

Week 11

Course. Introduction to Machine Learning **Theory 11. Recommender Systems**

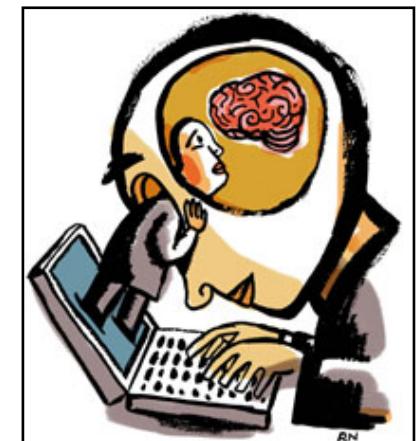
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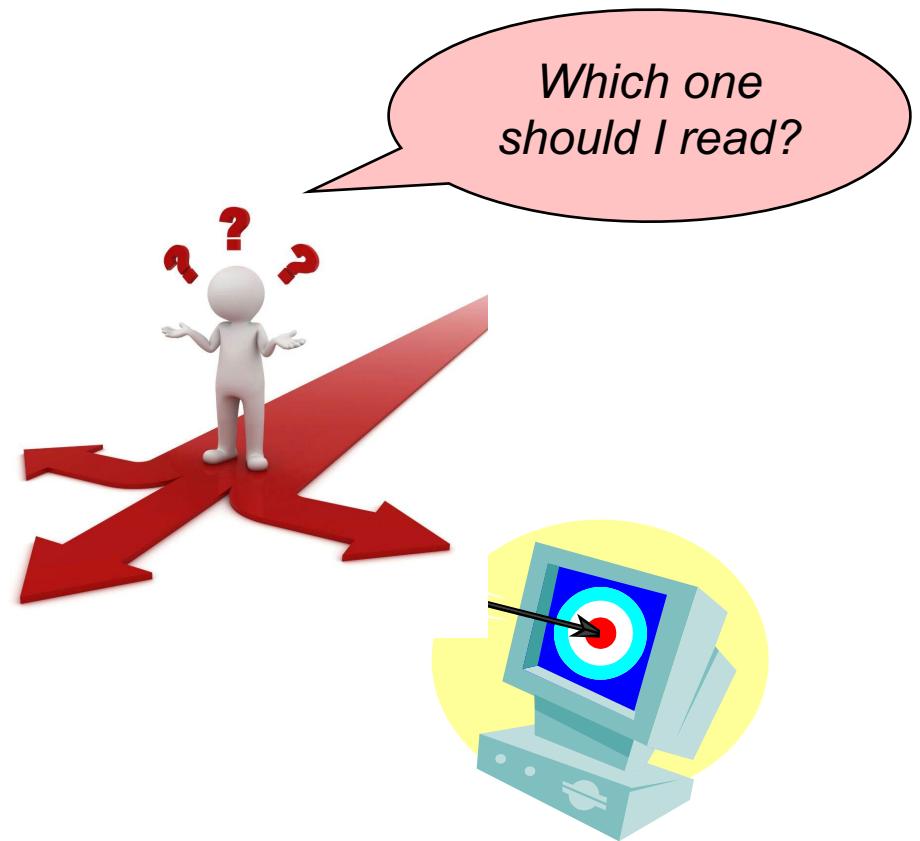
Introduction to Recommender Systems



Introduction to Recommender systems



***Recommendations
from friends***



***Recommendations
from Online
Systems***

Which one should I choose?



***Make a
decision***

For example, IMDb contained in January 2018
IMDb: 4.734.693 titles and 8.702.002 users

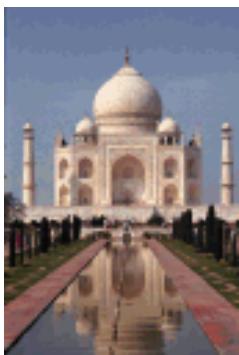
What travel should I do ?



I would like to escape from this ugly and tedious work life and relax for two weeks in a sunny place. I am fed up with these crowded and noisy places ... just the sand and the sea ... and some "adventure".



I would like to bring my wife and my children on a holiday ... it should not be too expensive. I prefer mountainous places... not too far from home. Children parks, easy paths and good cuisine are a must.



I want to experience the contact with a completely different culture. I would like to be fascinated by the people and learn to look at my life in a totally different way.

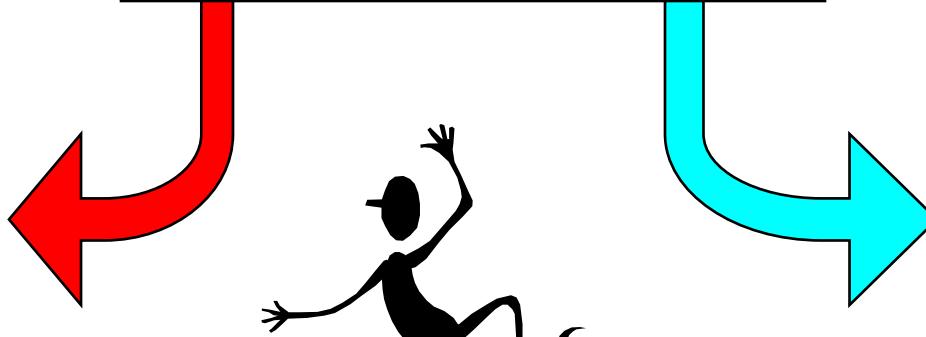
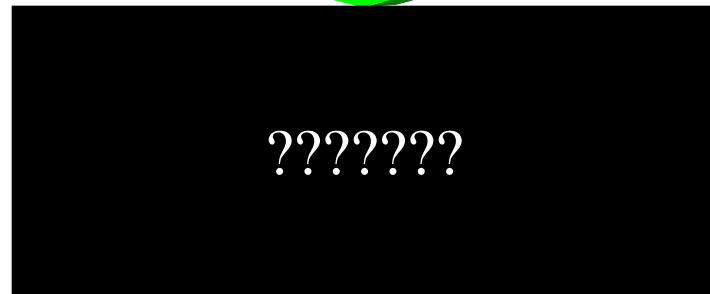
Information Overload

- **Internet = information overload**
 - the state of having too much information to make a decision or remain informed about a topic
- Information retrieval technologies can assist a user to **locate content** if the user knows exactly what he is looking for (with some difficulties!)
 - The user must be able to say “yes this is what I need” when presented with the right result
- But in many information search tasks, e.g., product selection, the user is...
 - not aware of the range of available options
 - may not know what to search
 - if presented with some results he may not be able to choose.

- When there are 100 million of options it is obvious we need tools for searching, filtering, ranking options
- *But even when there are a few dozen of options we need support*
- **Examples**
 - Where to go for dinner tonight?
 - What flight for going to London?
 - What Digital camera should I buy?



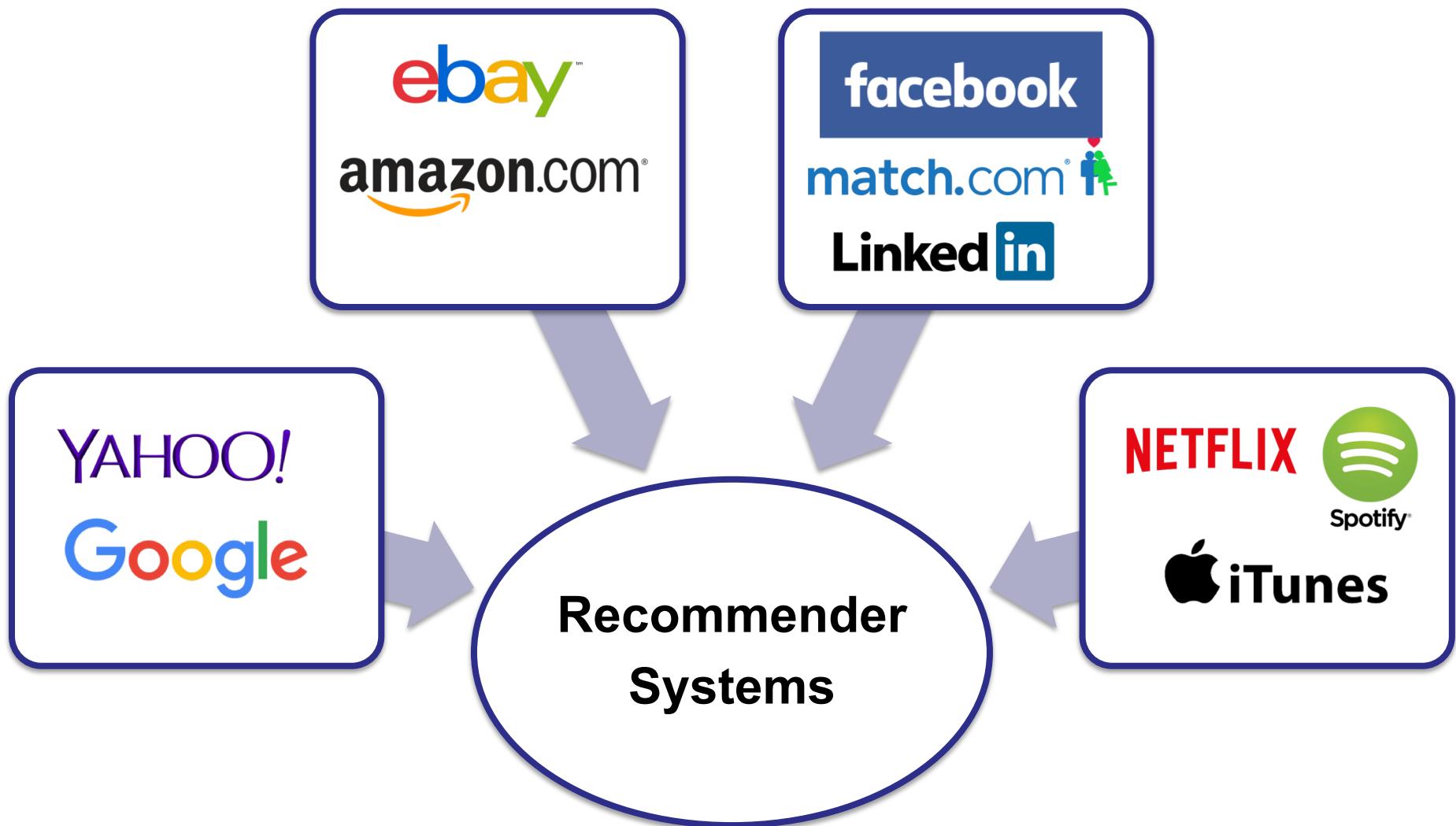
A Solution



- A **recommender system** helps to make choices without sufficient personal experience of the alternatives
 - To **suggest products** to their customers
 - To provide consumers with **information to help them decide** which products to purchase
- They are based on a number of **technologies**: information filtering, machine learning, adaptive and personalized system, user modeling, intelligent user interfaces, ...

- Automates quotes like:
 - "I like this book; you might be interested in it"
 - "I saw this movie, you'll like it"
 - "Don't go see that movie!"
- Many of the top commerce sites use recommender systems to improve sales
- Users may find new books, music, or movies that were previously unknown to them
 - Also can find the opposite for e.g., movies or music that will definitely not be enjoyed

Use of RecSys



Basic interaction paradigm of RecSys

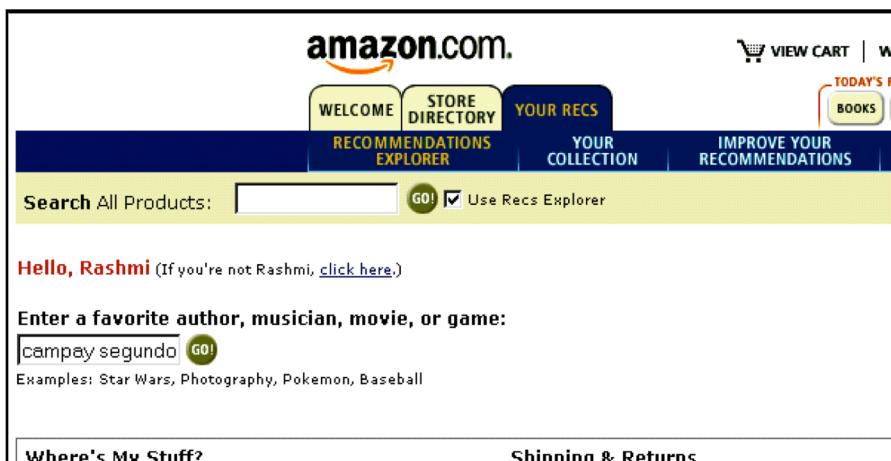


Input (ratings of movies):
“I recently enjoyed *Harry Potter, Star Wars, Joker*”



