

Intelligent learning system for online learning

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Abstract. The paper presents an Adaptive Intelligent Learning System (AILS) designed to be used with any Learning Management System (LMS). The adaptiveness provides uniquely identifying and monitoring the learner's learning process according to the learner's profile. AILS has been implemented as a multi-agent system. The agents were developed as JADE agents. The paper presents the learning model, system components, agent behavior in learner scenarios, the ontologies used in agent communications, and the adaptive strategies. The sample application of the AILS to a dummy LMS is also given.

Keywords: Adaptive Learning Systems, Intelligent Learning Management Systems, Multi-agent Systems, Distance Learning, Fusion of Agents and Learning

1. Introduction

Distance learning with emerging computer technologies has offered many promises in the field of education. A crucial issue in educational technology is the provision of instructional environments and conditions that can comply with individually different educational goals and learning abilities. The learning management systems provide educational services to a wide range of students and they can help students to achieve their learning goals by delivering knowledge in an adaptive or individualized way [1].

Adaptiveness is a crucial issue in today's online learning environments (OLE). In [1], it is argued that virtual learning environments (VLE) are best at achieving learning effectiveness when they adapt to the needs of individual learners. OLEs should be able to identify learning needs and customize solutions that foster successful learning and performance, with or without an instructor to supplement instruction [2]. In [3], it is explained that the ultimate goals of online learning environments are to achieve adaptive learning and help learners to create their own knowledge.

The adaptive intelligent learning systems inherit the advantages of both artificial intelligence and learning

management systems. AI has been seen as a way to extend and improve the adaptation for a Learning Management System (LMS). The intelligence of a LMS is largely attributed to its ability to adapt to a specific learner's needs during the learning process. Flexible OLE can be established according to the knowledge of the subject domain, information of the individual student or the groups of students, and the teaching methodology [4].

Pedagogical agents are autonomous agents that support human learning by interacting with students in the context of the intelligent learning environment. They extend and improve upon previous work on intelligent tutoring systems in a number of ways. They adapt their behavior to the dynamic state of the learning environment, taking advantage of learning opportunities as they arise. They can support collaborative learning as well as individualized learning, because multiple students and agents can interact in a shared environment.

There are already some adaptive systems developed such as iWeaver [5], INSPIRE [6], MANIC [7], ARTHUR [8], CS388 [9], AEC-ES [10], etc. The adaptation strategies of these systems are based on a learning style model. They differ in the learning style model they use and the way they adapt it. For example ARTHUR, iWeaver, MANIC, CS388 base on sensory preferences; AEC-ES categorizes learners as

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either field-dependent(FD) or independent (FI) learners; CS388 functions in global-sequential dimension of Felder-Silverman; Tangow focuses on the sensing-intuitive dimension of Felder-Silverman; and INSPIRE is based on Honey and Mumford model.

Almost most of the presented systems except iWeaver and MANIC, assess the learning styles through psychometric questionnaire. The disadvantage of this approach is that the learners are classified into stereotypical groups and the assumptions about their learning styles are not updated during the following interaction with the system [11].

Although these adaptive systems provide important adaptive features, it is not possible to integrate any of them with an existing LMS. They are designed to be used as separate systems. However, there are lots of LMS used in practice and it might be very effective to plug adaptive features to these already existing and widely used learning management systems. Moreover, these adaptive systems do not have any compatibility with any learning standard. Neither in keeping the learner information, nor in storing the learning materials they adapt a standard. For reusability and interoperability of the learning content and learner information, the learning standards are essential for the researchers.

In this research study, a multi-agent intelligent learning system is proposed. Unlike the other systems, the AILS system has been designed to work on top of an existing LMS. To achieve this modularity, the interface for the adaptive system has been developed so that an agent has been totally assigned to the task of AILS-LMS communication. Since there is no standard interface defined for interaction among the adaptive systems and the LMS, it is necessary to add extensions for the specific LMS in order to establish AILS-LMS communication.

The aim of AILS is to provide e-learning services for online learners. The main operations to be adapted can be summarized as modeling the learner, presenting adapted instructional materials, searching for keywords, and communicating with other systems. In AILS environment, all agents interact with each other to accomplish their roles using the available resources so that the learners' needs are met.

