A Multiagent Approach to Educational Resources Retrieval

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We propose

a **multiagent architecture**

for web **educational resources retrieval**

that **helps users** to find courses

according to their **personal** and **cultural** aspects.

- Students and professors are faced with the necessity of finding courses according to their needs and cultural characteristics.

This is usually a big task because of

- the great amount of existing electronic educational resources (courses),
- the difficulty to automatically manage different cultural aspects since some of them may be uncertain or imprecise,
- the difficulty for the user to correctly specify his/her search.

Problems:

- The user has difficulty to correctly specify his/her search.
- Subject search: It is not simple due to the semantic complexity of vocabulary.
  - "***matrix***" can also be expressed as "***array***"(in mathematics)
  - "***matrix***" can refer to a ***rectangular array*** of elements set out by rows and columns, or to a ***container*** into which liquid is poured to create a given shape when it hardens.
- Find educational resources according to their needs and cultural characteristics

Student profile

Involves personal and cultural aspects.

- **Personal aspects**

  include characteristics of each particular student such as:

  Age, Foreign languages, Learning style and Professional background.

- **Cultural aspects** are preferences and ways of behavior determined by a person's culture.

  (the features that distinguish between students' preferences from different regions)

  Some of them are: Country or Region, Language, Attitude, Learning Styles, Activities Affinity.

- **Country or Region**.
  - The **history**, **climate**, **religion**, **economy**, etc. are elements of each country that **determinate the habits of its people**.
- **Language**.
  - The **best way to communicate** with a person is by using her/his **mother language**, and the idiomatic expressions and common usage verb tenses of her/his culture.
- **Attitude**.
  - It is related with the **level of interaction**: **active**, **passive** or **reactive**. (i.e., if the student is a reactive person, the course should offer dynamic activities).
- **Activities**.
  - can be classified according to the **level of reaction and interaction** that they require (to implement a solution, to select a solution, and "passive" activities: listening, read or see some material).
  - can require **interaction between students**, and/or **interaction within the system** (i.e. the use of different tools: forum, chat, additional software).

- **Learning Styles**.
  - It **determines** how to **organize and represent the information** to the student **for** his/her **better comprehension** and **fast knowledge acquisition**.

  - They are:
    - ***Holistic* style**: **parallel process** of the information.
      - The student adopts a **global boarding**. They prefer to see **real applications or examples** as soon as possible.
      - ***Holistic Verbal*** : prefer information presented with **declarative text**
      - ***Holistic Visual*** : prefer information presented with **graphics**, **images**, etc.

    - ***Analytic* style**: **linear or sequential process** of the information.
      - The students adopt a **focal boarding**, studying topics, one per time.
      - ***Analytic Verbal :*** prefer information in **plain text**, organised in **small paragraphs**, each one with one idea.
      - ***Analytic Visual*** : prefer **images** or **diagrams**.

Ontology for Cultural Aspects

An **ontology** is a formal, explicit specification of a shared conceptualization (Gruber, 1993).

It consists on

- entities, relations and restrictions of a domain,
- expressed in a formal language to enable machine understanding.

It is encoded in **OWL** language,
developed using **Prótegé**, and the reasoner **Racer**,
using metadata standards **LOM** and **Dublin Core**.

Multiagent systems and Graded BDI Agents

The **BDI architecture** [Rao and George] is based on the **explicit representation of** the agent's **beliefs** (B), its **desires** (D), and its **intentions** (I).

