

# Erabiltzaile-ereduak, moldagarritasuna eta gomendioak

*User models, adaptation, and  
recommendation*

Ainhoa Alvarez, Ana Arruarte, Mikel Larrañaga  
Lengoaia eta Sistema Informatikoak saila

eman ta zabal zazu



Universidad  
del País Vasco

Euskal Herriko  
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# User Models

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Understanding the user

Can be...?: <http://www.google.com/analytics/>

**GETTING TO KNOW THE INDIVIDUAL USER**

# Research topic

- Cross-disciplinary
  - Artificial intelligence, linguistics, human-computer interaction, psychology, philosophy, design...
  - Artificial intelligence perspective
- Parents
  - Seventies: Allen, Cohen and Perrault / Elaine Rich
  - Eighties: Kobsa

# What is a user model?

- A data structure that characterizes a user  $U$  at a certain moment in time
- An internal representation of user characteristics used by a system:
  - As a basis for **adaptation** OR
  - To **predict** user behaviour
  - ...

# What user characteristics

- Demographic information
- User goals and tasks
- User background knowledge
- User interests
- User skills and capabilities
- User traits
- User mood

# What user data can be of relevance

- **Personal data, demographics**
  - Name, address, age, birthday, email address, gender, phone number, credit card information, . . .
  - Education, profession, . . .

Can be used for a rough initial ne-tuning of the interface
- **Contacts and friends**
  - I Friends' personal data, groups and group membership, chatlogs, . . .
- **Social Media**
  - User Ids or User Names for social media (e.g. Skype, Twitter, Facebook, LinkedIn, Xing)
  - Login data (direct or via a token) for accessing the contents of the social media profiles
  - Privacy controls (which data may be retrieved and used)
- **Device Information**
  - System specs, display resolution, network speed and bandwidth, software and tools
- **Location**
  - Position, direction, speed, vehicle, . . .
- **Browsing-History & Bookmarks**
  - Bookmark Folder
  - History
  - Search history
  - Ratings of pages, sites and other objects
  - Learning actions
- **Visited pages**
  - Test scores
  - Number of test attempts
  - Time spent learning
  - . . .
  - And much more

# Types of user models: explicit vs implicit

- **Explicit:** much of the information about the user is added by specific actions on the part of system designers or users
  - Classifying users with respect to a pre-defined set of possibilities (a stereotype)
  - Directly querying the users
  - Allowing the users to modify the system as they wish



# Types of user models: explicit vs implicit

- **Implicit:** built by the system on the basis of the normal interaction
  - Simple facts
  - More sophisticated behaviour (AI techniques)

# Types of user models: short term vs long term

- **Short term**

- Focus on building models that are valid for a specific session or task

- **Long term**

- Focus on building up a user model and maintaining it over a whole series of sessions

# Types of user models: individual vs group

- **Individual models**
  - Store information about a particular user
- **Group models**
  - Represent group of users (e.g. a class of learners)

# Types of user models: empirical vs analytical

- **Empirical** observation about the user
  - Feature-based
  - Stereotype
- **Analytical** models
  - Simulate the user processes that take during permanent interaction with the system

# Analizing Amazon

- 2<sup>nd</sup> task: User model in Amazon
  - What does it know about you?
  - What doesn't it know about you?

# Analizing Amazon

- The Amazon online store recommends items of interest based on (among others)
  - Items that you bought, searched or browsed in the past
  - Items that you recently visited
  - Items that similar users bought, searched or browsed (similar means that there is an overlap between items visited by you and them)

# Analizing Amazon

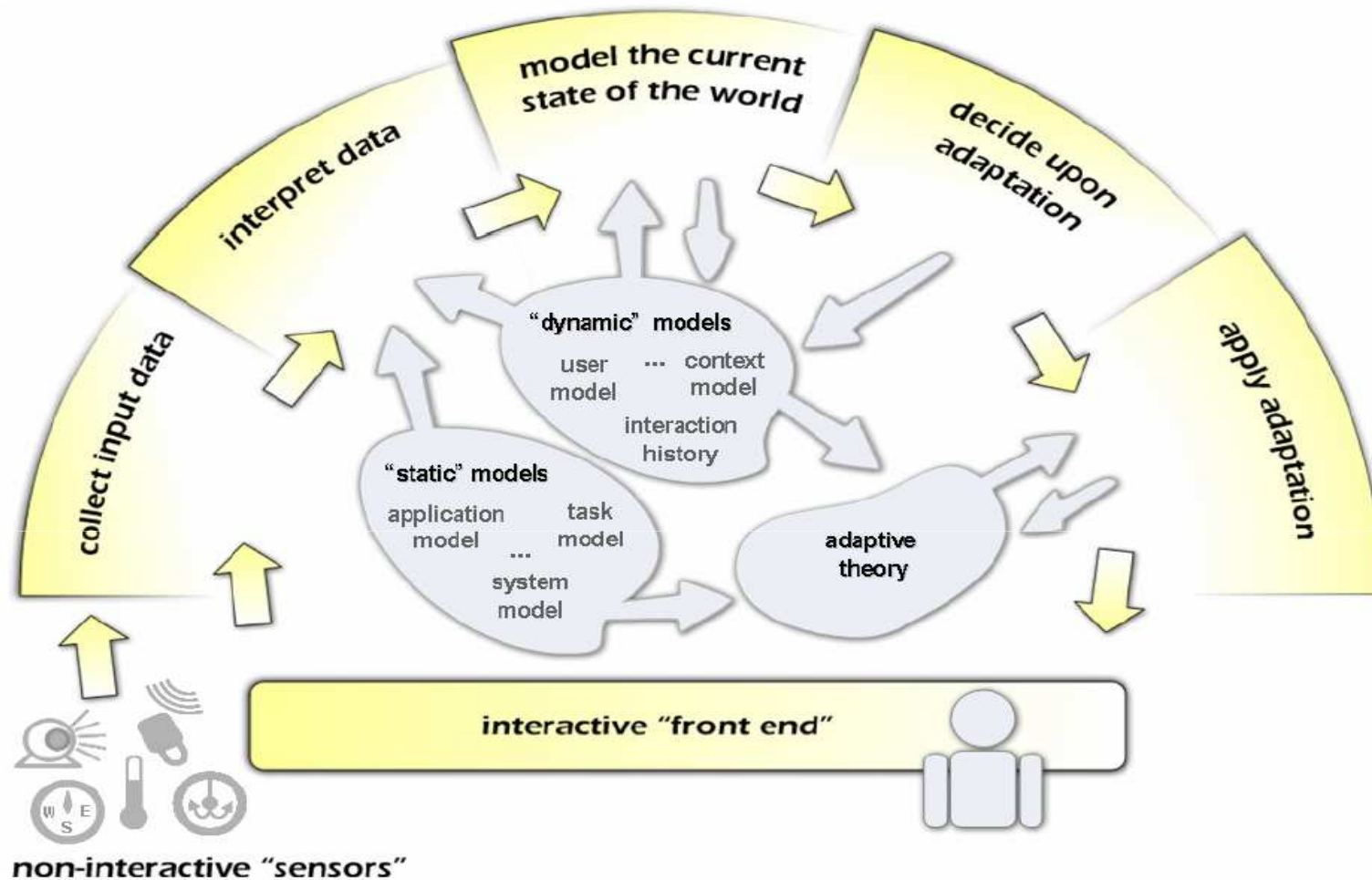
- But Amazon does not know
  - Whether you look for items for yourself or for your mother-in-law
  - Whether you are window shopping, shopping for work, or for private reasons
  - Whether you already have these items
- Still, these methods work quite well (and users can tell Amazon when assumptions are wrong)

