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A Platform-Independent Tracking and Monitoring Toolkit

P.G. Rossi, S. Carletti, D. Bonura[i]

Università degli Studi di Macerata, ITALY
pg.rossi@unimc.it
simone.carletti@unimc.it
diego.bonura@unimc.it

Abstract

Issues concerning students involved with online learning paths, that need to be faced by e-Tutors on their day-to-day activity, most often than not fall into known pedagogical patterns – that are problems and difficulties already occurred in the past and dealt with. These pedagogical patterns belong to e-Tutors' know-how and experience and their resolution are frequently a matter of activating routine processes or giving pre-factored answers; nevertheless statistical data indicates that these issues consume a considerable slice of tutors' time.

While a portion of the scientific community is still devoting much effort in developing artificial tutoring systems – by deploying AI/MAS-enabled technologies – the solution being investigated by our team focuses on enhancing already-available, open source LMS by implementing a general-purpose tracking and monitoring toolkit able to support e-Tutors in recognizing and dealing with pedagogical patterns stored into a decentralised Knowledge Base.

The system architecture is designed to house multiple platforms (only one adapter interface needs to be written for each LMS) and is able to perform real-time, as well as scheduled, data collection by means of Jade-based agents and schedulers. Information obtained from the processed data is then returned to the platform via web services and specific interfaces (instant messaging chatbot).

The first deployed prototype is currently being experimented in adult higher education learning paths and is able to track student activity, forum readings and writings and offers a basic chat-based help interface. Our aim is to turn a standard LMS into a knowledge aggregator where information about its users, its contents and interactions between the two can be mined via Knowledge Services; resulting data could then be used to refine users' and groups' profiles, to monitor learners' deviance from expected learning path, and ultimately to adjust the applied pedagogical model.

Research Background

The online learning environment can be seen not simply as a technological support, but as a "theoretical approach". Brown (Brown et al. 2005) stresses the difference between pull platforms and push programs and he highlights the transition from instructionism to constructivism perspectives. A well-structured environment gives the student tools to connect kaleidoscopic productions, to build, share and negotiate knowledge (Rossi 2007). The online environment is not a space, but a place (Giannandrea 2008, Wahlstedt et al. 2008), where emotional and relational factors are as relevant as the cognitive ones. Accordingly, the environment should be networked, flexible, autopoietic and it should perform the following tasks:

- mapping the learning path and orientating students in the learning process;
- aggregating materials, in this way it increases processes of re-crossing and meaning attribution of single products. (Rossi 2009)

The environment can be represented as three networks, mutually connected and overlapping:
1) the network of tools and materials
2) the network of writings
3) the network of interactions among users

The environment architecture depends on the above mentioned didactical approach. During the knowledge building process, highlighting fragments in wiki or forum to students is extremely important. Tutor should have not only the results of assigned tasks at his disposal, but also the way student reached them: how he took part the discussion in groups, which topics he proposed, how he can give support to the class.

In order to develop the above mentioned process, tutors should have both discipline and relational competences. The e-Tutor manages the on line interaction, the group relational growth and the growth of concept connections. In other words, he pays attention to inputs of different users, he mediates disagreements and he stresses the values of different contributions.

Undoubtedly, effective and efficient interventions can be ensured only by a functional appropriate tracking tool.

Analyzing on line post degree courses, which in our University involved about 520 students in 3 years, two categories of tutor's interventions can be identified: the first includes routine actions, while the second consists in highly situated interventions. About the first, patterns can be found, as habitual didactical conditions persist and reiterate during the learning process. They can be managed by standard procedures. In this first category the following examples are included: no presence in the online activities, no delivery of tasks, questions for more details about tasks (often related to a partial reading of duties), short and generic posts in forum or blogs (written only to fulfill a task, without any attention to quality), a first feedback about task achievement. Other patterns gives an asynchronous feedback to inform students, tutors and teachers, even if this information does not produce new automatic action. When a teacher opens a forum thread and gives related materials to study the topic in depth, he knows the main aspects for the discussion. Checking if all relevant aspects have been pointed out is important both for teachers and tutors and the key words analysis permit it. Moreover, we found out indicators (Accorroni and Bentivoglio 2009), based on use of words, to understand how the discussion is going on, if it is too much developed and the tutor needs to stop it, or if it is not enough developed and the tutor needs to support it.

