Recommender Systems

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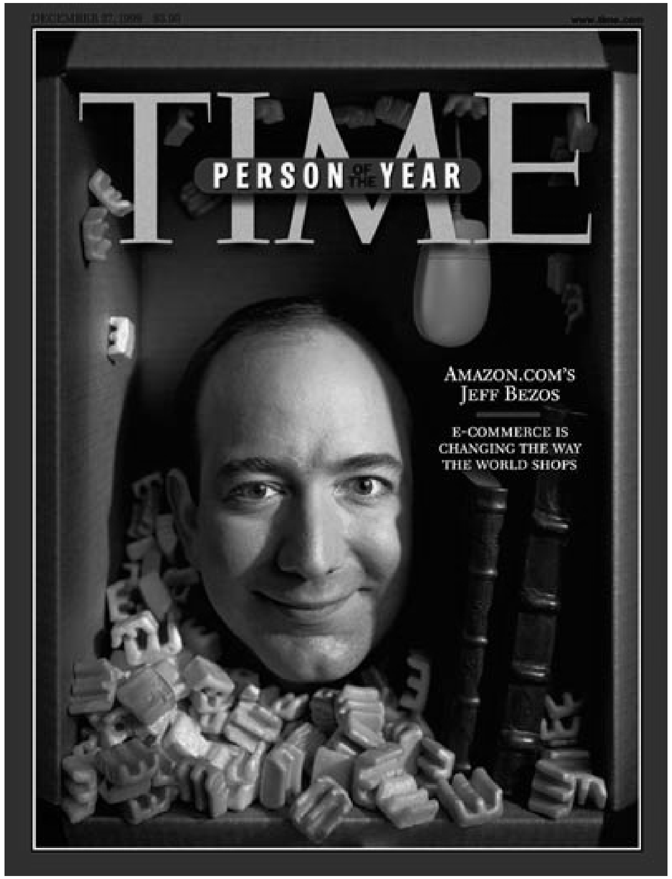
Content

- Example of Recommender System
- The basic idea of collaborative-based filtering
- Collaborative-based filtering: technical details
- Content-based filtering
- Knowledge-based recommender systems
- Evaluating recommender systems
- Challenges

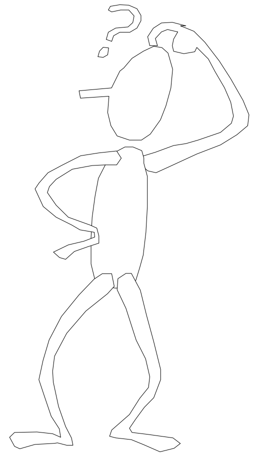
Jeff Bezos

- *“If I have 3 million customers on the Web, I should have 3 million stores on the Web”*
  - Jeff Bezos, CEO of Amazon.com
  - Degree in Computer Science
  - $4.3 billion, ranked no. 147 in the Forbes list of the World's Wealthiest People



[Person of the Year-1999]

What movie should I see?



The Internet Movie Database (IMDb) provides information about actors, films, television shows, television stars, video games and production crew personnel.
Owned by Amazon.com since 1998, as of June 21, 2006 IMDb featured 796,328 titles and 2,127,371 people.

Movie Lens

http://movielens.umn.edu

Movielens Approach

- You rate/ evaluate some movies on a 1 (“Awful”) to 5 (“Must to see”) scale
  - The system stores your ratings and build your user model
- You ask for recommendations, i.e., movies that you would like and you have not seen yet
  - The system exploits your user model and the user model of other “similar” users to compute some predictions, i.e., it guess what will be your rating for some movies and displays those movies having higher predicted ratings
- You browse the list of recommendations and eventually decide to watch one of these recommended movies.

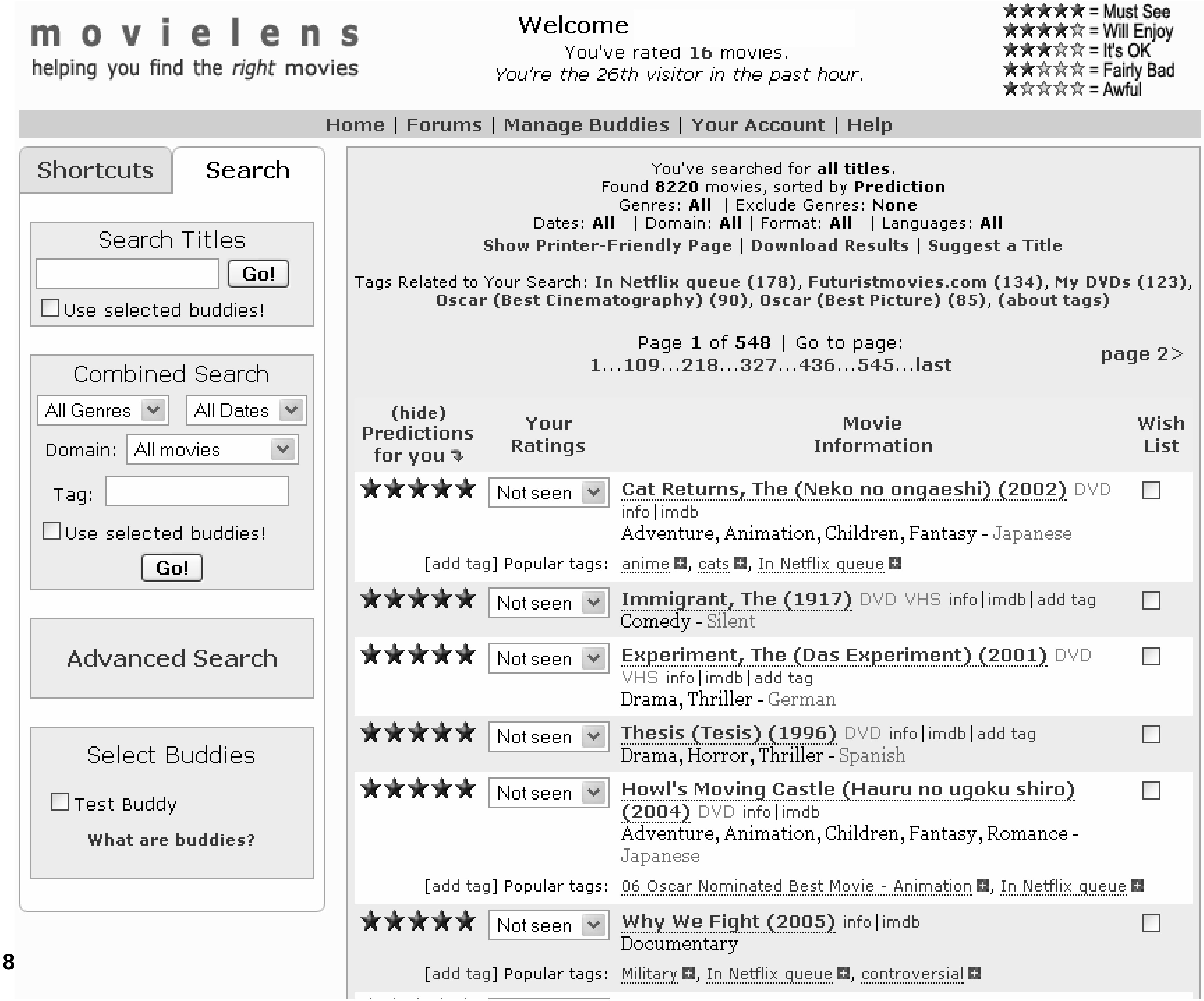
So far you have rated **0** movies.
MovieLens needs at least **15** ratings from you to generate predictions for you.
Please rate as many movies as you can from the list below.

next >

	Your Rating	Movie Information
★★★	3.0 stars	**Austin Powers: International Man of Mystery (1997)** Action, Adventure, Comedy
★★★★	4.0 stars	**Contact (1997)** Drama, Sci-Fi
???	Not seen	**Crouching Tiger, Hidden Dragon (Wu Hu Zang Long) (2000)** Action, Adventure, Drama, Fantasy, Romance
???	Not seen	**Demolition Man (1993)** Action, Comedy, Sci-Fi
???	Not seen	**Eraser (1996)** Action, Drama, Thriller
???	Not seen	**Maverick (1994)** Action, Comedy, Western
★★★★½	4.5 stars	**Philadelphia (1993)** Drama
★★★½	3.5 stars	**Piano, The (1993)** Drama, Romance
???	Not seen	**Toy Story 2 (1999)** Adventure, Animation, Children, Comedy, Fantasy
★★★½	3.5 stars	**X-Men (2000)** Action, Adventure, Sci-Fi

next >

To get a new set of movies click the **next>** link.


m o v i e l e n s
helping you find the right movies
Welcome
You've rated 16 movies.
You're the 26th visitor in the past hour.
★★★★★ = Must See
★★★★☆ = Will Enjoy
★★★☆☆ = It's OK
★★☆☆☆ = Fairly Bad
★☆☆☆☆ = Awful
Home | Forums | Manage Buddies | Your Account | Help
Shortcuts
Search
Search Titles
Go!
Use selected buddies!
Combined Search
All Genres
All Dates
Domain: All movies
Tag:
Use selected buddies!
Go!
Advanced Search
Select Buddies
Test Buddy
What are buddies?
You've searched for all titles.
Found 8220 movies, sorted by Prediction
Genres: All | Exclude Genres: None
Dates: All | Domain: All | Format: All | Languages: All
Show Printer-Friendly Page | Download Results | Suggest a Title
Tags Related to Your Search: In Netflix queue (178), Futuristmovies.com (134), My DVDs (123), Oscar (Best Cinematography) (90), Oscar (Best Picture) (85), (about tags)
Page 1 of 548 | Go to page:
1...109...218...327...436...545...last
page 2>
(hide) Predictions for you
Your Ratings
Movie Information
Wish List
Not seen
Cat Returns, The (Neko no ongaeshi) (2002) DVD info | imdb
Adventure, Animation, Children, Fantasy - Japanese
[add tag] Popular tags: anime, cats, In Netflix queue
Not seen
Immigrant, The (1917) DVD VHS info | imdb | add tag
Comedy - Silent
Not seen
Experiment, The (Das Experiment) (2001) DVD VHS info | imdb | add tag
Drama, Thriller - German
Not seen
Thesis (Tesis) (1996) DVD info | imdb | add tag
Drama, Horror, Thriller - Spanish
Not seen
Howl's Moving Castle (Hauru no ugoku shiro) (2004) DVD info | imdb
Adventure, Animation, Children, Fantasy, Romance - Japanese
[add tag] Popular tags: 06 Oscar Nominated Best Movie - Animation, In Netflix queue
Not seen
Why We Fight (2005) info | imdb
Documentary
[add tag] Popular tags: Military, In Netflix queue, controversial


m o v i e l e n s
helping you find the right movies
Welcome
You've rated 32 movies.
You're the 26th visitor in the past hour.
★★★★★ = Must See
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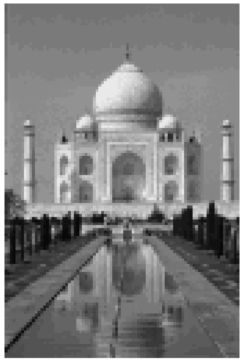
★★☆☆☆ = Fairly Bad
★☆☆☆☆ = Awful
Home | Forums | Manage Buddies | Your Account | Help
Shortcuts
Search
- Top Picks For You
- Your Ratings
- Your Wishlist
- Newest Additions
- Rate Random Movies
- Most Often Rated
- Your Tags
- Suggest Title
- About Your Ratings
- New Drama
V for Vendetta (2006)
Inside Man (2006)
Match Point (2005)
- New DVDs
Capote (2005)
Walk the Line (2005)
Good Night, and Good...
- New Movies
V for Vendetta (2006)
Why We Fight (2005)
Inside Man (2006)
How to create shortcuts
Publish your shortcuts
V for Vendetta (2006)
Your Prediction:
Rate This Movie:
Not seen
Wish List:
Movie Information
Starring: Natalie Portman, Hugo Weaving, Stephen Rea, John Hurt
Directed by: James McTeigue
Genres: Action, Drama, Sci-Fi, Thriller
Language: English
Average rating: (4 stars)
Rated by: 128 users
Links: IMDb, Rotten Tomatoes
Movie Tags (more about tags)
Add and edit tags here
My Tags [edit]
- none
[add new tags]
Popular tags:
Click on this icon ( ) to add a tag to your list!
comic book (2)
revenge (1)
Alan Moore (1)
john hurt (1)
1984 (1)
guy fawkes (1)
Futuristmovies.com (1)
revolutionary (1)
disacknowledged (1)
Forum Posts
These posts mention V for Vendetta (2006)
Write about V for Vendetta (2006) in the MovieLens Forums!
Related Forum Posts
These posts mention movies similar to V for Vendetta (2006)
Topic
Author
Re: Fitting into movie groups
(shitdisturber)
Re: What's the last thing you watched an...
(PolarisDiB)
Re: Fitting into movie groups
(FarmerF)
Re: Fitting into movie groups
(Bec1029)
Re: Ask Dr. Vigilans
(Vigilans)
Ask Dr. Vigilans
(PolarisDiB)
Re: Fitting into movie groups
(Ryuukuro)
Re: What's the last thing you watched an...
(vargus)

What travel should I do ?

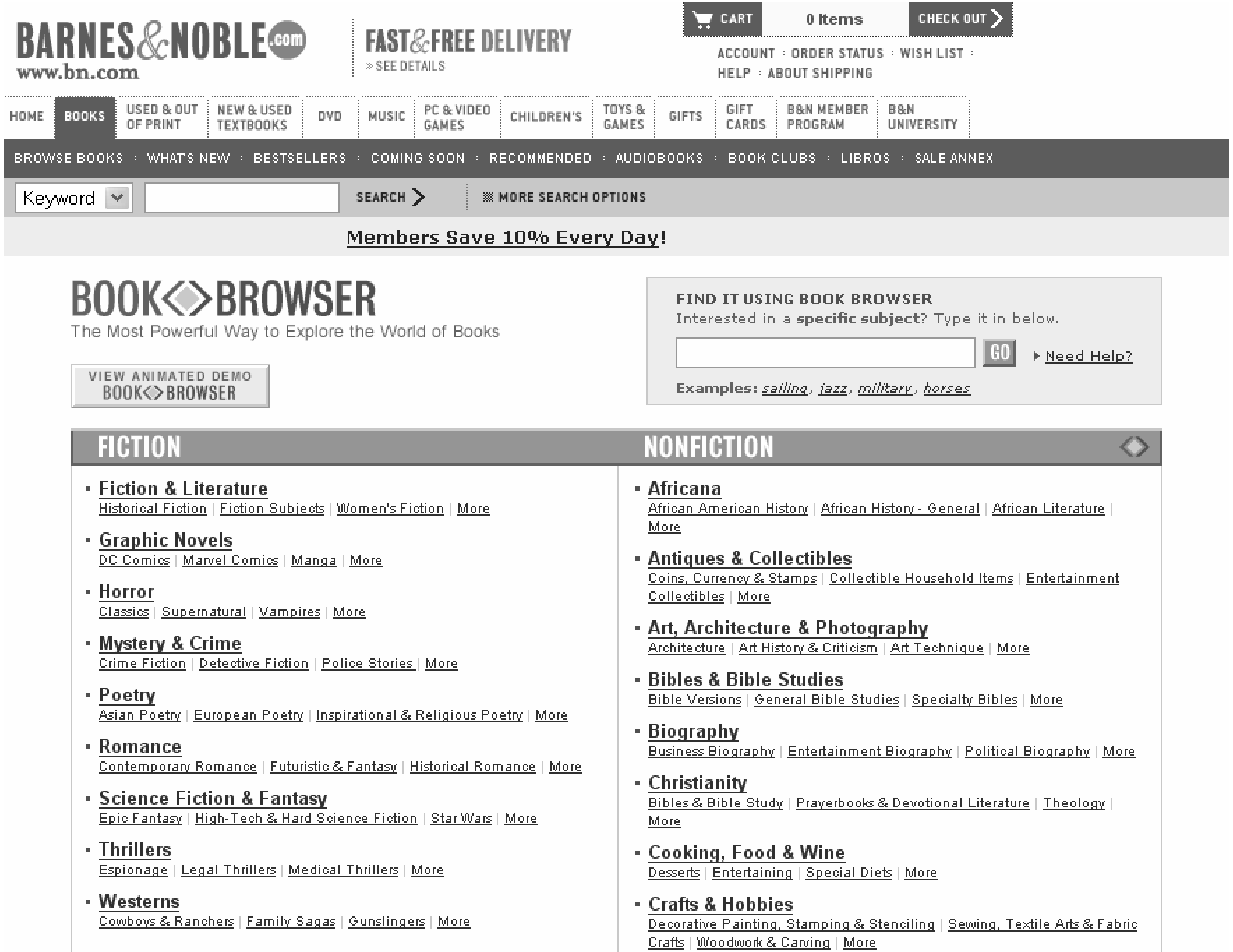
- I would like to escape from this ugly an tedious work life and relax for two weeks in a sunny place. I am fed up with these crowded and noisy places … just the sand and the sea … and some “adventure”.