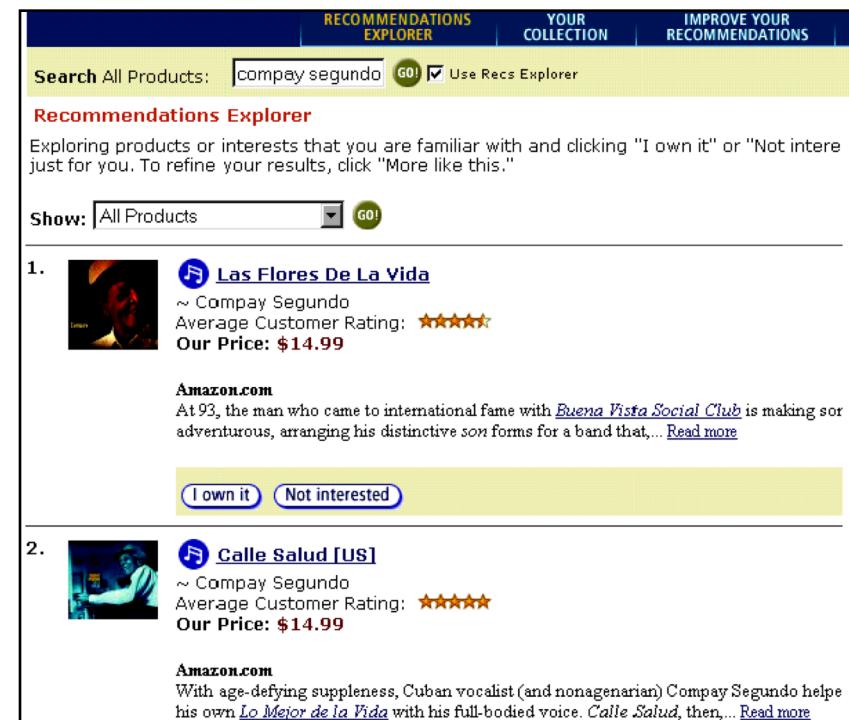
Output (Recommendations):
“Movies you might enjoy are... ”

Amazon's Recommendation Process



The screenshot shows the Amazon.com homepage with a blue header bar. On the left, there are links for "WELCOME", "STORE DIRECTORY", "YOUR RECS", "RECOMMENDATIONS EXPLORER" (which is highlighted in yellow), "YOUR COLLECTION", and "IMPROVE YOUR RECOMMENDATIONS". On the right, there are links for "VIEW CART", "TODAY'S FINDS", and "BOOKS". Below the header, there is a search bar with the placeholder "Search All Products:" and a "GO!" button. To the right of the search bar is a checkbox labeled "Use Recs Explorer". The main content area displays a message "Hello, Rashmi" and a section for entering a favorite author, musician, movie, or game, with "campay segundo" entered and a "GO!" button. Below this, there is a "Examples:" section with "Star Wars, Photography, Pokemon, Baseball". At the bottom, there are links for "Where's My Stuff?" and "Shipping & Returns".

Input: One artist/author name



The screenshot shows the "RECOMMENDATIONS EXPLORER" section of the Amazon website. At the top, there is a search bar with "campay segundo" and a "GO!" button. To the right of the search bar is a checkbox labeled "Use Recs Explorer". Below the search bar, there is a heading "Recommendations Explorer" with a sub-instruction: "Exploring products or interests that you are familiar with and clicking "I own it" or "Not interested" just for you. To refine your results, click "More like this.". There is also a dropdown menu set to "All Products" with a "GO!" button.

1.  **Las Flores De La Vida**
 ~ Compay Segundo
 Average Customer Rating: ★★★★☆
 Our Price: \$14.99

Amazon.com
 At 93, the man who came to international fame with *Buena Vista Social Club* is making some adventurous, arranging his distinctive son forms for a band that,... [Read more](#)

I own it **Not interested**

2.  **Calle Salud [US]**
 ~ Compay Segundo
 Average Customer Rating: ★★★★☆
 Our Price: \$14.99

Amazon.com
 With age-defying suppleness, Cuban vocalist (and nonagenarian) Compay Segundo helps his own *Lo Mejor de la Vida* with his full-bodied voice. *Calle Salud*, then,... [Read more](#)

Output: List of recommendations
 Opportunity to Explore / Refine

The recommendation process from the user's perspective

User inputs
preferences...

Time and effort
to input
Privacy concerns

...receives
recommendations...

Time and
effort to
review recs

...and decides if he/she will
sample recommendation

In the end, a user benefits only
if recommendations turn out to
be good ones.



What Users Want

Fast

Engaging

New to me

PROCESS

Easy

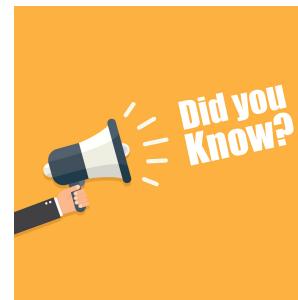
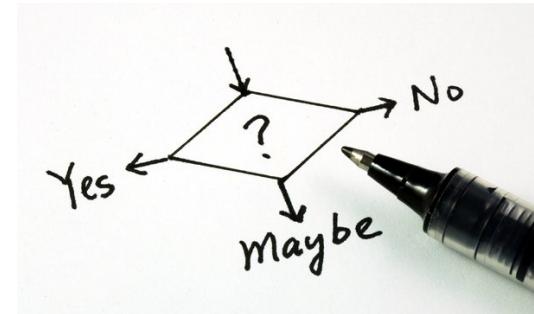
RECOMMENDATIONS

Good

To succeed, collaborative filtering recommender systems
need a LOT of motivated regular users

Objective of RecSys

- Help people **make decisions**
 - Where to spend attention
 - Where to spend money
- Help **Maintain awareness**
 - New products
 - New information



In both cases: Many options, limited resources

Definition of Recommender

- Recommender systems are a specific type of **information filtering** technique that attempt to present to the user information **items** (movies, music, books, news, web pages) the **user is interested in**. To do this the **user's profile** is compared to some reference characteristics

from:

http://en.wikipedia.org/wiki/Recommendation_system

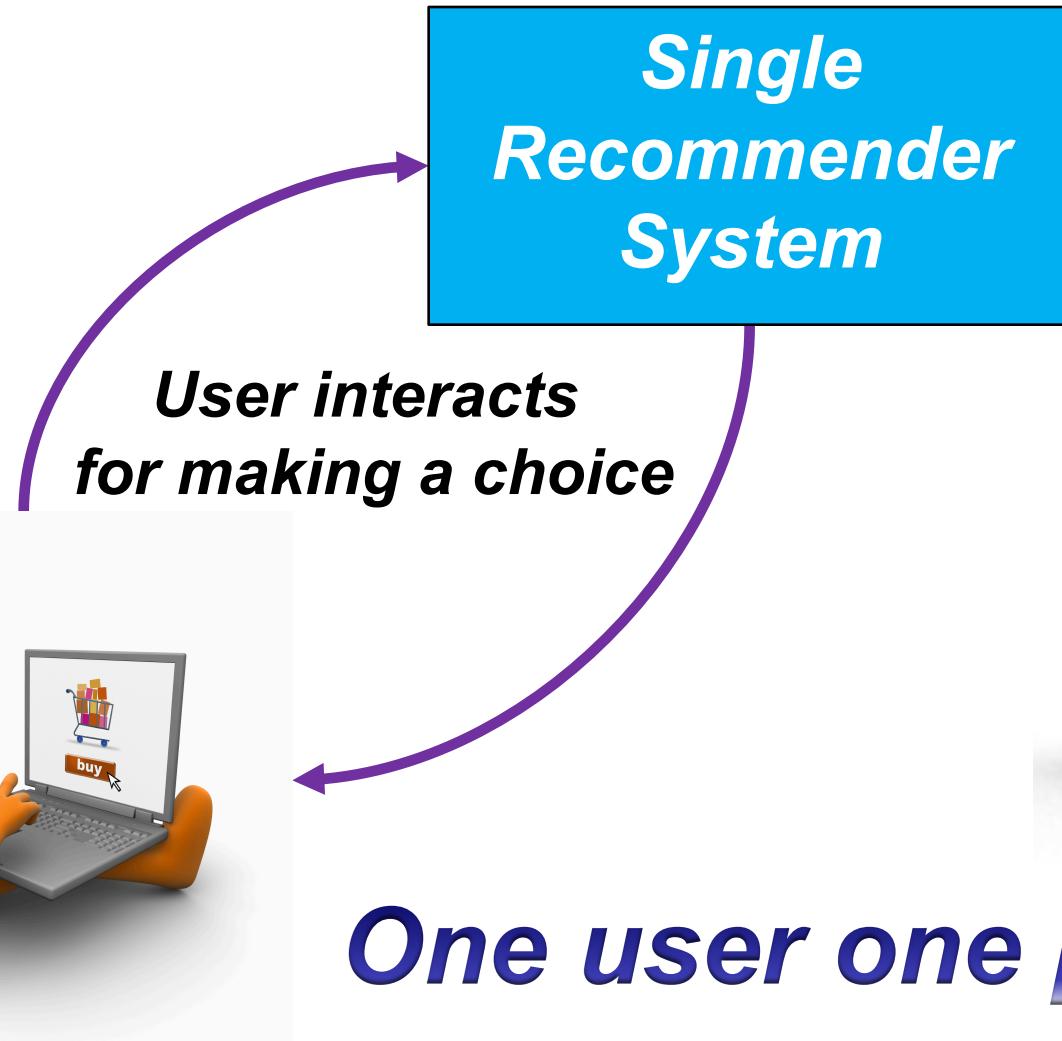
Recommender definitions

- Recommender systems are personalized **information systems** that provide recommendations: suggestions for items likely to be of use to a user (Burke, 2007)
- **Recommendation as a prediction problem** (Celma & Lamere, 2007)
 - Attempt to predict items that a user might be interested in
 - compute *similarity* between objects
 - user-user
 - item-item
 - form *predictions* based on the computed similarities



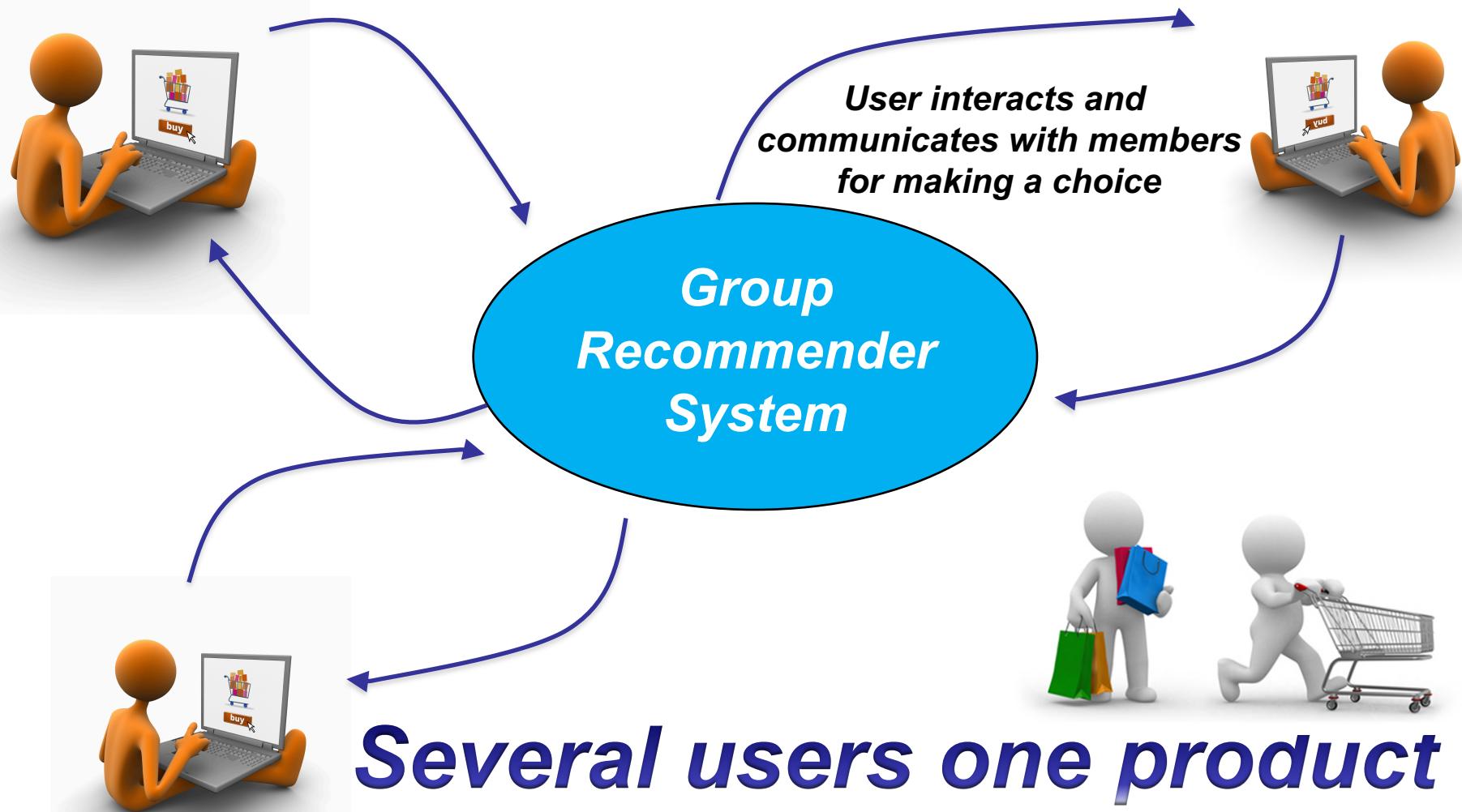
Recommendation techniques

Single Recommenders





Group Recommenders



Objective

- Address recommendations to groups of users
- First we have to **identify user's individual preferences**
- Second, we try to find a **compromise that is fair** and **acceptable** to all the users



