A Multi-Agent Based Architecture Proposal with Integrated Question Answering System for Collaborative E-Learning

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Summary
In recent years, many multi-agent e-Learning systems have been developed, each one proposes an architecture composed of different layers with multiple agents. Most of these architectures present a general e-Learning solution.
But, in an e-Learning environment, and to help learners to benefit the maximum from their courses, tutors are faced with the arduous task of writing answers - containing detailed, useful information - to every query and question they receive daily from their students. The task can take up a considerable amount of the time they spend each day on teaching. Therefor there is a need for a system that takes in consideration the importance of an automatic question answering system in collaborative e-Learning environment.
In this paper, we are going to introduce a multi-agent based e-Learning architecture with integrated Question Answering System that helps learners to achieve their learning goals and to find the best answers to their questions and helps tutors to answer questions asked by their students in a collaborative e-Learning environment.
Key words:
e-Learning; Multi-Agent Systems; collaborative e-Learning; Question Answering System; Ontology.

1. Introduction

With the rapid progress in technology and the advancement in learning systems, adaptive and intelligent e-Learning systems appear as a superior alternative to the traditional approach for the development of educational systems. An intelligent e-Learning system provides help to the learner during problem solving and aids the student in determining the best sequence through the learning material.
To develop this kind of intelligent e-learning systems, multi-agent technology is frequently being used. The application of Multi-Agent Systems brings to e-Learning many advantages compared to other architectures (peer to peer and Server/Client) thanks to its adaptability, interactivity, distribution, collaboration, personalization, security and intelligence.
Using intelligent and reactive agents in an e-learning architecture enables researchers to obtain a personalized e-learning system that adapts to the goals and characteristics of each learner [1].
As a result, multi-agent systems contribute powerful resources to develop educational systems and provide new options for designing and delivering educational content [2,3].
In collaborative e-Learning environment, learners frequently ask questions, but instructor may not be always available online to deal with these questions. Therefore, an efficient Questions-Answering System (QAS) plays an important role in the process of an e-Learning course, by helping the learners to achieve the end of the course without a problem and by finding the best answers to their questions. But the challenge is that the questions in an e-Learning environment are considered more complex as they require a source/domain knowledge and also long answers require to be extracted from multiple sources.
To face this challenge, we present herein a multi-agent architecture that provides an efficient collaborative e-learning system with integrated Question Answering System. The components of the e-learning system are designed to provide all the information needed to the Question Answering System in the process of finding answers to the questions asked by the learners.
The benefits of such architecture is that the components of the e-learning system are designed to be reused in the Questions-Answering System.
By taking in consideration both systems, we can achieve an efficient and intelligent e-learning system.
In [4] Hammami AND Mathkour introduce an adaptive e-learning system based on multi-agent technology using a distributed intelligent blackboard agent, which provides an easy way for agents to communicate, collaborate, and coordinate their actions and resolve conflicts. In this paper we try to improve the architecture presented in [4] with an integrated Question Answering System.

2. Existing multi-agent based e-learning systems

Many e-Learning MAS have been developed in recent years each one proposes an architecture composed of different layers with multiple agents. In [5] and [6] the authors present a list of multi-agent based E-Learning Systems and give a comparison between them in different measurements (Interactivity, Collaboratively, Adaptability and Security).

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We introduce here a short description of Existing Multi-Agent Based e-Learning Systems

2.1 MAS-PLANG

MAS-PLANG was designed by Pena et al. [7]. It is a Multi-agent based Intelligent Tutoring system, which supports distance learning through the web. It is an adaptive E-learning system, which provides content, navigation strategy and navigation tools according to the students learning style. MAS-PLANG consists of two levels of agents (1) Interface Agent-(i) Navigation agent, (ii) Monitor Agent, (iii) Synthetic agent and (iv) Sonia programmed agent (2) Information Agent- (i) User Agent and (ii) didactic agent.