# User modelling

User modelling is the process of creating and updating a user model, by deriving user characteristics from user data – which is either data that is explicitly provided by the user or data that stems from indirect events and observation

*Eelco Herder, User Modeling and Personalization, 2015  
Leibniz University of Hanover*





Alexandros Paramythis, Stephan Weibelzahl, Judith Mastho. Layered evaluation of interactive adaptive systems: framework and formative methods. *User Model. User-Adapt. Interact.* 20(5): 383-453 (2010)

# Steps in User Modelling

- Create the user model
  - Acquisition of user data
  - Inference of knowledge from data
  - Representation of the user model
- Apply the model and perform adaptation or decision
- Evaluate

# Acquisition of user data

User data consists of events and observations on the user's interaction with the system that can be either directly be used for adaptation purposes, or need to be resolved to user characteristics

# Direct input from the user

The screenshot shows a user profile page for Charlotte Witmer at Acme Corp. The page is divided into a left sidebar and a main content area. The sidebar contains navigation links for Home, @Mentions, Private Messages, Flagged, Sent, Company Stream, Recommended, Widget 9 Product Stream, and Add a custom stream. Below these are sections for GROUPS, TOWN HALLS, and PEOPLE. The main content area is titled 'Edit Profile' and has tabs for About Me, Interests, Notification Settings, Account Settings, Password, and Applications. The 'Interests' tab is selected, showing sections for Job Description, Passions, Certifications, What is your alma mater?, and Where's your favorite restaurant in the city? Each section has a text input field for user input.

**ACME CORP**

Charlotte Witmer

Home  
@Mentions  
Private Messages  
Flagged  
Sent  
Company Stream  
Recommended  
Widget 9 Product Stream  
Add a custom stream

**GROUPS**  
Groups Directory  
Acme Human Resources  
Bring Your Own Mobile ...  
Customer Council  
E2.0  
Employee Benefits Group  
Employee Recognition ...  
Implementation of CRM ...  
Sales Group  
Add a new group

**TOWN HALLS**  
Town Halls Directory  
Schedule a Town Hall

**PEOPLE**  
Company Directory  
People you follow  
People following you

**Edit Profile**

About Me **Interests** Notification Settings Account Settings Password Applications

**Interests**

**Job Description:**  
I work as the VP of Sales, managing all sales activities for Widget X at Acme Corp. My goal is to be a coach for all sales reps and the company while driving the strategy for our product vision. Previously worked as the Director of Marketing and in Sales Enablement.

**Passions:**  
International Travel, Six Sigma, Reading, Cooking, My Family

**Certifications**  
Six Sigma Green Belt, MSCE, CISSP, A+

**What is your alma mater?**  
Stanford

**Where's your favorite restaurant in the city?**

User profile

# Direct input from the user

MovieLens will help you find movies that you actually want to watch.

All we need to know is your ratings about movies you love and hate, and we can generate *personalized recommendations* for you. MovieLens is simple to use:

**Rate Movies.** Using our pulldown interface, you tell us what you think about movies you have seen.

**Receive Recommendations.** Then you can search for recommendations by genre, by year of release, by title and more!

Predictions for you	Your Ratings	Movie Information	Wish List
★★★★★	Not seen	<b>About a Boy (2002)</b> DVD, VHS, info   imdb Comedy, Drama	<input checked="" type="checkbox"/>
★★★★★	Not seen	<b>Chicago (2002)</b> info   imdb Comedy, Crime, Drama, Musical	<input checked="" type="checkbox"/>
★★★★★	Not seen	<b>And Your Mother Too (Y Tu Mamá También) (2001)</b> DVD, VHS, info   imdb Comedy, Drama, Romance	<input type="checkbox"/>
★★★★★	Not seen	<b>Monsoon Wedding (2001)</b> DVD, VHS, info   imdb Comedy, Romance	<input type="checkbox"/>
★★★★★	Not seen	<b>Talk to Her (Hable con Ella) (2002)</b> info   imdb Comedy, Drama, Romance	<input type="checkbox"/>

This is an image of our recommendation interface. The recommendations are in red stars, and you can rate movies you have seen using the pulldowns.

Continue the tour: [Advanced MovieLens Features](#)

Relevance  
feedback

# Direct input from the user

The image shows a screenshot of the Google iGoogle homepage, which is a highly customizable web interface. The layout includes a top navigation bar with the iGoogle logo, search buttons, and links to advanced search and preferences. Below this, the page is divided into several sections:

- Personalize this page:** A sidebar on the left with a list of widgets that can be added to the dashboard, including Home, Updates, Gmail, Google Calendar, Weather, To-do List, Top News, Books, Google Finance, Fun, YouTube, Frogger, Crossword, CRAFT Magazine, Sudoku, and Calvin and Hobbes.
- Books:** A section with a search bar and a grid of book covers under the heading "Reading list". Below this is a "Friends' books" section showing books from friends like Heather and Cass.
- Gmail:** A section showing the user's email inbox with a list of messages, including one from Steve and another from Netflix.
- Google Finance:** A section displaying stock market data for Dow, Nasdaq, and GOOG, including their current values and percentage changes.
- Top News:** A section with a "Top stories" list, including a headline about an ex-commander of NATO named Mideast Lanson.
- Updates:** A section showing social media updates from friends, such as a post from Rose about giving a flower and a post from Ray about a new album.
- To-do List:** A section with a "New item" input field and a list of tasks, including "deposit checks", "pay bills", "buy groceries", and "water plants".
- Weather:** A section showing the current weather for Mountain View, CA, with a temperature of 35°F and a forecast for the next two days.
- Google Calendar:** A section showing a calendar for November 2007, with a focus on the 12th and 25th.

At the bottom of the page, there is a copyright notice for 2007 Google and links to Google Home, Advertising Programs, Business Solutions, and About Google.

Users make adaptations

# Observing the user



# Processing data

Inference of knowledge. Knowledge inference is the process of interpreting events and observations on a user  $U$ , making use of conditions, rules or other forms of reasoning, and the storage of the inferred knowledge in the user model.