Finally, it's important to stress how a suitable tracking tool can monitor and support relational aspects: if particular words are present, we can understand if discussion or planning have been correctly developed and the participation is distributed, or if some participants monopolizes tasks and suppresses group activities.

As a granular structure is an essential feature for a not instructional LMS, an architecture where the LMS is only a LO storage unit does not reach our goals. In other words, the architecture for a flexible autopoietic LMS should ensure a horizontal tracing. It cannot be structured in isolated objects (LO) sending scheduled pre-planned output. It should permit the following actions:

- to monitor the whole process;
- to extract text fragments out of every item present in the online environment;
- to analyze tags – assigned by tutors and teachers or generated by the system – in every element present in the online environment.

Research Focus and Objectives

The research aims to reduce, or make easier, the tutor's routine actions thanks to the implemented applications. In this way, tutors can focus on activities requiring situated solutions, more creativity and pedagogical awareness.

Practically every modern LMS is able to monitor students' activity through a dedicated component (logger, audit manager), which is normally hard-coded within the software architecture and is in charge of logging users' activity. These built-in components are frequently tightly-coupled to the platform, often preventing an easy, scalable, plug-in integration of third-party, external solutions.

Secondly, built-in tracking components normally feature a limited number of data representation methods (reports, charts), or do not offer an easy way to expose gathered data to external analysis and reporting systems. These limits constitute often the main obstacle for deep, real-time data analysis needed for a thorough understanding and representation of pedagogical patterns.

Possible approaches to overcome these limits are to enhance the LMS tracking components and to perform platform-specific queries in order to log desired actions and to produce customised reports and charts. The problem with these two approaches, as already experimented and adopted by our institution, is that all efforts are immediately wasted as soon as we shifted to a new LMS or even, sometimes, when upgrading the same platform to a newer version.

These are the main factors that led us to focus our efforts in designing and developing a platform-independent tracking and monitoring solution; that is an application able to gather data from multiple, heterogeneous LMS, to return data in a structured format, and to initiate events (actions having an impact on the platform and on its users) when particular conditions (pedagogical patterns) take place.

At the moment of writing the prototype application is loosely-coupled to a OLAT 6.1 LMS, is able to collect data on users' access and permanence time to each course elements (resources and activities such as Forums), can give real-time feedback via Instant Message (IM) chatbot and can schedule offline, cpu-heavy calculations (e.g. forum indicators).

By implementing and testing this framework with quantitative analysis we intend to lay the foundations for more wide-ranging, qualitative (introducing later semantic filtering and leveraging tagging features) analysis aimed at the achievement of a knowledge aggregator – rather than a simple LMS – that could be queried through Knowledge Services.

It has to be pointed out that a Knowledge Service (KS) in this context represents a single access point for all the data and information stored into the (many) LMS; our aim it is not to implement a Service-Oriented Architecture (SOA) for paid KS (as in the Knowledge Market business) but to take advantage of SOA design principles in order to ensure the interoperability, reusability and hence long-lasting of our developments.

System Architecture

We propose a design and implementation of an independent tracking and monitoring system focused on an modular and easily extendible architecture (Fig.1). The system is hence made up by four main components:

- a logger adapter based on Messaging techniques;
- a Multi Agent System (MAS);

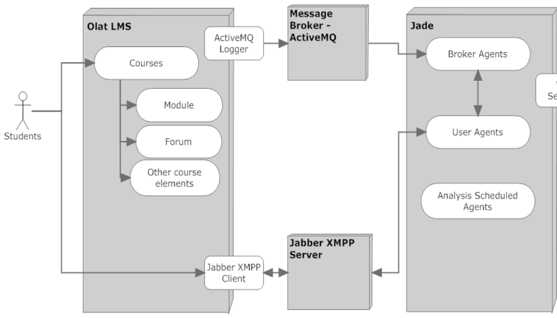

Fig.1 System Architecture

- a client XMPP;
- different web services as interfaces.

