

## **Database Support for Recommender Systems**

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# Talk Outline

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- **Background on Recommender Systems**
- **DBMS for Recommender Systems**
- **RecBench: *A Benchmark for Recommender System Architectures***
- **RecStore: *A Storage Engine Support for Recommender Systems***
- **LARS: *A Location-Aware Recommender System***
- **Recathon: *A Context-Aware Recommender System***
- **Summary, Commercial Ads, and Acknowledgments**

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### Today's Recommendations For You

Here's a daily sample of items recommended for you. Click here to [see all recommendations](#).



**Predictably Irrational, Revised and Expanded Edition** (Paperback) by Dan Ariely  
 ★★★★★☆ (419) \$9.51  
[Fix this recommendation](#)



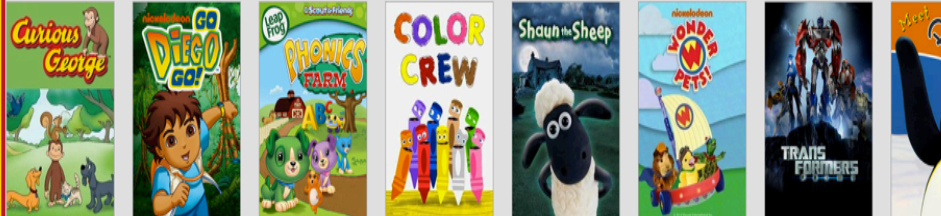
**Switch: How to Change Things When You Really Need To** (Hardcover) by Chip Heath  
 ★★★★★☆ (178) \$16.22  
[Fix this recommendation](#)



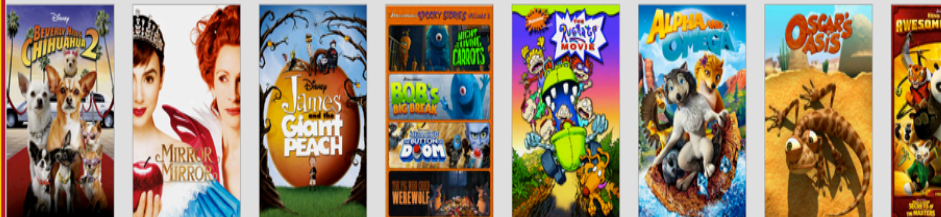
**Sway: The Irresistible Pull of Irrationality** (Paperback) by Ori Braffman  
 ★★★★★☆ (157) \$8.04  
[Fix this recommendation](#)

NETFLIX Watch Instantly - Just for Kids - Instant Queue Personalize

Because you watched Cars Toons: Mater's Tall Tales



Because you watched Rango



yelp Real people. Real reviews.®

Search for (e.g. taco, cheap dinner, Max's) Near (Address, Neighborhood, City, State or Zip) Minneapolis, MN, USA

Welcome About Me Write a Review Find Reviews Find Friends Messaging Talk Events Member Search

Yelp Minneapolis Other Cities | San Francisco | New York | San Jose | Los Angeles | Chicago | Palo Alto | More »

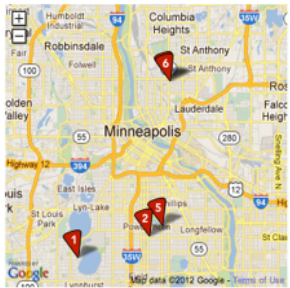
Browsing: Minneapolis » Restaurants

**Old Chicago** 17790 Highway 7  
 Categories: Pizza, American (Traditional), Salad  
 Location: Minnetonka, MN (952) 401-0030

Old Chicago is a traditional, casual dining restaurant specializing in Chicago-style, made-from-scratch pizzas, pastas, caizones, burgers and more. Nothing complements our pizza better than... read more »

**Best of yelp**


- Clancey's Meats and Fish** 59 reviews  
 Neighborhood: Linden Hills  
 Categories: Butcher, Meat Shops
- Blue Ox Coffee Company** 19 reviews  
 Neighborhood: Powderhorn  
 Categories: Cafes, Coffee & Tea
- Smack Shack** 70 reviews  
 Categories: Seafood, Southern
- El Taco Riendo** 81 reviews  
 Neighborhood: Northeast  
 Category: Mexican
- May Day Café** 50 reviews  
 Neighborhood: Powderhorn  
 Categories: Breakfast & Brunch, Coffee & Tea
- Crescent Moon Bakery** 57 reviews  
 Neighborhood: Northeast  
 Categories: Afghan, Bakeries



Category iPad Apps iPad Upgrades Search

### Genius Recommendations


Based On PrintCentral for iPad



**Pocket Informant HD**  
 Category: Productivity  
 ★★★★★ 404 Ratings  
 \$6.99

Not Interested


Based On NetNewsWire for iPad



**MobileRSS HD - G...**  
 Category: News  
 ★★★★★ 105 Ratings  
 \$4.99

Not Interested


Based On Echofon Pro for Tw...



**Colloquy - IRC Client**  
 Category: Social Networ...  
 ★★★★★ 56 Ratings  
 \$1.99

Not Interested


Based On TowerMadness™ HD



**Tesla Wars HD**  
 Category: Games  
 ★★★★★ 878 Ratings  
 \$3.99


Not Interested

Based On Winding Road Mag...




**Audi Magazine**  
 Category: Lifestyle  
 ★★★★★ 27 Ratings  
 FREE

Based On Modern Conflict™ HD




**Flight Control HD**  
 Category: Games  
 ★★★★★ 422 Ratings  
 \$4.99

Based On Analytics HD



**SketchyPad**  
 Category: Productivity  
 ★★★★★ 41 Ratings  
 \$4.99

Based On Flipboard



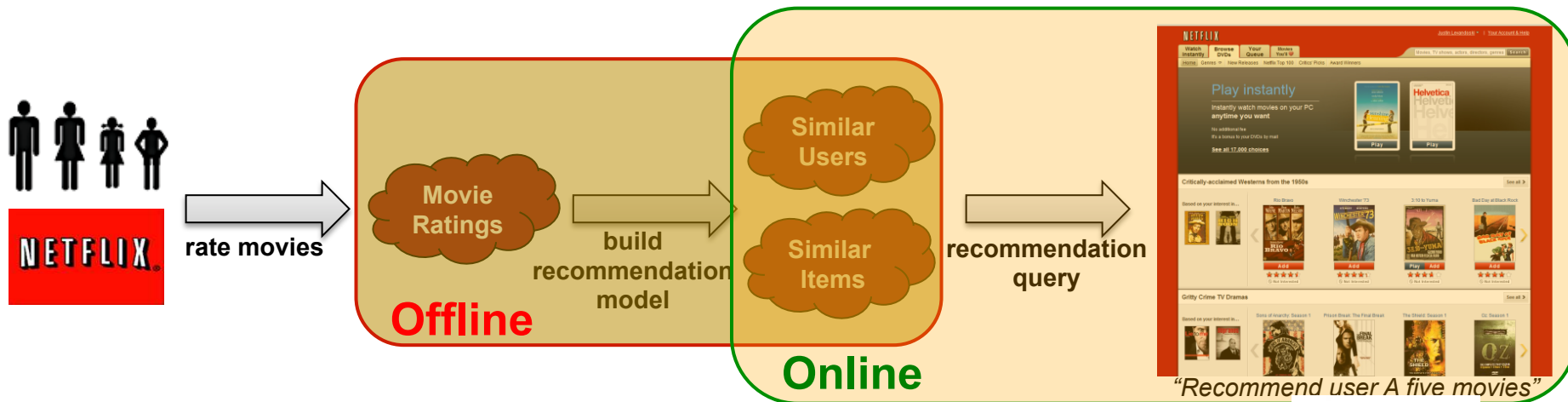
**牛一周**  
 Category: News  
 ★★★★★ 8 Ratings  
 FREE

Featured Top Charts Categories Updates Genius

# Recommender Systems



- Analyze user behavior to recommend personalized and interesting things to do/read/see



amazon.com

iTunes  
Ping

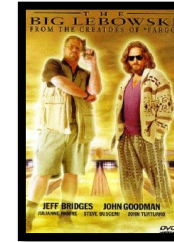
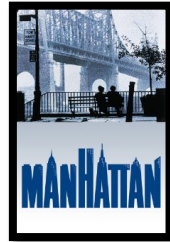
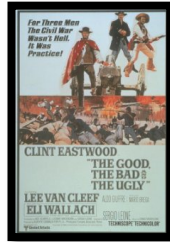
Introducing Ping. A social network for music.  
Follow your favorite artists and friends to discover the music  
they're talking about, listening to, and downloading.

freshdirect  
FIND OUT IF WE'RE DELIVERING  
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tv  
genius

- Collaborative filtering** process is the most commonly used one in Recommender Systems

# Collaborative Filtering (CF)

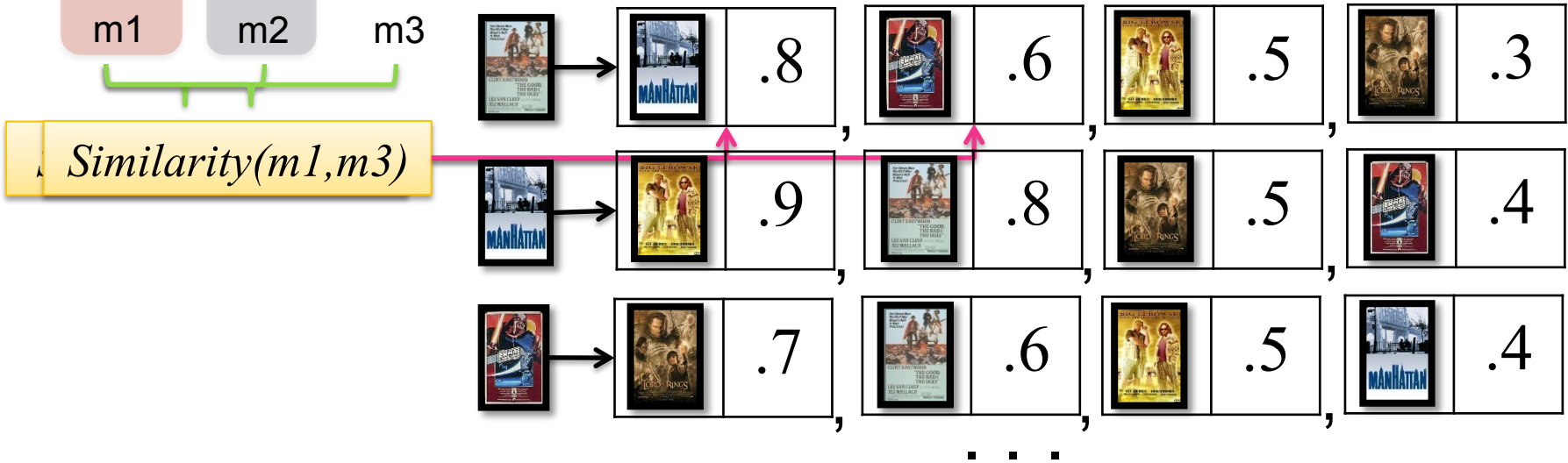


★★★★★	★★★★★	★★★★	★★	★★★★★★
?	★★	★★★★★	?	?
★★★★★★	★★★★		★★★★	
	★★★★★			★★★★

# Item-Based CF Model Building



★★★★	★★★★	★★★	★★	★★★★★
	★★	★★★★		
★★★★★	★★★		★★★	
	★★★★			★★★



- **Similarity measures**
  - ① Cosine distance
  - ② Pearson correlation
  - ③ Spearman correlation
  - ④ Adjusted cosine distance

...

