



DATA ANALYTICS

Unit 4: Knowledge-Based Recommender System

Jyothi R.

Department of Computer Science
and
Engineering

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.

- knowledge-based recommender systems are appropriate in the following situations:
 1. Customers want to explicitly specify their requirements. Therefore, interactivity is a crucial component of such systems. Note that collaborative and content-based systems do not allow this type of detailed feedback.
 2. It is difficult to obtain ratings for a specific type of item because of the greater complexity of the product domain in terms of the types of items and options available.
 3. In some domains, such as computers, the ratings may be time-sensitive. The ratings on an old car or computer are not very useful for recommendations because they evolve with changing product availability and corresponding user requirements.

Knowledge-based recommender systems types



- Knowledge-based recommender systems can be categorized on the basis of user interactive methodology and the corresponding knowledge bases used to facilitate the interaction.
- There are two primary types of knowledge-based recommender systems:
 1. Constraint-based recommender systems: In constraint-based systems users typically specify requirements or constraints (e.g., lower or upper limits) on the item attributes. Furthermore, domain-specific rules are used to match the user requirements or attributes to item attributes. These rules represent the domain-specific knowledge used by the system.
 2. Case-based recommender systems: In case-based recommender systems, specific cases are specified by the user as targets or anchor points. Similarity metrics are defined on the item attributes to retrieve similar items to these targets. The similarity metrics are often carefully defined in a domain-specific way.

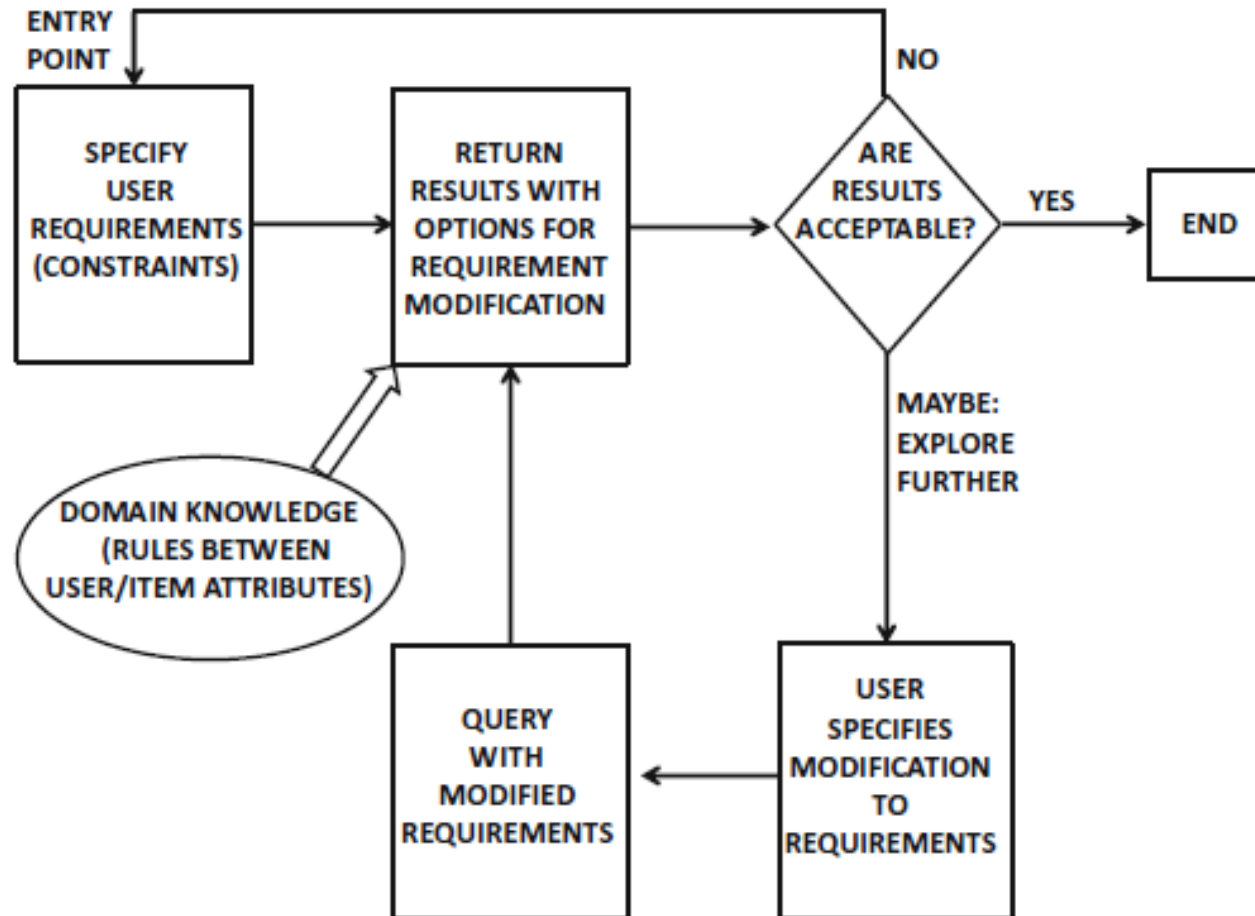
The Conceptual goals of various recommender systems

Approach	Conceptual Goal	Input
Collaborative	Gives us recommendations based on a collaborative approach that leverages the ratings and actions of our peers/myself	User ratings + Community ratings
Content-based	Gives us recommendations based on the content (attributes) we have favored in our past ratings and actions.	User ratings + item attributes + domain knowledge
Knowledge-based	Gives us recommendations based on our explicit specification of the kind of content (attributes) we want	User specification + Item attributes + domain knowledge

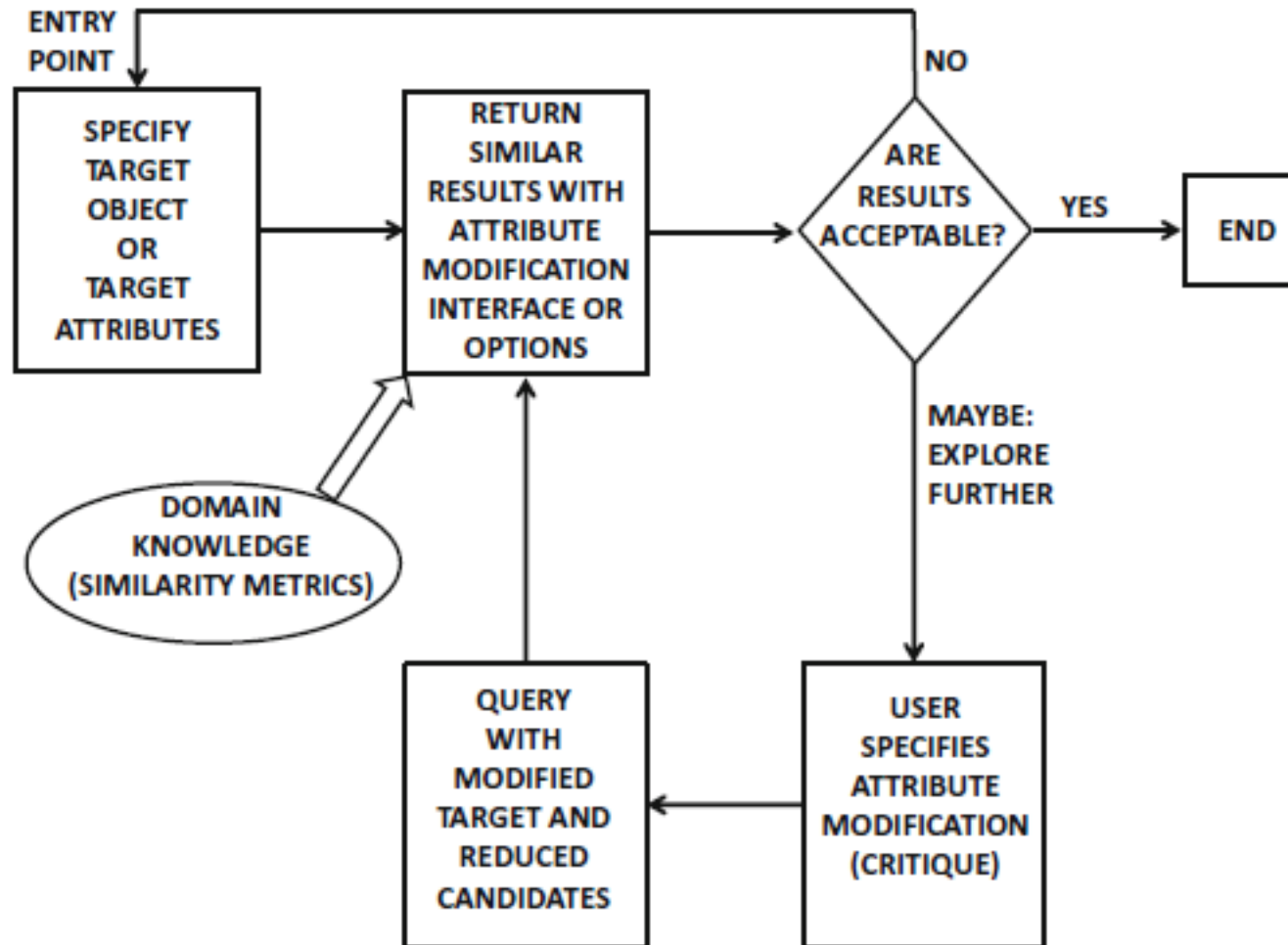
- The Interaction between user and recommender may take the following forms.
1. **Conversational Systems:** The user preferences are determined in the context of a feedback loop. The item domain is complex, and the user preferences can be determined only in the context of an iterative conversational system.
 2. **Search-based systems:** User preferences are elicited by using a preset sequence of questions such as the following;” Do you prefer a house in a suburban area or within the city?”
 3. **Navigation-based recommendation:** The user specifies a number of change requests to the item being currently recommended. Through an iterative set of change requests, it is possible to arrive at a desirable item. Eg. “ I would like a similar house about 5 miles west of the currently recommended house.” Such recommender systems are also referred to as critiquing recommender systems.

- Critiquing recommender systems are naturally designed for case-based recommender systems, because one critiques a specific case in order to arrive at the desired outcome.
- A search-based system can be used to set up user requirements for constraint-based recommenders.

Constraint-based Recommender systems.



Case-based Recommender systems.



Difference between Constraint-based and Case-based Recommender systems.

- In constraint-based systems, specific requirements or constraints are specified by the user.
- The Original query is modified by addition, deletion, modification, or relaxation of the original set of user requirements.
- Users are not in apposition to exactly state their requirements up front in a complex product domain, this problem is partially addressed through a knowledge-base of rules, which map user requirements to product attributes.
- In case-based systems, specific targets or cases are specified.
- Either the target is modified through user interaction, or the search results are pruned through the use of directional critiques.
- This problem is addressed through a conversational style of critiquing.

Knowledge-based recommender systems types

Examples of attributes in a recommendation application for buying homes.

Item-Id	Beds.	Baths	Locality	Type	Floor Area	Price
1	3	2	BTM	Town House	1600	220,000
2	5	2.5	JP	Split-level	3600	973,000
3	4	2	RT	Ranch	2600	630,000
4	2	1.5	MAJESTIC	Condo	1500	220,000
5	4	2	Dollars	Colonial	2700	430,000

- 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, i.e., the set of preferred features for a product
- 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.**

Knowledge-Based Recommender Systems

5

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
- ☐ Backpack
- ☐ Waist pack
- ☒ No preference

I prefer cameras that have an Epinions.com rating of

at least

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

GET RESULTS

I want to spend... [More Info](#)

From \$ up to \$

My camcorder should fit inside a... [More Info](#)

- ☐ Shirt pocket
- ☐ Backpack
- ☐ Waist pack
- ☒ 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

GET RESULTS

I want to spend... [More Info](#)

From \$ up to \$

My preferred brands... [More Info](#)

