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A PROPOSAL OF A MULTI-AGENT SYSTEM FOR ADAPTING LEARNING CONTENTS TO USER COMPETENCES, CONTEXT AND MOBILE DEVICE

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ABSTRACT

E-learning has been a revolution in recent years in the training field. This, combined with the increased use of the mobile devices has caused the emergence of the m-learning. Hence new problems have appeared in the training field, such as showing correctly some learning contents in a mobile device that has restricted features or taking into account the learner's context in the learning process, because the learner can be anywhere. Because of this, this paper proposes a new multi-agent system for adapting the learning contents to the learner's competences, to the learner's context and to his/her mobile device. The paper also describes in detail the prototype developed for testing the proposed design.

KEY WORDS

Adaptation, multi-agent system, mobile device, context, competences

INTRODUCTION

E-learning has been a revolution in recent years in the training field. It has been based on the use of Information and Communication Technologies, and its most important characteristic is offering distance learning and training. This characteristic is frequently underlined as the main advantage of these systems, however, in traditional e-learning the minimum requirement of hardware continues being a personal computer (PC), therefore this is not an absolutely independence in location. This independence is not yet accomplished with the use of a laptop because a really independence in time and location means learning where and when a learner wants and having access to the learning contents [1].

For these reasons the mobile learning (m-learning) has emerged, an evolution of e-learning based on the use of mobile devices. An advantage of this system is the availability of these devices, because most of the population has a mobile device [2], e.g. phone, Personal Digital Agent (PDA), etc. in their hand or in their pocket during most of the day. Therefore, m-learning could be an important tool for the continuous learning.

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But m-learning presents also some challenges and difficulties:

- There are many types and models of mobile devices with different operating systems, this means that not all devices support the same files and formats. Therefore not all devices could show the same learning contents, it depends on its features. For example, if there is a learning content in a video format and there is a learner with a mobile device that does not support video, the learning content could not be opened.
- The nature of these mobile devices (possibility of use in wherever) means that a learner can learn in different situations and conditions (context) [5]. For this reason, each learner has a different context when he/she use his/her mobile device for the training. In the other hand, there are some learning contents which are not appropriated for certain contexts (e.g. a very long text when a learner is surrounded by people and noise).
- Learners have different competences acquired previously and it would be interesting to adapt the learning contents to these competences [4] because this would optimize the learning process [3].

This paper presents the design of a multi-agent system which is able to (1) adapt learning contents to different types of mobile devices and (2) the contexts of the learners, and also to (3) adapt the subjects and courses to the competences of the learners.
Section 2 describes the proposed system for solving the problem indicated in the introduction. Section 3 shows the obtained results of implementing the proposed solution and finally in Section 4 conclusions and future work are discussed.

THE DESIGNED MULTI-AGENT SYSTEM

The main aim of this work is proposing a new design of a multi-agent system (Figure 1) able to adapt the learning contents to the learner's context, to his/her mobile device and to his/her competences. Five different agents have been designed for carrying out this task, whose work collaboratively making up a multi-agent system.

