

# *Research Challenges in Recommenders*

John Riedl, U of Minnesota

Todd Beaupre, Yahoo!

Jon Sanders, Netflix



# Structure

- Introductions
- Eight Challenges
- John Riedl will define the Challenge
- Jon Sanders or Todd Beaupre will explain key issues
- Other panelist will respond
- Audience discussion of *that* Challenge

# *John Riedl*

- Professor at the University of Minnesota
- Co-Leader of GroupLens Research
- Net Perceptions Founder, CTO, and Director, 1996-2004
- Your Friendly Moderator

*Todd Beaupre*

Yahoo!



# Yahoo! is ranked among the top 3 sites in 26 key categories and #1 in 12 of them

Yahoo! Monthly Unique Visitors (000) Noted in Yellow

## E-mail

1. **Yahoo! Mail**
  2. Win. Live Hotmail
  3. Google Gmail
- Y! UVs: 106,166

## Autos

1. eBay Motors U.S.
  2. **Yahoo! Autos**
  3. KBB.com
- Y! UVs: 6,972

## Entertainment News

1. **omg!**
  2. TMZ
  3. People
- Y! UVs: 20,428

## Local/Maps

1. Google Maps
  2. Mapquest
  3. **Yahoo! Maps**
- Y! UVs: 13,163

## Groups

1. Facebook Groups
  2. **Yahoo! Groups**
  3. Google Groups
- Y! UVs: 7,654

## Home Pages

1. **Yahoo! HP**
  2. Google HP
  3. Facebook HP
- Y! UVs: 118,011

## Games

1. **Yahoo! Games**
  2. EA Games
  3. Nickelodeon
- Y! UVs: 18,797

## Search

1. Google Search
  2. **Yahoo! Search**
  3. ASK Network
- Y! UVs: 90,191

## Finance

1. **Yahoo! Finance**
  2. AOL Money & Finance
  3. MSN Money
- Y! UVs: 21,671

## TV

1. **Yahoo! TV**
  2. AOL TV
  3. MSN TV
- Y! UVs: 15,085

## News

1. **Yahoo! News**
  2. CNN
  3. MSNBC
- Y! UVs: 48,433

## IM

1. **Yahoo! Messenger**
  2. AIM.com/AIM App
  3. MSN Msngr
- Y! UVs: 38,140

## Movies

1. IMDB.com
  2. **Yahoo! Movies**
  3. Moviefone
- Y! UVs: 17,942

## Travel

1. TravelAd Network
  2. Tripadvisor
  3. **Yahoo! Travel**
- Y! UVs: 10,167

## Music

1. AOL Music
  2. MySpace Music
  3. **Yahoo! Music**
- Y! UVs: 21,889

## My (Custom)\*

1. **My Yahoo!**
  2. iGoogle
  3. My MSN
- Y! UVs: 24,644

## Sports

1. **Yahoo! Sports**
  2. ESPN
  3. Fox Sports on MSN
- Y! UVs: 30,718

## Portals

1. **Yahoo! Sites**
  2. Microsoft Sites
  3. AOL LLC
- Y! UVs: 156,506

## Shopping (Comparison)

1. **Yahoo! Shopping**
  2. Shopzilla.com
  3. Shopping.com
- Y! UVs: 22,901

## Careers

1. Careerbuilder
  2. **Yahoo! HotJobs**
  3. Monster
- Y! UVs: 16,697

## Reference

1. Wikimedia
  2. **Yahoo! Answers**
  3. Answers.com
- Y! UVs: 43,164

## Personals

1. **Yahoo! Personals**
  2. SingelsNet
  3. PlentyofFish
- Y! UVs: 3,330

## Photos

1. Facebook.com Photo
  2. Photobucket
  3. **FLICKR.COM**
- Y! UVs: 24,686

## Real Estate

1. Move Network
  2. **Yahoo! Real Estate**
  3. AOL Real Estate
- Y! UVs: 7,525

Source: comScore Media Metrix, July 2009

Base: P2+ U.S. data, Note: Homepages is not a traditional category in comScore's service

\*Not Shown: Yahoo! Green ranks #2 in Environment, Yahoo! Health ranks #3 in Health  
Monthly figures unless otherwise indicated

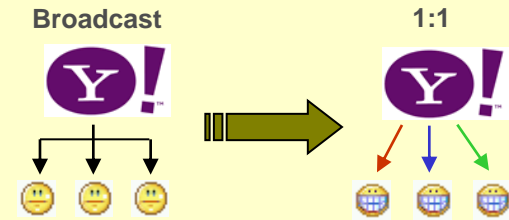


**I think our clear strength is ‘relevance’ – whether that means knowing what weather to give you or serving up headlines you’ll be interested in. It’s all about really getting you and we have more work to do in that area.**

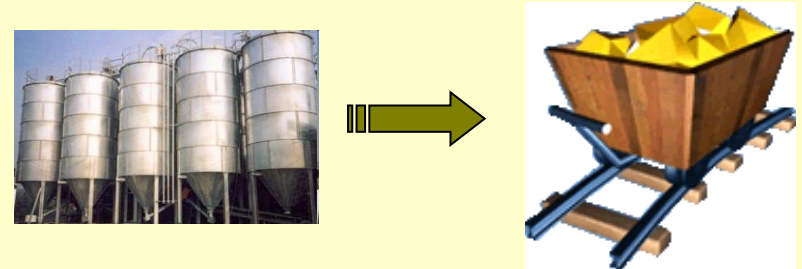
**- Carol Bartz, CEO, Yahoo!**

Make Yahoo! the most ***relevant experience***  
on the Web by recommending  
the **right content** and products  
to the **right user** at the **right time**

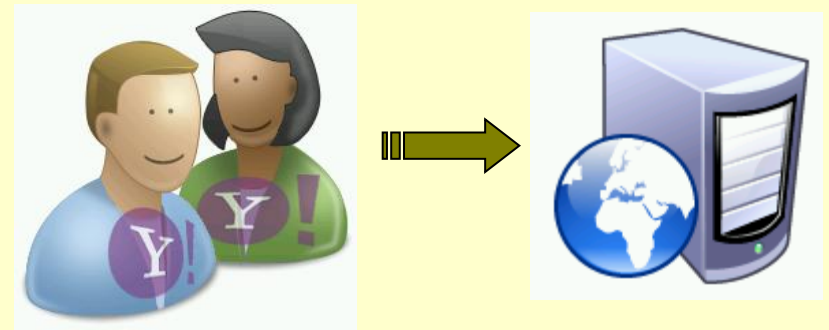
- **Fundamentally shift** Yahoo!'s content programming and serving paradigm from broadcast to 1:1



- **Break down data silos** to extract more value from our behavioral data goldmine



- **Automate content programming** in global markets where editorial headcount is not available







**Most Popular**

*“What’s most engaging overall?”*



**Personalized Recommendations**

*“What’s most relevant to me based on my interests and attributes?”*



**Related Items**

***Behavioral Affinity:**  
People who did X, did Y*

***Similarity: Based on metadata***



**Voice and  
Business Rules**



**Real-time  
Dashboard**



**Business  
Optimization**

YAHOO!

Web | Images | Video | Local | Shopping | More

Web Search

## MY FAVORITES

+ Add

Yahoo Sites &gt;

Mail (3) &gt;

Weather (72°) &gt;

Finance (Dow ↑) &gt;

Sports (2) &gt;

Movies (2) &gt;

Horoscope &gt;

eBay (2) &gt;

Local &gt;

USAToday &gt;

NY Times &gt;

Shopping &gt;

Facebook (12) &gt;

OMG &gt;

Y! Buzz &gt;

Messenger (9) &gt;

## RECOMMENDED

Netflix &gt;

Wired &gt;

Amazon &gt;

...



Edit

+ Add



## Sights to see before you die

A globetrotting travel writer names 10 unforgettable spots that belong on your list. » [Places of immense beauty](#)

- Tips for finding cheap airfare
- Great family destinations
- Find vacation package deals



Sights to see before you die



Rihanna at the Grammy's



10 meals in 20 minutes or less



Tiger wins Buick Invitational

&lt; Prev

...