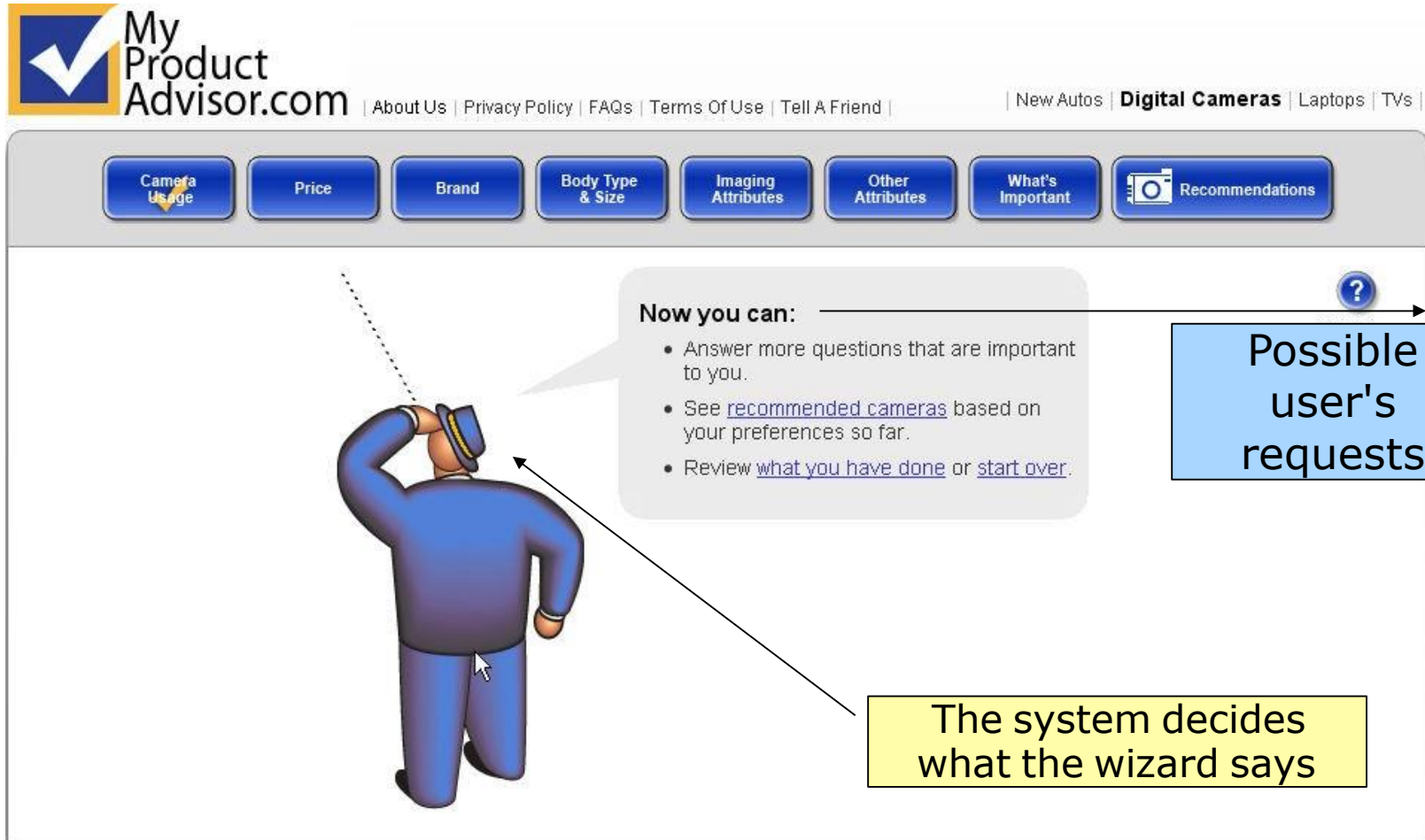
check all -- clear all

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

[more brands...](#)

MORE GUIDANCE

GET RESULTS



The screenshot shows the 'My Product Advisor.com' website. The header includes the site logo, navigation links (About Us, Privacy Policy, FAQs, Terms Of Use, Tell A Friend), and product categories (New Autos, Digital Cameras, Laptops, TVs). A row of buttons allows filtering by Camera Usage, Price, Brand, Body Type & Size, Imaging Attributes, Other Attributes, What's Important, and Recommendations. The main content area features a wizard character and a list of actions the user can take. Annotations highlight the user's requests and the system's decision-making process.

My Product Advisor.com | About Us | Privacy Policy | FAQs | Terms Of Use | Tell A Friend | New Autos | **Digital Cameras** | Laptops | TVs |

Camera Usage | Price | Brand | Body Type & Size | Imaging Attributes | Other Attributes | What's Important | Recommendations

Now you can:

- Answer more questions that are important to you.
- See [recommended cameras](#) based on your preferences so far.
- Review [what you have done](#) or [start over](#).

Possible user's requests

The system decides what the wizard says





Welcome to VACATIONCOACH.COM - TRAVEL PLANNING AS UNIQUE AS YOU - Mic...

File Modifica Visualizza Preferiti Strumenti ?

Indietro Cerca Preferiti Cronologia

Indirizzo <http://www.vacationcoach.com> Vai Collegamenti

BE A MEMBER! : WHY JOIN? : HOW DOES THIS WORK? : ABOUT VACATIONCOACH : FAQs : MEMBERS LOG-IN : HOME

If you liked Paris and Vicinity, you'll probably like these destinations as well:

MATCH	DESTINATION	FIND OUT MORE
88%	New York City, NY	more
87%	Berlin	more
87%	London	more
85%	Greater Montreal, QC	more
85%	Beijing	more
83%	Washington D.C.	more
83%	Philadelphia and Lehigh Valley, PA	more
83%	Chicagoland Region, IL	more
83%	Hesse (Frankfurt and Vicinity)	more
82%	Greater Boston, MA	more

[*BACK TO TOP](#)

Want to try Someplace Similar with a different destination? [Click here](#).

© VacationCoach Inc., 2000, 2001. All rights reserved.

Operazione completata Internet



Welcome to VACATIONCOACH.COM - TRAVEL PLANNING AS UNIQUE AS YOU - Micro...

File Modifica Visualizza Preferiti Strumenti ?

Indietro → → → → → Cerca Preferiti Cronologia

Indirizzo <http://www.vacationcoach.com> Vai Collegamenti

BE A MEMBER! WHY JOIN? HOW DOES THIS WORK? ABOUT VACATIONCOACH FAQs MEMBERS LOG-IN HOME

VACATION COACH .COM
TRAVEL PLANNING AS UNIQUE AS YOU

SOMEPLACE SIMILAR

Overview
YOUR PROS
YOUR CONS
NOTEWORTHY
EVENTS
DINING
LODGING
GETTING THERE

SOMEPLACE SIMILAR

ABOUT NEW YORK CITY, NY

SOMEPLACE SIMILAR 1 FIND ME A PLACE LIKE... 2 ABOUT THIS DESTINATION

Recommended for: Culture Creature
Cost: (per person/per day \$364-793
-- meals and lodging)

Overall Score: 99%

why? Find out why we recommended this place for you.

★ Go back to [Find Me a Place Like...](#)

Overview
Where to, Mack? Central Park? You got it. First time to the Big Apple? Well, that's the Manhattan skyline over there -- \$24 in glass beads. The deal of the last millennium, I call it. Then, of course, we have Queens, da Bronx, Staten Island, and Brooklyn, where yours truly was born. In these five boroughs you'll find more landmarks, history, museums, restaurants, shopping, and people than I got problems. Can I name one of each? With my eyes closed. Relax, Mack! It's just a figure of speech. The Empire State Building, The American Museum of Natural History, the Metropolitan Museum of Art, the Carnegie Deli, Bergdorf's, and Sy Glickman. He lives on 86th and Amsterdam. I see you like to be entertained. Well, for you we got theater, nightlife (and I mean all night, Mack), music, and sports. Where? You don't get out much, huh? Ever hear of Broadway, Times Square, Lincoln Center, and the Bronx Bombers? The Yankees. Riiight -- I see your meds are kickin' in. We also got the NFL, NHL, NBA, bocci ball in Little Italy, and ping-pong in Chinatown. Say what? You like multiculturalism? You mean who lives here, right? EV-ER-Y-BOD-Y! Name a country and you have a little piece of New York. OK, my friend, we're here. That'll be 80 bucks. It seems expensive? Welcome to New York, sweetheart!

Principal Cities
New York City



BOOK LODGING **BOOK AIRFARE**

<http://www.vacationcoach.com/visitor/request/recommend/aboutdest.jhtml?tc> Internet

DATA ANALYTICS

Knowledge-Based Recommender Systems

Trip.com - Vacation and Travel Destinations - Microsoft Internet Explorer

 **Hurry, the London for FREE sale ends January 16th!** [book now!](#) 

[Home](#) [Flights](#) [Lodging](#) [Condo Rentals](#) [Cars](#) [Vacation Packages](#) [Cruises](#) [Last Minute Trips](#) [Travel Resources](#) [My Profile](#) [My Trips](#)

Welcome! Tell us what you think about our new site. [Register/Log In](#) | [Help](#) 1.800.TRIP.COM









Travel Resources

- > **Trip Coach**
- > [FlightTracker](#)
- > [Driving Directions](#)
- > [Street Maps](#)
- > [Destination Guides](#)
- > [Airport Maps](#)
- > [Airport Delays](#)
- > [Weather](#)
- > [Travel Tips](#)
- > [Int'l Calling Codes](#)
- > [Wireless](#)

Trip Coach

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.


<input type="radio"/>  WINTER WARRIOR All you need on your trip is snow. Skiing, snow boarding, and hanging out at the lodge mark your final destination.	<input type="radio"/>  SPORTS ENTHUSIAST Whether spectator or participant, your ideal trip involves anything sports-related - golf, tennis, baseball, football, and everything in between.
<input type="radio"/>  SIGHT SEEKER You revel in trips that keep you busy searching for the next tour, attraction, or landmark.	<input type="radio"/>  SEASONED SHOPPER Your motto is "shop 'til you drop." For you, traveling is all about finding the best shops and bargains in town.
<input type="radio"/>  OUTDOOR ADVENTURER The great outdoors and all that goes with it - hiking, biking, kayaking, canoeing, skiing, exploring - is your idea of a perfect getaway.	<input type="radio"/>  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.
<input type="radio"/>  CULTURE CONNOISSEUR Your perfect destination offers an abundance of art, architecture, galleries, and theaters.	<input type="radio"/>  BEACH BUM Your ideal trip revolves around enjoying the latest water sports, sipping tropical drinks, and working on your tan.

If you did not find a personality that fits you,

☐ **Build your own travel personality.**

[CONTINUE](#)

Book a car now and save more money!



TripleHop Technologies - TripMatcher - Microsoft Internet Explorer

File Modifica Visualizza Preferiti Strumenti ?

Indietro Cerca Preferiti Cronologia

Indirizzo <http://www.triplehop.com/Showcase/TripMatcher/searchPa> Vai Collegamenti

TECHNOLOGIES

Home Company Solutions Product Demos Clients Partners Press Room Contact Us

Overview
Technology
Knowledge Management
Recommendation Engines

Wednesday, September 26, 2001

TripMatcher™

Welcome to TripMatcher™, the Web's first vacation advisor. We have researched all the major resorts for you. Answer a few simple questions, and we'll suggest the ski resort that best matches your preferences.

No time to answer ? Click here ...

Activities

What do you enjoy?

- ☒ Adventure Sports
- ☒ Relaxing
- ☐ Dining Out
- ☐ Leisure Activities
- ☐ Nightlife
- ☐ Shopping
- ☐ Sights & Culture
- ☐ Theme Parks & Zoos
- ☐ Water Sports
- ☐ Winter Sports

Optional Criteria

You may refine your search.

- ☒ Avoid Crowded Destinations
- ☐ Avoid Jet Lag
- ☐ Choose Weather Conditions
- ☐ Good Safety Conditions
- ☐ Improve A Foreign Language
- ☐ Select A Specific Environment
- ☐ Set A Budget
- ☐ Specify A Region
- ☐ Traveler Support
- ☐ Traveling With Companions

Timing

When are you leaving?

Late November

How long will you be gone?

One Week

Departure City

Please choose your gateway.

Washington Dc

Search by Destination

Operazione completata

Internet

TripleHop Technologies - TripMatcher - Microsoft Internet Explorer

File Modifica Visualizza Preferiti Strumenti ?

Indietro Cerca Preferiti Cronologia

Indirizzo <http://www.triplehop.com/Showcase/TripMatcher/search> Vai Collegamenti

TRIPLEHOP
TECHNOLOGIES

Home Company Solutions Product Demos Clients Partners Press Room Contact Us

Wednesday, September 26, 2001

Tell us more !


Give us a better idea about what you like. Feel free to skip any question, but the more you tell us, the better our recommendation will be.

Knowledge Management

- Management Consulting
- Financial Services
- Media
- Legal
- Other Industries

Knowledge Management

- Travel
- Retail
- Employment

 Search by Destination

Adventure Sports

Any favorite adventure sports?

- ☐ Children's Adventure Sports
- ☒ Hiking
- ☐ Mountain Biking
- ☐ Paragliding
- ☐ Rock Climbing
- ☐ Whitewater Rafting


Relaxing

Which of these do you enjoy?

- ☐ Enjoying Spa Treatments
- ☐ Lying On A Beach
- ☒ Sitting In Cafes
- ☐ Strolling In Parks
- ☐ Watching Sports

Save Your Preferences

Email Address :

Search 

Internet

TripleHop Technologies - TripMatcher - Microsoft Internet Explorer

File Modifica Visualizza Preferiti Strumenti ?

Indietro Cerca Preferiti Cronologia

Indirizzo <http://www.triplehop.com/Showcase/TripMatcher/resultPage.asp> Vai Collegamenti

TRIPLEHOP
TECHNOLOGIES

Home Company Solutions Product Demos Clients Partners Press Room Contact Us

Wednesday, September 26, 2001

We found **15** matches for you. To read more or book a vacation, please click on the destination name or the picture.