Recommendation techniques

- **Knowledge-based (KB)** – knowledge about users and products used to reason what meets the user's requirements, using discrimination tree, decision support tools, case-based reasoning (CBR)
- **Collaborative Filtering (CF)** – aggregation of consumers' preferences and recommendations to other users based on similarity in behavioral patterns
- **Content-based (CN)** – supervised machine learning used to induce a classifier to discriminate between interesting and uninteresting items for the user
- **Hybrid filtering techniques** – combine one or more of the techniques mentioned above

Classification based on knowledge source

- **Knowledge-based (KB)**
 - Domain knowledge, product features, user's need/query
 - Inferences about user's needs and preferences
- **Collaborative (CF)**
 - User's ratings “only”
- **Content-based (CN)**
 - Product features, user's ratings
 - Classifications of user's likes/dislikes

- Context
 - What is context? Additional information, besides information on *Users*, that is *relevant* to recommendations
 - Relevant in:
 - Identifying pertinent subsets of data when computing recommendations
 - Building richer rating estimation models
 - Providing various types of constraints on recommendations outcomes



Context-aware recommender systems

Obtaining context

- Explicitly specified by the user
 - E.g., I want to watch a movie at home with my parents
- Observed or deduced by the system
 - Time (from system clock)
 - Location (from GPS)
 - Deduced from user's behaviour
- How to obtain the context is a separate problem that lies beyond the scope of this course
 - Context-aware recommender systems are very important for mobile computing

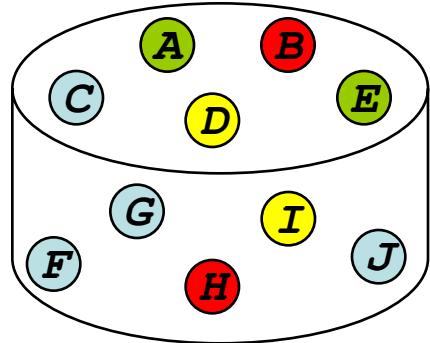
- **Cold-start problem** – concerns the issue that the system cannot draw any **inferences** for **users** or items about which it has not yet gathered sufficient information
- **Latency problem** – new items incorporated into a Rec cannot be used in CF recommendations before a substantial amount of users have evaluated it

- **Sparsity problem** – few users have rated the same items
- **Gray-sheep problem** – refers to a user that fall on a border between existing cliques of users

Summary of the techniques

- **Knowledge-based** methods go to the root of the decision problem
- **Collaborative-based** methods are the most popular
 - Suffers from bootstrapping problems
- **Content-based** methods are well rooted in information retrieval
- **Hybrid methods** are the most powerful and popular right now – there are plenty of options for hybridization

Components of a recommender



Choice Set
-Products
-Web Pages
-Movies
-TV shows
...

Recommender
An algorithm that generates personalized recommendations

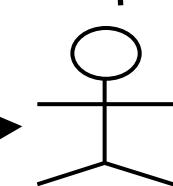
Preference Profile for Target User

What the system “knows” about the user’s preferences



Preference Capture

The system learns about the user’s preferences



Target User

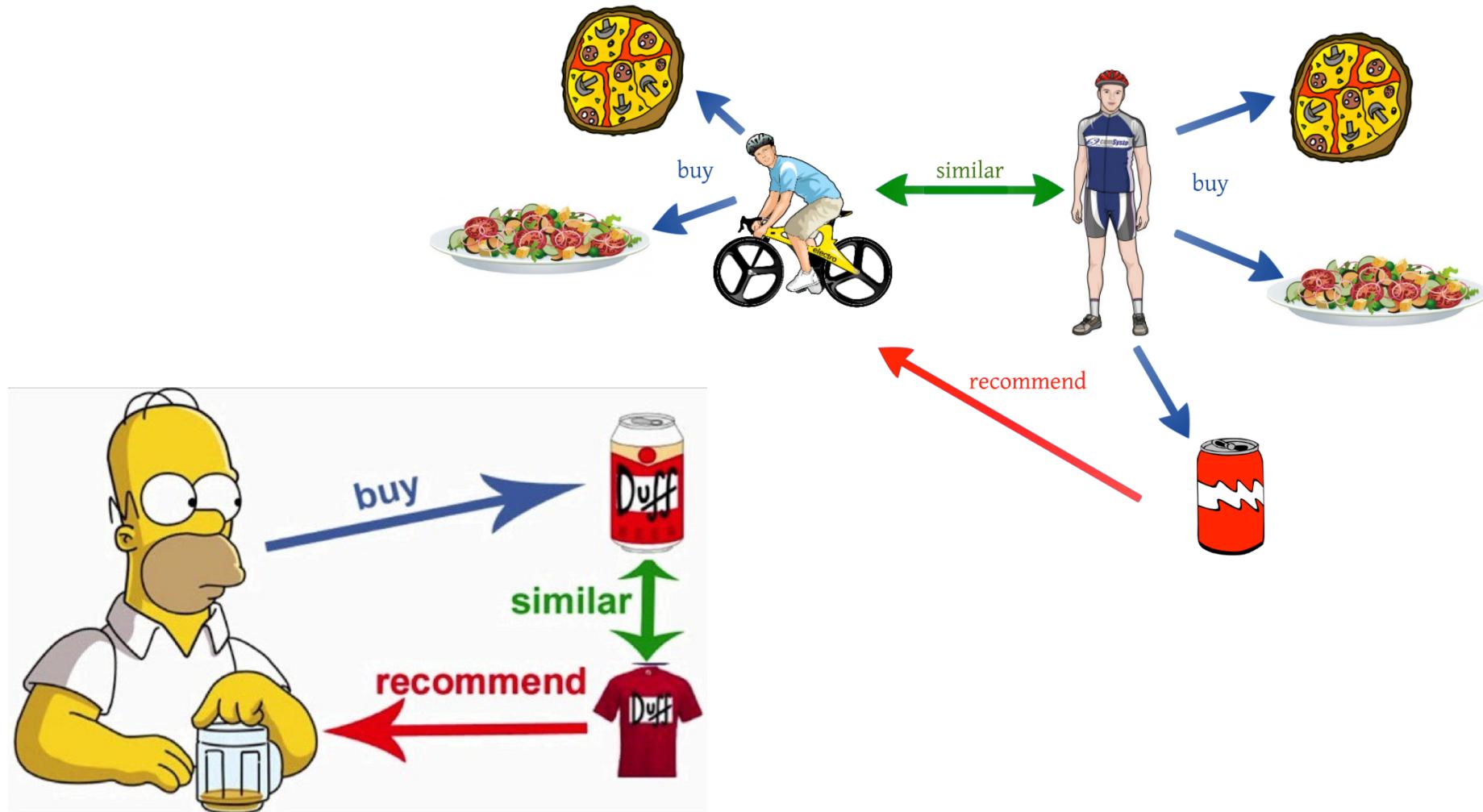
Personalized Recommendations for Target User

An overview of Collaborative Filtering Recommenders

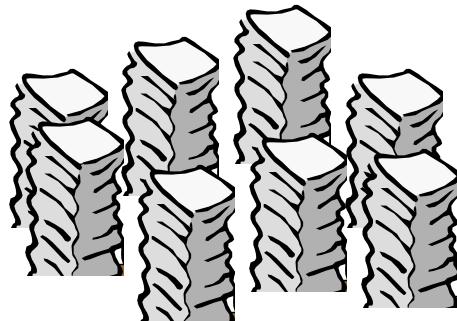




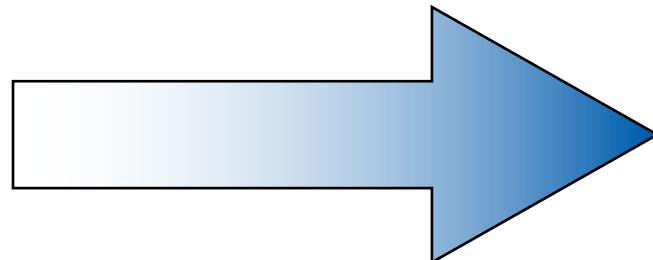
Basic idea of RecSys



Collaborative Filtering



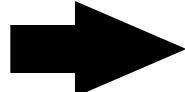
Unseen items



Community Opinions



Items you've
experienced



Predictions



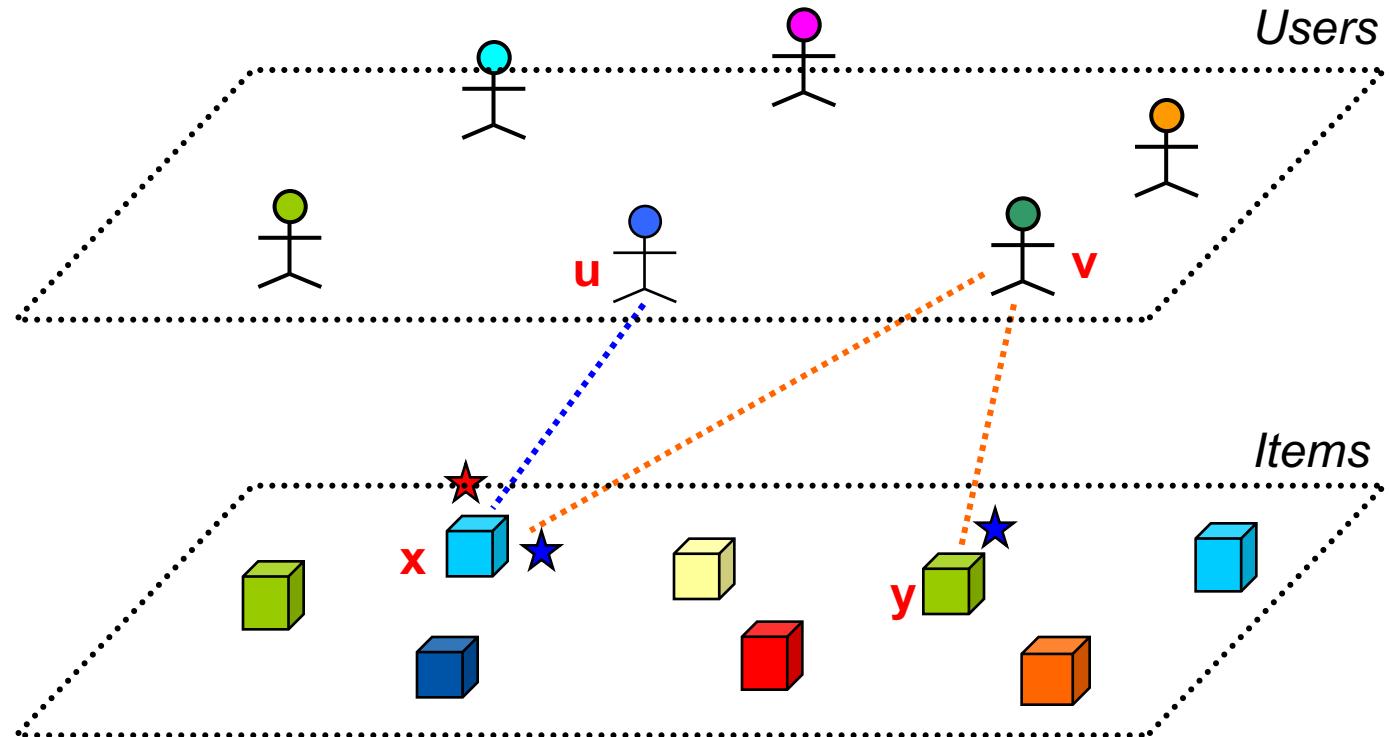
Your Opinions



Collaborative
Filtering
Process



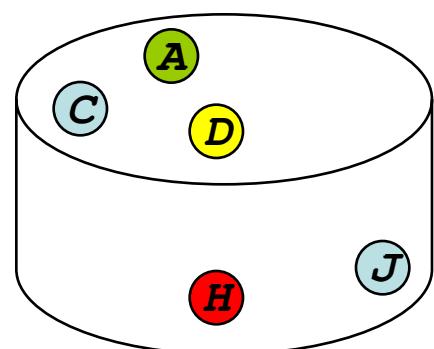
Collaborative Filtering



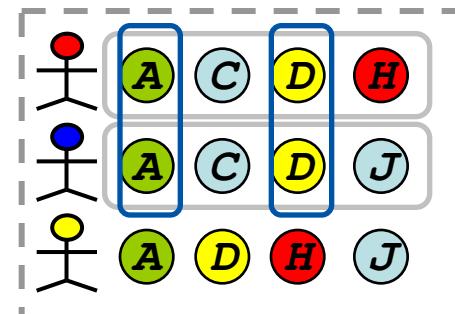
Definition

- **Collaborative Filtering (CF)** is the process of filtering or evaluating items through the opinions of other people
 - Maintain a database of many users' ratings of a variety of items
 - For a given user, find other similar users whose **ratings** strongly correlate with the current user
 - Recommend items rated highly by these similar users, but not rated by the current user
 - Almost all existing commercial recommenders use this approach (e.g., Amazon)

