

Optimizing the management of distance courses through Multi-Agent System

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Abstract—The increasing use of Learning Management Systems - LMS - in educational institutions has created difficulties for coordinators and administrators effectively manage the Distance Learning Courses. This paper proposes and describes a support system for the management of online courses through Intelligent Agents (IAs). By the use of the proposed system, the coordinator of a LMS courses may rapidly obtain a summary of each current course, optimizing the visualization through reports and graphics, receiving periodically a message via e-mail about the present situation of each course. As a result, AIs show specific situations such as number of access of students, tutors and teachers, also help the follow-up activities. To verify the work, it conducted a case study in the Graduate courses in distance education with numerous real disciplines, occurring simultaneously in a tertiary and technician institution in Amazon state, Brazil. The case study aimed to evaluate the feasibility of the proposal, the results obtained in the tests may be concluded that developed system usage reached the goal, improving the standards of monitoring of online courses, supporting in the process of decision-making thus enable the adoption of new teaching strategies.

Keywords—LMS, Multi-Agent System, Management of Distance Course, Managerial Tool, Monitoring Report, Graphics Visualization, Report Submission.

I. INTRODUCTION

The Distance Education has grown by increasing the number of students and the number of courses offered, because of this, institutions are required to adopt management and perception tools in order to obtain effective communication, improving monitoring of process and minimizing present errors. In this context, it is necessary for the institutions to adopt management tools able to monitor the demands of the actors involved in the processes of Distance Education [1].

The wide administrative perception of what is occurring in distance learning courses has its relevance, mainly in the crucial moments, and many institutions have realized the need to incorporate a new strategic approach to improve management purposes [1][2].

This paper presents the Multi-Agent System MANAGER (MASM) that offers a new perspective of online course management. The monitoring of activities is provided by reports and graphs on management level. The system sends

reports, simplified emails of each course to respective coordinators through intelligent agents. The function of these reports is highlight situations that require significant attention by the course coordinators.

To describe this research, the article is divided into six sections: Introduction, Literature Review, The Proposed Multi-Agent System, Methodology and Procedure of Validation, Results and Discussions, and Conclusion.

II. LITERATURE REVIEW

A. Online Course Management

The implementation of a course of distance education demands that institutions be concerned with various aspects such as support to students and teachers, observed from an administrative and pedagogical perspective. These points are essential to the permanence of the student in the course [3] [4].

Reference [5] argues that distance education has many aspects being discussed or in phase of construction, such as the structure and organization of institutions which work with distance education, the new roles and responsibilities of teachers and students, as well as the appropriate use of communication technologies. Nonetheless, related to the organizational viewpoint, there are pioneer institutions in distance education that promote the alignment of organizational strategies to their particular manners of organization, also required by distance learning [6].

The effect of this change may be the imposition to adopt a management model that considers the need of managing teams, which work with a high degree of operability and a dynamic interaction among its participants. These considerations reflect the predominant features of work in the distance education institutions [7].

Therefore, scientists claim that the Distance Education system may reach some benefits, such as reputation and prestige, from supporting institution already prevails [8]. In the social sphere, it is believed that some students prefer to develop its distance studies, when the course is linked to a recognized institution in attendance education. For a qualitative analysis of the courses, the historical experience of the institution exerts great influence on the acceptability by distance learning courses [8].

The managers of distance education program have considered this evidence, then creating a sort of affiliate of the sponsor may use financial, social, cultural, and, mainly, intellectual assets that the institution-matrix already retains. This manager is responsible for planning, organization, direction and control of training processes of the distance learning. It also is important that person have knowledge of the inherent implications of the subordination of distance education to attendance teaching, especially its subordination to a central management (which usually considers distance education as a subcategory) [7] [8].

Consequently, the management of distance education courses in quality criteria, planning and organization has been discussed and has its degree of relevance in the academic world, as the main factor of this discussion is the quality of offered services and the continuity of these.

B. Intelligent Agents and Multi-Agent Systems

For this work, we adopt the paradigm of Intelligent Agent of software. In the 80s came the Distributed Artificial Intelligence, formed by the areas of Artificial Intelligence and Distributed Systems (SD). The Distributed Artificial Intelligence solves problems of manner cooperative and distributed, using agents. The approaching of agents using Artificial Intelligence techniques in learning environments enables greater flexibility and adaptability, improves cooperation and promotes society of agents.

An Intelligent Agent is an autonomous entity capable to interact with the environment, with other intelligent agent, cooperating or even competing against others and make decisions without the interference of a system or human beings [9]. An Intelligent Agent operates in an environment through sensors and acts through actuators using autonomy, social ability, reactivity, proactivity [10]. In summary, a Multi-Agent System is characterized as a system where numerous agents act together on an environment in the search for solving a problem.

It is known that Multi-Agent Systems make part of one of research areas of Distributed Artificial Intelligence and are used in educational systems, entertainment, industry and so on. Regarding the development of agents in MASs, the Intelligent Agents are inserted in environments where the use of their knowledge and skills, may develop activities related to their speciality. This type of application may be observed in various studies that employ this paradigm, applied to a Learning Management Systems (LMS) [11] [12] [13] [14] [15].