1. Monterey Bay - California **70%**

Like the Pacific Ocean that runs up and down the **Monterey Bay** and Big Sur coastline, it's almost impossible to define and contain this area. There are many towns, each with a distinct flavor. Monterey, with its seal, sea otter, and whale fille ...more

(Flying time : 5 hours)

★★★★★ Sitting In Cafes ★★★★★ Hiking

2. Salem And The North Shore - Massachusetts **68%**

Imagine for a moment that you could disintegrate yourself, Willy Wonka or Star Trek style, into little bits, and then transplant yourself whole onto the pages of your favorite New England coffee table book...
...Right ...more

(Flying time : 2 hours)

★★★★★ Sitting In Cafes ★★★★★ Hiking

3. Marin County - California **67%**

Often dubbed the "Bay Area's Backyard," **Marin County** is an area of recreational and geographic diversity. It is worth visiting for its location alone, as it is bordered by the Pacific Ocean, the Golden Gate Bridge, the San Francisco Bay, and Wine County. ...more

(Flying time : 7 hours)

★★★★★ Sitting In Cafes ★★★★★ Hiking

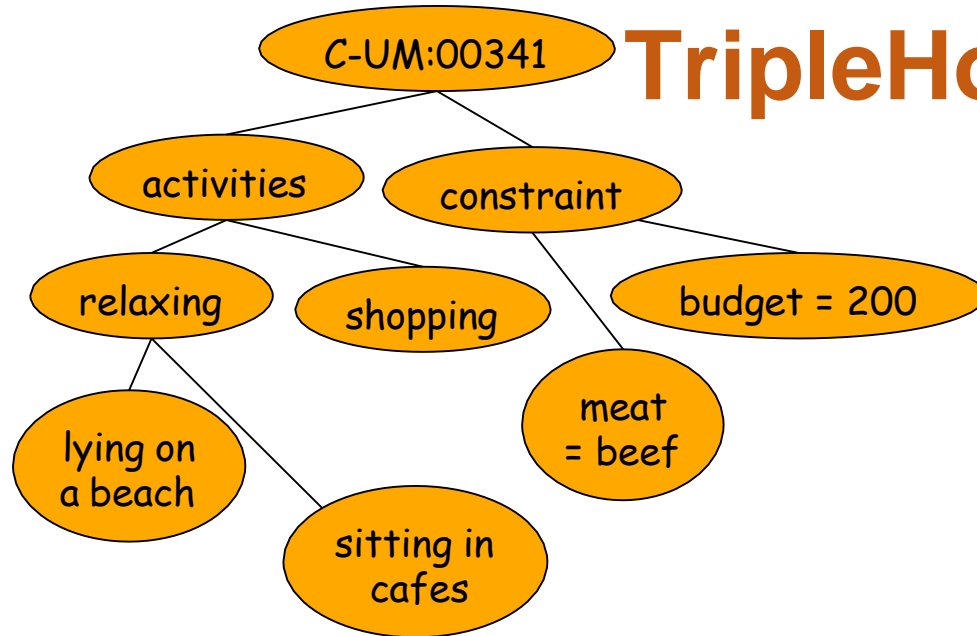
Search by Destination

Internet

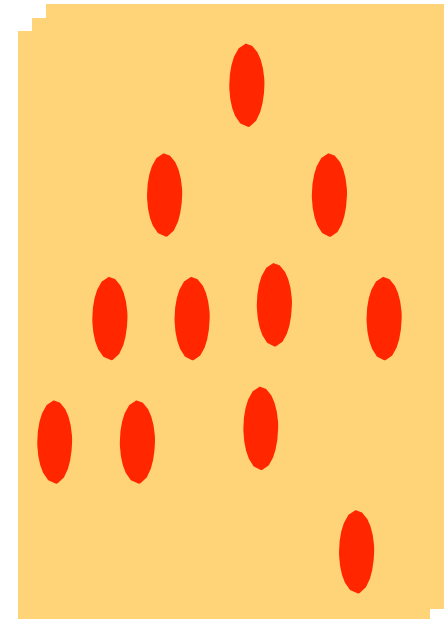
Example: TripleHop

Matching in TripleHop

Catalogue of Destinations

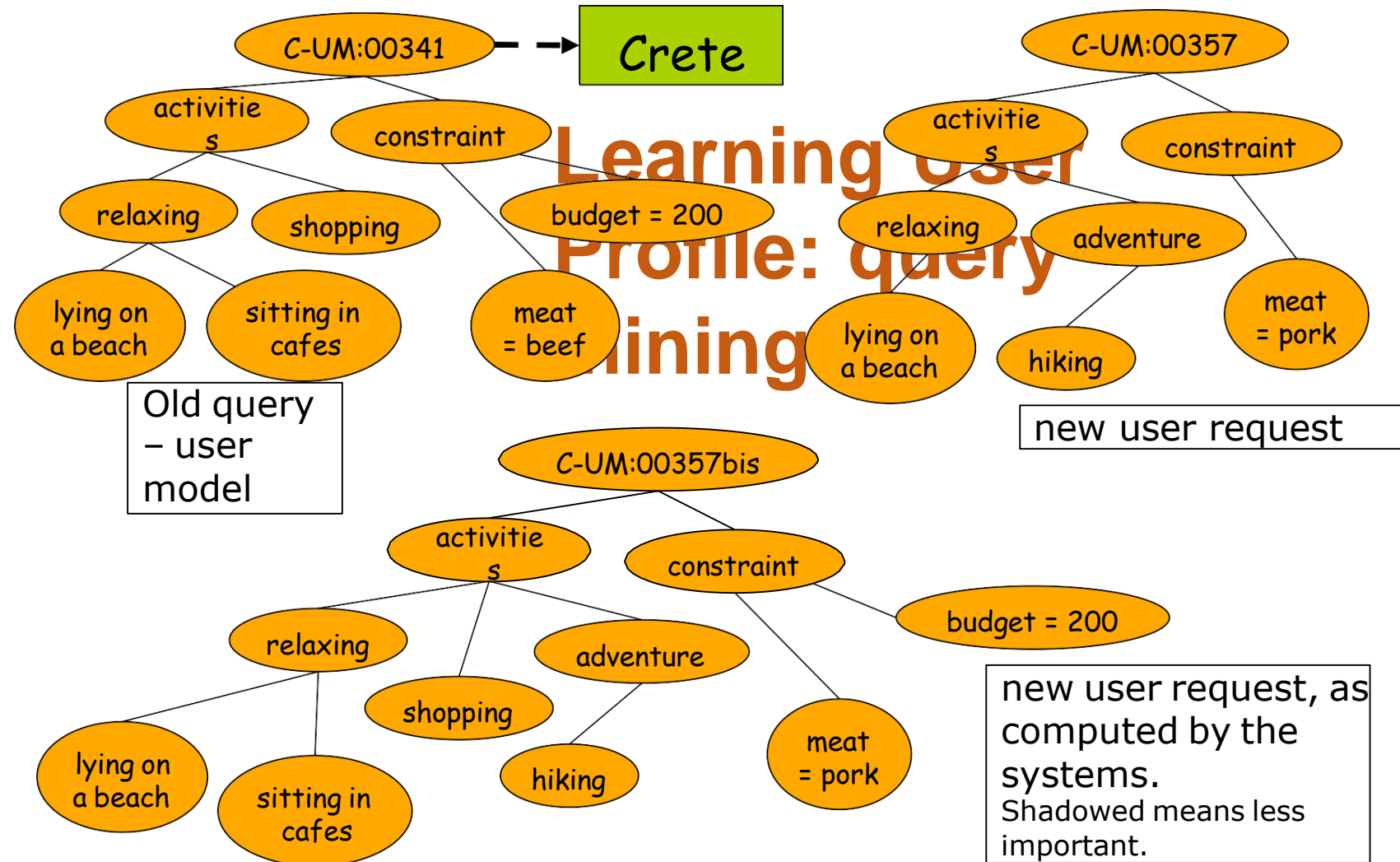


matching



TripleHop and Content-Based RS

- The content (destination description) is exploited in the recommendation process
- A classical Content-Based method would have used a “simpler” content model ,e.g., keywords or TF-IDF
- Here a more complex **knowledge structure** – a tree of concepts – is used to model the product (and the query)
- The query is the user model and it is acquired every time the user asks for a new recommendation - (not exactly, more details later)
- Stress on ephemeral needs rather than building a persistent user model
- Typical in Knowledge-Based RS, they are more focused on ephemeral users – because Collaborative Filtering and Content-Based methods cannot cope with that users.



Query Augmentation

- Personalization in search is not only “information **filtering**”
- **Query augmentation:** when a query is entered it can be compared against contextual and individual information to refine the query
- Ex1: If the user is searching for a restaurant and enter a keyword “Thai” then the query can be augmented to “Thai food”
- Ex2: If the query “Thai food” does not retrieve any restaurant the query can be refined to “Asian food”
- Ex3: If the query “Asian food” retrieves too many restaurant, and the user searched in the past for “Chinese” food the query can be refined to “Chinese food”.

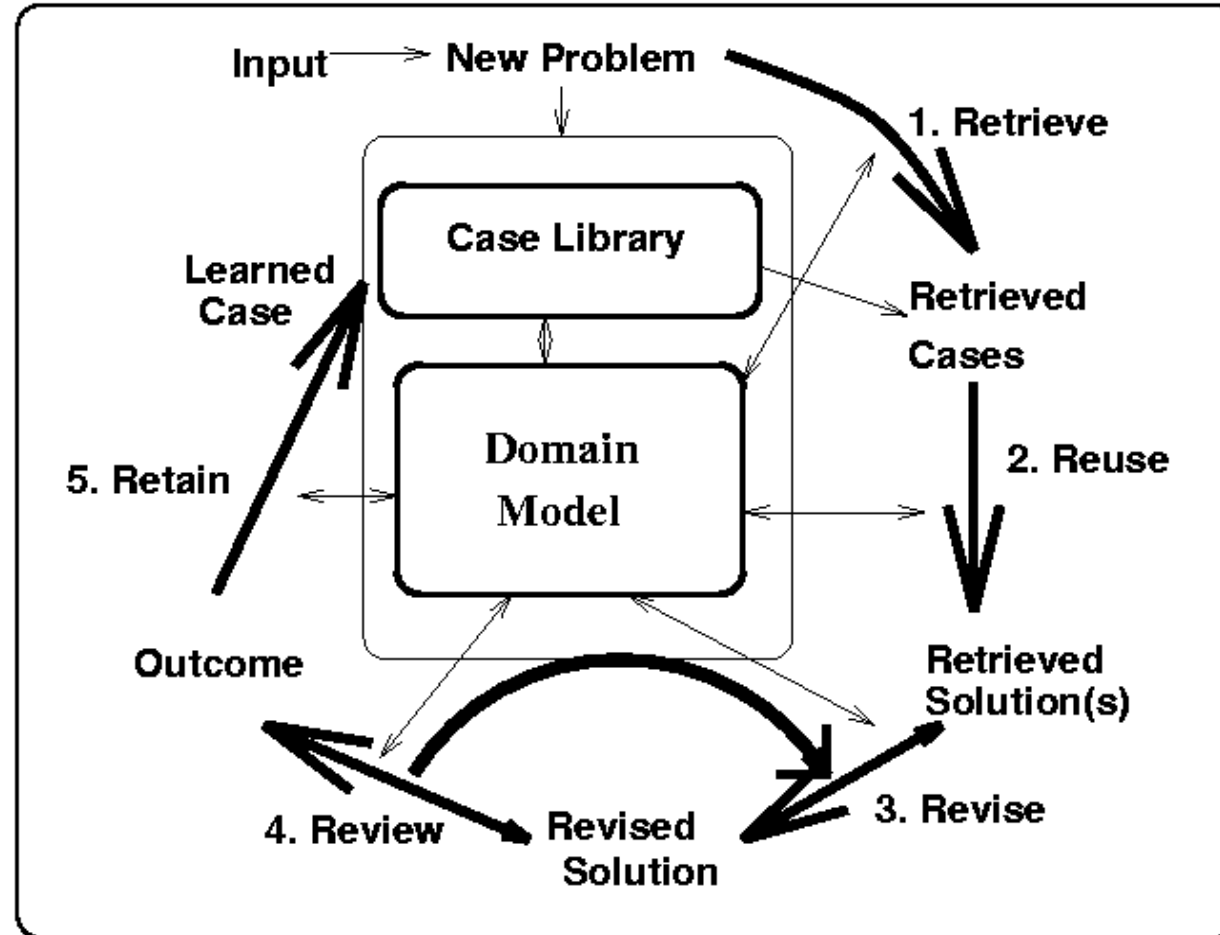
Query Augmentation in TripleHop

1. The current query is **compared** with **previous queries** of the **same user**
2. Preferences expressed in past (similar) queries are identified
3. A new query is built by **combining the short term preferences** contained in the query with the **“inferred”** preferences extracted from the persistent user model (past queries)
4. When the query is matched against an item (destination) if two destinations have the **same degree of matching for the explicit preferences** then the **“inferred”** preferences are used to break the tie
 - This is another example of the **cascade** approach
 - the two combined RS are based on the same knowledge but with two definitions of the user model.

What is Case Based Reasoning ?