The AILS system was analyzed and designed using an agent-oriented software engineering method, namely Gaia [12,13]. The AILS system has been developed according to the systems requirements and design issues. The AILS's agents have been implemented as JADE agents. JADE [14] is a middleware that facilitates the development of multi-agent systems. The

agent behavior is based on the learner's actions performed on the LMS, which are explained in the form of scenarios. In this study, the scenarios such as "user login", "user action to view the lecture note" and "user search request entering a keyword" are explained and their implementation results are given. In order to explain the systems better and test easily, a dummy LMS has been developed. During the development phase, we have used this dummy LMS to test the system through a sample course on "Java Programming". The paper also covers sample results from this experiment.

2. AILS: Adaptive intelligent learning system

2.1. The components

The aim of AILS is to provide e-learning services for online learners. The main components of the system are as follows:

- **Student Modeling:** AILS provides online learners a personalized learning experience. AILS maintains a learner profile. It not only allows the learner to specify his/her preferences, but also exhibits self-learning ability to learn the learner's characteristics by monitoring his/her behavior.
- **Adapted Instruction:** AILS adapts the learning services according to the learners' needs, which are defined according to the profile of the student modeled by the system. Adapting services involves content adaptation using Sharable Content Object Reference Model (SCORM) compliant lecture notes. AILS chooses the most appropriate lecture note using metadata of the content and learner' learner profile information.
- **Communication with other AILSs:** The system can communicate with other AILSs and it maintains keyword information of the learning objects stored in those systems to provide an inter-AILS search functionality.
- **Integration with LMSs:** The system integrates with any LMS having the following features as being SCORM compliant, having "upcoming events" tools that is used to display any message, and providing keyword search opportunity.
- **Learning Object Search:** A learner can search the available learning objects by entering keywords to the search tool in the LMS. The system responds to the user'S search request with the resources which exist in the repository and with the resources which exist in other AILS the system communicates with.

Table 1
The learning resources for sensor and intuitive learners

Learning resource type	Dimension
DATA, EXPERIMENT, PROCEDURE, CONCEPT	Active
THEORY, PRINCIPLE, INNOVATION, CONCEPT _(new) , MATHEMATICAL MODELS	Reflective

2.2. The architecture

Adaptive Intelligent Learning System system mainly involves two modules: agents module and environment module (See Fig. 1).

The agent module involves the necessary software agents to support adaptive learning in LMS. The communication and coordination between AILS agents occur in the agent module. The second module of the system is the environment module. The environment involves the following entities:

- **LMS:** AILS is a system built on the top of an LMS. It is a platform where the learning content is delivered and managed, and a combination of software tools provides a variety of functions related to online learning.
- **Learner Profile:** Learner profile collects data about a student's learning experiences, learning preferences, learning style, and learning habits. AILS system itself creates, stores and manages the learner profile repository. The system gets the information about the learner from the LMS' database and updates the learner profile repository.
- **SCORM Content:** SCORM stands for Shareable Content Object Reference Model. It is a collection of specifications that enable interoperability, accessibility, and reusability of web-based learning content.

2.3. The agents

The AILS has six agents: LMSINTERFACE-MANAGER, LEARNERASSISTANTAGENT, CONTENTADAPTERAGENT, PROFILEAGENT, RESEARCHERAGENT and AGENTMANAGER. The descriptions and roles of each agent are as follows:

- **LMSINTERFACEMANAGER** is the communication party with the LMS. The other AILS agents communicate with LMSINTERFACEMANAGER to handle the course related functions in LMS part. It also informs the other agents about the LMS events.

- **LEARNERASSISTANTAGENT** keeps track of the learner's learning process. It deals with learner modeling and content adaptation issues. Because of the complexity, it has two worker agents, CONTENTADAPTERAGENT and PROFILEAGENT.
- **CONTENTADAPTERAGENT** prepares an adapted content template for the learner using the learner profile information received from PROFILEAGENT. It applies adaptive strategies defined for AILS which is explained in detail in the paper. This agent also provides a content template for RESEARCHERAGENT to conduct adaptive searching.
- **PROFILEAGENT** initializes and updates the learner profile. It provides learner profile information requested by the other agents.
- **RESEARCHERAGENT** keeps track of the learners searching criteria and provide an ongoing search about the learner's search concepts, even when the learner is not online.
- **AGENTMANAGER** deals with launching new agents, registering new services, monitoring agents, and similar activities performed to manage agent creation and handling.