Thus, the Multi-Agent Systems are a mix of diverse agents in order to solve problems, from autonomous and flexible actions, as this type of application is present in numerous LMSs facilitating several tasks.

III. THE PROPOSED MULTI-AGENT SYSTEM

A. Verifying the necessity of a system of management of distance course

Before starting the development of the system, it was necessary to apply a descriptive and quantitative research with the participation of professionals from some public institutions of the State of Amazonas and Roraima, Amazon region of

Brazil. The intention was to define the characteristics and performance of a system responsible to assist in managing distance learning courses. However, we noted rare researches related to the management of distance education, mainly by educational institutions that offer courses in this type of education.

This step was based on the results presented by [16], because they were obtained through an online questionnaire, consisting 15 closed questions and 4 open questions that sought to capture indicators to establish the degree of satisfaction with the use of LMS, is in management, in the process of obtaining information on the environment or presenting information. The purpose of the questions was about the experiences and opinions of the participants on the use of LMS in management courses.

The use of the questionnaire in the survey was considered positive, because it allowed the participation of selected public, although some of them were not present at the time. For the researcher, it was possible to collect data on a particular topic from a specific audience, obtaining value information to understand better the gaps of the problem.

Reference [17] states in his research that the LMS Moodle stores the history of access and activities executed by students, teachers and tutors, however this information is scattered in predefined pages and reports within Moodle, requiring more time and effort technical team responsible for follow distance learning courses.

During the research, we found that distance education is idealizing alterations in teaching and learning, some institutions is reconsidering the management of education in this area. Working with people in organizations, including in educational institutions, is a commitment that these days has intensified and urging managers, regardless of educational level at which they operate. The management courses in the distance pursues a singularized management because of their characteristics and needs [1][3][7][8].

The final results presented by reference [16] indicate the need for a tool that facilitates the follow-up courses, supporting managers in the LMS itself, without the use of spreadsheets and data analysis part. In addition, the results were the basis for proposing and developing a support system for the management courses in distance education, as it is believed that this system can ensure speed, the progress of the activities and the accuracy of information collected and compiled in the virtual environment.

B. Overview of the system

To resolve the problem, it was decided to adopt the paradigm of intelligent agents, as explained in Section II, because its wide application allows implementation of repetitive tasks, to remember forgotten events, summarize intelligently complex data, learn and until make recommendations to the user. In this paradigm, we highlight the characteristics of proactivity, interaction and independence, which when applied in the context of a LMS may contribute for significant improvements of monitoring process of distance courses managed by this environment.

The Multi-Agent Systems are systems composed of numerous agents that produce or act together in order to achieve a given set of tasks or goals. These goals may be common to all agents or not. Agents within a MAS may be different or similar, cooperative or competitive and so on. The definition of the types of agents depends on the application purpose of the Multi-Agent Systems is inserted [9][10]. These benefits produce significant gains regarding the optimization of time and ease in operating systems that did not use this type of programming the LMS.

The architecture of the proposed system is shown in Fig. 1, where are observed the roles and relationships between the elements involved: Moodle courses, MySQL database, and Intelligent Agents (Notifier, Analyzer, Course Searching, Teachers Searching, Tutors Searching, Students Searching and Activities Searching).

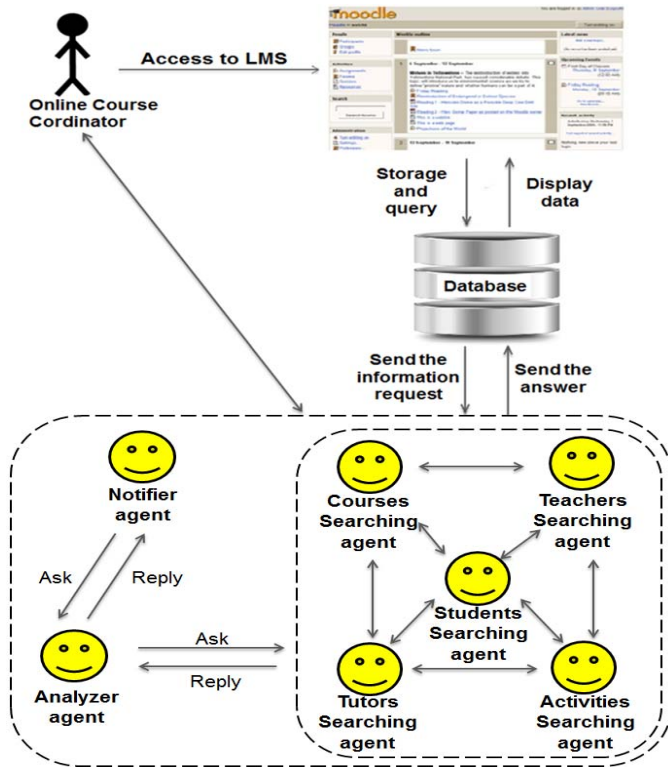


Fig. 1. Architecture of Multi-Agent System.