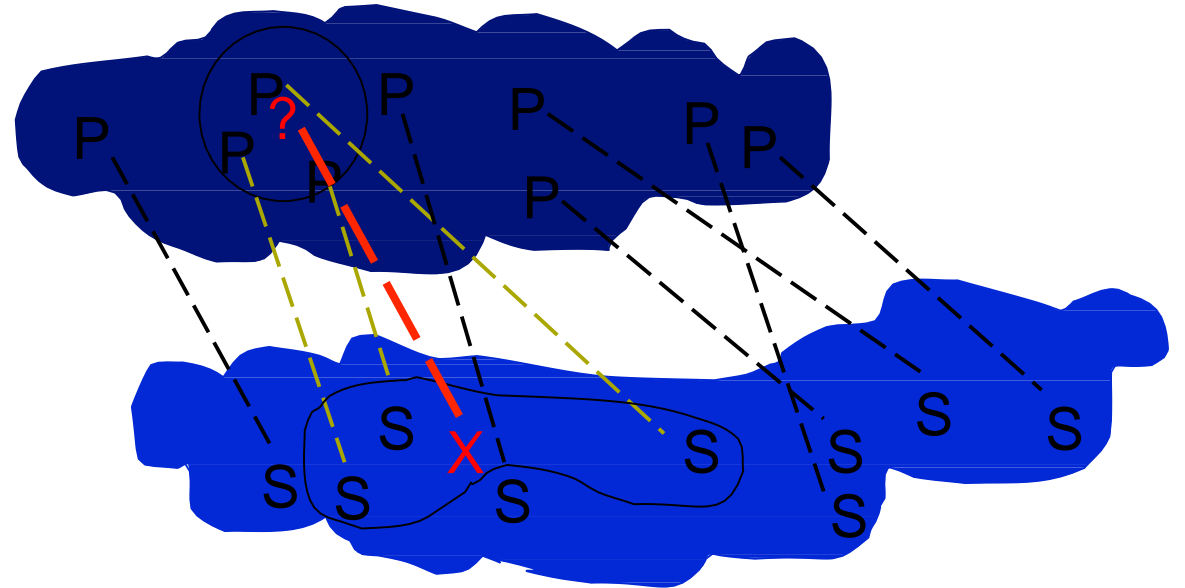
- **A case-based reasoner solves new problems by adapting solutions that were used to solve old problems** (Riesbeck & Shank 1989)
- CBR problem solving process:
- store previous experiences (cases) in memory to solve new problems
- Retrieve from the memory similar experience about similar situations
- Reuse the experience in the context of the new situation: complete or partial reuse, or adapt according to differences
- Store new experience in memory (learning)

Case-Based Reasoning



CBR Assumption

- New problem can be solved by
 - retrieving similar problems
 - adapting retrieved solutions
- Similar problems have similar solutions



Examples of CBR

- Classification: “The patient`s ear problems are like this prototypical case of otitis media”
- Compiling solutions: “Patient N`s heart symptoms can be explained in the same way as previous patient D`s”
- Assessing values: My house is like the one that sold down the street for \$250,000 but has a better view
- Justifying with precedents: “This Missouri case should be decided just like Roe v. Wade where the court held that a state`s limitations on abortion are illegal”
- Evaluating options: “If we attack Cuban/Russian missile installations, it would be just like Pearl Harbor”

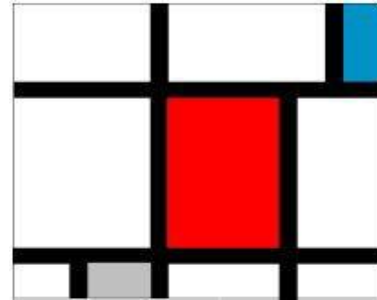
Instance-based learning – Lazy Learning

- One way of solving tasks of approximating discrete or real valued target functions
- Have training examples: $(x_n, f(x_n))$, $n=1, \dots$
- Key idea:
- just store the training examples
- when a test example is given then find the closest matches
- use the closest matches to guess the value of the target function on the test example.

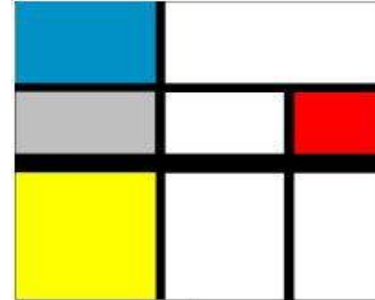
The distance between examples

- We need a **measure of distance** (or similarity) in order to know who are the neighbors
- Assume that we have T attributes for the learning problem. Then one example point x has elements x_t , $t=1, \dots, T$
- The distance between two points x and y is often defined as the **Euclidean** distance:

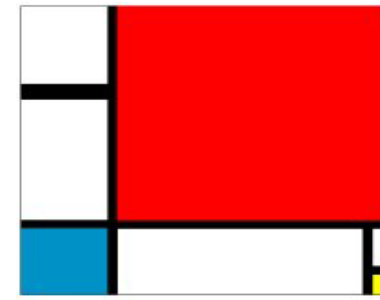
$$d(x, y) = \sqrt{\sum_{t=1}^T [x_t - y_t]^2}$$



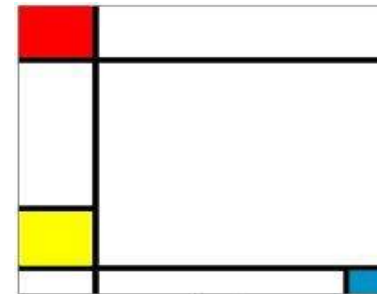
no



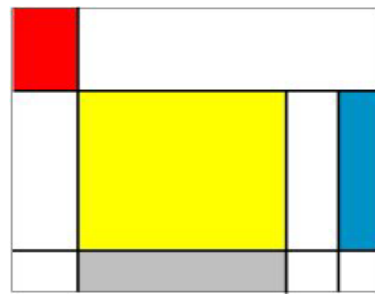
no



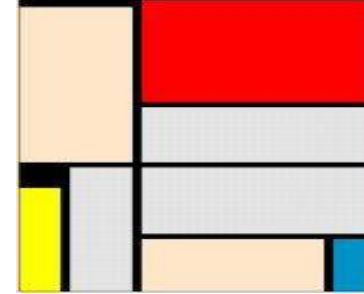
yes



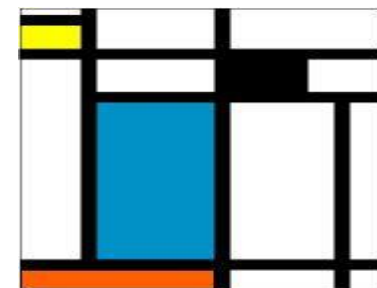
yes



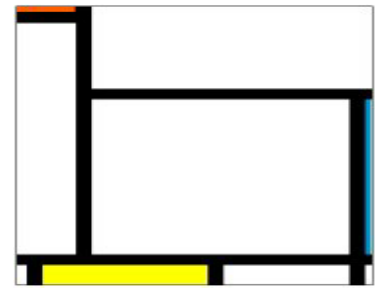
no



yes



no



?

Training data

Number	Lines	Line types	Rectangles	Colours	Mondrian?
1	6	1	10	4	No
2	4	2	8	5	No
3	5	2	7	4	Yes
4	5	1	8	4	Yes
5	5	1	10	5	No
6	6	1	8	6	Yes
7	7	1	14	5	No

Test instance

Number	Lines	Line types	Rectangles	Colours	Mondrian?
8	7	2	9	4	

Knowledge-Based Recommender Systems

	Lines	LinesT	Rect	Colors	Class	Distance to test
Train1	4	2	8	5	no	3,32
Train2	5	2	7	4	yes	2,83
Train3	5	1	8	4	yes	2,45
Train4	5	1	10	5	no	2,65
Train5	6	1	8	6	yes	2,65
Train6	7	1	14	5	no	5,20
test	7	2	9	4		
Train1	-0,32	0,32	-0,11	0,06	no	0,80
Train2	-0,08	0,32	-0,21	-0,28	yes	0,52
Train3	-0,08	-0,16	-0,11	-0,28	yes	0,69
Train4	-0,08	-0,16	0,08	0,06	no	0,77
Train5	0,16	-0,16	-0,11	0,39	yes	0,86
Train6	0,40	-0,16	0,47	0,06	no	0,76
test	0,40	0,32	-0,02	-0,28		

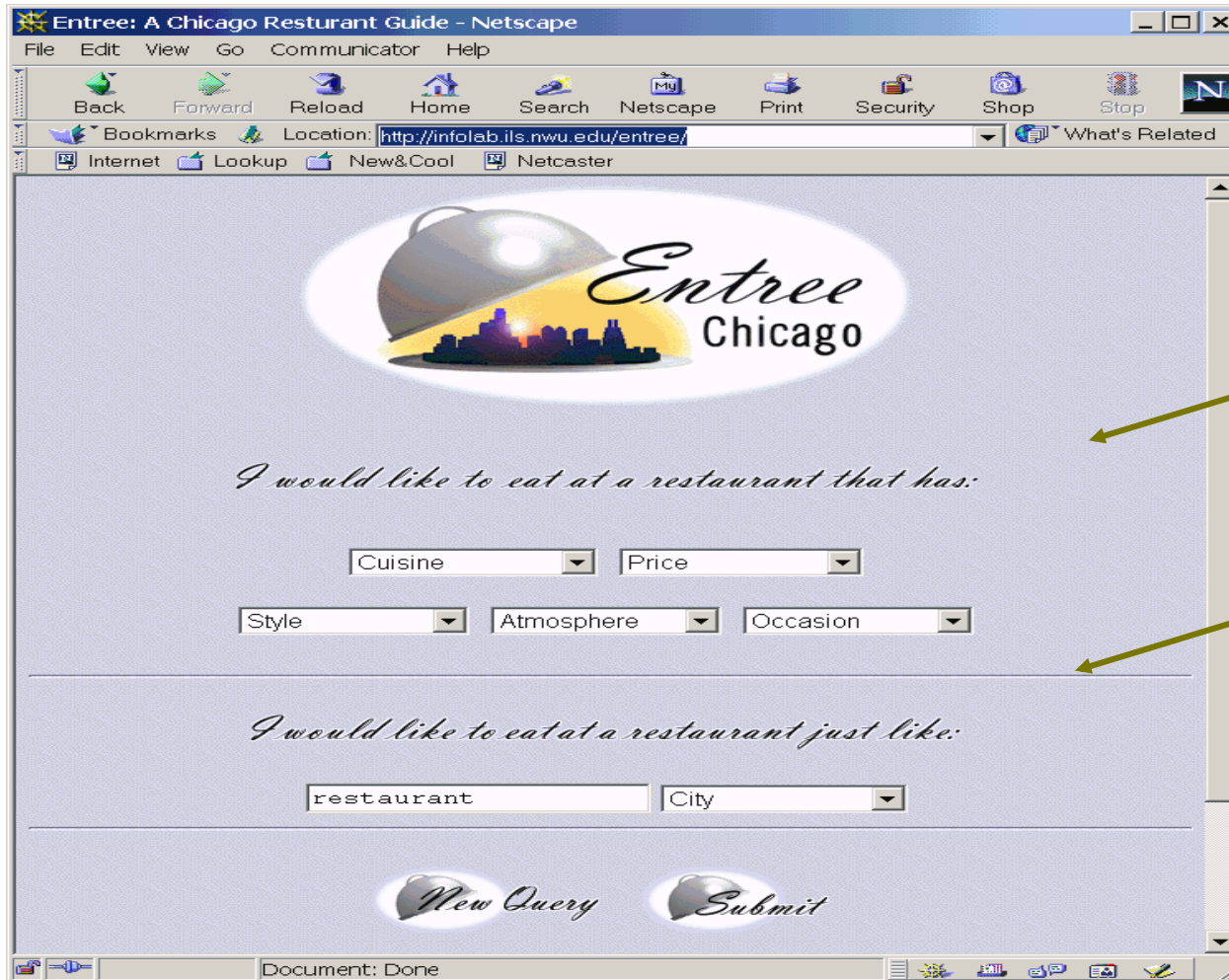
Feature values are not normalized

Feature values are normalized

What is the difference between this feature value normalization and vector Normalization in IR?