User-based

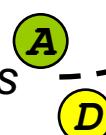


Choice Set
LIMITED to those items selected, and/or purchased by users



Recommender
Looks at profiles of “similar” users and recommends their most frequently selected or highest-ranked items

Personalized Recommendations for Target User

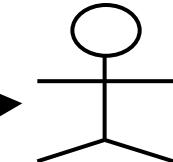


Target User

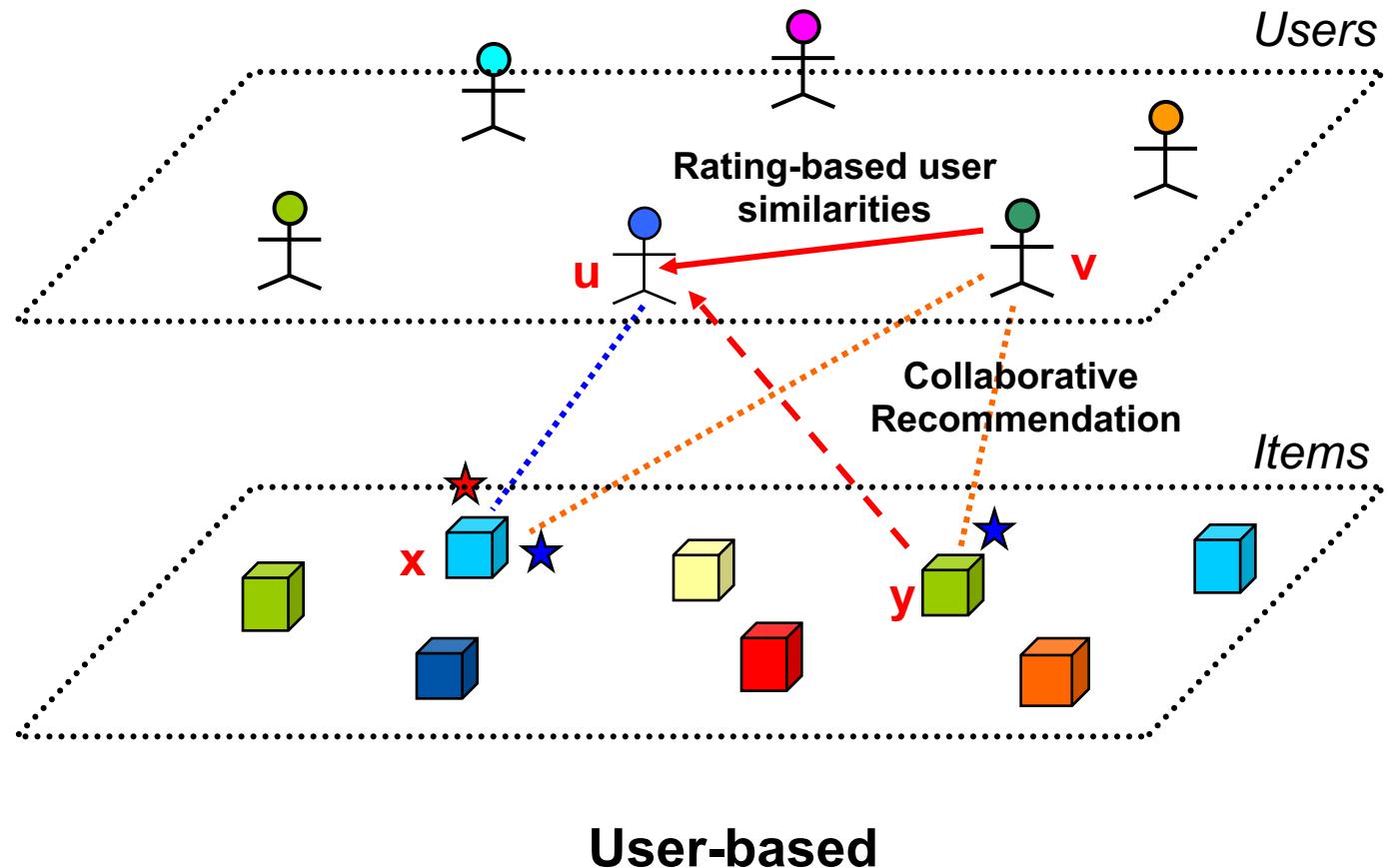
Preference Profile for Target User



Preference Capture
User selects Item C



Collaborative Filtering



Rating predictions

- Recommend to u those items ranked by v “similar” to u

$$(a) \quad r(u, x) = c \sum_{v \in \eta(u)} sim(u, v) r(v, x) \quad \text{Similarity between users}$$

$$(b) \quad r(u, x) = \bar{r}(u) + c \sum_{v \in \eta(u)} sim(u, v) (r(v, x) - \bar{r}(v))$$

Predicted vote
for “active
user” u
is a weighted
sum

$$\bar{r}(u) = \frac{1}{|S(u)|} \sum_{x \in S(u)} r(u, x) \quad S(u) = \{x \in \mathcal{I} \mid r(u, x) \neq \emptyset\}$$

$$c = \frac{1}{\sum_{v \in \eta(u)} |sim(u, v)|} \quad \text{Normalizing factor}$$

Similarity between users

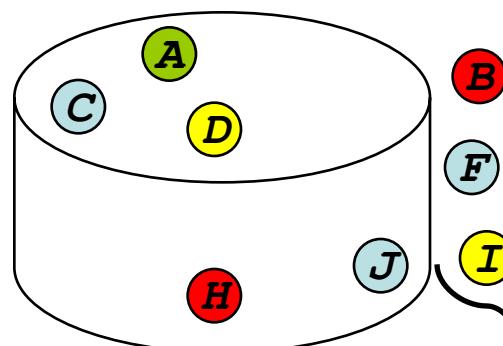
- The most popular approaches are:
 - **Cosine-based** user similarity (from IR)

$$\text{sim}(u, v) = \cos(r(u), r(v)) = \frac{\sum_{x \in \mathcal{I}} r(u, x)r(v, x)}{\sqrt{\sum_{x \in \mathcal{I}} r(u, x)^2 \sum_{x \in \mathcal{I}} r(v, x)^2}}$$

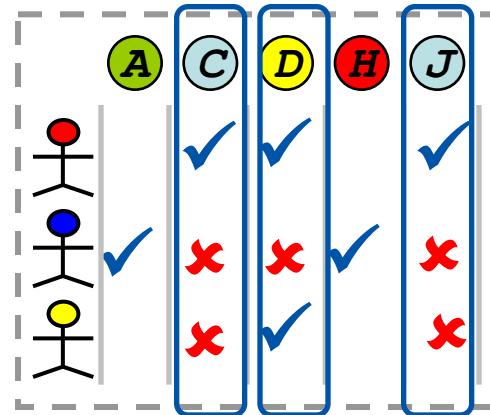
- **Correlation-based** user similarity (from GroupLens)

$$\text{sim}(u, v) = \frac{\sum_{x \in \mathcal{I}} (r(u, x) - \bar{r}(u))(r(v, x) - \bar{r}(v))}{\sqrt{\sum_{x \in \mathcal{I}} (r(u, x) - \bar{r}(u))^2 \sum_{x \in \mathcal{I}} (r(v, x) - \bar{r}(v))^2}}$$

Item-based



Choice Set
LIMITED to those items selected, and/or purchased by users



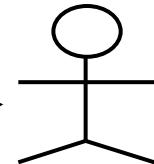
Personalized Recommendations for Target User

Preference Profile for Target User



Preference Capture
User selects Item C

J
D



Target User

- Recommend to u items “similar” to those best ranked by u

**Weighted
sum**

$$r(u, x) = c \sum_{y \in S(u)} sim(x, y) r(u, y)$$

$$c = \frac{1}{\sum_{y \in S(u)} |sim(x, y)|}$$

Similarity between items

Cosine

$$sim(x, y) = \cos(r(x), r(y)) = \frac{\sum_{u \in \mathcal{U}} r(u, x)r(u, y)}{\sqrt{\sum_{u \in \mathcal{U}} r(u, x)^2 \sum_{u \in \mathcal{U}} r(u, y)^2}}$$

Pearson

$$sim(x, y) = \frac{\sum_{u \in \mathcal{U}} (r(u, x) - \bar{r}(x))(r(u, y) - \bar{r}(y))}{\sqrt{\sum_{u \in \mathcal{U}} (r(u, x) - \bar{r}(x))^2 \sum_{u \in \mathcal{U}} (r(u, y) - \bar{r}(y))^2}}$$

Adjusted Cosine

$$sim(x, y) = \frac{\sum_{u \in \mathcal{U}} (r(u, x) - \bar{r}(u))(r(u, y) - \bar{r}(u))}{\sqrt{\sum_{u \in \mathcal{U}} (r(u, x) - \bar{r}(u))^2 \sum_{u \in \mathcal{U}} (r(u, y) - \bar{r}(u))^2}}$$

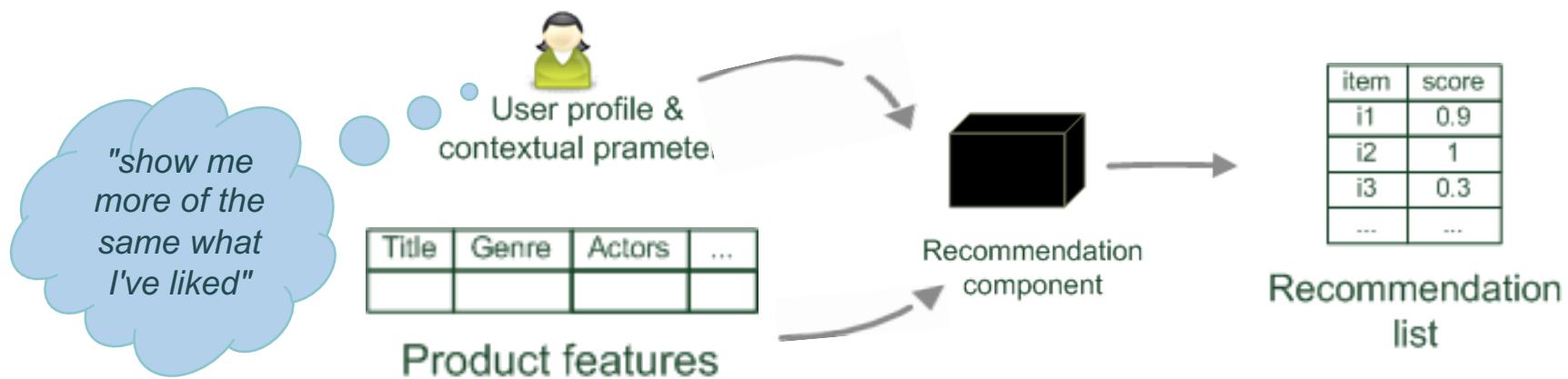
An overview of Content-based Recommenders



- Based on the conjecture that a person likes items with features similar to those of other items she liked in the past
- Closely related to **Information Retrieval**
- Items are suggested according to:
 - A comparison between their content and the user profiles
- A **user profile** contains information about the user' tastes, interests and needs