Next &gt;

NEWS

WORLD

SAN FRANCISCO

FINANCE

- Fed lowers key interest rate
- New bird species discovered in China
- Nintendo profit soars on strong Wii sales
- "Lionel" actor to show sculptures at the Louvre
- Study: Drinking coffee can reduce chances of Alzheimer's
- Two-faced Mars likely caused by big impact, scientists say
- 4,300-year-old pyramid discovered in Egypt
- Fed lowers key interest rate
- Court hears Prop. 8 arguments - S.F. Chronicle
- Rain is about to go away for a while - SJ Mercury News

updated 5:47 pm PST

» More: [News](#) | [Popular](#) | [Politics](#)Markets: Dow: 8,514 **+20.34%** Nasdaq: 1,247.62 **-10.34%**

enter ticker symbol

Get Quotes

SPONSORED BY: **Scottrade**

## TOP SEARCHES

&lt;&lt; Prev | Next &gt;&gt;

- |                      |                     |
|----------------------|---------------------|
| 1. Blagojevich       | 6. Jay Leno         |
| 2. vtv               | 7. Jesse Jackson Jr |
| 3. The Longest Loser | 8. Robert Pattinson |
| 4. ...               | 9. Casey Anthony    |
| 5. ...               | 10. Twilight        |

» More Top Searches

THE ALL-NEW 2010 RX  
REINVENTING THE VEHICLE  
THAT INVENTED IT ALL.

click to explore optional equipment shown

Visit [lexus.com](http://lexus.com) - Ad Feedback

## SPOTLIGHT

&lt;&lt; Prev | Next &gt;&gt;

## Soup Recipes

FOOD



- Big Batch Vegetable Soup
- Chicken Noodle Soup
- Butternut Squash Soup
- Broccoli Chowder
- Pumpkin Soup

» More Soup Recipes



Fixed rates dropped. \$200k for \$1,074/mo. Compare your customized loan offers: Empower yourself. **Lending Tree®**



## My Yahoo!: Module and Feed Recommendations



A screenshot of the My Yahoo! homepage. The top navigation bar includes the "MY YAHOO!" logo, a search bar with a "Web Search" button, and a series of tabs: "Quicklinks", "FrontPage", "Plus", "Todd" (active), "Feeds", "My New Page", and "New Tab". Below the tabs are links for "Add Content", "Change Appearance", and "More Options". The main content area is titled "Add Content" and displays a grid of six recommended modules: "Horoscopes", "Gizmodo", "Wired: Top Stories", "My Yahoo! Blog", "This Old House: How-To And Repair", and "EW.com: Movie Reviews". Each module has a "+ Add" button and a corresponding icon. On the right side, there is a "Search content..." bar and a "Browse Content" section with a list of categories: "My Yahoo! Essentials", "Entertainment", "Money", "News", "Sports", "Technology", and "More Categories". At the bottom, there is an "I'm Done" button, a "Preloaded Tabs" indicator, an "Add RSS Feed" link, and a pagination control showing "1 - 6 of 19".

- Personalized based on Age, Gender, Location, BT, and module subscriptions

## Recommended Apps and Buttons



**Y! Toolbar Settings**

Edit Apps | Preferences | Help

Change Layout | Add Apps

Search

**Browse Categories**

- Featured
- All Apps
- My Custom Apps
- Yahoo! Services
- Search Tools
- News Sections
- Communities
- Sports
- Entertainment
- Shopping & Classifieds
- Mail
- + Create a custom app

**Featured**

+ Add	USA TODAY	+ Add	HowStuffWorks
+ Add	People	+ Add	Local Events
+ Add	Forbes	+ Add	Health

1 - 6 of 47

I'm Done

Personalized based on BT profiles



Destination Recommendations



Today's Picks for \*Todd Beaupré

Traveling from: Sunnyvale, CA [Change Location]

SHOW ME ▶ My Recommendations ▼

Salem, OR »



The main – and perhaps the only – reason to visit SALEM is to see the modern, white Vermont-marble State Capitol ... [More](#)

[Photos](#) | [Hotels](#) | [Things To Do](#) | [Map](#)

Portland, OR »



Having been spared the kind of aggressive, remorseless development that many Seattle residents have come to loathe, PORTLAND ... [More](#)

[Photos](#) | [Hotels](#) | [Things To Do](#) | [Map](#)

Showing Recommendations 1 - 2 of 10



Most popular by category

TOP 5 CARD GAMES			
1		Hold 'Em Poker	
2		Pyramids	
3		HOT UNO - Undercover	
4		HOT Aloha Solitaire	
5		Super Solitaire Turbo	



## Most popular by category



### Yahoo! Autos User's Picks

Most Viewed SUVs on Yahoo!  
Autos



#### 1 2009 Honda CR-V



MSRP \$21,245 - \$28,945  
Avg. Rating ★★★★☆  
(38 reviews)

"This is my 2nd CRV and it's as good as the last. Super reliable, love..." [more](#)

by Heath



#### 2 2009 Volkswagen Tiguan

#### 3 2009 Nissan Rogue

#### 4 2009 Jeep Patriot

#### 5 2010 Mercedes-Benz GLK-Class

## Search affinity



### Similar Searches

People that searched for Nissan Murano also searched:

[Nissan Maxima](#)

[Nissan Pathfinder](#)

[Nissan Altima](#)

[Honda Accord](#)

[Toyota Camry](#)

[Toyota RAV4](#)

[Infiniti FX35](#)

[Honda CR-V](#)

[Toyota Highlander](#)

[Toyota 4Runner](#)

## Listing & M/M/T Affinity



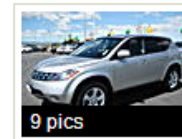
### Other People Also Viewed

People that viewed the **2005 Nissan Murano SL** listing also viewed these vehicles.



#### 2006 Nissan Murano

\$15,800 / 27,472 miles  
Dealer : Alameda County Auction  
Dublin CA



#### 2004 Nissan Murano

\$12,784 / 80,304 miles  
Dealer : Tracy Mazda  
Tracy CA



#### 2004 Nissan Murano

\$13,988 / 71,302 miles  
Dealer : Formula #1 Motors  
Hayward CA

## Related Listings (Behavioral & Metadata)



People who viewed 1103 Lund Ter also viewed



29% also viewed

521 Porpoise Bay Ter  
Sunnyvale, CA  
Beds: 3 | Bath: 2.50

**\$658,000**

Save



27% also viewed

722 Saranac Dr  
Sunnyvale, CA  
Beds: 5 | Bath: 2.50

**\$1,035,000**

Save



20% also viewed

1118 Breezewood Ct  
Sunnyvale, CA  
Beds: 3 | Bath: 2

**\$440,000**

Save



19% also viewed

1071 Mango Ave  
Sunnyvale, CA  
Beds: 3 | Bath: 2

**\$1,049,000**

Save

## Similar Shows



### SIMILAR SHOWS

- The Apprentice (NBC)
- Big Brother: All-Stars
- The Real World 18 - Denver
- American Idol
- Project Runway

## Recommended Products



Apple iPod touch, 32GB MP3 Player

**\$339.99 - \$339.99**

★★★★★ 51 ratings | 8 reviews



Apple iPod classic 80GB - Black ...

**\$299.95 - \$299.95**

★★★★★ 109 ratings | 10 reviews



Garmin nuvi 360 GPS Receiver

**\$139.95 - \$362.99**

★★★★★ 31 ratings | 13 reviews



## Related Products

Shoppers who viewed this product also viewed:



Garmin Nuvi 660 GPS Receiver

**\$459.95 - \$459.95**

★★★★★ 90 ratings | 23 reviews



Garmin nuvi 760 GPS Receiver

**\$189.99 - \$532.99**

★★★★★ 20 ratings | 2 reviews



Garmin nuvi 360 GPS Receiver

**\$139.95 - \$362.99**

★★★★★ 31 ratings | 13 reviews



## YAHOO! SMALL BUSINESS (Stores)



You may also be interested in these items:

**fingerprint-proof  
rectangular recycler**

**\$179.99**



**40 liter / 10.5 gallon  
fingerprint-proof  
semi-round step can**

**\$139.99**



**40 liter / 10.5 gallon  
fingerprint-proof  
round step can**

**\$99.99**





# Across the network

- News Top Stories

**News Top Stories**



AP


## Mexico criticizes 'repressive' quarantines abroad

AP – 7 mins ago

MEXICO CITY – Mexico announced a return to "normalcy" on Monday, preparing to reopen businesses and schools even as the virus sickened more than 1,200 people in 20 countries. [Full Story»](#)

 Slideshow: [Swine Flu](#)

 Interactive: [Swine flu](#)

 Video: [Signs of Swine Flu Ending](#) ABC News



Congress leery about Obama's plan on tax loopholes

AP – 13 mins ago

 Video: [Obama Cracks Down on Tax Code](#) ABC News

 Related: [Three things Obama could learn from Thatcher](#) Time.com



Iraq insists on US leaving cities by June 30

AP – 13 mins ago

 Video: [Mending the wounds of war](#) Reuters

# *Across the network*

- News Top Stories
- Finance Top Stories

## TOP STORIES

### **Dow, S&P in the Red in Midday Trade** - AP

Stocks rose Friday in early trade, following gains in markets overseas and a round of buying on Thursday, but gains have been pared in later trade.

- House targets Fed in Bank of America investigation - AP
- Energy prices drop with gas supplies healthy - AP
- Stanford indicted in US in alleged \$7B fraud case - AP
- Airbus sees bottom of industry slump - AP
- US Democrats try to regain health care momentum - AP
- 11 states ask TARP chief for AIG bonus probe - Reuters
- Pilot's death could renew debate over US age limit - AP
- E-Trade shares fall on pricing for public offering - AP
- Don't Believe the Rally? Bullish Fund Manager Says That's Why He's Buying - Tech Ticker

» [View more top stories](#)

# News Article Related content

Without state budget, California readies "IOUs"

## Featured



### Michael Jackson

Yahoo! News' complete coverage includes latest news and videos.  
» Slideshow



### Eyes on the prize

Canadian author Alice Munro wins the Man Booker Prize in The Week in Photos.

## Education



### Careers That Fight Recession

These fields offer strong careers that stay in demand during an economic slowdown.



### Surprising Stay-Home Salaries

Working from home is more popular than ever. See the most lucrative stay home careers.