$x' = (x - \text{avg}(X)) / 4 * \text{stdev}(X)$, where x is a feature value of the feature X

Example of CBR Recommender System




Entree: A Chicago Restaurant Guide - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Shop Stop

Location: <http://infolab.ils.nwu.edu/entree/>

Internet Lookup New&Cool Netcaster

 Entree Chicago

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:

restaurant City

New Query Submit

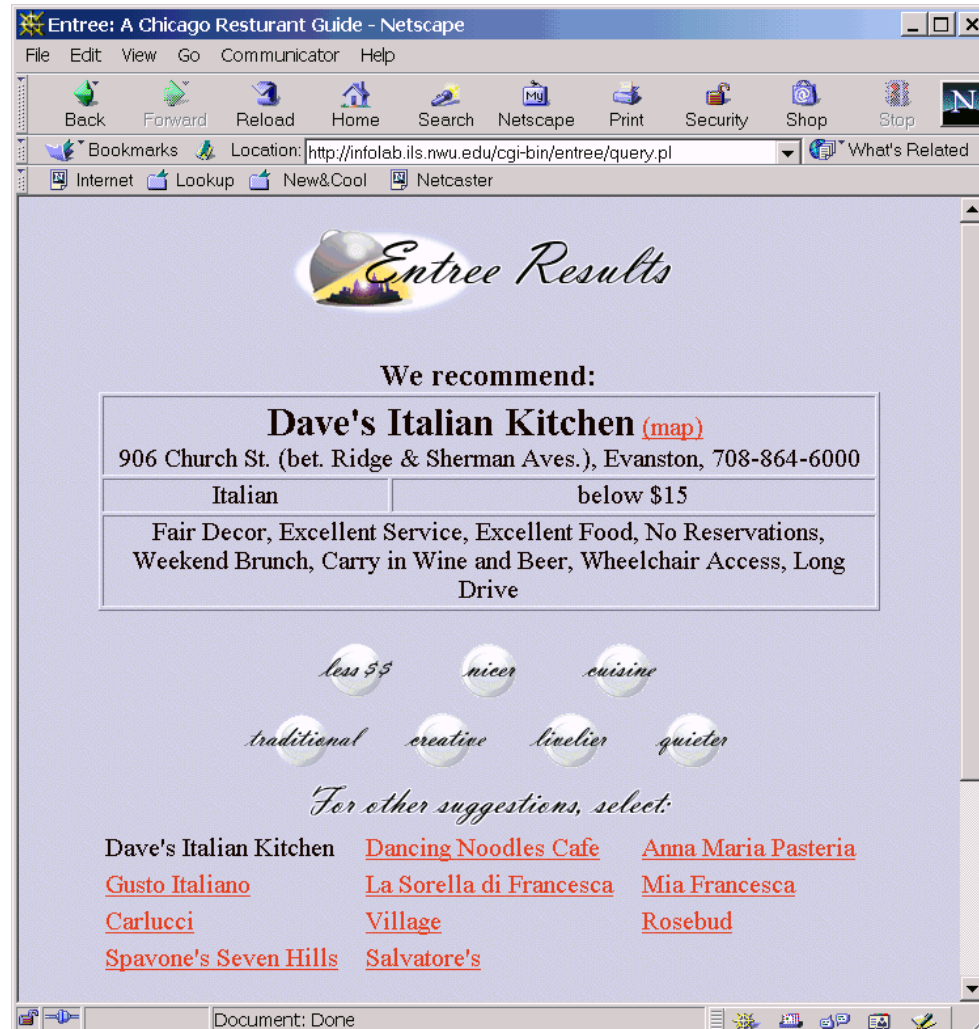
Entree is a restaurant recommender system – it finds restaurants:

1. matching some user goals (case features)
2. or similar to restaurants the user knows and likes

The Product is the Case

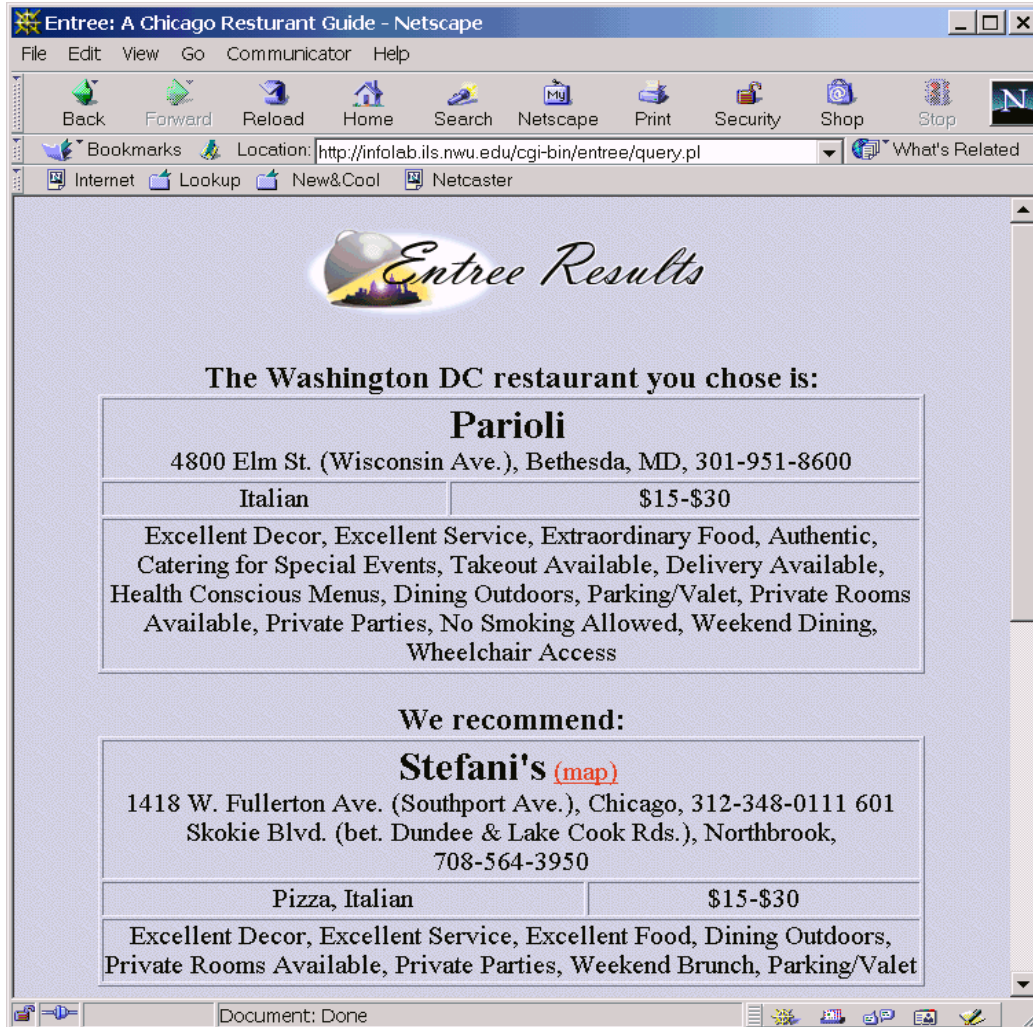
- In Entrée a case is a restaurant – **the case is the product**
- The **problem** component is the description of the restaurant given by the user
- The user will input a partial description of it – this is the only difficulty
- The **solution** part of the case is the restaurant itself – i.e. the name of the restaurant
- The assumption is that the needs of the user can be modeled as the features of the product description

Partial Match



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

Nearest Neighbor



The screenshot shows a Netscape browser window titled "Entree: A Chicago Restaurant Guide - Netscape". The address bar displays the URL "http://infolab.ils.nwu.edu/cgi-bin/entree/query.pl". The browser's toolbar includes buttons for Back, Forward, Reload, Home, Search, Netscape, Print, Security, Shop, and Stop. Below the toolbar, there are links for Bookmarks, Location, and What's Related. The main content area displays "Entree Results" with a logo. It lists "The Washington DC restaurant you chose is: Parioli" with its address, phone number, and a table of details. Below this, it says "We recommend: Stefani's" with its address, phone number, and a table of details. The browser's status bar at the bottom shows "Document: Done".

Entree Results

The Washington DC restaurant you chose is:

Parioli	
4800 Elm St. (Wisconsin Ave.), Bethesda, MD, 301-951-8600	
Italian	\$15-\$30
Excellent Decor, Excellent Service, Extraordinary Food, Authentic, Catering for Special Events, Takeout Available, Delivery Available, Health Conscious Menus, Dining Outdoors, Parking/Valet, Private Rooms Available, Private Parties, No Smoking Allowed, Weekend Dining, Wheelchair Access	

We recommend:

Stefani's (map)	
1418 W. Fullerton Ave. (Southport Ave.), Chicago, 312-348-0111 601 Skokie Blvd. (bet. Dundee & Lake Cook Rds.), Northbrook, 708-564-3950	
Pizza, Italian	\$15-\$30
Excellent Decor, Excellent Service, Excellent Food, Dining Outdoors, Private Rooms Available, Private Parties, Weekend Brunch, Parking/Valet	

Recommendation in Entree

- The system first selects from the database the set of all restaurants that satisfy the largest number of logical constraints generated by considering the input features type and value
- If necessary, implicitly relaxes the lowest important constraints until some restaurants could be retrieved
- Typically the relaxation of constraints will produce many restaurants in the result set
- Sorts the retrieved cases using a similarity metric
 - this takes into account all the input features.

Similarity in Entree

- This similarity metric assumes that the user goals, corresponding to the input features (or the features of the source case), could be sorted to reflect the importance of such goals from the user point of view
- Hence the global similarity metric (algorithm) sorts the products first with respect the most important goal and then iteratively with respect to the remaining goals (multi-level sort)
- Attention: it does not works as a maximization of a Utility-Similarity defined as the sum of local utilities.

Example

Restaurant	Price	Cuisine	Atmosphere
Dolce	10	A	A
Gabbana	12	B	B

- If the user query q is: **price=9 AND cuisine=B AND Atm=B**
- And the weights (importance) of the features is: 0.5 price, 0.3 Cuisine, and 0.2 Atmosphere
- The Entrée will suggest Dolce first (and then Gabbana)
- A more traditional CBR system will suggest Gabbana because the similarities are (30 is the price range):
- $\text{Sim}(q, \text{Dolce}) = 0.5 * (1 - 1/30) + 0.3 * 0 + 0.2 * 0 = \mathbf{0.48}$
- $\text{Sim}(q, \text{Gabbana}) = 0.5 (1 - 3/30) + 0.3 * 1 + 0.2 * 1 = 0.45 + 0.3 + 0.2 = \mathbf{0.95}$

File Edit View Go Bookmarks Tools Help

 Powered by Trip@dvce

Home Travel Plan My Travels My profile FAQs

 > Travel Plan [Are you already registered? Click here.](#)


Please tell us what you'd like to do on this trip. Your answers will help the system to make the best possible recommendations. (The answers you give apply only to this trip. [Why?](#))

Tip: If you'd like to save your travel plans, please [register](#) now.

TRAVEL COMPANIONS	DEPARTURE	ACTIVITIES
Who will you travel with? <input type="text" value="with family"/>	Where are you from? <input type="text" value="Italy"/>	What would you like to do on this trip?
TRANSPORT How will you travel? <input type="text" value="car"/>	PERIOD When do you want to travel? <input type="text" value="August"/>	<input type="checkbox"/> Sports
ACCOMMODATION What kind of accommodations do you want? <input type="text" value="hotel"/>	How long do you want to stay? <input type="text" value="one week"/>	<input type="checkbox"/> Adventure
What's your daily budget (for accommodation)? <input type="text" value="between 20 and 40 €"/>	PREVIOUS VISITS Have you ever visited Trentino? <input type="text" value="a few times"/>	<input checked="" type="checkbox"/> Relaxing
		<input checked="" type="checkbox"/> Art & Culture
		<input type="checkbox"/> Wine and Food
		<input checked="" type="checkbox"/> Environment and Landscape
		<input type="checkbox"/> Fitness and Wellness
		<input type="button" value="NEXT"/>

© 2003 - eCommerce & Tourism Research Lab - ITC - first - All rights reserved
[Webmaster](#)

Done



The screenshot displays the NutKing website, a travel planning tool. The interface includes a navigation bar with links like Home, Travel Plan, My Travels, My profile, and FAQs. A search sidebar on the left allows filtering by altitude and activities. The main content area shows search results for "ARCO" and "TRENTO".

NutKing Powered by Trip@dvce

Home | Travel Plan | My Travels | My profile | FAQs

Locations | Accommodation | Sporting activities | Events | Culture | Maps

Are you already registered? [Click here.](#)

Search

Search by location

Altitude (min-max): m to m

Activities:

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](#)

[Why this recommendation for you?](#)

Alto Garda, Valle di Ledro, Valle dei Laghi

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](#)

[Why this recommendation for you?](#)

Valle dell'Adige, Trento e Monte Bondone

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 way to Rome, kings and ... [more >](#)

javascript:popUp('why.do?travelasset=TRAVELASSET-473&myTaName=ARCO&score=52&type=LOCATION&icodep=50','6...)

Query Tightening




[Home](#)
[Travel Plan](#)
[My Travels](#)
[My profile](#)
[FAQs](#)

[Locations](#)
[Accommodation](#)
[Sporting activities](#)
[Events](#)
[Culture](#)


[Maps](#)

[> Travel Plan > Accommodation](#)

[Are you already registered? Click here](#)

Search

[Suggestions...](#)

Area

Location

Accommodation type

Category

Cost day / person

€ max. €

Number of beds



[Legenda](#)

24 results



I found **24** results that matched your request. Below we suggest ways to modify your request and receive more refined results.


Add "**Cost**" to your query.


Add "**Car park**"  to your query.


Add "**TV**"  to your query.