The MASM architecture shown in Fig. 1 is designed to be extensible, allowing future inclusion of new agents. Table 1 shows the seven agents proposed in the Multi-Agent System and summarized papers. And then, the various features will be detailed.

TABLE I. INTELLIGENT AGENTS AND THEIR RESPECTIVE OF PROPOSED MULTI-AGENT SYSTEM [18]

Intelligent Agent	Role
Notifier Agent	Responsible in maintaining the interaction with the user Coordinator, through receiving and sending information is for the Analyzer Agent or LMS. This agent monitors situations considered outside the normal course of standards and in this case, it will send notifications via email and on the user's screen.
Agent Analyzer	Responsible to receive, process, organize and send the information sent by the other intelligent agents that make up the MASM so that they can play their roles.
Courses Searching Agent	Responsible to access and query the tables in the database pertaining to required courses.
Students Searching Agent	Responsible to access and query the tables in the database relating to students of a particular course.
Teachers Searching Agent	Responsible to access and query the tables on the bank of relevant data to teachers of a particular course.
Tutors Searching Agent	Responsible collection agent to access and query the tables in the database relevant to the guardians of a particular course.
Activities Searching Agent	Responsible agent to access and consult the relevant tables in the database to the various activities of a particular course.

In this work, the MASM was modeled using the methodology MaSE (Multi-Agent System Engineering) [19]. It provides necessary support for the development of Multi-Agent Systems based on the principles of software engineering. The MaSE methodology is used in various scientific research projects in the world [13] [20] [21]. Due to the nature of this problem and complexity, was decided by MaSE as this methodology enables the organized development of Multi-Agent System and shows an appropriate methodology for the proposed system in this research.

C. Recognizing the Multi-Agent System of management of course distance

The MASM was developed using the Windows 7 operating system, the JADE framework [22] and the Java programming language [23]. From the agents presented in the previous subsection, enabling to execute the design and implementation of system agents.

In LMS used was installed a plugin developed in block format with a link available to access the main interface of MASM, featured in Fig. 2.

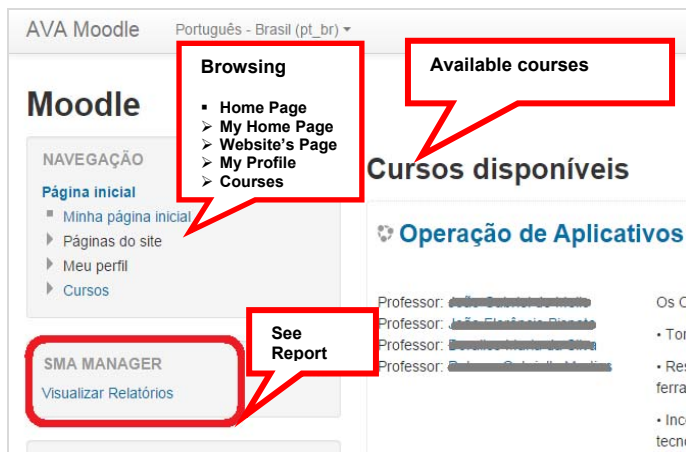


Fig. 2. View of LMS screen with the block to access the MASM.

After initial testing and implementation on the local server, we transferred the content to the external server, in order to be used further by coordinators.

In this section, we summarize the technologies that were used in the construction of Multi-Agent System, as well as the development of the prototype. Understanding the purpose of each technology has facilitated the construction of the system, considering the importance of each software in the process. We have to emphasize the laborious development work was facilitated by project to use the MaSE Methodology.

We found usually the first agents were implemented more difficult to program, but in the past we used reuse of agents, allowing them to be better prepared, besides the developer has acquired greater experience.

We emphasize that the solution has a certain independence of the Moodle platform may be adapted to other platforms, with some effort and adjustment. The MASM was subjected to various experiments and had changed its architecture, as can be seen in the following section.

IV. METHODOLOGY AND PROCEDURE OF VALIDATION

The experiments were performed during the period proposed by the research. The results were the basis for assessing the viability of the prototype of the initial design in a simulated environment as well as to check the performance of the system in a real LMS, which was defined as the Case Study. It is important to emphasize that the two experiments were applied in times and different purposes and using different versions of Moodle.

A. Testing and evaluation of MASM in simulated environment

The developed system is available as a plugin Moodle 2.8 [24]. To use the system, it is necessary that the course coordinator visit the LMS, the main screen you may view and access the link available in the plug-in. By clicking the link, the LMS is directed to another screen where the main interface of the system is presented, as seen in Fig. 3.



Fig. 3. View the main system interface.

On the left side of the interface, the system lists all the courses managed automatically by a certain engineer, although the tests presented in this section should explain the results obtained in the course “Application Operation” that was created in the simulated environment. The system generated the reports and graphs of other courses and provided this information to the user.

