



ICML'11 Tutorial: Recommender Problems for Web Applications

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Other Significant Y! Labs Contributors

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- Ad Targeting
 - Nagaraj Kota



Agenda

- Topic of Interest
 - Recommender problems for **dynamic, time-sensitive** applications
 - Content Optimization (main focus today), Online Advertising, Movie recommendation, shopping,...
- Introduction (20 min, Deepak)
- Offline components (40 min, Deepak)
 - Regression, Collaborative filtering (CF), ...
- Online components + initialization (70 min, Bee-Chung)
 - Time-series, online/incremental methods, explore/exploit (bandit)
- Evaluation methods + Multi-Objective (10-15 min, Deepak)
- Challenges (5-10 min, Deepak)

Three components we will focus on today

- Defining the problem
 - Formulate objectives whose optimization achieves some long-term goals for the recommender system
 - E.g. How to serve content to optimize audience reach and engagement, optimize some combination of engagement and revenue ?
- Modeling (to estimate some critical inputs)
 - Predict rates of some positive user interaction(s) with items based on data obtained from historical user-item interactions
 - E.g. Click rates, average time-spent on page, etc
 - Could be explicit feedback like ratings
- Experimentation
 - Create experiments to collect data proactively to improve models, helps in converging to the best choice(s) cheaply and rapidly.
 - Explore and Exploit (continuous experimentation)
 - DOE (testing hypotheses by avoiding bias inherent in data)

Modern Recommendation Systems

- Goal
 - Serve the right item to a user in a given context to optimize long-term business objectives
- A scientific discipline that involves
 - Large scale Machine Learning & Statistics
 - Offline Models (capture global & stable characteristics)
 - Online Models (incorporates dynamic components)
 - Explore/Exploit (active and adaptive experimentation)
 - Multi-Objective Optimization
 - Click-rates (CTR), Engagement, advertising revenue, diversity, etc
 - Inferring user interest
 - Constructing User Profiles
 - Natural Language Processing to understand content
 - Topics, “aboutness”, entities, follow-up of something, breaking news,...

Some examples from content optimization

- Simple version
 - I have a content module on my page, content inventory is obtained from a third party source which is further refined through editorial oversight. Can I algorithmically recommend content on this module? I want to improve overall click-rate (CTR) on this module
- More advanced
 - I got X% lift in CTR. But I have additional information on other downstream utilities (e.g. advertising revenue). Can I increase downstream utility without losing too many clicks?
- Highly advanced
 - There are multiple modules running on my webpage. How do I perform a simultaneous optimization?



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Web Search

My Yahoo! | Make Y! your homepage

Sign In | New here? Sign Up | Have something to share? | Page Options ▾

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TODAY - July 14, 2010



World Cup octopus could make millions

Paul the octopus is in high demand after a perfect run of predicting soccer game winners. » Possible opportunities

More on the octopus
Cup winners and losers
U.S.'s top moments



Salsa tied to food illness



Octopus could be worth millions



Lottery winner rich in mystery



High schooler's impressive dunk

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NEWS WORLD LOCAL FINANCE

- 9 killed, 10 missing as typhoon lashes Philippines | Photos
- Testing delayed on tighter cap for Gulf oil well | Photos
- W.Va. mine disaster prompts bill to toughen worker safety rules
- Military won't establish 'separate but equal' housing for gays
- Small banks struggling despite gov't bailouts, watchdog reports
- Tiny mushroom blamed for 400 deaths in southwest China
- CHP pursuit ends in two-car crash in San... - SJ Mercury N...
- Oakland talks break down: layoffs for 80... - S.F. Chronic

TRENDING NOW

1. Kourtney Kardash...
2. Anna Chapman
3. Al Pacino
4. French Toast Rec...
5. Nina Garcia
6. Susan Boyle
7. Job Search
8. Yogi Berra
9. Philippines Typh...
10. Sunscreen

Recommend search queries

Recommend packages:

Image

Title, summary

Links to other pages

Pick 4 out of a pool of K

$K = 20 \sim 40$

Dynamic

Routes traffic other pages

Recommend news article

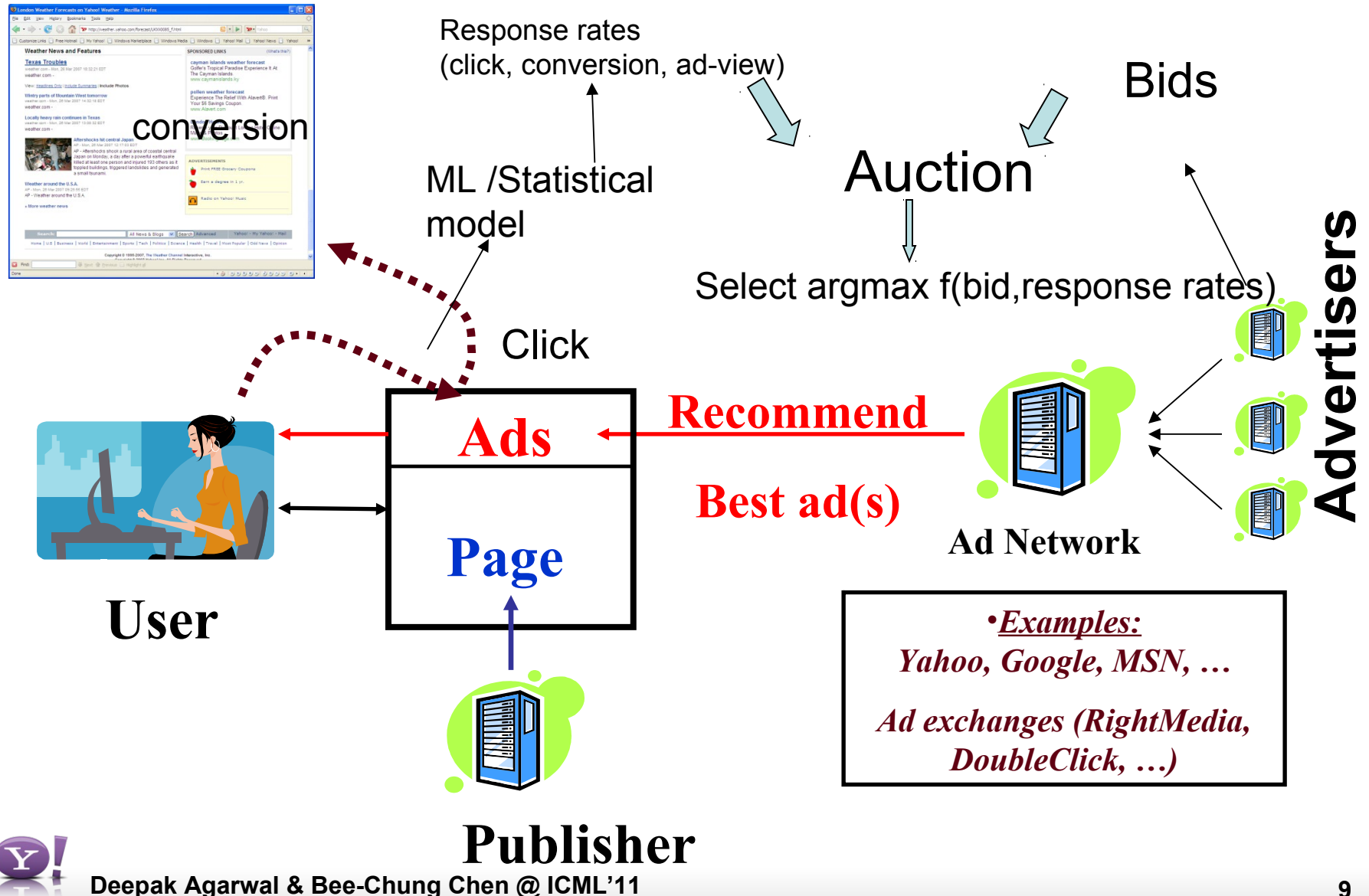
Recommend applications

Problems in this example

- Optimize CTR on multiple modules
 - Today Module, Trending Now, Personal Assistant, News
 - Simple solution: Treat modules as independent, optimize separately. May not be the best when there are strong correlations.
- For any single module
 - Optimize some combination of CTR, downstream engagement, and perhaps advertising revenue.