# Item-Based CF Recommendations



	→		.8		.6		✗		✗
	→		.9		.8		.5		.4
	→		.7		.6		.5		.4
	→		.9		✗		.5		✗
	→		.7		✗		.5		✗

$$\left( \begin{matrix} \text{The Simpsons} \\ \text{Manhattan} \end{matrix} \right) \rightarrow \left( \begin{matrix} \text{Manhattan} \\ \text{The Simpsons} \end{matrix} \right) \begin{matrix} .8 \\ .6 \end{matrix} \times 2 + \begin{matrix} \text{The Simpsons} \\ \text{The Simpsons} \end{matrix} \begin{matrix} .6 \\ .5 \end{matrix} \times 4 \Big/ (.8 + .6) = 2.86$$

$$\left( \begin{matrix} \text{The Simpsons} \\ \text{The Simpsons} \end{matrix} \right) \rightarrow \left( \begin{matrix} \text{Manhattan} \\ \text{The Simpsons} \end{matrix} \right) \begin{matrix} .9 \\ .5 \end{matrix} \times 2 + \begin{matrix} \text{The Simpsons} \\ \text{The Simpsons} \end{matrix} \begin{matrix} .5 \\ .7 \end{matrix} \times 4 \Big/ (.9 + .5) = 2.71$$

$$\left( \begin{matrix} \text{The Simpsons} \\ \text{The Simpsons} \end{matrix} \right) \rightarrow \left( \begin{matrix} \text{Manhattan} \\ \text{The Simpsons} \end{matrix} \right) \begin{matrix} .5 \\ .7 \end{matrix} \times 2 + \begin{matrix} \text{The Simpsons} \\ \text{The Simpsons} \end{matrix} \begin{matrix} .7 \\ .5 \end{matrix} \times 4 \Big/ (.7 + .5) = 3.17$$



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# Recommender Systems: Quality vs. Performance



- Recommender systems community have only focused on “quality” issues; “performance” is considered a secondary issue

*“We have chosen not to discuss computation performance of recommender algorithms. Such performance is certainly important, and in the future we expect there to be work on the quality of time-limited and memory-limited recommendations.”*

Herlocker et al. “Evaluating Collaborative Filtering Recommender Systems”, ACM TOIS 2004

*“[Our] solution is based on a huge amount of models and predictors which would not be practical as part of a commercial recommender system. However, this result is a direct consequence of the nature and goal of the competition: obtain the highest possible accuracy at any cost, disregarding completely the complexity of the solution and the execution performance.”*

Team BelKor’s Pragmatic Chaos, Winner of the 2009 Netflix Prize

- All heavy work are done offline
- Models are built over long time period, e.g., movie or books ratings
- The rank of one item in the system slowly change

# Things have changed...



## ■ We live in an increasingly social and “real-time” world

- ❑ Number of things to recommend is growing exponentially
- ❑ Users expressing opinions faster than ever
- ❑ Recommendations change second-to-second

Microsoft Research Eric Horvitz of Microsoft Research discusses Artificial Intelligence and when talking, thinking machines might become commonplace. <http://bit.ly/agbAr7>

**Artificial Intelligence – how smart are our machines?**  
| 89.3 KPCC  
bit.ly  
89.3 KPCC | Southern California Public Radio's home page with news, podcasts, radio broadcast schedules, and links to its productions including AirTalk with host Larry Mantle, Pat Morrison, Off-Ramp, Marketplace, All Things Considered, Day to Day, Fresh Air, This American Life, Morning Edition, and...

July 15 at 12:02pm · Comment · Like · Share

11 people like this.

**Manoj Jain** wow...!!! really amazing...  
July 15 at 12:05pm · Like · Flag

Write a comment...

**“Like” button**

Facebook Posts

Fraternity of the Wired Works in the Wee Hours

By JENNA WORTHAM  
Published: July 25, 2010

**NY Times “Recommend” button**

NEW YORK — After college, most people do their best to avoid having to pull any more all-nighters. But for some, even after graduation, the wee hours of the morning are the most productive.

Enlarge This Image That is what led Amber Lambke and Allan Grinshtein to start a group called the New York Nightowls, a sort of study hall for entrepreneurs, freelancers and software developers who gather at 10 every Tuesday night

FACEBOOK  
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SIGN IN TO E-MAIL  
PRINT  
REPRINTS  
SHARE

Blog/News Items

● “Offline” step can no longer be tolerated

# Recommender Systems in DBMS ?



- Incoming stream of ratings data: *(user, item, rating)*
- Ratings are used to build a recommendation model as:
  - Item-based collaborative filtering: *(item, item, similarity)*
  - User-based collaborative filtering: *(user, user, similarity)*
- Recommendation query:
  - Item-based collaborative filtering:
    - *Given a user  $u$ , find the top- $k$  items that are most similar to the items that  $u$  has liked before*
  - User-based collaborative filtering:
    - *Given a user  $u$ , find the top- $k$  items that the users who are similar to  $u$  have liked*

Recommender Systems have all the ingredients of a data management problem

# DBMS Challenge



Lets not try to find a new way of doing recommendation\*

\* ACM RecSys community is already doing excellent job in this frontier. Lets start from there.

We need to provide online support and scale up the computations of existing recommender methods.

***Can DBMS do it ?***

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Justin J. Levandoski, Michael D. Ekstrand, Michael J. Ludwig, Ahmed Eldawy, Mohamed F. Mokbel and John T. Riedl. " **RecBench**: Benchmarks for Evaluating Performance of Recommender System Architectures". In Proceedings of the International Conference on Very Large Databases, **VLDB 2011**, Seattle, WA, September 2011

# MovieLens



**movieLens**

helping you find the *right* movies

Welcome to MovieLens!

Free, personalized, non-commercial, ad-free, great movie recommendations.  
Have questions? Take the [MovieLens Tour](#) for answers.  
Not a member? [Join MovieLens now](#).

Need a gift idea? Try [MovieLens QuickPick!](#)

New to MovieLens?

**Join today!**

You get **great recommendations** for movies while **helping us do research**. Learn more:

- Try out [QuickPick: Our Movie Gift Recommender](#)
- Take the [MovieLens Tour](#)
- Read our [Privacy Policy](#)
- See our [Browser Requirements](#)
- Learn about [Our Research](#)

Hello MovieLens Users!

**Please login to be directed to your proper location**

Please log in:

Username/E-mail:

Password:

Save login:

[Forgot your password?](#)


[New member? Join now](#)

MovieLens is a free service provided by [GroupLens Research](#) at the [University of Minnesota](#). We sometimes study how our members use MovieLens in order to learn how to build better recommendation systems. We promise to never give your personal information to anyone; see our [privacy policy](#) for more information.

<http://www.movielens.org>

■ **MovieLens: A Movie Recommender System, built and maintained at University of Minnesota (GroupLens Research)**

- ❑ 10 Million ratings
- ❑ 10,000 Movies
- ❑ 72,000 Users



**ACM Software Award 2010:** – GroupLens Collaborative Filtering Recommender Systems:  
Peter Bergstrom, Lee R Gordon, Jonathan L Herlocker, Neophytos Iacovou, Joseph A Konstan,  
Shyong (Tony) K. Lam, David Maltz, Sean McNee, Bradley N Miller, Paul J Resnick, John T Riedl,  
Mitesh Suchak

# RecBench:



## A Benchmark for Recommender System Architectures

### ■ Goals:

- ① Prompt DB & RecSys research communities to work together
- ② A benchmark to test performance of different system architectures

### ■ Six common recommendation tasks are carefully selected

### ■ Every task is implemented on three different architectures

#### MultiLens

- “Hand-built” system
- Code optimized for item-based CF
- Uses DBMS for metadata and text-search queries

#### PostgreSQL

- Unmodified DBMS
- Ratings relation:  
ratings(usr,itm,rating)
- Model relation:  
model(itm, itm, sim)
- All tasks implemented in standard SQL

#### Custom DBMS


- DBMS (PostgreSQL) modified to optimize for fast recommender model updates
- SQL same as unmodified DBMS approach








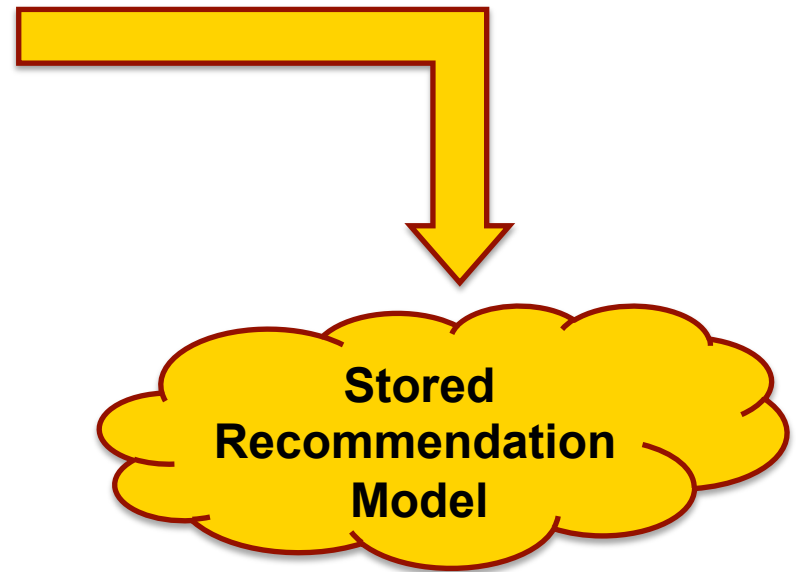
# RecBench – Task 1: Initialization



Prepare system to start serving user recommendations



					
Mr. Burns	★★★★		★★★	★★★	★★★★★
Homer Simpson		★★	★★★★★		
Bart Simpson	★★★★★			★★★	
Lisa Simpson		★★★★			★★★



# RecBench – Task 2: Pure Recommend



Produce top-k recommendations from system's entire item pool

**movielens**  
helping you find the *right* movies

Welcome [justin@cs.umn.edu](#) (Log Out)  
You've rated **15** movies.  
You're the **23rd** visitor in the past hour.