In order to prevent the courses coordinator visit several links to obtain the necessary information, the report and each course chart they were grouped in links in the sublevels. Clicking on the link “Report” the system displays the current report, organized and practical, containing information such as name and start date of a course, names of tutors, e-mail and last access tutors and teachers, number of students who accessed versus students who never accessed the course.

It is noteworthy that the request of the current report is sent to the Multi-Agent System which is responsible for forwarding it to the specific intelligent agents, as was foreseen in the system architecture, to complete the purpose of the requested task.

When is the situation of teachers or tutors never access the course, this information is highlighted in red so that the engineer's attention is focused on the situation detected by the system. This featured information is filtered by proactively Intelligent Agents. The report can be printed from the browser to the coordinator to take the necessary measures, or for registration purposes.

The other display option available to course coordinator is through graphs. Clicking on the link “Chart”, the interface shows three graphs for the course “Basic Computer”: Professor log ratio, log ratio Tutor and Students access the course.

Log rates can be filtered for a period defined by the user, but to facilitate the visualization of information, the period is already preset for the last seven days. It is important to note that the logging rate not only records the access of teachers and tutors on the course, however also accounts for the access, visualization, correction of tasks and interaction with other participants, finally records the interactions in the course.

Interactions in some educational institutions are key factors to evaluate the continuity of a teacher or tutor in new courses offered.

The system sends, every seven days, a report via e-mail to the coordinator. As mentioned before, during the experiment the system highlighted proactively, situations where teachers and tutors never accessed the course.

During this experiment-simulated environment, numerous adjustments were made, including improvements in the graphics and the overall interface of the system. The simulation results were important because they enabled an overview of what was necessary to add or change, before performing system tests on real courses.

This step has enabled significant improvements to the progress of the work, such as adding and highlight in red the name of teachers and tutors who were more than five days without access the course, since the absence during this period cause serious impact on the progress and quality of the courses.

Another important change was to add information in the report about the activity “Task” as it is considered one of the activities most used in LMS, however, the information is not available in an easier way for course coordinators. Thus, the agent was set to obtain the job name, number of registered participants, number of participants sent and number of corrected tasks.

After adjustments to the system, the next expected step was the test in a real virtual environment. The steps and results of this test are presented in the following subsection.

B. Testing and evaluation of MAS in real environment

The monitoring process of learning is an essential step in the training capacity of the students and the positive outcome of the course to have an extended administrative perception of what is happening in the courses also has its relevance, especially in the important moments. Major institutions have realized the need to incorporate a new strategic approach to improve management purposes [2][7].

Then, in this subsection we introduce the test cases of the 2nd experiment and the results of the case study in a real LMS of a Higher Education Institution of the Amazon. This institution offering courses in classroom and distance modalities, for technical secondary education levels, higher and postgraduate students, all properly regulated by the Ministry of Education and Culture (MEC) [25]. In Fig. 4 we can see the LMS interface of this institution, which displays the list of Graduate courses that are offered there

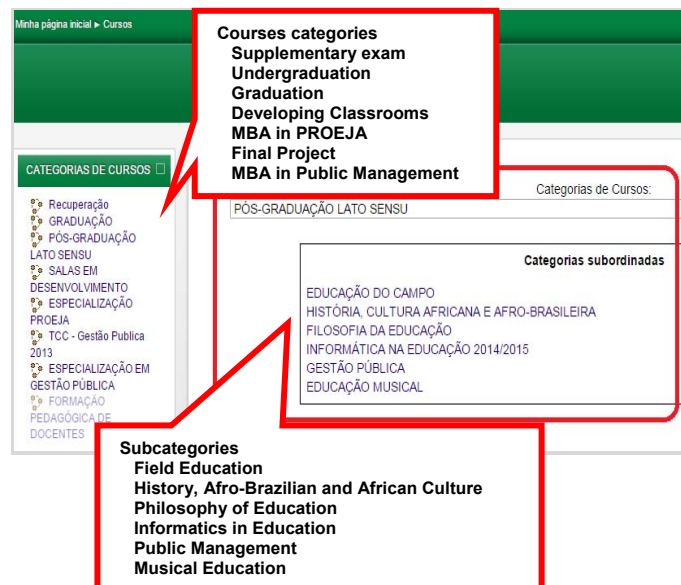


Fig. 4. LMS Interface for Graduate distance learning courses of the higher education institution.

In other LMSs, the term “course” is equivalent to the term “discipline” of the curriculum of graduate courses offered by the institution, as an example, there are the Rural Education courses and Philosophy of Education, now linked to the Open University of Brazil. Currently, these courses are underway, and being in the form of modules, courses are offered with working hours from 15 to 45 hours / total.

It is noteworthy that, for the tests of the proposed MAS were selected 2 Graduate courses: Public Management and Informatics in Education, to have at that time recent classes and activities in progress, and consequently, the coordinators of the different courses have different profiles between itself.

The tests for the case study occurred during 30 days of August 2015 and the corrected version of the system was tested in this experiment. The week before the system test period, participants received coordinators through tutorial, instructions the developer to add the plugin and use the tool (Fig. 5).