For each online learner, each type of agent is instantiated once. In other words, there are as many agents as the number of online learners in the LMS at runtime.

The communication links that exist between the agent types are given in Fig. 2. It indicates that communication pathways exist.

3. Implementation

AILS's agents are developed as JADE agents. JADE (Java Agent Development Framework) is a software development framework aimed to develop multi-agent systems and applications conforming to Foundation for Intelligent Physical Agents (FIPA) standards for intelligent agents. In this study, the version JADE 3.5 has been used. JADE has been one of the most commonly used agent middleware and it has well-structured agent management mechanism providing a runtime environment, a library of classes that programmers have to/can use, and a suite of graphical tools that allows administrating and monitoring the activity of running agents.

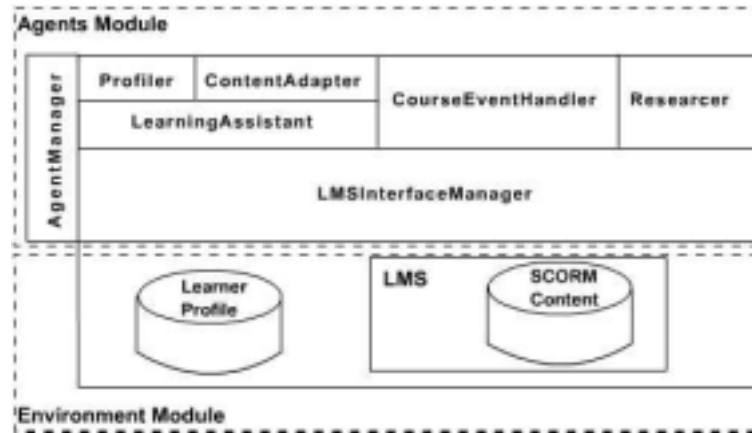


Fig. 1. The AILS System Overview.

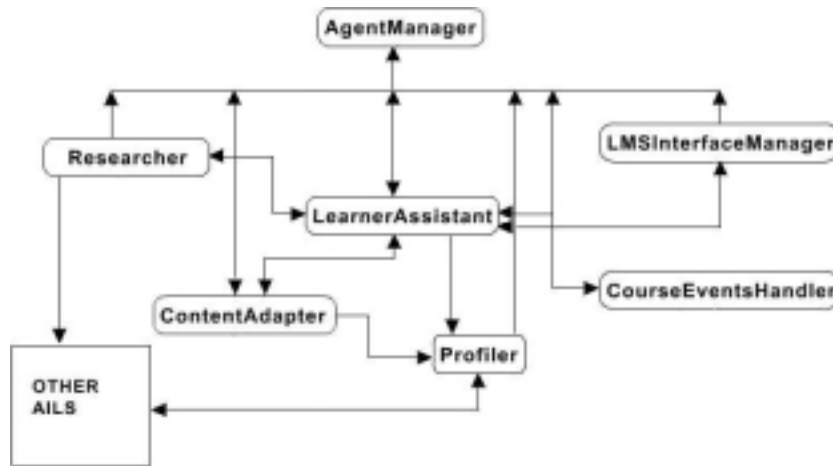


Fig. 2. The acquaintance model.

The implementation of AILS involves modeling learner, describing agent behaviors in terms of scenarios, creating ontologies used in agent communication, creating LMS-AILS connector interface, and defining content adaptation strategies. Each of the implementation issues are explained in detail in the following sections.

In order to test the system, we have also developed a simple dummy LMS. Through this LMS, we have conducted a demo application of AILS. At the end of this section, we provided sample screens from this demo application.

3.1. Learner modeling

Learner modeling is crucial to provide adaptive instruction. Each student requires an individualized stu-

dent model. The learner model consists of information about the learner's style, the learner's domain knowledge, progress, preferences, goals, interests and other information about the learner, which is crucial in adapting the learning process of the learner in an LMS.