★★★★ = Must See  
★★★★ = Will Enjoy  
★★★☆☆ = It's OK  
★★☆☆☆ = Fairly Bad  
★☆☆☆☆ = Awful

[Home](#) | [Find Movies](#) | [Q&A \(new\)](#) | [Preferences](#) | [Help](#)

Shortcuts

**Rate and Find Movies**

- Top Picks For You**
- Newest Additions (24)
- Most Often Rated
- Rate Random Movies
- Browse Movies by Tags

**Your Movies**

- Your Ratings
- About Your Ratings
- Your Wishlist
- Your Tags

**Your Account**

- Your Profile (edit)
- Preferences
- Manage Buddies
- Manage RSS Feeds

**Help MovieLens**

- Volunteer Center
- Suggest a Title (returning soon)

(We've moved your saved searches to the [search tab](#))

There are **12320** movies matching your search:  
Movies without a prediction are **Not Shown**  
Movies you've rated are **Not Shown**  
You've sorted by: **Prediction**  
[Show Printer-Friendly Page](#) | [Download Results](#) | [Permalink](#)

Tags Related to Your Search: [based on a book \(1985\)](#), [sci-fi \(1975\)](#), [comedy \(1756\)](#), [action \(1623\)](#), [atmospheric \(1489\)](#), ([about tags](#))

Page 1 of 822 Skip to page #:

Prediction or Rating	Your Rating	Movie Information	Wish List
★★★★★	Not seen	<a href="#">Barney's Version (2010)</a> DVD info imdb flag Movie Tuner  Drama [add tag] Popular tags: <a href="#">based on a book</a>   <a href="#">twist ending</a>   <a href="#">adapted from:book</a>	<input type="checkbox"/>
★★★★★	Not seen	<a href="#">I Was Born, But... (Otona no miru ehon - Umarete wa mita keredo) (1932)</a> DVD info imdb flag Movie Tuner  Comedy, Drama - Japanese [add tag] Popular tags: <a href="#">Criterion</a>   <a href="#">BD-R</a>	<input type="checkbox"/>
★★★★★	Not seen	<a href="#">Young Philadelphians, The (1959)</a> DVD info imdb flag Movie Tuner  Drama [add tag] Popular tags: <a href="#">based on a book</a>   <a href="#">lawyers</a>   <a href="#">Vincent Sherman</a>	<input type="checkbox"/>
★★★★★	Not seen	<a href="#">Brute Force (1947)</a> DVD info imdb flag Movie Tuner  Drama, Film-Noir, Thriller [add tag] Popular tags: <a href="#">10/10</a>   <a href="#">Criterion</a>   <a href="#">07/10</a>	<input type="checkbox"/>
★★★★★	Not seen	<a href="#">Conspiracy (2001)</a> DVD info imdb flag Movie Tuner  Drama, War [add tag] Popular tags: <a href="#">conspiracy</a>   <a href="#">disturbing</a>   <a href="#">World War II</a>	<input type="checkbox"/>
★★★★★	Not seen	<a href="#">Human Condition III, The (Ningen no joken III) (1961)</a> DVD info imdb flag Movie Tuner  Drama, War - Japanese [add tag] Popular tags: <a href="#">Criterion</a>   <a href="#">Tatsuya Nakadai</a>   <a href="#">Japan</a>	<input type="checkbox"/>
★★★★★	Not seen	<a href="#">Misérables, Les (1935)</a> DVD info imdb flag Movie Tuner  Drama, Romance [add tag] Popular tags: <a href="#">Victor Hugo</a>   <a href="#">based on a book</a>   <a href="#">adapted from:book</a>	<input type="checkbox"/>
★★★★★	Not seen	<a href="#">Barbarians at the Gate (1993)</a> DVD info imdb flag Movie Tuner  Drama [add tag] Popular tags: <a href="#">true story</a>   <a href="#">business</a>	<input type="checkbox"/>
★★★★★	Not seen	<a href="#">Tall T, The (1957)</a> DVD info imdb flag Movie Tuner  Western	<input type="checkbox"/>



# RecBench – Task 3: Filtered Recommend



Produce top-k recommendations that match item constraints

**movie lens**  
helping you find the right movies

Welcome [justin@cs.umn.edu](mailto:justin@cs.umn.edu) (Log Out)  
You've rated **15** movies.  
You're the **25th** visitor in the past hour.

★★★★ = Must See  
★★★★ = Will Enjoy  
★★★☆☆ = It's OK  
★★☆☆☆ = Fairly Bad  
☆☆☆☆ = Awful

Home | Find Movies | Q&A (new) | Preferences | Help

**Shortcuts** Search

Basic Search  
Title: \_\_\_\_\_  
Comedy 1990s  
Domain: All movies  
Tag: \_\_\_\_\_  
 Use selected buddies!  
 Exclude your ratings  
 Exclude movies without predictions  
**Search!**

Select Buddies  
 Test Buddy  
[What are buddies?](#)

Advanced Search

Member Search  
\_\_\_\_\_  
**Search!**

Saved Searches  
- **New Drama**  
Crazy, Stupid, Love...  
Beginners (2010)  
Harry Potter and the...  
- **New DVDs**  
Barney's Version (2010)  
Jane Eyre (2011)  
Win Win (2011)  
- **New Movies**  
Crazy, Stupid, Love...  
Beginners (2010)  
Harry Potter and the...  
[How to save searches](#)

There are **1122** movies matching your search:  
Movies with genres matching ANY of : **Comedy**  
Movies released in: **1990s**  
Movies without a prediction are **Not Shown**  
Movies you've rated are **Not Shown**  
You've sorted by: **Prediction or Rating**  
[Show Printer-Friendly Page](#) | [Download Results](#) | [Permalink](#) | [Suggest a Title](#)

Tags Related to Your Search: **comedy (524)**, **dark comedy (311)**, **quirky (249)**, **black comedy (233)**, **funny (199)**, (about tags)

Page 1 of 75  
1 2 3 4 ... 75 next Skip to page #:  **Go**

Prediction or Rating	Your Rating	Movie Information	Wish List
★★★★	Not seen	<b>Zombie and the Ghost Train (Zombie ja Kummitusjuna) (1991)</b> DVD info imdb flag Movie Tuner <b>Comedy, Drama - Finnish, English, Turkish</b> [add tag] Popular tags: Finnish   rock   alcoholism	<input type="checkbox"/>
★★★★	Not seen	<b>I Hired a Contract Killer (1990)</b> DVD info imdb flag Movie Tuner <b>Comedy, Drama - English, Finnish</b> [add tag] Popular tags: rare   Aki Kaurismäki   library vhs	<input type="checkbox"/>
★★★★	Not seen	<b>Shadows in Paradise (Varjoja paratiisissa) (1986)</b> DVD info imdb flag Movie Tuner <b>Comedy, Romance - Finnish</b> [add tag] Popular tags: Criterion   rare   Aki Kaurismäki	<input type="checkbox"/>
★★★★	Not seen	<b>Blackadder Back &amp; Forth (1999)</b> DVD info imdb flag Movie Tuner <b>Comedy</b> [add tag] Popular tags: short   funny   Rowan Atkinson	<input type="checkbox"/>
★★★★	Not seen	<b>Bottle Rocket (1996)</b> DVD info imdb flag Movie Tuner <b>Adventure, Comedy, Crime, Romance</b> [add tag] Popular tags: quirky   off-beat comedy   Wes Anderson	<input type="checkbox"/>
★★★★	Not seen	<b>Life Is Sweet (1991)</b> DVD info imdb flag Movie Tuner <b>Comedy, Drama</b> [add tag] Popular tags: movielens top pick   12/09   Mike Leigh	<input type="checkbox"/>
★★★★	Not seen	<b>Office Space (1999)</b> DVD info imdb flag Movie Tuner <b>Comedy, Crime</b> [add tag] Popular tags: dark comedy   cult film   satire	<input type="checkbox"/>
★★★★	Not seen	<b>Rushmore (1998)</b> DVD info imdb flag Movie Tuner <b>Comedy, Drama</b> [add tag] Popular tags: quirky   Bill Murray   coming of age	<input type="checkbox"/>
★★★★	Not seen	<b>Swingers (1996)</b> DVD info imdb flag Movie Tuner <b>Comedy, Drama</b> [add tag] Popular tags: Vince Vaughn   funny   vegas	<input type="checkbox"/>
★★★★	Not seen	<b>All About My Mother (Todo sobre mi madre) (1999)</b> DVD info imdb flag Movie Tuner <b>Comedy, Drama - Spanish, Catalan, English</b> [add tag] Popular tags: Spanish   homosexuality   Oscar (Best Foreign Language Film)	<input type="checkbox"/>



# RecBench – Task 4: Blended Recommend



Produce top-k recommendations based on blended text-search and recommendation score

**movie lens**  
helping you find the right movies

Welcome [justin@cs.umn.edu](#) (Log Out)  
You've rated **15** movies.  
You're the 25th visitor in the past hour.

★★★★ = Must See  
★★★★ = Will Enjoy  
★★★★ = It's OK  
★★★ = Fairly Bad  
★ = Awful

Home | Find Movies | Q&A (new) | Preferences | Help

Shortcuts Search

Basic Search  
Title: **aliens**  
All Genres | All Dates  
Domain: All movies  
Tag:  
 Use selected buddies!  
 Exclude your ratings  
 Exclude movies without predictions  
**Search!**

Select Buddies  
 Test Buddy  
[What are buddies?](#)

Advanced Search

Member Search  
  
**Search!**

Saved Searches  
- **New Drama**  
Crazy, Stupid, Love....  
Beginners (2010)  
Harry Potter and the...  
- **New DVDs**  
Barney's Version (2010)

There are 9 movies matching your search:  
Movies with titles matching: **aliens**  
You've sorted by: **Prediction or Rating**  
[Show Printer-Friendly Page](#) | [Download Results](#) | [Permalink](#) | [Suggest a Title](#) | [Search IMDb for 'aliens'](#)  
Tags Related to Your Search: **aliens (39)**, **sci-fi (24)**, **space (20)**, **animation (14)**, **androids (12)**, (about tags)  
Page 1 of 1

Prediction or Rating	Your Rating	Movie Information	Wish List
★★★★	Not seen	<b>Aliens (1986)</b> DVD info   imdb   flag   Movie Tuner Action, Horror, Sci-Fi, Thriller [add tag] Popular tags: <a href="#">action</a>   <a href="#">sci-fi</a>   <a href="#">space</a>	<input type="checkbox"/>
★★★★	Not seen	<b>Aliens of the Deep (2005)</b> DVD info   imdb   flag   Movie Tuner Documentary, IMAX [add tag] Popular tags: <a href="#">nature</a>   <a href="#">ocean</a>   <a href="#">submarine</a>	<input type="checkbox"/>
★★★★	Not seen	<b>Monsters vs. Aliens (2009)</b> DVD info   imdb   flag   Movie Tuner Animation, IMAX, Sci-Fi [add tag] Popular tags: <a href="#">alien invasion</a>   <a href="#">animation</a>   <a href="#">aliens</a>	<input type="checkbox"/>
★★★★	Not seen	<b>Aliens in the Attic (2009)</b> DVD info   imdb   flag   Movie Tuner Adventure, Children, Fantasy, Sci-Fi [add tag] Popular tags: <a href="#">Teen movie</a>   <a href="#">childish</a>   <a href="#">aliens</a>	<input type="checkbox"/>
★★★★	Not seen	<b>Cowboys and Aliens (2011)</b> info   imdb   flag   Movie Tuner Action, Sci-Fi, Thriller, Western [add tag] Popular tags: <a href="#">cowboys</a>   <a href="#">Harrison Ford</a>   <a href="#">aliens</a>	<input type="checkbox"/>
★★★★	Not seen	<b>Evil Aliens (2005)</b> DVD info   imdb   flag   Movie Tuner Comedy, Horror, Sci-Fi [add tag] Popular tags: <a href="#">British</a>   <a href="#">aliens</a>   <a href="#">nerds</a>	<input type="checkbox"/>
★★★★	Not seen	<b>Monsters vs Aliens: Mutant Pumpkins from Outer Space (2009)</b> info   imdb   flag   Movie Tuner Animation, Comedy, Sci-Fi [add tag] Popular tags: <a href="#">monster</a>   <a href="#">sequel</a>   <a href="#">aliens</a>	<input type="checkbox"/>
★★★	Not seen	<b>AVPR: Aliens vs. Predator - Requiem (2007)</b> DVD info   imdb   flag   Movie Tuner Action, Horror, Sci-Fi [add tag] Popular tags: <a href="#">franchise</a>   <a href="#">teens</a>   <a href="#">aliens</a>	<input type="checkbox"/>
???	Not seen	<b>Mutant Aliens (2001)</b> DVD info   imdb   flag   add tag   Movie Tuner Animation, Comedy, Sci-Fi	<input type="checkbox"/>