2.2 Allegro

Allegro was developed by Viccari et al. [8]. It is a Multi-agent based system which support Adaptive as well as Collaborative Learning. It is composed of 7 agents: Tutor Agent, Student Agent, Interface Agent, Expert Agent, Diagnosis Agent, and Collaboration Agent.

2.3 I-MINDS

Intelligent Multi-Agent Infrastructure for Distributed Systems (I-MINDS) was developed by Leen-Kiat Soh et al. [9]. It is a Multi-agent based collaborative E-learning system. It provides a synchronous learning environment to the students. With the help of I-MINDS Teacher can deliver their lectures from the classroom and those lectures can be directly sent to the students via whiteboard technology. I-Minds works on three agents: Tutor Agent, Student Agent, Group Agent.

2.4 Electrotutor

Electrotutor was proposed by Ricardo Silveria and Rosa Maria [10] . It is a Multi-agent based E-learning system which works for teaching Electrodynamics. And for this it uses four different Agents. Pedagogic Agent, Communication Agent, Student Model Agent, Remote Agent.

2.5 F-SMILE

File-Store Manipulation Intelligent Learning Environment (F-SMILE) was proposed by Katerina Kabassi and Maria Virvou [11]. It is a Multi-agent based system for GUI, it teaches the beginners how to store a file into the personal Computer and for this it uses four different agents: Learner Module Agent, Advising Agent, Tutoring Agent, Speech-driven Agent.

2.6 Baghera

Baghera was designed by Sylvie Pesty and Carine Webber [12]. It is a Multi-agent based system for Adaptive E-learning. It is a web based application which works for teaching Geometry. Baghera works on five agents: Student's Personal Interface Agent, Tutor Agents, Mediator Agent, Teacher's Personal Interface Agent, and Assistant Agent.

2.7 EMASPEL

Emotional Multi-Agents System for Peer to peer E-Learning (EMASPEL) was proposed by Mohammad Bin Ammar and Mohammad Neji. It is a Multi-agent based adaptive E-learning system; it takes the facial expression of the learner and provides help accordingly. This System uses 5 different Agent: Interface Agent, Emotional Agent, Emotional Embodied Conversational agent, Tutor Agent, Curriculum Agent.

2.8 I-MBLS

I-MBLS (Interactive Multi-Agent Based Learning System) presented in [13] designed for distance learning on the web. This architecture makes use of six different agents named Student Interface Agent (SIA)- responsible for monitoring student learning activity, Tutor Interface Agent (TIA)- responsible for providing an interactive interface to the tutor, Decision support Intelligent Agent (DSIA)- responsible for important decision making, Collaborate agent (CA)- responsible for establishing collaboration among students, Test Agent(TA) – responsible for conducting tests, evaluating marks scored and lesson Planning agent (LPA) – responsible for helping tutor for preparing a course content.
After taking the review of various research papers discussing multi-agent based e-Learning architecture, it is found that there is no common strategy for designing MAS based e-learning systems. E-learning systems are designed and developed by using different methodologies, techniques and frameworks.
In general, the existing MAS based e-Learning systems have different levels of benefiting of what offers muti-agent technology (interactivity, distribution, collaboration, personalization, security and intelligence). There is no clear integration of Question Answering System in most of these architectures. In this paper we try to benefit from these architectures and present a new approach to Question Answering in an e-Learning environment.

3. Proposed architecture

To meet the needs of the new generation of learners and teachers, e-Learning systems architects and developers are under constant pressure to develop and deliver courses

related to learner's style and tutor's strategy. In order to be effective with providing e-Learning systems, the architecture must be based on a deep understanding of different pedagogical practices and models that can help in teaching by taking into consideration the myriad of learning styles of students and the variety of instructional resources and techniques that can facilitate student learning. In the same time, the architecture must take in consideration the integrated Question Answering System.
In Fig.1, we present the concept of the proposed architecture.

