Multi-expert system design for educational and career guidance: an approach based on a multi-agent system and ontology

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Abstract

This paper presents the design of a multi-expert system for educational and career guidance based on a multi-agent paradigm and the semantic web. This paradigm seeks to distribute a problem on a set of agents that communicate between them, coordinate their behavior and cooperate in order to solve a problem. The problem to be dealt in this article is that of educational and career guidance where different types of knowledge come from four sources: pedagogical expert, psychological expert, sociological expert and economic expert. In addition to the four mentioned experts, other two experts are added which are a coaching expert and the system supervisor. The latter, that organizes tasks between agents, is considered as expert in the sense that he has its own database of rules. Such a system is a tool for decision support that allows students and job seekers to build their professional projects while taking into account the various factors involved in the process of educational and vocational guidance.

The use of ontology allows to identify the different guidance concepts and semantic links between them, in order to establish a better representation of the existing while staying within the context of sharing and reusing of knowledge.

Keywords*:* Educational and career guidance, multi-expert system, multi-agent system, decision support, semantic web, ontolgy**.**

1. Introduction

Choosing a career guidance is not always an easy task for students, especially since the choice should be based on several criteria and at a relatively early age. This important decision not only affects the academic and professional life of the student but also the efficiency of schools. In fact, a bad educational or professional guidance may be at the origin of several educational and social problems: school failure, school dropout, lack of skills, integration difficulties, unemployment, etc.

Choosing an orientation is often based on several criteria or parameters whose weights (or coefficients) are of different natures. In fact, several studies have examined demographic and personal factors that can influence the vocational and educational choice. Among personal factors, general aptitude level [1], cultural capital or status culture [2], values and principles [3], self-esteem [4] self-efficacy [5], interests [5], and personality [6] are determining factors in students' choice of vocational and educational guidance. Among these demographic factors are parents' occupation [7], parents' educational level [8], ethnic origins [2], as well as students' socio-economic status, gender and age [1].

With regard to IT interventions, they have experienced a great growth since their introduction in the mid-1960s due to the development of information technology and communication (ICT), for their many benefits: reduction of costs of psychological consultations, great ease in the updating and revision of data, improvement of the interactive dialogue, large process control, high speed, precision, availability of results, increase in the motivation and autonomy of the user, and ease at counting and analyzing tests' scores, Individualization of labor which allows everyone to progress at one's own pace[9, 10, 11].

This article aims to develop a multi-expert system for educational and career guidance by using a multi-agent approach and the semantic web. In fact in this approach, we envisage four areas of expertise, and thus four experts: pedagogical expert, psychological expert, sociological expert and economic expert. In addition to

the four mentioned experts, other two experts are added which are a coaching expert and the system supervisor.
The latter, that organizes tasks between agents, is considered as expert in the sense that he has its own database of rules. Use the multi-agent paradigm allows us to distribute a problem on a set of agents that communicate between them, coordinate their behavior and cooperate in order to build the individual career plan.

2. General presentation

In a socio-economic environment that is evolving and changing rapidly, it is extremely important that a country builds its policy in terms of education and training directly related to the needs of its labor market, for this, the country must give major importance to its guidance system. In fact, today there is no question of allowing young people to make 'vacuum' educational and professional careers by following erroneous studies, because it will result in only increasing the rate of unemployment. For this purpose, the orientation should not be far from the knowledge of the labor market and its trends.

Regard to the proposed design, we envisage an economic expert whose role is to determine the trends of the labor market and an 'Additional knowledge database' intended to contain knowledge about the country's policy in terms of training, hiring and major development projects.

2.1 Goal and principle

The proposed system as part of this work is supposed to make a triple works:

- The first one is to make a better pairing between an individual profile (profile acquired) and that of different trades (profile required) according to a set of criteria involved in the guidance process.
- The second is to generate adapted training paths in accordance with previously established pairing.
- The third is dedicated to monitoring the individual to the maturation and implementation of her/his career plan.

To do this works, the system is based on several fields of expertise (see 2.3), but also on the additional knowledge basis intended to contain; in particular, elements on the policy of the country in terms of training, hiring and major development projects. These latest knowledge are very useful, especially to help young people avoid following erroneous studies and making vacuous training paths.