*Eelco Herder, User Modeling and Personalization, 2015*



# Processing data – General approaches

- Detecting patterns in user behaviour
- Matching user behaviour with the behaviour of other users
- Classifying users based on user behaviour

# Representing the user data

- Virtually any format and mechanism
  - Attribute-Value pairs
  - Probability intervals
  - Booleans
  - Fuzzy intervals
  - Lists, possibly including weights
  - Rules
  - Heuristics
  - References to external objects
  - ...
- Metadata

# Explicit user model structures

- Flat model
  - Collection of variables and associated values
- Hierarchical model
  - Represents user characteristics and relation between these characteristics
- Stereotype models (*oldest approach*)
  - One or more stereotypes usually activated by triggers
- Domain overlay (*most popular*)
  - For each item in a domain, attributes represent the user's knowledge of or interest in this item
- Logic-based
  - Representation and reasoning with first-order predicate logic

# Stereotype User Model

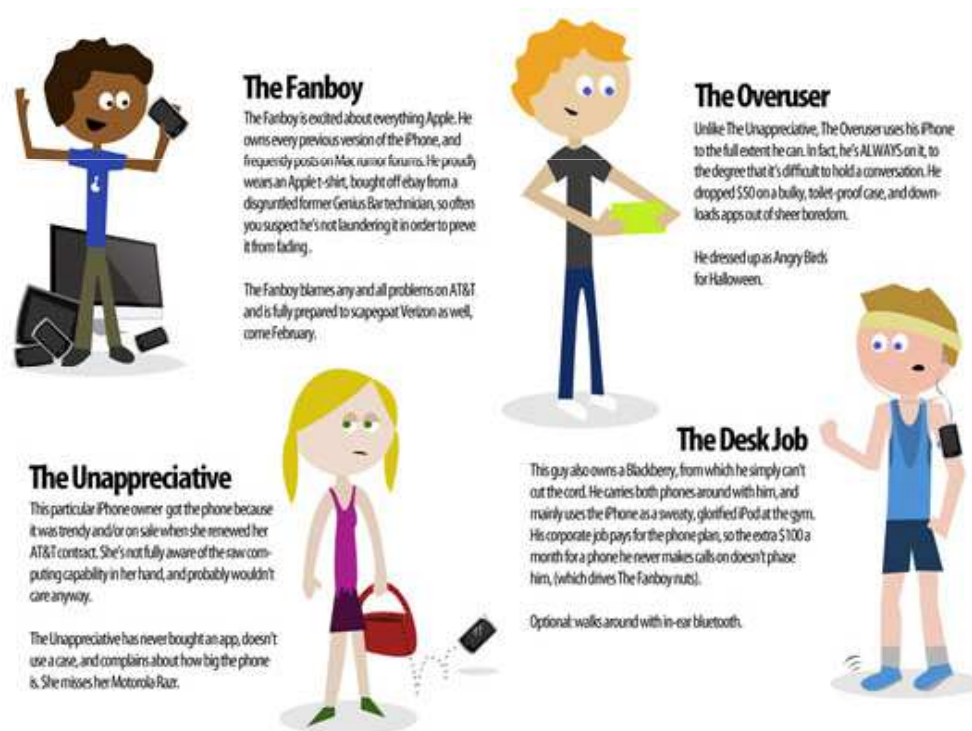
- For quickly inferring the kind of user

A stereotype user model consists of one or more stereotypes, one or more triggers for activating these stereotypes, and user data that is used as input for these triggers.

*Eelco Herder, User Modeling and Personalization, 2015*

# Stereotyping

- Set of characteristics (e.g. attribute-value pairs) that describe a group of users



<http://www.gadg.com/wp-content/uploads/2011/02/iPhoneUsers1.jpg>

# Stereotype User Model

Rich, E. User Modeling via Stereotypes. Cognitive Science, 3, 329-354, 1979

- Scenario 1: In a library a person looks for some books on China
  - What will the librarian recommend?
- Scenario 2: The phone rings in the information division of a large pharmaceutical firm. The caller wants information about a drug the company makes.
  - What sort of information should be provided?

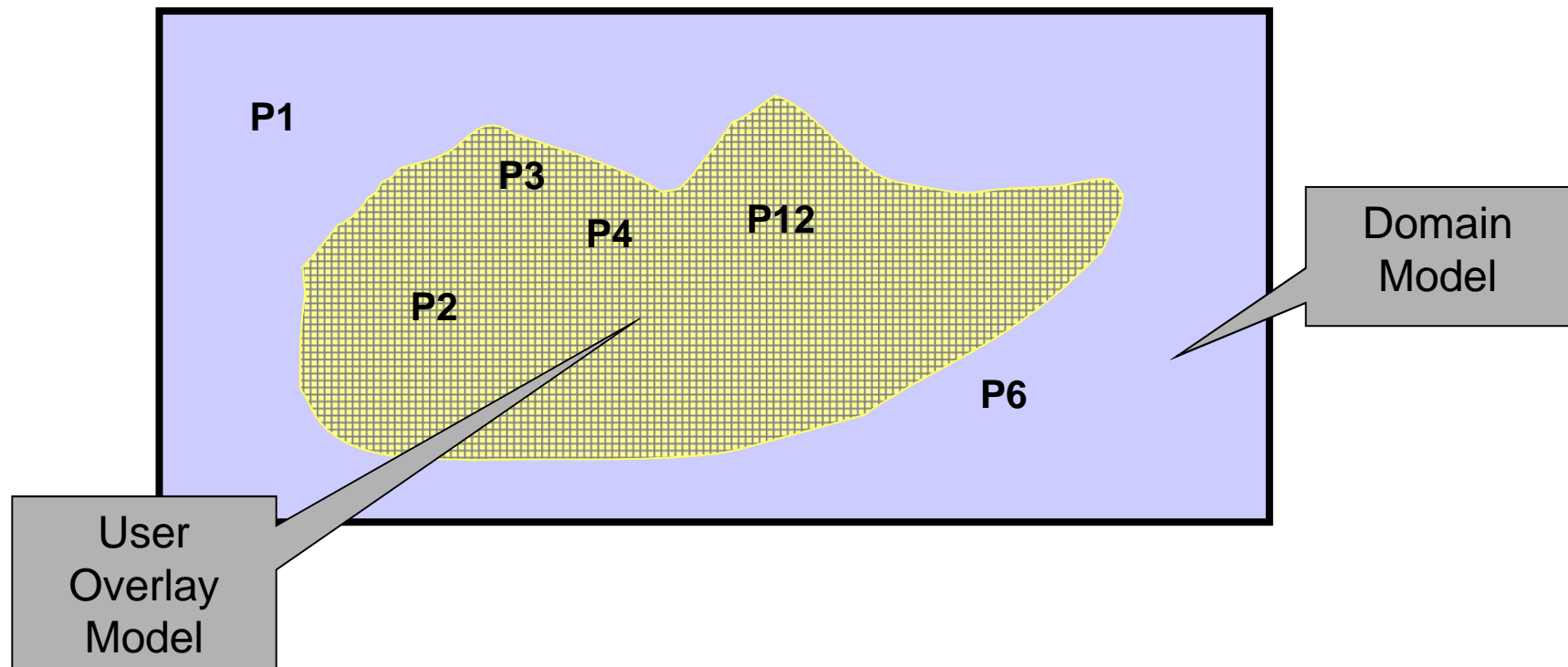
# Overlay User Model

- Originally designed for knowledge modeling

An overlay user model represents an individual user's knowledge, interests, goals or other features as a subset of the domain model that resembles expert knowledge of the subject.

# Overlay Model

- The system has all the knowledge concerning the domain and the learner has only a part of this knowledge





# Overlay example: SCHOLAR

...

Sch: El idioma de Brasil es el francés. ¿Bien o mal?

U: **Mal**

Sch: Tiene razón, el idioma de Brasil es el portugués  
¿Es cierto que la capital de Brasil es Brasilia?

U: **Si**

Sch: Muy Bien

U: **Dígame algo más de Argentina**

Sch: Espere un momento voy a mirar mis archivos. Prosigamos.  
Argentina es un país.  
Está en Sudamérica.  
Sus países limítrofes son Uruguay, Paraguay, Brasil, Bolivia y Chile.  
La capital es Buenos Aires.  
Ahora responda a la pregunta que no contesto antes

U: **p/r**

Sch: ¿Desea cambiar el modo general de interacción a p/r?.