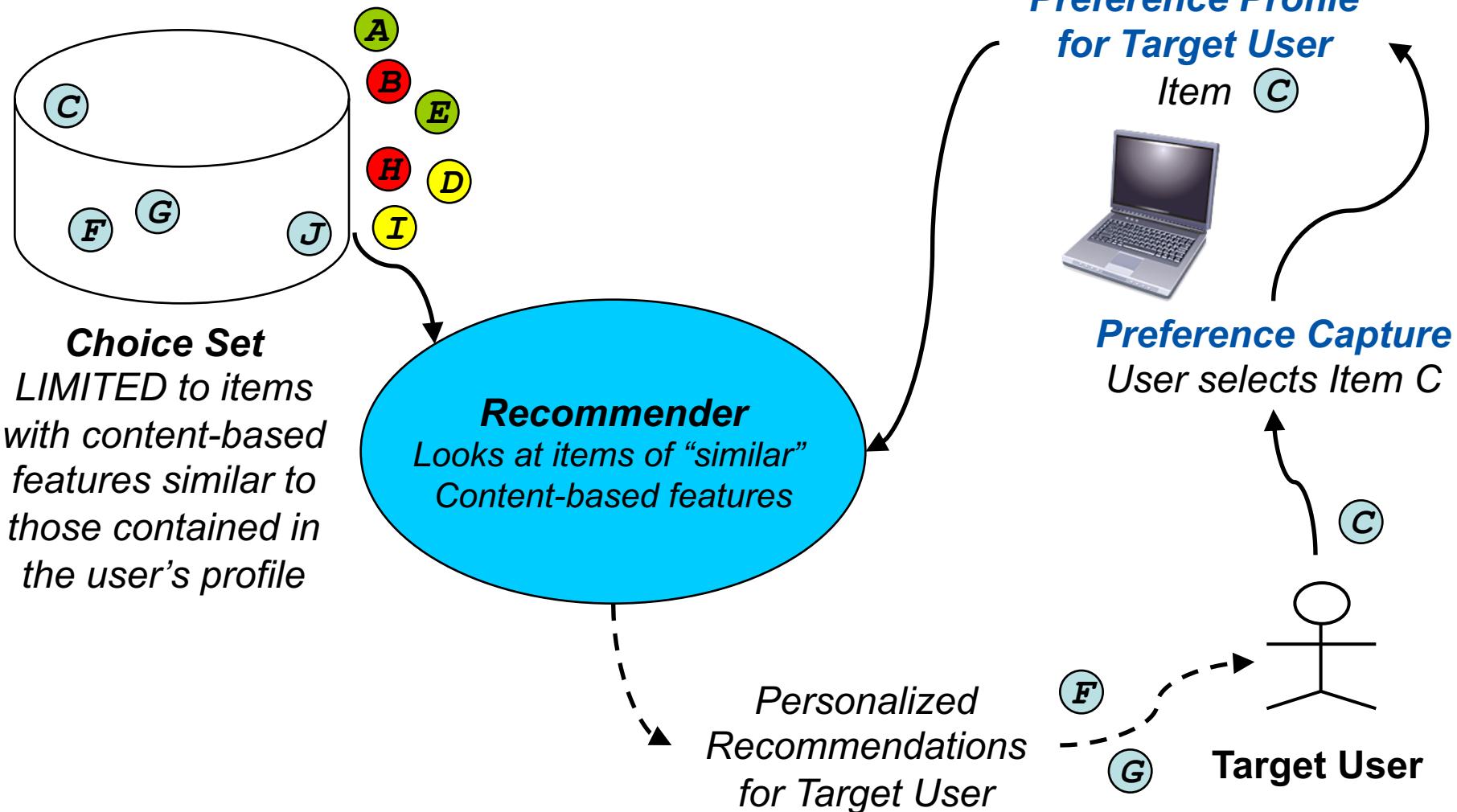
Content-based recommendation

- While CF – methods do not require any information about the items,
 - it might be reasonable to exploit such information; and
 - recommend fantasy novels to people who liked fantasy novels in the past
- What do we need:
 - some information about the available items such as the genre ("content")
 - some sort of user profile describing what the user likes (the preferences)
- The task:
 - learn user preferences
 - locate/recommend items that are "similar" to the user preferences

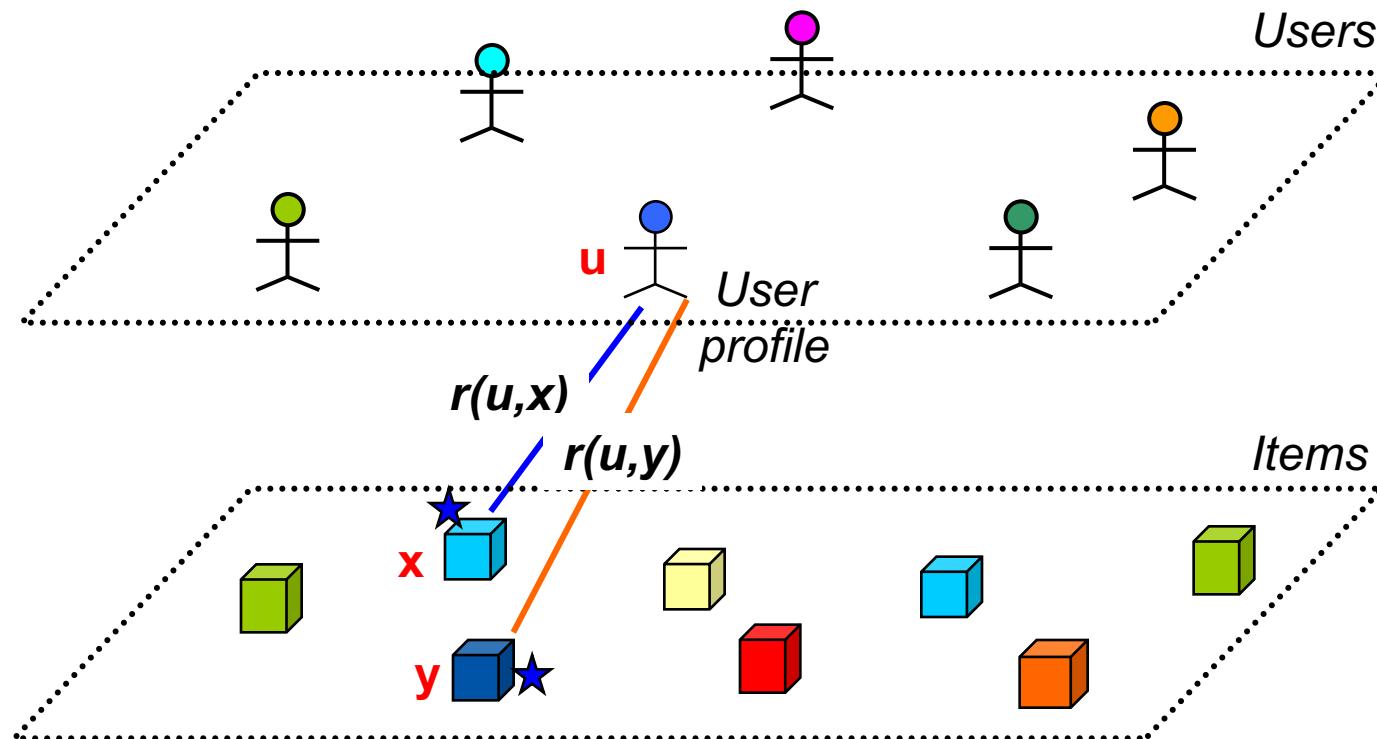


- **Content-based recommendation** systems share in common a means for:
 - Describing the items that may be recommended
 - Creating a profile of the user that describes the types of items the user likes
 - Comparing items to the user profile to determine what to recommend
- The profile is often created and updated automatically in response to **feedback** on the desirability of items that have been presented to her

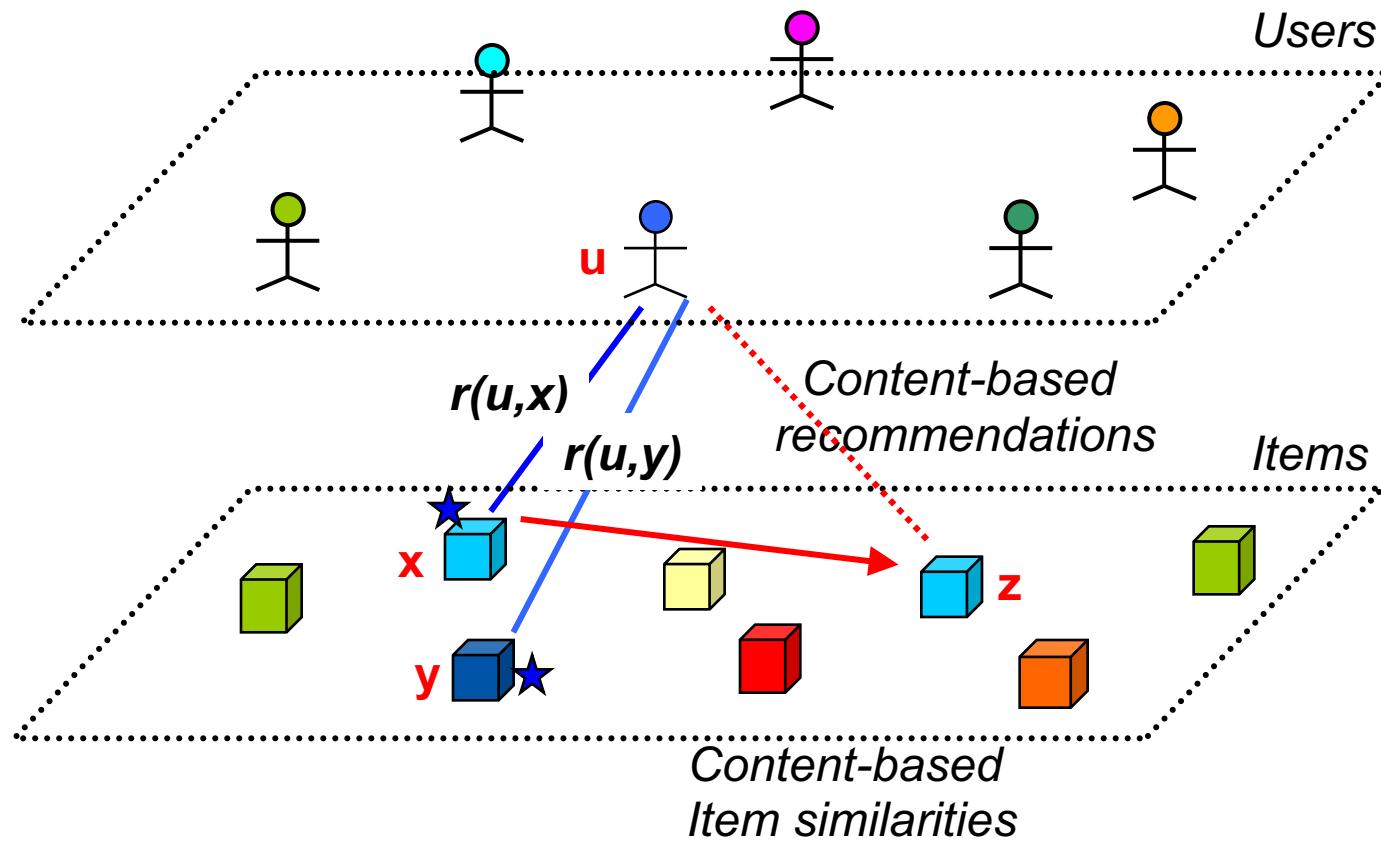
Content-based



Content-based



Content-based



Definition

- **Content-based recommendation** systems analyze item descriptions to identify items that are of particular interest to the user
- Items are suggested according to a comparison between their content and user profiles, which contain information about the users' tastes, interests and needs
- Most systems differ in the representation of items and how they get the feedback from users

Representation of items

Called attributes, features, characteristics, fields or variables

- **Database table**

Id	Name	Cuisine	Service	Cost
10001	Bella Italia	Italian	Counter	Low
10002	Amour	French	Table	Medium
10003	Jacques Bistro	French	Table	High

- Attributes names with well-defined values
- **Unstructured data**, unrestricted text such as news, articles
 - There are no attribute names with well-defined values
- **Semi-structured data**
 - Some attributes with a set of restricted values and
 - Some free-text fields

User profiles

- A profile of the user's interest is used by most recommendation systems
- **Types of information in a profile:**
 - A model of the **user's preferences**, a description of the types of items that interest the user
 - A **history of the user's interactions** with the recommendation system. This includes:
 - Storing the items that the user has viewed and
 - Other information about the user's interaction



Learn a user model

Learning a user model

- Creating a user model of the user's preference from the user history is a form of classification learning
- **Explicit feedback**, the user rates items via some interface for collecting feedback
 - Few data but an accurate set of preferences
- **Implicit feedback**, the system observes the user's interactions with items
 - Can collect a large amount of data with some uncertainty as to whether the user actually likes the item

- **User independence**, no need for data on other users
 - No cold-start or sparsity problems
- **No grey sheep problem**, it is able to recommend to users with unique tastes
- **New item**, it is able to recommend new and unpopular items
 - No first-rater problem
- **Transparency**, can provide explanations of recommended items by listing content-features that caused an item to be recommended

- **Requires content analysis**, content that can be encoded as meaningful features
 - The effectiveness of the Rec depends on the available descriptive data
- Users' tastes must be represented as a learnable function of these content features
- **Content over-specialization**, it only retrieves items that score highly against a specific user profile
- **Portfolio-effect**, non diversity problem, the user should be presented with a diverse range of options, not with a homogeneous set of alternatives
- Unable to exploit quality judgments of other users
 - Unless these are somehow included in the content features