Page 1 of 1



# RecBench – Task 5: Item Prediction



## Generate a user's predicted rating for a target item

**Shortcuts** [Search](#)

**Rate and Find Movies**

- Top Picks For You
- Newest Additions
- Most Often Rated
- Rate Random Movies
- Browse Movies by Tags

**Your Movies**

- Your Ratings
- About Your Ratings
- Your Wishlist
- Your Tags

**Your Account**

- Your Profile (edit)
- Preferences
- Manage Buddies
- Manage RSS Feeds

**Help MovieLens**

- Volunteer Center
- Vote for Titles
- Submit a Title

(We've moved your saved searches to the [search tab](#).)

### Godfather, The (1972)

Your Prediction: ★★★★★ Rate This Movie:  Wish List:

**Movie Information** (edit info) (flag)

**Starring:** Marlon Brando, Al Pacino, James Caan, Richard S. Castellano, Robert Duvall, Sterling Hayden, John Marley, Richard Conte, Al Lettieri, Diane Keaton, Abe Vigoda, Talia Shire, Gianni Russo, John Cazale, Al Martino, Alex Rocco  
**Directed By:** Francis Ford Coppola  
**Genres:** Crime, Drama  
**Languages:** English Italian

**Average rating:** ★★★★★ (4.38 stars) ←

**Your Prediction:** ★★★★★ (4.0 stars)

**Rated by:** 37960 users  
**Links:** [IMDb](#), [Rotten Tomatoes](#)

**Movie Tags** (more about tags)  
Add and edit tags here or [update all of your tags](#)

**Community Tags** (2) Tags represent how MovieLens users feel about this movie

Action adapted from:book Al Pacino atmospheric  
based on a book classic crime drama family view  
imdb top 250 immigrants Mafia melancholy New York City  
Nudity (Topless) organized crime Oscar (Best Actor) Oscar (Best Picture) robert de niro stylized

**My tags for this movie** (2)

What I like about movie	I'm neutral about	What I dislike about movie
Add... Edit	Add... Edit	Add... Edit

**The Godfather**



When organized crime family patriarch Vito Corleone (Marlon Brando) barely survives an attempt on his life, his youngest son, Michael (Al Pacino), steps in to take care of the would-be killers, launching a campaign of bloody revenge. Francis Ford Coppola brings Mario Puzo's multigenerational crime saga to life in this Oscar-winning epic that also spawned Best Actor honors for Brando, who refused the prize for political reasons.

[Report Wrong Movie](#) [Delivered by Netflix \(add to queue\)](#)

**Movie Tuner** (2) Updated!

Find similar movies with less or more of particular qualities. The movie list below will update as you indicate your preferences. Use the lock button to select multiple qualities.

	This movie	less	ok	more
classic	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
action	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
violence	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
dark	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
crime	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Enter selection...

[reset all](#)

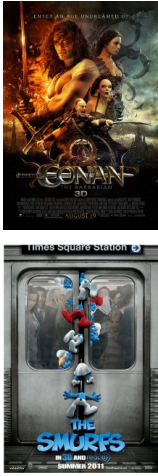
**Search Criteria:** Similar to *The Godfather*

<b>Godfather: Part II, The (1974)</b>	★★★★★
<b>Goodfellas (1990)</b>	★★★★★
<b>On the Waterfront (1954)</b>	★★★★★
<b>Departed, The (2006)</b>	★★★★★
<b>Road to Perdition (2002)</b>	★★★★★

# RecBench – Task 6: New Item(s)



Incorporate new item(s) into the system for recommendation



**movielens**  
helping you find the *right* movies

Welcome **justin@cs.umn.edu** (Log Out)  
You've rated **15** movies.  
You're the **23rd** visitor in the past hour.

★★★★ = Must See  
★★★★ = Will Enjoy  
★★★★ = It's OK  
★★★☆☆ = Fairly Bad  
★★☆☆☆ = Awful

Home | Find Movies | Q&A (new) | Preferences | Help

Shortcuts Search

Submit a Movie Title (help)

IMDb URL

Find the movie you want to add on **IMDb** and enter its URL. We use this to check if the movie is already in MovieLens.

- Top Picks For You
- Newest Additions
- Most Often Rated
- Rate Random Movies
- Browse Movies by Tags

Your Movies

- Your Ratings
- About Your Ratings
- Your Wishlist
- Your Tags

Your Account

- Your Profile (edit)
- Preferences
- Manage Buddies
- Manage RSS Feeds

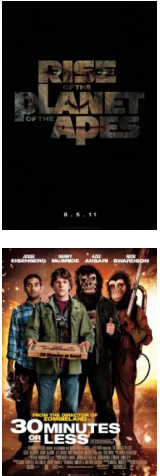
Help MovieLens

- Volunteer Center
- Vote for Titles
- Submit a Title

(We've moved your saved searches to the [search tab](#) )

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# RecBench: Summary of Results



## ■ Datasets

- ❑ MovieLens: 10 M movie ratings, 10K movies, and 72K users
- ❑ Netflix Challegne: 100 M movie ratings, 18K movies, and 480K users

## ■ Tasks 1 & 2 (Initialization & Pure Recommend)

- ❑ PostgreSQL has by far the worst performance
- ❑ Custom DBMS does a good job but not as excellent as MultiLens

## ■ Tasks 3 & 4 (Filtered & Blended Recommend)

- ❑ CustomDBMS way outperforms Multilens as it takes advantage of its select & top-k operators
- ❑ PostgreSQL performance in the middle.

## ■ Tasks 5 & 6 (Item Prediction & New Items)

- ❑ MultiLens outperforms others in Task 5 (a basic component in Task 1)
- ❑ CustomDBMS outperforms others in Task 6 due to the built-in incrementally maintained statistics

# Talk Outline



- Background on Recommender Systems
- DBMS for Recommender Systems
- RecBench: *A Benchmark for Recommender System Architectures*
- **RecStore: A Storage Engine Support for Recommender Systems**
- **LARS: A Context-Aware Recommender System**
- **Recathon: A Context-Aware Recommender System**
- **Summary, Commercial Ads, and Acknowledgments**

Justin J. Levandoski, Mohamed Sarwat, Mohamed F. Mokbel, and Michael D. Ekstrand. " **RecStore**: An Extensible and Adaptive Framework for Online Recommender Queries inside the Database Engine". In Proceedings of the International Conference on Extending Database Technology, **EDBT 2012**, Berlin, Germany, March 2012



# RecStore:



## A Storage Engine Support for Recommender Systems

**RecStore** pushes the recommender model building inside the Database Engine to provide online support and scale up the computations of existing recommender methods.

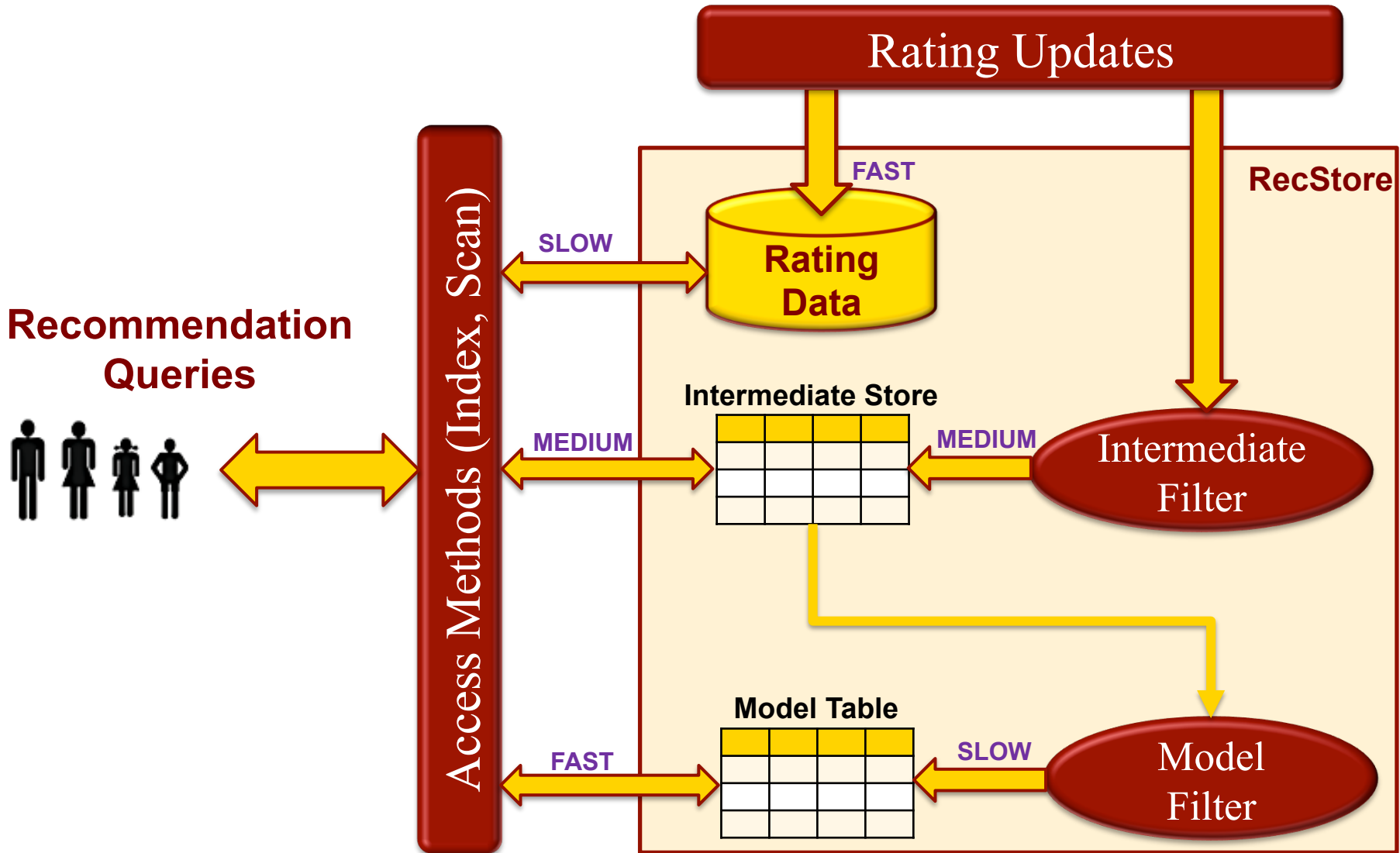
### ■ **Adaptivity of RecStore**

- ❑ RecStore is adaptive to different system workloads (Query Intensive vs. Update Intensive)

### ■ **Extensibility of RecStore**

- ❑ RecStore is extensible to support many recommendation methods (e.g., item-based CF, user-based CF).