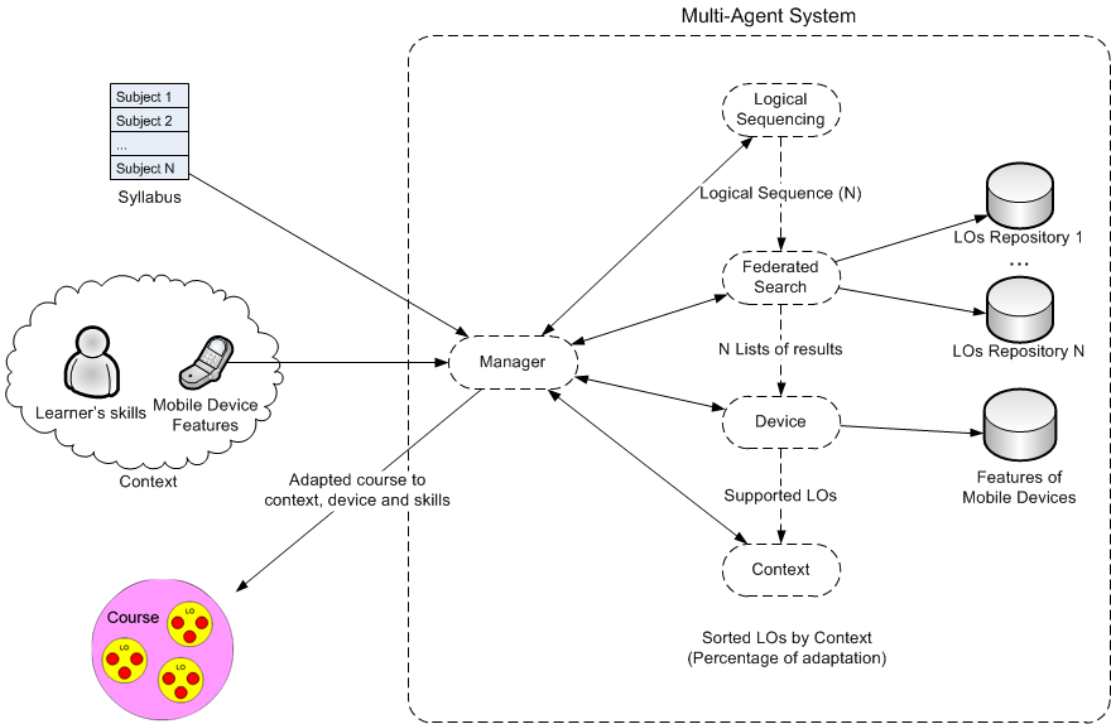

***Fig. 1** Designed multi-agent system*

The designed system has three elements as inputs: the learner's competences, the features of his/her mobile device, his/her current context and the learner's syllabus. The output will be an adapted course (a set of learning objects) to these parameters.

Each of the agents is explained below with their inputs and outputs.

Logical Sequencing Agent

The logical sequencing agent establishes a sequence of the topics or subjects that the learner has in his/her syllabus. This problem is represented as a Permut-CSP (Constraint Satisfaction Problem) [4] where the topics/subjects are the elements for permuting and their prerequisites and the competences obtained are the restrictions.

The inputs of this agent are the competences of the learner and his/her syllabus. The output is a sequence with the plan adapted to the learner.

Federated Search Agent

This agent performs a federated search in different learning objects repositories with each element of the result sequence of the previous agent. The specification SQI (Simple Query Interface) [6] is used for searching in different learning repositories, the titles of the subjects/topics of the syllabus are used as keywords for the search. After searching in the learning repositories a list of learning objects is created with the results for each subject/topic, removing the duplicated Los (Learning Objects).

For example, for a sequence of N elements (topics or subjects), this agent would return N lists of learning objects (one for each topic or subject).

Only the LOs packaged with a LOM (Learning Object Metadata) file are kept in the lists (the remaining of the LOs are discarded) because the next agents use this file for obtaining information about the LO.

Device Agent

The main aim of this agent is filtering the learning objects that the learner's mobile device does not support, e.g., if a mobile device does not support Flash format, all learning objects in Flash format are removed from the list.

The inputs of this agent are the results obtained by the previous agent and the features of the learner's mobile device. These features are searched in WURFL (Wireless Universal Resource FiLe) using the User-Agent when the learner connects with the system. Once his/her mobile device is located in WURFL some features of this mobile device are obtained, e.g., the screen resolution can be found in the 'resolution_width' and 'resolution_height' fields; the fields 'bmp', 'jpg', 'png', 'gif', etc. with true/false values represent if the mobile device shows or does not show this images format.

On the other hand, in the LOM file there is a field that shows the format of the LO, this field is called 'format' and it is within the 'technical' category, according to the specification 'this data element shall be used to identify the software needed to access the learning object'. The possible values are defined by the MIME (Multipurpose Internet Mail Extensions) standard, e.g., 'image/gif', 'text/html', 'video/mpeg', etc.

Each LO format is compared with the allowed formats of the learner's mobile device, discarding those incompatible learning objects.

Context Agent

Once all learning objects are supported by the learner's mobile device, these learning objects are sorted by context.

Each learning object is designed for a specific context, represented using IEEE LOM (Learning Object Metadata) [7], using the field number 5.6 'Context' of the specification. The possible values of this field are each specific contexts categorized by Kim *et. al* [8], e.g., 'hand: one, emotion: low', etc., in CSV (Comma Separated Values) format.

On the other hand, the learner's context is obtained from the learner through a questionnaire.

Taking into account the learner's context and the contexts of the LOs, the number of matches can be obtained, e.g., a learner could have a low level visual distraction and a specific learning object could be designed for low level visual distraction, this is a match.