We modeled the learner using three factors derived from the conceptual model proposed in [16]. These factors are: behavioral factors, knowledge factors and personality factors.

3.1.1. Behavioral factors

The behavioral factors involve the actions of the learner using the LMS module. The action history of the learner is kept using the following information such as "learner username", "LMS resource name (Search Tool, Login, Lecture Notes)", "Action name (Search, View Lecture Notes, Login)", "Time to start action",

“Time to end action”, “Concept (if applicable)” and “Action id”. This history, later on, is used to keep personal information about the user.

3.1.2. Knowledge factors

AILS system works with a SCORM-compliant LMS. In the design of the AILS, it is decided to keep the learning objects repository on the LMS part. The AILS just keeps domain knowledge with five attributes so that it becomes possible to search in the resource repository. The attributes of each knowledge unit are “Concept”, “Content”, “Type (image, text, exercise, activity, question, fact, definition, exam, advance organizer, concept map)”, “Sign (“UNDERSTOOD”, “NOT UNDERSTOOD”, “MISUNDERSTOOD”)", and “Location, path where the learning resource is kept in the LMS part”.

3.1.3. Personality factors

The personality factors are composed of learning standards and learning styles.

Learning Standard: IMS LIP (Instructional Management Systems Learner Information Package) [17] is one of the standards defining the learner. It addresses the interoperability of the Internet-based Learner Information systems with other systems that support the Internet learning environment. It involves the information such as biographic and demographic data relevant to learning; career and other objectives and aspirations; qualifications, certifications and licenses granted by recognized authorities; any learning-related activity (informal education, training, work experience, and military or civic service) in any state of completion; transcript; information describing hobbies and recreational activities; skills, knowledge, and abilities acquired in the cognitive, affective, and/or psychomotor domains; membership of professional organizations; the set of passwords and security keys [17].

Although the standards cover lots of information, they are both incapable to be taken as the basis to provide the personalized education [16]. For example, learning style is very important in adaptation. However, IMS LIP does not provide this information. Therefore, we decided to use the personality factors including the learner’s IMS LIP and the learning style information.

Learning Style: Learners have different ways of perception, construction and retention of knowledge. These differences which occur during the learning process are unique to each individual based on many factors like previous experience, mental abilities, and personal characteristics. In order to provide adapted in-

struction, the learning styles must be concerned and instructors must ask “how can this learner achieve more?” instead of “why is this learner not high-achiever?”.

There is different learning style models used in the literature. These are

- The Myers-Briggs Type Indicator [18]
- Kolb’s Learning Style Model [19]
- Honey and Mumford’s Typology of Learners [20]
- Felder-Silverman Model [21]
- Dunn, Dunn and Price Model [15]

In this study, the Felder-Silverman model was taken as the core learning style model which is one of the most widely used model. There is a well-known questionnaire used to categorize individual learning style, called Felder-Solomon Index of Learning Style (ILS) [22].¹ This questionnaire is validated in [23].

According to [21], the Felder-Silverman model classifies students according to where they fit on a number of scales pertaining to the ways they receive and process information. In [21], Felder and Silverman provide definitions of learning styles which are described as follows:

Active: Active learners like to try things out and see how they work and like to work with others.

Reflective: Reflective learners like to think things through first.

Sensing: Sensors like to learn facts, use well established methods. They are practical and careful.

Intuitive: Intuitors tend to work fast and be innovative and can often handle abstract and mathematical concepts well.

Visual: Visual learners like diagrams, pictures, graphs and films.

Verbal: Verbal learners get more out of words heard and written.

Sequential: Sequential learners like to work in linear steps that follow logically.

Global: Global learners like to jump in, absorb material nearly at random and then get the big picture.

The Felder-Silverman learning style model categorizes a student’s learning style on a sliding scale of four dimensions such as Active-Reflective, Sensing-Intuitive, Visual-Verbal and Sequential-Global.

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3.2. Agent behavior: Scenarios

AILS agents work cooperatively to perform the operations such as login, search keywords and view lecture notes. For the sake of simplicity, each operation is explained as scenarios such as “login”, “search” and “view lecture note”.