This pairing is based on a set of factors (criterion) involved in the process of orientation [12, 13], among individual factors

- Professional interests, personality traits and values are used to generate a profession capital corresponding to the profile of the individual.
- Skills, training, socio-economic class, sex and health-appearance are used, rather, to apply some 'filtering', that is to say, eliminate the possible trades to adapt the best two possible profiles.

In their turn, the trades are subject to a certain categorization according to the criteria, professional interests, personality, values, skills, employability, wages, safety and comfort.

The following figure (Fig. 1) shows concisely the working principle of the system.

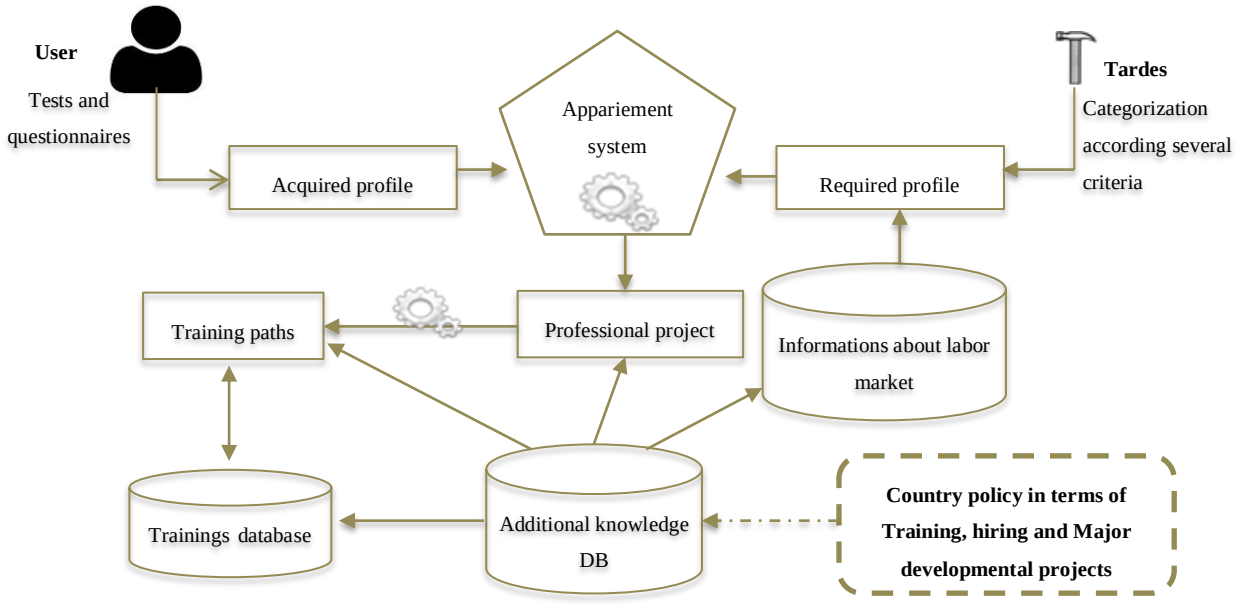

Fig. 1: Working principle of the system

2.2 General Architecture

The proposed system is based on four areas of expertise: pedagogical expert, psychological expert, sociological expert and economic expert. In addition to the four mentioned experts, other two experts are added which are a coaching expert and the supervisor of system. The latter, which organizes tasks between agents, is considered so in the sense that it has its own database of rules. These different experts use a collaborative knowledge base powered and updated through several sources of knowledge. The following figure shows an overview of the system architecture [14].