Fig. 5. LMS screen display with access block MAS support the management of distance learning courses.

Participants reported that the use of the system occur at least 2 times a week, because the management activity of the courses take place on demand.

During the duration of the experimental test, the subjects involved had not a registered specific tutor, but a mentoring coordinator. Thus, the gathering of information about user access with this profile was not monitored. If discipline had the distance tutors enrolled in the course, we could have access preview of the report is as shown in Fig. 6.

Tutor Access

Tutor*: [REDACTED]
E-mail: [REDACTED]

Days total in the period: --
Logs total no periodo: --
Last access: --

* The course wasn't accessed, until now, by the tutor.

Tutor*: [REDACTED]
E-mail: [REDACTED]

Days total in the period: 9
Logs total in the period: 17
Last access: 22-01-2015 16:40:14

* Tutor of more than 15 days without access this course.

Fig. 6. Report partial view of some tutors.

For this case study, the Activities Searching Agent performs the information search tasks only, as results shown in Fig. 7.

Subtítulo
1 - Students Access
Total students who have never accessed the course until this date: 12 of 38 enrolled.
Information about participation in the task: Atividade 1 - PRÉ-PROJETO DE TCC I
Delivery date:** 23-08-2015 23:55
Total submitted assignments: 17
**** Alert:** Deadline expired or lack below five (5) days to finish the deadline for tabling.

Fig. 7. Partial view of the report regarding access students and recent activities.

An important observation in Fig. 7 that one of the tasks was the deadline expired and there were only 17 submissions task relatively low number for this class, considering the number of 38 students enrolled. Another important issue to be analyzed, refers to discipline “Elaboração de TCC/Monografia, Projeto e Artigo Científico”, where we observe that the teaching material available in LMS and the teacher were the same, and yet were no reports of students without access the discipline.

Note that this discipline has a total of 157 students enrolled, and 35.03% of the students have never used until now. In this scenario, it is important to follow up and rapid action of the course coordinator and mentoring coordinator, in order to encourage the return and participation of students in the subjects offered in the course.

Analyzing the access teachers, let's take as an example still the same discipline, where we have in Fig.8 a partial view of a particular teacher report.

<p>Relatório gerado em Terça-feira, 25 de Agosto de 2015 às 8:02 - PM</p> <p>CURSO: 13-Elaboração de TCC/Monografia, Projeto e Artigo Científico - IE - BV - RR Nome Abreviado: 13-Elaboração de TCC/Monografia, Projeto e Artigo Científico - IE - BV - RR Polo de Ensino: BOA VISTA - RR - IE Data de Início: Segunda-feira, 17 de Agosto de 2015 às 12:00 Formato: topics</p> <p>Acesso de Professores) Professor: Mateus</p> <p>Total de dias no período: 5 Total de logs no período: 27 Último Acesso: 23-08-2015 17:24:39</p>	<p>Relatório gerado em Terça-feira, 25 de Agosto de 2015 às 8:02 - PM</p> <p>CURSO: 13-Elaboração de TCC/Monografia, Projeto e Artigo Científico - IE - CR - RR Nome Abreviado: 13-Elaboração de TCC/Monografia, Projeto e Artigo Científico - IE - CR - RR Polo de Ensino: CARACARAÍ - RR - IE Data de Início: Segunda-feira, 17 de Agosto de 2015 às 12:00 Formato: topics</p> <p>Acesso de Professores) Professor: Mateus</p> <p>Total de dias no período: 4 Total de logs no período: 14 Último Acesso: 23-08-2015 17:23:57</p>
<p>Relatório gerado em Terça-feira, 25 de Agosto de 2015 às 8:02 - PM</p> <p>CURSO: 13-Elaboração de TCC/Monografia, Projeto e Artigo Científico - IE - TF - AM Nome Abreviado: 13-Elaboração de TCC/Monografia, Projeto e Artigo Científico - IE - TF - AM Polo de Ensino: TEFÉ - IE Data de Início: Segunda-feira, 17 de Agosto de 2015 às 12:00 Formato: topics</p> <p>Acesso de Professores) Professor: Mateus</p> <p>Total de dias no período: 5 Total de logs no período: 160 Último Acesso: 23-08-2015 17:22:42</p>	<p>Relatório gerado em Terça-feira, 25 de Agosto de 2015 às 8:02 - PM</p> <p>CURSO: 13-Elaboração de TCC/Monografia, Projeto e Artigo Científico - IE - MN - AM Nome Abreviado: 13-Elaboração de TCC/Monografia, Projeto e Artigo Científico - IE - MN - AM Polo de Ensino: MANAUS - IE Data de Início: Segunda-feira, 17 de Agosto de 2015 às 12:00 Formato: topics</p> <p>Acesso de Professores) Professor: Mateus</p> <p>Total de dias no período: 5 Total de logs no período: 17 Último Acesso: 23-08-2015 17:21:56</p>

Fig. 8. Partial view of some teachers report.