- I would like to bring my wife and my children on a holiday … it should not be to expensive. I prefer mountainous places… not to 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.

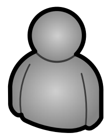
What book should I buy?



Example: Book recommendation

Ephemeral

- I'm taking two weeks off
- Novel
- I'm interested in a Polish writer
- Should be a travel book
- I'd like to reflect on the meaning of life



Long Term

- Dostoievsky
- Stendhal
- Checov
- Musil
- Pessoa
- Sedaris
- Auster
- Mann

Recommendation

Joseph Conrad, Hearth of darkness

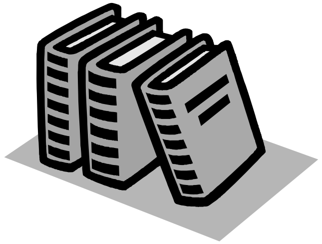
What news should I read?

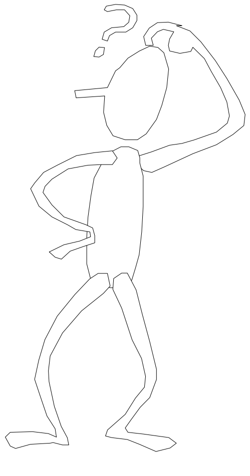
Examples

- Some examples found in the Web:

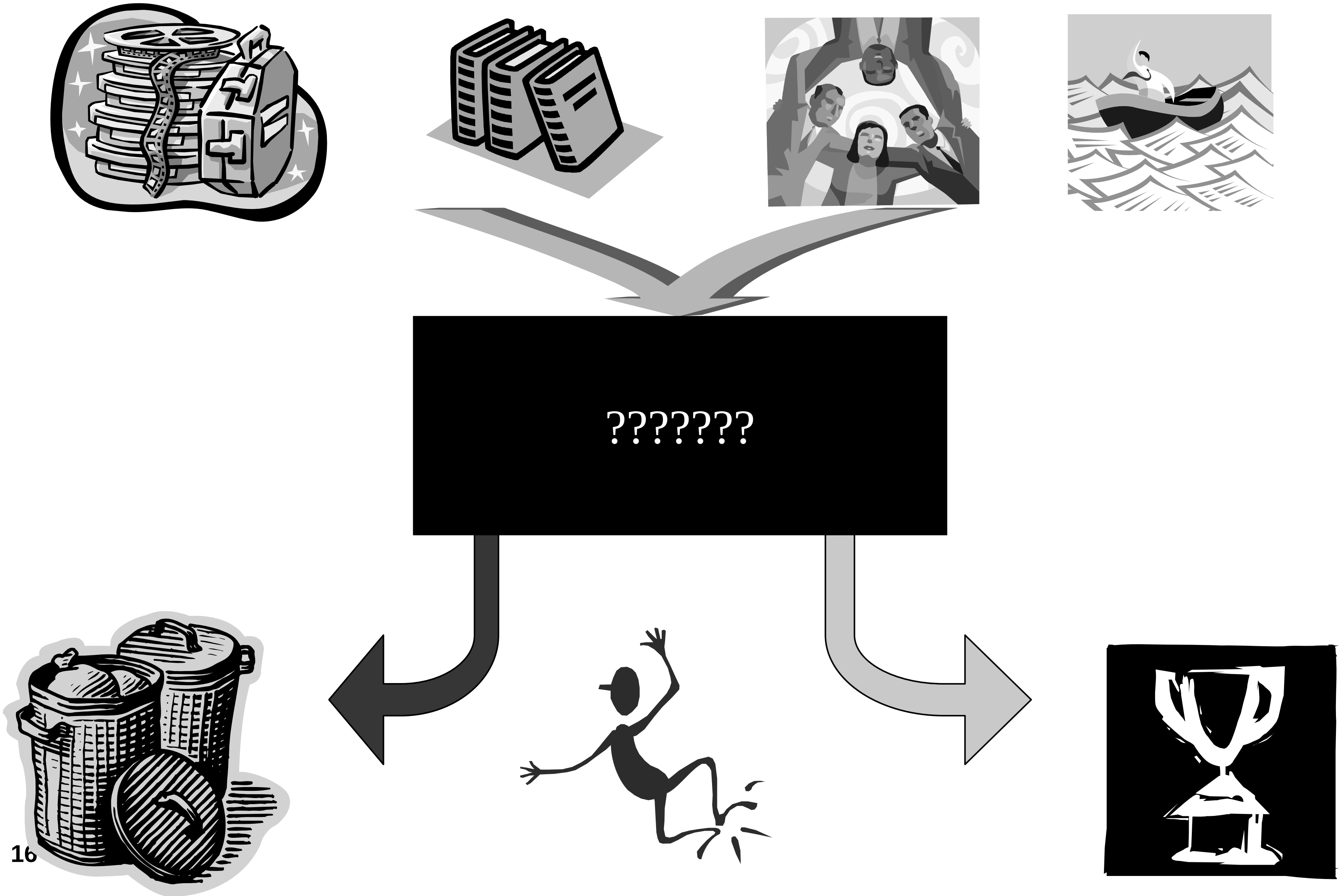
1. **Amazon.com** – looks in the user past buying history, and recommends product bought by a user with similar buying behavior
2. **Tripadvisor.com** - Quoting product reviews of a community of users
3. **Activebuyersguide.com** – make questions about searched benefits to reduce the number of candidate products
4. **Trip.com** – make questions and exploits to constraint the search (exploit standardized profiles)
5. **Smarter Kids** – self selection of a user profile – classification of products in user profiles.

The Problem





A Solution

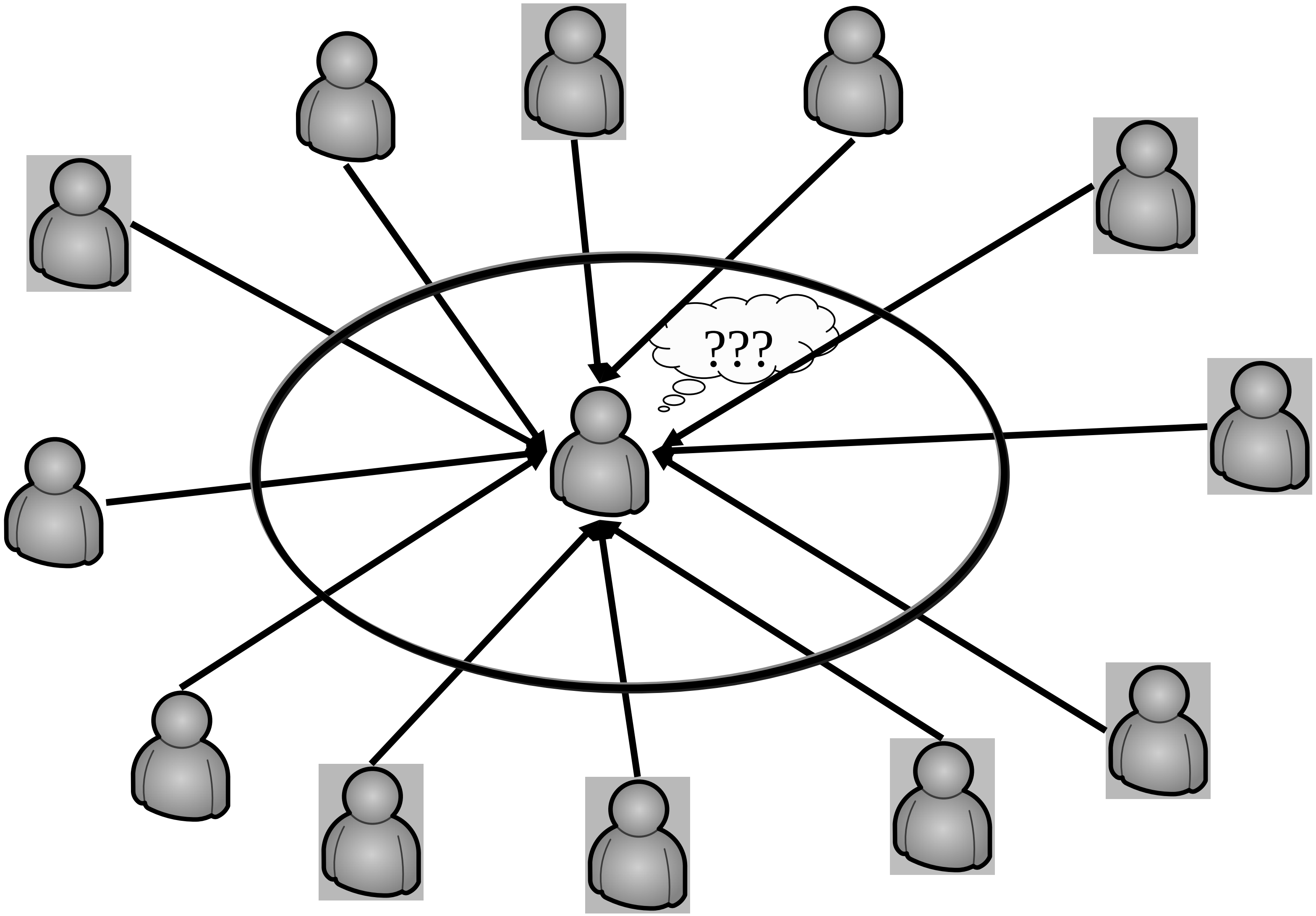


Original Definition of RS

- *In everyday life we rely on recommendations from other people either by word of mouth, recommendation letters, movie and book reviews printed in newspapers ...*
- In a typical recommender system people provide recommendations as inputs, which the system then aggregates and directs to appropriate recipients
  - Aggregation of recommendations
  - Match the recommendations with those searching for recommendations

[Resnick and Varian, 1997]

Social Filtering



Recommender Systems

- 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: search engines
  - machine learning: classification learning
  - adaptive and personalized system: adaptive hypermedia
  - user modeling

Information Overload

- **Internet = information overload**, i.e., the state of having too much information to make a decision or remain informed about a topic:
  - Too much mails, too much news, to much papers, …
- Information retrieval technologies (a search engine like Google) 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 task, 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 may not be able to choose.

Ratings

Traveler Reviews (1-1 of 1)

Language: English first **Sort by:** Date: Newest first

Traveler reviews (1-1 of 1)

Traveler rating: ○○○○○

Bolzano: Hotel Gasthof Gruner Baum Glurns/Glorenza: "A complete find....one of the loveliest places to stay"

Oct 15, 2006 *gascony*, london

Gasthof Gruner Baum in the Southern Tyrol is a truly wonderful little hotel. The hotel is in the town square of Glurns (Glorenza depending on your choice of the german or italian version!). The old hotel has been completely refurbished by the local owner/manager and is a fantastic marriage of traditional and modern funky.....it's a really beautiful place. The value of your overnight accomodation is really quite tremendous --- a lovely room, dinner (3-5 courses!) and breakfast for under £50 per person...

i would prefer not to recommend this hotel for fear of not being able to get a reservation myself next time but the owners deserve to have the recommendation.

This TripAdvisor Member:
Liked: the location and the food!
Disliked: the bar lacked a bit of atmosphere but that might have been due to time of the year

My experience with this property took place in: September, 2006

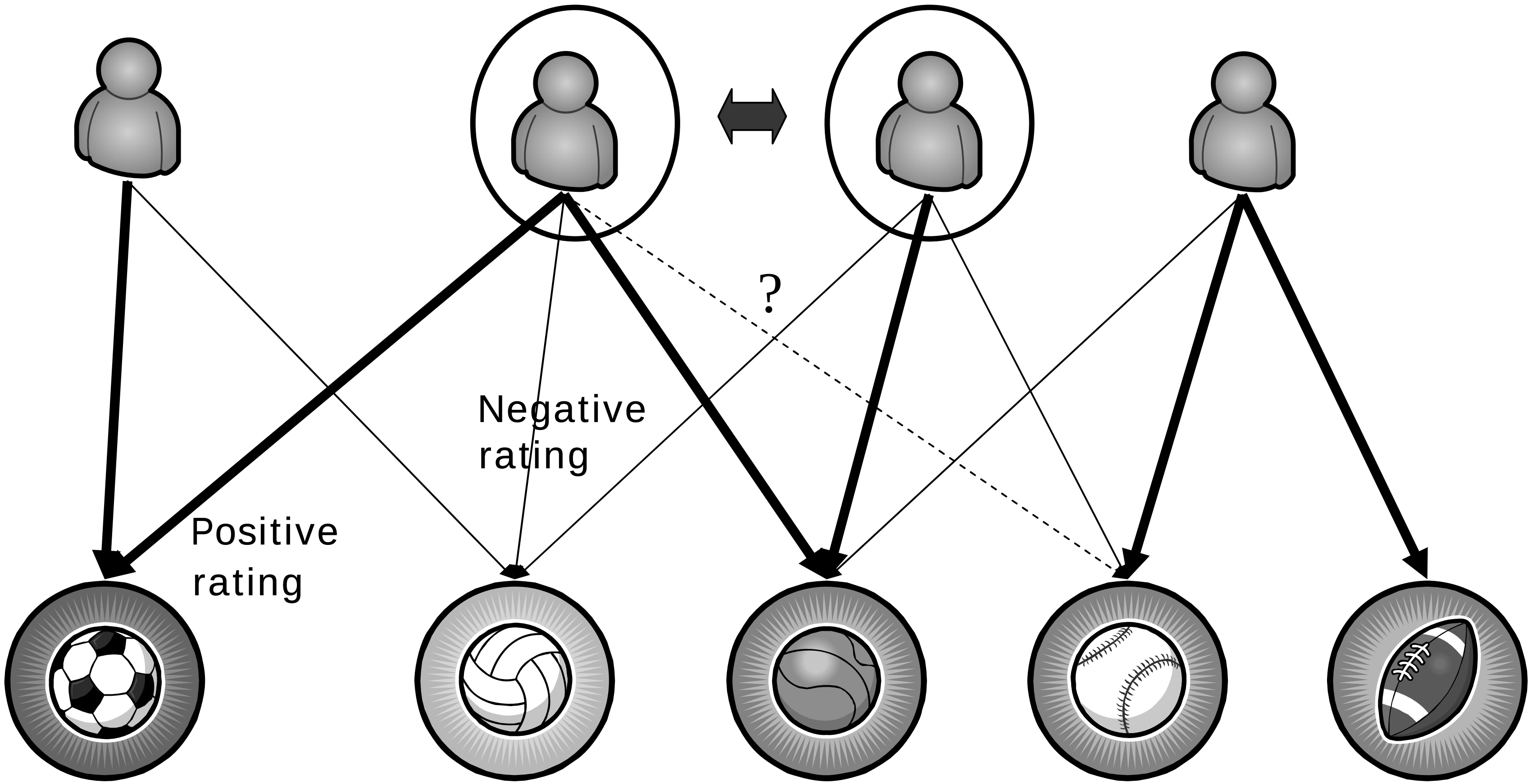
Would I recommend this hotel to my best friend? absolutely!