3.2.1. Login

1. User enters username and password
2. LMS invokes LMSINTERFACEMANAGER about the login and provides the user information through AILSLMSConnector
3. LMSINTERFACEMANAGER sends login action to LEARNERASSISTANTAGENT
4. LEARNERASSISTANTAGENT receives new action
5. LMSINTERFACEMANAGER sends user instance to LEARNERASSISTANTAGENT
6. LEARNERASSISTANTAGENT receives user concept instance
7. LEARNERASSISTANTAGENT sends user concept to PROFILEAGENT
8. LEARNERASSISTANTAGENT sends new action instance to PROFILEAGENT
9. PROFILEAGENT receives user concept
10. PROFILEAGENT receives login action instance
11. PROFILEAGENT checks whether user exists. If the user exists, it retrieves learner profile.
12. PROFILEAGENT updates the learner’s action history
13. PROFILEAGENT sends profile to LEARNERASSISTANTAGENT
14. LEARNERASSISTANTAGENT receives the learner profile (LEARNERASSISTANTAGENT will provide profile info to others)

3.2.2. View lecture notes

1. Learner selects “View Lecture Notes”
2. LMS informs LMSINTERFACEMANAGER through AILSLMSConnector and provide view lecture note action instance
3. LMSINTERFACEMANAGER sends action information to LEARNERASSISTANTAGENT
4. LEARNERASSISTANTAGENT receives action information
5. LEARNERASSISTANTAGENT sends action history instance to profiler to update the learner’s profile information

6. LEARNERASSISTANTAGENT sends action history to CONTENTADAPTERAGENT to display the appropriate content
7. PROFILEAGENT receives view content action instance
8. PROFILEAGENT receives the profile request
9. PROFILEAGENT updates the profile
10. PROFILEAGENT sends the updated profile information
11. CONTENTADAPTERAGENT receives the action history
12. CONTENTADAPTERAGENT asks for the profile information to PROFILEAGENT
13. CONTENTADAPTERAGENT receives the profile information
14. CONTENTADAPTERAGENT finds the appropriate content resource, i.e adapt content according to the profile information
15. CONTENTADAPTERAGENT sends resource name to LEARNERASSISTANTAGENT
16. LEARNERASSISTANTAGENT receives content resource
17. LEARNERASSISTANTAGENT sends resource to LMSINTERFACEMANAGER
18. LMSINTERFACEMANAGER receives the resource to display
19. LMS displays the learning content resource invoked by LMSINTERFACEMANAGER

3.2.3. Search keywords

The agent communication for this scenario is given as:

1. LMSINTERFACEMANAGER receives action history instance (through constructor)
2. LMSINTERFACEMANAGER sends action information e (involving lms ID) to LEARNERASSISTANTAGENT
3. LMSINTERFACEMANAGER sends search case information to LEARNERASSISTANTAGENT
4. LEARNERASSISTANTAGENT receives action information
5. LEARNERASSISTANTAGENT sends the action history instance to profiler to update the profile information
6. PROFILEAGENT receives the actions
7. PROFILEAGENT updates the profile action history
8. LEARNERASSISTANTAGENT receives search case instance
9. LEARNERASSISTANTAGENT sends search case to RESEARCHERAGENT

10. RESEARCHERAGENT receives the search case
11. RESEARCHERAGENT sends search case to CONTENTADAPTERAGENT agent
12. CONTENTADAPTERAGENT receives the profile-content template
13. CONTENTADAPTERAGENT request the learner's profile
14. PROFILEAGENT receives the profile request
15. PROFILEAGENT finds and sends the profile to CONTENTADAPTERAGENT
16. CONTENTADAPTERAGENT receives the learner profile
17. CONTENTADAPTERAGENT prepares a content template
18. CONTENTADAPTERAGENT sends the resulting content template to Researcher
19. RESEARCHERAGENT receives the content template and adds keyword information to the template
20. RESEARCHERAGENT sends the resulting template to LEARNERASSISTANTAGENT
21. LEARNERASSISTANTAGENT receives the template
22. LEARNERASSISTANTAGENT sends the content template to LMSINTERFACEMANAGER to find LMS resources
23. LMSINTERFACEMANAGER receives the template
24. LMSINTERFACEMANAGER asks LMS to display the resources which are suitable to that template
25. LMS displays the appropriate content

3.3. The AILS JADE ontologies

Messages exchanged by JADE agents have a format specified by the agent communication language (ACL) language defined by FIPA (<http://www.fipa.org>) international standard for agent interoperability. This format comprises a number of fields such as the sender, the list of receivers, the content, content language, the ontology etc. The jade ontology describes the vocabulary of the symbols used in the content and their meaning. Both the sender and the receiver must ascribe the same meaning to symbols for the communication to be effective.