We note that the same teacher, has different amounts of hits on every Polo, going to a disparity between them. It is worth mentioning the importance of the teacher must maintain access levels approximate between classes, and this reflects in the unfastened accompaniment to each and may reflect good or unpleasant results.

In Fig. 9, we can see the information provided in the chart the course “Elaboração de TCC/Monografia, Projeto e Artigo Científico”, in Tefé City. In this view, the filtrate was period of 8 days teacher access.

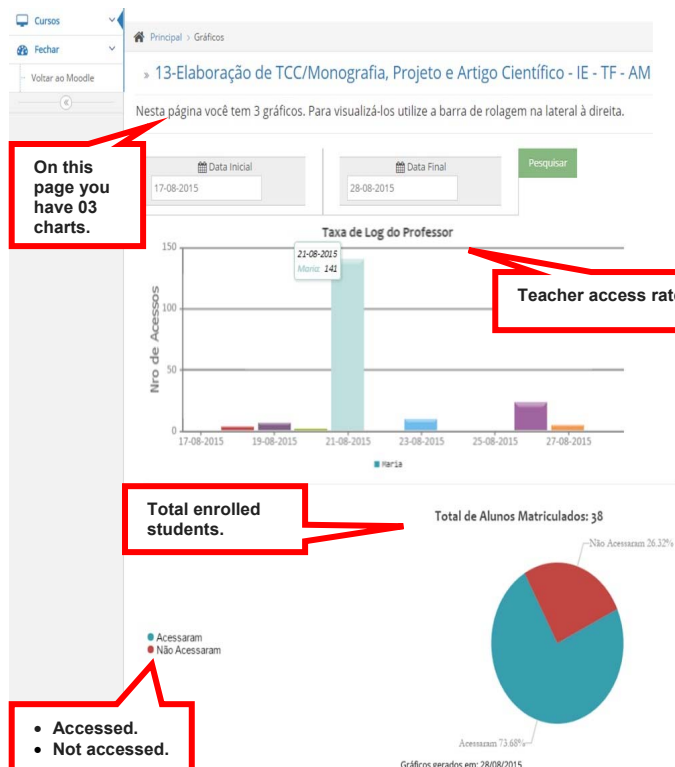


Fig. 9. MASM display screen for the Coordinator participant 1.

About some days, there was no access in the discipline by the teacher, but on a particular day there was greater access compared to other days. Generally, this occurs when the teacher corrects the activities. This type of graphic display is interesting for the engineers, because it has unified and summarized access information, also enables a teacher participation parameter or guardian in the discipline.

V. RESULTS AND DISCUSSIONS

At the end of system test period, a system of evaluation on-line questionnaire was applied, stating the total of 15 questions, 11 closed questions and 4 open questions. With regard to closed questions, the objective was to collect data about the degree of satisfaction to the MAS interface, the waiting time for the system to provide the reports and graphs to support the monitoring of courses and continued to use the system after test period. The responses were based on the Likert scale, with 5 response options: 1-Strongly Disagree, Disagree-2, 3-I do not agree nor disagree, 4-agree, 5-totally agree, as is shown in Fig. 10.

Assessment of the Multi-Agent System MANAGER

Assessment of the system interface.

***Obrigatório**

When inserting the plugin of the Multi-Agent System, it stayed well located and easy to memorize in the LMS screen. *

Choose the option that most closely approximates the level of agreement. 1 - Strongly disagree; 2 - I disagree; 3 - I don't agree nor disagree; 4 - I agree; 5 - Totally agree.

Strongly disagree	1	2	3	4	5	Totally agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

About Multi-Agent System MANAGER, in general, I consider that the interface makes it easy to search and view the information. *

Choose the option that most closely approximates the level of agreement. 1 - Strongly disagree; 2 - I disagree; 3 - I don't agree nor disagree; 4 - I agree; 5 - Totally agree.

Strongly disagree	1	2	3	4	5	Totally agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Fig. 10. Partial view of the final evaluation questionnaire system.

Regarding the open questions, participants were able to report how used the system information, the good points, the points to be improved in the system and a space for comments on the MAS user experience.

According to the answers of the participants, it was easy to remember and locate the system plug-in, and in general, the system facilitates the search and display of information. Participants approved the system response time in the presentation of each discipline reports and the graphic presentation. Using the MASM, according to the responses, to realize the optimization of time to obtain an updated information of the subject, and the e-mails sent by the system, helped to keep the same courses without being online at LMS.

There was agreement among participants that the information needed to facilitate the management of courses process, including suggestions for improvement there when system upgrade. The suggestion refers to include the ability to view the list of students who have never used the discipline and those who, after a certain period, left the course. Still, the information generated by the system in the test period were considered important to intervene at certain stages of the discipline.

The responses of the participants was verified that the information was used to notify the support team, especially on the issue of access to the LMS (Fig. 11). From there, the tutors and the Polo coordinators were driven to contact with the students, either by phone or email.