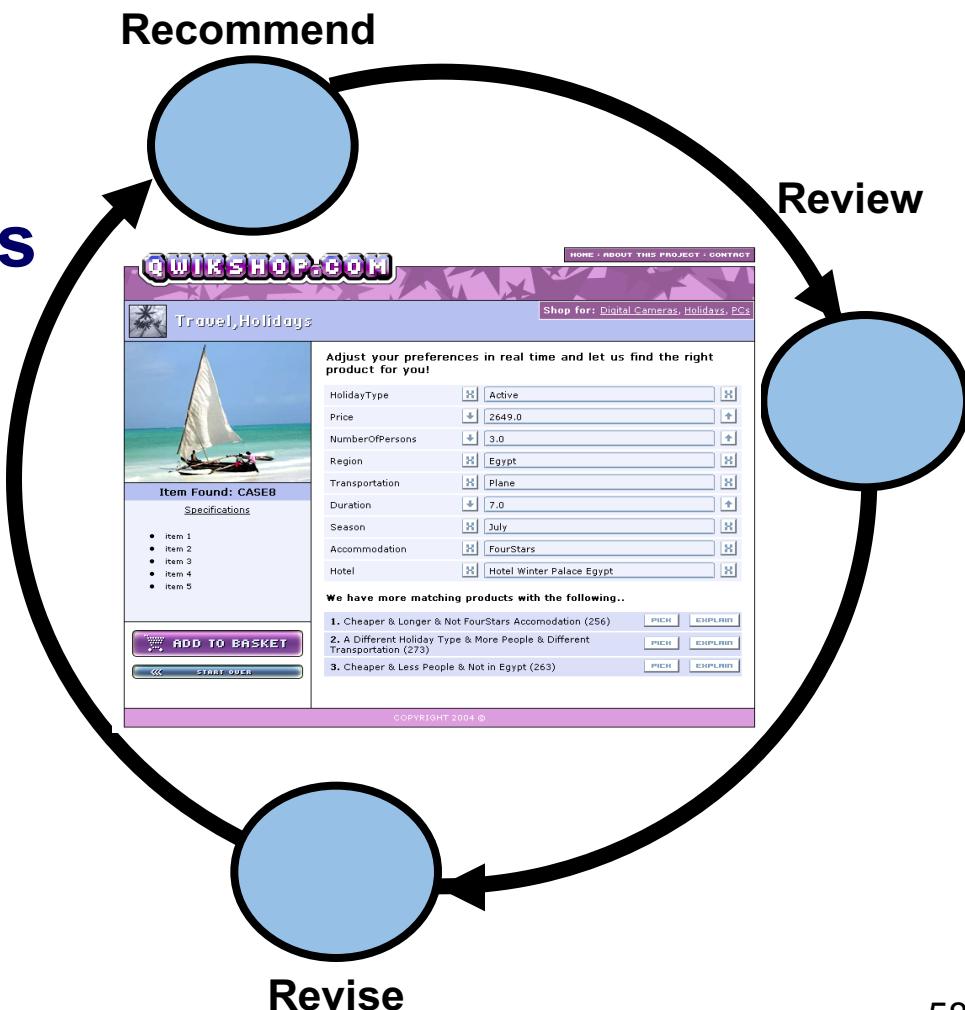


Conversational Recommender Systems

Conversational recommenders

(Jannach et al., 2020) guide the user through a complex problem space by alternatively making **suggestions** and using **user feedback** to influence future suggestions.

One way to provide **feedback** is based on **critiquing elicitation**
(Chen and Pu, 2012)



- **Items are retrieved using similarity measures**
- Distance similarity

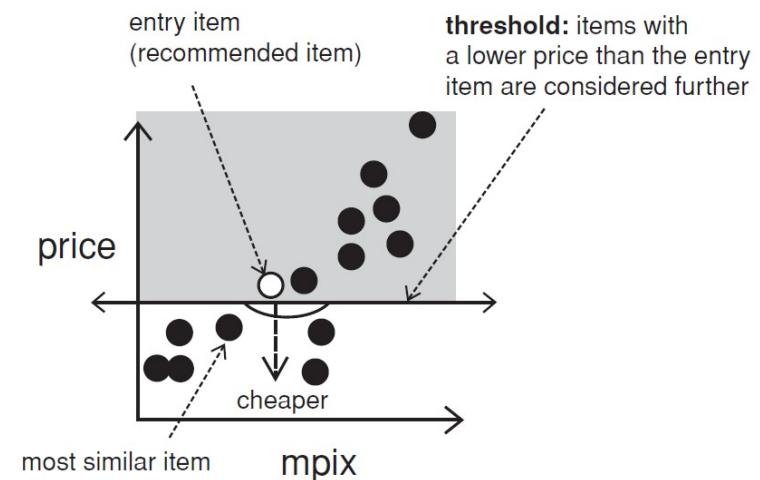
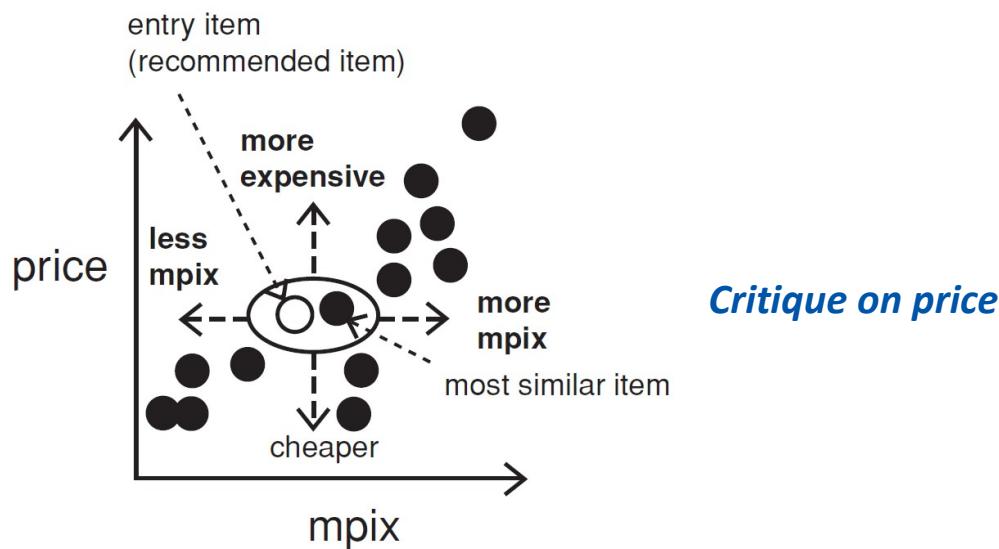
$$\text{similarity}(p, \text{REQ}) = \frac{\sum_{r \in \text{REQ}} w_r * \text{sim}(p, r)}{\sum_{r \in \text{REQ}} w_r}$$

- similarity (p, r) expresses for each item attribute value φr (p) its distance to the customer requirement $r \in \text{REQ}$.
- w_r is the importance weight for requirement r
- In real world, customer would like to:
 - maximize certain properties. i.e. resolution of a camera, "more is better" (MIB)
 - minimize certain properties. i.e. price of a camera, "less is better" (LIB)

Forms of feedback

- **Value elicitation**, approaches ask the user to provide details relating to specific features
- **Preference-based feedback and Rating-based**,
 - ask the user to indicate which product they prefer when presented with a small set of alternatives
 - to provide ratings for these alternatives
- **Critiquing or tweaking**, the user expresses a directional preference over the value-space for a particular product feature

- Customers maybe not know what they are seeking
- Critiquing is an effective way to support such navigations
- Customers specify their change requests (*price or mpix*) that are not satisfied by the current item (*entry item*)



The Critiquing Approach

- **“FindMe Systems”**
 - Robin Burke [DePaul University], Kris Hammond [Northwestern University]
 - Previously of Computer Science Department of the University of Chicago.
 - Use CBR as a way of recommending products in e-commerce catalogs and provide critique-based navigation as a primary user interface.
- **Basic Assumption**
 - User has some product requirement.
 - Requirement is sufficiently vague (user cannot simply list all of the features).
 - User provides some initial features.
 - User is helped to locate a good product by critiquing additional features from intermediate recommendations.
 - Recommendations help influence the user's elaborate their initial query.
- **Practical Applications**
 - Restaurants, cars, cameras, property etc.

An Example – “Find Me” Systems



I would like to eat at a restaurant that has:

Cuisine Price
Style Atmosphere Occasion

I would like to eat at a restaurant just like:

Chinois on Main Los Angeles

New Query Submit

Figure 1: Entry point for the Entree system

- **Entrée – A Restaurant Recommender System**
 - Users start off by indicating what kind of a restaurant they are looking for.
 - The system retrieves restaurants that are considered to be **similar** to the user's current requirements.

Retrieval and User Feedback in Entrée

Entrée Results

The Chicago restaurant you chose is:

Michael Jordan's
 500 N. LaSalle St. (Grand Ave. & Illinois St.), Chicago, 312-644-3865
 American (New) \$15-\$30
 Excellent Decor, Good Service, Good Food, Business Scene, Hip Place To Be, Private Rooms Available, Private Parties, People Keep Coming Back, Parking/Valet, Great for People Watching, See the Game, Singles Scene, Pub Feel, Weekend Brunch

We recommend:

Planet Hollywood ([map](#))
 638 N. Wells St. (Ohio St.), Chicago, 312-266-7827
 American (New) \$15-\$30
 Excellent Decor, Good Service, Good Food, Traditional, Hip Place To Be, Private Rooms Available, Private Parties, No Reservations, Place for Singles, For the Young and Young at Heart, People Keep Coming Back, Late Night Menu, After Hours Dining, Parking/Valet, Great for People Watching, See the Game, Singles Scene, Pub Feel, Weekend Brunch, Tourist Appeal

Unit Critique

→ *less \$\$* *nicer* *cuisine*
traditional *creative* *livelier* *quieter*

- **User Feedback**

- The user indicates a feature critique or tweak to constrain the value range of that feature. E.g., Show me “more like this but cheaper”

- **Unit critiquing**
 - Express preference over a single feature
 - [price, < , 1500]
- **Compound critiquing**
 - Critique operates over multiple features
 - [price, < , 1500] and [memory, >, 2]

Critique-based feedback

QWIKSHOP.COM

HOME : ABOUT THIS PROJECT : CONTACT

Digital Cameras

Shop for: Digital Cameras, Holidays, PCs

Adjust your preferences in real time and let us find the right product for you!

Manufacturer	<input checked="" type="checkbox"/> Canon	<input type="checkbox"/>
Model	<input checked="" type="checkbox"/> EOS-300D	<input type="checkbox"/>
Price (\$)	<input type="button" value="▼"/> 871.0	<input type="button" value="▲"/>
Format	<input checked="" type="checkbox"/> SLR	<input type="checkbox"/>
Resolution (M Pixels)	<input type="button" value="▼"/> 6.29	<input type="button" value="▲"/>
Optical Zoom (X)	<input type="button" value="▼"/> 10.0	<input type="checkbox"/>
Digital Zoom (X)	<input type="checkbox"/> 0.0	<input type="button" value="▲"/>
Weight (grams)	<input type="button" value="▼"/> 645.0	<input type="button" value="▲"/>
Storage Type	<input checked="" type="checkbox"/> Compact Flash	<input type="checkbox"/>
Storage Included (MB)	<input type="checkbox"/> 0.0	<input type="button" value="▲"/>

Item Found: CASE2

Specifications

6.3 Megapixel CMOS sensor
 7-point wide-area AF
 High-performance DIGIC processor
 100-1600 ISO speed range
 Compatible with all Canon EF lenses and EX Speedlites
 PictBridge, Canon Direct Print and Bubble Jet Direct compatible – no PC required

ADD TO BASKET

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Unit
Critiques

Critique-based feedback

Unit Critiques

QUIKSHOP.COM

Travel, Holidays

Shop for: Digital Cameras, Holidays, PCs

Adjust your preferences in real time and let us find the right product for you!

HolidayType	Active	X
Price	2649.0	↑ ↓
NumberOfPersons	3.0	↑ ↓
Region	Egypt	X
Transportation	Plane	X
Duration	7.0	↑ ↓
Season	July	X
Accommodation	FourStars	X
Hotel	Hotel Winter Palace Egypt	X

Item Found: CASE8

Specifications

- item 1
- item 2
- item 3
- item 4
- item 5

ADD TO BASKET

START OVER

We have more matching products with the following..

1. Cheaper & Longer & Not FourStars Accomodation (256) **PICK EXPLAIN**
2. A Different Holiday Type & More People & Different Transportation (273) **PICK EXPLAIN**
3. Cheaper & Less People & Not in Egypt (263) **PICK EXPLAIN**

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The user indicates a directional feature preference in relation to a presented recommendation

Critique-based feedback

Unit Critiques

QUIKSHOP.COM

Travel, Holidays

Shop for: Digital Cameras, Holidays, PCs

Adjust your preferences in real time and let us find the right product for you!

HolidayType	Active	▼ ▲
Price	2158.0	▼ ▲
NumberOfPersons	2.0	▼ ▲
Region	Corfu	▼ ▲
Transportation	Plane	▼ ▲
Duration	7.0	▼ ▲
Season	July	▼ ▲
Accommodation	FourStars	▼ ▲
Hotel	Hotel Regency Corfu	▼ ▲

Item Found: CASE275

Specifications

- item 1
- item 2
- item 3
- item 4
- item 5

We have more matching products with the following..