In the AILS, six jade ontologies are developed in order to meet the requirements of the system such as LearnerProfileOntology, LearningContentOntology,

ActionHistoryOntology, LMSUserOntology, SearchCaseOntology, and AgentMessageOntology. Figure 3 shows an example figure for the ontology map for the learner profile.

3.4. The AILS adaptation strategies

The adaptive strategies of the AILS is divided into four main categories: Content Adaptation, Presentation Adaptation, Participation Adaptation and Perspective Adaptation. These are defined as follows:

3.4.1. Content adaptation

The content adaptation of the AILS relies on the sensor and intuitive dimensions of learner's style. Everyone uses both faculties, but most people tend to favor one over the other. According to Felder [21], *Sensors* like facts, data, and experimentation; *intuitors* prefer principles and theories. *Sensors* like solving problems by standard methods and dislike "surprises", *intuitors* like innovation and dislike repetition. *Sensors* are patient with detail but do not like complications; intuitors are bored by detail and welcome complications. *Sensors* are good at memorizing facts; *intuitors* are good at grasping new concepts. *Intuitors* are more comfortable with symbols than are *sensors*.

We defined out the applicable learning content resources for the sensor and intuitive type of learners as in Table 1.

According to the learner's style on this sensor-intuitive dimension, the list of appropriate learning resources are listed to the learner. Apart from the resources listed, the content adaptation of the AILS also involves the complexity level of the content. As explained above, unlike sensor learners, intuitive learners are not comfortable with the complex content. This is also taken into consideration while presenting the adapted content to the learner.

3.4.2. Presentation adaptation

The content is presented using the visual and audio properties of the content resource. In other words, a visual content or an audio resource is displayed to the user.

The learning style constitutes one of the aspects considered in the presentation adaptation. The visual or verbal dimension is the corresponding dimension in the learning style. According to the Felder-Silverman learning style, *visual* learners remember best what they see: pictures, diagrams, flow charts, time lines, films, demonstrations. If something is simply said to them