## Entertainment

### Daily Features



All Comics »

Hayden Panettiere Opens Up

LAUNCH A WEB SITE  
FOR YOUR BUSINESS.  
SIGN UP TODAY AND  
SAVE 35%.

Find Out More

REPLAY

YAHOO! SMALL BUSINESS

More from Yahoo! Entertainment »

## Also on Yahoo! News

- Today in History
- Obituaries
- Corrections
- News by Region (Yahoo! Directory)
- Yahoo! News & Media Sites

## U.S. Video



AP Top Stories AP



In Hot Water FOX News



After-school Attack FOX News



Squatters clash with Peruvian police Reuters

More U.S. Video »

## Photo Highlight



Photo Highlight Slideshow

A boy jumps while playing football in a field near Pretoria. AFP/Yasuyoshi Chiba

# Across the Network

- News Top Stories
- Finance Top Stories
- Related News content
- **Buzz Ranking**



The screenshot shows the Yahoo! Buzz interface. At the top is the 'Y! buzz' logo. Below it are three tabs: 'Today's Buzz', 'Buzz Updates', and 'My Activity'. A navigation bar includes links for 'Top', 'Up & Coming', 'Seen on Yahoo.com', 'Buzz Log', and 'Categories'. A 'View by:' dropdown is set to '12 hrs'. The main content area lists three news stories, each with a 'Buzz up!' button:

- Police focus on medical treatment in Jackson death (AP)**  
Yahoo! News - Made Popular: 9 hours ago  
AP - Police investigating Michael Jackson's death looked into his medical treatment Friday, seeking to interview one of the pop king's doctors and seizing a car that they said may contain drugs or...  
» See more  
Comments (230) | First buzzed by: anonymous
- Israel Doubts Unrest Will Transform Iran**  
Washington Post - Made Popular: 11 hours ago  
JERUSALEM -- The storm of protests over the disputed election in Iran may have raised the prospect of a weakened regime, but it has done little to curb Israeli concerns about Iran's nuclear program or its support for militant groups in the region. » See more  
Comments (55) | First buzzed by: Andre
- Jackson death causes media scramble (AP)**  
Yahoo! Finance - Made Popular: 8 hours ago  
Two broadcast TV networks were already planning dueling prime-time specials on Farrah Fawcett's death Thursday. Then Michael Jackson died. » See more

# Best of the Web

**MY SUBSCRIPTIONS**

[View All Subscriptions](#)

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Market Summary

Most Emailed Photos on Yahoo! News Photos

CNN.com

Top Stories Photos on Yahoo! News Photos

Top Stories from Reuters

Yahoo! News: Most Popular

Technology News from Reuters Internet Report

Yahoo! News: Music News

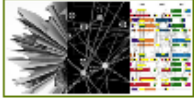
Technology News from Reuters

+

amaze anchor asset bad barron bartz  
 battelle broady chart closet cpi decide  
 detect division escher examine excel  
 existence graphic happiness  
 homepage inequality keyboard layoff  
 logo mybloglog napster obsolete photoshopped  
 pic poem poll portfolio prediction  
 productivity ranking ratings recommend  
 recommendation recording reddit scrabulous  
 spoon statistics sticker tattoo theory  
 thing traffic trend


=


▼ Top Picks from Your Page


 **Synchronous Objects: Visualizing Choreographic Information in New Ways** - information aesthetics - 1 day ago


Synchronous Objects  
 [synchronousobjects.osu.edu] is a beautiful project that aims to visualize choreographic information in "new ways". It focuses on revealing the interlocking systems of


---


 **Hell Hole: Zimbabwe prison called 'death camp'** - reddit.com: what's new online - 20 hours ago

 **Is Yahoo Ready for Its Closeup?** - Gawker: Valleywag - 21 hours ago

 **Will Newspapers Boo Eric Schmidt?** - The Business Insider - 21 hours ago

 **The New Atheism is Destructive** - MetaFilter - 21 hours ago

 **Perhaps The Major Record Labels Will Discover Twitter In 2015** - Techdirt - 22 hours ago

 **Behind the Scenes in an Unmarked Netflix Warehouse (Pics)** - reddit.com: what's new online - 22 hours ago

	Today	Future
Learns from...	My Yahoo! views/clicks	On- and off-network activity
User profiles are...	Sources, keywords	Sources, keywords, entities, topics
Content pool pulls from...	Subscribed feeds	All feeds, no setup required

*Jon Sanders*

Netflix



# Personalizing Netflix

(in 10 minutes)

Jon Sanders  
Recommendation Systems Engineering  
Netflix  
Los Gatos, CA  
jsanders @ netflix.com



# Fun facts about Netflix

## **World's largest online movie rental service**

Founded 1997

## **#1 in customer satisfaction**

Video rental companies (Consumer Reports)  
Online retail (ForeSee)

## **With more than...**

10M subscribers, \$1B revenue  
100K DVD titles, 50 distribution centers  
12K streaming movies & TV episodes  
1.5B minutes streamed to 1M Xbox360's  
3B movie ratings, 200 per member

## **On a typical day**

2M DVDs shipped  
3M movie ratings received  
30B ratings predicted



**60% of movies selected based on personalized recommendations**

**Connecting people with movies they'll love**



# Recommender domain

## **Customers**

Paid subscription  
Long term relationship  
Households  
Seeking entertainment  
Unlimited consumption

## **Products**

Long-lived  
Finite, growing catalog  
Rich metadata  
Single-use  
Varied external demand generation  
Varied inventory constraints

## **Primary interactions**

Subscribe  
DVD queue/ship/return  
Stream play/shuttle/stop  
Rate movies/categories

# In the beginning...

The screenshot shows the early version of the Netflix website. At the top, there are promotional banners for "The Avengers" (labeled "Stylish Action"), "Armageddon" (labeled "Action Movie"), and "Out of Sight" (labeled "Sexy Crime Com"). The central logo for "NETFLIX.COM" is prominently displayed, with the tagline "The Easiest Way to Rent a DVD!". Below the logo, navigation links for "New Visitor Registration" and "Returning Visitor Check In" are visible. A yellow banner at the top right encourages users to "Rent from Netflix.com, Buy from Amazon.com". The main navigation bar includes links for "Home", "Top 10 Rentals", "New DVD Releases", "Upcoming DVD Releases", "All DVD Releases", and "Browse the Aisles". A search bar labeled "FlixFinder" is present, with a "Movie Title" input field and "Go!" and "Search" buttons. The "Featured DVDs for Sunday, January 17, 1999:" section highlights two movies: "Blade" and "Six Days, Seven Nights". Each movie entry includes a small image, the title, the rental price ("Rent It - \$4.00"), a "Remind Me!" link, and a brief description. For "Blade", the description mentions Wesley Snipes and the vampire theme. For "Six Days, Seven Nights", it mentions Harrison Ford and Anne Heche. Below these, there are more recommendations like "Young Cinematographer" and "The Mask of Zorro". On the right side, a yellow box titled "First Time to NetFlix.com?" offers a "FREE DVD Rental" and provides details about the rental process, including shipping and handling charges. It also lists benefits like 7-day rental for \$4, access to virtually all DVD titles, and the option to earn \$55 as a NetFlix.com Associate.

Over 2,600 DVDs to rent!

**NETFLIX.COM**  
The Easiest Way to Rent a DVD!

New Visitor Registration | Returning Visitor Check In

Pioneer and Toshiba DVD Player Owners Click Here! | News! Rent from Netflix.com, Buy from Amazon.com | Get the Details!

Home | Top 10 Rentals | New DVD Releases | Upcoming DVD Releases | All DVD Releases | Browse the Aisles

FlixFinder > | Movie Title: | Go! | Search

**Featured DVDs for Sunday, January 17, 1999:**

**Blade**  
Rent It - \$4.00  
[Remind Me!](#)  
[Wesley Snipes](#) is [Blade](#), a half-human, half-vampire sworn to protect humanity by wiping out bloodsucking evil wherever he finds it. Can he stop an ambitious vampire ([Stephen Dorff](#)) who plans to magically summon the "Blood God" and make the world an inhuman feast?

Check out more vampire tales like [Bram Stoker's Dracula](#) in our [Bloodsucking Blockbusters](#) Collection!

**Six Days, Seven Nights**  
Rent It - \$4.00  
[Remind Me!](#)  
[Six Days, Seven Nights](#) sounds like a vacation – but when [Harrison Ford](#) and [Anne Heche](#) crash on a South Seas desert island, it's anything but fun in the sun. [Ivan Reitman](#) directed this castaway couple comedy, with [Ford](#) and [Heche](#) as an unlikely couple in paradise.

If you long to see more aching hearts, check out our [Complicated Couples](#) Collection for other great DVDs.