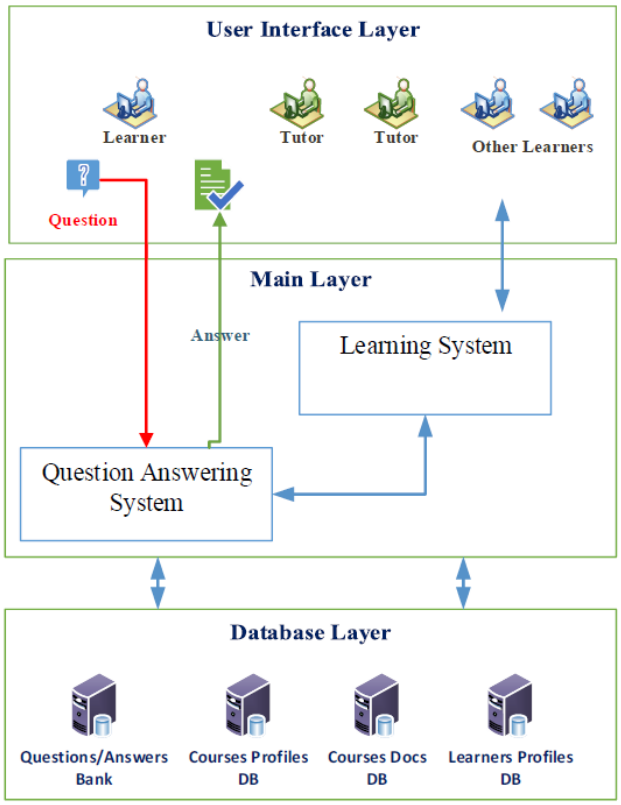

Fig 1 Proposed Architecture

Using the platform's interface, Learners and Tutors can access to the e-learning system and the Question Answering System. A number of databases is used to store all the data and recourses needed for the system. If a question is asked, the Question Answering System collaborate with the e-learning system to find the best answer to the asked question. Next, we present the detailed architecture of these 2 main components.

4. The proposed multi-agent e-learning architecture

Our objective is to develop an e-learning system that can help students learn more efficiently based on their learning styles and by collaborating with their tutors and other learners. Ontology is used to take advantages of machine processing ability and reasoning capability. The system is a multi-agent one, human and artificial agents work together to achieve the learning tasks. The artificial agents are defined to be used in the learning process and to help the Question Answering System in the process of finding the best answers for learners' questions.

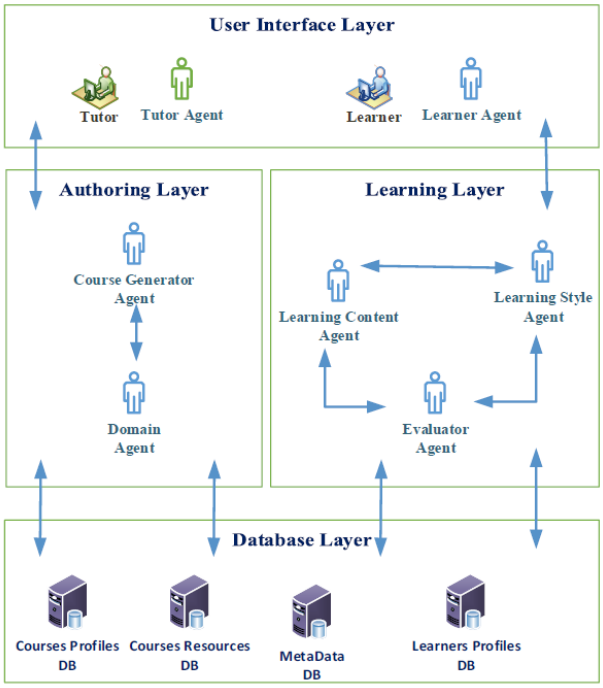

Fig 2 The proposed multi-agent e-learning architecture

Fig.2 illustrates the proposed multi-agent e-learning architecture. The model is composed of 4 layers:

- User Interface Layer: contains agents that provide the services required by Tutors and Learners to interact with the system. Tutor Agent and the Learner Agent represent each human tutor or learner connected to the platform.
- Authoring Layer: contains the agents that provide the main functionalities of our architecture to the educational content author. This layer contains a Course Generator Agent and a Domain Agent.
- Learning Layer: contains three types of agents that provide the functionality required by the learners in the learning process: Learning content Agent, Learning Style Agent and Evaluator Agent
- Database Layer: This layer contain the different databases needed to accomplish the course, it is composed of Courses Profiles Database, Courses Documents Database, Learners Profiles Database and Metadata database.