My ratings for this hotel are:

○○○○○ Value
○○○○○ Rooms
○○○○○ Location
○○○○○ Cleanliness
○○○○○ Check in / front desk
○○○○○ Service

I recommend this hotel for: Young singles, An amazing honeymoon, A romantic getaway, Older travelers, Families with young children, Tourists

Collaborative Filtering

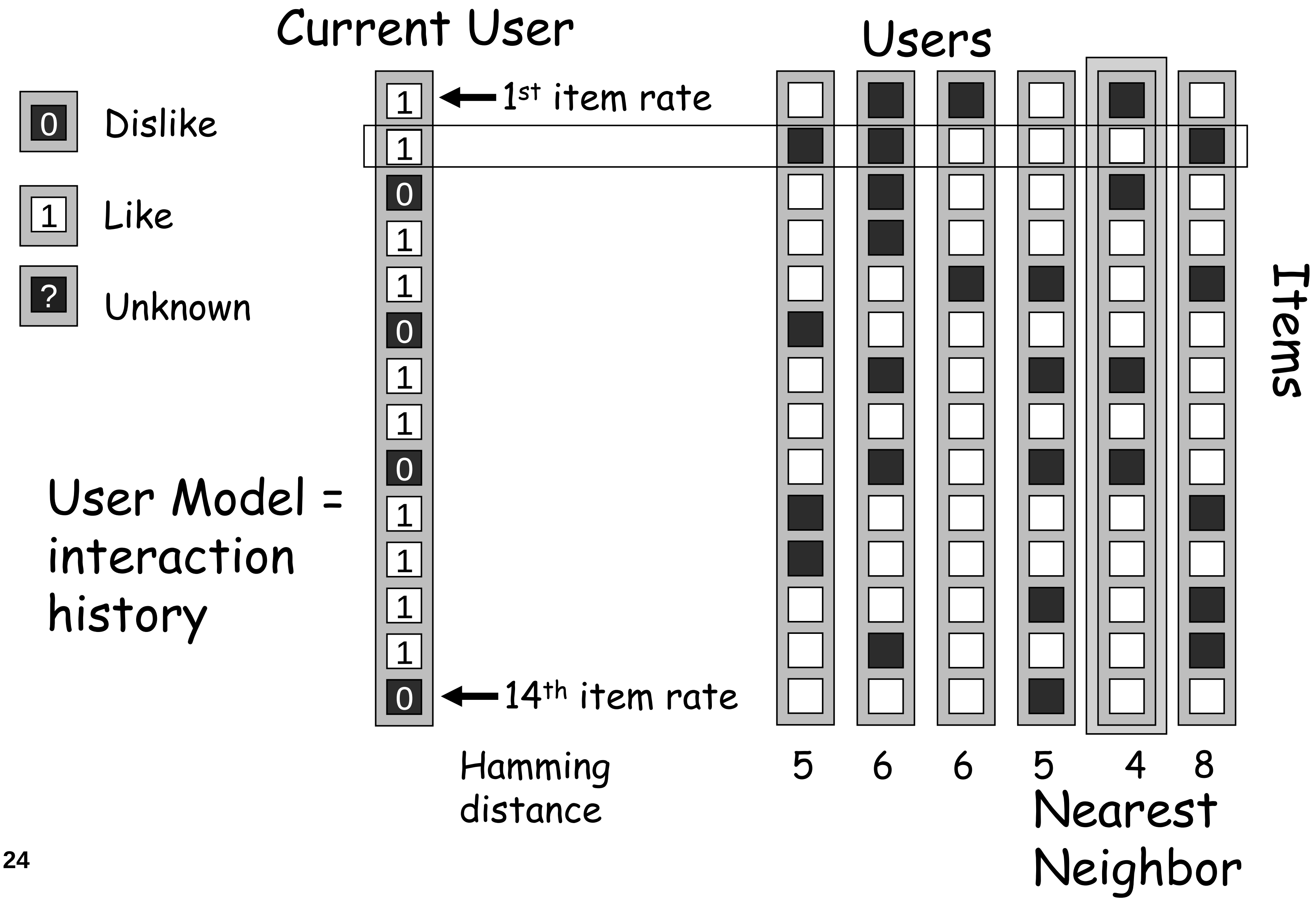


Collaborative-Based Filtering

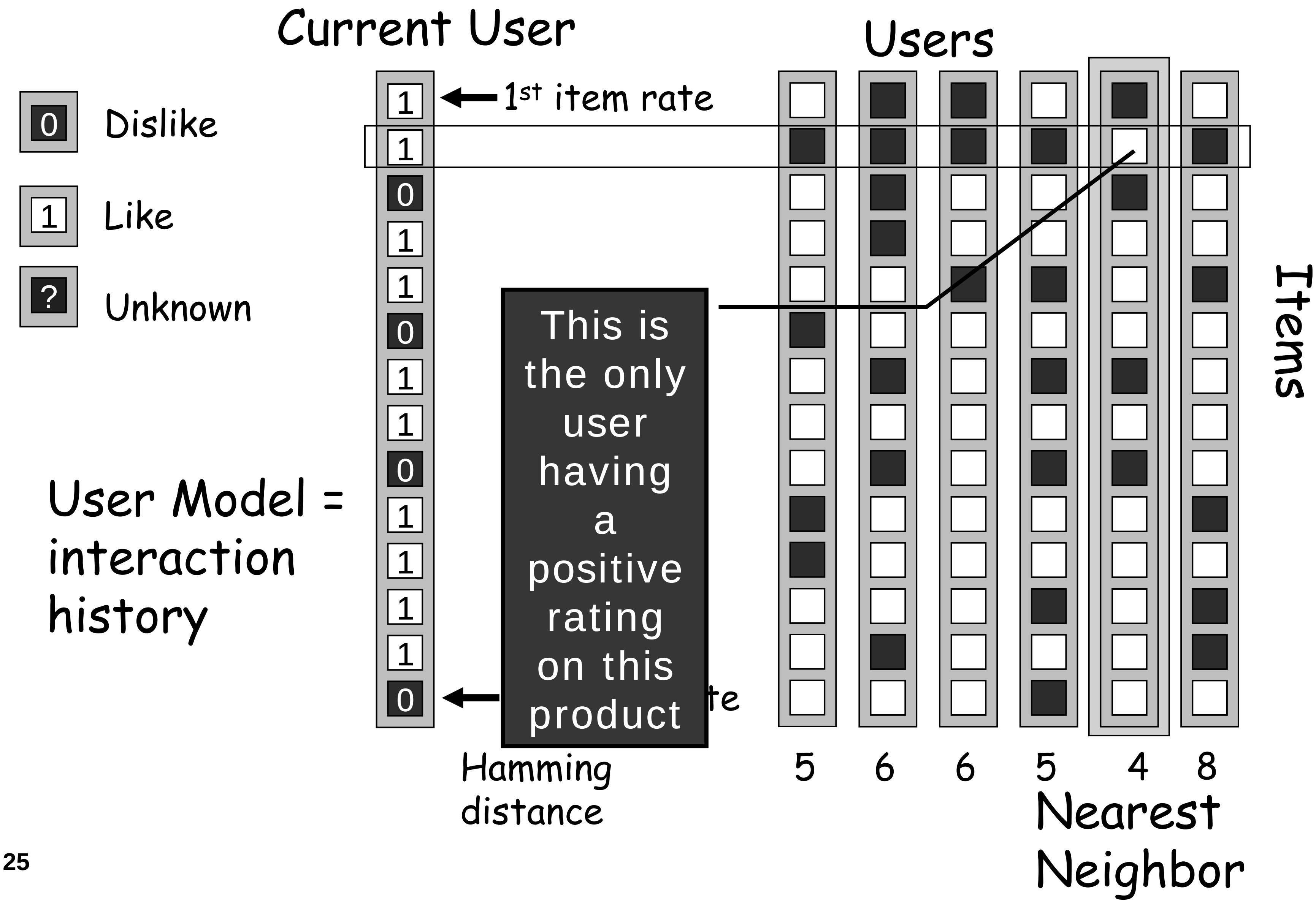
- The collaborative based filtering recommendation techniques proceeds in these steps:

  1. For a target/active user (the user to whom a recommendation has to be produced) the set of his ratings is identified
  2. The users more similar to the target/active user (according to a similarity function) are identified (neighbor formation)
  3. The products bought by these similar users are identified
  4. For each one of these products a prediction - of the rating that would be given by the target user to the product - is generated
  5. Based on this predicted rating a set of top N products are recommended.

Nearest Neighbor Collaborative-Based Filtering



1-Nearest Neighbor can be easily wrong



Matrix of ratings

Items

Users

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
a			1		4	5			4		3					2			4		2				
b			4							3							5	1		3					
c		5		4			4						3		5					4		5			
d								3				5				3			4		2			3	
e		3					5			4	5				5					1			5	4	
f			4				1		3	5		4	1		5	4	4		4				3		
g	2	4				4		2			5		1	4	5		4	2	4		5			4	
h			2		1		4		3	5		4	2		5	4	5						5		
i		1					3			5				5		4	4		5			4		3	
j			4			4				5			1		5		4		4				4		
k		5				4			2		5		1	5		4		2		4				2	
l					3			3				4	1		4		4	2	4					3	
m	5		3					5	3		5	4		5	5	3			4	4	5	4		4	
n			1		4	5				4	5		1	5		4		3		4		4	3		
o			4			4				5		4		5			4	2		5		5		3	
p				4			5								5	4		2	4	4	5	4		2	
q					3			3					1	5		4	4		4			4		3	
r		4			1	4		2					2		5		4				5	4		4	
s			2		4		4			5			1			4		2	4		4		5		
t		1		4			3					4		5	5		4			4				3	
u			2		1		4		3				1		5	4		2	4		5	4			
v					4	5				4	3		5			2					2			5	
w				2			2		3			5			4	5		4	2		3	4			
x	4			5				3		3				4	5					1					
y			1			3				2	3						3	3		5		4			

Collaborative-Based Filtering

- A collection of user u_i, $i=1, \ldots n$ and a collection of products p_j, $j=1, \ldots, m$
- A $n \times m$ matrix of ratings v_{ij} , with $v_{ij} = ?$ if user i did not rate product j
- Prediction for user i and product j is computed as:

$$v^*_{ij} = v_i + K \sum_{v_{kj} \neq ?} u_{ik} (v_{kj} - v_k)$$

- Where, v_i is the average rating of user i, K is a normalization factor such that the sum of u_{ik} is 1, and

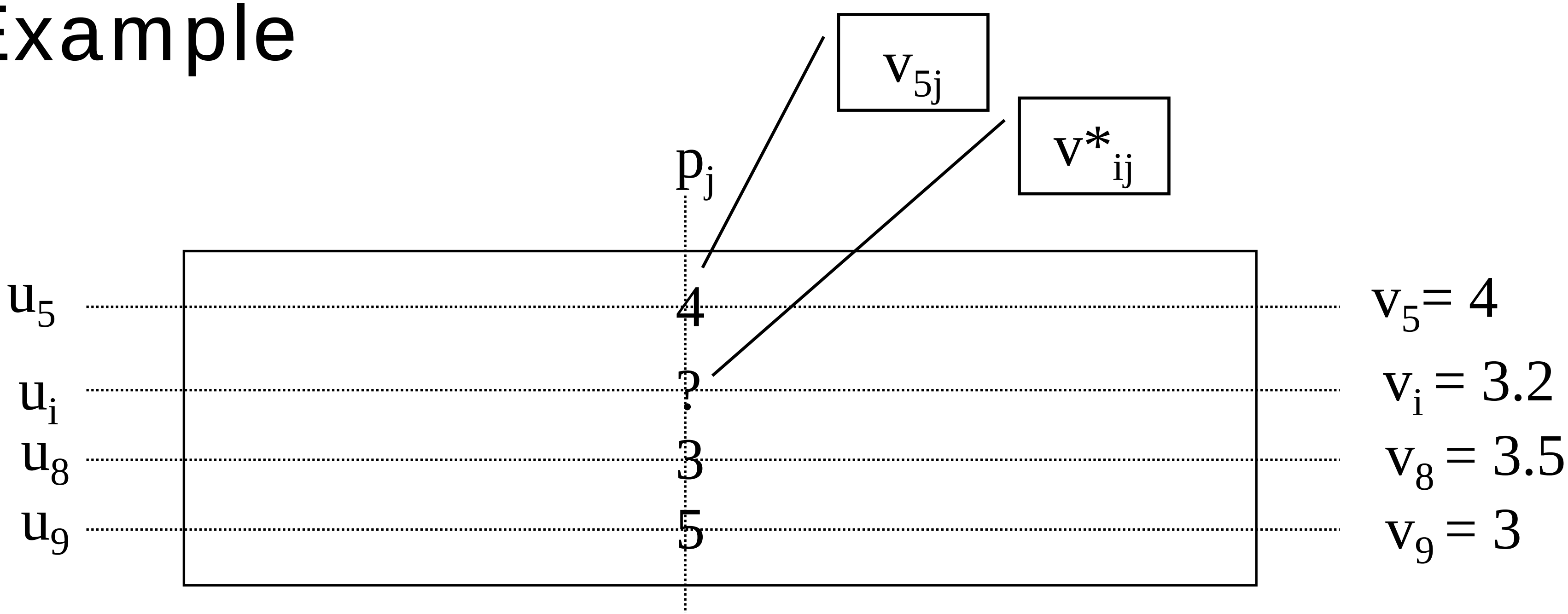
$$u_{ik} = \frac{\sum_j (v_{ij} - v_i)(v_{kj} - v_k)}{\sqrt{\sum_j (v_{ij} - v_i)^2 \sum_j (v_{kj} - v_k)^2}}$$

Similarity of users i and k

- Where the sum (and averages) is over j s.t. v_{ij} and v_{kj} are not "?".

[Breese et al., 1998]

Example



Users' similarities: $u_{i5} = 0.5$, $u_{i8} = 0.5$, $u_{i9} = 0.8$

$$v^*_{ij} = v_i + K \sum_{v_{kj} \neq ?} u_{ik} (v_{kj} - v_k)$$

$v^*_{ij} = 3.2 + 1/(0.5+0.5+0.8) * [0.5 (4 - 4) + 0.5 (3 - 3.5) + 0.8 (5 - 3)$

$= 3.2 + 1/1.8 * [0 - 0.25 + 1.6] = 3.2 + 0.75 = 3.95$

Proximity Measure: Cosine

- Correlation can be replaced with a typical Information Retrieval similarity measure (u_i and u_j are two users, with ratings v_{ik} and v_{jk}, k=1, ..., m)

$$\cos(u_i, u_j) = \frac{\sum_{k=1}^{m} v_{ik} v_{jk}}{\sqrt{\sum_{k=1}^{m} v_{ik}^2 \sum_{k=1}^{m} v_{jk}^2}}$$

- This has been shown to provide worse results by someone [Breese et al., 1998]
- But many uses cosine [Sarwar et al., 2000] and somebody reports that it performs better [Anand and Mobasher, 2005]

Evaluating Recommender Systems

- The majority focused on system's accuracy in supporting the "find good items" user's task
- Assumption: "if a user could examine all items available, he could place them in a ordering of preference"
  1. Measure how good is the system in predicting the exact rating value (value comparison)
  2. Measure how well the system can predict whether the item is relevant or not (relevant vs. not relevant)
  3. Measure how close the predicted ranking of items is to the user's true ranking (ordering comparison).

How Accuracy Has Been Measured

- Split the available data (so you need to collect data first!), i.e., the user-item ratings into two sets: training and test
- Build a model on the training data
  - For instance, in a nearest neighbor (memory-based) CF simply put the ratings in the training in a separate set
- Compare the predicted rating on each test item (user-item combination) with the actual rating stored in the test set
- **You need a metric to compare the predicted and true rating**

Accuracy: Comparing Values

- Measure how close the recommender system's predicted ratings are to the true user ratings (for all the ratings in the test set).
- **Predictive accuracy (rating):** Mean Absolute Error (MAE), p_i is the predicted rating and r_i is the true one:

$$MAE = \frac{\sum_{i=1}^{N} |p_i - r_i|}{N}$$

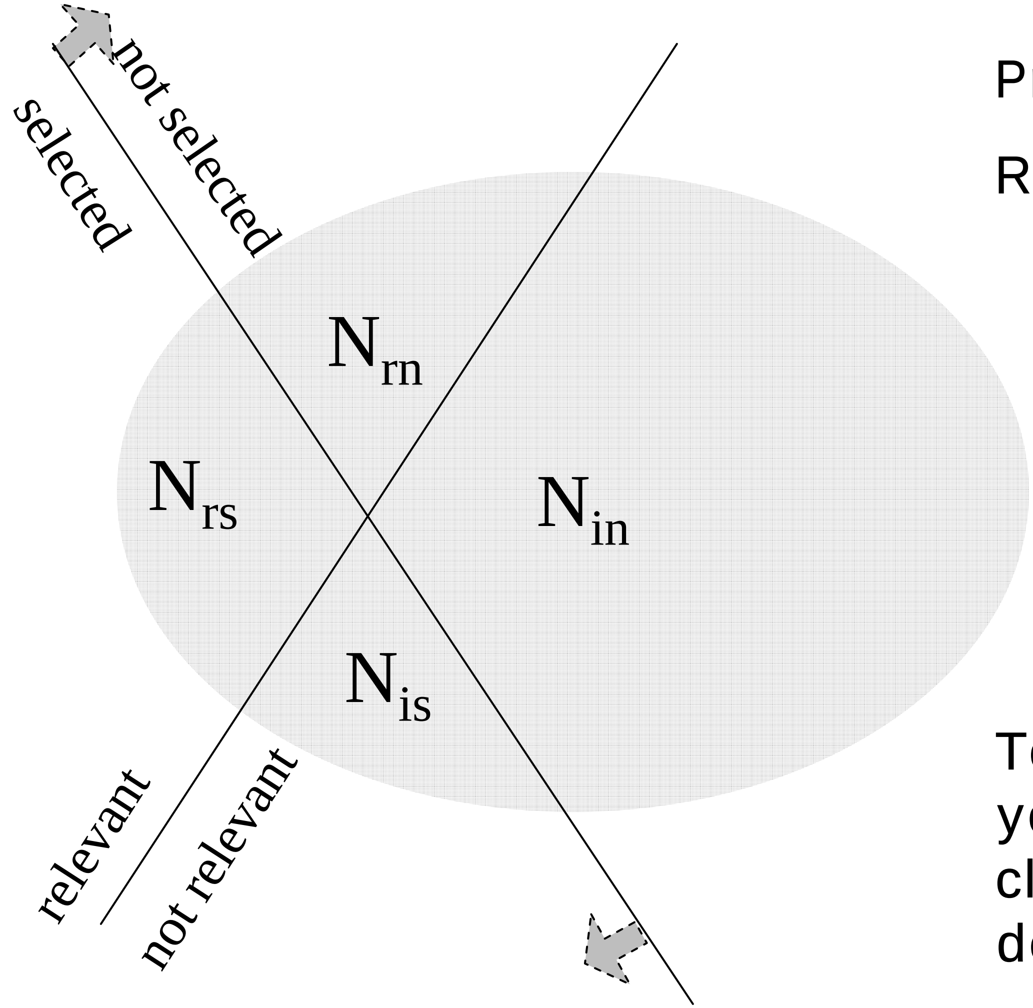
- Variation 1: mean squared error (take the square of the differences), or root mean squared error (and then take the square root). These emphasize large errors.
- Variation 2: Normalized MAE – MAE divided by the range of possible ratings – allowing comparing results on different data sets, having different rating scales.