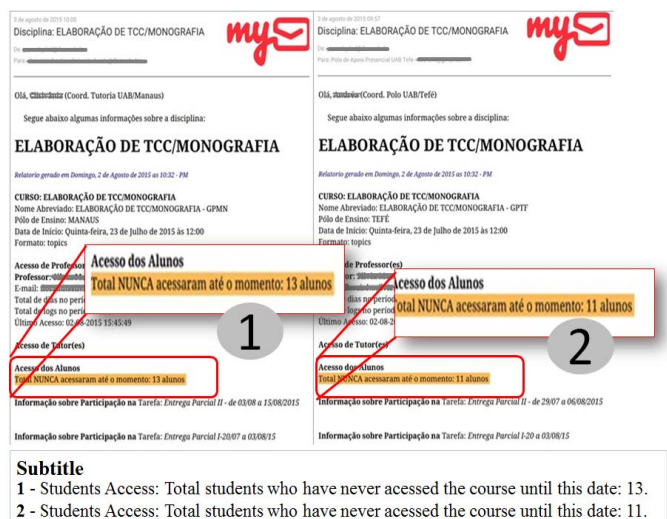


Fig. 11. Example of use of the notification via e-mail, sent by MAS.

The tool has also facilitated the verification of scheduled tasks. According to participants, the system made it possible to obtain a clear, reliable and summarized information, grouping them in one place.

The indications of improvements in the system were compared to plug-in access, because the existing access link was considered very simple, and add the check to participate in forums and questionnaires. It is worth mentioning that the collection agent activity has been adapted to scan only Tasks in Case Study, but in its essence, MAS already has the functionality suggested for verification of participation in forums.

Another suggestion for improvement was related to the possibility of the system generate and send custom reports. For example, the MAS could identify the student X accessed rarely Y. activity With this information, the system will send a notification to the student X, warning of their performance, as to the tutor / teacher there would be a monitoring framework of customized reports sent to students.

In summary, the participants were satisfied with the tool, and reported that the tool is great and very helpful in monitoring the distance education courses and after the period of the experimental test indicated intention to continue using the system and would recommend to other coordinators of distance education courses.

VI. CONCLUSIONS

In this paper we presented a Multi-Agent Systems Application proposal in a Learning Management system. The research enabled the development of a system whose architecture is composed of seven Intelligent Agents, which acted in online courses and assisted in monitoring the activities carried out by students, tutors and teachers in the LMS. The proposed system contributed to the coordinators of distance education courses acquire the unified information quickly.

The work presented used the software engineering methodology, focused on Intelligent Agents, called MaSE, whose purpose is to model the agents implemented in the

system and thus obtain the necessary documentation to support, in case of failure, as well as for better understanding the organization of the implemented agents. The MaSE methodology was very useful to the creation of Multi-Agent System process, as it allowed a broad and detailed view of the agents. With the use of MaSE, the inclusion of new agents is possible, because this action is facilitated by the documentation of the current structure.

After modeling, the work has gone through several refinements that could be tested. The verification of system functionality consisted of two stages: a functional test in a simulated environment, and a study of exploratory case in real virtual environment. MAS based on an architecture that has evolved through evaluations, and new versions of the prototype have emerged from the perception of the concept of use in distance education courses. The goal at this stage was to provide a version of the system that could assist managers in monitoring activities.

The case study, through a real test, found that the course coordinator will always have the reports and concise and updated graphics because the Intelligent Agents provide the information quickly and proactively, out in the report content situations that they deserve special attention from the course coordinator.

The system was implemented using the Moodle LMS, being structured on the concept of course. Therefore it was necessary to study its structure and philosophy of work, and understand the table schema, which is quite large and complex (more than 200 tables). We found that the tables Moodle version 2.2, where the experimental test was performed, were still inefficient to obtain more complete results. In the Moodle version 2.8, as has been reported in the first experiment, the Intelligent Agents behaved more fully.

It is important to emphasize two key points: the period of the experimental test, the course coordinators reported that the tool was very helpful in getting the information and optimized the unfastened time for monitoring and deliberations. The implemented Multi-Agent System may be used by any Moodle course, because it was designed to be independent of course, it can be used in more than one course simultaneously, as shown in the experiment. For future work, we hope to develop the architecture extensions, including new Intelligent Agents and specializing existing agents. The goal is to improve the proactivity, the perceptiveness and monitoring of access of students, teachers and tutors, and the activities offered in the courses.

Another possibility for future work is to integrate the system with other Multi-Agent Systems, such as those responsible in following the interactions of students, and also those who help and motivate the tasks. In this stage of integration, we believe to develop an interface that enables the manager to configure the system according to the nature of work in the LMS as they have been identified other coordinators and were not included in the survey, such as Polo Coordinator and coordinator of Mentoring, which assume very specific roles in the scenario presented in this research.