U: **s**

Sch: Muy bien. Sigamos

U: **Dígame algo más de Argentina, por favor**

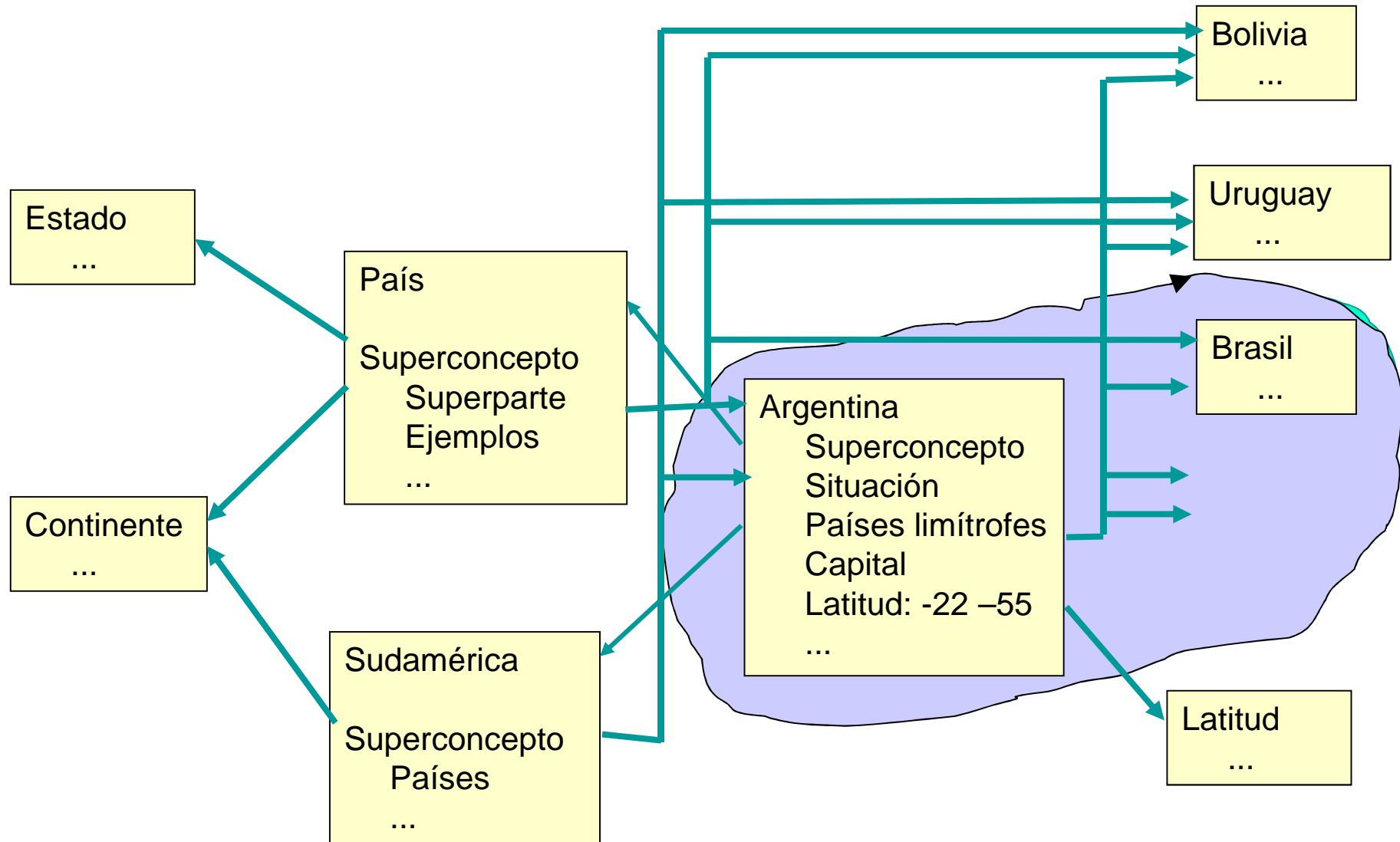
Sch: La superficie es de 2.800.000 Km2 aproximadamente  
El idioma es el español

U: **¿qué superficie tiene Brasil?**

...

Carbonell, 1970

# Overlay example: SCHOLAR

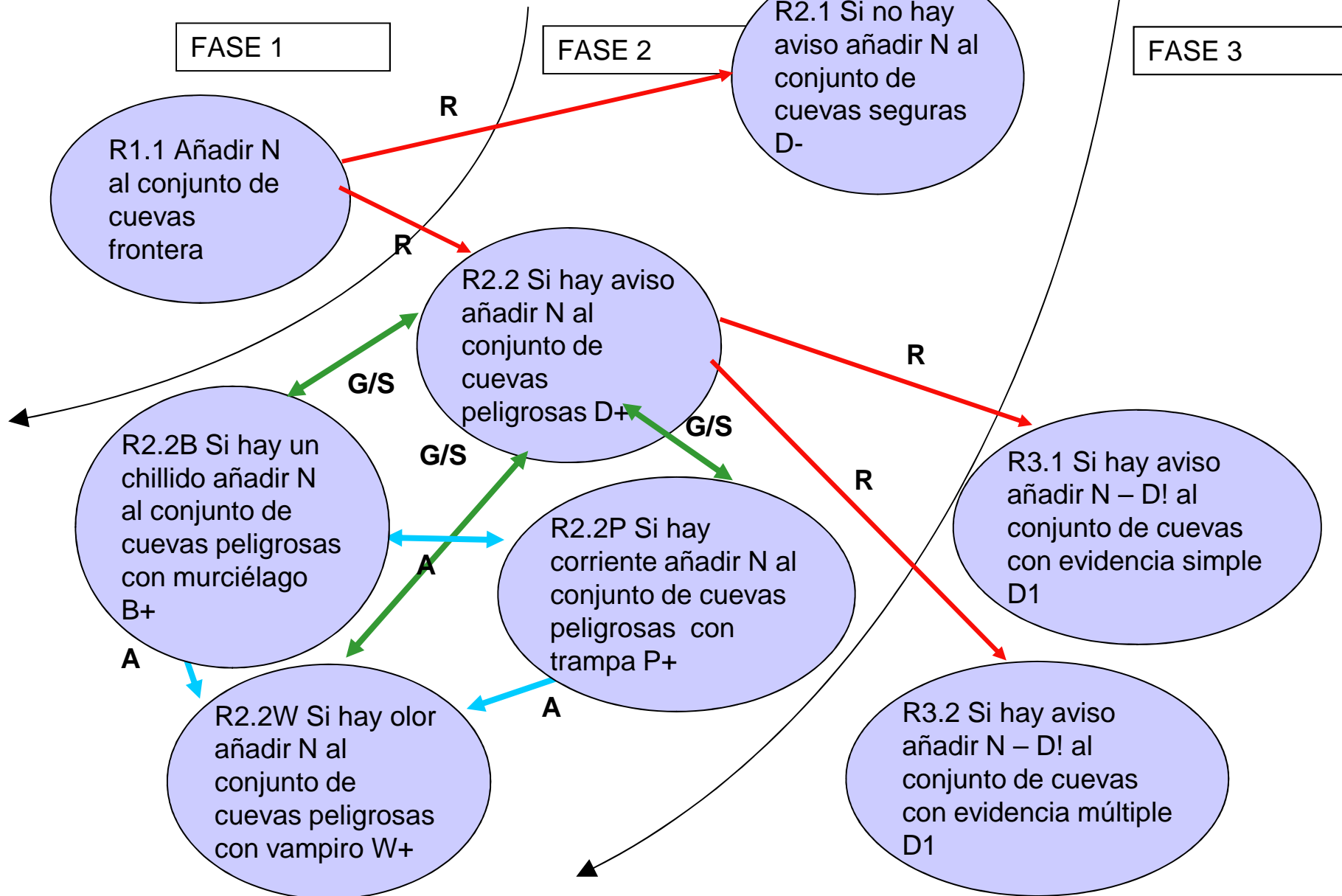


# Genetic Graph

Goldstein, P. The Genetic Graph: a representation for the evolution of procedural knowledge. *International Journal of Man-Machine Studies*, 3(1), 51-77, 1979