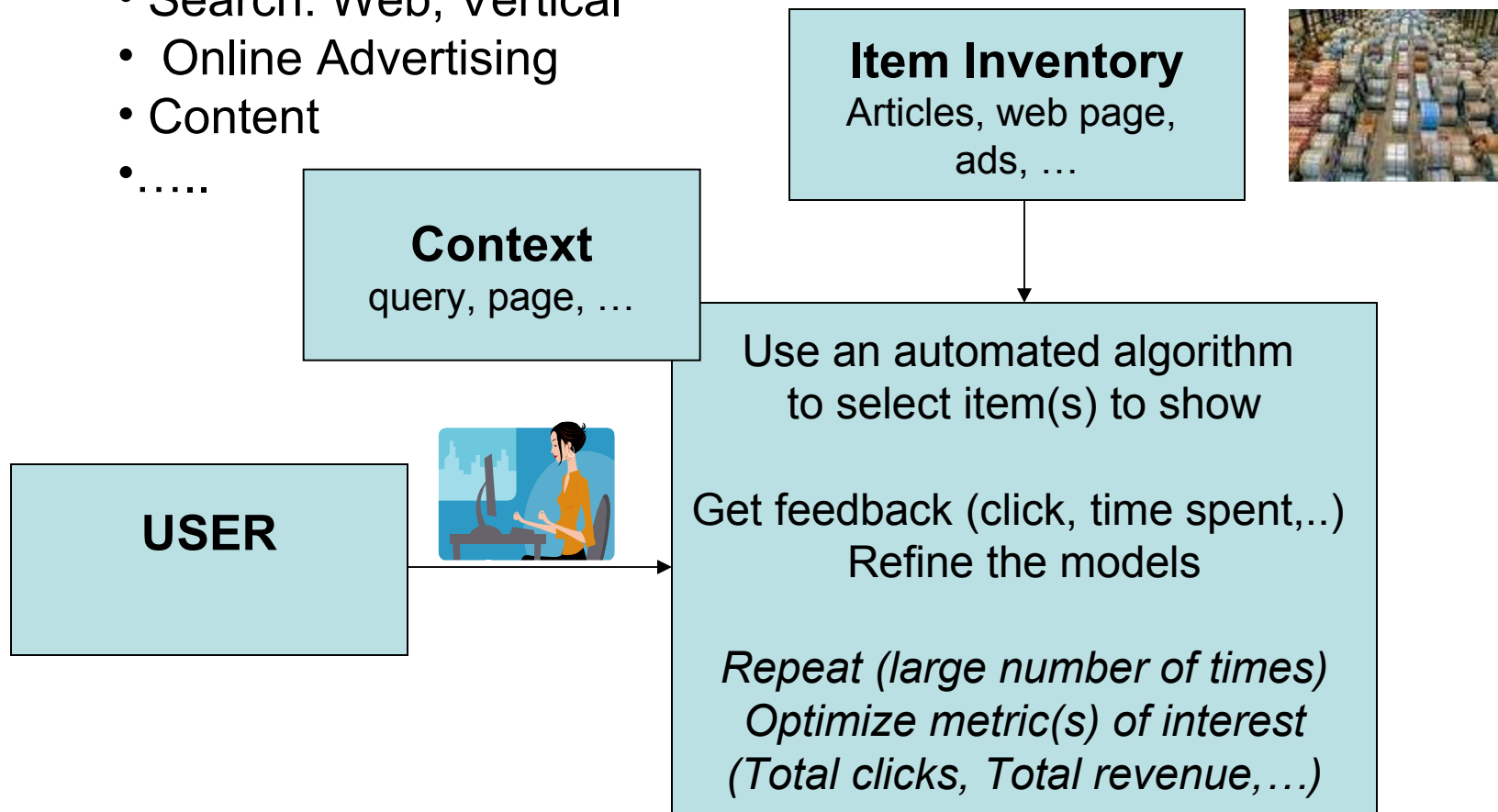


Online Advertising



Recommender problems in general

- Example applications
 - Search: Web, Vertical
 - Online Advertising
 - Content
 -



Important Factors

- **Items:** Articles, ads, modules, movies, users, updates, etc.
- **Context:** query keywords, pages, mobile, social media, etc.
- **Metric** to optimize (e.g., relevance score, CTR, revenue, engagement)
 - Currently, most applications are single-objective
 - Could be multi-objective optimization (maximize X subject to Y, Z, \dots)
- **Properties of the item pool**
 - Size (e.g., all web pages vs. 40 stories)
 - Quality of the pool (e.g., anything vs. editorially selected)
 - Lifetime (e.g., mostly old items vs. mostly new items)