4.1 User Interface Layer

This layer contains agents that facilitate the interaction between Tutors and Learners ant the system. It contains the Tutor Agent and the Learner Agent.

- The Learner Agent: is an agent that is associated with the Learner's interface and has a wide range of goals. This agent primarily helps the learner in the registration process or in logging in to the system, monitors the Learner's actions, and provides access to the system resources. This agent presents information to the user about the entire learning environment. The agent shows, builds and refreshes the interface that is displayed to the learner and attempts to adapt this interface to be personalized for each particular Learner.
- The Tutor Agent: This agent has the same functionality as the Learner Interface Agent but with a focus on the author rather than the learner.

4.2 Authoring Layer

This layer contains the agents that provide the main functionalities of our architecture to the educational content author. This layer contains a Course Generator Agent and a Domain Agent.

- Course Generator Agent: This Agent is devoted to help tutors in the process of creating course structures or learning paths based on the ontologies as well as on information of learning styles. This agent selects concepts from the Domain Agent and assigns them to course topics, selects specific sequences of course topics to achieve the learning goals. Each topic is represented as a learning object.
- Domain Agent: This agent is responsible for managing the information about the courses, units, and learning paths. It helps in defining the different ontologies needed by the system.

4.3 Learning Layer

This layer contains three types of agents that provide the functionality required by the learners in the learning process: Learning content Agent, Learning Style Agent and Evaluator Agent.

- Learning Content Agent: This agent is responsible for retrieving and generating the related teaching materials for the Learner and determining what kind of learning materials should be delivered to each learner based on his learning style. Learning content Agent collaborate with Learning Style Agent to present to the learner the accurate learning resources according to the learner's style.
- Learning Style Agent: When the learners access the system, the Learning Style Agent asks him/her to answer a questionnaire. The result of the evaluation of this questionnaire allows the initial Learner learning profile to be assigned. Each time the learner is connected to the system, this agent tracks his/her actions and updates his/her learning profile.
- Evaluator Agent: This agent is responsible for monitoring the learner's actions and updating his/her learning profile. In addition, the Evaluator Agent selects an assessment level according to a particular instructional role that is assumed by a certain instructional resource, including definitions, introductions, illustrations, and examinations. The Evaluator Agent arranges and presents the material to the learner and collects the assessment results. These results are then stored in the databases to be used by other agents.

4.4 Database Layer

This layer contain the different databases needed to manage all kind of data in an e-learning system, it is composed of Courses Profiles Database, Courses Resources Database, Learners Profiles Database and Metadata database.

- Courses Profiles Database: This database contains all the information about the courses: basic information, course domain, related domains, course Concepts, related concepts, level of difficulty and other information. The structure of this database is designed to be ontology based, so it can be used by artificial agents when is needed.
- Courses Resources Database: This database contains the different resources and content of the courses.
- Learners Profiles Database: All learner's information and data are stored in this database. It is used by the Learning Style Agent to define the learner's learning style. The Learning Content Agent use this database to determine the kind of content to be selected for the learner.
- Metadata database: This database is used to store all the meta data of the e-learning system.

5. Integrated question answering system

A Question Answering system (QAS) is an important tool for improving e-learning and education. Several approaches employ different technologies to understand questions given in natural language text and after analyzing the question returns the answer in form of parts of textbooks or hyperlinks to documents containing the answers, which is inconvenient for the students or learners.