# RecStore: Architecture



# RecStore: Query Latency vs. Maintenance Cost



## Materialize-All

- Low Latency Recommendation Query.
- High Storage and maintenance Cost.

## Materialize-None

- High Latency Recommendation Query
- Low Storage and maintenance Cost.

## Intermediate Store Only

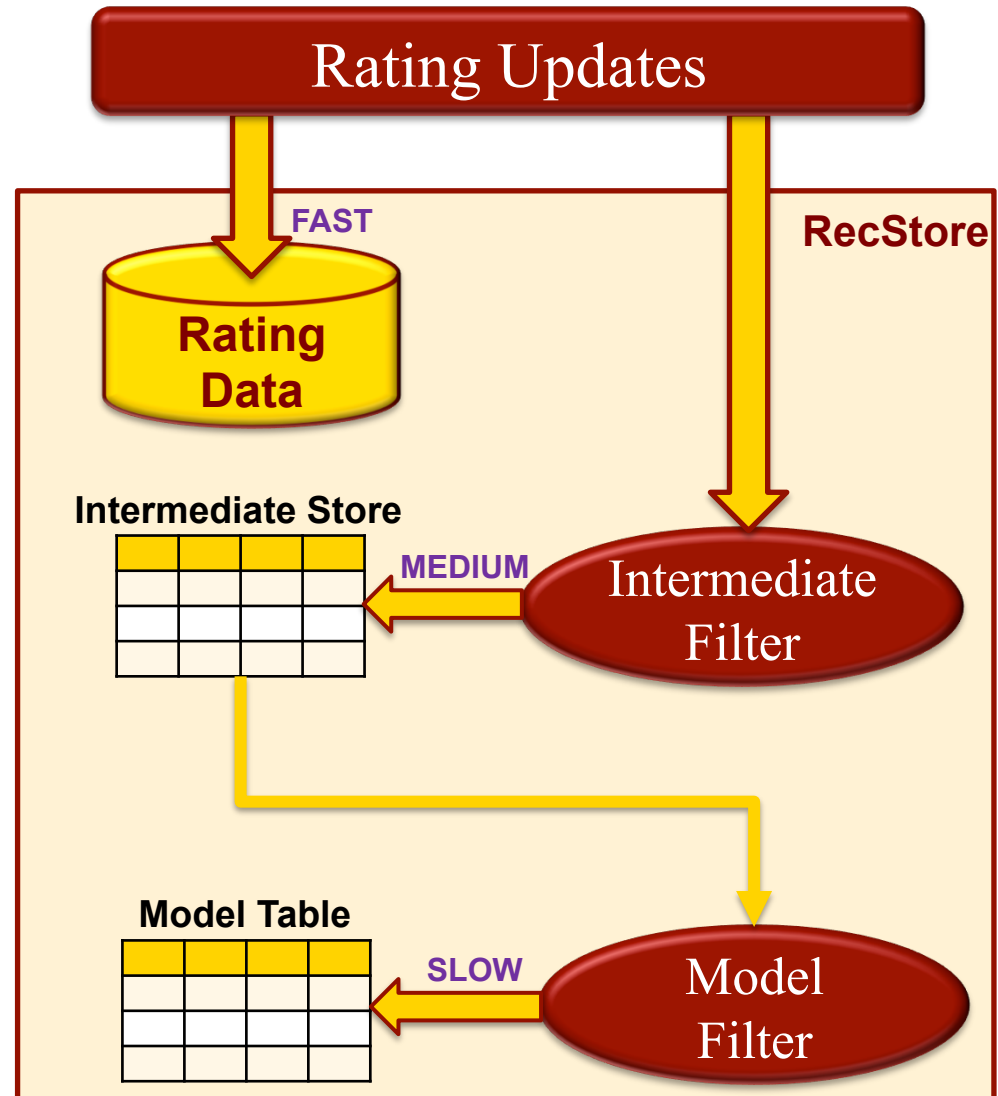
- Middle Ground between Materialize-All and Materialize-None

## Intermediate Store / Partial Model Store

- Middle Ground between Materialize-All and Intermediate-Only

## Partial Intermediate Store / Partial Model Store

- Lies between Partial Model and Intermediate Only



# RecStore: Defining a Recommender Model



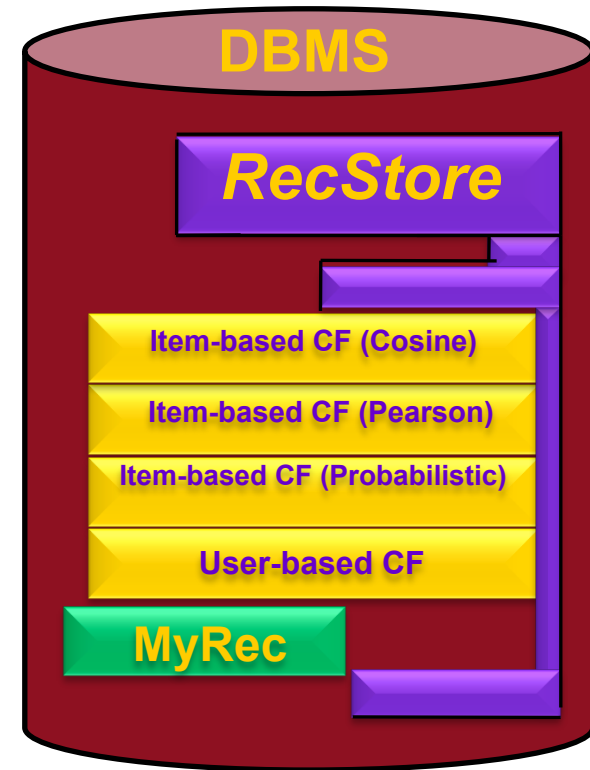
```
DEFINE RECSTORE MODEL ItemItemCosine
FROM Ratings R1, Ratings R2
WHERE R1.ItemId <> R2.itemId AND R1.userId = R2.userId

WITH INTERMEDIATE STORE:
    (R1.itemID as item, R2.itemId as rel_itm,
    vector_lenp, vector_lenq, dot_prod, co_rate)

WITH INTERMEDIATE FILTER:
    ALLOW UPDATE WITH My_IntFilterLogic(),
    UPDATE vector_lenp AS vector_lenp + R1.rating * R1.rating,
    UPDATE vector_lenq AS vector_lenq + R2.rating * R2.rating,
    UPDATE dot_prod AS ot_prod + R1.rating * R2.rating,
    UPDATE co_rate AS 1

WITH MODEL STORE:
    (R1.itemId as item, R2.itemId as rel_itm, COMPUTED sim)

WITH MODEL FILTER:
    ALLOW UPDATE WITH My_ModFilterLogic(),
    UPDATE sim AS if (co_rate < 50)
        co_rate * dot_prod / ( 50*sqrt(vector_lenp)
                                * sqrt (vector_lenq));
    else
        co_rate / sqrt(vector_lenp) *
        sqrt(vector_lenp);
```



Simple SQL to Plug-in a new Recommendation Method

# RecStore: Querying a Recommender Model



## User/item ratings

uid	mid	rating
1	1	3.5
2	1	5
...	...	...

```
/* Find movies rated by REC_USER_X,  
 * store in temp table usrXMovies */  
CREATE TEMP TABLE usrXMovies AS  
SELECT R.mid as itemId, R.rating as rating  
FROM ratings R  
WHERE R.uid = REC_USER_X;
```

## Model

itm	rel_itm	Prediction
1	2	4.0
...	...	...
...	...	...

```
/* Generate predictions using weighted sum */  
SELECT M.itm as Candidate Item,  
       SUM(M.sim * U.rating) / SUM(M.sim) as Prediction  
FROM   Model M usrXMovies U  
WHERE  M.rel_itm = U.itemId AND  
       M.itm NOT IN (select itemId FROM usrXMovies)  
GROUP BY M.itm ORDER BY Prediction DESC;
```

Maintain the recommendation *Model* to efficiently answer recommendation queries

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Mohamed Sarwat, Justin J. Levandoski, Ahmed Eldawy, and Mohamed F. Mokbel. " **LARS\***: A Scalable and Efficient Location-Aware Recommender System". IEEE Transactions on Knowledge and Data Engineering, **TKDE 2013**, *To Appear*.

Justin J. Levandoski, Mohamed Sarwat, Ahmed Eldawy, and Mohamed F. Mokbel. " **LARS**: A Location-Aware Recommender System". In Proceedings of the IEEE International Conference on Data Engineering, **ICDE 2012**, Washington D.C., April 2012

# “Locations” and “Recommendations”



- **Recommender systems rely on the input triple :**  
*(user, item, rating)*

- Recommender systems completely ignore the spatial aspects of both users and items

**Do we need to consider “Locations” ?**

- **Adding Location-awareness to Recommender Systems**

- Recommend movies based on the locations of the ratings

- **Adding Recommendation-awareness to Location-based services**

- Instead of asking about restaurants in a certain area or closest to me, I can ask a recommender system to suggest few restaurants to me

# Location Matters: Netflix Rental Patterns



## Movie preferences differ based on the user location (zip code)



The New York Times N.Y. / Region

Search All NYTimes.com Orange Home Loans As low as 3.05% APR

WORLD U.S. N.Y. / REGION BUSINESS TECHNOLOGY SCIENCE HEALTH SPORTS OPINION ARTS STYLE TRAVEL JOBS REAL ESTATE AUTOS

CLICK HERE TO FIND OUT MORE ForSaleByOwner.com Real Estate. Reinvented. Advertise on NYTimes.com

Published: January 8, 2010

### A Peek Into Netflix Queues

Examine Netflix rental patterns, neighborhood by neighborhood, in a dozen cities. Some titles with distinct patterns are *Mad Men*, *Obsessed* and *Last Chance Harvey*. [Comments \(135\)](#)

100 titles that were frequently rented from Netflix in 2009

Change how movies are sorted: **Most rented** Alphabetical By metacore

### I Love You, Man

A man without a woman is like a pistol without a hammer, wrote Victor Hugo. But a romantic comedy without a female lead, well, that's just a fine bromance and now Hollywood business as usual, as most recently demonstrated by "I Love You, Man," a fitfully funny comedy that owes much to Judd Apatow, the king of such sublimated man-on-man affairs. Though Mr. Apatow isn't officially credited, his DNA is all over this bromance, which stars Paul Rudd as a wuss who mans up by befriendng a guy's guy (Jason Segel) whose masculinity is so secure he wears Uggs boots and shorts to walk his wee dog.