**Young Cinematographer**

**The Mask of Zorro**

**First Time to NetFlix.com?**  
**Get Your First DVD Rental Free!**

Get a FREE DVD Rental from Netflix.com. How? It's easy! The first DVD rental that you put into your shopping cart will be priced at \$0. [Let us tell you more!](#)

(Offer limited to one per customer the first time you rent from Netflix.com. Regular Shipping and Handling charges apply. Offer not available for DVD rental reservations. [Get more information about your free rental!](#))

**It's The Easiest Way to Rent a DVD!**  
Order your DVDs, and they arrive via mail in 2-3 days. Keep the DVDs for 7 full days. When you're finished, use the pre-addressed, pre-paid mailer, and drop them back in the mail. [Find out more!](#)

- 7-Day Rental for just \$4. [Save when you rent 4 or more!](#)
- Virtually all DVD titles! [Find them fast!](#)
- Earn \$55 as a [NetFlix.com Associate!](#)
- [NetFlix.com vs. DVD.com comparison chart](#)

Everyone sees the same site

Evolve methodically

# The rating widget



- Ask about & predict movie Enjoyment
- User-similarity collaborative filter
- Recommendations fuel discovery

**Recommendations**



**[Pan's Labyrinth](#)**  


In this fairy tale for adults, 10-year-old Ofelia (Ivana Baquero) stumbles on a decaying labyrinth guarded by Pan (Doug Jones), an ancient satyr who claims to know her destiny. With a new home, a new stepfather (Sergi Lopez) -- a Fascist officer in ... [Read More](#)

**Ratings Legend**

  
Loved it

  
Really Liked It

  
Liked It










  
Didn't Like It

  
Hated It

Not interested in this movie

I don't know enough about this movie to have an opinion

# Score & sort any movie

<a href="#">Smokin' Aces</a>  <b>In Queue</b> ★ ★ ★ ★ ☆ <input type="radio"/> Not Interested	<a href="#">Norbit</a>  <b>Add</b> ★ ★ ★ ★ ☆ <input type="radio"/> Not Interested	<a href="#">Avenue Montaigne</a>  <b>Add</b> ★ ★ ★ ★ ☆ <input type="radio"/> Not Interested
<a href="#">Candy</a>  <b>Add</b> ★ ★ ★ ★ ☆ <input type="radio"/> Not Interested	<a href="#">The Good German</a>  <b>Add</b> ★ ★ ★ ★ ☆ <input type="radio"/> Not Interested	<a href="#">Everything Is Illuminated</a>  <b>Add</b> ★ ★ ★ ★ ☆ <input type="radio"/> Not Interested
<a href="#">Rome: Season 1 (8-Disc Series)</a> 	<a href="#">Old Joy</a> 	<a href="#">Dead Silence</a> 

Combine popularity & enjoyment prediction

# Tune recommendations

- Movie-similarity collaborative filter
- K-nearest-neighbor algorithm
- More credible connections




## WHY IS THIS RECOMMENDED

Die Hard 2: Die Harder	★★★★★
Beverly Hills Cop II	★★★★★
Bad Boys II	★★★★★
Live Free or Die Hard	★★★★★
The Rock	★★★★★
The Fast and the Furious	★★★★★
Die Hard With a Vengeance	★★★★☆
Demolition Man	★★★★☆

# Interest-based discovery

**Movies most like Live Free or Die Hard** Close X




**Live Free or Die Hard**  
has been added to your DVD Queue at position #15

Move to position #1

More Formats: [Blu-ray](#)  
Bonus Discs:  
[Add](#) Live Free or Die Hard: Bonus Material


**Die Hard 2: Die Harder**



[Add](#)

★★★★★  
[Not Interested](#)


**Die Hard With a Vengeance**



[Add](#)

★★★★★  
[Not Interested](#)


**Tears of the Sun**



[Add](#)

★★★★★  
[Not Interested](#)


**Sin City**



[Add](#)

★★★★★  
[Not Interested](#)


**Death Race**



[Add](#)

★★★★★  
[Not Interested](#)

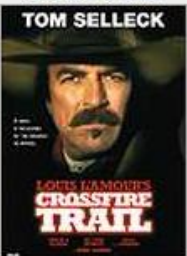
**Punisher: War Zone**



[Add](#)

★★★★★  
[Not Interested](#)


**Crossfire Trail**



[Add](#)

★★★★★  
[Not Interested](#)


**The Three Burials of Melquiades Estrada**



[Add](#)

★★★★★  
[Not Interested](#)

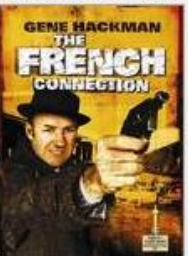
**Kingdom of Heaven: Director's Cut**



[Add](#)

★★★★★  
[Not Interested](#)

**The French Connection**



[Add](#)

★★★★★  
[Not Interested](#)

Metadata connections: actor, director, genre, ...



# Ask about Interest

Jennifer, take a minute to create a **personalized** Netflix website.

How often do you watch...	Never	Sometimes	Often
Action & Adventure	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Children & Family	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Comedies <a href="#">Show Examples</a>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
Comedies	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

How often do you watch...	Never	Sometimes	Often
Romantic	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Independent	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>

Prioritize catalog areas



# Ask other people

## Members' Top 10 Lists

Lists of movies created by Netflix members




<a href="#">10 Ten Movies Ever</a>	(10 movies)
<a href="#">Politics of Fear &amp; Hope</a>	(10 movies)
<a href="#">Thought-Provoking Suspense</a>	(9 movies)

## YOUR FRIENDS' AND FAVES' ACTIVITY




Highlights from your friends' and faves' recent activity

03/12	<a href="#">Eagleheart</a>	Rated	<a href="#">College</a> 3 stars
03/12	<a href="#">.G</a>	Rated	<a href="#">Miracle at St. Anna</a> 2 stars

### Your Friends Loved

		
<a href="#">Add</a>	<a href="#">Add</a>	<a href="#">+ All</a>

### Your Friends Hated

		
<a href="#">Add</a>	<a href="#">Add</a>	<a href="#">▶ +</a>

## Latest Member Reviews

(Mouse over to pause)



[Add](#)

### [Classic Mystery Movies](#)



All 3 of these movies were great, in thier own age period, in thier own way. And then there were none was wonderfully scary and kept you guessing, Cry Panic had great acting, with a surprise twist, ...

[Read the full review](#)

Bloomingrosebud



**41%**

Similar to you

Community offers decision support

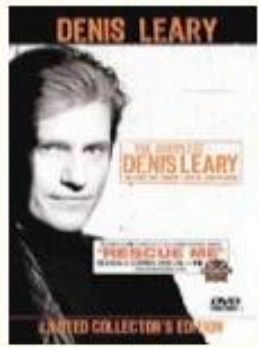
# Explain why

**Because you enjoyed:**

Suicide Kings  
Clerks

We think you'll enjoy:  
[Denis Leary: The Complete Denis Leary](#)

**Add**



★★★★☆  
Not Interested

## Action Comedies

Based on your interest in:

Big Trouble in Little China  
Zoom: Academy for Superheroes  
Batman: The Movie

Want to rate it?

Action Comedies



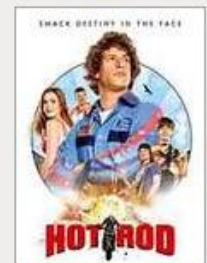
Midnight Run



**Play** **Add**



Hot Rod



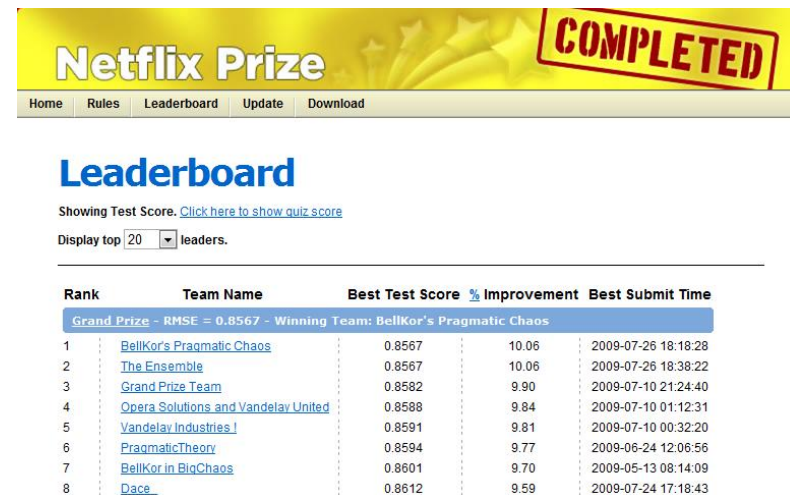
**Add**



Build trust with reflected evidence

# Netflix Prize

- Improve accuracy of Enjoyment predictions
  - 100M ratings
  - Achieve 10% better than Netflix RMSE
- Innovative, engaged research community
- Highly relevant results
  - Global and time-based corrections
  - SVD, RBM models
  - Blending predictors

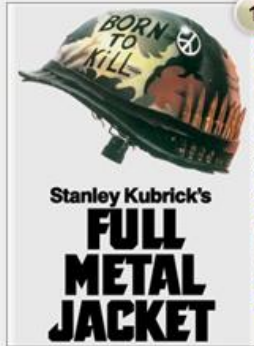


Rank	Team Name	Best Test Score	% Improvement	Best Submit Time
Grand Prize - RMSE = 0.8567 - Winning Team: BellKor's Pragmatic Chaos				
1	<a href="#">BellKor's Pragmatic Chaos</a>	0.8567	10.06	2009-07-26 18:18:28
2	<a href="#">The Ensemble</a>	0.8567	10.06	2009-07-26 18:38:22
3	<a href="#">Grand Prize Team</a>	0.8582	9.90	2009-07-10 21:24:40
4	<a href="#">Opera Solutions and Vandelav United</a>	0.8588	9.84	2009-07-10 01:12:31
5	<a href="#">Vandelav Industries I</a>	0.8591	9.81	2009-07-10 00:32:20
6	<a href="#">PragmaticTheory</a>	0.8594	9.77	2009-06-24 12:06:56
7	<a href="#">BellKor in BigChaos</a>	0.8601	9.70	2009-05-13 08:14:09
8	<a href="#">Dace</a>	0.8612	9.59	2009-07-24 17:18:43

# Experiment

## Top 10 for Todd

Full Metal Jacket



Play



Not Interested



## More like this...

Tell us a favorite movie or TV show...