Precision and Recall

	Selected	Not Selected	Total
Relevant	N_{rs}	N_{rn}	N_r
Irrelevant	N_{is}	N_{in}	N_i
Total	N_s	N_n	N

- The rating scale must be binary – or one must transform it into a binary scale (e.g. items rated above 4 vs. those rated below)
- **Precision** is the ratio of relevant items selected by the recommender to the number of items selected (N_{rs}/N_s)
- **Recall** is the ratio of relevant items selected to the number of relevant (N_{rs}/N_r)
- **Precision and recall** are the most popular metrics for evaluating information retrieval systems.

Precision and Recall



Precision = N_{rs} / (N_{rs} + N_{is})

Recall = N_{rs} / (N_{rs} + N_{rn})

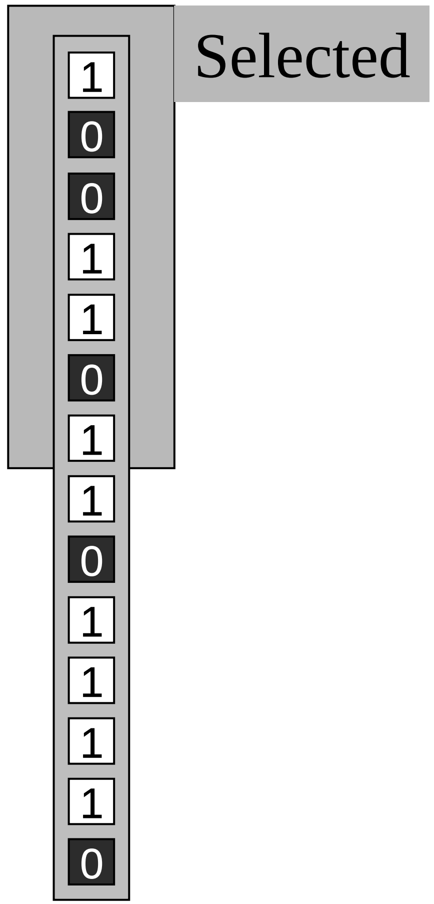
To improve both P and R you need to bring the lines closer together - i.e. better determination of relevance.

Example – Complete Knowledge

- We assume to know the relevance of all the items in the catalogue for a given user
- The orange portion is that recommended by the system

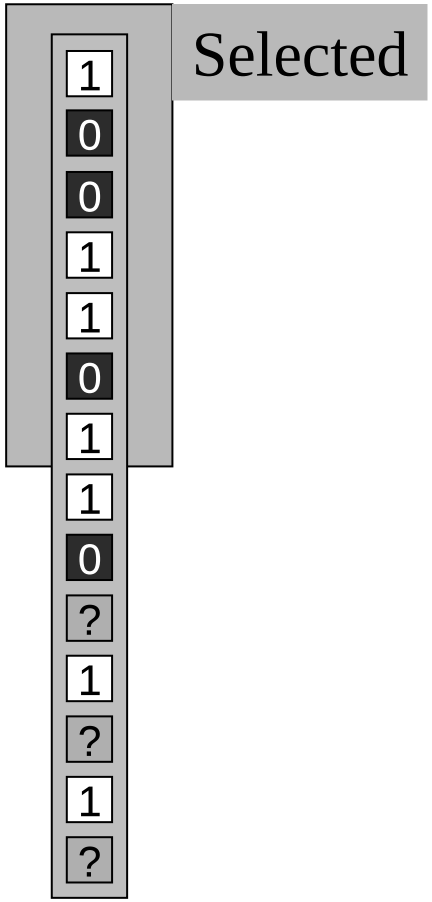
Precision=4/7=0.57

Recall=4/9=0.44



Example – Incomplete Knowledge

- We **do not know** the relevance of all the items in the catalogue for a given user
- The orange portion is that recommended by the system



Precision=4/7=0.57 – *As before*

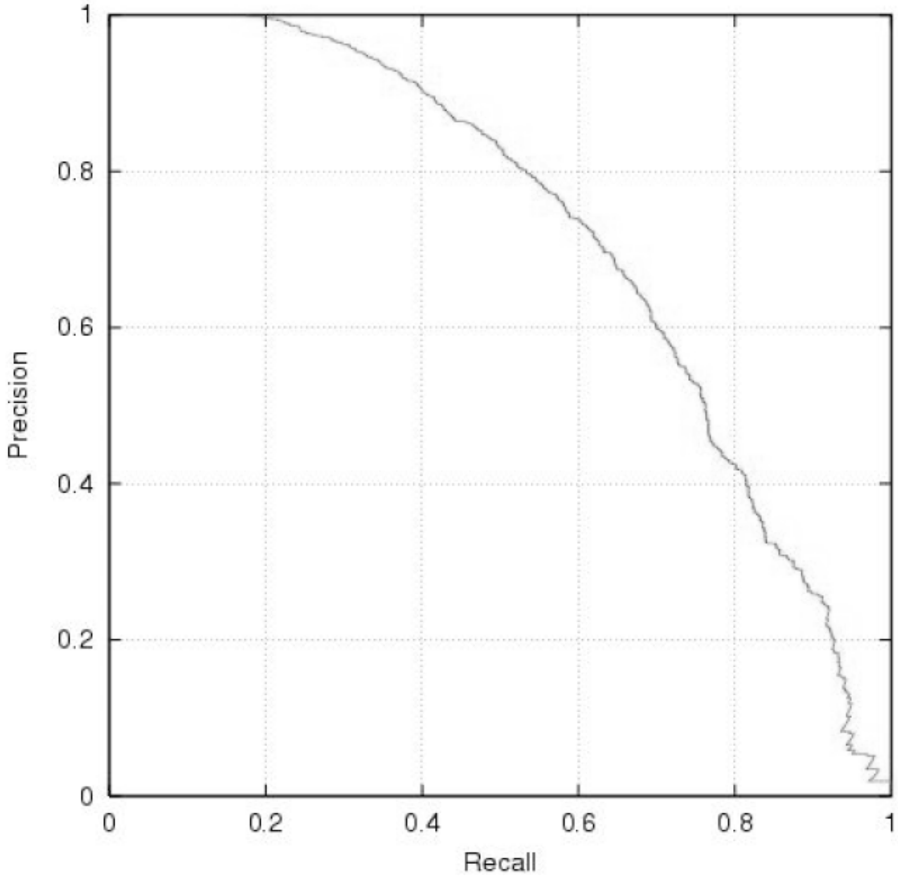
Recall=4/?

4/10 <= R <= 4/7

4/10 if all unknown are relevant

4/7 if all unknown are irrelevant

Precision vs. Recall

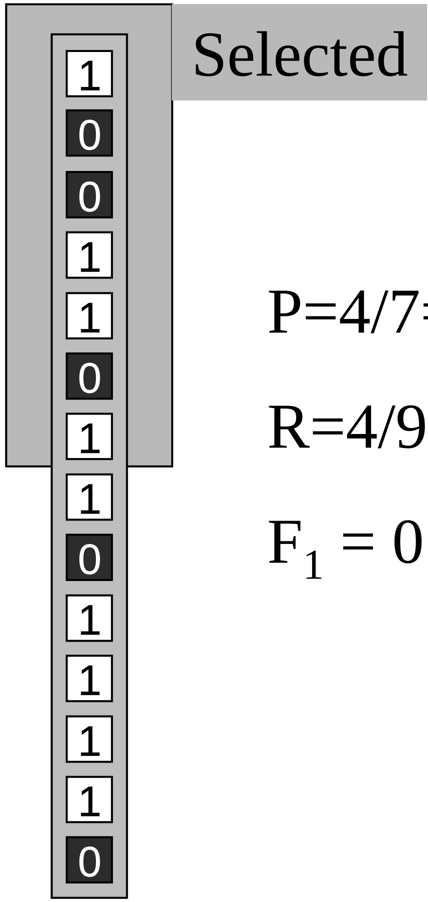


A typical precision and recall curve

F1

- Combinations of Recall and Precision such as F_1
- Typically systems with high recall have low precision and vice versa

$$F_1 = \frac{2PR}{P+R}$$



P=4/7=0.57

R=4/9=0.44

F_1 = 0.5

Problems with Precision and Recall

- To compute them we must know what items are relevant and what are not relevant
- Difficult to know what is relevant for a user in a recommender system that manages thousands/millions of products
- May be easier for some tasks where, given the user or the context, the number of recommendable products is small – only a small portion could fit
- Recall is more difficult to estimate (knowledge of all the relevant products)
- Precision is a bit easier – you must know what part of the selected products are relevant (you can ask to the user after the recommendation – *but has not been done in this way – not many evaluations did involve real users*).

Example of Evaluation of a Collaborative Filtering Recommender System

- **Movie data:** 3500 users, 3000 movies, random selection of 100,000 ratings – obtained a matrix of 943 users and 1682 movies
  - Sparsity = 1 – 100,000 / 943*1682 = 0.9369)
  - On average there are 100.000/943 = 106 ratings per user
- **E-Commerce data:** 6,502 customers, 23,554 products and 97,045 purchase records
  - Sparsity = 0.9994
  - On average 14.9 ratings per user
- **Sparsity** is the proportion of missing ratings over all the possible ratings (#missing-ratings/#all-possible-ratings).

All the possible ratings

[Sarwar et al., 2000]

Evaluation Procedure

- They evaluate top-N recommendation (10 recommendations for each user)
- Separate ratings in training and test sets (80% - 20%)
- Use the training to make the prediction
- Compare (precision and recall) the items **in the test set of a user** with the top N recommendations **for that user**
- Hit set is the intersection of the top N with the test (selected-relevant)
- Precision = size of the hit set / size of the top-N set
- Recall = size of the hit set / size of the test set (*they assume that all the items not rated are not relevant – optimistic assumption*)
- They used the cosine metric in the CF prediction method.

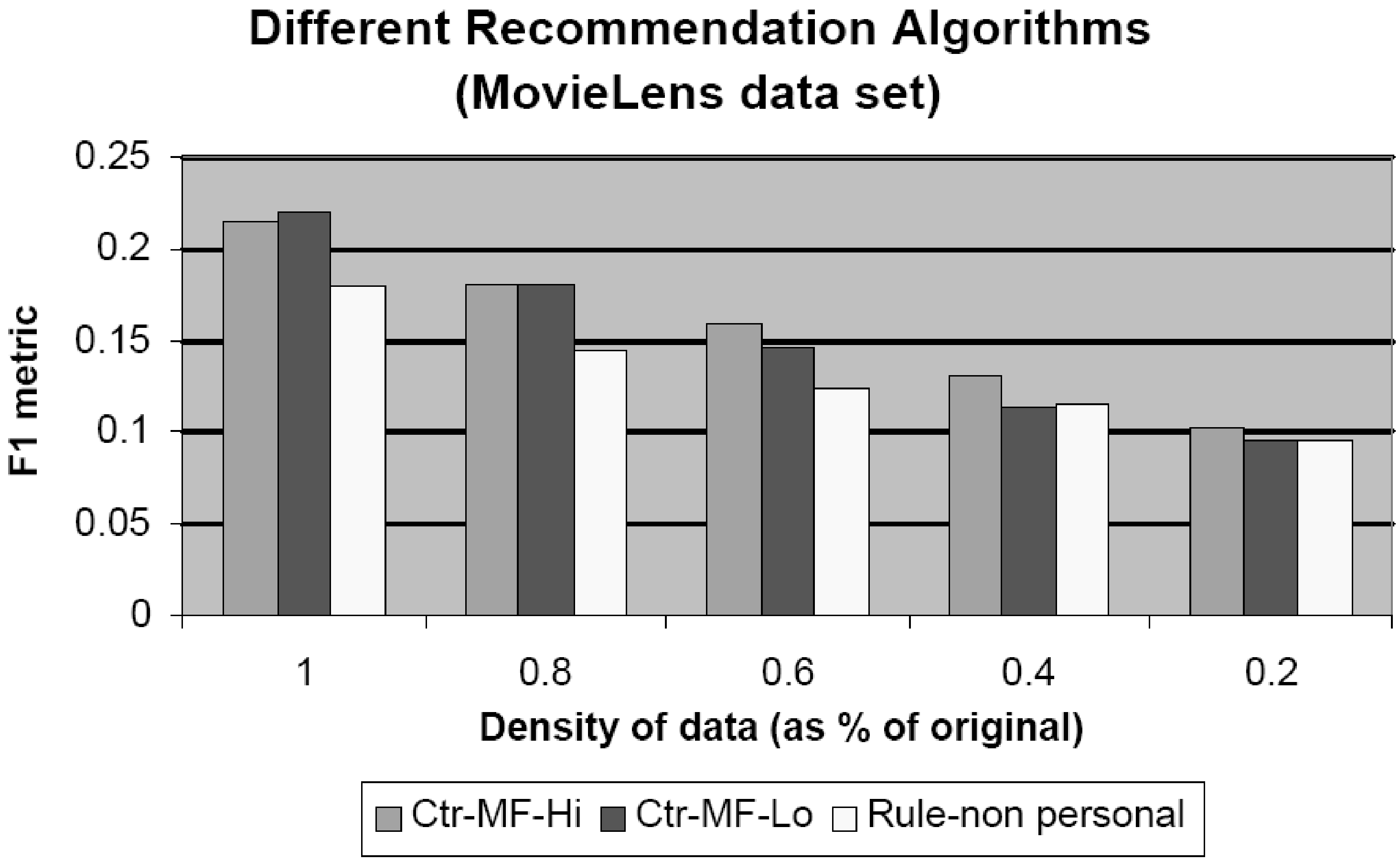
Generation of recommendations

- Instead of using the average

$$v^*_{ij} = v_i + K \sum_{v_{kj} \neq ?} u_{ik}(v_{kj} - v_k)$$

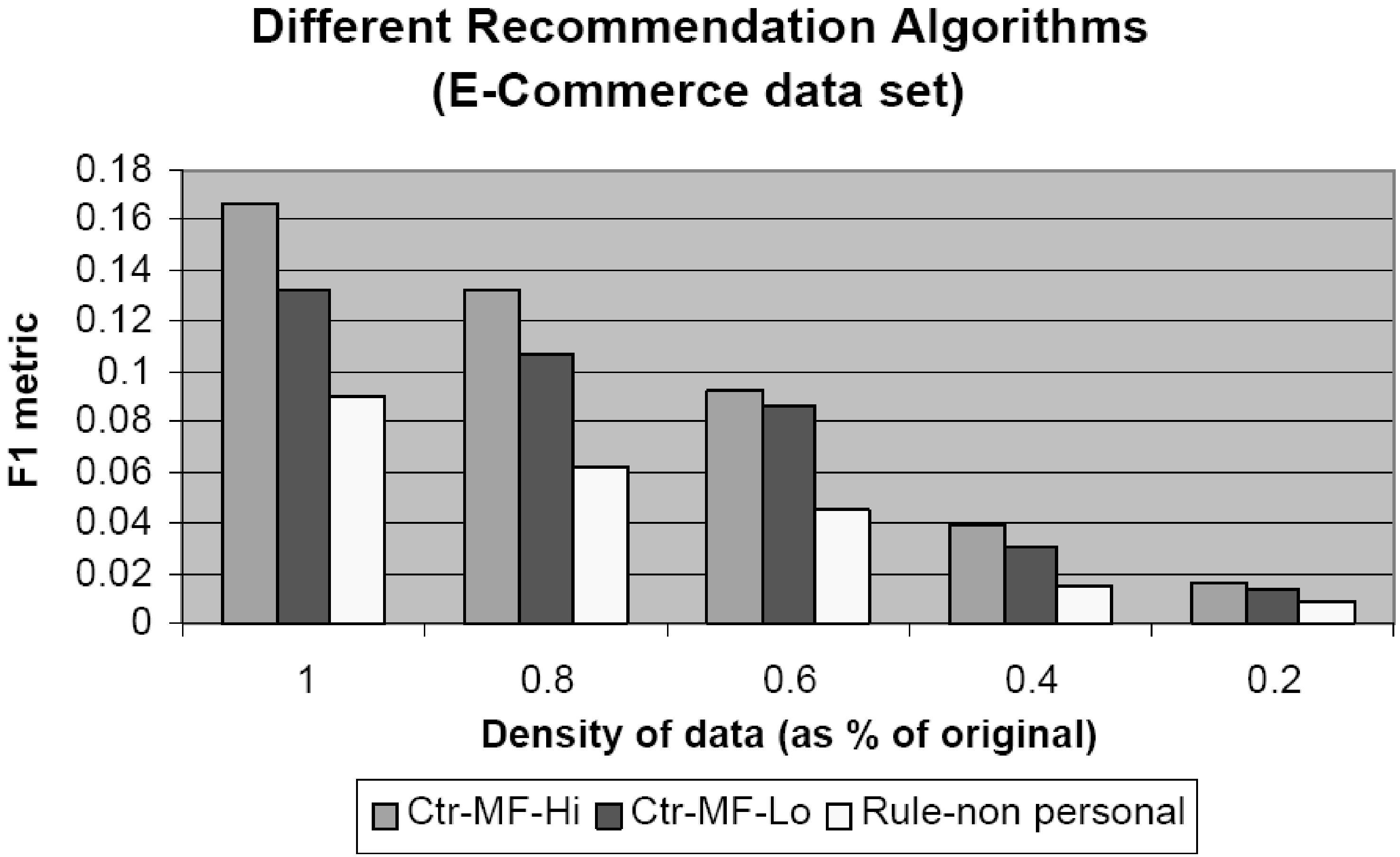
- They used the **most-frequent item recommendation** method
  - Looks in the neighbors (users similar to the target user) scanning the purchase data
  - Compute a frequency count of the products (the frequency of a product in the neighbors purchases)
  - Sort the products according to the frequency
  - Returns the N most frequent products