Skip the refinement

[Get all results](#)

File Edit View Go Bookmarks Tools Help

 Powered by Trip@dvce

Home Travel Plan My Travels My profile FAQs

Locations Accommodation Sporting activities Events Culture Maps

Home > 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](#)

© 2003 - eCommerce & Tourism Research Lab - ITC - Irist - All rights reserved
[Webmaster](#)

Done

Knowledge-Based Recommender Systems



The image shows a screenshot of the NutKing website, which is powered by Trip@dvce. The website has a navigation bar with links to Home, Travel Plan, My Travels, My profile, and FAQs. Below this is a secondary navigation bar with links to Locations, Accommodation, Sporting activities, Events, Culture, and Maps. The main content area is titled "We recommend" and features a sidebar with a "New Travel Plan" link. The recommended travel plans are listed in a table-like format with details such as Description, From, To, Locations, Accommodation, and Sporting activities.

Powered by Trip@dvce

NutKing

Home Travel Plan My Travels My profile FAQs

Locations Accommodation Sporting activities Events Culture Maps

> Travel Plan > Suggested Travels Are you already registered? [Click here.](#)

> [New Travel Plan](#)

We recommend

These are the travel plans we recommend.
We have examined travel plans of users with similar preferences to yourself.
Click on the name for details.

Garda Lake in July

Description:
From 2002-07-01 **To** 2002-07-13
Locations: RIVA DEL GARDA
Accommodation: RESIDENCE SPIAGGIA
Sporting activities: Malga Grassi ; Fraglia Vela Riva

Vacanza in montagna 2002

Description: Con la famiglia nel Primiero
From 2002-09-06 **To** 2002-09-15
Locations: IMER
Accommodation: AL BIVIO
Sporting activities: Passeggiata Passo Rolle e Baita Segantini ; Passo Brocon -Col del Boia e rit.
Culture: Palazzo del Dazio o delle Miniere ; Sentiero Etnografico nell' Ecomuseo del Vanoi ; Castel Pietra ; Museo della Grande Guerra sul Lagorai

TRAVEL 09-12-2002

Description: val di fassa
From 2002-07-01 **To** 2002-07-01
Accommodation: RESIDENCE DOLOMITA
Sporting activities: Pozza-Buffaure-Sela Brunech-Rif. Passo S. Nicolò
Culture: Torre di Pozza ; Molin de Pezol - mulino ad acqua

[New Travel Plan](#)
[Suggested Travels](#)

Suggested Travel Plan

Here's a trip we recommend. If you like you can [save this as your trip](#).


Garda Lake in July

General information	
Name:	Garda Lake in July
Description:	
Start date:	2002-07-01
End date:	2002-07-13
Travel plan preferences	
Travel companions:	with family
Accommodation:	apartment / between 20 and 40 €
Transport:	car
Period:	July
Length of stay:	two weeks
Activities:	Sports Relaxing Whine and Food Environment and Landscape

The travel plan includes:

Locations: RIVA DEL GARDA

Description



In Riva, Lake Garda is particularly charming. The colour blue of the water is more intense, the sunlight more vivid and the air is oxygenated by the mountains and purified by the Lake Garda breeze which blows and fills the coloured sails of the windsurfs. The beaches, surrounded by vegetation or...[more](#)


Services

Museums	Mountain bike	Mountaineering
Hiking	Places of historic interest	Swimming
Windsurfing	Eno-gastronomic events	Canoeing
Classical music	Sailing	
Pop music	Jazz	

[Give us your feedback](#)

Accommodation: RESIDENCE SPIAGGIA

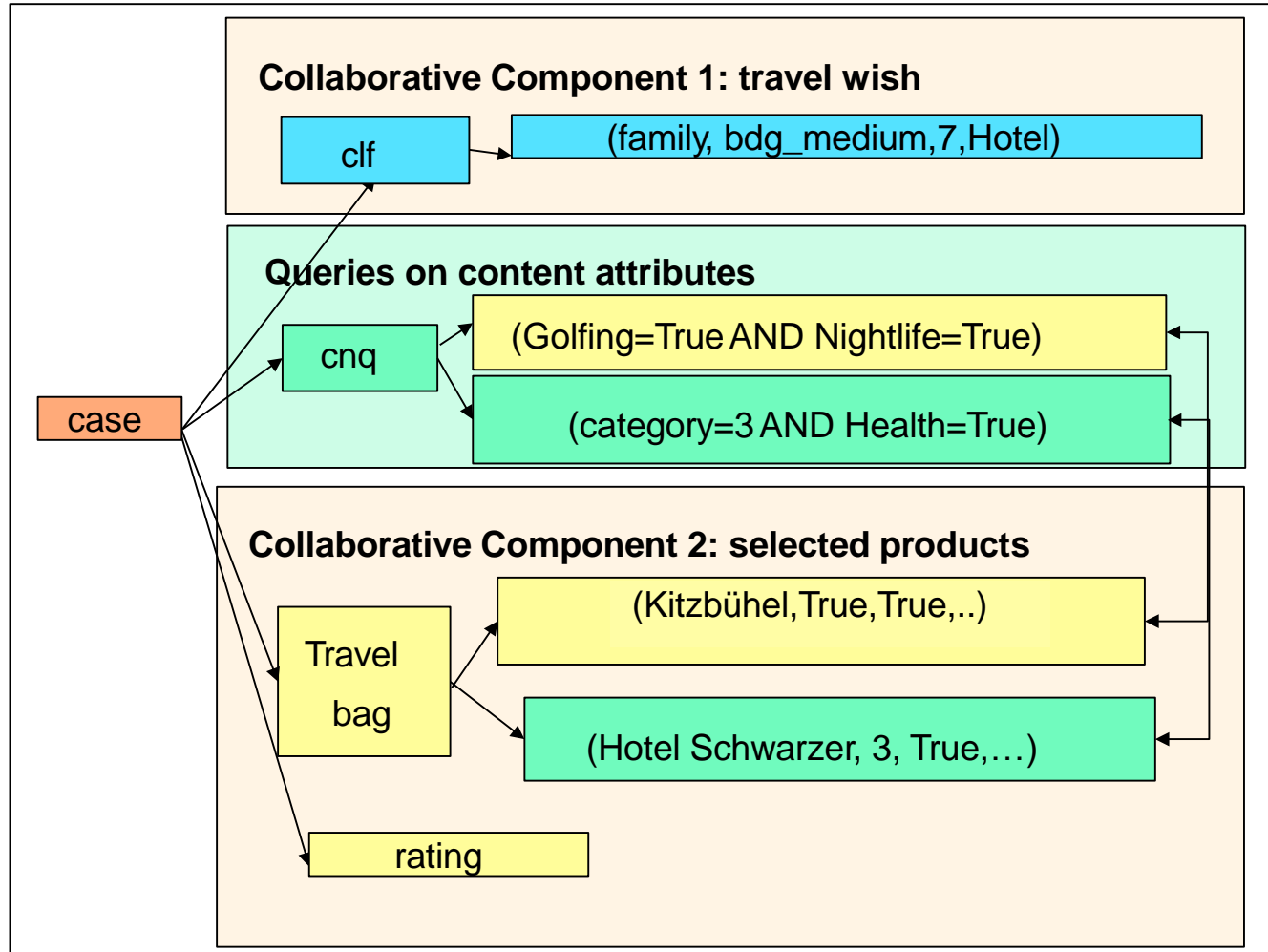
Details




Address:
Telephone:
Fax:
Web: www.rivadelgarda.com/spiaggia
E-mail:
Max Cost: 25 €

NutKing as a CBR System

- **Problem** = recommend a set of tourism related products and build a travel plan
- **Cases** = All the recommended travel plans that users have built using the system (how they were built and what they contain)
- **Retrieval** = search in the memory travel plans built during “similar” recommendation sessions
- **Reuse**
 1. extract from previous travel plans elementary components (items) and use them to build a new plan
 2. rank items found in the catalogues

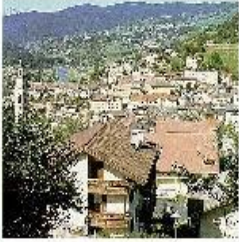


July in Fiemme Valley












Thanks for planning your trip with us. Remember that you can review details of your trip by clicking on My Travels. Bon Voyage! Come back to NutKing soon.

Locations: TESERO


Description

Situated on terraces facing the Lagorai mountain range, Tesero is called the citadel of the Fiemme craftsmanship. This is expressed in various fields, from artistic to productive, and is constantly growing; renowned the musical instruments (organs and pianos), the furniture, doors, sport articles and textiles. Tesero has always been the artistic and cultural centre of Fiemme as evidenced by its very rich history and tradition: churches, shrines, sundials, the frescoes on the old houses. Worth mentioning the important Alpe di Pampeago ski area which is part of the Ski Center Latemar and the Cross Country Ski Centre in Lago di Tesero, the place of the 1991 World Championships and those planned for 2003.

Services

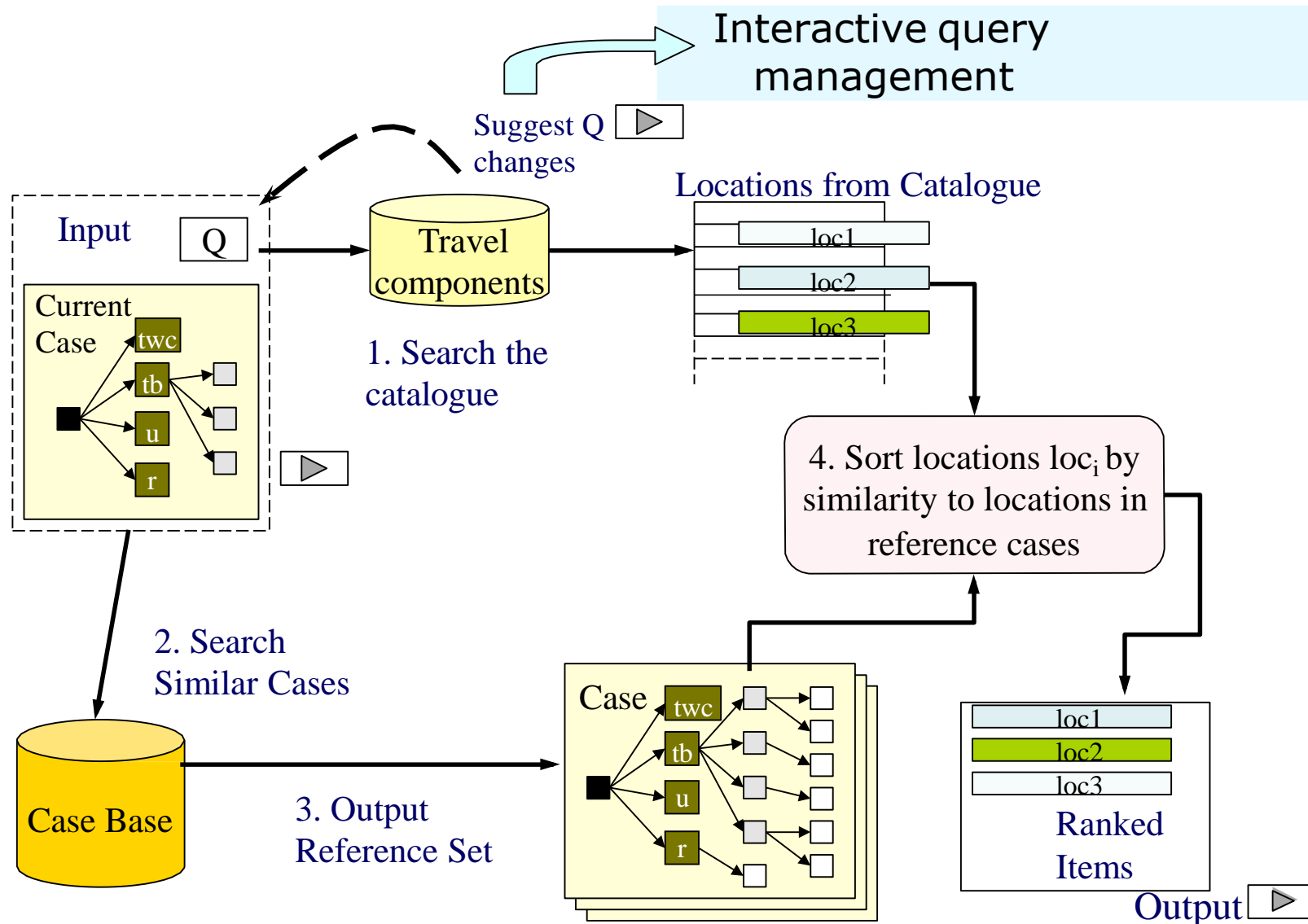
 Downhill skiing	 Cross country skiing	 Snowboarding
 Cycle paths	 Alpine skiing	 Mountaineering
	 Mountain bike	 Horse riding
		 Folklore