[Read Rest of NYT Review >](#)

Ranked No. 1 No. 50

NEW YORK BOSTON CHICAGO WASHINGTON BAY AREA L.A. SEATTLE MINNEAPOLIS DENVER ATLANTA



- ### Most rented in 55418
1. Milk
  2. The Curious Case of Benjamin Button
  3. Burn After Reading
  4. The Wrestler
  5. Slumdog Millionaire
  6. Gran Torino
  7. Doubt
  8. Changeling
  9. Rachel Getting Married
  10. Twilight
  - ...
  16. I Love You, Man

- ### Most rented in 55113
1. The Curious Case of Benjamin Button
  2. Slumdog Millionaire
  3. Gran Torino
  4. Doubt
  5. Milk
  6. Seven Pounds
  7. Burn After Reading
  8. Changeling
  9. The Wrestler
  10. New in Town
  - ...
  24. I Love You, Man

- ### Most rented in 55455
- 70 Metacritic score  
100=loved by critics, 0=hated
1. I Love You, Man
  2. Slumdog Millionaire
  3. Adventureland
  4. My Best Friend's Girl
  5. Nick and Norah's Infinite Playlist
  6. Sunshine Cleaning
  7. Forgetting Sarah Marshall
  8. Away We Go
  9. Role Models
  10. Confessions of a Shopaholic

- ### Most rented in 55404
1. Burn After Reading
  2. Milk
  3. The Curious Case of Benjamin Button
  4. Slumdog Millionaire
  5. The Wrestler
  6. Twilight
  7. Doubt
  8. Rachel Getting Married
  9. Changeling
  10. Gran Torino
  - ...
  12. I Love You, Man



# Location Matters:



## Top-3 Check-In Destinations in Foursquare

- Destination preferences differ based on the user location (zip code) and the destination location

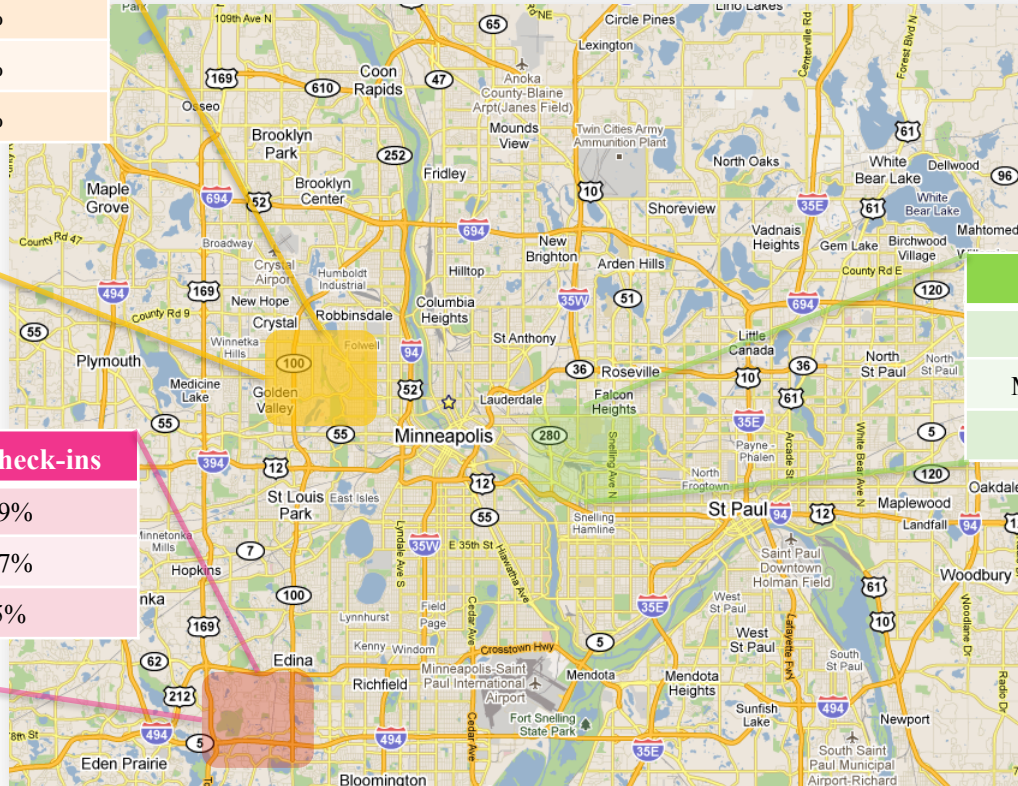
Fousquare users from Robbinsdale tend to visit venues in ...



City	% of check-ins
Brooklyn Park	32%
Robbinsdale	20%
Minneapolis	15%

Fousquare users from Edina tend to visit venues in ...

City	% of check-ins
Edina	59%
Minneapolis	37%
Edin Prarie	5%



Fousquare users from Falcon Heights tend to visit venues in ...

City	% of check-ins
St. Paul	17%
Minneapolis	13
Roseville	10%

# LARS:

## A Location-Aware Recommender System



■ We need to go beyond the traditional rating triple (*user, item, rating*) to include the following taxonomy:

① *Spatial Rating for Non-spatial Items*

- (*user\_location, user, item, rating*)
- *Example:* A user with a certain location is rating a movie
- *Recommendation:* Recommend a movie that neighbor users have liked

② *Non-spatial Rating for Spatial Items*

- (*user, item\_location, item, rating*)
- *Example:* A user with unknown location is rating a restaurant
- *Recommendation:* Recommend a restaurant within a close vicinity

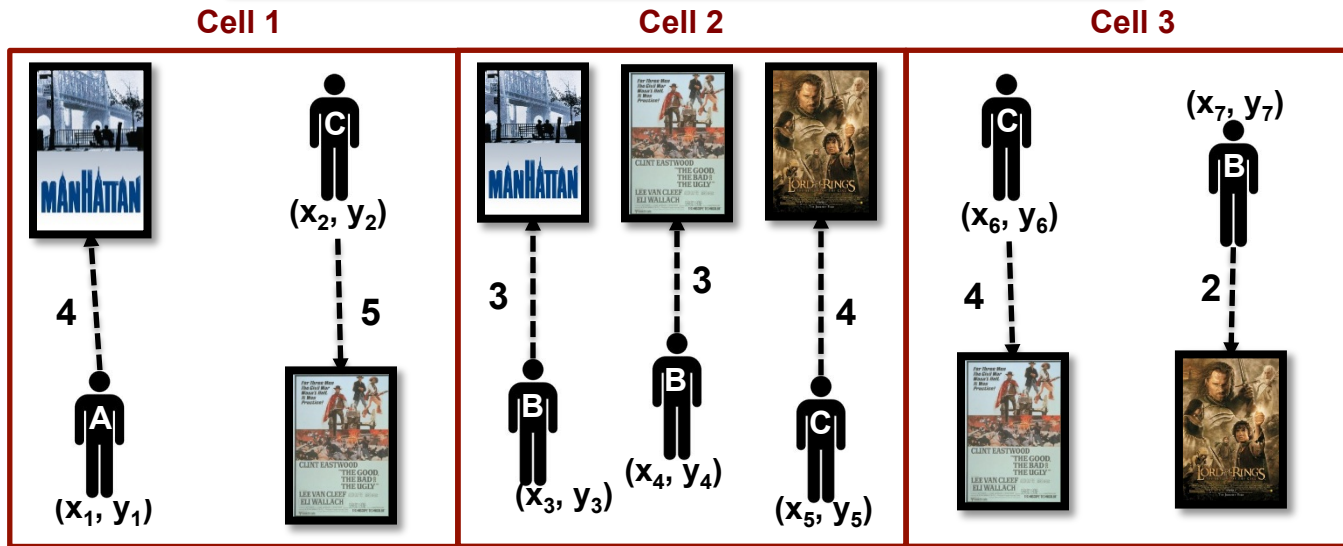
③ *Spatial Rating for Spatial Items*

- (*user\_location, location, item\_location, item, rating*)
- *Example:* A user with a certain location is rating a restaurant

# Spatial User Ratings For Non-Spatial Items



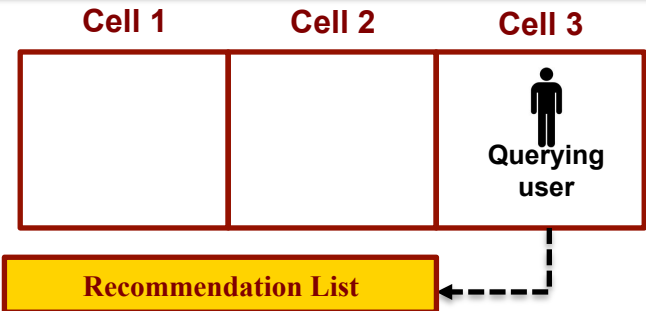
## 1. Partition ratings by user location



## 2. Build collaborative filtering model for each cell using only ratings contained within the cell

## 3. Generate recommendations using collaborative filtering using the model of the cell containing querying user

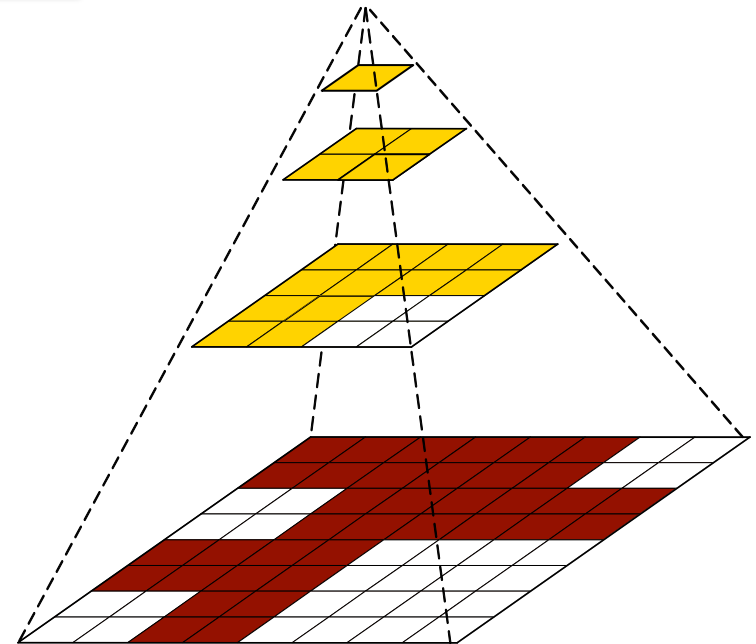
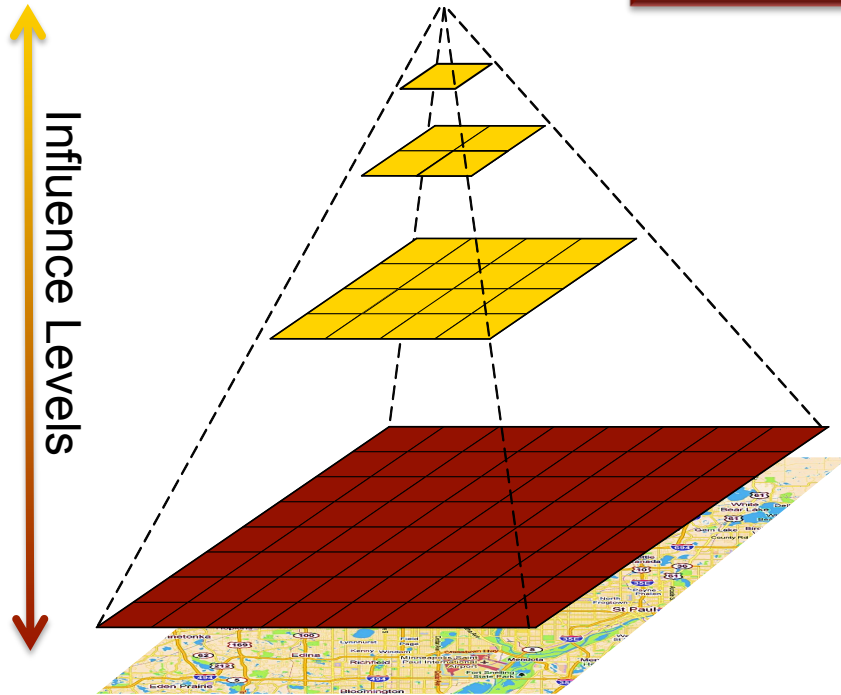
Cell 1			Cell 2			Cell 3		
Build Collaborative Filtering Model using:			Build Collaborative Filtering Model using:			Build Collaborative Filtering Model using:		
User	Item	Rating	User	Item	Rating	User	Item	Rating
A		4	B		3	B		4
C		5	B		3	C		5
			C		4			