Comparison with Association Rules



"Lo" and "Hi" means low (=20) and original dimensionality for the products dimension achieved with LSI (Latent Semantic Indexing)

Comparison with Association Rules



"Lo" and "Hi" means low (=20) and original dimensionality for the products dimension achieved with LSI (Latent Semantic Indexing)

“Core” Recommendation Techniques

U is a set of users
I is a set of items/products

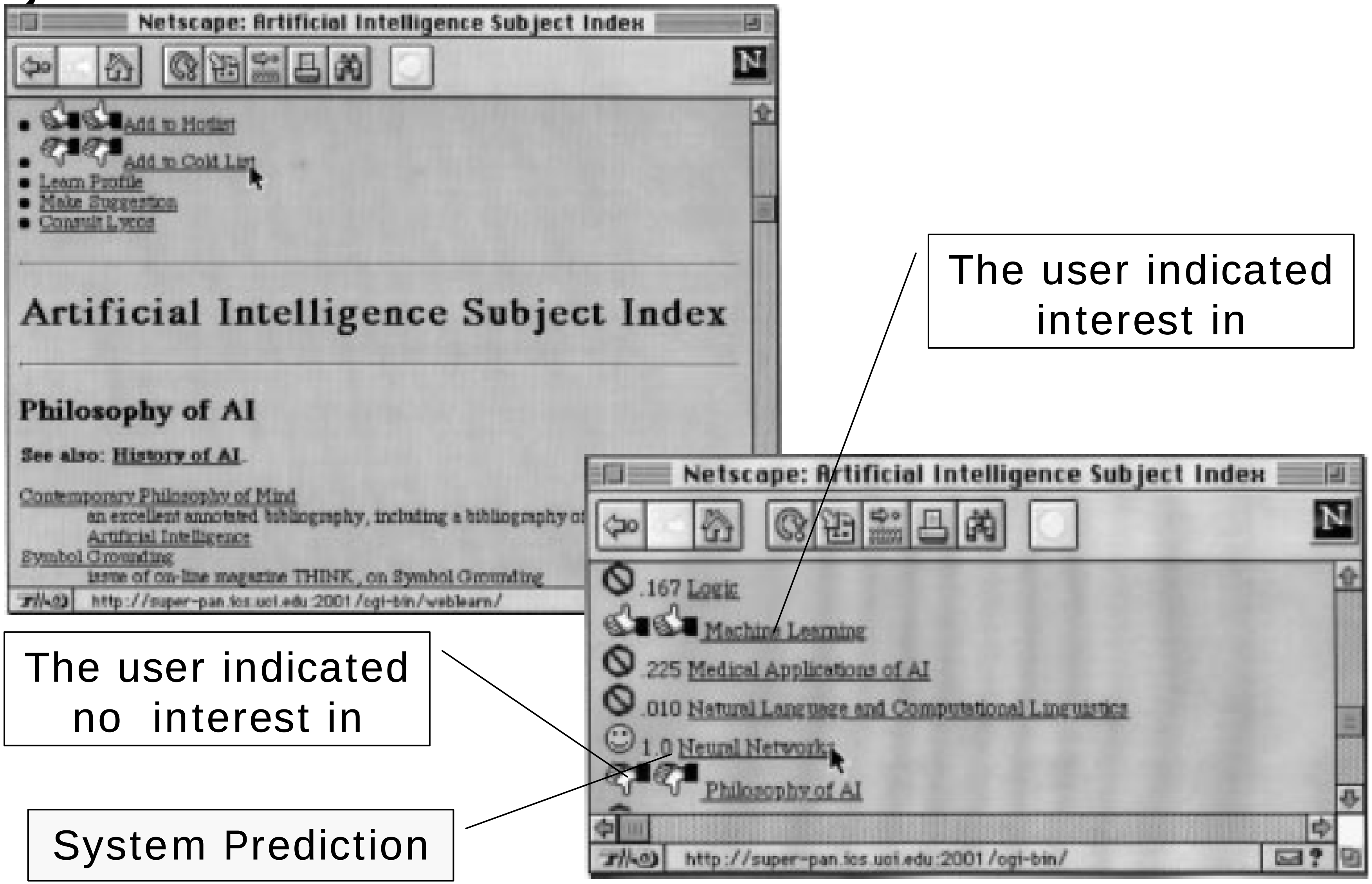
Technique	Background	Input	Process
Collaborative	Ratings from **U** of items in **I**.	Ratings from **u** of items in **I**.	Identify users in **U** similar to **u**, and extrapolate from their ratings of **i**.
Content-based	Features of items in **I**	**u**’s ratings of items in **I**	Generate a classifier that fits **u**’s rating behavior and use it on **i**.
Demographic	Demographic information about **U** and their ratings of items in **I**.	Demographic information about **u**.	Identify users that are demographically similar to **u**, and extrapolate from their ratings of **i**.
Utility-based	Features of items in **I**.	A utility function over items in **I** that describes **u**’s preferences.	Apply the function to the items and determine **i**’s rank.
Knowledge-based	Features of items in **I**. Knowledge of how these items meet a user’s needs.	A description of **u**’s needs or interests.	Infer a match between **i** and **u**’s need.

[Burke, 2002]

Content-Based Recommender

- Has its root in **Information Retrieval** (IR)
- It is mainly used for recommending **text-based products** (web pages, usenet news messages) – products for which you can find a textual description
- The items to recommend are “described” by their associated **features** (e.g. keywords)
- The **User Model** can be structured in a “similar” way as the content: for instance the features/keywords more likely to occur in the preferred documents
  - Then, for instance, text documents can be recommended based on a comparison between their content (words appearing in the text) and a user model (a set of preferred words)
- The user model can also be a **classifier** based on whatever technique (e.g., Neural Networks, Naive Bayes, C4.5).

Syskill & Webert User Interface



Content Model: Syskill & Webert

- A document (HTML page) is described as a set of Boolean features (a word is present or not)
- A feature is considered important for the prediction task **if the Information Gain is high**
- **Information Gain:** G(S,W) = E(S) –[P((W is present)*E($S_{\text{W is present}}$) + P(W is absent)*E($S_{\text{W is absent}}$)]

$$E(S) = \sum_{c \in \{hot, cold\}} -p(S_c)\log_2(p(S_c))$$

- E(S) is the Entropy of a labeled collection (how randomly the two labels are distributed)
- W is a word – a Boolean feature (present/not-present)
- S is a set of documents, S_{hot} is the subset of interesting documents
- They have used the 128 most informative words (highest information gain).

Learning

- They used a Bayesian classifier (one for each user), where the probability that a document $w_1=v_1$, ..., $w_n=v_n$ (e.g. car=1, story=0, ..., price=1) belongs to a class (cold or hot) is

$$P(C=hot|w_1=v_1,\ldots,w_n=v_n) \cong P(C=hot)\prod_j P(w_j=v_j\,|\,C=hot)$$

- Both $P(w_j = v_j|C=hot)$ (i.e., the probability that in the set of the documents liked by a user the word w_j is present or not) and $P(C=hot)$ is estimated from the training data

- After training on 30/40 examples it can predict hot/cold with an **accuracy between 70% and 80%.**

A Better Model for the Document

- TF-IDF means Term Frequency – Inverse Document Frequency

$$d_{t_i} = \left(0.5 + 0.5\frac{tf_i}{tf_{max}}\right)\left(\log\frac{n}{df_i}\right)$$

The less frequent the word is in the corpus the greater is this

The greater the frequency of the word the greater is this term

- tf_i is the number of times word t_i appears in document d (the term frequency),
- df_i is the number of documents in the corpus which contain t_i (the document frequency),
- n is the number of documents in the corpus and tf_{max} is the maximum term frequency over all words in d.

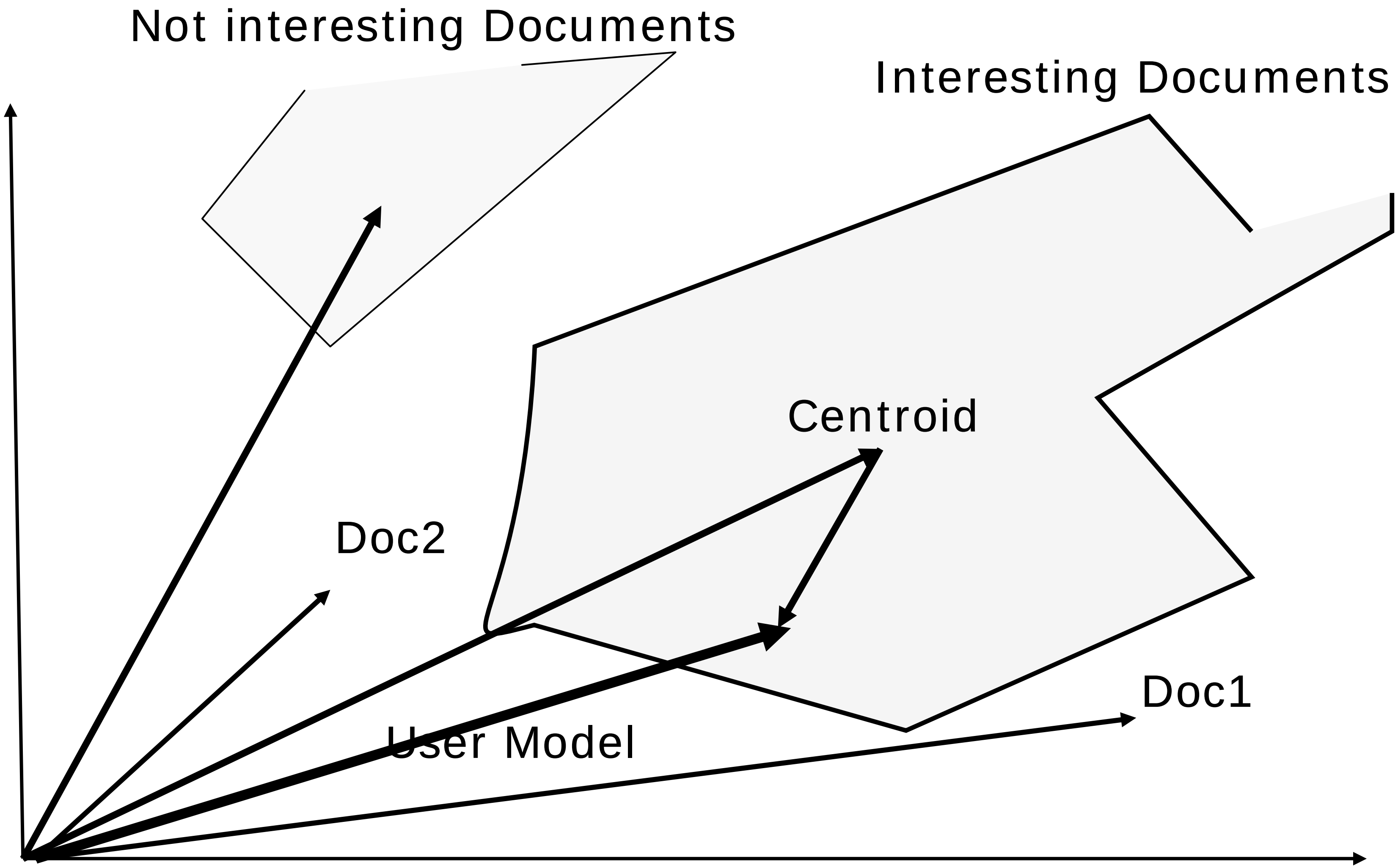
Computing TF-IDF -- An Example

- Given a document D containing terms (a, b, and c) with given frequencies:
  - freq(a,D)=3, freq(b,D)=2, freq(c,D)=1
- Assume collection contains 10,000 documents and the term total frequencies of these terms are:
  - N_a=50, N_b=1300, N_c=250
- Then:
  - a: tf = 3/3; idf = log(10.000/50) = 5.3; tf-idf = 5.3
  - b: tf = 2/3; idf = log(10.000/1300) = 2.0; tf-idf = 1.3
  - c: tf = 1/3; idf = log(10.000/250) = 3.7; tf-idf = 1.2

Using TF-IDF

- One can build a classifier (e.g. Bayesian) as before, where instead of using a Boolean array for representing a document, the array now contains the tf-idf values of the selected words (a bit more complex because features are not Boolean anymore)
- But can also build a **User Model** by (Rocchio, 1971)
  - Average of the tf-idf representations of interesting documents of a user (Centroid)
  - Subtracting a fraction of the average of the not interesting documents (0.25 in [Pazzani & Billsus, 1997]
- **Then new documents close (cosine distance) to this user model are recommended.**

Example



Doc1 is estimated more interesting than Doc2

Problems of Content-Based Recommenders

- A very shallow analysis of certain kinds of content can be supplied
- Some kind of items are not amenable to any feature extraction methods with current technologies (e.g. movies, music)
- Even for texts (as web pages) the IR techniques cannot consider multimedia information, aesthetic qualities, download time (*any ideas about to use them?*)
  - Hence if you rate positively a page it could be not related to the presence of certain keywords!

Problems of Content-Based Recommenders (2)

- **Over-specialization:** the system can only recommend items scoring high against a user's profile – the user is recommended with items similar to those already rated
- **Requires user feed-backs:** the pure content-based approach (similarly to CF) **requires user feedback** on items in order to provide meaningful recommendations
- **It tends to recommend expected items** – this tends to **increase trust** but could make the recommendation not much useful (no serendipity)
- Works better in those situations where the **"products" are generated dynamically** (news, email, events, etc.) and there is the need to check if these items are relevant or not.

Knowledge Based Recommender

- Suggests products based on inferences about a user's needs and preferences
- Functional knowledge: about how a particular item meets a particular user need
- The **user model** can be any knowledge structure that supports this inference
  - A query
  - A case (in a case-based reasoning system)
  - An adapted similarity metric (for matching)
  - A part of an ontology
- **There is a large use of domain knowledge encoded in a knowledge representation language/approach.**

ActiveBuyersGuide

digital camera product advisor

Find by: Product Use | **Product Features**

I need photo quality high enough for... More Info

- ○ 5" x 7" prints (2 megapixels)
- ○ 8" x 10" prints (4 megapixels)
- ○ 11" x 14" prints (6 megapixels)
- ◉ No preference

My camera should fit inside a... More Info

- ○ Shirt pocket
- ○ Waist pack
- ○ Backpack
- ◉ No preference

I prefer cameras that have an Epinions.com rating of

at least --select--

GET RESULTS

I want to spend... More Info

From $ ____ up to $ ____

I want to zoom in on subjects across a... More Info

- ○ Small room (8 ft. away)
- ○ Living room (15 ft. away)
- ○ Backyard (35 ft. away)
- ◉ No preference

My preferred brands... More Info

select all that apply

- ☐ Canon
- ☐ Fujifilm
- ☐ Kodak
- ☐ Nikon
- ☐ Olympus
- ☐ Sony

more brands...

MORE GUIDANCE GET RESULTS

camcorder product advisor

Find by: Product Use | **Product Features**

I need a camcorder for... More Info

- ○ Occasional & casual recordings
- ○ Home and vacation movies
- ○ Business productions
- ◉ No preference

I want to zoom in on subjects across a... More Info

- ○ Playground (40 ft. away)
- ○ Tennis court (60 ft. away)
- ○ Park (80 ft. away)
- ◉ No preference

I prefer camcorders that have an Epinions.com rating of

at least --select--

GET RESULTS

I want to spend... More Info

From $ ____ up to $ ____

My camcorder should fit inside a... More Info

- ○ Shirt pocket
- ○ Waist pack
- ○ Backpack
- ◉ No preference

My preferred brands... More Info

check all -- clear all

- ☐ Canon
- ☐ JVC
- ☐ Panasonic
- ☐ Samsung
- ☐ Sony

more brands...