1. Different Transportation & Longer & Not FourStars Accommodation (239) **PICK EXPLAIN**
2. A Different Holiday Type & More People & Not in July (379) **PICK EXPLAIN**
3. Longer & Not in the Hotel Regency Corfu (490) **PICK EXPLAIN**

ADD TO BASKET

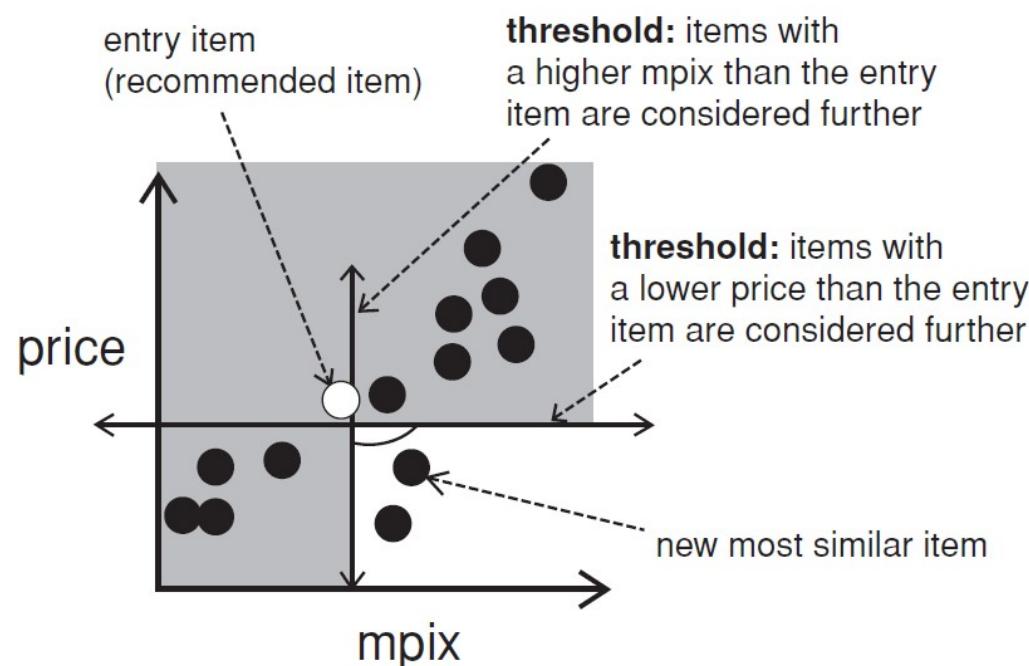
« START OVER

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The traditional implementation of critiquing can lead to protracted recommendation sessions as there is a tendency towards relatively minor changes in the values of critiqued features from cycle to cycle

Compound critiques

- Operate over multiple properties can improve the efficiency of recommendation dialogs





Dynamic Critiquing

QUIKSHOP.COM

HOME : ABOUT THIS PROJECT : CONTACT

Digital Cameras

Shop for: Digital Cameras, Holidays, PCs



Adjust your preferences in real time and let us find the right product for you!

Manufacturer	<input checked="" type="checkbox"/> Canon	<input type="checkbox"/>
Model	<input checked="" type="checkbox"/> EOS-300D	<input type="checkbox"/>
Price (\$)	<input type="button" value="↓"/> 871.0	<input type="button" value="↑"/>
Format	<input checked="" type="checkbox"/> SLR	<input type="checkbox"/>
Resolution (M Pixels)	<input type="button" value="↓"/> 6.29	<input type="button" value="↑"/>
Optical Zoom (X)	<input type="button" value="↓"/> 10.0	<input type="checkbox"/>
Digital Zoom (X)	<input type="checkbox"/> 0.0	<input type="button" value="↑"/>
Weight (grams)	<input type="button" value="↓"/> 645.0	<input type="button" value="↑"/>
Storage Type	<input checked="" type="checkbox"/> Compact Flash	<input type="checkbox"/>
Storage Included (MB)	<input type="checkbox"/> 0.0	<input type="button" value="↑"/>

Item Found: CASE2

Specifications

6.3 Megapixel CMOS sensor
7-point wide-area AF
High-performance DIGIC processor
100-1600 ISO speed range
Compatible with all Canon EF lenses and EX Speedlites
PictBridge, Canon Direct Print and Bubble Jet Direct compatible - no PC required

ADD TO BASKET

START OVER

We have more matching products with the following..

1. Less Optical Zoom & More Digital Zoom & A Different Storage Type (139)
2. A Lower Resolution & A Different Format & Cheaper (169)
3. A Different Manufacturer & Less Optical Zoom & More Storage (167)

Unit Critiques

Compound Critiques

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Explanatory Benefits

Storage Included (MB) 32.0

We have more matching products with the following..

- 1.** A Different Manufacturer & A Lower Resolution & Cheaper (67)
- 2.** A Different Format & Less Digital Zoom & Less Optical Zoom (60)
- 3.** A Different Model & Heavier & More Expensive (54)

The Compound Critique you have chosen is:
A Different Manufacturer & A Lower Resolution & Cheaper

This critique covers **67** cases in the casebase.

Explanation:

Manufacturer
- Value = Sony,
- Critique = Not Equal To Nominal ('<>')
- Range Remaining =
(Nikon, Kodak, Canon, Ricoh, Fuji, Pentax, Toshiba, Samsung, Olympus, Konica Minolta, Casio, Contax, Hewlett-Packard, Kyocera)

Resolution
- Value = 5.0
- Critique = Less Than Ordinal ('<')
- Range Remaining =
(1.9 to 4.92)

Price (\$)
- Value = 289.0,
- Critique = Greater Than Ordinal ('>')
- Range Remaining =
(292.0 to 7439.0)

 Done  Internet

Diversity Enhancement

1. A Different Manufacturer & Less Pixels & Cheaper (72)

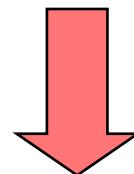
PICK

2. Less Pixels & Less Memory & Cheaper (84)

PICK

3. A Different Type of Memory & Different Software & Cheaper (80)

PICK



1. A Different Manufacturer & Less Pixels & Cheaper (72)

PICK

2. A Different Model & More Memory & More Expensive (79)

PICK

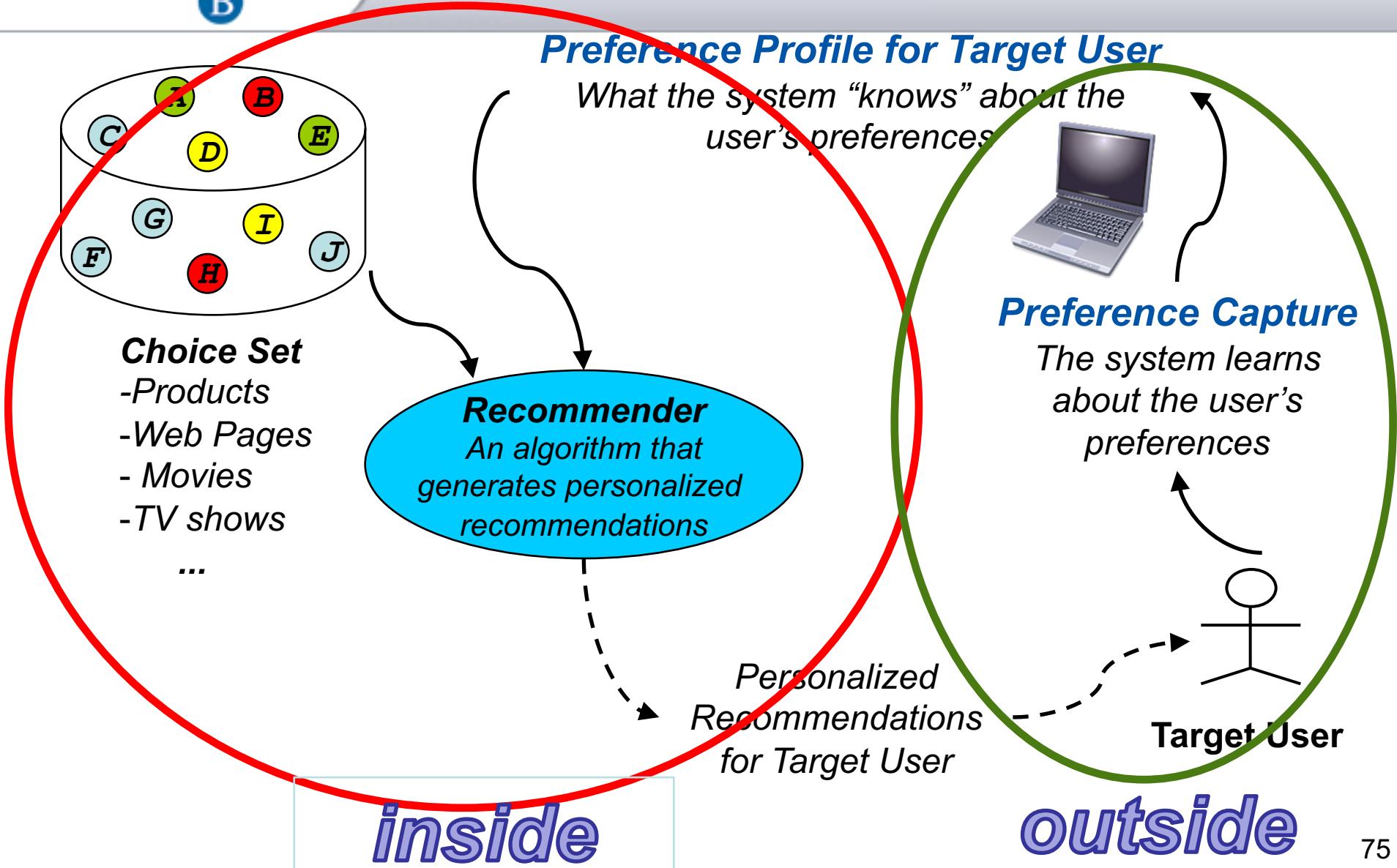
3. A Different Type of Memory & Different Cable & Less Memory (83)

PICK

- **Advantages**
 - No ratings are necessary
 - Avoid cold start problem
- **Limitations**
 - cost of knowledge acquisition
 - from domain experts
 - from users
 - from web resources
 - accuracy of preference models
 - very fine granular preference models require many interaction cycles

Outside Recommender Systems

Components of a recommender



- **Recommenders need an interface for capturing user's interactions**
- **The interface is the key component** for obtaining user's preferences and it is designed based on:
 - The type of recommender
 - The type of preferences that should be collected for the user profiles
- Common taxonomy of interfaces:
 - 2D interfaces
 - Mobile interfaces
 - 3D Interfaces



Conversational Recommender Systems

- ❑ Recommenders and its interaction to 2D (web-based) and 3D interfaces (Virtual Worlds)
- ❑ Recommenders and natural language interaction with assistants
- ❑ Single Recommenders
- ❑ Group Recommenders



Outside Conversational Recommender Systems

1. 3D Virtual Worlds
2. Cognitive Assistants
3. gCoach: Collaborative Group Recommender

3D Virtual Worlds and Recommenders

- Contreras, D., Salamó, M., Rodríguez, I., Puig, A. ***Shopping Decisions Made in a Virtual World: Defining a State-Based Model of Collaborative and Conversational User-Recommender Interactions***, Journal IEEE Consumer Electronics Magazine, 7(4), pp. 26-35 (2018), [doi: 10.1109/MCE.2017.2728819](https://doi.org/10.1109/MCE.2017.2728819)
- Contreras, D., Salamó, M., Rodríguez, I., Puig, A. ***A 3D Visual Interface for Critiquing-based Recommenders: Architecture and Interaction***. Journal IJIMAI 3 (3): pp. 7-15 (2015)



Goal in 3D Virtual Conv. Rec

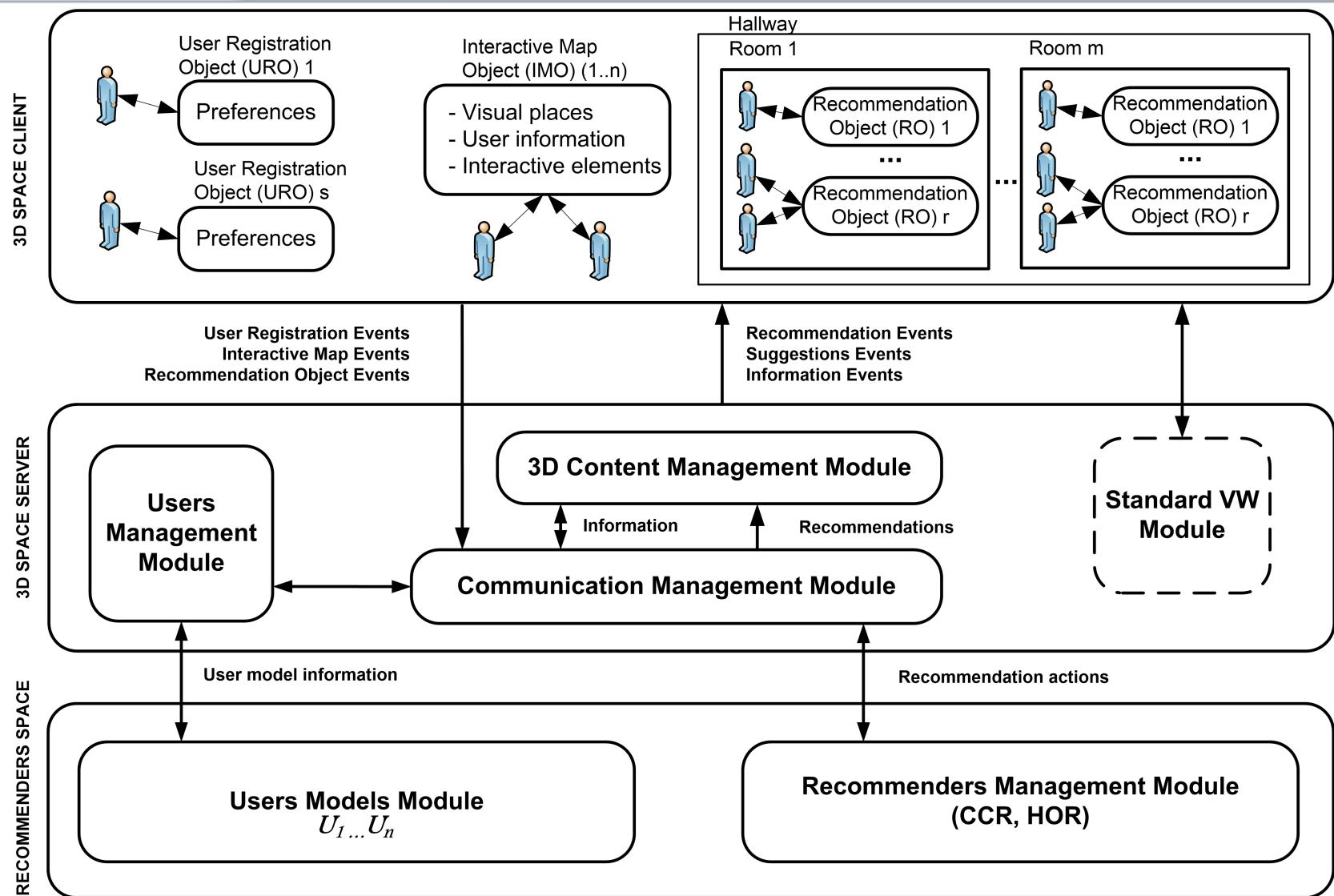


Design a SCALABLE framework to enhance and facilitate user buying experience in a large 3D eCommerce space



