  – “Themes” on many websites like Yahoo, Google, many mobile devices, etc
  – Explicit interests, as in e.g. Quora
  – Portfolio list in finance sites
  – Location
Data Personalization

• Idea: user id significantly determines site behavior

• Examples:
  – Email providers
  – Social update streams
    • facebook, myspace, twitter, etc
Model-Based Personalization

• Idea: rich user model informs presentation of page

• Examples
  – Amazon.com recommendations
  – pandora.com music genome recommendations
  – facebook.com “best view” news feed
Summary of Page Types

- No personalization: same page for every user
- Profile personalization: User-settable features significantly determine site behavior
- Data personalization: user id significantly determines site behavior
- Model personalization: rich user model informs presentation of page
## Categories of pageviews

<table>
<thead>
<tr>
<th>Main category</th>
<th>Sub-category</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social</td>
<td></td>
<td>24.3%</td>
</tr>
<tr>
<td>Mail</td>
<td></td>
<td>9.4%</td>
</tr>
<tr>
<td>Forum</td>
<td></td>
<td>1.4%</td>
</tr>
<tr>
<td>Blog</td>
<td></td>
<td>0.4%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>35.5%</strong></td>
</tr>
<tr>
<td>Content</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Game</td>
<td></td>
<td>6.2%</td>
</tr>
<tr>
<td>MM</td>
<td></td>
<td>5.4%</td>
</tr>
<tr>
<td>Portal</td>
<td></td>
<td>5.4%</td>
</tr>
<tr>
<td>Head Listings</td>
<td></td>
<td>3.4%</td>
</tr>
<tr>
<td>News</td>
<td></td>
<td>3.4%</td>
</tr>
<tr>
<td>Other Vertical</td>
<td></td>
<td>28.1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>52.0%</strong></td>
</tr>
<tr>
<td>Search</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main</td>
<td></td>
<td>6.2%</td>
</tr>
<tr>
<td>MM</td>
<td></td>
<td>1.4%</td>
</tr>
<tr>
<td>Item</td>
<td></td>
<td>1.4%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>9.0%</strong></td>
</tr>
<tr>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>3.4%</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vertical</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail</td>
<td>3.4%</td>
</tr>
<tr>
<td>Travel</td>
<td>1.8%</td>
</tr>
<tr>
<td>Other</td>
<td>1.6%</td>
</tr>
<tr>
<td>Finance</td>
<td>1.4%</td>
</tr>
<tr>
<td>Education</td>
<td>1.2%</td>
</tr>
<tr>
<td>Personals</td>
<td>1.0%</td>
</tr>
<tr>
<td>Jobs</td>
<td>1.0%</td>
</tr>
<tr>
<td>Services</td>
<td>1.0%</td>
</tr>
<tr>
<td>B2B</td>
<td>1.0%</td>
</tr>
<tr>
<td>Social</td>
<td>0.8%</td>
</tr>
<tr>
<td>Entertainment</td>
<td>0.8%</td>
</tr>
<tr>
<td>Mobile</td>
<td>0.8%</td>
</tr>
<tr>
<td>Reference</td>
<td>0.8%</td>
</tr>
<tr>
<td>Sports</td>
<td>0.8%</td>
</tr>
<tr>
<td>Real estate</td>
<td>0.6%</td>
</tr>
<tr>
<td>Movies</td>
<td>0.6%</td>
</tr>
<tr>
<td>Auto</td>
<td>0.6%</td>
</tr>
<tr>
<td>TV</td>
<td>0.6%</td>
</tr>
<tr>
<td>Local</td>
<td>0.6%</td>
</tr>
<tr>
<td>Radio</td>
<td>0.4%</td>
</tr>
<tr>
<td>Food</td>
<td>0.4%</td>
</tr>
<tr>
<td>Health</td>
<td>0.4%</td>
</tr>
<tr>
<td>Government</td>
<td>0.4%</td>
</tr>
</tbody>
</table>
Breakdown (rough estimate)

Fraction of Pageviews

- No personalization: 57%
- Profile-based: 5%
- Data-based: 18%
- Model-based: 20%
Potential for Personalization
Trends

• More walled gardens and cleaner content – more ability to provide model-based personalization
• More value to logged-in users?
Value Assessment

• Pick any webpage. Could a web-savvy “personal butler” knowing everything about you improve the page?
  – If so, this page is a candidate for model-based personalization.
Personalization by Problem Domain

• Advertising
• Content Optimization
• Search
• Recommendations
Advertising personalization

• [Chen et al] KDD09:
  – Traffic-based behavioral targeting for display ads
  – 20% lift in CTR

• [Yan et al] WWW09:
  – Query-based behavioral targeting
  – 6.7x lift in CTR
Content Optimization

- 40% CTR lift (Agarwal et al, NIPS08)
  - Click dynamics much more important than personalization
  - Other work showed a 13% max lift due to segment personalization in this setting
Search Personalization

• Teevan, Dumais and Horwitz show that committing to a ranking for even 6 people is 46% worse than customizing the ranking for each (under NDCG)

• And search is “high intent,” so difficult to personalize
Recommender Systems

• Koren (NetFlix Grand Prize writeup) reports these RMSE values:
  – Baseline item and user features: 0.96
  – Temporal item and user features: 0.92
  – Full model: 0.86

• [Jahrer et al] KDD10
  – Training: ~2hrs -> ~160hrs
  – Performance: improve RMSE in 4\textsuperscript{th} significant digit

• Chen et al, CHI2010, “Short and Tweet”:  
  – 33\% interesting -> 72\% interesting
Item-item Systems

• Not necessarily model-based personalization, but uses rich intent information
  – Eg, amazon related items, youtube related videos
Obvious Omissions

- Mobile personalization
- Social network advertising
- Social network content recommendation
Research landscape
Problems in Personalization

• Item Recommendation
• Task completion tools
• Information delivery
• State management
Item Recommendation Breakdown

• Serendipitous Content Discovery:
  – Input: user, discovery constraints
  – Output: Interesting stuff
  – Examples: portals, social networks, multimedia

• Task-Specific Recommendations
  – Input: user, task
  – Output: recommendations
  – Examples: search, shopping, local
Item Recommendation Problems

• Many problems are hybrids of serendipitous content discovery and task completion
  – Shopping item recommendation
  – Advertising (search, contextual, display)

• Uniform representation for all these different item types?
Rich Task Completion

- **Examples**
  - Travel planning, events, considered purchase

- **Challenge:**
  - Most domains are small (see previous slide)
  - Requires significant domain customization
  - Difficult to justify investment
Information Delivery

- [Broder], many venues
End States

• State 1: local state. User behavior is aggregated separately by each provider, leading to:
  – Fragmentation
  – Oligopoly in each segment due to a “rich get richer” pattern of customized experience

• State 2: shared state. User behavior is combined and sent to a user-specified profile service, made available to all sites
Shared State Personalization

• Develop the right feature spaces:
  – Rich enough to capture niche interests/prefs
  – Structured enough to reason about
  – Examples
    • Raw clicks, queries, visits
    • Categories, topics, entities, normalized representations
    • Preferences for language, multimedia, sophistication, style…

• Securely store and deliver user behavioral/profile data

• Give user comprehensible control of delivery
Modeling Internal User State

- Work / home
- Research / entertainment
- Moods
- provider architecture, incentive schemes. Start with profiles, move to behavior?
Bigger Questions

• Metrics: CTR, Happiness, Social welfare, User education / capability / knowledge
  – User should choose
  – We don’t know how to do this yet

• Longitudinal optimization
  – Current focus is largely single-page optimization
  – How much do we leave on the table?
The End

Questions and discussion