***Graded* BDI Agents**: capability to have a better performance in **uncertain** and **dynamic environments**.

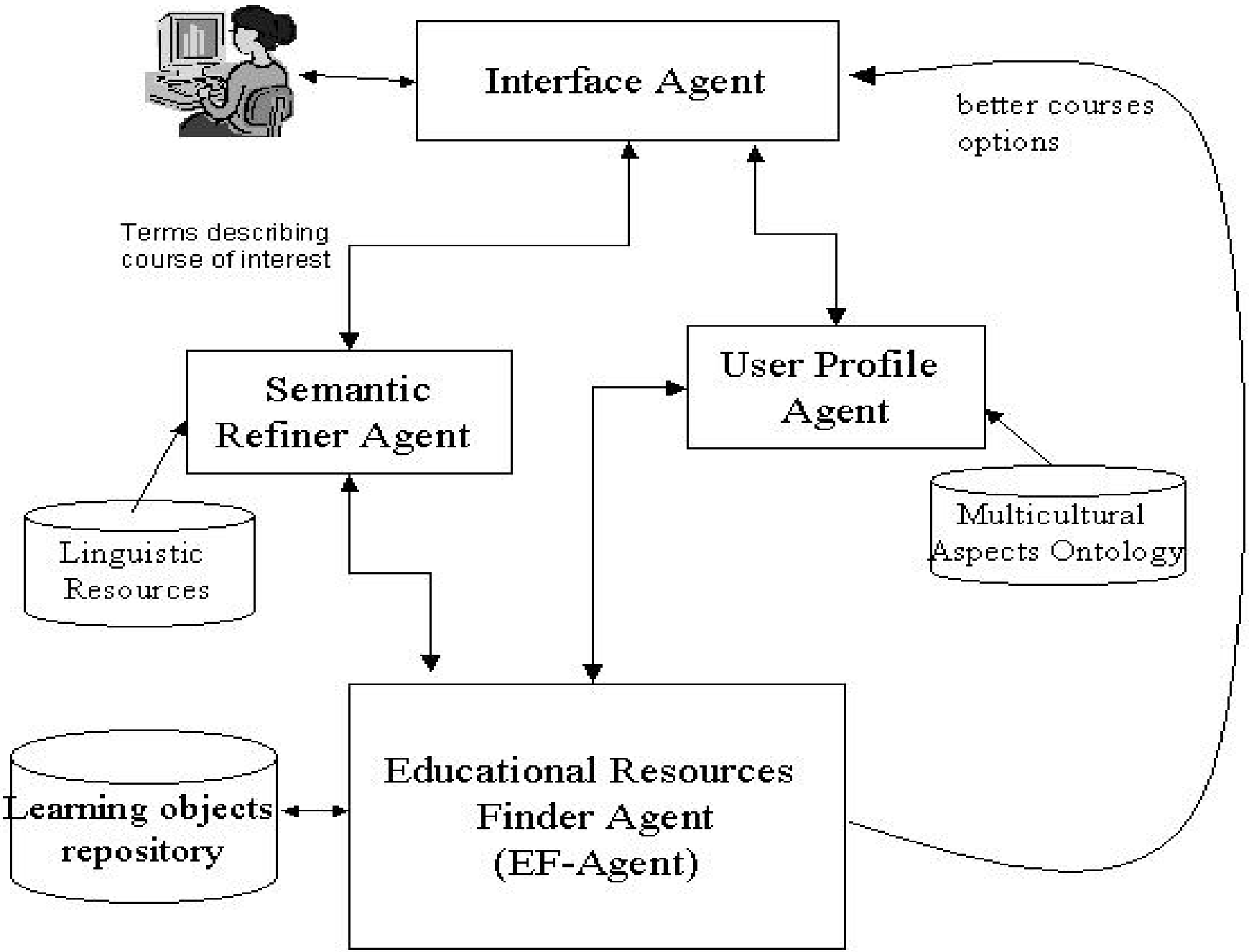
- **Belief degrees**: represent to what extent the agent believes a **formula is true**.
- **Degrees of positive or negative desires** allow the agent to set **different levels of preference or rejection** respectively.
- **Intention degrees** give a preference measure **modeling the cost/benefit trade** off of reaching an agent's goal.

Multiagent Architecture

- Semantic Refiner Agent (**SR-Agent**):
  produces the search strategy associated to the user's interest,

- User Profile Agent (**UP-Agent**):
  extracts data from user's behavior in order to build the user profile,

- Educational Resources Finder Agent (**EF-Agent**):
  - modeled as a **graded BDI agent**
  - LO and student's preferences may be graded


Interface Agent
better courses options
Terms describing course of interest
Semantic Refiner Agent
User Profile Agent
Linguistic Resources
Multicultural Aspects Ontology
Learning objects repository
Educational Resources Finder Agent (EF-Agent)

The Semantic Refiner Agent:

- **Produces the search strategy** associated to the user's interest.