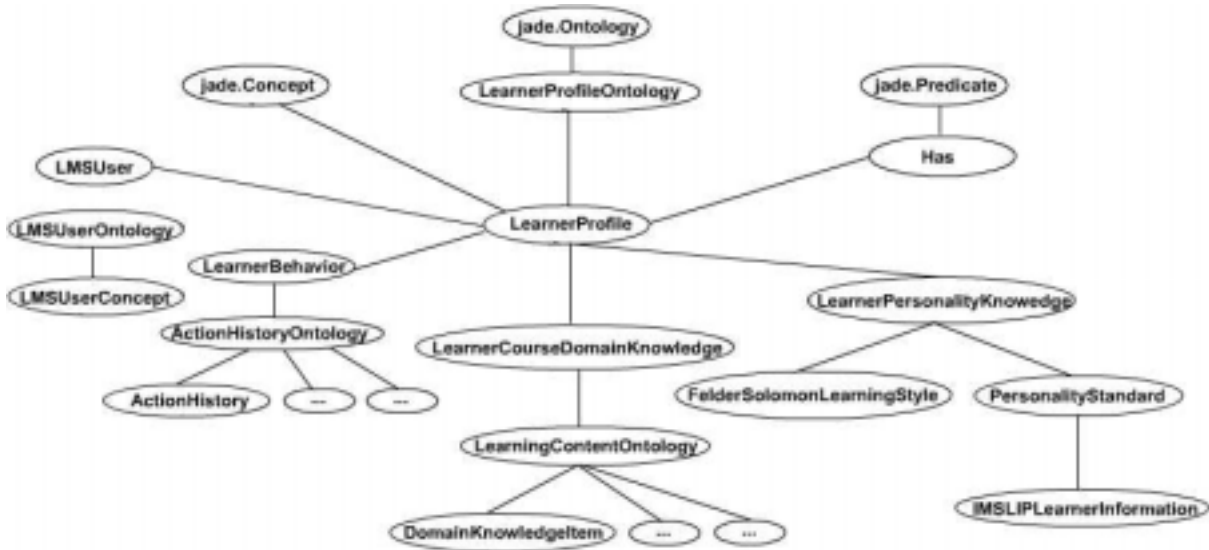


Fig. 3. The ontology map for the learner profile.

Table 2
The learning Resources for Visual and Verbal Learners

Learning resource type	Dimension
IMAGE, DIAGRAM, CHART	Visual
AUDIO, TEXT	Verbal

they will probably forget it. *Auditory* learners, on the other hand, remember much of what they hear and more of what they hear and then say. They get a lot out of discussion, prefer verbal explanation to visual demonstration, and learn effectively by explaining things to others.

Table 2 lists the appropriate learning resource types for visual and verbal learners.

The learner preferences such as favoring simple or complex visual designs, color choices (if applicable), language are also considered when personalizing the content.

3.4.3. Participation adaptation

The complex mental processes by which perceived information is converted into knowledge can be conveniently grouped into two categories: active experimentation and reflective observation [19]. Active experimentation involves doing something in the external world by discussing it, explaining it, or testing it. Reflective observation involves examining and manipulating the information introspectively.

Felder [21] explains the active learners as experimentalists, the reflective learners as theoreticians. He stated that active learners need to be active in order to

Table 3
The learning resources for active and reflective learners

Learning resource type	Dimension
EXAMPLE, EXERCISE, ACTIVITY, DISCUSSION, PROBLEM SOLVING	Active
QUESTION, EXAMPLE, LINKS, CRITIQUE	Reflective

learn, and reflective learners need to have an opportunity to think about the information being presented. It is obvious that when the students in a class are passive, then neither active learner not reflective learner can learn effectively.

As explained in the learning style model, the active learners work well in groups. However, the reflective learners work better by themselves or with at most one other person.

Table 3 summarizes the type of learning resources with corresponding learner type (active and reflective).

Felder [21] suggests to present material that emphasizes both practical problem solving (active) and fundamental understanding (reflective). It might be good to present lectures with occasional pauses for thought (reflective) and brief discussion or problem-solving activities (active). An exceptionally effective technique for reaching active learners is to have students organize discussion groups in the forum and let them come up with collective answers to questions posed by the instructor. To support this, the AILS agents ask the learner to work with the other learners who have common goals which are hold in the IMS LIP standard information.



Fig. 4. The search tool.

3.4.4. Perspective adaptation

Most formal education involves the presentation of material in a logically ordered progression with the pace of learning dictated by the clock and the calendar. When a body of material has been covered the students are tested on their mastery and then move to the next stage. Some students are comfortable with this system; they learn sequentially, mastering the material more or less as it is presented [21].

Sequential learners may be strong in convergent thinking and analysis; global learners may be better at divergent thinking and synthesis. Sequential learners learn best when material is presented in a steady progression of complexity and difficulty; global learners sometimes do better by jumping directly to more complex and difficult material. The curricula, course syllabi, textbooks, the lecture notes prepared for the online education are generally designed as sequential, which is already suitable for sequential learners. In order to reach the global learners, it might be good to provide overall picture of the course or goal of a lesson before presenting the steps, doing as much as possible to es-

Table 4

The learning resources for sequential and global learners

Learning resource type	Dimension
SEQUENTIAL CONTENT, TOC	Sequential
CONCEPT MAP,	Global
SYLLABUS, ADVANCE ORGANIZER, LEARNING STYLE	

establish the context and relevance of the subject matter and to relate it to the students' experience.

Table 4 summarizes the type of learning resources with corresponding learner type (sequential and global).

3.5. AILS-LMS interface

AILS-LMS Connector is an interface developed for integration of AILS with the LMS. The fields about the learner, learning session, learner action, course, content and searching operation are summarized in Table 5. AILS receives these fields, performs adaptation tasks, and provides results by updating the necessary fields. See section 3.2 for the details of these agents.