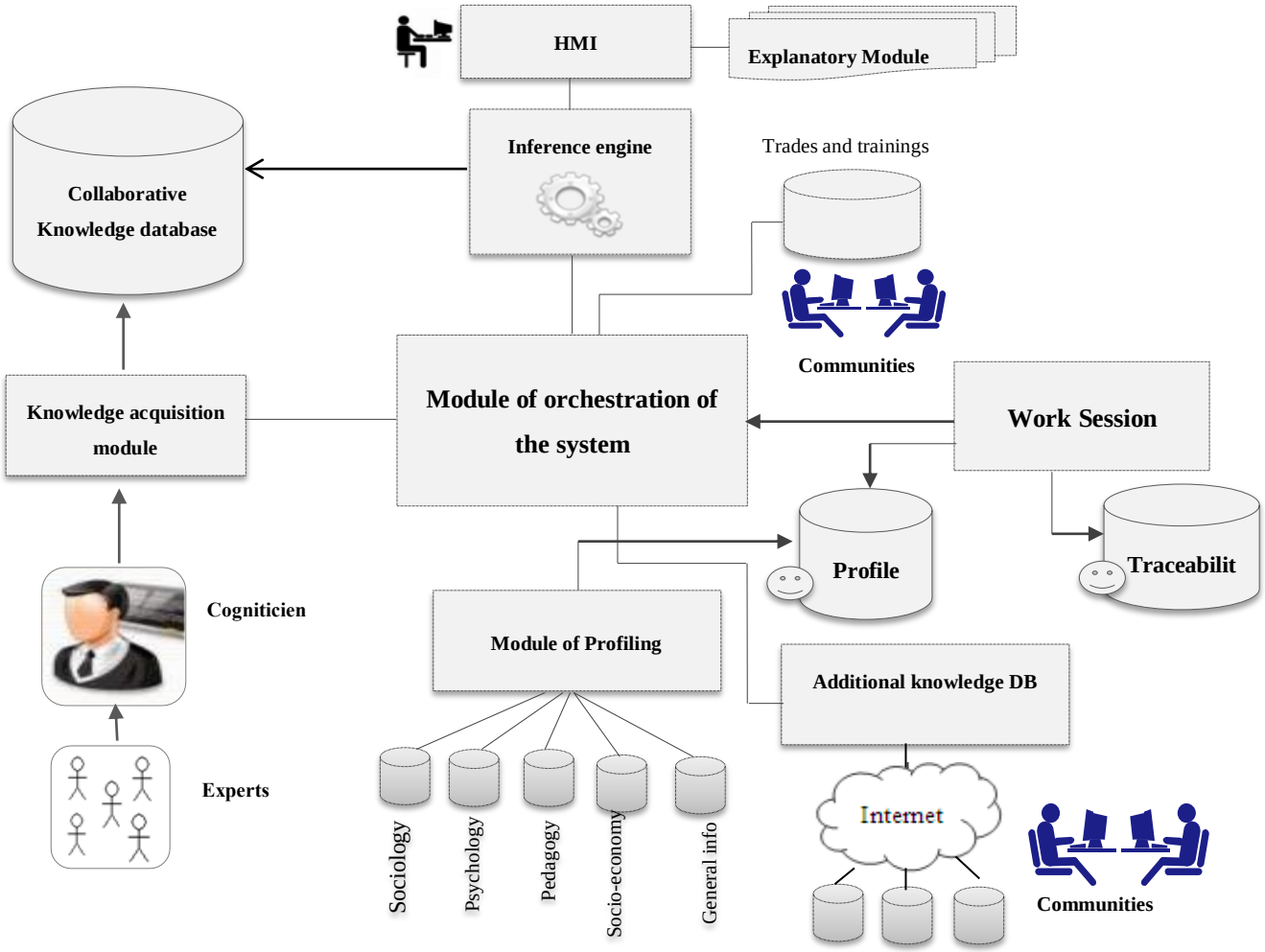

Fig. 2: General architecture of the system

The above scheme (fig. 2) illustrates the following points:

- The system consists of several applications (modules);
- A set of actors are solicited by this system;
- The system is accessed by multiple categories of actors (Students, job seekers, counselors, ...);
- The system is powered by data from external sources;
- The system is evolutionary in term of contents as well as of services and components;
- The system uses data coming from several different sources, physically isolated;

From this architecture we highlight the following principles and concepts:

- The use of multi-agent systems (MAS) to represent the different agents of the system;
- Integrating methodologies from Artificial Intelligence (AI) based on mathematical theories to render certain intelligent agents:Analysis of data, Genetic Algorithms, Networks bays, Neural Networks, Fuzzy logic, Petri nets, Case-based reasoning, Data mining,Etc.
- Architecture to allow effecient use, based on Service Oriented Architecture (SOA);
- Flexible distribution based on the principle of SAAS;
- The use of the principle of Big data;

2.3 The different sources of expertise

The proposed system uses the following experts:

- *The psychologist :* his role is to determine the individual's personality traits in order to know its vocational trends. He relies on a psychological model of vocational choice
- *The sociologist :* his job is to break down the values of the user. He relies on an analytical model of personality. The intervention of these two experts (psychologist and sociologist) allows determining the vocational group of individual.
- *The pedagogue:* he is responsible for determining the balance of skill of the user. He is interested in everything that is training, education, skills, abilities, etc.
- *The economist :* he is the expert of the labor market; he knows its trends, its requirements, the new occupations, trades in the process of disappearing, etc.
- *The Coach :* he is involved in monitoring the user. His role begins only after the determination of the professional project.
- *The supervisor :* he organizes the tasks between the different experts; he has his own database of rules.

3. Using ontologies to structure and modeling guidance domain

3.1 Ontology Concept

In literature, there are several definitions of the ontology according to the communities of thought. In the world of engineering knowledge, we include the definition of Grüber in his article available on the web entitled "what *is Ontology":* "In the context of knowledge sharing, I use the term ontology to mean a *specification of a conceptualization*. That is, ontology is a description (like a formal specification of a program) of the concepts and relationships that can exist for an agent or a community of agents". He states that this definition is made in the context of sharing and reusing of knowledge, and that what matters is what purpose an ontology is made. Although there are others [15, 16], the definition of Gruber is the most widely adopted [17].
Typically, ontology contains a hierarchical description of the important concepts of a domain and describes the properties of every concept through a mechanism of attributes-values [17].

Currently, Ontologies are used in several areas of knowledge engineering, information retrieval, information extraction, management and organization of knowledge, e-commerce, etc.

3.2 Ontology Representation Language

RDF, RDFS and OWL are main languages to represent ontologies [18]. In this work, we chose to use OWL (Web Ontology Language) because it is the standard currently recommended by the W3C for representing ontologies and it includes tools for comparing properties and classes: identity, equivalence, contrary, cardinality, symmetry, transitivity, disjunction, etc.

In fact, OWL is an extension of the vocabulary of RDF (s); it enriches the model of RDFS by defining a rich vocabulary for describing complex ontologies. So, OWL is based on a formal semantics defined by a rigorous syntax advantage of the universality of XML syntax.

3.3 Ontology use

In this work, the use of ontology allows us to identify guidance concepts and semantic links between them in order to establish a better representation of the existing while staying within the context of sharing and reusing of knowledge. So we have distinguished the following main domains of ontology (Fig. 3).

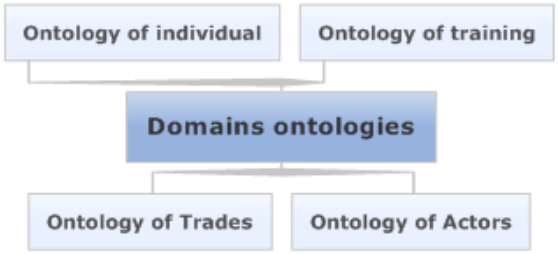

Fig. 3: Domain ontologies

Ontology of individual: This ontology allows us to identify the different concepts of guidance that depend on the individual himself as well as the semantic links between them. The following figure shows a schematic description of a part of this ontology.