REFERENCES

- [1] O. Petters. "Distance education in transition – Developments and Issues". Ed. BIS-Verlag, Oldenburg, 5th Edition. 2010.
- [2] A. Aggarwal. "Web-based learning and teaching technologies: opportunities and challenges". Ed. Idea Group Publish, USA, First Edition, 2000.
- [3] A. Y. Kolb and D. A. Kolb, "Learning styles and learning spaces: enhancing experiential learning in higher education". *Academy of Management Learning and Education*, vol. 4, n° 2, 2005, pp. 193-212.
- [4] E. O. Carrillo, A. I. Rivera, C. P. Garcia, and E. Contreras. "A Novel, international masters program to address the sustainable energy challenge". *Proceedings of IEEE Frontiers in Education Conference*, Texas, 2015, pp. 2248-2253.
- [5] J. E. Brindley. "Learner support in online distance education: essential and evolving." *Online distance education: Towards a research agenda*. Ed. AU Press, Canada, 2014, pp. 287-310.
- [6] T. Rekkedal. "Internet based e-learning, pedagogy and support systems." Ed. J. E. Brindley, C. Walti, & O. Zawacki-Richter, Oldenburg, 2004.
- [7] C. Latchem. "Quality Assurance in Online Distance Education." *Online distance education: Towards a research agenda*. Ed. AU Press, Canada, 2014, pp. 311-342.
- [8] M. G. Moore. "Handbook of distance education". Ed. Routledge, USA and UK, 3th Edition, 2013.
- [9] S. Russel and P. Norvig. "Artificial intelligence: A modern approach". Ed. Pearson, UK, 3th Edition, 2009.
- [10] M. Wooldridge. "An introduction to multiagent systems". Ed. Wiley, USA, Second Edition. 2009.
- [11] C. E. G. Palomino, R. A. Silveira, and M. K. Nakayama. "An intelligent tutoring systems integrated with learning management system". *Proceeding of 11th International Workshops of Practical Applications of Agents and Multi-Agent Systems in Spain*, Springer Berlin Heidelberg, Berlin, vol. 365, 2013, p. 316-327.
- [12] R. A. Silveira and R. M. Vicari. "Developing distributed intelligent learning environment with JADE — java agents for distance education framework. *Proceeding of 6th International Conference*, Springer – Verlag, Berlin, 2002, p. 105-118.
- [13] M. Alencar and J. M. Netto. "Improving cooperation in Virtual Learning Environments using multi-agent systems and AIML." *Proceedings of IEEE Frontiers in Education Conference*, South Dakota, 2011.
- [14] M. Ghanilou and R. J. Oskouei. "Enhancing performance of Learning Management Systems (LMSs) through intelligent agents." *MAGNT Research Report*, Ed. BRIS Journal of Advances in S & T, vol. 2, n° 3, 2014, pp. 192-198.
- [15] M. L. Morales-Rodríguez, J. A. Ramírez-Saldivar, J. P. Sánchez-Solis, and A. Hernández-Ramírez. "Design of an intelligent agent for personalization of Moodle's contents." *Research in Computing Science*, vol. 56, 2012, pp. 11-17.
- [16] N. B. Xavier, J. F. M. Netto, and M. A. S. Alencar. "Análise de requisitos para viabilidade da proposta de um sistema de gestão em EaD". *Proceedings of 22th International Congress ABED of Distance Education*, Bento Gonçalves, 2015, pp. 1-10.
- [17] R. M. França, A. E. F. Oliveira, A. Dahmer, and L. Barreto. "MonSys - Monitoring system for students and tutors of postgraduate courses of UNASUS / UFMA in distance mode using Moodle". *Proceedings of 1st Moodle Research Conference*, Moodle Research Library, Creta-Grécia, 2012, p. 140-147.
- [18] N. B. Xavier, J. F. M. Netto, and M. A. S. Alencar. "MANAGER: um sistema multiagente para auxiliar a gestão de cursos EaD em um ambiente virtual de aprendizagem". *RENOTE - Revista Novas Tecnologias na Educação*, vol. 12, n° 2, December 2014.
- [19] S. A. Deloach and M. Wood. "Developing multiagent systems with AgentTool". *Proceedings of Lecture Notes in Artificial Intelligence*. Ed. Springer – Verlag, Berlin, 2001.
- [20] X. Luo, C. Miao, N. R. Jennings, M. He, Z. Shen, and M. Zhang. "KEMNAD: a knowledge engineering methodology for negotiating agent development." *Computational Intelligence: an international journal*, Ed. Wiley Online Library, USA, vol. 28, February 2012, pp. 51–105.
- [21] Y. Abushark, T. Miller, J. Thangarajah, M. Winikoff, and J. Harland. "Requirements specification via activity diagrams for agent-based systems." *Journal Autonomous Agents and Multi-Agent Systems*, Ed. Springer, USA, February 2016, pp. 1-46.
- [22] Java Agent Development Framework (JADE), jade.tilab.com, last accessed 21 Jan. 2016.
- [23] Java, www.java.com/pt_BR, last accessed 21 Jan. 2016.
- [24] Moodle. "A free, open source course management system for online learning", www.moodle.org, last accessed 21 Jan. 2016.
- [25] MEC. "Ministério da Educação e Cultura.", www.mec.gov.br, last accessed 25 Jan. 2016.