In this paper we present a syntactic and semantic multi-agent approach to question answering in e-learning platforms. Our proposal is to improve existing approaches

([14], [15]) by integrating the QAS in an e-learning system. This integration facilitates the communication and collaboration between different components and artificial agents in the process of finding answers to the questions asked by the learners.
This approach allows the use of different strategies and the reduction of errors introduced by individual methods and independent QAS. The cooperation among the agents aims to reach better solutions in each step of the processing.

5.1 Existing Question Answering Systems

The QASs play an important role in the process of an e-Learning course, by helping the learners to achieve the end of the course without a problem and by finding the best answers to their questions. But the challenge is that the questions in an e-Learning environment are considered more complex as they require a source/domain knowledge and also long answers require to be extracted from multiple documents. Therefore, there are many QASs architectures that uses different methods and techniques.
In [14] T.Alinaghi, et al. introduce a multi agent approach to Question Answering that applies all available resources to find answers to questions, three types of resources are used Frequently Asked Questions (FAQ) , course materials and answers by other learner.
In [16] Chun-Chia Wang and C. Hung introduce a semantic-based automated (QA) system like a virtual teacher to respond to student questions online.
In [17] V. Lopez et al. present AquaLog as an ontology-driven question-answering system which takes queries expressed in natural language and an ontology as input, and returns answers drawn from one or more knowledge bases (KBs).
In [18] P. Malhotra et al. focuses on creating semantic analyzer for automatic Question-answering system for domain specific database, it provides user with the relevant answers to the user questions using Natural Language processing (NLP) and Natural language Interface for DataBase (NLIDB).
In [19] M. JEMNI & I. BEN ALI present a tool that can answer automatically students by using and exploiting past cumulated experiences in past e-learning sessions.
In [20] Cassia Trojahn et al. present a multi-agent approach to question answering for the Portuguese language. their proposal is composed by three modules: (1) document and query processing; (2) ontology construction; and (3) answer generation.
These systems and others proposed different approach to Question Answering (Semantic, NLP, ontology-driven, past cumulated experiences,) and each one of these systems focuses on a specific technique or methodology, what gives us good results in some cases and not most cases.
By analyzing these existing systems, we propose an integrated architecture that combine several techniques and methods, so that we can introduce an efficient integrated QAS as part of an e-learning system.

5.2 Proposed Question Answering System

In this paper, we propose a QAS that i) receives the question from the learner and take it to the analyzing phase, where a syntactic and semantic analyze is performed on the question to define its nature and type and other properties, using Natural Language Processing, we try to analyze the question and present it in form of pedagogical Ontologies, after that , ii) the system verify if the question is already has been answered (from the Questions/Answers database), if there is an answer we send it to the learner, else iii) we start the Finding Answer Process, where different agents in the QAS and learning system, work together on several sources and databases to find the best answer.
If the answer cannot be found automatically, other tutors and learners contribute in answering the question.
After identifying the adequate answers, a validation is accomplished by learners and tutors, by using Learning To Rang (L2R) method presented in [21]. This method is trained to learn the answer rating, based on the feedback and ratings that other learners and tutors give to answers in our QAS. The selected answer is send to the learner after being saved to the Q/A database.