(OPTIONAL) <https://youtu.be/jX91kSnmQn8>

Framework 3D VW and Conv. Rec



User Registration Object (URO)

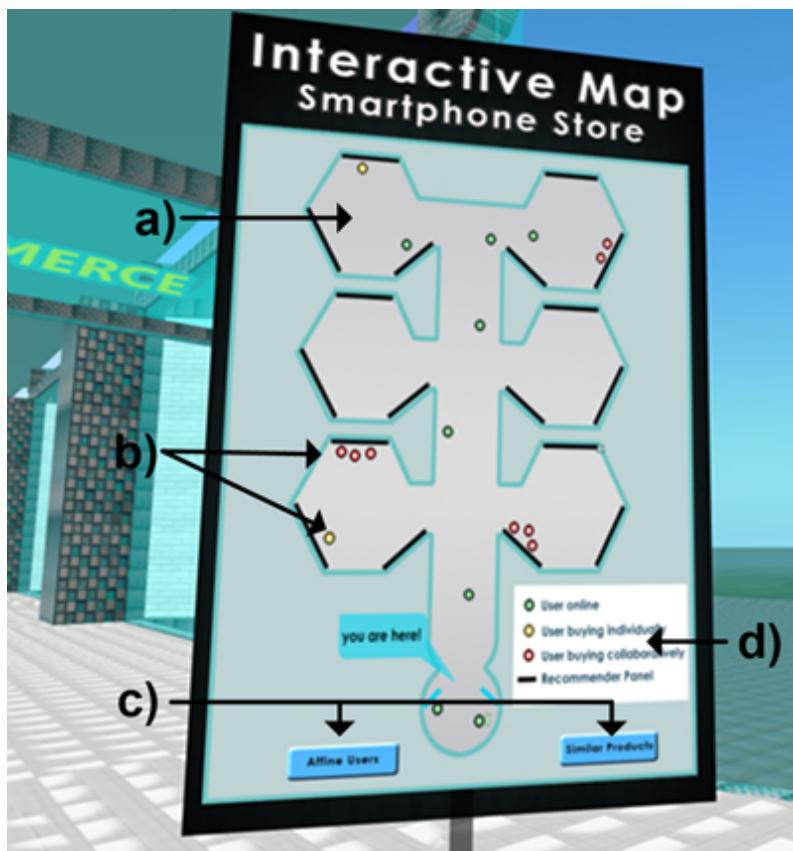


- URO allows users register their initial preferences when they arrive to 3D eCommerce Space.
- Later, the system provides the users with recommendations based on these preferences.
- It complements the conversational recommendation process.

In the figure are shown the following preferences:

- mobile phone operating system and price, in the Smartphone domain

Interactive Map Object (IMO)



The user can:

- a) See all rooms in the eCommerce space,
- b) Know which other users are interacting with Recommendation Objects (RO).
- c) Ask for suggestions about rooms where they should go to find the users or products that matches their preferences.

Recommendation Object (RO)

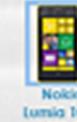


Manufacturer	Sony	 3 GB RAM
Model	Xperia Z2	 2.3 GHz Qualcomm
		 2.3 GHz Qualcomm
 \$599.00		 20.7 MP
Description		 Android 4.4
Manufacturer: Sony Model: Xperia Z2 O.S.: Android 4.4	 163 g	 Android 4.4
	 5.2"	 1/2.3" sensor size touch focus

Based on User Preferences and History recommendations

Suggestions

Are you interested in?



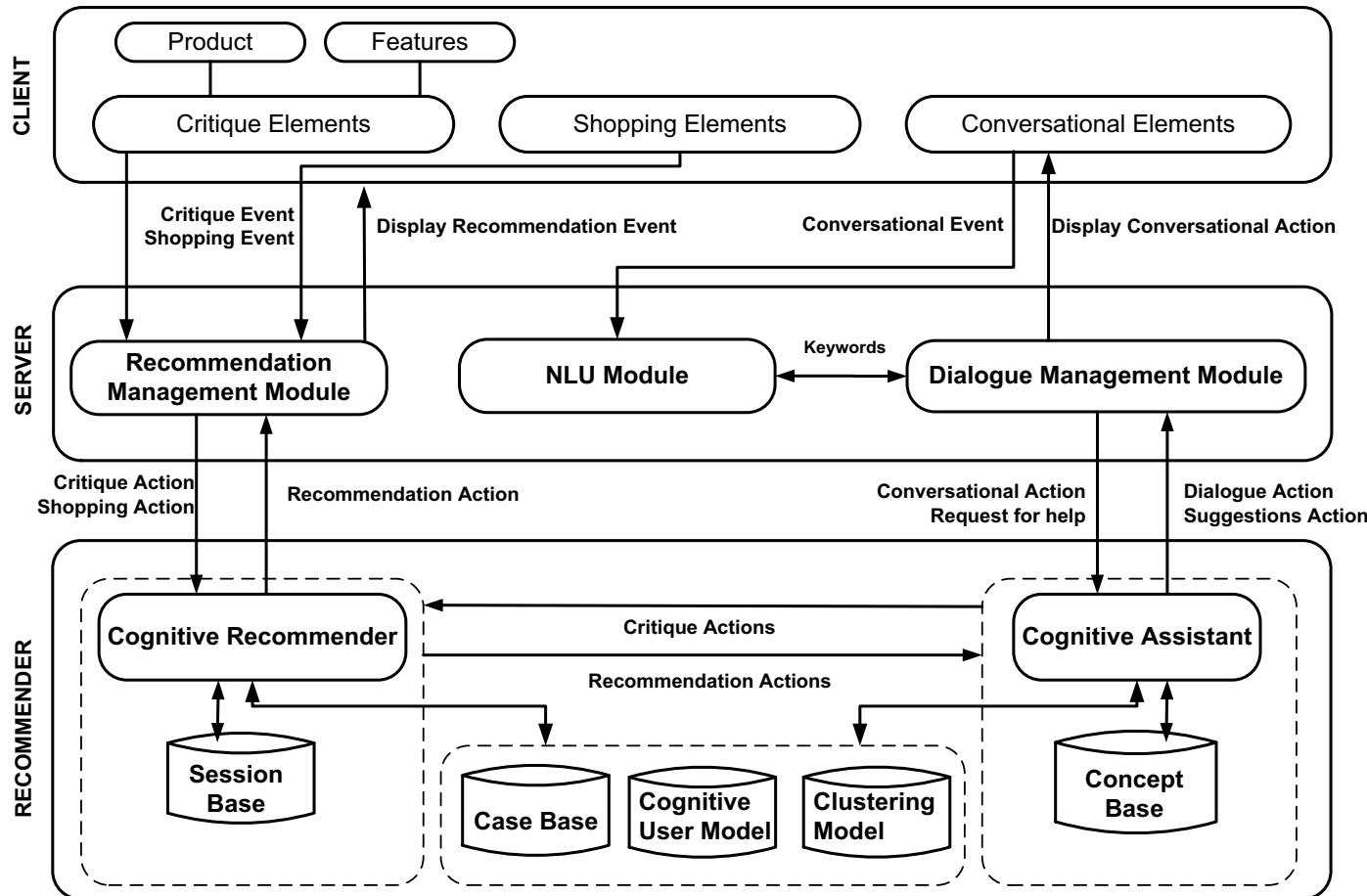
Like you collaborate?



Cognitive Assistant

Güell, M., Salamó, M., Contreras, D., Boratto, L. **Integrating a cognitive assistant within a critique-based recommender system.** Journal Cognitive Systems Research, Volume 64, pp. 1-14, (2020), <https://doi.org/10.1016/j.cogsys.2020.07.003>

Conceptual Architecture





User Interface

Recomendación / Recommendation

Objetivo / Target

Manufacturer: HTC
Model: DROIDIncredible2
Weight: 135.00 gr
Size: 4.00 "
Storage: 1.10 Mb
Ram: 768.00 Mb
CAM: 8.00 Mpixels
O.S.: Android OS, v2.2 (Froyo), upgradable to v4.0 (Ice Cream Sandwich)
CPU: 1 GHz Scorpion
Price: 220.00 euro

Manufacturer	Model	Weight	Size
Huawei	AscendY300	130.00 gr	4.00 "
- +			

Storage	Ram	CAM	O.S.
4.00 Mb	512.00 Mb	5.00 Mpixels	Android OS, v4.1 (Jelly Bean)
- +			

CPU	Price
Dual-core 1 GHz Cortex-A5	90.00 euro
- +	- +

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<div style="position: absolute;

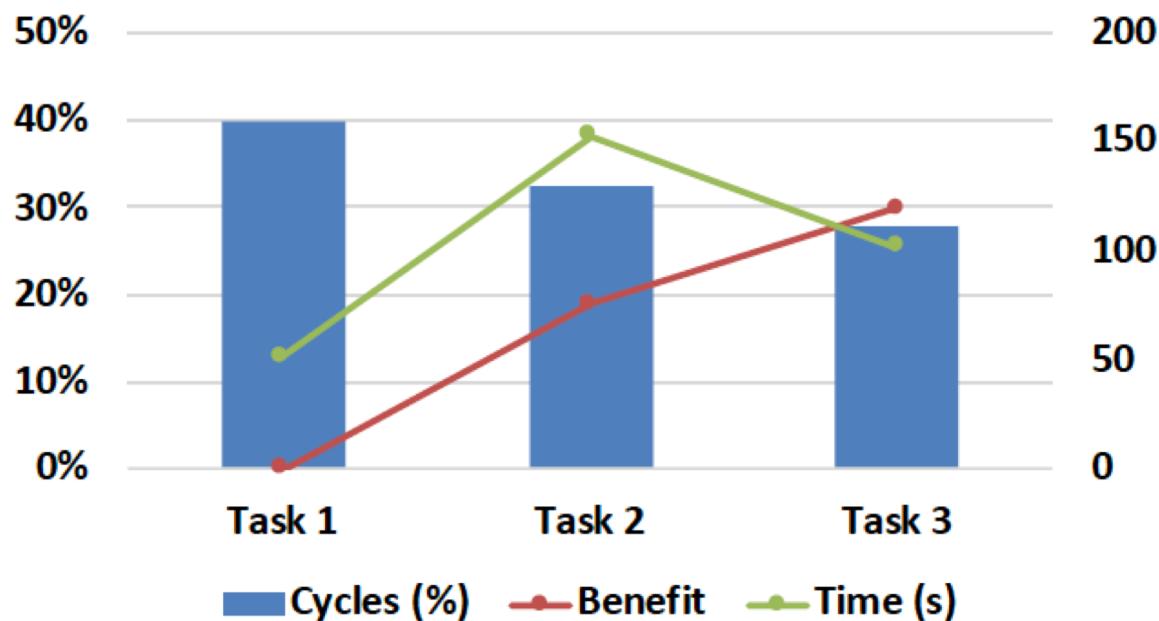
Results: Efficiency

Task 1. Only buttons

Task 2. Only the assistant

Task 3. Both buttons and assistant

Between subject test
40 users



Smartphone dataset



TO READ:

An Introduction to Recommender Systems

Aggarwal, C.C.

Sections 1.1, 1.2, 1.3

Sections 1.4, 1.5, 1.6 and 1.7 are optional



Look at the video (OPTIONAL)

Recommender Systems: Beyond Machine Learning
Joseph A. Konstan

<https://youtu.be/uupJmZG5xxA>

From minute 5:30 to the end

Week 11

Course. Introduction to Machine Learning **Theory 11. Recommender Systems**

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