Stardust

The Ultimate Gift



Add

The Lives of Others



Add

Your Selection



Stardust

Master and Commander



Add

We Were Soldiers



Add

Enemy at the Gates

Notes on a Scandal

## Critically-acclaimed Gritty Dramas

Your taste preferences created this row.

Dramas

As well as your interest in...



The Postman Always Rings Twice



Play



Not Interested

On the Out



Play



Not Interested

## Dark + Based on real life

Mix-and-match from the categories below...

☒ Dark

☐ Gritty

☐ Suspenseful

☐ Prison

☐ Political

☐ Crime

☒ Based on real life

☐ Based on a book

☐ Based on a play

Show only:

☐ Blu-ray

☐ Streaming

Anne Frank: The Whole Story

Notorious

When the Levees Broke

## Find a movie that matches your mood!

## Do you want to:

Amuse Kids

Experiment

Swoon

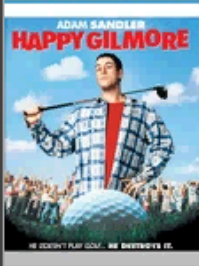
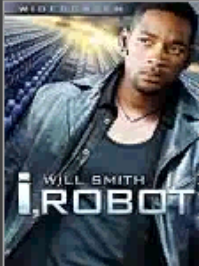

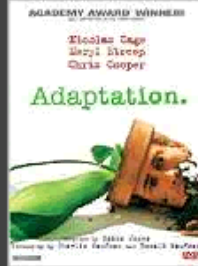




# Optimize, optimize

Suggestions (117) Rate Movies Taste Preferences Movies You've Rated (105)

**Rate Movies you've seen to discover movies you'll love**

Rating Movies in **All Genres** ▼

**RATED MOVIES 105**

<p>Happy Gilmore</p>  <p>★ ★ ★ ★ ★</p> <p>Haven't Seen It</p>	<p>I, Robot</p>  <p>★ ★ ★ ★ ★</p> <p>Haven't Seen It</p>	<p>Bowling for Columbine</p>  <p>★ ★ ★ ★ ★</p> <p>Haven't Seen It</p>	<p>Adaptation</p>  <p>★ ★ ★ ★ ★</p> <p>Haven't Seen It</p>
<p>The Bone Collector</p> 	<p>Hancock</p> 	<p>Troy</p> 	<p>Rushmore</p> 

Test everything



# A website for each subscriber

The screenshot displays the Netflix website interface for a subscriber named Jon Sanders. The top navigation bar includes links for "Jon Sanders", "Your Account", "Buy / Redeem Gift", and "Help". Below this, the main navigation bar features tabs for "Browse DVDs", "Watch Instantly", "Your Queue", and "Movies You'll ♥". A search bar is located on the right side of the main navigation bar.

The main content area is divided into several sections:

- Because you enjoyed:** This section recommends "Suicide Kings" and "Clerks". It also suggests "We think you'll enjoy: Denis Leary: The Complete Denis Leary" with an "Add" button.
- YOUR RECENT ACTIVITY:** This section lists recent activity, including "You watched Modern Marvels: The Manhattan Project" (03/10), "You watched CJ7" (03/04), "We shipped Hancock" (03/03), "We received Indiana Jones/Kingdom of the Crystal Skull" (03/03), and "We received Wanted" (02/24).
- SUGGESTIONS FOR YOU:** This section states "You have new suggestions in Movies You'll ♥".

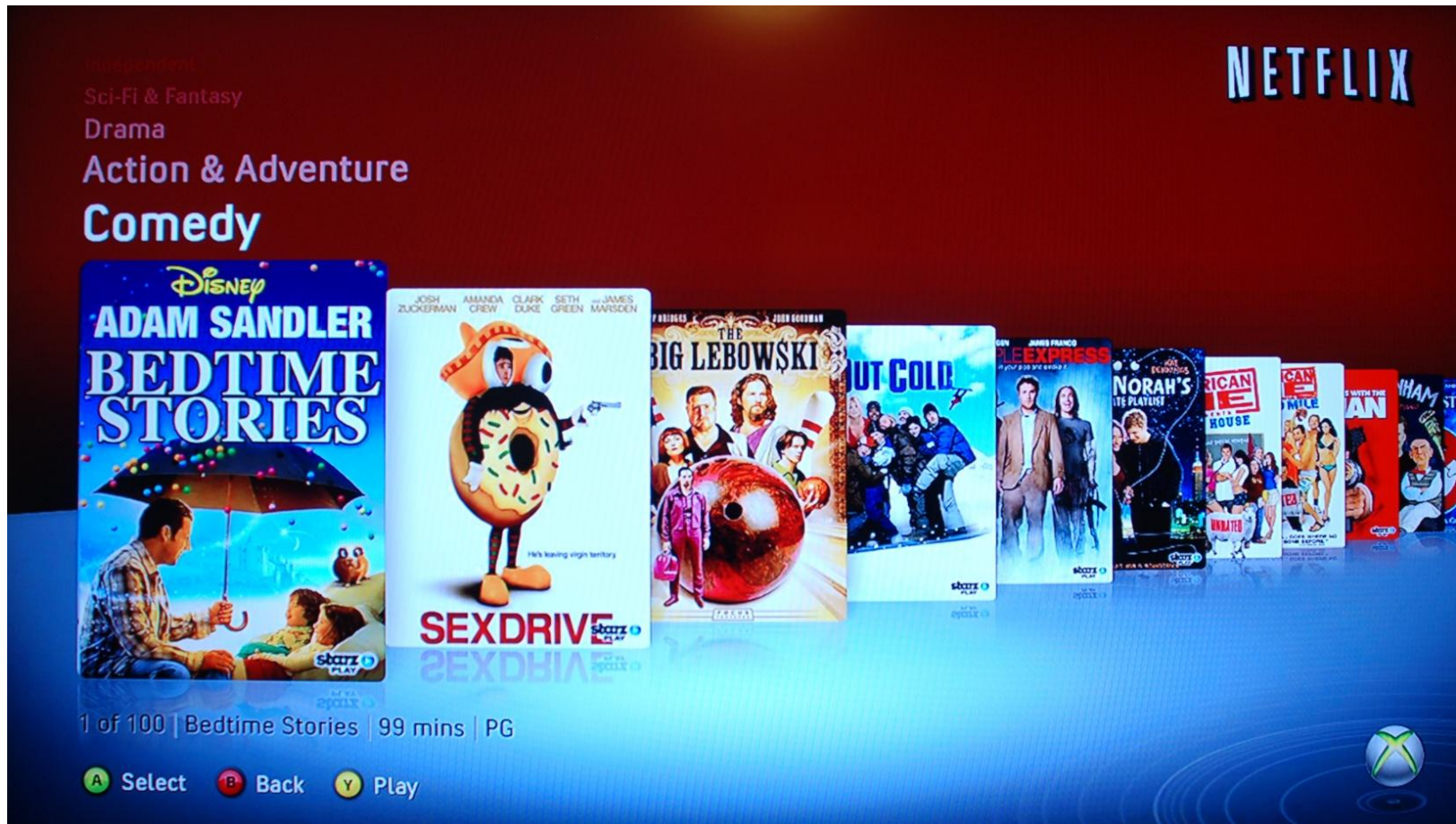
The interface also features a "BBC" section with a "See All >" link. This section includes a "Based on your interest in:" list (Fawlty Towers: The Complete Set, Monty Python's Flying Circus, Coupling: Season 1) and a "Want to rate it?" section with a "BBC" label and a star rating system. Below this, four BBC titles are displayed with "Add All" or "Add" buttons and star ratings:

- Wire in the Blood: Season 1
- Miss Austen Regrets
- The State Within
- North and South

The "TV Sitcoms" section also has a "See All >" link. It includes a "Based on your interest in:" list (Fawlty Towers: The Complete Set, 30 Rock: Season 2) and four sitcom titles displayed with "Add" buttons and star ratings:

- The Sarah Silverman Program: Season 1
- Keeping Up Appearances
- Arrested Development: Season 1
- The Munsters: Season 1

# Personalizing the TV



# Just beginning

- So many opportunities
- Streaming-specific personalization



- Collaborative Filtering is a component of personalization
- Offer discovery, focus and decision support

**Connecting people with movies they'll love**



# *Key Challenges*

1. Transparency
2. Exploration versus Exploitation
3. Guided Navigation
4. Time Value
5. User Action Interpretation
6. Evaluating Recommenders
7. Scalability
8. **Academic/Industry Partnerships**

# *Missing Challenges*

- Information Diet
- Serendipity
- Privacy
- Balkanization
- Driving Traffic Strategically
- Combining Content and Collaborative Recommenders

# *Ground Rules: Be Nice!*

- NO “My 1993 paper solved this problem ...”.
- NO: “What’s the answer?”
- YES: “What would a solution look like?”
- YES: “How would the solution be different between Yahoo! and Netflix?”