# Spatial User Ratings For Non-Spatial Items



## User Partitioning



- Smaller cells → More “localized” answer
- Each user can select a personalized localized level
- Scalability problem in terms of maintaining large numbers of recommendation models

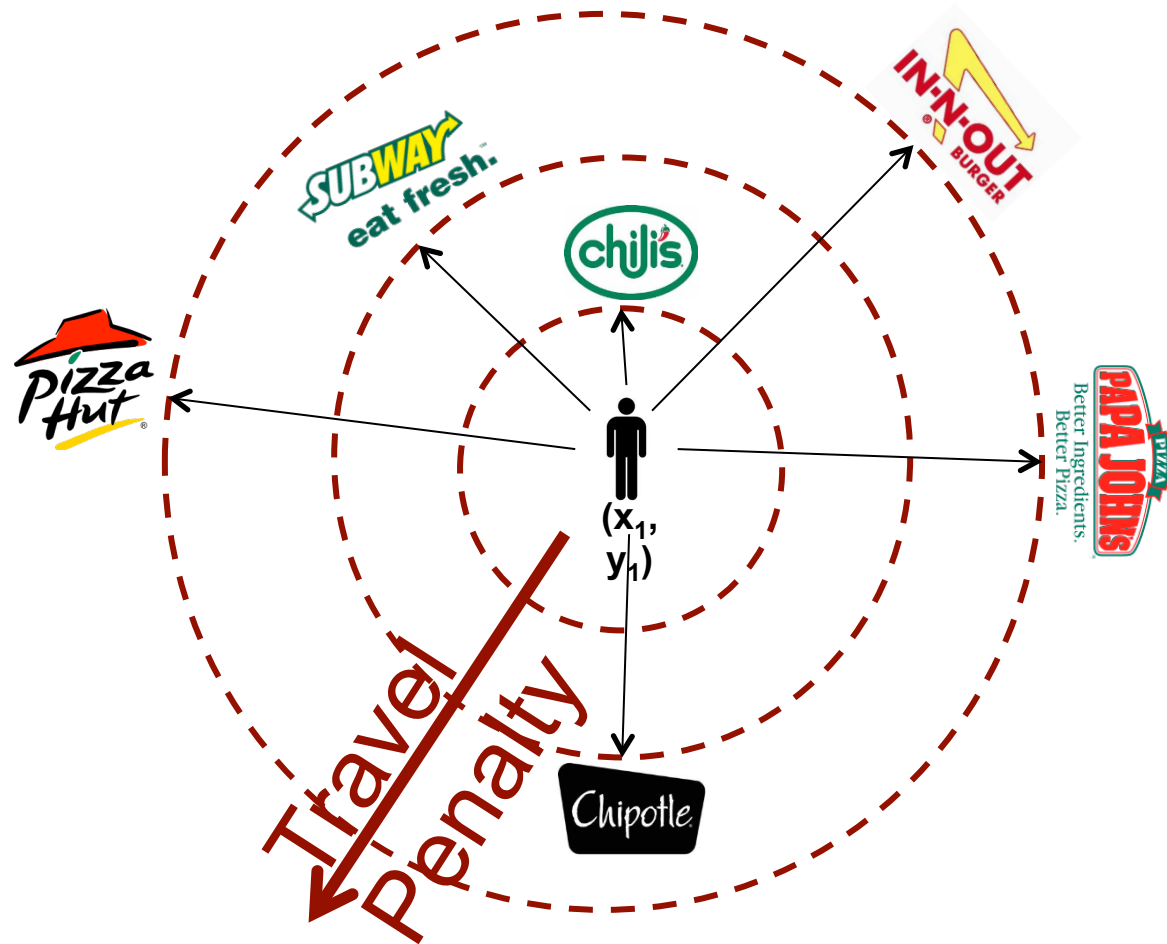
- No need to maintain all cells
- If four cells will end up giving the same recommendations, merge them.
- If ratings inside a cell are diverse, split it
- Merging and splitting balance between localization and storage/maintenance

# Non-Spatial User Ratings For Spatial Items



## Travel Penalty

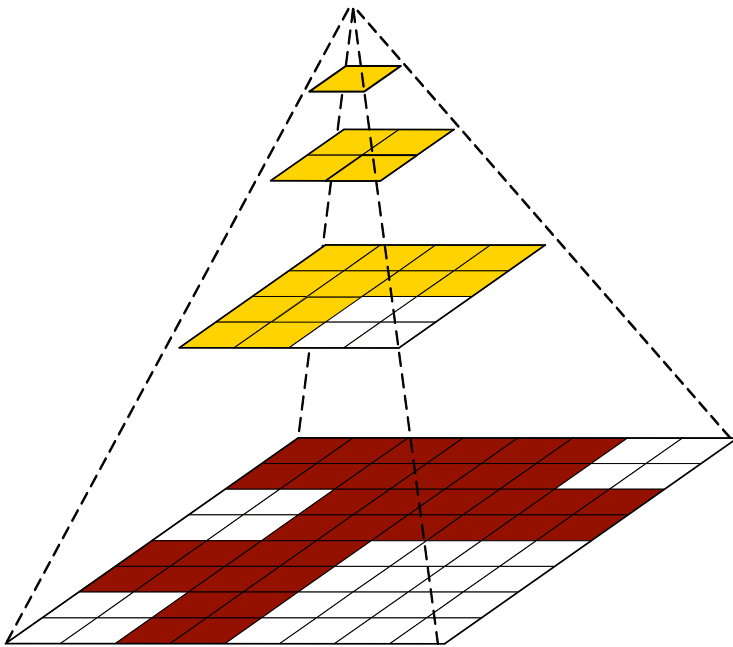
- Penalize items based on their distance from the user.
- Distance from the user is normalized to the ratings scale to get the Travel Penalty.
- Use a ranking function that combines the recommendation score and travel penalty
- Incrementally, retrieve items based on travel penalty, and calculate the ranking score on an ad-hoc basis
- Employ an early stopping condition to minimize the list of accessed items to get the K recommended items



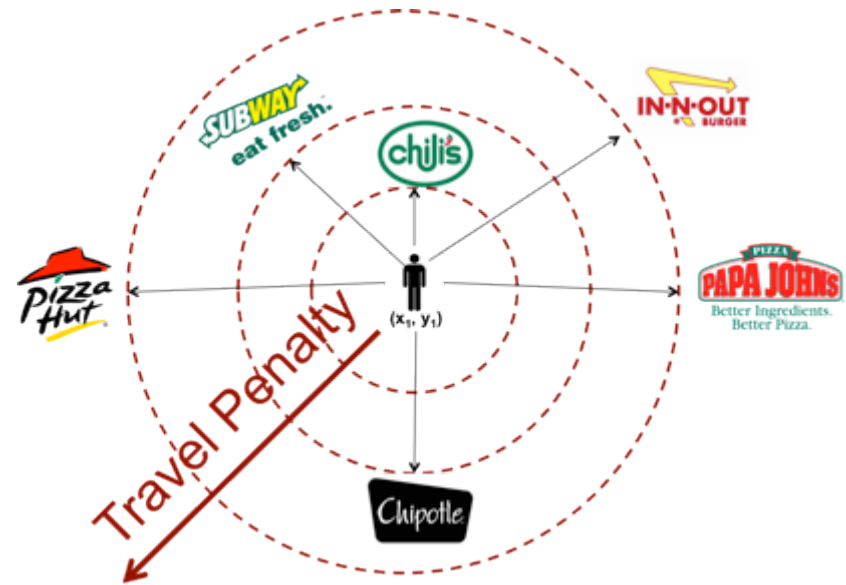
# Spatial User Ratings For Spatial Items



User Partitioning



Travel Penalty



# Talk Outline



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# Context-Aware Recommendation: Why?



amazon.com Hello, David E Erickson. We have [recommendations](#) for you. (Not David?)  
David's Amazon.com Today's Deals Gifts & Wish Lists Gift Cards

Shop All Departments Search All Departments

Your Amazon.com Your Browsing History Recommended For You Rate These Items

David, Welcome to Your Amazon.com (if you're not David E Erickson, click here.)

### Today's Recommendations For You

Here's a daily sample of items recommended for you. Click here to [see all recommendations](#).