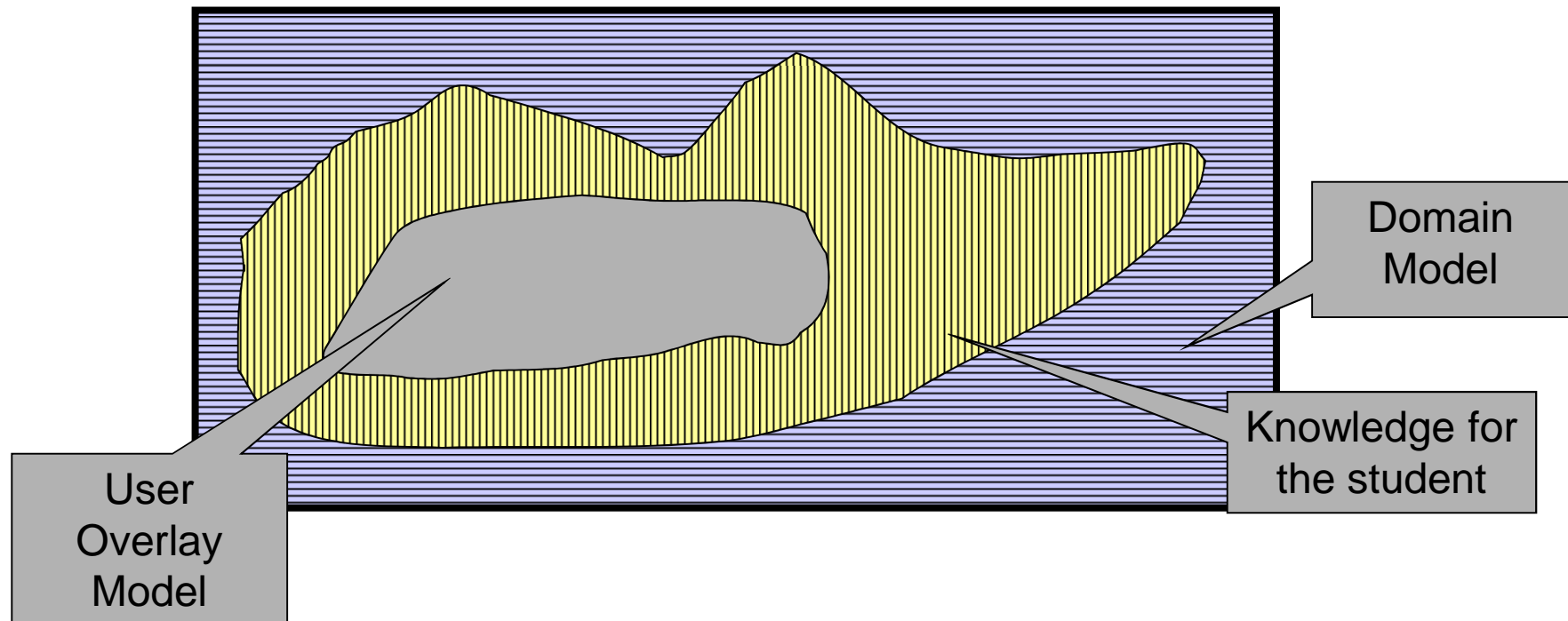
- Overlay model evolution
  - Representing also various evolutionary relationships

# WUMPUS (Goldstein, 79)



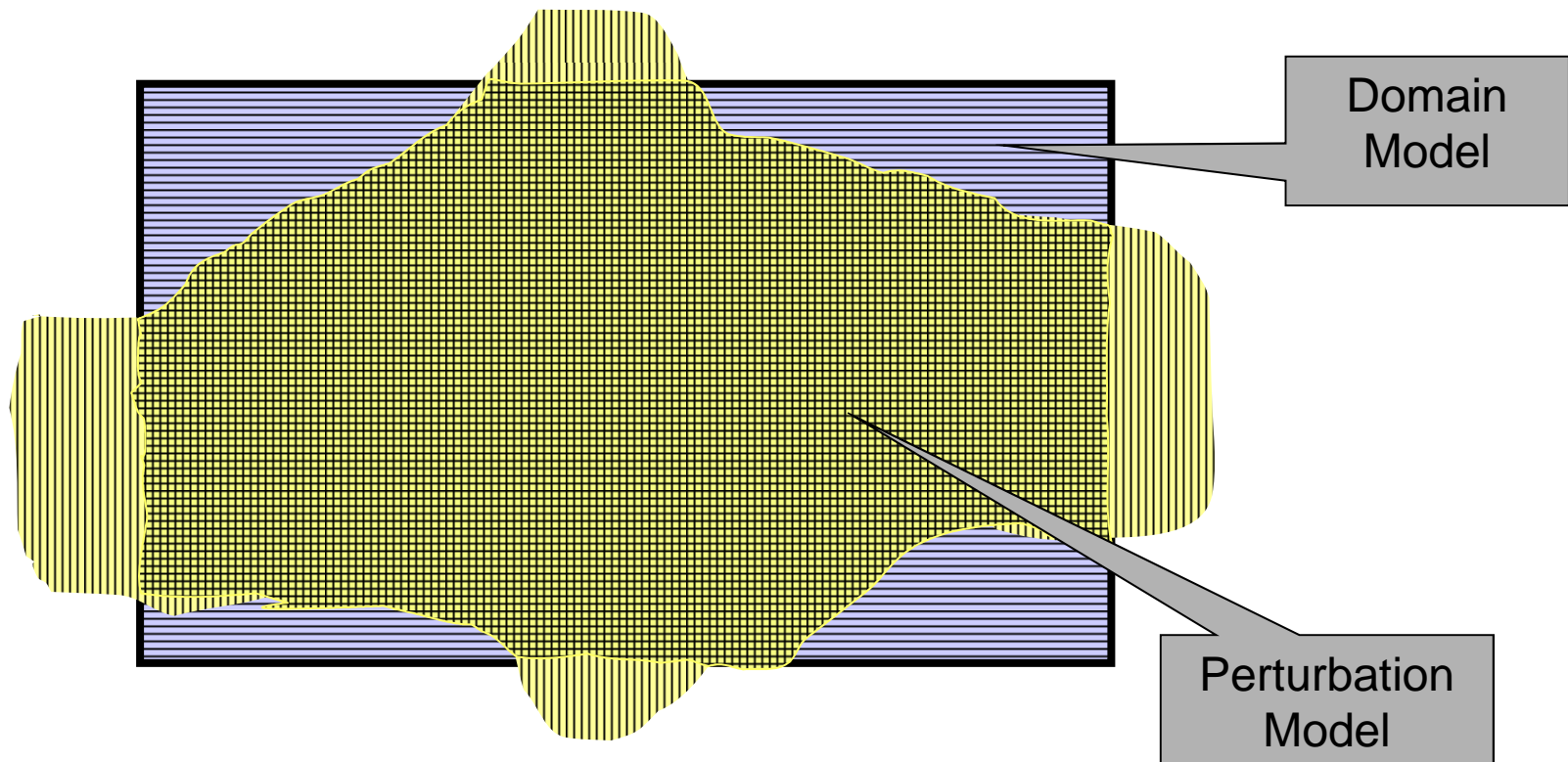
# Differential Model

- Extension of the overlay
- It focuses on the differences between the student's knowledge and that of the expert