# 1. *Transparency*

We recommend Fargo because it is tagged with ***quirky, dark comedy***, and ***Coen Brothers***, and we believe you like movies with these tags.”

- Convince a user to accept a recommendation
- Help a user make a good decision
- Help a user fit a goal or mood
- What types of transparency are valuable?
- **Jon Sanders Lead**

# 1. Transparency

- Explaining “Why” increases engagement
- Where?
- When?
- How?

**Recommendations**



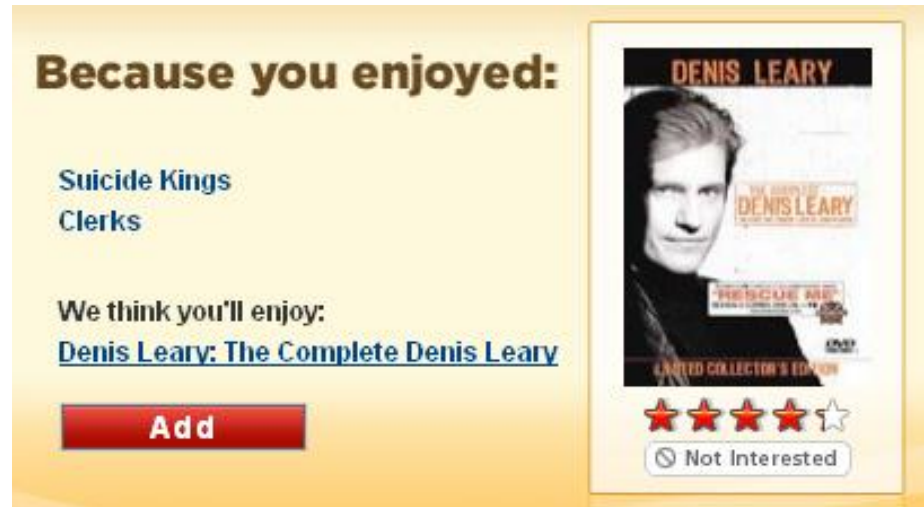
[Pan's Labyrinth](#)  
  


[Add](#)

In this fairy tale for adults, 10-year-old Ofelia (Ivana Baquero) stumbles on a decaying labyrinth guarded by Pan (Doug Jones), an ancient satyr who claims to know her destiny. With a new home, a new stepfather (Sergi Lopez) -- a Fascist officer in ... [Read More](#)

# 1. Transparency

- Explaining “Why” increases engagement
- Where?
- When?
- How?



# 1. Transparency

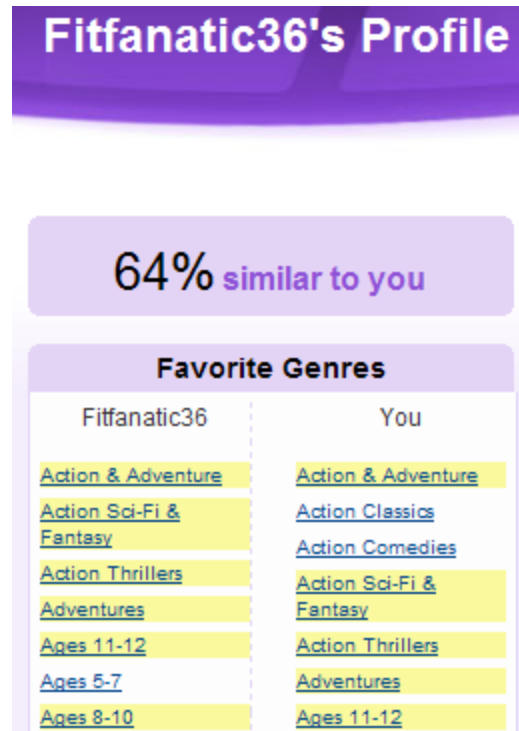
- Explaining “Why” increases engagement
- Where?
- When?
- How?



# 1. Transparency

- Explaining “Why” increases engagement

- Where?
- When?
- How?





# 1. Transparency

- Explaining “Why” increases engagement
- Where?
- When?
- How?



**South Park: Season 1**  
1997 **TV-MA** 3 discs / 13 episodes

The first season of Comedy Central's groundbreaking, foul-mouthed series -- featuring some of the most original pint-sized characters ever to mouth off in the cartoon world -- is finally all in one place.

**Starring:** Trey Parker, Matt Stone  
**Director:** Trey Parker  
**Genre:** TV Animated Comedies  
**Format:** DVD and streaming

★★★★★ **4.1** Our best guess for Jon

Top # **9** Pick for Jon

Based on your interest in: *Team America: World Police*

Adventure on Blu-ray

# 1. Transparency

- Explaining “Why” increases engagement
- Where?
- When?
- How?



# 1. Transparency

- Explaining “Why” increases engagement
- Where?
- When?
- How?

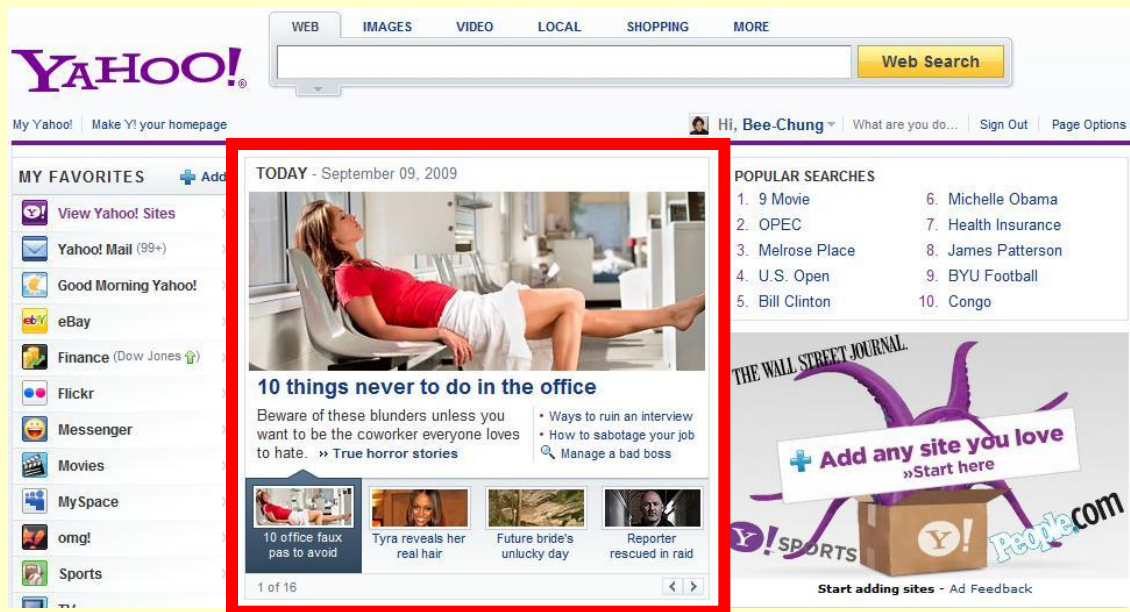


## 2. *Exploration versus Exploitation*

- Cold start problems
  - For new items
  - For new users
- Choosing what questions to ask users
  - Trade-off between optimizing for *this* user vs. for all users
- How can meta-data on user or item help?
- **Todd Beaupre Lead**

## 2. Exploration versus Exploitation

- Pick the top four stories from a pool of ~20 editorially programmed stories for each user visit to the Front Page in order to maximize clicks in the Today Module



In general, one may want to pick  $m$  **items** from a set of  $K$  **items** to maximize some easily observable metric

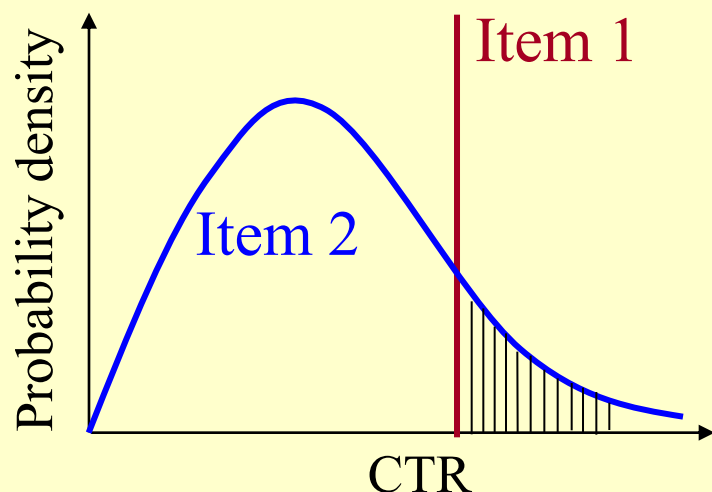
**Items**: Articles, ads, modules, configuration parameters of page layout

## 2. *Exploration versus Exploitation*

- Only consider the first position
  - ~ 2/3 clicks happen at the first position
  - Pick the best **one** from  $K$  items (stories)
- Tradeoff between explore and exploit
  - We want to show the item currently having the highest CTR
  - We need to explore every available item (using some fraction of traffic) to estimate its CTR
    - Explore too little → Unreliable CTR estimates
    - Explore too much → Little traffic to show the highest CTR item
- We want make the optimal decision: What fraction of page views should we give to each item for each small time interval in order to maximize the expected total number of clicks over a long period?