Table 5
The information in AILS-LMS communication

Information	Fields
Learner	username, id number, first name, last name, email, icq, skype, msn, phone1, phone2, institution, department, address, city, country, lang, time zone, description, time modified, course id, grade, time access, start time, lesson time
Learner action	learner ID, first access, last access, last login, current login, course id, action
Course	id, full name, short name, description, format, instructors, students, start date, number of sections, language, time created, time modified, SCORM content
Content	SCORM name, reference, version, max grade, grade method, maximum attempt, summary, time modified, SCO manifest, maximum time allowed, time limitation, next SCO, previous SCO, visible sections, hidden sections
Search	course id, learner id, time, keywords
Message	Message learner id, AILS message, time created



Fig. 5. The searching for the learner whose participation style is active.

4. An example

To understand the system better and to design, develop and test the system easily, a dummy LMS was developed. The dummy LMS keeps the user information and the lecture notes. AILS system talks with the dummy LMS through the connector. The dummy LMS has login, search and view lecture note functionalities. The implementation of the AILS has been continuing, and the other functionalities will also be added to the system such as assignment, announcement, and forum. The dummy LMS keeps the learning resources and user information, whereas the AILS keeps the learner profile and the domain knowledge.

A demo session involves the following sections:

4.1. Login

The learner enters the username and password information, AILS retrieves this information and activates the learner profile accordingly. The activated profile is used in the other functionalities such as searching and viewing content.

4.2. Search

The activated learner enters the keyword to search. The AILS agents create a content resource template



Fig. 6. The Searching for the learner whose participation style is Active.

which best fit to the learner profile. The dummy LMS keeping the resource repository uses that template to display the appropriate resource. To be adaptive, the AILS uses the learner profile to construct the personalized content template. Figure 4 shows the search screen in the dummy LMS

Figure 5 displays an example for the search results found from the search of a learner who has participation type as "Active".

4.3. Lecture notes

When the learner wants to view the lecture notes, AILS uses the learner profile information to find and display the personalized content. Figure 6 shows the personalized content for the learner who has participation type, "Active". Another example for personalized content given for the user having participation type as, "Reflective" is given in Fig. 7.

5. Conclusion

There is a need for providing education to students in different places around the world. To support teaching

and to facilitate learning, learning management systems must provide adaptive learning features. This yields the necessity for smart learning environments offering personal services with capabilities to learn, reason, have autonomy, and be totally dynamic. The adaptive intelligent technologies might diminish the barriers of learning in distance education.

The purpose of the research is to develop an adaptive learning system that enrich online learning management systems with machine learning techniques, namely AILS. The AILS is aimed to fulfill the needs of adaptiveness of on-line learning environments. It is based on the learning objects and the learning profiles to achieve the goal of adaptive learning in virtual learning environments. The main requirement is to provide learners to be uniquely modeled and to be monitored with their respective learner profile.

The AILS has six agents: LMSINTERFACE-MANAGER, LEARNERASSISTANTAGENT, CONTENTADAPTERAGENT, PROFILEAGENT, RESEARCHERAGENT, and AGENTMANAGER. These agents have specific roles such as registering agent's services, activating learner profile, adaptive searching of keyword locally and globally (inter-AILS communication), and viewing lecture notes. In this study we have



Fig. 7. The lecture Notes for the learner whose participation style is “Active”.

implemented the functions such as registering agent’s services, LMS-AILS communication, activating existing learner’s learner profile, conducting adaptive search locally in the current AILS, and viewing adapted lecture notes which are adapted according to the learner’s profile and adaptive strategies. We have also developed and used a dummy LMS in order to test the system. To establish agent-communication, we have developed Jade ontologies. The agent-communication and LMS integration worked properly. As the future work of this study, we are planning to complete the implementation of the agent’s behaviors.

We are also planning to use data mining techniques to learn association rules in the learner profile kept in the AILS. The adapting strategies will be updated accordingly when new associations are figured out. After that, we are planning to use the AILS in a sample session of a course offered through a LMS, such as Moodle. This yields to gather information about the effectiveness and usability of the system from the real online learners.

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