Factors affecting Solution (continued)

- **Properties of the context**
 - Pull: Specified by explicit, user-driven query (e.g., keywords, a form)
 - Push: Specified by implicit context (e.g., a page, a user, a session)
 - Most applications are somewhere on continuum of pull and push
- **Properties of the feedback on the matches made**
 - Types and semantics of feedback (e.g., click, vote)
 - Latency (e.g., available in 5 minutes vs. 1 day)
 - Volume (e.g., 100K per day vs. 300M per day)
- **Constraints specifying legitimate matches**
 - e.g., business rules, diversity rules, editorial Voice
 - Multiple objectives
- **Available Metadata** (e.g., link graph, various user/item attributes)

Predicting User-Item Interactions (e.g. CTR)

- Myth: We have so much data on the web, if we can only process it the problem is solved
 - Number of things to learn increases with sample size
 - Rate of increase is not slow
 - Dynamic nature of systems make things worse
 - We want to learn things quickly and react fast
- Data is sparse in web recommender problems
 - We lack enough data to learn all we want to learn and as quickly as we would like to learn
 - Several Power laws interacting with each other
 - E.g. User visits power law, items served power law
 - Bivariate Zipf: Owen & Dyer, 2011

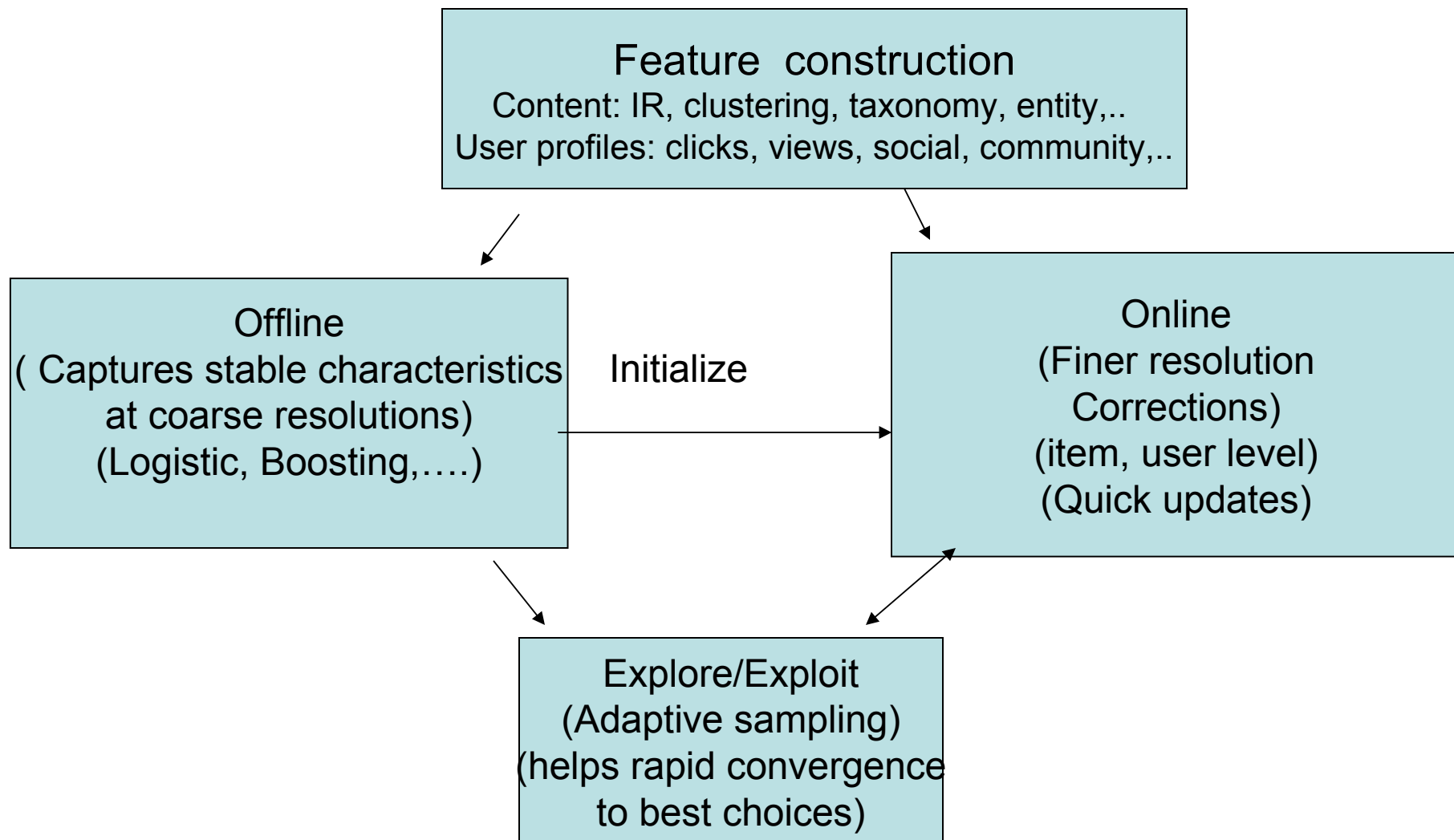


Can Machine Learning help?

- Fortunately, there are group behaviors that generalize to individuals & they are relatively stable
 - E.g. Users in San Francisco tend to read more baseball news
- Key issue: Estimating such groups
 - Coarse group : more stable but does not generalize that well.
 - Granular group: less stable with few individuals
 - Getting a good grouping structure is to hit the “sweet spot”
- Another big advantage on the web
 - Intervene and run small experiments on a small population to collect data that helps rapid convergence to the best choices(s)
 - We don't need to learn all user-item interactions, only those that are good.



Predicting user-item interaction rates



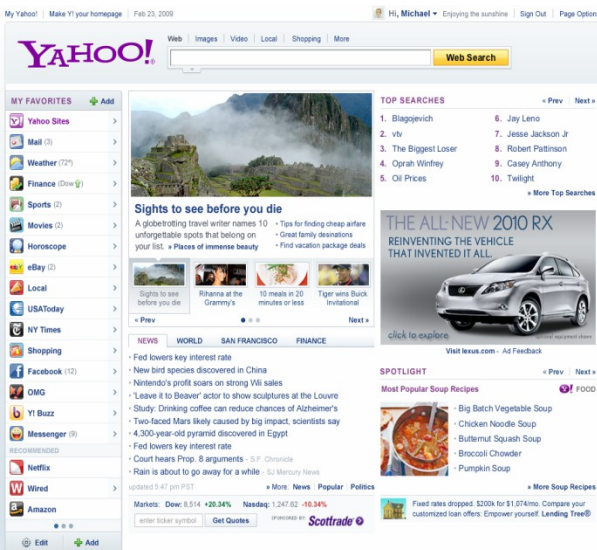
Post-click: An example in Content Optimization

Recommender

EDITORIAL

content

Clicks on FP links influence downstream supply distribution



AD SERVER

DISPLAY
ADVERTISING Revenue

SPORTS

NEWS

OMG

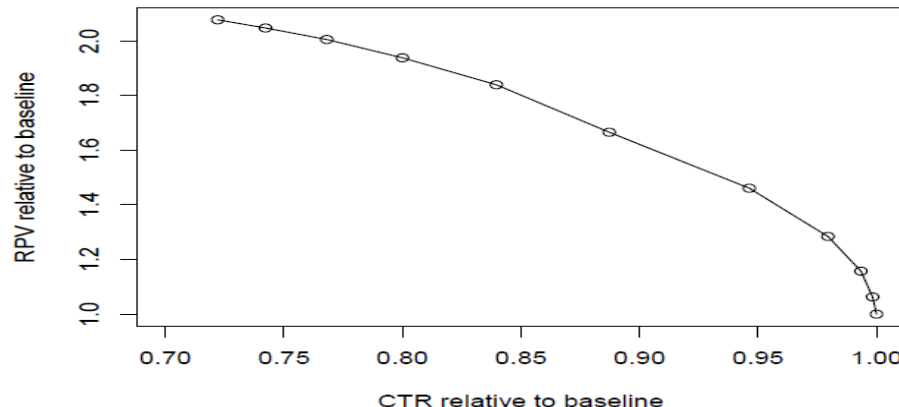
FINANCE

Downstream
engagement
(Time spent)