Due to the heterogeneity of the LMS systems present on the market, we have studied an easy and fast solution to link the information among systems. That heterogeneity is addressed by providing each LMS with a simple adapter that publishes data in a comprehensible format using standard technologies as Message Broker and Xml. About the Message Broker we introduced in our architecture ActiveMQ[1], a software service for message routing able to exchange messages decoupling sender (LMS) and receiver system (Tracking and Monitoring system).

This solution has many advantages, first of all the simplicity. Actually it is needed a few set on instructions to develop a simple adapter for each different LMS system. Second, the adapter is just an extension of the logger or audit manager present on every LMS platform so the introduction of that new component does not effect on existing systems. Actually, thanks to our logger adapter, we can catch and send every single action of users in a standard format. In this way, the Messaging technology is highly reliable and scalable for our environments, making possible the exchange of an high volume of messages per second. That messages are composed by different aspects as information about platform, information about the user and his roles and finally information about the action made by the user. We already developed and deployed our first adapter made for the Olat LMS Platform[2]. That logger adapter makes possible to track every single user's action on the course and specific information for particular course elements as forum and chat. When the Message Broker receives a new message, it routes the information to our Multi Agent System. That software application developed using Jade[3] (Java Agent Development framework) is composed by different agents, among which the most important are the following:

[1] http://activemq.apache.org/
[2] http://www.olat.org
[3] http://jade.tilab.com/

Fig. 2: Users statistics integrated in OLAT LMS Platform

Broker Agents have the responsibility to route new messages to special purpose agents (User Agents) for real-time analysis and to store information for a scheduled post analysis;

User Agents are created and disposed automatically by the system when new students enter into LMS platforms. These agents respond in a real-time environment directly to students using XMPP protocol[4] with information based on a set of rules and an inference engine (Drools[5]). The User Agent and student interaction supports bidirectional exchange of information so when the software agents write new messages based on student activity, for example when a student open a forum the agents inform him about the possibility and importance of collaborating, the students could interact with the system using the chat integrated into the LMS. Actually we have implementing different agents behaviors based on AIML standard[6] (Artificial Intelligence Markup Language) with generic knowledge repository. We have planned to build a special web interface only for e-tutors to support the growing of knowledge repository. By this way the e-tutor will have the possibility to add course-specific information to the knowledge repository.

Scheduled Agents, which we introduced about the analysis of the user actions stored by the Broker Agents. Manly scheduled software agents build and update user profiles, course profiles and special course elements profiles. Considering single user sessions, the agents just elaborate user navigation path and make possible to compare data related to different dates.

[4] http://www.xmpp.org/
[5] http://www.jboss.org/drools/
[6] http://www.alicebot.org/aiml.html