Accommodation: POZZOLE

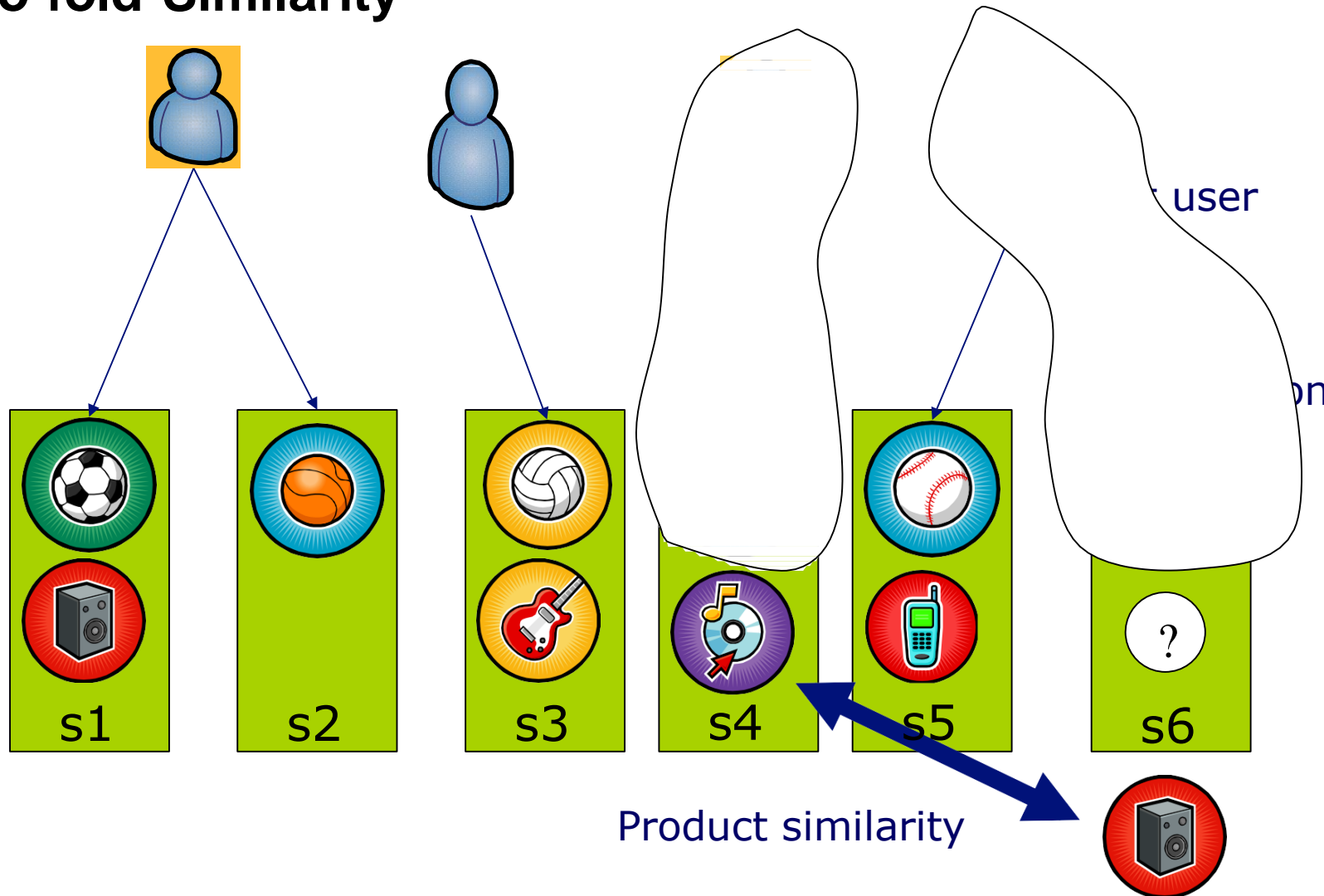
Details

Address: VIA POZZOLE, 8 38038 STAVA
Telephone: 0462813788
Fax: 0462813788
Web:
E-mail:
Max Cost: 32 €

Item Ranking



Two-fold Similarity



Rank using Two-Fold Similarity

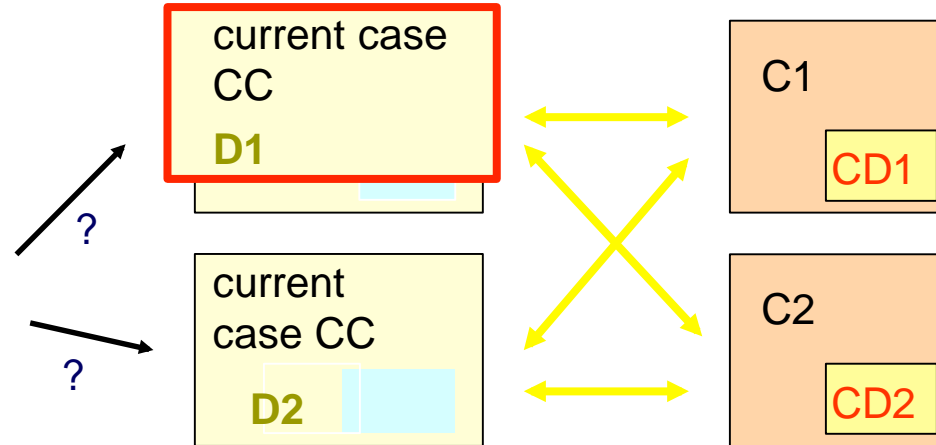
Given the current session case c and a set of retrieved products R (using the interactive query management facility - IQM)

1. retrieve 10 cases (c_1, \dots, c_{10}) from the repository of stored cases (recommendation sessions managed by the system) that are most **similar** to c with respect to the collaborative features
2. extract products (p_1, \dots, p_{10}) from cases (c_1, \dots, c_{10}) of the same type as those in R
3. For each product r in R compute the $\text{Score}(r)$ as the maximum of the product of
a) the similarity of r with p_i , the similarity of the current case c and the retrieved case c_i containing p_i
4. sort and display products in R according to the $\text{Score}(r)$.

Example: Scoring Two Destinations

Destinations
matching the
user's query

D1 D2



similar
cases in
the case
base

$$\text{Score}(D_i) = \text{Max}_j \{ \text{Sim}(\text{CC}, C_j) * \text{Sim}(D_i, \text{CD}_j) \}$$

Sim(CC,C1)	0.2
Sim(CC,C2)	0.6

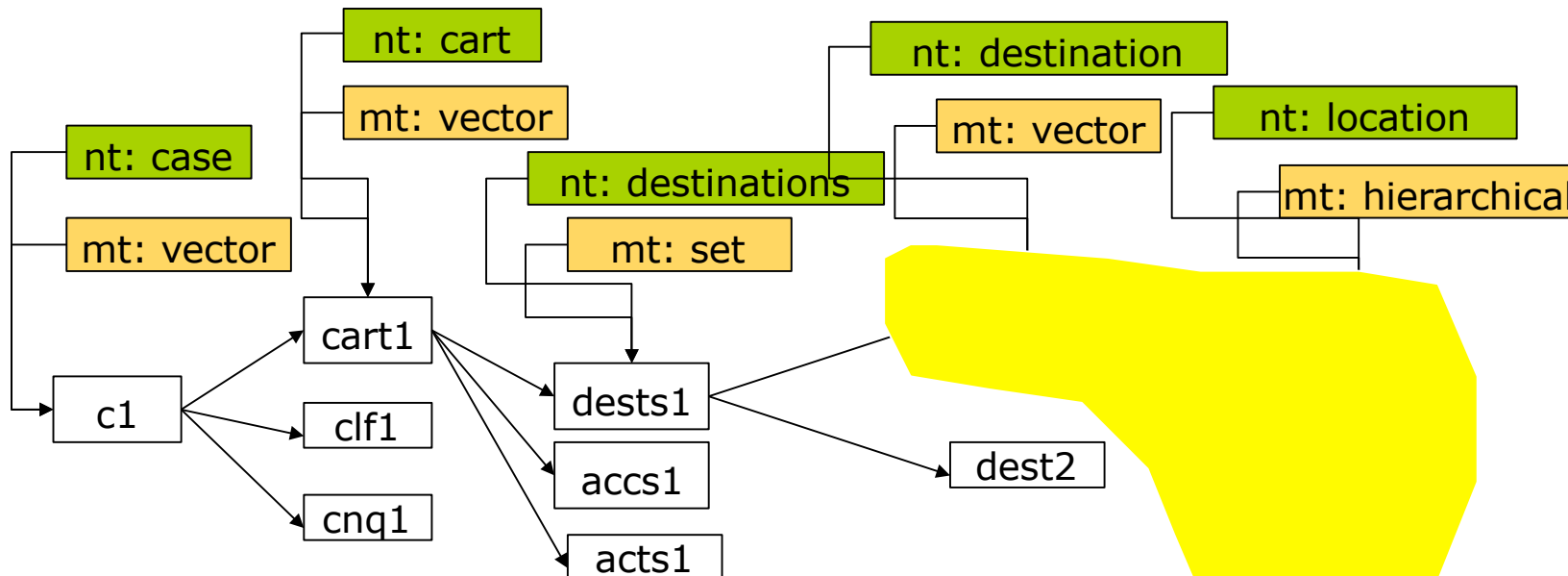
Sim(D1, CD1)	0.4
Sim(D1, CD2)	0.7
Sim(D2, CD1)	0.5
Sim(D2, CD2)	0.3

$$\text{Score}(D1) = \text{Max}\{0.2*0.4, 0.6*0.7\} = 0.42$$

$$\text{Score}(D2) = \text{Max}\{0.2*0.5, 0.6*0.3\} = 0.18$$

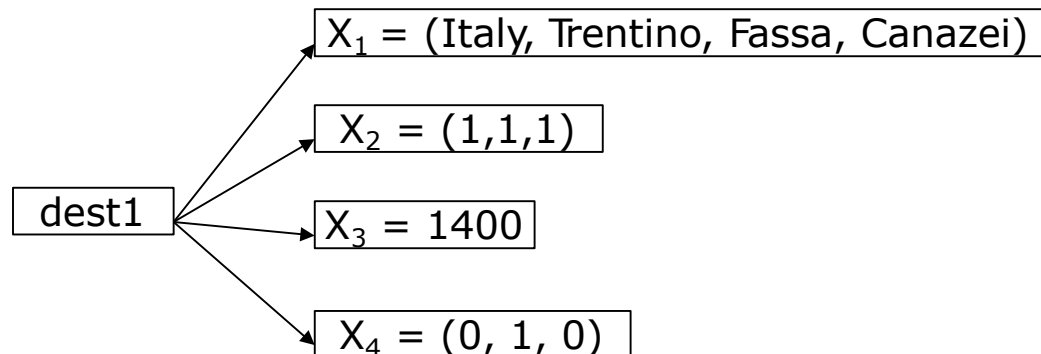
Tree-based Case Representation

- A case is a rooted tree and each node has a:
 - node-type:** similarity between two nodes in two cases is defined only for nodes with the same node-type
 - Metric type:** node content structure - how to measure the node similarity with another node in a second case



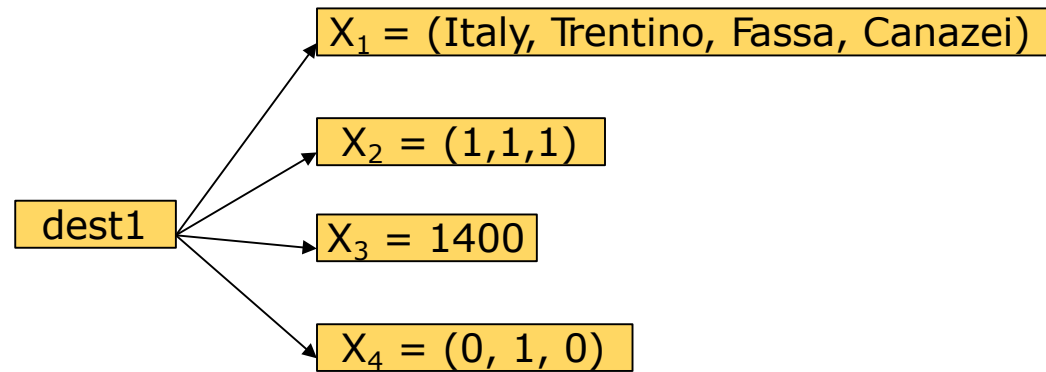
Item Representation

	Node Type	Metric Type	Example: Canazei
X_1	LOCATION	Set of hierarchical related symbols	Country=ITALY, Region=TRENTINO, TouristArea=FASSA, Village=CANAZEI
X_2	INTERESTS	Array of Booleans	Hiking=1, Trekking=1, Biking=1
X_3	ALTITUDE	Numeric	1400
X_4	LOCTYPE	Array of Booleans	Urban=0, Mountain=1, Rivereside=0



Item Query Language

- For querying purposes items x are represented as simple vector features $x = (x_1, \dots, x_n)$



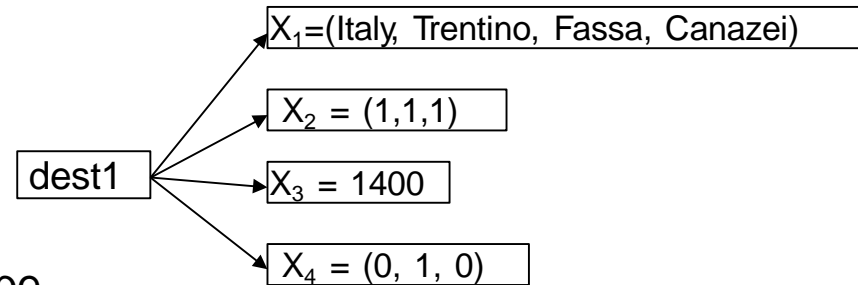
(Italy, Trentino, Fassa, Canazei, 1, 1, 1, 1400, 0, 1, 0)