MORE GUIDANCE GET RESULTS

mp3 player product advisor

Find by: Product Use | **Product Features**

My MP3 player (Digital Music Player) needs to be compatible with a... More Info

select all that apply

- ☐ Windows operating system
- ☐ Mac operating system

I want my MP3 player to hold... More Info

- ○ A handful of songs (less than 128 MB)
- ○ A few dozen songs (128 MB - 512 MB)
- ○ Hundreds of songs (512 MB - 5 GB)
- ○ Thousands of songs (5 GB or more)
- ◉ No preference

I prefer MP3 players that have an Epinions.com rating of

at least --select--

GET RESULTS

I want to spend... More Info

From $ ____ up to $ ____

My preferred brands... More Info

check all -- clear all

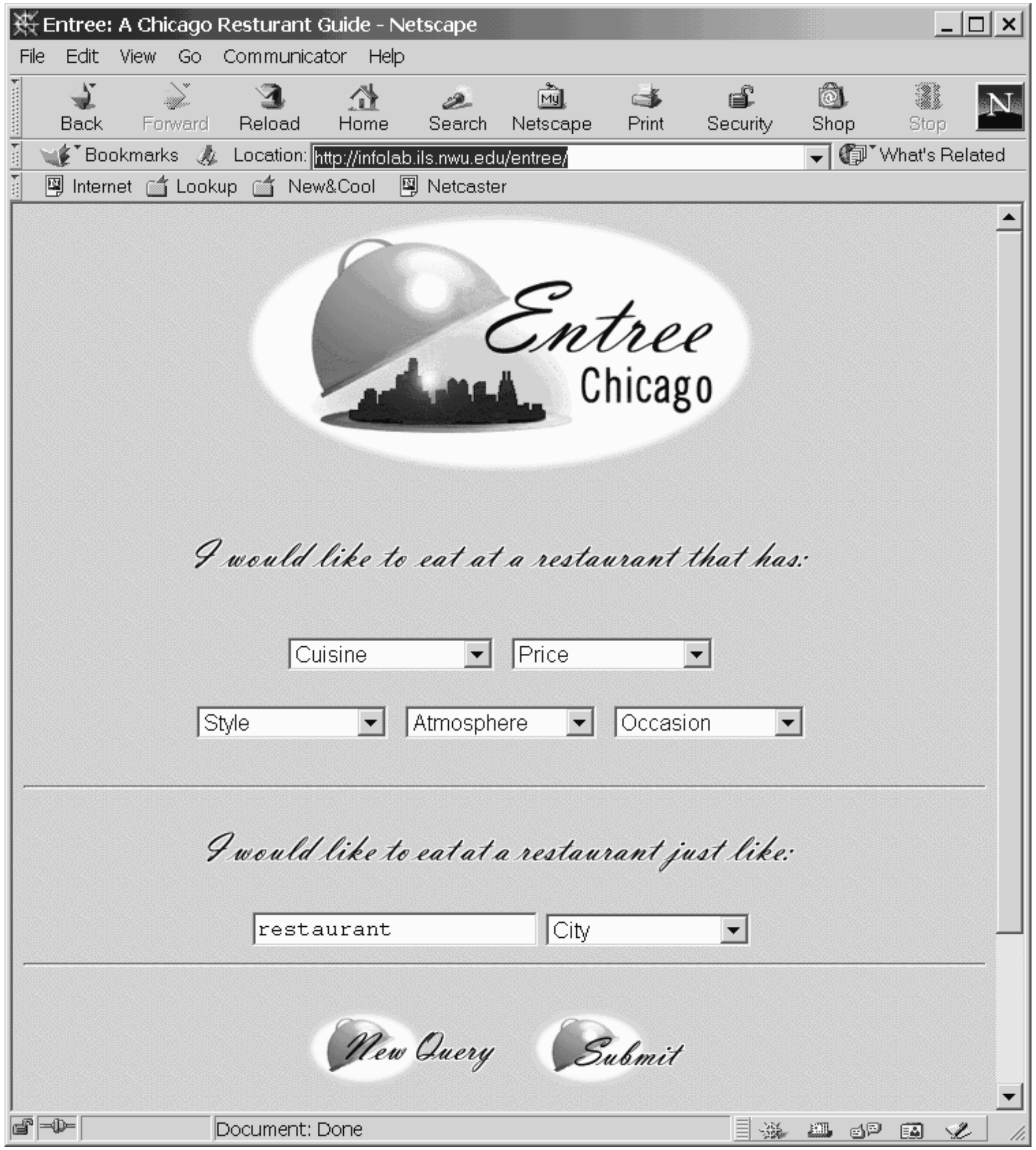
- ☐ Apple/iPod
- ☐ Creative Labs
- ☐ iRiver
- ☐ Lexar
- ☐ RCA
- ☐ Rio

more brands...

MORE GUIDANCE GET RESULTS

www.myproductadvisor.com

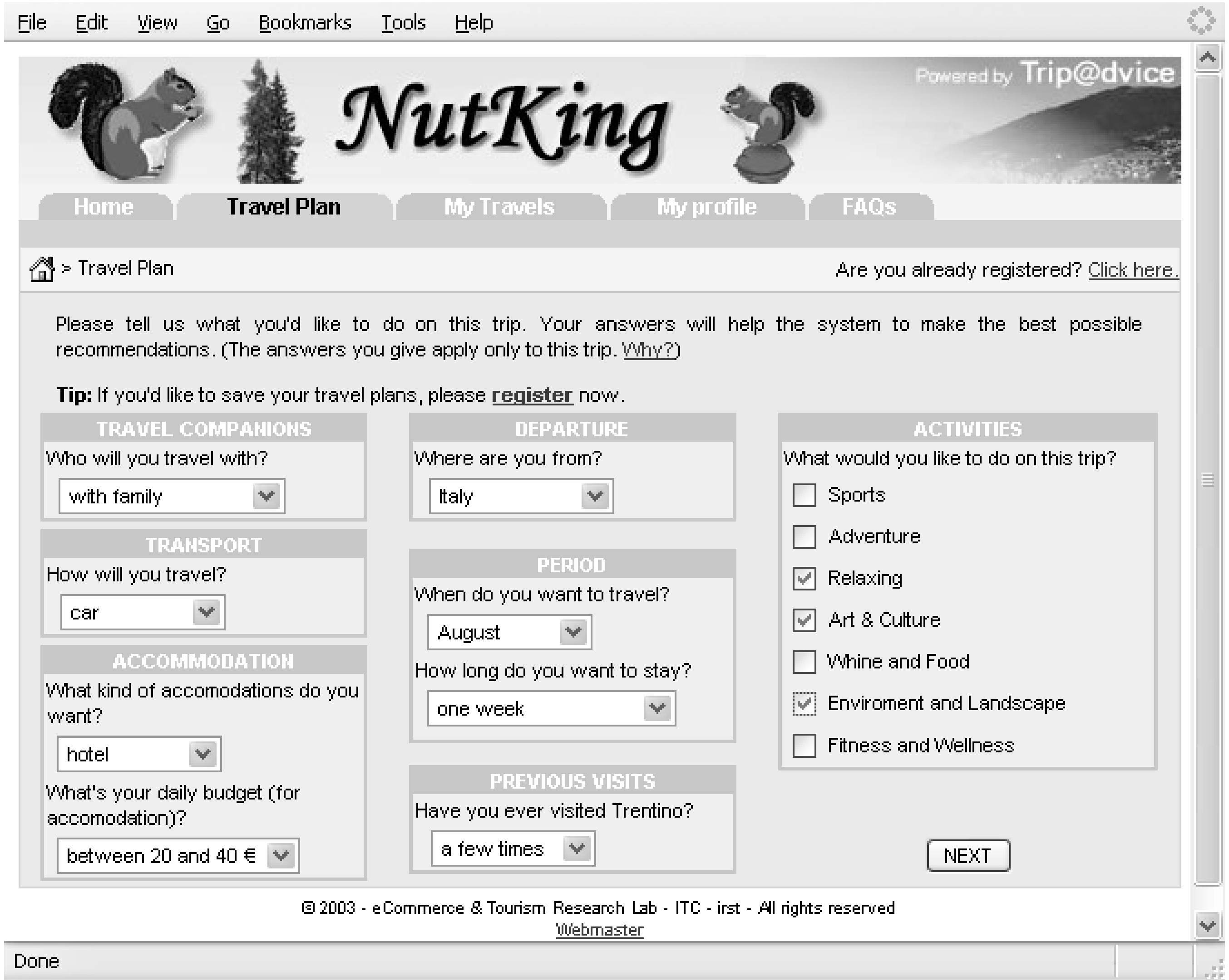
Entrée: Case-Based Recommender



- Entree is a restaurant recommender system – it finds restaurants:
  1. in a new city similar to restaurants the user knows and likes
  2. or those matching some user goals (case features).

Partial Match

- In general, only a subset of the preferences will be matched in the recommended restaurant.



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NutKing
Home
Travel Plan
My Travels
My profile
FAQs
Locations
Accommodation
Sporting activities
Events
Culture
Maps
> Travel Plan > Locations
Are you already registered? Click here.
Search
Search by location
Altitude (min-max)
m
m
Activities:
Legenda
Area
[List of Areas]
Search
Reset
3 Locations found.
The elements found meet all research criteria. The number of green trees indicates how suitable it is for your request (for more information >>>).
To include a location in your travel plan, click on Add
ARCO
Search on the web
Alto Garda, Valle di Ledro, Valle dei Laghi
Why this recommendation for you?
Arco is situated on the northern fringe of Lake Garda. It is a historical and cultural centre of great interest with a well documented tradition of hospitality and tourism. The town of Arco, as well as the whole area surrounding it, enjoys the natural benefits of a mild climate and the florid ... more >
Altitude: 91
Activities:
How to get to
Where is it?
Add
Other User's feedback
Give us your feedback
TRENTO
Search on the web
Valle dell'Adige, Trento e Monte Bondone
Why this recommendation for you?
Trento is a city that hides itself from the hasty traveller. Shaped by the old course of the river Adige, it withdraws behind the splendid walls of painted edifices portraying illustrious visitors of long ago: mythological figures of ancient times, German emperors on their
javascript:popUp('why.do?travelasset=TRAVELASSET-473&myTaName=ARCO&score=52&type=LOCATION&icodep=50','6...

Query Tightening


File Edit View Go Bookmarks Tools Help
Powered by Trip@dvice
NutKing
Home
Travel Plan
My Travels
My profile
FAQs
Locations
Accommodation
Sporting activities
Events
Culture
Maps
> Travel Plan > Accommodation
Welcome fmr59 - (sign-out)
Current travel plan
TRAVEL 18-08-2004
Search
Suggestions...
Area
Alto Garda, Valle di Ledro
Location
ARCO
Accommodation type
Hotel
Category
[Min]
[Max]
Cost day / person
min. 20 € max. 40 €
Number of beds
2
Legenda
Search
Reset
Update research
Sorry. We don't have anything to satisfy your requirements.
You can change your request by:
Trying to remove "Location" from the research and you obtain 15 results. Click on Remove and Get results to view.
Remove and Get results
Trying to modify "Cost" from the research and you obtain 2 results. Click on Modify and Get results to view.
Modify and Get results
Trying to remove "Outdoor swimming pool" from the research and you obtain 1 result. Click on Remove and Get results to view.
Remove and Get results
Trying to remove "Solarium" from the research and you obtain 6 results. Click on Remove and Get results to view.
Remove and Get results
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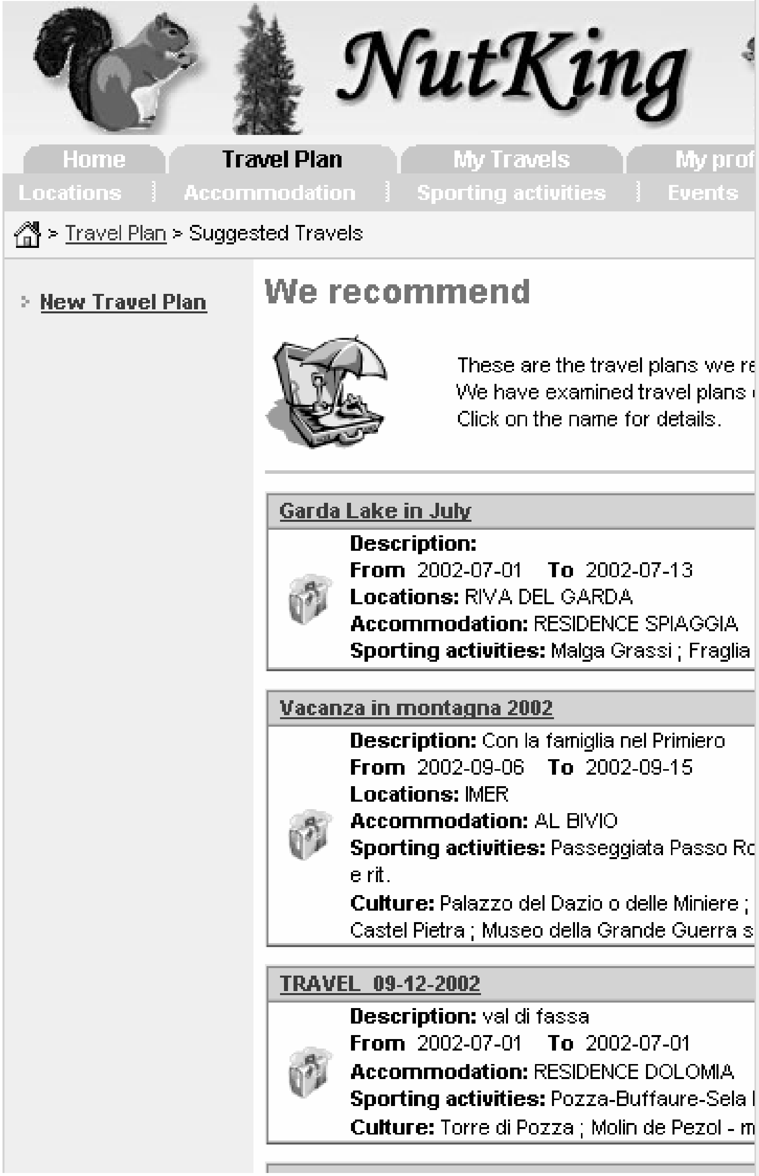
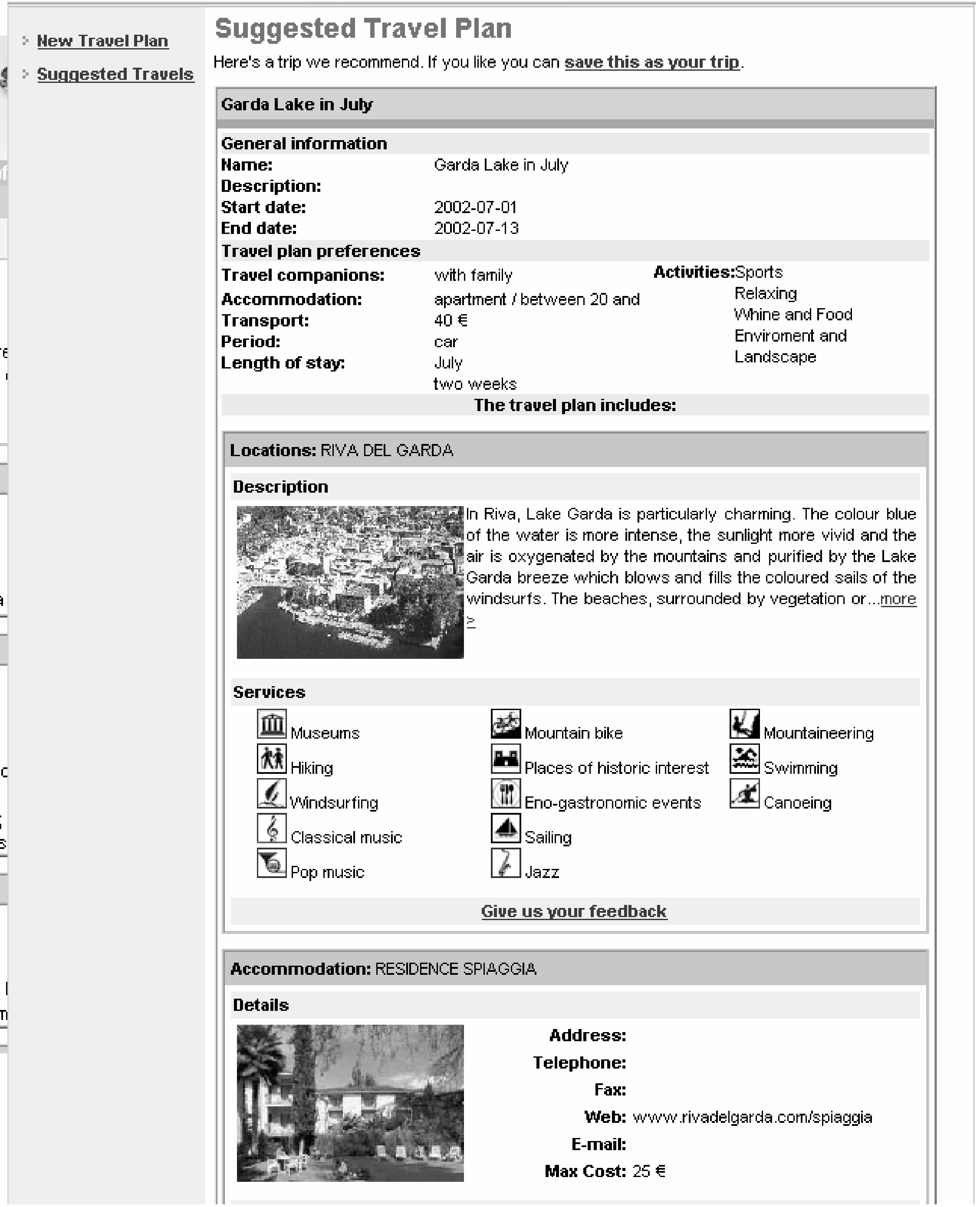
Webmaster
Done