# Perturbation Model

- It combines the standard overlay model with a representation of faulty knowledge
- Bug catalogue



# Example - LMS *(Sleeman, 1983)*

## Condition

1.  $(x=M)$
2.  $(x=M/N)$
3.  $(M*x=N)$
4.  $(M*x +/- P = N)$
5.  $(M +/- N)$
6.  $(M*//N)$
7.  $(M*x +/- N*x)$
8.  $(M * (N*x +/- P))$

## Action

- $(M)$
- $(M/N)$
- $(x=N/M)$  or infinity
- $(M*x = N -/+ P)$
- Evaluate operator
- Evaluate operator
- $((M +/- N)* x)$
- $(M*N*x +/- M*P)$

## Erroneous rules

- 1R  $(M*x=N)$
- 2R  $(M*x +/- P = N)$
- 3R  $M * (N*x +/- P)$

- $(x=M/N)$
- $(M*x = N +/- P)$
- $(M*N*x +/- P)$

$$2*x + 3*x - 3 = 2*3 + 1$$

R6 ( $M*/N$ )  $\rightarrow$  Evaluate operator

R5 ( $M+/-N$ )  $\rightarrow$  Evaluate operator

R7 ( $M*x +/- N*x$ )  $\rightarrow ((M +/- N)* x)$

R5 ( $M+/-N$ )  $\rightarrow$  Evaluate operator

R4R ( $M*x +/- P = N$ )  $\rightarrow (M*x = N +/- P)$

Identified error

R4 ( $M*x +/- P = N$ )  $\rightarrow (M*x = N -/+ P)$

R5 ( $M+/-N$ )  $\rightarrow$  Evaluate operator

R3R ( $M*x=N$ )  $\rightarrow (x=M/N)$

Identified error

R3 ( $M*x=N$ )  $\rightarrow (x=N/M)$

R ( $x=M/N$ )  $\rightarrow (M/N)$

$$2*x + 3*x - 3 = 6 + 1$$

$$2*x + 3*x - 3 = 7$$

$$(2 + 3)*x - 3 = 7$$

$$5*x - 3 = 7$$

$$5*x = 7 - 3$$

**It is not correct**

$$5*x = 7 + 3$$

$$5*x = 10$$

$$x = 5/10$$

**It is not correct**

$$x = 10/5$$

$$2$$

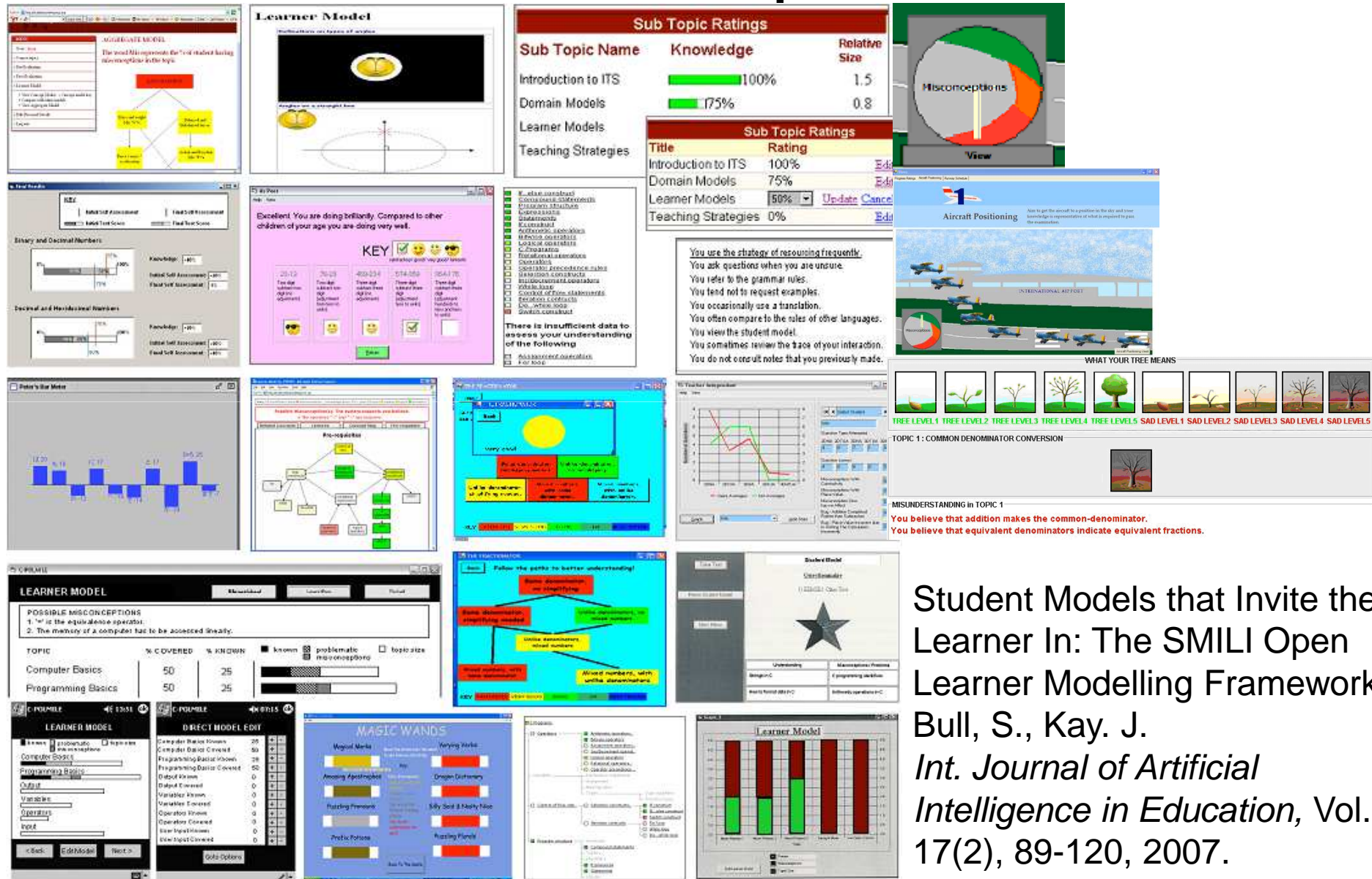
**CORRECT!!**



# Open User Model

Open user models are models that are accessible to the user – usually the user being modeled, but sometimes also to other users.