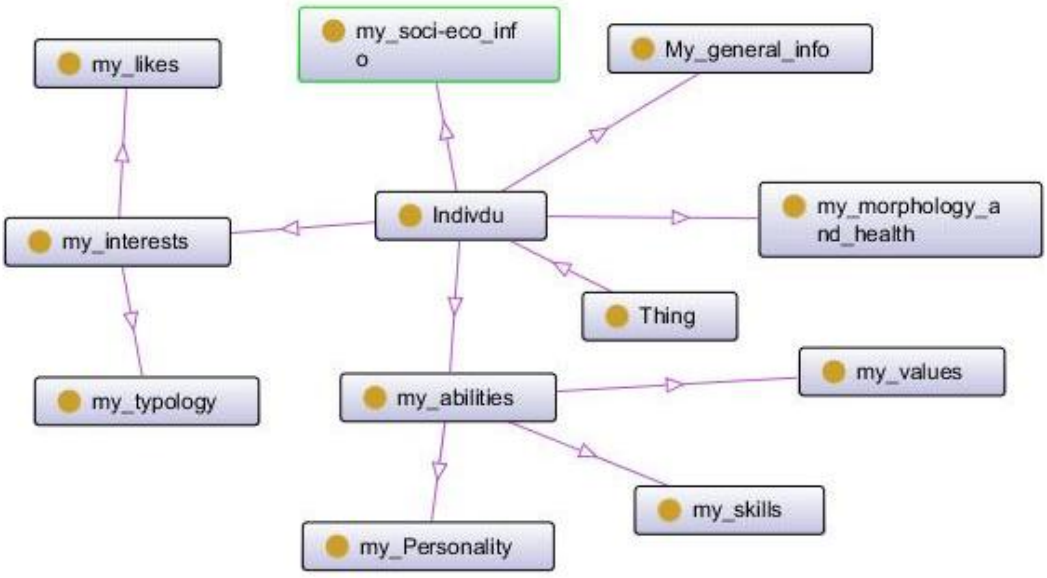

Fig. 4: Schematic description of a part of individual ontology

Ontology of trades: In its turn, the ontology of the trades allows identifying and representing the concepts involved in the process of guidance and relate to trade. In this work we used a categorization of trades based on several factors.

Ontology of trainings: This ontology is used to identify and represent the concepts concerning the trainings to generate; for each individual, personalized trainings paths.

Ontology of actors: The main actors of our system are students, job seekers, job providers, counselors and parents. The ultimate goal of these actors is to provide an individual (user) a most suitable profile orientation, calculated with respect to all the factors and parameters of the orientation. The final goal of these various actors is to supply an individual (user) a guidance the most adapted to his/her profile, calculated with respect to all the factors and the parameters of the guidance. The intervention of these actors is going to enrich the model increasingly with time.

4. The multi-agent architecture

Multi-agent systems have shown their relevance to the design of complex and robust distributed applications. The concept of agent is today more than an effective technology, it represents a new paradigm for software development in which the agent is autonomous software that has a goal, evolves in an environment and interacts with other agents by means of language and protocol [19].

In the context of this work, we used the Agent technology in order to implement flexible and modular solutions.

4.1 Concept of agent

In literature, there are several definitions of the agent concept; meanwhile, in the world of software, the term 'Agent' or software Agent is essentially a special software component that has autonomy that provides an interoperable interface to an arbitrary system and/or behaves like a human agent, working for some clients in pursuit of its own agenda [20].

An agent is a physical or virtual entity that can act, perceive its environment (in a partial way) and communicate with others; it is autonomous and has skills to achieve its goals and tendencies. In a multi-agent system (MAS) an agent can communicate with other agents which behavior is the result of these observations, knowledge and interactions with others agents [21, 22].

4.2 Communication between agents

The communication between agent is one of the key components of multi-agent system [20] and is its primary property [23]. In fact, agent needs to be able to communicate with users, with system resources, and with each other in order to cooperate, collaborate, negotiate, and so on.This communication is achieved by using some special communication languages. The first one was KQML which was developed in the early 1990s as part of the US government's ARPA knowledge Sharing effort. It is a language and protocol for exchanging information and knowledge that defines a number of performative verbs and allows message content to be represented in a first-order logic-like language called KIF [20].

Currently, the language most used and studied is the FIPA ACL which incorpartes many aspect of KQML [20].