[Ricci et al., 2002]

www.visiteurope.com

- Major European Tourism Destination Portal of the European Travel Commission (ETC)
- 34 National Tourism Organizations
- Project started 2004
- Consortium: EC3, TIScover, ITC-irst, Siemens, Lixto
- On line since April 06
- 500.000 page views/month
- 100.000 visitors/month

Evaluation of RS

- There are many criteria for evaluating RS
  - User satisfaction/usability
  - User effort (e.g. time or rec. cycles required)
  - Accuracy of the prediction
  - Success of the prediction (the product is bought after the recommendation)
  - Coverage (recall)
  - Confidence in the recommendation (trust)
  - Understandability of the recommendation
  - Degree of novelty brought by the recommendation (serendipity)
  - Transparency
  - Quantity
  - Diversity
  - Risk minimization
  - Cost effective (the cheapest product having the required features)
  - Robustness of the method (e.g. against an attack)
  - Scalability

Challenges

- Generic user models (multiple products and tasks)
- Generic recommender systems (multiple products and tasks)
- Distributed recommender system (users and products data are distributed)
- Portable recommender systems (user data stored at user side)
- (user) Configurable recommender systems
- Multi strategy – adapted to the user
- Privacy protecting RS
- Context dependent RS
- Emotional and values aware RS
- Trust and recommendations
- Persuasion technologies
- Easily deployable RS
- Group recommendations

Challenges (2)

- Interactive Recommendations – sequential decision making
- Hybrid recommendation technologies
- Consumer Behavior and Recommender Systems
- Complex Products recommendations
- Mobile Recommendations
- Business Models for Recommender Systems
- High risk and value recommender systems
- Recommendation and negotiation
- Recommendation and information search
- Recommendation and configuration
- Listening customers
- Recommender systems and ontologies

Summing up

- **At the beginning** – user recommendations (ratings/evaluations) are used to build new recommendations – collaborative or social filtering
  - The recommender system is a machine that burns recommendations to build new recommendations
- **The expansion** – many new methods are introduced (content-based, hybrid, clustering, ...) – the aim is to tackle information overload and improve the behavior of CF methods (considering context and product descriptions)

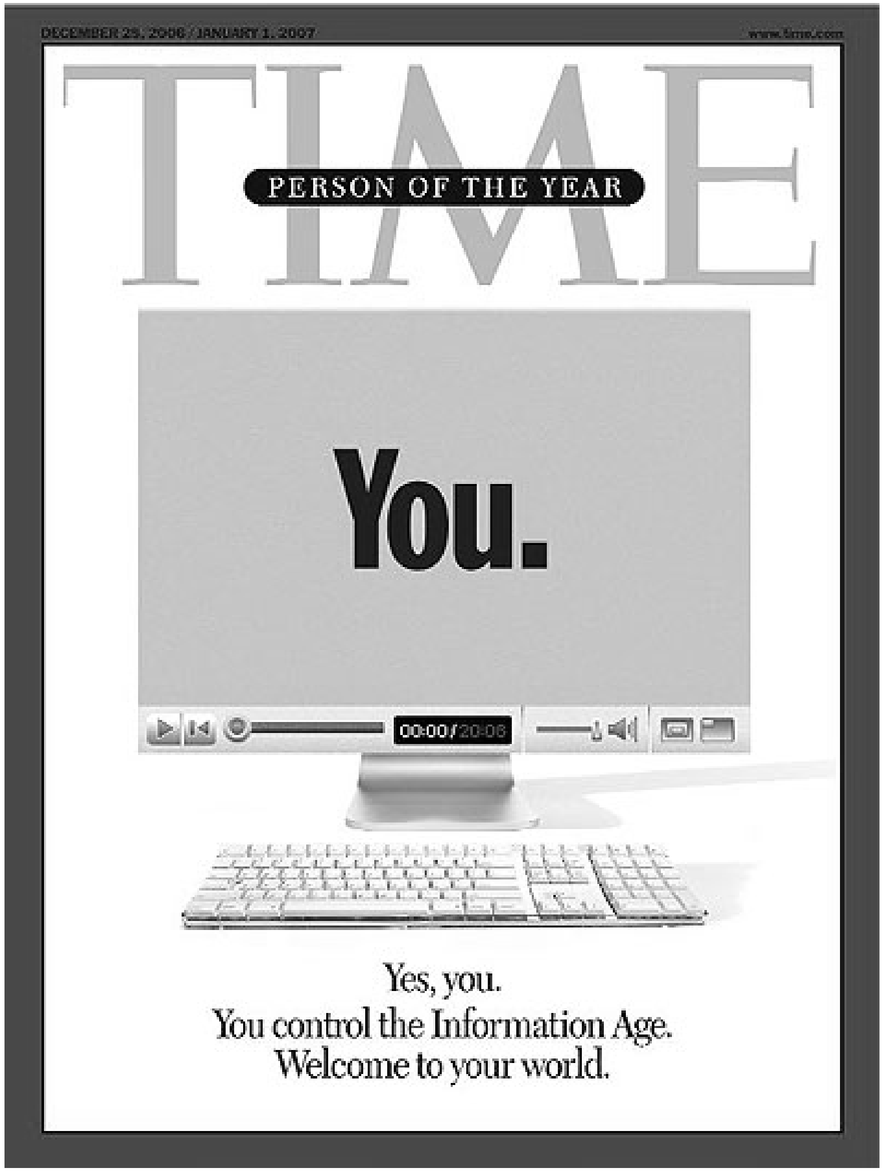
Summing up (2)

- Decision support – recommender systems are tools for helping users to take decision (what product to buy or what news to read)
  - The gain in “utility” (personalized) without and with recommendation is the metric;
  - Information search and processing cannot be separated from the RS research;
  - The recommendation process becomes an important factor
  - Conversational systems are introduced
  - More adaptive and flexible conversations should be supported

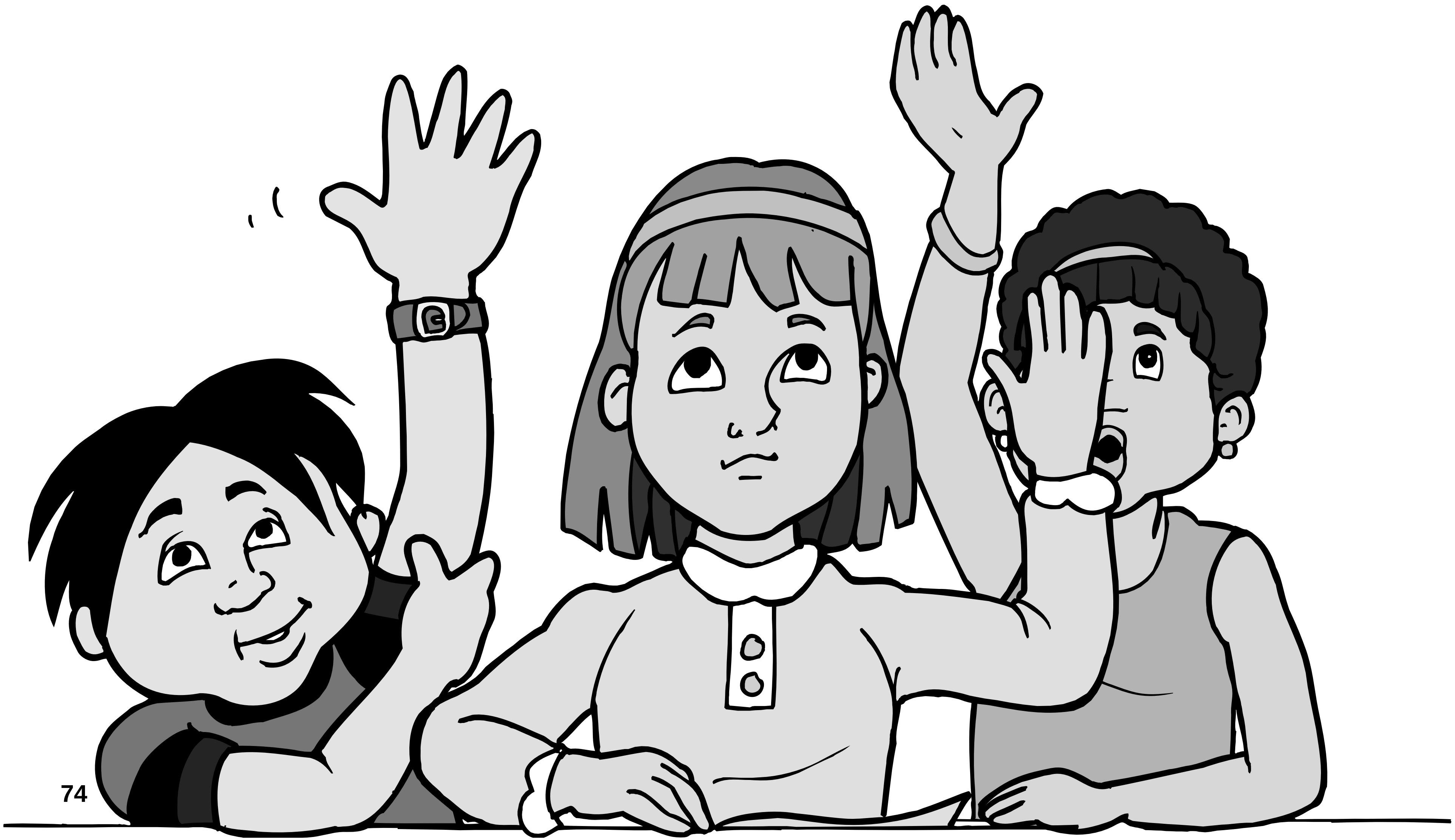
Conclusions

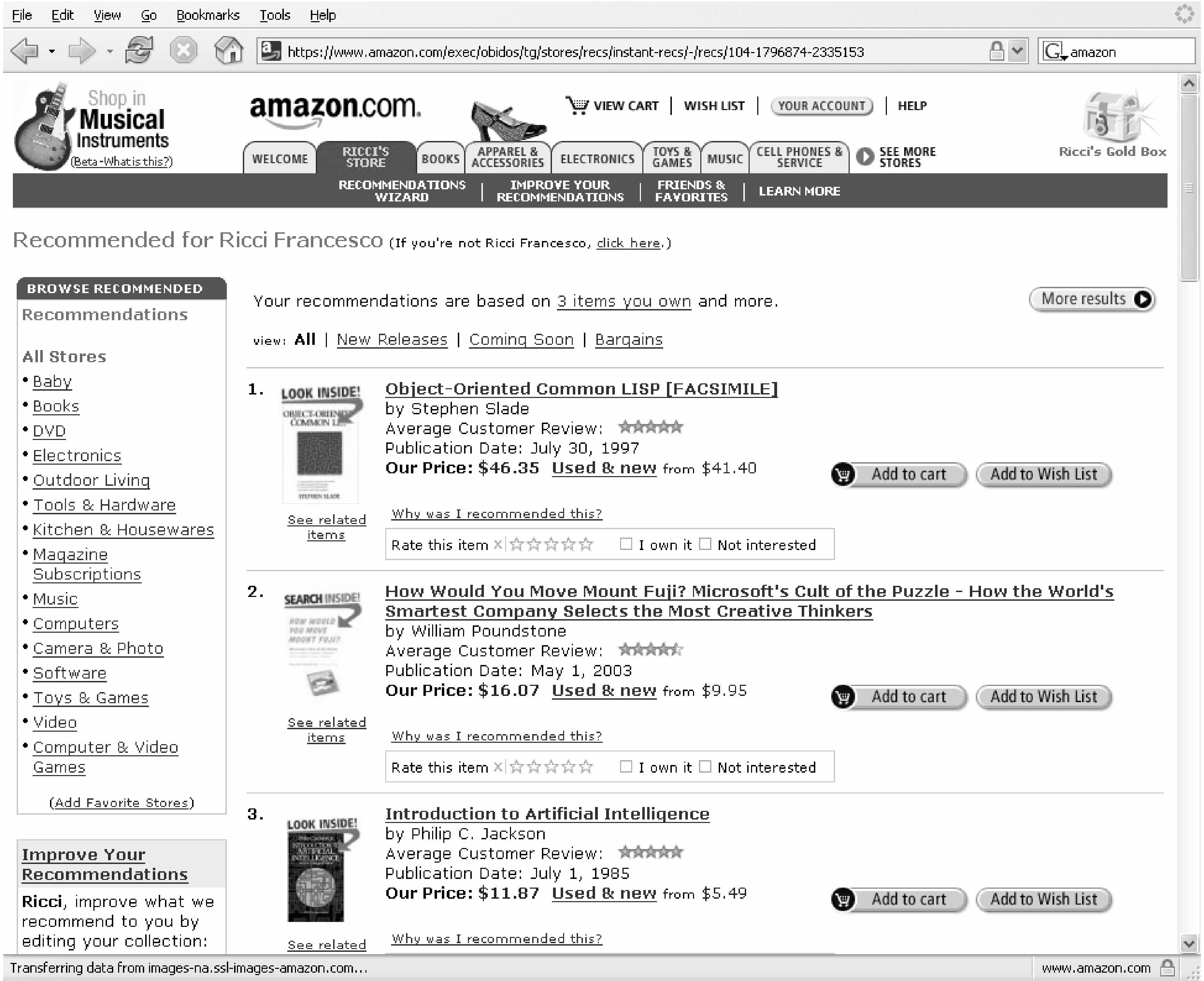
- A recommender system main task is helping to choose products that are potentially more interesting to the user from a large set of options
- Recommender systems "personalize" the human-computer interaction – make the interaction adapted to the specific needs and characteristics of the user
- Personalization is a complex topic: many factors and there is no single theory that explain all.

It’s all about You



Questions?