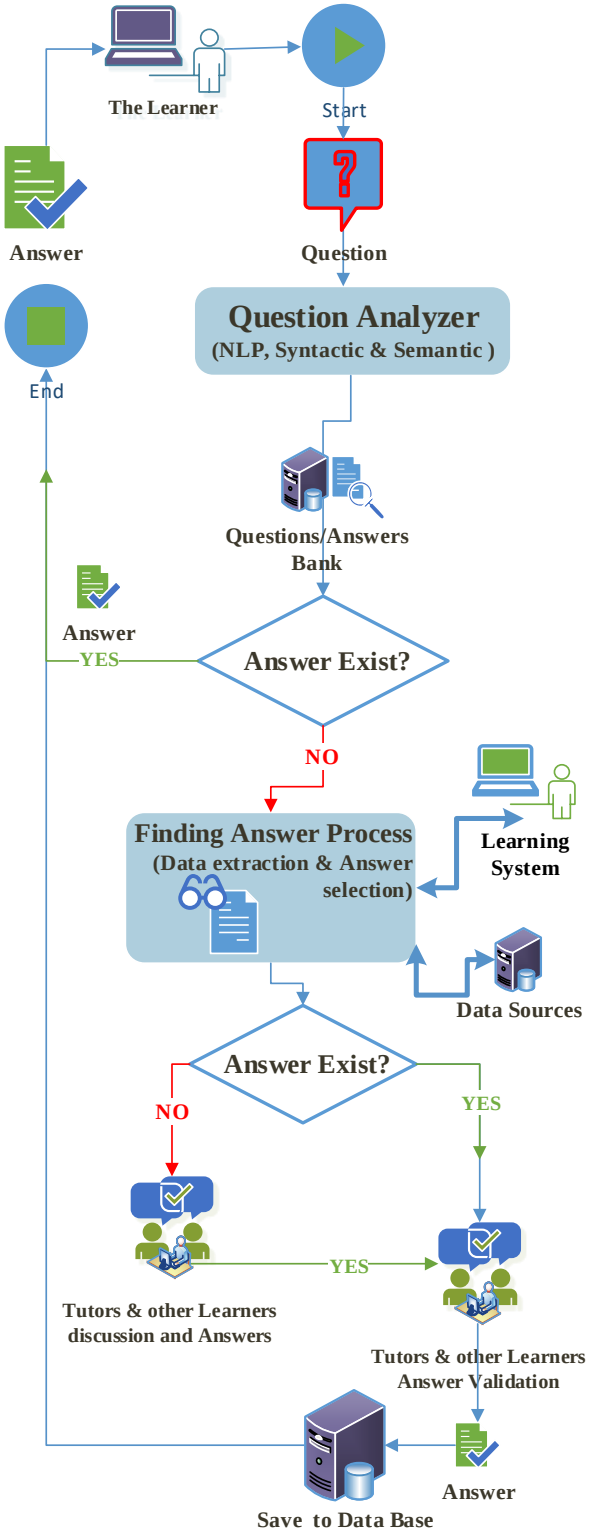

Fig. 3 Proposed Question Answering System

In Fig 3 we present the general idea of the proposed question answering system, the learner posts his question the system, the first phase start by analyzing the question syntactically and semantically and ending by reforming the input question to an ontology form that specifies the nature, the type, the domain and others properties of the submitted question. Next, the system verifies if the question's answer exists in the local database, if not Answer Finding Process is lunched. We are going to explain more details in the conceptual model for this proposed QAS.

5.3 Proposed integrated QAS Architecture

Our proposed Architecture is part of the full e-learning system – presented before - composed of three layers: User Interface layer, Main Layer (QAS & Learning System) and Database layer.

In [22] P.Q. Dung and A. M. Florea proposed a domain ontology for personalized e-learning in education systems. The ontology describes learning material that composes a course as well as describes learners and their learning styles. We try to improve the domain ontology described in [22] and use it in our proposed architecture.

Next, we present, our QAS architecture that uses the global User Interface Layer and the Database layer in the e-learning system.

In this architecture, the question is received as input and the answer is generated as output. To find the right answer different agents work together in 3 global phases:

- Question Analyzing: For the purpose of correctly answering a question, we need to understand what type of information the question seeks, so syntactical and semantical analyses is performed on the input text to define the type, nature and ontology domain of the question.
- Answer Generation: After analyzing the question, the system verifies if the answer of the question is in the Q/A bank, if yes, it is automatically redirected to the learner, else the system is ready to generate the answer from the different sources and by the collaboration of several agents. To generate the answer, the Answer Generation Agent needs to collaborate and work with a number of agents on different data to extract the right components of the answer, respecting the learner profile and the course profile.
- Answer Validation: After generating the answer, a validation is needed before saving the Question/Answer to the database, so the Validation Agent communicate with the tutor's agents and other learner's agents to validate the generated answer.