<p><a href="#">Predictably Irrational, Revised and Expanded Edition</a> (Paperback) by Dan Ariely ★★★★☆ (419) \$9.51 <a href="#">Fix this recommendation</a></p>	<p><a href="#">Switch: How to Change Things When It Really Counts</a> (Hardcover) by Chip Heath ★★★★☆ (178) \$16.22 <a href="#">Fix this recommendation</a></p>	<p><a href="#">Sway: The Irresistible Pull of Implicit Forces</a> (Paperback) by Ori Brafman ★★★★☆ (157) \$8.04 <a href="#">Fix this recommendation</a></p>

*“Recommend me five books”*



*“Recommend me five books, based on my **location**”*



*“Recommend me five books, based on my **age**”*



*“Recommend me five books, based on my **job**”*



*“Recommend me five books, based on my **budget**”*



**A need for a system that generates context-aware recommendations**



# Recathon: A Context-Aware Recommender System



**Main Idea:** Treat recommender systems in the same way as indexing in databases

## ■ Same as Indexing:

- A recommender can be built on one (or more) attribute(s)
- A recommender can be dropped anytime
- A recommender is maintained with inserting new items
- There are different methods of building a recommender

## ■ Different from Indexing

- A query needs to explicitly specify which recommender model to use
- Recommenders are maintained differently based on query and transaction workload
- Recommenders can be maintained partially to provide part of the final answer or fully to directly give the final answer

# Recathon: Creating a Recommender



**CREATE RECOMMENDER** *RecommenderName*  
**USERS FROM** *User\_Table\_Name*  
**ITEMS FROM** *Items\_Table\_Name*  
**RATINGS FROM** *Rating\_Table\_Name*  
**ATTRIBUTES** *User\_Attributes*  
**USING** *RecommenderMethod*

**CREATE RECOMMENDER** *AgeRec*  
**USERS FROM** *MovieUsers*  
**ITEMS FROM** *MovieTable*  
**RATINGS FROM** *MovieRating*  
**ATTRIBUTES** *Age*  
**USING** *ItemBasedCF*

**CREATE RECOMMENDER** *AgeCityRec*  
**USERS FROM** *MovieUsers*  
**ITEMS FROM** *MovieTable*  
**RATINGS FROM** *MovieRating*  
**ATTRIBUTES** *Age, City*  
**USING** *SVD*

UserID	Age	City	Salary
1	20	Minneapolis	3K
2	35	Saint Paul	4K
3	18	Falcon Heights	3.5K
4	23	Edina	5K
5	31	Minnetonka	10K

**MovieUsers**

ItemID	Movie
1	Lord of the Rings
2	Manhattan
3	The Good, the Bad, and the Ugly

**MovieTable**

UserID	ItemID	Rating
1	1	3.5
1	3	4.5
3	2	1.5
4	1	5.0
5	1	3.0

**MovieRating**

# Recathon: Querying a Recommender



- Once a recommender is created, a set of intermediate tables and views are created
- Tables and views are continuously maintained, based on an adaptive maintenance technique
- Recommenders are exposed to Recathon users as views that can be queried with standard SQL

*Recommend me a movie based  
on my **Age***

```
SELECT      ItemID
FROM        AgeRec R1
RECOMMEND(10) R1.uid = 1 AND
            R1.age = 20
```

*Recommend me a movie based  
on my **Age & City***

```
SELECT      ItemID
FROM        AgeRec R1
RECOMMEND(10) R1.uid = 1 AND
            R1.age = 20 AND
            City = 'Edina'
```

# Talk Outline

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- Background on Recommender Systems
- DBMS for Recommender Systems
- RecBench: *A Benchmark for Recommender System Architectures*
- RecStore: *A Storage Engine Support for Recommender Systems*
- LARS: *A Context-Aware Recommender System*
- Recathon: *A Context-Aware Recommender System*
- **Summary, Commercial Ads, and Acknowledgments**

# Summary



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*"Recommend me five books"*



*"Recommend me five books, based on my **location**"*



*"Recommend me five books, based on my **age**"*



*"Recommend me five books, based on my **job**"*



*"Recommend me five books, based on my **budget**"*



# Related Publications



## Papers

- ➔  Mohamed Sarwat, Justin J. Levandoski, Ahmed Eldawy, and Mohamed F. Mokbel. "**LARS\*: A Scalable and Efficient Location-Aware Recommender System**". IEEE Transactions on Knowledge and Data Engineering, **TKDE 2013**, To Appear.
- ➔  Justin J. Levandoski, Mohamed Sarwat, Ahmed Eldawy, and Mohamed F. Mokbel. "**LARS: A Location-Aware Recommender System**". In Proceedings of the IEEE International Conference on Data Engineering, **ICDE 2012**, Washington D.C., April 2012
- ➔  Justin J. Levandoski, Mohamed Sarwat, Mohamed F. Mokbel, and Michael D. Ekstrand. "**RecStore: An Extensible and Adaptive Framework for Online Recommender Queries inside the Database Engine**". In Proceedings of the International Conference on Extending Database Technology, **EDBT 2012**, Berlin, Germany, March 2012
- Jie Bao, Yu Zheng and Mohamed Mokbel. "**Location-based and Preference-Aware Recommendation Using Sparse Geo-Social Networking Data**". In Proceedings of the ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems, **SIGSPATIAL GIS 2012**, Redondo Beach, California, November 2012
- ➔  Justin J. Levandoski, Michael D. Ekstrand, Michael J. Ludwig, Ahmed Eldawy, Mohamed F. Mokbel and John T. Riedl. "**RecBench: Benchmarks for Evaluating Performance of Recommender System Architectures**". In Proceedings of the International Conference on Very Large Databases, **VLDB 2011**, Seattle, WA, September 2011
- ➔  Mohamed Sarwat, James Avery, and Mohamed F. Mokbel. "**Recathon: A Unified Architecture for Personalized Recommendation in Database Systems**". Under Preparation.

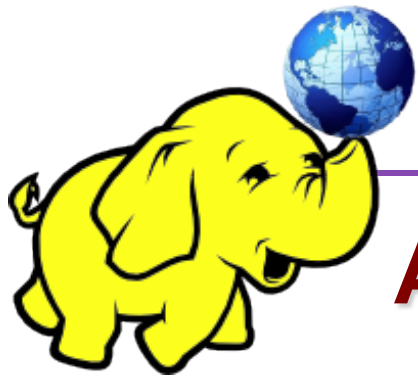
## Demos

- Mohamed Sarwat, Jie Bao, Ahmed Eldawy, Justin J. Levandoski, Amr Magdy, and Mohamed F. Mokbel. "**Sindbad: A Location-based Social Networking System**". In Proceedings of ACM SIGMOD Conference on Management of Data, **ACM SIGMOD 2012**, Scottsdale, AZ, May, 2012.
- Badrish Chandramouli, Justin J. Levandoski, Ahmed Eldawy and Mohamed F. Mokbel. "**StreamRec: A Real-Time Recommender System**". In Proceedings of ACM SIGMOD Conference on Management of Data, **ACM SIGMOD 2011**, Athenes, Greece, Jun., 2011.
- ➔  Mohamed Sarwat, James Avery, and Mohamed F. Mokbel. "**Recathon: A Unified Architecture for Personalized Recommendation in Database Systems**". Under Preparation.



# Commercial Ads



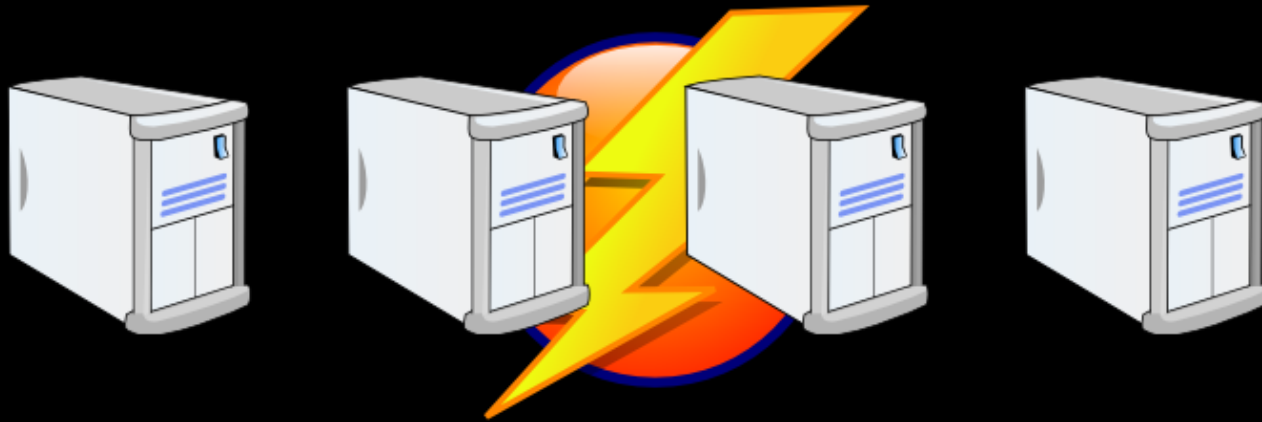


# Spatial Hadoop



**Analyze your spatial data efficiently**

## Efficient Spatial Operations



Analyze your data on large clusters with built-in spatial

Website: <http://spatialhadoop.cs.umn.edu/>

Download source code, binary distribution, and instructions



# MNTG: Web-based Traffic Generator



- Easy-to-generate traffic data for road networks
  - ❑ No need to do the installation/configuration
  - ❑ Very easy to get the data, just clicks
  - ❑ Works for road networks in US
  - ❑ Dedicated server for data generation
  - ❑ Email notifications
  - ❑ Visualization tools



MinnesotaTG: Web-based U.S. Traffic Generator

The screenshot shows the MinnesotaTG web interface. At the top, there is a search bar and a dropdown menu currently set to 'Brinkhoff'. Below the search bar is a map of the Minneapolis area. A form is overlaid on the map, titled 'Please enter the following information to request traffic:'. The form contains the following fields and values:

- Name: Traffic (Thursday, 21-Feb-13 14:07:20 CST)
- Email: (empty)
- Starting Vehicles: 5 vehicles
- Simulation Time: 20 time units
- Added Vehicles each Time Unit: 5 vehicles/time unit

At the bottom of the form, there are two buttons: 'Generate Thomas Brinkhoff Traffic' and 'Cancel'.

**Website:** <http://mntg.cs.umn.edu>

**Video:** <http://www.youtube.com/watch?v=dVP4oc0k9nU>



# Acknowledgment



# The RecBench, RecStore, LARS, and Recathon Team



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**(PhD, 2011)**

Researcher at Microsoft  
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Redmond, USA

## ■ Current Members: Ph.D. Students



**James Avery**



**Ahmed Eldawy**



**Mohamed Sarwat**

# Other Group Members



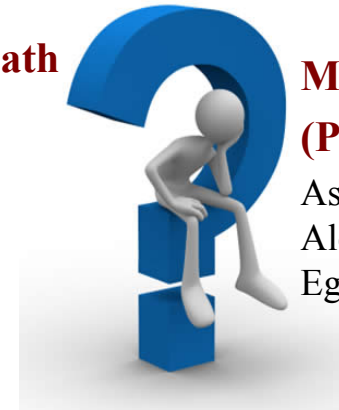
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**Jie Bao**



**Abdeltawab Hendawi**



**Amr Magdy**

# Acknowledgment: Funding



- **NSF-IIS:** Towards Spatial Database Management Systems for Flash Memory Storage. 2012 -2015



- **Microsoft Research.** *Microsoft Unrestricted Gift, October, 2010*



- **NSF- CAREER:** Extensible Personalization of Spatial and Spatio-temporal Database Management Systems. 2010 -2015



- **Microsoft Research.** *Microsoft Unrestricted Gift, January, 2010*



- **Microsoft Research.** *Microsoft Unrestricted Gift, April, 2009*



- **NSF- IIS:** Towards Ubiquitous Location Services: Scalability and Privacy of Location-based Continuous Queries. 2008 -2012



- **NSF- IIS:** Preference- And Context-Aware Query Processing for Location-based Data-based servers. 2008 -2012



- **NSF- CNS:** Infrastructure for Research in Spatio-Temporal and Context-Aware Systems and Applications. 2007 - 2012



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# Thanks