Serving Content on Front Page: Click Shaping

- What do we want to optimize?
- Current: Maximize clicks (maximize downstream supply from FP)
- But consider the following
 - Article 1: CTR=5%, utility per click = 5
 - Article 2: CTR=4.9%, utility per click=10
 - By promoting 2, we lose 1 click/100 visits, gain 5 utils
- If we do this for a large number of visits --- lose some clicks but obtain significant gains in utility?
 - E.g. lose 5% relative CTR, gain 40% in utility (revenue, engagement, etc)





Example Application: Today Module on Yahoo! Homepage

Currently in production, powered by some methods
discussed in this tutorial

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- Anna Chapman
- Al Pacino
- French Toast Rec...
- Nina Garcia
- Susan Boyle
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- Yogi Berra
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- Sunscreen

AdChoices

Anything you want, you got it with Ultimate Rewards.

Recommend packages:

Image

Title, summary

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Pick 4 out of a pool of K

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Dynamic

Routes traffic other pages

DAILY OFFERS



Mortgage rates low as 3.32% APR

Problem definition

- Display “best” articles for each user visit
- Best - Maximize User Satisfaction, Engagement
 - BUT Hard to obtain quick feedback to measure these
- Approximation
 - Maximize utility based on immediate feedback (click rate) subject to constraints (relevance, freshness, diversity)
- Inventory of articles?
 - Created by human editors
 - Small pool (30-50 articles) but refreshes periodically

Where are we today?

- Before this research
 - Articles created and selected for display by editors
- After this research
 - Article placement done through statistical models
- How successful ?

"Just look at our homepage, for example. Since we began pairing our content optimization technology with editorial expertise, we've seen click-through rates in the Today module more than double. ----- Carol Bartz, CEO Yahoo! Inc (Q4, 2009)



Main Goals

- Methods to select most popular articles
 - This was done by editors before
- Provide personalized article selection
 - Based on user covariates
 - Based on per user behavior
- Scalability: Methods to generalize in small traffic scenarios
 - Today module part of most Y! portals around the world
 - Also syndicated to sources like Y! Mail, Y! IM etc



Similar applications

- Goal: Use same methods for selecting most popular, personalization across different applications at Y!
- Good news! Methods generalize, already in use

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HOME U.S. BUSINESS WORLD ENTERTAINMENT SPORTS

Video Photos The Upshot The Starting Point Local Odd News

Search All News News Search TRENDING NOW:

Afghan attacks kill 8 US soldiers in 24 hours

AP - 2 hrs 37 mins ago
KANDAHAR, Afghanistan - Eight American troops died in attacks in southern Afghanistan, including a car bombing and gunfight outside a police compound in Kandahar, officials said Wednesday as the Taliban push back against a coalition effort to secure the volatile region. Full Story »

Video: Kandahar Province Key to Taliban Defeat ABC News
Slideshow: Afghanistan

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MARKET SUMMARY

US EUROPE ASIA

Dow 10,370.21 +7.19 +0.07%

DOW Jul 14 01:16pm EDT

Nasdaq 2,253.83 +11.80 +0.53%

S&P 500 1,095.66 +0.32 +0.03%

10 Yr Bond(%) 3.0860% -0.2800

Oil 77.47 +0.32 +0.41%

Gold 1,204.00 -9.30 -0.77%

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- Why earnings are beating estimates as econ. data flops - Business Insider
- SEC eyes changes to shareholder voting system - Reuters
- Fermented tea kombucha: an alcoholic drink? - AP
- Home sellers slash prices while banks mow the lawn - CNBC
- Sen. Brown flexes muscle in Wall Street reform - CNBC
- The gold stock the smart money is buying - WSJ
- Oil prices rise after crude stockpiles fall - AP
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- Steinbrenner a Boost for all Baseball Franchises - FOX Business Now
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QUOTES

Next few hours

	Most Popular Recommendation	Personalized Recommendation
Offline Models		Collaborative filtering (cold-start problem)
Online Models	Time-series models	Incremental CF, online regression
Intelligent Initialization	Prior estimation	Prior estimation, dimension reduction
Explore/Exploit	Multi-armed bandits	Bandits with covariates