# Some examples



Student Models that Invite the Learner In: The SMILI Open Learner Modelling Framework. Bull, S., Kay, J. *Int. Journal of Artificial Intelligence in Education*, Vol. 17(2), 89-120, 2007.

# Possible advantages

- Promoting metacognitive activities such as reflection, planning and selfmonitoring;
- Allowing the learner to take greater control and responsibility over their learning, encouraging learner independence;
- Prompting or supporting collaborative and/or competitive interactions amongst groups of students;
- Facilitating interaction between learners and peers, teachers and parents;
- Facilitating navigation to materials, exercises, problems or tasks, etc., where links are available from the learner model;

# Possible advantages

- Supporting assessment - in particular providing formative assessment opportunities for students, but also enabling the learner model to be used as a summative assessment;
- Increasing the accuracy of the learner model data if the user is allowed to contribute additional or corrective information, to enable a more precise adaptive interaction to follow;
- Increasing learner trust in an adaptive educational environment by showing the system's inferences about their knowledge;
- The (non-educational) issue of people having the right to access electronic data about themselves.

Open Learner Models. Bull, S., Kay. J.

*Advances in Intelligent Tutoring Systems Studies in Computational Intelligence*,  
Vol. 308, 301-322, 2010.

# Externalization ways

- Data raw models
- Visual models
- Decision support models

Urko Rueda. Desarrollo de SW reutilizable de Mapas Conceptuales y estudio de su aplicación en contextos de aprendizaje y en los Modelos Abiertos de Estudiante, PhD UPV/EHU, 2009.

# Data raw models

The pronoun is:		YOUR CONFIDENCE	SYSTEM CONFIDENCE
Pre-verbal in negatives	<i>Não os compra</i>	unsure	very sure
Post-verbal in positive main clauses	<i>Compra-os</i>	almost sure	unsure

system: The system's confidence in *your use* of the rule for positive main clauses is currently: unsure.  
What do you believe the system's confidence should be?

- very sure
- almost sure
- very unsure
- (cancel)

student (selects): *very sure.*

system: Your choice of 'very sure' is different from the system's assessment. What do you wish to do?

- accept system's decision
- system justify itself
- view student model
- accept compromise
- justify myself

student (selects): *system justify itself.*

system: You are trying to change the system's confidence from 'unsure' to 'very sure'. This confidence value is too high. Your last five attempts to place the pronoun in positive main clause statements were:

- \*O Manuel a mostrou no mapa.
- O Manuel mostrou-a no mapa.
- \*O homem o veio rapidamente.
- \*O Manuel mostrou a no mapa.
- O homem veio-o rapidamente.

You have probable transfer from Spanish for pronoun placement twice.

# Visual models

Search	Select/Deselect	Infer	
--------	-----------------	-------	--

Term Expansion    Less ☐ ☒ ☐ More

- heuristic evaluation
  - evaluate model
- usability / usability study
  - product development process
  - iteration
- human-centred / user-centred design
  - exploratory testing
  - usability and prototyping
  - requirements engineering
  - usability
  - efficiency measurement
  - attractiveness
- usability evaluation
  - documentable
- predictive validity
  - heuristics
  - checklist
- learning
  - structured
- cognitive task design
  - user interface critique
- performance
  - quantitative
  - beliefs about the user
  - system usage
  - effectiveness
  - consistency
  - user involvement
  - motivation
  - user-centred design prototype
  - low-fidelity prototype

Views: [My User Model](#) | [Me vs. Average](#) | [Average of Class](#)

Current concept: [Show evidence](#)

## Concept: prototyping (0.98)

You are performing better than average.

**Audio Evidence (raw 0.80, contribution 0.20)**
[Show/Hide Evidence](#)

The lecture slide [PredCognitive3](#) was attended for a duration of 66 seconds.  
The lecture slide [ScreenBackground11](#) was attended for a duration of 207 seconds.

**Tutorial Evidence (raw 1.00, contribution 0.75)**
[Show/Hide Evidence](#)

The tutorial [Week07](#) has a mark of 10 out of 10.  
The tutorial [Week10](#) has a mark of 10 out of 10.  
*Note - tutorial evidence is weighted higher than audio evidence in resolving the final score shown above.*

**Inferred Evidence (contribution 0.03)**
[Show/Hide Evidence](#)

This extra contribution has been inferred from the terms visible at depth 2.