Once the number of matches is established for each learning object the percent of adaptation to the context can be obtained as follows:

$$Adaptation\ Context\ Percentage = \frac{\#\ matches\ with\ the\ learner's\ context}{\#\ total\ of\ specific\ contexts\ of\ the\ LO} * 100$$

This percent is calculated for each learning object and later the LOs are sorted by this percent in descending order. The first LO in the list will be the most adapted to the learner.

The sorted list is showed to the learner with the coefficient of adaptation of each LO, so he/she can choose one different from the most adapted.

Manager Agent

The main aim of this agent is to manage the other agents because they are not aware of the others. It is the responsible of establishing the agents' inputs and outputs for running correctly. All agents are called by this manager agent and when they ends their execution the manager agent receives the results and it invokes the next agent (if it would be necessary).

This agent also has the aim of interacting with the learner and it is also responsible of invoking the execution of an specific agent if any parameter of the learner is changed, e.g., if the learner changes his/her mobile device it is necessary a new execution of the 'Device Agent' for filtering again the learning objects, or if the learner's context is changed the 'Context Agent' should sort again the list of the LOs.

The execution's sequence of the four main agents (sequencing, federated search, device and context) has been established based on the probability of changing, e.g., the learner's context should be probably more changing than his/her mobile device because the learner can move between different places or he/she can change some component of his/her context while the mobile device could be the same in all situations.

RESULTS

A prototype has been developed using the Java web technology. This prototype implements all agents using web-services as communication.

As example, the lessons of the subject entitled ‘Usability’ of the Master in Web Software Engineering program of the University of Alcalá have been selected for using this prototype. This subject is composed of fourteen lessons, nine of which are mandatory lessons and five are optional lessons.

Each lesson of this syllabus is represented with its prerequisites and competences obtained as a state-diagram showing the precedence and requirements of each lesson.

In the first screen of the prototype the learner can choose his/her context and competences (what knowledge he/she has got). The type of mobile devices is detected automatically using the HTTP headers, specifically the ‘User-Agent’. Later the mobile device model is searched using WURFL.

Next to this, the sequence of lessons is showed after the ‘Logical Sequencing Agent’ execution, showing which is the lesson most adapted to his/her competences. The first element of the sequence is recommended to the learner.

Once the learner selects a specific lesson the ‘Manager Agent’ invokes the execution of the rest of agents (Federated Search, Device and Context Agent). The Federated Search Agent searches in different repositories with the chosen lesson, and these results are filtered by the Device Agent taking into account the mobile device used by the learner.

Next, the learning objects allowed by the mobile device are sorted using the context selected by the learner and the percentage of adaptation is calculated.

The learning object with more adaptation percentage is the most adapted to the learner’s context. Finally the learner chooses one of them and it is showed.

CONCLUSIONS AND FUTURE WORK

A system for adapting learning contents to the learner’s competences, to the learner’s context and to his/her mobile device has been designed. This system presents some advantages with respect to other similar systems: it has been designed as a multi-agent system, allowing to delimit the functionality of each agent and being easily expandable with new functionality if it would be necessary. On the other hand, the system takes into account a complex learner’s context, according to context categorization of Kim *et al*. [8], showing the learning contents to the learner in an accurate way and showing the percentage of adaptation of each learning content. In addition, the system filters the learner contents based on mobile devices features, removing the learning contents that cannot be showed.

On the other hand, a disadvantage has been detected in this system: it may be necessary to adapt the learning contents to the mobile devices changing its graphical interface, e.g., if a learning content is in HTML format but it is designed for a large screen, it would be interesting to adapt it to a small screen by transforming its appearance. Although this could be solved by incorporating to the proposed system a new agent capable of transforming the learning contents using transformation languages, such as XSLT (Extensible Stylesheet Language Transformations) language for texts or other transformation mechanisms between different file formats, e.g., WAV to MP3, etc.

For demonstrating the system viability a prototype has been developed, so the next step is testing this system in a real case. For testing the system in a real case an experiment with students will be carried out in the 'Usability' subject of the Master in Web Software Engineering program. Two groups of learners will be created, an experimental group which will use the new system and another group, which will use a traditional e-learning system. This experiment will allow to demonstrate if the learners perform better, i.e., they have better grades in the exam, and if they are more motivated for learning than with traditional e-learning systems.

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