## 2. Exploration versus Exploitation

Simplified setting: Two items with the CTR of one exactly known



If we only make a decision once,  
give item 1 100% page views

If we make multiple decisions in the future  
explore item 2 since it can be  
potentially better than item 1

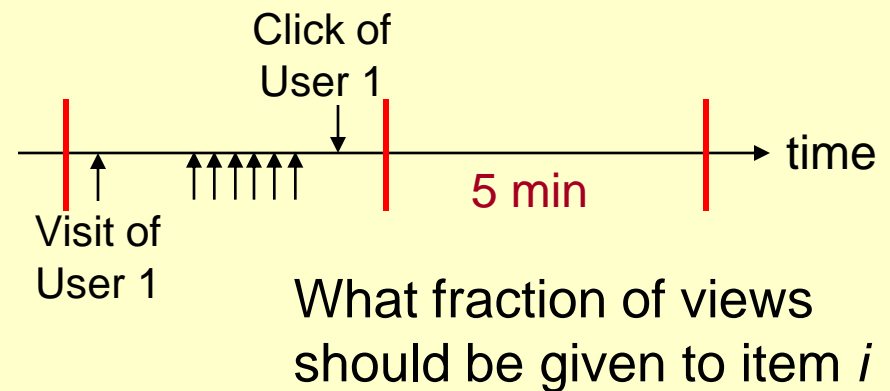
We know the CTR of Item 1 exactly (shown 10M times)

We are uncertain about the CTR of item 2 (only 100 times)



## 2. *Exploration versus Exploitation*

- Non-stationary CTR
  - CTR of an item can change dramatically over time
- Dynamic set of items
  - Items come and go with short lifetimes (hours)
  - Asymptotically optimal policies may fail to achieve good performance when item lifetimes are short
- Batch serving
  - For scalability reasons, click-through data is processed in batches (one batch per 5 min)
  - Delayed click feedback



## 2. *Exploration versus Exploitation*



**$p_1$**



**$p_2$**



**$p_3$**

Bandit “arms”

(unknown payoff probabilities)

- Goal: Pull arms sequentially to maximize the total expected reward; achieve the best trade-off between
  - Exploit: Use estimates of payoff probabilities  $\{p_i\}$
  - Explore: Don't be misguided by uncertainty in estimates; play arms that are potentially good

## 2. *Exploration versus Exploitation*

- **Bandit policy** : Sequential scheme to play arms
- **Regret of a policy** = Expected loss relative to best policy that plays the best arm at all times
  - Best arm: The arm with the highest success probability
  - Of course, the best arm is not known
  - Hence, the regret is the price of exploration
  - Low regret implies quick convergence to the best
- Two lines of research in the literature
  - Bayesian: Seek to find the Bayes optimal solution to a Markov decision process (with assumptions about distributions)
  - Minimax: Seek to find a policy that incurs bounded regret (with no or mild assumptions about distributions)
- Traffic volume per interval
- # of items to explore
- Lifetime of items

## *2. Exploration versus Exploitation*

- Explore/exploit is an effective strategy to maximize CTR in a content display system
- Bayesian solution provides superior performance
- Ongoing research
  - Explore/exploit for personalized recommendation
    - Hierarchical explore/exploit
    - Explore/exploit based on feature-based models
    - Exploring items vs. exploring users
  - Explore/exploit for multiple positions and page layout optimization
    - Positional effects not uniform over time and items
  - Explore/exploit in the presence of constraints

# 3. *Guided Navigation*

- Providing a guide over a vast body of content
  - UI design + intelligent algorithms
  - User's intent or mood
- **Jon Sanders Lead**

# 3. Guided Navigation

- Exploring the unknown
- Intent
- Approach
- UI
- Familiarity, serendipity, freshness
- Simple vs comprehensive

# 3. Guided Navigation

- Exploring the unknown
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- Simple vs comprehensive





# 3. Guided Navigation

- Exploring the unknown
- Intent
- Approach
- UI
- Familiarity, serendipity, freshness
- Simple vs comprehensive

### Dark + Based on real life

Mix-and-match from the categories below...

<input checked="" type="checkbox"/> Dark	<input type="checkbox"/> Prison	<input checked="" type="checkbox"/> Based on
<input type="checkbox"/> Gritty	<input type="checkbox"/> Political	<input type="checkbox"/> Based on
<input type="checkbox"/> Suspenseful	<input type="checkbox"/> Crime	<input type="checkbox"/> Based on literature

Show only: ☐ Blu-ray ☐ Streaming

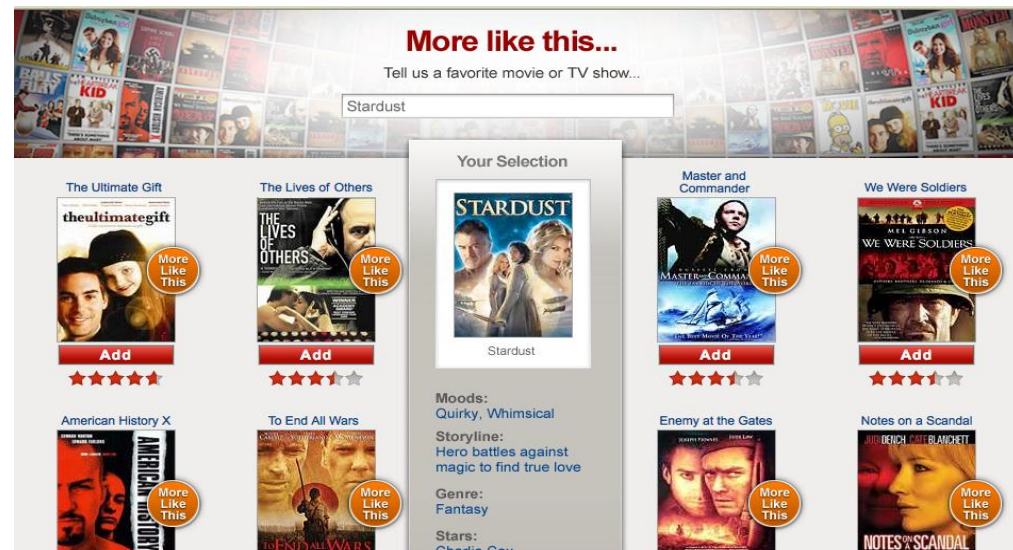
Anne Frank: The Whole Story

Notorious

When the Levees Broke

# 3. Guided Navigation

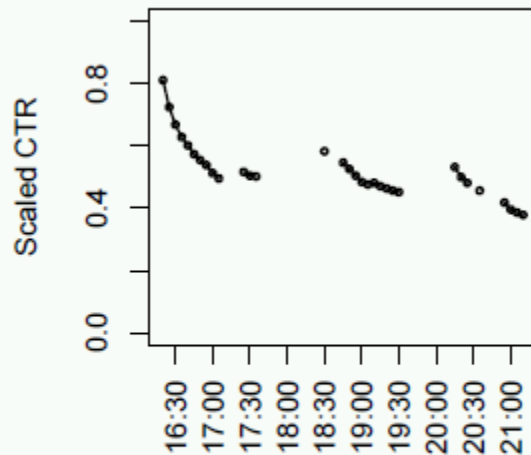
- Exploring the unknown
- Intent
- Approach
- UI
- Familiarity, serendipity, freshness
- Simple vs comprehensive



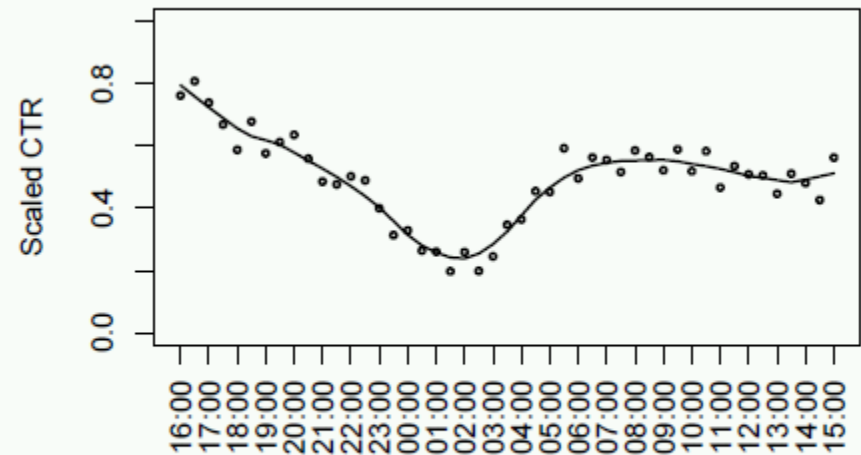
## *4. Time Value*

- Does value of user input decay with time?
- Do items change in relevance with time?
- How to adjust for recent user experience?
- **Todd Beaupre Lead**