- A query is a conjunction of constraints over features:

$$q = c_1 \wedge c_2 \wedge \dots \wedge c_m \quad \text{where } m \leq n \text{ and}$$

$$\begin{aligned}
 \clubsuit_k &= \text{true} \text{ if } x_{i_k} \text{ is boolean} \\
 c_k = x_{i_k} &= v \quad \text{if } x_{i_k} \text{ is nominal} \\
 \spadesuit_k \{ x_{i_k} \mid l \leq \cdot \leq u \} & \text{ if } x_{i_k} \text{ is numerical}
 \end{aligned}$$

Item Similarity



If X and Y are two items with same node-type

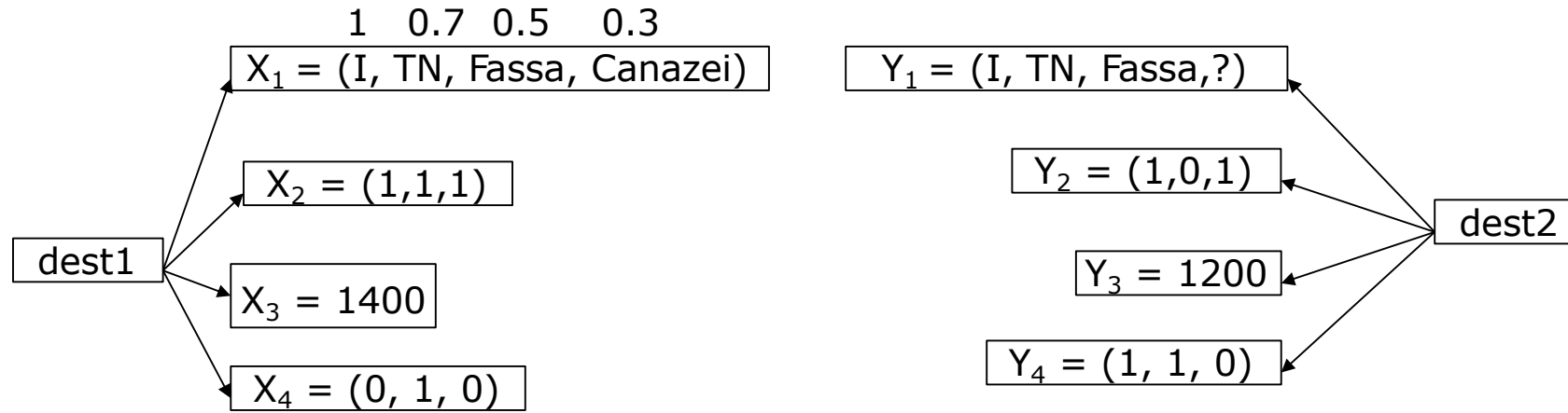
$$d(X,Y) = (1/\sum_i w_i)^{1/2} [\sum_i w_i d_i(X_i, Y_i)^2]^{1/2} \text{ where } 0 \leq$$

$w_i \leq 1$, and $i=1..n$ (number of features).

$$d_i(X_i, Y_i) = \begin{cases} 1 & \text{if } X_i \text{ or } Y_i \text{ are unknown} \\ \text{overlap}(X_i, Y_i) & \text{if } X_i \text{ is symbolic} \\ |X_i - Y_i|/\text{range}_i & \text{if } X_i \text{ is finite integer or real} \\ \text{Jaccard}(X_i, Y_i) & \text{if } X_i \text{ is an array of Boolean} \\ \text{Hierarchical}(X_i, Y_i) & \text{if } X_i \text{ is a hierarchy} \\ \text{Modulo}(X_i, Y_i) & \text{if } X_i \text{ is a circular feature (month)} \\ \text{Date}(X_i, Y_i) & \text{if } X_i \text{ is a date} \end{cases}$$

$$\text{Sim}(X,Y) = 1 - d(X,Y) \quad \text{or} \quad \text{Sim}(X,Y) = \exp(-d(X,Y))$$

Item Similarity Example

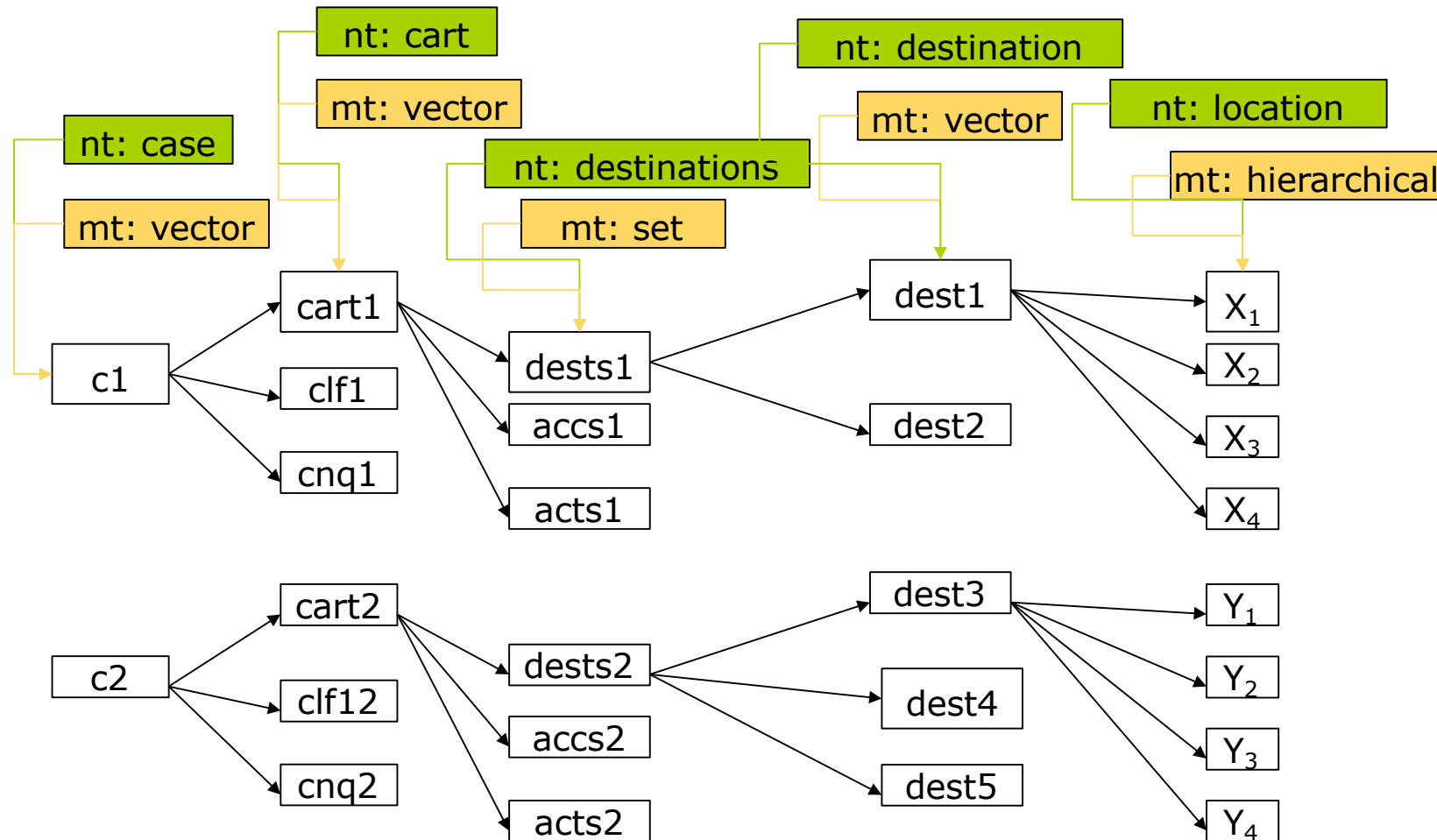


$$\begin{aligned}
 Sim(dest_1, dest_2) &= \exp\left(-\frac{1}{\sqrt{4}} \sqrt{d(X, Y)^2 + \frac{1}{4} + d(X, Y)^2}\right) \\
 &= \exp\left(-\frac{1}{\sqrt{4}} \sqrt{(0.3)^2 + \left(\frac{1}{2} - \frac{2}{3}\right)^2 + \left(\frac{1400 - 1200}{2000}\right)^2 + \left(\frac{1}{2} - \frac{1}{2}\right)^2}\right) \\
 &= \exp\left(-\frac{1}{\sqrt{4}} \sqrt{0.461}\right) = \exp(-0.339) = 0.712
 \end{aligned}$$

3 in the union

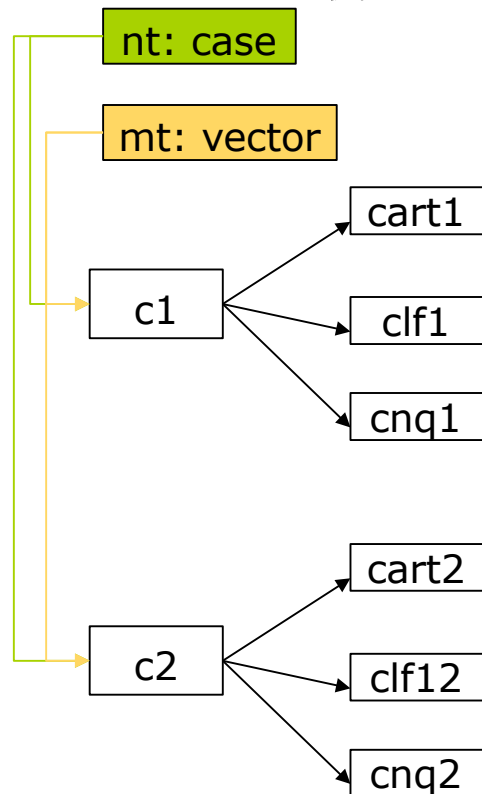
2 in the union

Case Distance



Case Distance

$$d(c_1, c_2) = \frac{1}{\sqrt{\sum_{i=1}^3 W_i}} \sqrt{W_1 d(cart_1, cart_2)^2 + W_2 d(clf_1, clf_2)^2 + W_3 d(cnq_1, cnq_2)^2}$$



CBR Knowledge Containers

1. CBR is a knowledge-based approach to problem solving
2. The knowledge is “contained” into four **containers**
3. **Cases:** the instances belonging to our case base
4. **Case representation language:** the representation language that we decided to use to represent cases
5. **Retrieval knowledge:** the knowledge encoded in the similarity metric and in the retrieval algorithm
6. **Adaptation knowledge:** how to reuse a retrieved solution to solve the current problem.

Conclusions

- Knowledge-based systems exploits knowledge to map a user to the products she likes
- KB systems uses a variety of techniques
- Knowledge-based systems requires a big effort in term of knowledge extraction, representation and system design
- Many KB recommender systems are rooted in Case-Based Reasoning
- Similarity of complex data objects is required often required in KB RSs.
- NutKing is a hybrid case-based recommender system
- The case is the recommendation session.

Questions

1. What are the main differences between a CF recommender system and a KB RS (such as activebuyers.com or Entree)?
2. What is the role of query augmentation?
3. What is the basic rationale of a CBR recommender system?
4. What is a case in a CBR recommender system such as Entree?
5. How a CBR recommender system learns to recommend?
6. What are the knowledge containers in a CBR RS?
7. What are the main differences between a “classical” CBR recommender system such as Entrée and Nutking?
8. What are the motivations for the introduction of the double- similarity ranking method?
9. What are the types of local similarity metrics used in Nutking?

- Suppose you set up a system, where a guided visual interface is used in order to determine the product of interest to a customer. What category of recommender system does this case fall into?
- Discuss a scenario in which location plays an important role in the recommendation process.
- The chapter mentions the fact that collaborative filtering can be viewed as a generalization of the classification problem. Discuss a simple method to generalize classification algorithms to collaborative filtering. Explain why it is difficult to use such methods in the context of sparse ratings matrices.

Text Book:

“Business Analytics, The Science of Data-Driven Making”, U. Dinesh Kumar, Wiley 2017

“Recommender Systems, The text book, Charu C. Aggarwal, Springer 2016 Section 5

DATA ANALYTICS

Image Courtesy



https://www.ics.uci.edu/~welling/teaching/CS77Bwinter12/presentations/course_Ricci/15-KnowledgeBased.pdf

https://www.researchgate.net/publication/331829548_Knowledge_based_Recommendation_System_in_Semantic_Web-A_Survey

<http://www.visitfinland.com/web/guest/travel-planner/home>

https://www.ics.uci.edu/~welling/teaching/CS77Bwinter12/presentations/course_Ricci/15-KnowledgeBased.pdf



THANK YOU

Jyothi R.
Assistant Professor,
Department of Computer Science
jyothir@pes.edu