- Guides the user for **sense disambiguation** of the concepts.
- Allows the user to **select concepts hierarchically** related
- **Expands semantically** concepts.

Using linguistic resources.

The User Profile Agent:

- **Extracts** data from the user and from the ontology MCA in order to build the **user profile**.

- Personal data: are obtained from the user by a set of queries driven by an appropriate ontology.

The Educational Resources Finder Agent:

- Looks for different LO in order to satisfy student's preferences
- Output: an ordered list of educational resources supplied by a set of universities.
- It decides the best order taking into account:
  - interests and cultural aspects of the student,
  - expected satisfaction of the preferences by the course,
  - the course cost (e.g. its estimated duration time)
  - the trust in the resource supplier

The EF-Agent modeled as a graded BDI agent is formalized using multi-context systems.

Components: contexts, logics, and bridge rules, which channel the propagation of consequences among theories.

Thus, an agent is defined as a group of interconnected units:

$$\mathbf{<\{Ci\}\ i \in I, \Delta br>}$$

Where:

- each context Ci is the tuple Ci = (Li, Ai, Ri)

  where Li: language,
  Ai: axioms
  Ri: inference rules

- and Δbr : bridge rules

When a theory (a needed set of formulae) is associated with each context, the specification of a particular agent is complete

Then, our BDI agent model is:

$$\text{EF-Agent} = (\{BC, DC, IC, SC, RC, CC\}, \Delta br).$$

Where

- BC: beliefs context
- DC: desires context
- IC: intentions context
- SC: social context (which represents the trust in other provider agents)
- RC: retrieving context (functional)
- CC: Communication context (functional)

- Δbr: Bridge Rules (interrelations between contexts).

- **Belief Context:**

  model the EF-Agent's beliefs about the **educational environment**: **knowledge** about the educational objects **with metadata** (subject, language, amount of practice, amount of figures and interactivity).

- **Desire Context:**

  represent the **student's preferences** in the **subject** and also in some **course characteristics**.

  Desires can be **positive** (e.g. subject: kinetics, style: holistic) or **negative** (e.g. language Portuguese). Both, can be **graded**.

The EF-Agent, starting from these desires, begins a chain of intra and inter-context deductions in order to determine which the best courses to recommend to the user are.

- **Social Context:**

  model the **social aspects of agency**.

  We consider that the trust depends only on the kind of course that the universities offer.

- **Intention Context:**

  represent the **agent's preferences**.

  By allowing **degrees in intentions** we represent a measure of the **cost/benefit relation** involved in the agent's actions towards the goal.

  Using this set of graded intentions, this agent derives the final intention and the best-recommended courses.

- **Retrieving and Communication Contexts:** (functional).

  Retrieving Context: **looks for feasible plans** in a repository of the courses offered by the different supplier agents.