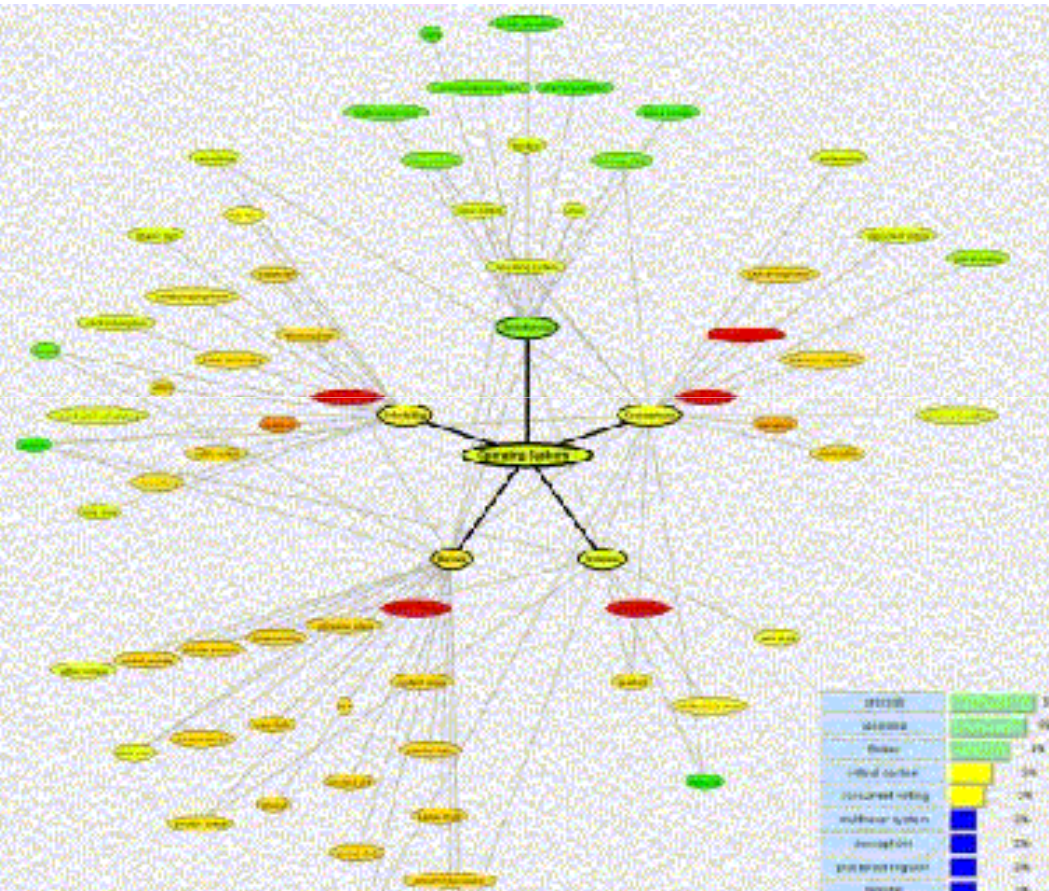
# Decision support models

The two most important terms are known by the author and a CT of

1.  $\text{type}(\text{point}) = \text{V}$ ,  $\text{weight}(\text{point}) = 1$
2.  $\text{type}(\text{edge}) = \text{E}$ ,  $\text{weight}(\text{edge}) = 1$
3.  $\text{source}(\text{point}) = \text{point}$ ,  $\text{target}(\text{point}) = \text{point}$ , and  $\text{weight}(\text{point}) = 1$
4.  $\text{source}(\text{edge}) = \text{point}$ ,  $\text{target}(\text{edge}) = \text{point}$ , and  $\text{weight}(\text{edge}) = 1$
5.  $\text{type}(\text{point}) = \text{V}$ ,  $\text{weight}(\text{point}) = 1$
6.  $\text{type}(\text{edge}) = \text{E}$ ,  $\text{weight}(\text{edge}) = 1$
7.  $\text{source}(\text{point}) = \text{point}$ ,  $\text{target}(\text{point}) = \text{point}$ , and  $\text{weight}(\text{point}) = 1$
8.  $\text{source}(\text{edge}) = \text{point}$ ,  $\text{target}(\text{edge}) = \text{point}$ , and  $\text{weight}(\text{edge}) = 1$
9.  $\text{type}(\text{point}) = \text{V}$ ,  $\text{weight}(\text{point}) = 1$
10.  $\text{type}(\text{edge}) = \text{E}$ ,  $\text{weight}(\text{edge}) = 1$
11.  $\text{source}(\text{point}) = \text{point}$ ,  $\text{target}(\text{point}) = \text{point}$ , and  $\text{weight}(\text{point}) = 1$
12.  $\text{source}(\text{edge}) = \text{point}$ ,  $\text{target}(\text{edge}) = \text{point}$ , and  $\text{weight}(\text{edge}) = 1$

The ten firms that this student knows with  $W > 35\%$  are:

2. *Shallal's measure* (with a CV of 1.3 and a weight of 0.01)
3. *Eric's measure* (with a CV of 0.1 and a weight of 0.01)
4. *John's measure* (with a CV of 0.8 and a weight of 0.01)
5. *Robert's measure* (with a CV of 0.3 and a weight of 0.01)
6. *Central tendency* (with a CV of 0.0 and a weight of 0.2)
7. *SPRT* (with a CV of 0.1 and a weight of 1.0)
8. *Debtors' measure* (with a CV of 1.0 and a weight of 0.0)
9. *Newton's algorithm* (with a CV of 0.1 and a weight of 0.0)
10. *Atkinson's measure* (with a CV of 0.4 and a weight of 0.0)
11. *Chatterjee's measure* (with a CV of 1.3 and a weight of 0.0)

[illegible]



# Open user models types

- Inspectable user models
- Editable user models
- Negotiated user models

Bull, S., McEvoy, A.T. And Reid, E. Learner Models to Promote Reflection in Combined Desktop PC/Mobile Intelligent Learning Environments.  
AIED Supplementary Proceedings, Vol. 5, 199-208, 2003.

# Generic User Modeling Systems

Systems that are independent independent from the architecture and from the user model of a specific user-adaptive application.

Kobsa, A., Generic User Modeling Systems, *Lecture Notes in Computer Science*, Vol. 4321, 136-154, 2007.

# Advantages

- All information about the user is maintained in a repository with clearly defined points of access
- User information is at the disposal of more than one application at a time
- User information acquired by one application can be employed by other applications, and viceversa
- Information about users is stores in a non-redundant manner

# Advantages

- It is easier to maintain consistency and coherence of information gathered by different applications
- Information about user groups (e.g. stereotypes) can be maintained with low redundancy
- Methods and tools for system security, identification, authentication, access control and encryption can be applied and maintained
- Privacy, transparency

# Different approaches to GUMS

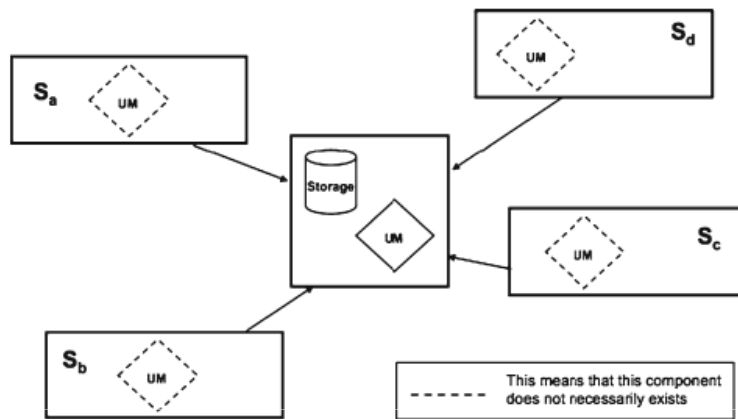


Fig. 1 Centralized approach to UM interoperability

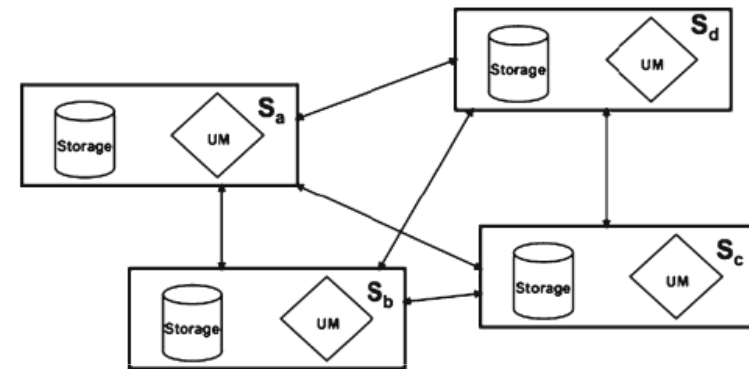


Fig. 2 Decentralized approach to UM interoperability

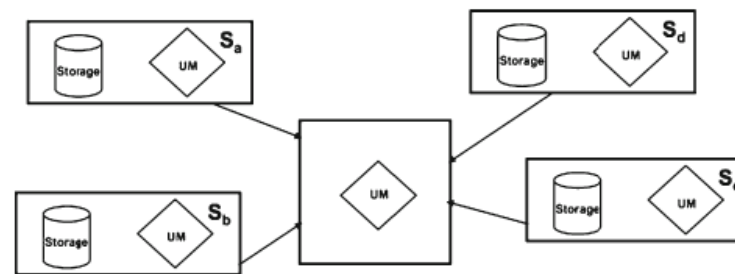


Fig. 3 Mixed approach to UM interoperability

# Additional reading

- User Modeling – Recommender Systems

Jawaheer, G., Weller, P., Kostkova, P. Modeling User Preferences in Recommender Systems: A Classification Framework for Explicit and Implicit User. *ACM Transactions on Interactive Intelligent Systems*, 4(2), Article 8, 2014.

# Journals & Conferences

- Journals
  - User Modeling and User Adapted Interaction (UMUAI):  
<http://www.umuai.org/>
- Conferences
  - User Modeling (UM) and Adaptive Hypermedia (AH) series of conferences – today UMAP conference  
<http://www.um.org/conferences/>
  - Intelligent User Interfaces (IUI) series of conferences  
<http://iui.acm.org/2016/>