4.3 The different agents

We present bellow the main agents (non exauhstive list) of our system:

- Interface Users Agent (IUA) : Retrieves and transmits requests from and to the AS agent
- Users Manager Agent (UMA): Allows Manage users: initialize, update and delete profiles.
- Professional Interests Agent (PIA) : Retrieves and transmits requests from and to the AS agent, Generates the RIASEC profile of the person
- Trait Personality Agents (TPA) : Retrieves and transmits requests from and to the AS agent, Determines personality traits
- Economist agent (EA) : Retrieves and transmits requests from and to the AS agent, Evaluates the employability of job
- Pedagogue agent (PA): Retrieves and transmits requests from and to the AS agent, Evaluates the educational profile
- Supervisor Agent (Manager) (SA): Retrieves and transmits requests from and to the AIU agent, organizes the activities of the different agents.
- Inference Engine Agent (IEA) : Retrieves and transmits requests from and to the AS agent, it is the core of the Inference Engine
- Generator Professional Project Agent (GPPA): Retrieves and transmits requests from and to the AS agent, Generates the professional project.
- Agents Coach (AC): Retrieves and transmits requests from and to the AS agent, Assists the individual to put into practice professional project Sends notifications to the individual.

5. Technical architecture

It is a multi-expert system supervised and organized around a multi-agent system, which is based on the n-tier model of the web application. This design allows different expert, specialized in their domain, to build the different components of the system.

Fig.5 shows the components of the system and the interaction between them. This system builds its collaborative knowledge base bay using different ontologies. The domain expert can to enhance their ontology (update) by using Protégé.

The system uses Protégé to edit the ontologies, JENA API, SPARQL to edit the OWL file; JADE to implement the SMA and JESS that is a rule engine environment and scripts written entirely in JAVA by Ernest Friedman-Hill au Sandia National Laboratories. In a multi-agent environment, JESS can be used as an element of decision of an agent.

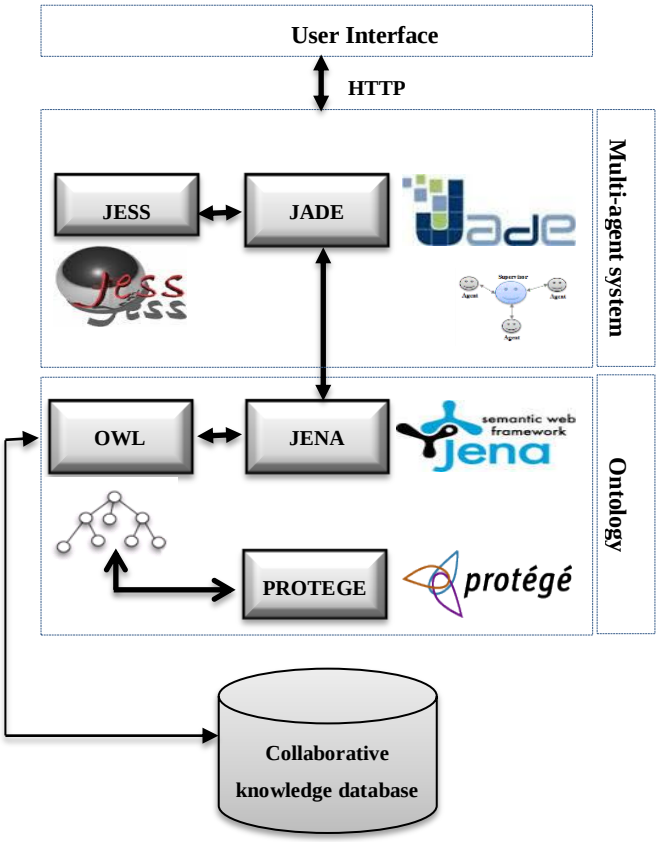

Fig. 5: technical architecture

6. Conclusion and perspectives

In this article we have presented the design of a multi-expert system for decision support in the guidance field by using the multi-agent paradigm and the ontology approach. The generation of a professional project is according to several criteria and requirements the collaboration between several agents. The future works, will be focused on the use of several scientific methods coming from artificial intelligence in order to make the agents of system more intelligent, at the same time the results obtained will be exploited in the implementation of a social network intended to the guidance in order to enable the communication and collaboration between different actors: students and their parents, job seekers, teachers, guidance counselors, professionals and providers of employment.

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