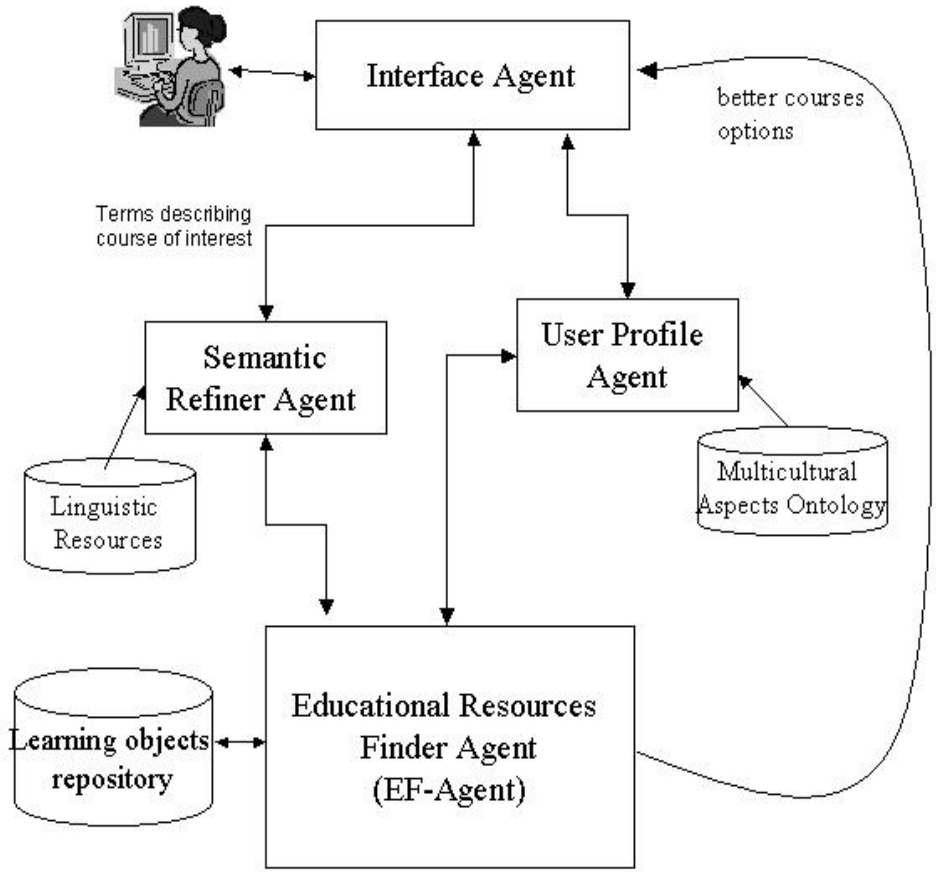
  Communication unit: **encapsulates the agent's internal structure** by having a unique and well-defined interface with the environment.

  (sending and receiving of messages to and from other agents in the multi-agent society).

An example

María, an Argentinean physics student, wants to find courses about “dynamics”

She asks for the more general concept “mechanics”.



1. The **SR-Agent** is in charge of the **semantic refinement**.

- **takes mechanics** and verifies that it is orthographically correct.
- **shows different senses** of that word (help the user to disambiguate).
  - ***Mechanics***: branch of physics concerned with the motion of bodies in a frame of reference;
  - ***Mechanics***: technical aspects of doing something, e.g. mechanisms of communication.

María chooses the first sense.

- **shows the hyponyms** using a linguistic resource (e.g. WordNet)

María moves in the hierarchy and selects the term *dynamics*

- takes this phrase, **expands it, and automatically incorporates** the term ***kinetics*** (synonym).

- **automatically builds the search strategy**

dynamics OR ***kinetics***

2. The **UP-Agent makes the user's profile** proposing a set of questions and using the Multicultural Aspects Ontology.

Maria's profile

(Language = "Spanish", 1)
(Language = "English", 0.7)
(style 1 = holistic, 0.4)
FigurePreference = "High"
(style 2 = visual, 0.8)
ExercisePreference = "Low"

3. Maria's profiles, and **subject** of interest are **sent to the EF-Agent**.

4. EF-Agent:

models these preferences as positive and negative desires that the agent will try to satisfy through an appropriate course.

For example:

If there are two courses that fulfill the subject search:

- ***Course 1***: English, **75% figures**, 35% of exercises,
- ***Course 2***: **Spanish**, **68% figures**, **0% exercises**;

Maria's profile

(Language = "Spanish", 1) - (Language = "English", 0.7)
FigurePreference = "High"
ExercisePreference = "Low"

then the **output** of the EF-Agent is an **ordered list of courses**:

Course 2
Course 1.

- We propose a **Multiagent Architecture** for web **Educational Resources Retrieval**
  - Semantic Refiner Agent
  - User Profile Agent
  - Educational Resources Finder Agent
- modeled as a graded BDI agent
- in charge of a flexible retrieval of the best courses according to the student profile (personal and cultural aspects).

- We plan to implement a prototype of the EF-Agent and the multiagent interactions.