## 4. Time Value

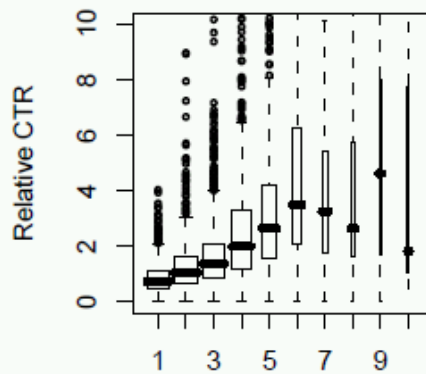


(a) CTR in the EMP Bucket



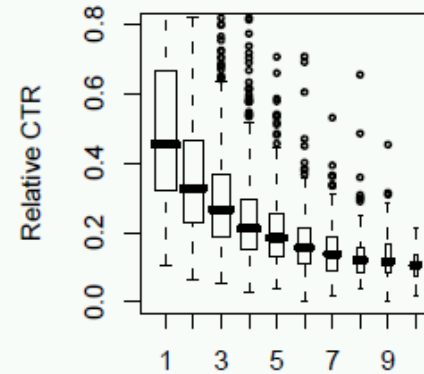
(b) CTR in the Random Bucket

# 4. Time Value



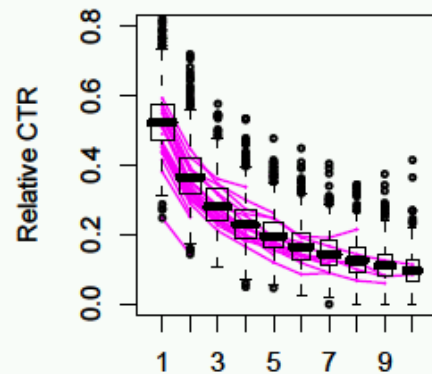
Number of previous clicks

(a) Previous clicks



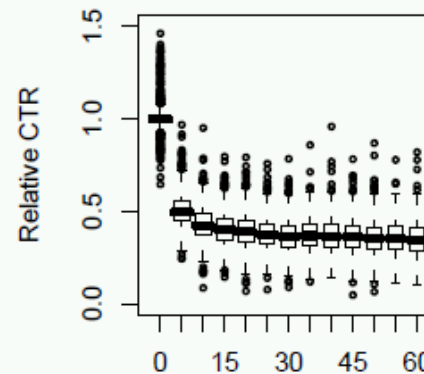
Number of views since last click

(b) Views since last click



Number of previous F1 views

(c) Previous F1 Views



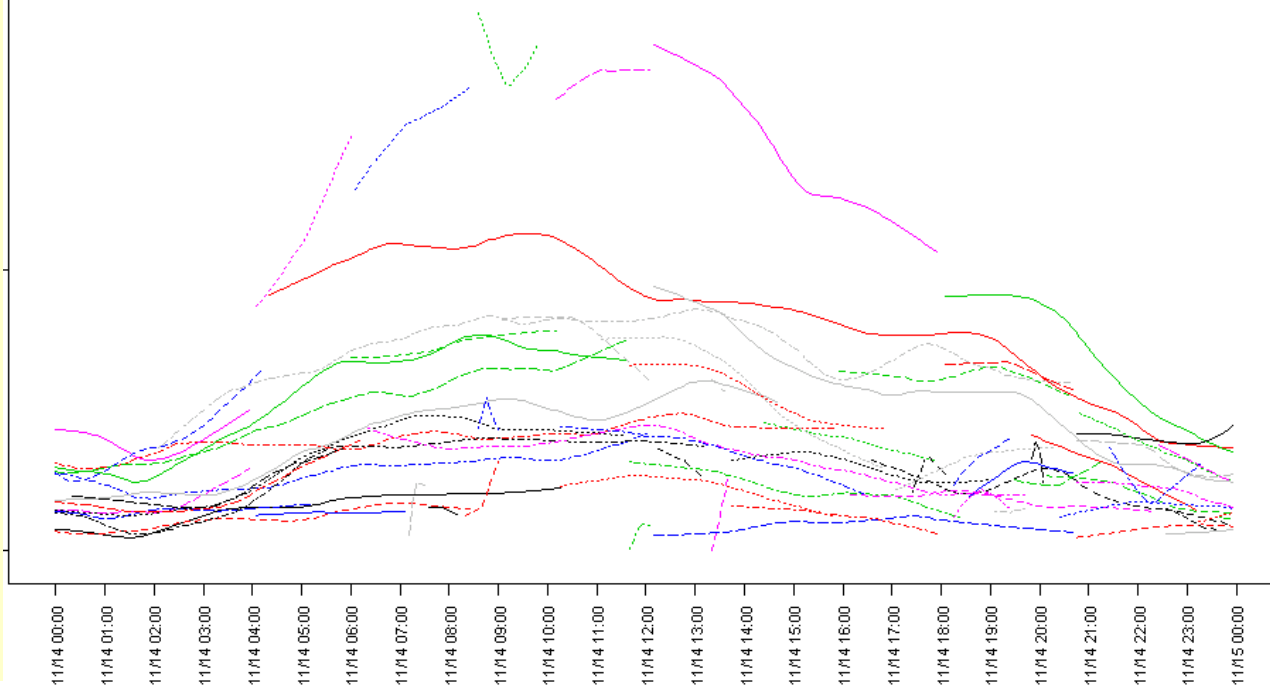
Minutes since 1st F1 View

(d) Time since 1st view

# 4. Time Value

## CTR Curves of All Items in a Day

Each curve is the 1st-position CTR of an item over time  
CTR's are estimated using 1% random bucket data



## 4. *Time Value*

- Short-term (news, trip to Hawaii)
- Intermediate term (Olympics)
- Long-term (Chicago Cubs)
- Identify content structure
- Identify intents (news interest may vary across users, exploit vs. pigeonhole)
- The right mix, de-duplication



## *5. User Action Interpretation*

- Ratings are valuable, but less frequent
- Positive & negative signal identification
- **Todd Beaupre Lead**

# *5. User Action Interpretation*

- Ratings: Billions per year
- Pageviews: Billions per day
- Every action is opportunity to learn about user and content
- Engineering challenge to collect, store, model, serve in real-time
- Research challenge to model user intent on behavioral data

## *5. User Action Interpretation*

- Click  $\approx$  Value (Scanning headlines)
- Hover (Weather)
- Negative learning is important to prevent positive feedback loops (Collaborative filtering)
- A view is a negative event, but not always a strong signal (Mail)
- Position and cross-position effects (Skips)

# *5. User Action Interpretation*

- Two users, one browser
- Friend behavior
- False registration data
- Robot detection
- Malicious users

## *6. Evaluating Recommenders*

- Evaluation of entire user experience
- Best practices for experiments
- Business metrics and Proxy metrics
  
- **Jon Sanders Lead**

# 6. Evaluating Recommenders

- Enjoyment Prediction is just part of a recommender experience
- RMSE? Even for predictions it's not enough
- Intuition, offline replay/score, qualitative, A/B test
- Goal vs proxies
- Interpretation
- Performance
- Deploying Prize solutions

The logo for the Netflix Prize, featuring the text "Netflix Prize" in a bold, white, sans-serif font. The text is set against a yellow background that includes a faint, stylized graphic of a film strip and stars on the right side.

**Netflix Prize**

## 7. Scalability

- What are the key scalability features you would value?
- What parallelization structure is best?
- What “hidden” requirements prevent algorithm adoption?
- **Todd Beaupre Lead**



# 7. Scalability

- Large user bases (100s of millions)
- Large user event sets (10s of K per second)
- Large item pools with short lives (100s of K per day)
- Data can't fit into memory
- Many models require iterative computation
- Sync cost across map-reduce framework is high
- Clustering with local optimization is lossy
- Think real-time: 15ms

# 8. *Academic/Industry Partnerships*

- How can academic researchers participate in interface innovation?
- What types of partnerships are fruitful?
- Tension with compulsion to publish versus access rich business data
- How can we make research more accessible to industry?
- **Jon Sanders Lead**

# 8. Academic/Industry Partnerships

- Use large data
- Netflix Prize
- Build experiences with Netflix API
- Design datasets & challenges
- Recs for groups

The logo for the Netflix Prize, featuring the text "Netflix Prize" in a bold, white, sans-serif font. The text is set against a yellow background that has a subtle, repeating pattern of stars and rays, giving it a celebratory or award-like appearance.

**Netflix Prize**

# 8. *Academic/Industry Partnerships*

- Data sharing with WebScope
- 19 data sets, including Music, Movies, Delicious
- <http://webscope.sandbox.yahoo.com/>
- Key Scientific Challenges
- Graduate students send proposals, Y! grants \$5k, invites 20-25 for summit.
- <http://labs.yahoo.com/ksc>
- Faculty Research Engagement Program
- Faculty send proposals around problem, come to our labs in summer. Up to \$25k grants.
- [http://labs.yahoo.com/Academic\\_Relations/Faculty](http://labs.yahoo.com/Academic_Relations/Faculty)
- Internships
- Universities invite Industry Partners to research showcases
- <http://research.yahoo.com/node/2742>

# *Research Challenges in Recommenders*

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Todd Beaupre, Yahoo!

Jon Sanders, Netflix