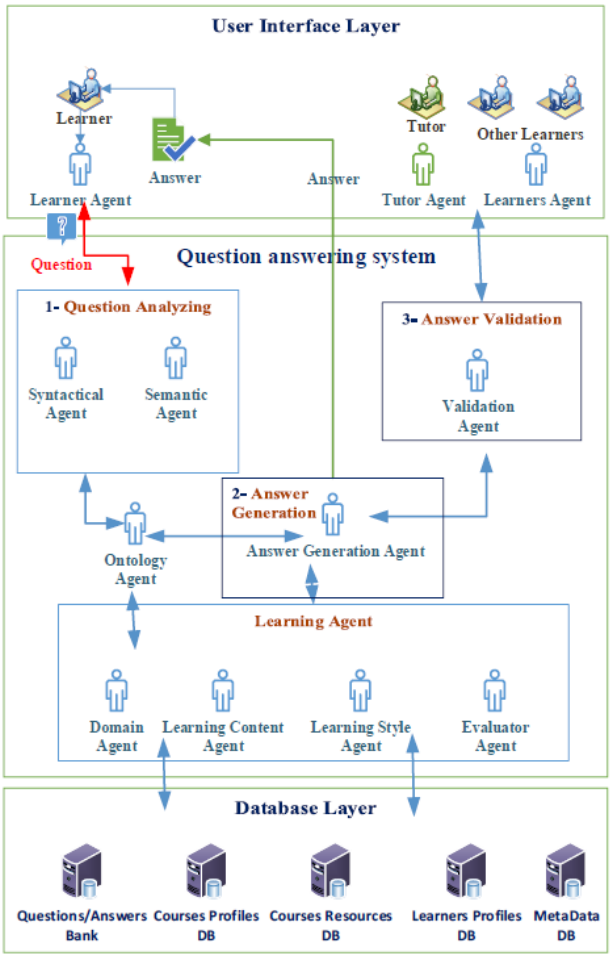

Fig. 4 Proposed integrated QAS Architecture

In Fig. 4 we presented the architecture of the proposed system, where we try to use the multi-agents approach, to make the benefit of its adaptability, interactivity, distribution, collaboration, personalization, security and intelligence.

In our architecture we use a number of agents that collaborate to answer the question submitted by the learner.

- Learner Agent: represent the learner in the system and it is the responsible of communicating with him via a user interface.
- Tutor Agent: represent the tutor in the system and it is the responsible of communicating with him via a user interface.
- Syntactical Agent: The syntactical agent is responsible for the parsing, adopting machine learning and linguistic methods, to select the most plausible syntactic analysis. To reach that, we are interested in the use of several approaches for syntactical analysis.
- Semantic Agent: The role of this agent is to associate a sentence with terms in the ontology. The semantic agent rewrites the syntactical structure in a semantic representation, taking into account the rules obtained from the ontology (Ontology Agent). To generate these semantic structures, it adopts strategies based on machine learning and linguistic techniques.
- Ontology Agent: is the responsible of finding the ontology domain of the question by collaborating with the Domain Agent from the learning system.
- Answer Generation Agent: it is the agent responsible of answer construction, by collaborate with the other agents.
- Validation Agent: communicate with the learner's and tutor's agents to validate the answer generated by the Answer Generation Agent.

6. Conclusion

E-learning has become a special part of education in recent times and in the same time question answering systems play an important role in collaborative e-Learning. Therefore, in this article we present a multi-agent based e-Learning architecture with integrated Question Answering System that helps learners to achieve the end of their courses without a problem and by finding the best answers to their questions. The proposed architecture aims to benefit from different technologies and methods to introduce an efficient system.

The future work is to improve this architecture and make an implementation of the system in e-Learning environment, using Jade platform and Ontology languages.

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