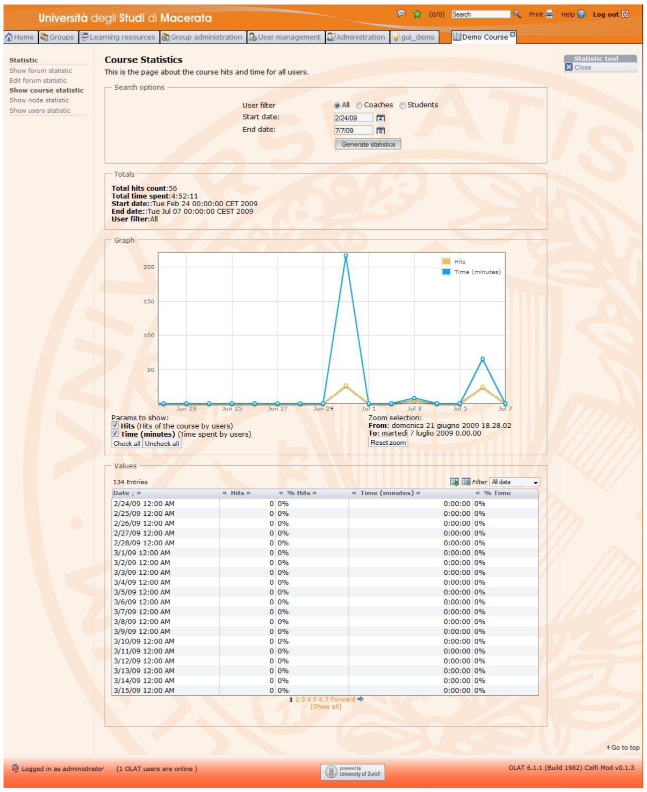

Fig. 3: Course statistics integrated on Olat LMS Platform

As mentioned in the Research Background, the elaborated profiles can be analyzed by tutors and teachers on the LMS platform by special interfaces based on Web 2.0 standards (Fig. 2 and 3). All the retrieved information data from our tracking and monitoring platform is available by open web services. We have deployed different web services to make possible further interaction between external analysis tools and to support service orchestration techniques. Special attention is paid on Forum Analysis Task integrating sophisticates algorithms to evaluate the project status.

Expected Results

Statistical analysis and calculated indicators from tracking tool should all merge into a "pedagogical dashboard" by which educational designers (teachers, tutors) could:

- monitor course activity and student participation;
- carry out first-level, routine actions (e.g.: set automatic messages to encourage participation).

Furthermore the dashboard should enable tutors and teachers to carry out situated actions of higher pedagogical value, such as:

- User Agent instruction with subject specific knowledge (information and external resources);
- create users profiles and personalize their paths;
- adjust pedagogical model on-the-go.

We expect to deploy the working prototype, after an initial testing phase, for all distance learning needs of our institution in order to collect enough significant data; results will be used to refine user profiles and rules into the inference engine.

Conclusions and Basis for Further Research

We already mentioned the basic advantages of having loosely coupled tools that can be plugged into multiple platforms; for our environment this is especially true as we frequently need to test and deploy new platforms for different needs (graduate, postgraduate, life-long and master degree courses).

Furthermore, by implementing KS exposing students' (and groups of students') activities and profiles we could imagine for the future to support services for the exchange of aggregated, anonymous information such as the ones on learners' profiles, learning styles, study profit and curricula.

The main advantage of the application we propose is related with the didactical-pedagogical approach. We already mentioned how useful the system is to make the tutor's activities easier. We would like also to stress how the above mentioned application can be strengthen in a near future.

Today, in the majority of LMS the technological support to knowledge production – that is, taking meaningful fragments to shape new multimedia kaleidoscopic items both as an individual and as a group activity – is extremely limited. Moreover, at present we can count only a few tools able to support students' reflection for an aware learning process. A platform with intelligent applications could support these activities in order to activate students, to let them produce knowledge and build their learning project.

The second goal follows the same direction. In the first paragraph we mentioned that autopoietic environments are necessary, as they re-shape and personalize their configuration according to individuals or group of users. Today some LMS include Knowledge Bases allowing to give pre-planned paths according to users performances; on the other hand LMS that are able to collect personalized, situated structures according to the current interactions are definitely more unusual.

On one side, autopoietic systems can be built by web 2.0 applications, but they need user's basic intervention and the technological semantic support is extremely limited. Our research supports projects and methods partly present in web 2.0 with knowledge management and artificial intelligence applications, to reach flexible autopoietic environments able to support students teaching to themselves (Presky 2008).

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[i] This contribute, although is the result of a shared design among the three authors, has been elaborated for the Research Background part by P.G. Rossi, Research Objectives, Focus and Conclusions by S. Carletti, and System Architecture by D. Bonura.