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SEE MORE STORES
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• Tools & Hardware
• Kitchen & Housewares
• Magazine Subscriptions
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• Computers
• Camera & Photo
• Software
• Toys & Games
• Video
• Computer & Video Games
(Add Favorite Stores)
Improve Your Recommendations
Ricci, improve what we recommend to you by editing your collection:
Your recommendations are based on 3 items you own and more.
More results
view: All | New Releases | Coming Soon | Bargains
1.
LOOK INSIDE!
Object-Oriented Common LISP [FACSIMILE]
by Stephen Slade
Average Customer Review:
Publication Date: July 30, 1997
Our Price: $46.35 Used & new from $41.40
Add to cart
Add to Wish List
See related items
Why was I recommended this?
Rate this item
I own it
Not interested
2.
SEARCH INSIDE!
How Would You Move Mount Fuji? Microsoft's Cult of the Puzzle - How the World's Smartest Company Selects the Most Creative Thinkers
by William Poundstone
Average Customer Review:
Publication Date: May 1, 2003
Our Price: $16.07 Used & new from $9.95
Add to cart
Add to Wish List
See related items
Why was I recommended this?
Rate this item
I own it
Not interested
3.
LOOK INSIDE!
Introduction to Artificial Intelligence
by Philip C. Jackson
Average Customer Review:
Publication Date: July 1, 1985
Our Price: $11.87 Used & new from $5.49
Add to cart
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See related
Why was I recommended this?
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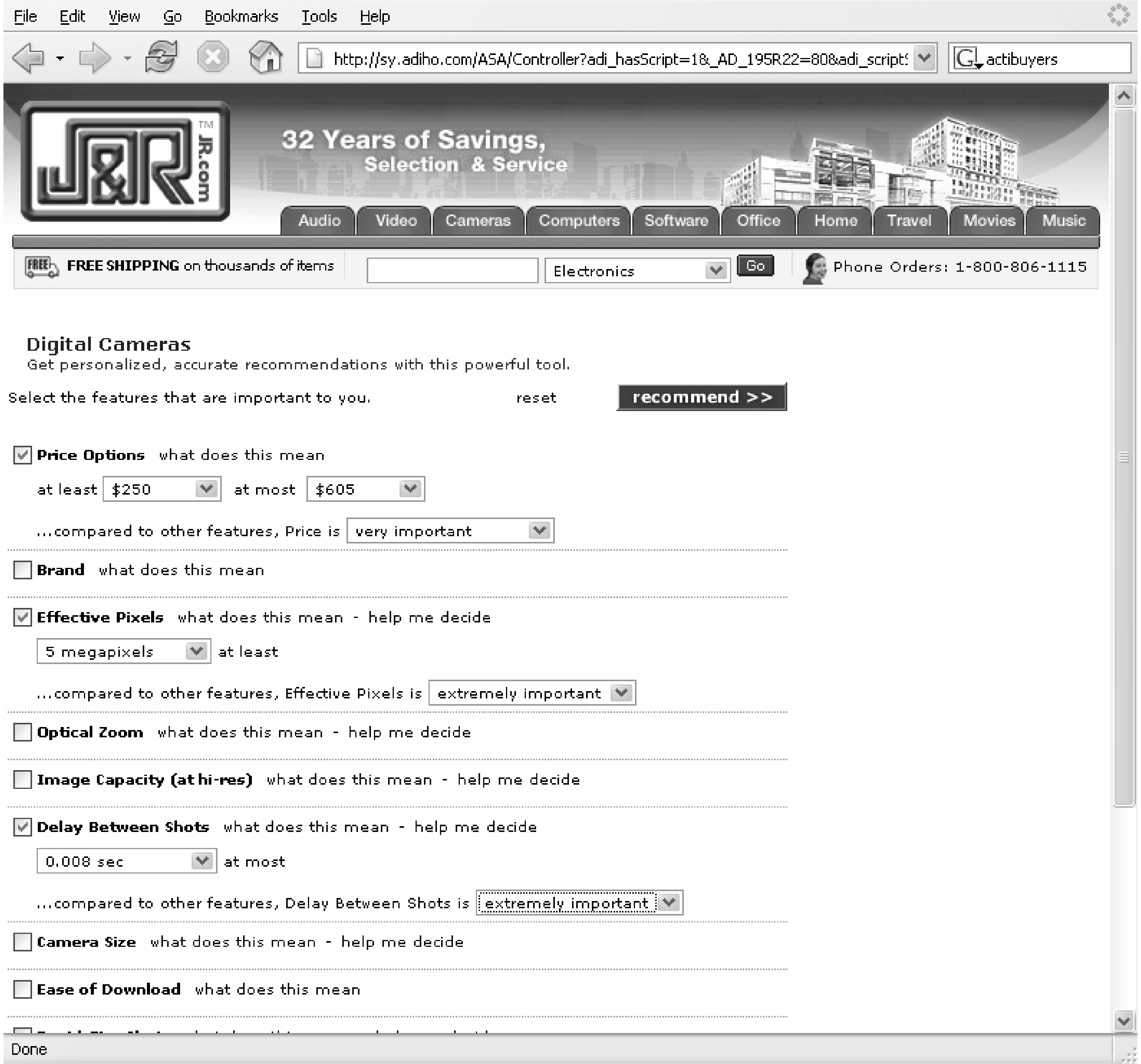
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J&R JR.com
32 Years of Savings,
Selection & Service
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Digital Cameras
Get personalized, accurate recommendations with this powerful tool.
Select the features that are important to you.
reset
recommend >>
Price Options what does this mean
at least $250 at most $605
...compared to other features, Price is very important
Brand what does this mean
Effective Pixels what does this mean - help me decide
5 megapixels at least
...compared to other features, Effective Pixels is extremely important
Optical Zoom what does this mean - help me decide
Image Capacity (at hi-res) what does this mean - help me decide
Delay Between Shots what does this mean - help me decide
0.008 sec at most
...compared to other features, Delay Between Shots is extremely important
Camera Size what does this mean - help me decide
Ease of Download what does this mean
Done

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http://rome-hotels.tripadvisor.com/ShowUserReviews-g187791-d239263-r2696664-Hotel_Santa_Maria-Rome_Lazio.html

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Reviews of hotels and vacations

Hotel Santa Maria: Deals and Reviews

Home > Europe > Italy > Lazio > Rome > Rome Hotels > Hotel Santa Maria > **User reviews**

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SEARCH

Go

(e.g., Boston hotels, Las Vegas, Paris art museum)

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Read more about Hotel Santa Maria

User reviews (1-5 of 83)

Rome: Hotel Santa Maria: "Great find in Rome"

Date: October 11, 2004
Reviewer: A TripAdvisor User, LONG ISLAND, N.Y.

We LOVED this hotel!It was clean,modern ammenities(great bathroom), friendly staff, and great restaurants in any direction close by! If you're looking for that big lobby kind of hotel, this is not for you! But if you're looking for everything else, look no further!!!

This review is the opinion of a TripAdvisor user and not of TripAdvisor, Inc.

This review was: <least helpful 1 2 3 4 5 most helpful> **Submit rating**

Read more about Hotel Santa Maria >>
Agree? Disagree? **Write your own review of Hotel Santa Maria >>**

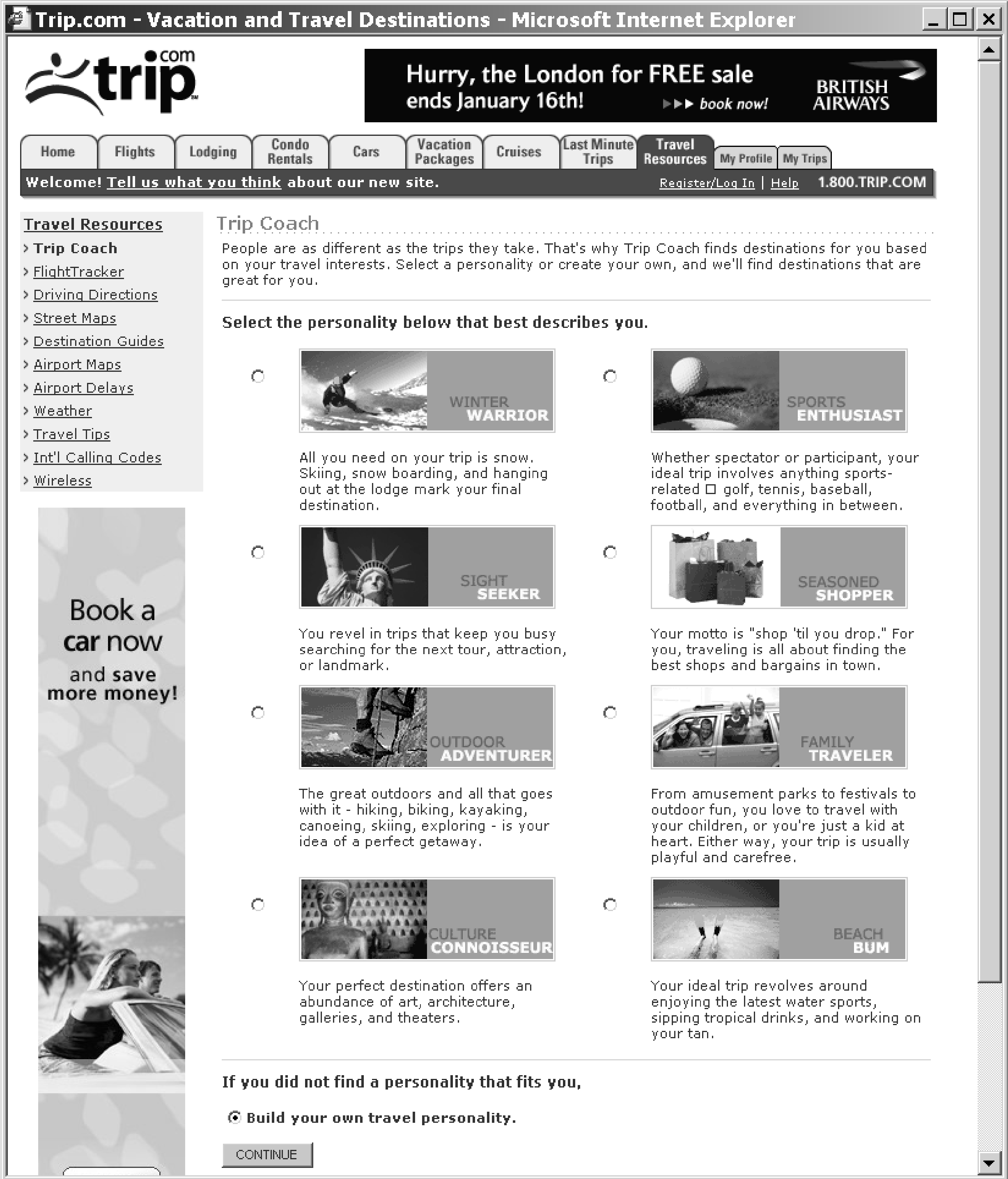
Rome: Hotel Santa Maria: "absolutely wonderful"

Date: October 10, 2004
Reviewer: A TripAdvisor User, Abingdon,Maryland

We just returned from our world wind two weeks in Italy. We started out our trip in Rome and stayed for four nights at the lovely Hotel Santa Maria. I cannot write enough positive things about this place. The grounds are lovely, the rooms very nice and the staff could not have been more helpful, courteous and friendly. Out of all the lodging we stayed at in Italy this one has ranked number one. After many long hours in Rome it was heavenly to return to such an incredible place every evening. The breakfast was also delicious.

Done

Trip.com



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People are as different as the trips they take. That's why Trip Coach finds destinations for you based on your travel interests. Select a personality or create your own, and we'll find destinations that are great for you.
Select the personality below that best describes you.
WINTER WARRIOR
All you need on your trip is snow. Skiing, snow boarding, and hanging out at the lodge mark your final destination.
SPORTS ENTHUSIAST
Whether spectator or participant, your ideal trip involves anything sports-related □ golf, tennis, baseball, football, and everything in between.
SIGHT SEEKER
You revel in trips that keep you busy searching for the next tour, attraction, or landmark.
SEASONED SHOPPER
Your motto is "shop 'til you drop." For you, traveling is all about finding the best shops and bargains in town.
OUTDOOR ADVENTURER
The great outdoors and all that goes with it - hiking, biking, kayaking, canoeing, skiing, exploring - is your idea of a perfect getaway.
FAMILY TRAVELER
From amusement parks to festivals to outdoor fun, you love to travel with your children, or you're just a kid at heart. Either way, your trip is usually playful and carefree.
CULTURE CONNOISSEUR
Your perfect destination offers an abundance of art, architecture, galleries, and theaters.
BEACH BUM
Your ideal trip revolves around enjoying the latest water sports, sipping tropical drinks, and working on your tan.
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Trip Information
*Required info.
*Departing From
City washington
State District of Columbia
*Departure Month and Year April/2003
*Length of Trip 7 Days
*Number of Travelers
Adults 2
Children 2
Traveling with a group?
Means of Travel Drive
Travel Time (one-way) No Preference Hours
Region to Visit Any Region
Budget Any (meals & lodging, per person/per day)
SHOW RESULTS

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Why This Destination is Good For You - Mi...
Why This Destination is Good For You
Here are the reasons this destination was recommended for you:
Overall Score: 79%
Destination: Central West, FL
Cities in this region: Clearwater
Sarasota
St. Petersburg
Tampa
Departing From: washington, DC
Departure Month: April 2003
Travel Time: Reasonable for 7 day trip by car
Number of Travelers: 2 Adults , 2 Children
Region to Visit: Any
Budget: $102 - $219
(meals & lodging, per person/per day)
Destination Highlights
Based on your interests, this destination is GREAT for:
Wildlife and Zoos
Soccer
Hockey
Baseball
Mountain Biking
Cycling
Swimming
Beaches
Amusement Parks
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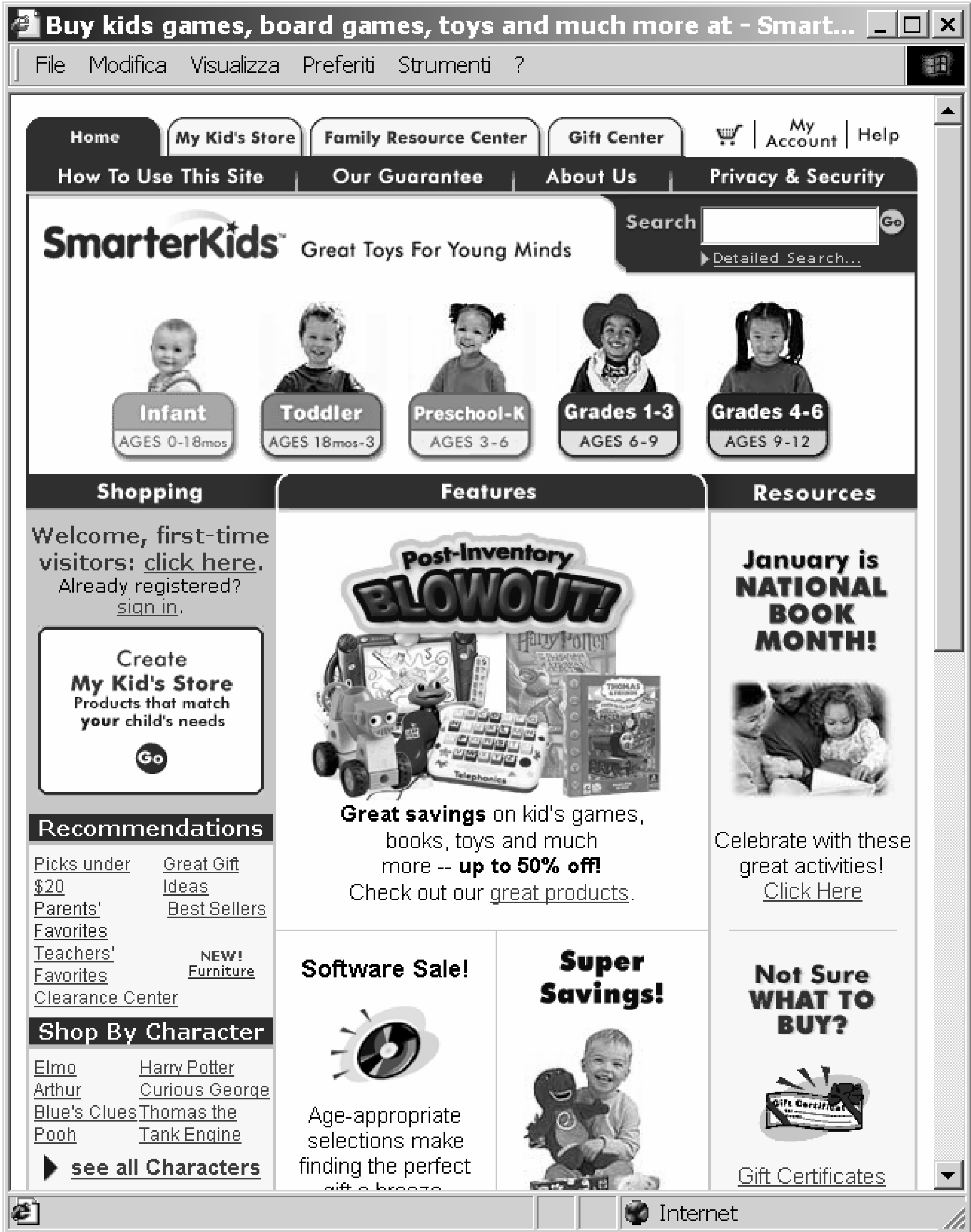
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Tops at the Box Office

1 The Prestige
2 The Departed
3 Flags of Our Fathers
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5 Flicka

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Opening this Week

- Running with Scissors
- Babel
- Saw III
- Tideland
- Catch a Fire
- Death of a President

more

Coming Soon

- Borat: Cultural Learnings of America for Make Benefit Glorious Nation of Kazakhstan
- The Santa Clause 3: The Escape Clause
- Volver
- Flushed Away
- Stranger Than Fiction
- Fur: An Imaginary Portrait of Diane Arbus
- The Return
- A Good Year
- Harsh Times
- Casino Royale

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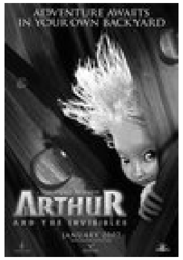

Trailer for *Arthur and the Invisibles*
Trailer for *300*
Trailer for *Charlotte's Web*
Trailer for *Eragon*
Trailer for *Stranger Than Fiction*
Trailer for *For Your Consideration*
Trailer for *Deck the Halls*
Trailer for *Sur's Up*
More Trailers

Today's IMDb Poll Question Is:

Daily Poll

Do you think box office lists should be adjusted for inflation? (Suggested by "rwdaniel") (vote)

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Movie and TV News

Wed 25 October 2006:

Celebrity News

- Holmes & Cruise Confirm Italian Wedding Plans
- Limbaugh Blasts Parkinson's Sufferer Fox for "Acting"
- Madonna and Malawian Authorities Dismiss Father's Claims

Studio Briefing

- 'The Prestige' Works Box Office Magic
- Redstone Defends Cruise Ouster
- Paramount To Provide Films Online Through AOL

Born Today

Wednesday, 25 October 2006:

Billy Barty (1924-2000)

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