Dissertation

Using Tracking Data as Reflexive Tools to Support Tutors and Learners in Distance Learning Situations: an Application to Computer-Mediated Communications

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Using tracking data as reflexive tools to support tutors and learners in distance learning situations: an application to Computer-Mediated Communications

Abstract

In distance learning situation, the traces of learners represent a privileged source of information to be exploited to gain a better understanding of how learners could better collaborate or how tutors could better intervene. This research effort focuses particularly on the traces of synchronous and asynchronous interactions on Computer-Mediated Communication tools (CMC), in situations of discussions, negotiations and arguments among learners. The main objective is to study how to use the collected traces to design “reflexive tools” for the participants in the learning process. Reflexive tools refer to the useful data indicators computed from the collected traces that support the participants in terms of awareness, assessment and evaluation of their CMC activities.

We explored different tracking approaches and their limitations regarding traces collection, traces structuring, and traces visualization. To improve upon these limitations, we have proposed (i) an explicit tracking approach to efficiently track the CMC activities, (ii) a generic model of CMC traces to answer to the problems of CMC traces structuring, interoperability and reusability, and (iii) a platform TrAVis (Tracking Data Analysis and Visualization tools), specifically designed and developed to assist the participants, both the tutors and learners in the task of exploiting the CMC traces.

Another crucial part of this research is the design of data indicators. The main objective is to propose different sets of data indicators in graphical representations in order to enhance the visualization and analysis of the information of CMC activities.

Three case studies and an experiment in an authentic learning situation have been conducted during this research work to evaluate the technical aspects of the tracking approach and the utility of TrAVis according to the pedagogical and learning objectives of the participants.

Keywords: Technology Enhanced Learning (TEL), E-Learning, Computer-Mediated Communication (CMC), Tracking data, Traces, Human-Computer Interactions (HCI), Data analysis and visualization
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The presentation of this thesis is divided into five chapters.

The **first chapter** covers the research interests in Technology Enhanced Learning toward the participants, and the use of Computer-Mediated Communication (CMC) tools to support their interactivities in the learning process. Tracking CMC is the discussion point of this chapter. We give a presentation of our research motivation regarding a tracking solution for CMC tools. The presentation also features the research questions, objectives and methodologies. Regarding tracking CMC, we examine different tracking methods and their practical issues. We also present in this chapter, a study on security and privacy concerns in learning environments.

The characteristics of CMC and the chosen CMC tool in the context of our research will be presented in **chapter 2**. We also present a particular discussion forum Confor (CONtextual FORum) that has been used in our research application. The rest of chapter 2 is dedicated to a study on the impact of tracking solution in distance learning. The study covers the positive effects of using tracking systems on CMC tools and the use of CMC traces that contributes to online teaching and learning enhancements. Another important part of this chapter is the presentation of the state of the art of different tools for exploiting CMC traces.

The **third chapter** focuses on the existing approaches for tracking CMC and their deficiencies. More precisely, we study the lack of existing tracking systems and the main issues in exploiting CMC traces. To improve upon the studied issues, we propose an explicit tracking approach, together with the solution to the problems relating to (i) data collection, (ii) data structuring and storage, and (iii) data analysis and visualization. We also present in this third chapter the development technologies of our tracking approach.

**Chapter 4** is dedicated to a presentation of TrAVis (Tracking Data Analysis and Visualization tools), which we design and develop to support both tutors and learners in traces analysis and visualization practices. We present the design approach of TrAVis and the technical aspects of the development of each component of TrAVis. This chapter also features another important aspect in relation to the design of data indicators of CMC activities to be computed by TrAVis. The examples of data indicators and their visualizations will also be illustrated.

Both case study and experiment will be presented in **chapter 5**. Three case studies were conducted to evaluate the technical aspects of the tracking approach and the usability of the first prototype of TrAVis. The experiment, on
the other hand, was carried out in an authentic learning situation with an objective to evaluate the utility of TrAVis and the proposed data indicators from the points of view of both tutors and learners.
Chapter 1

Tracking data in Technology Enhanced Learning
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Chapter 1 at first glance

This first chapter presents a general study of tracking data in Technology Enhanced Learning (TEL). Figure 1.1 illustrates the logical schema of the study that is divided into four separate sections. We highlight below the study content of each section.

In the first section, we look at one of the research interests in TEL toward the participants, and the use of Computer-Mediated Communication (CMC) tools to enhance their interactivities in the learning process. We also discuss the willingness of the researchers, pedagogical team and other practitioners to make distance learning a high quality education by integrating the tracking systems in the learning environments.

The second section is dedicated to a presentation of our research work. It features an overview of the research motivation, questions, objectives and methodologies. We commence with the research motivation regarding a tracking solution for the CMC tools, followed by the research questions, expressed on two different standpoints – as a researcher in TEL and as a researcher in Information Technology (IT). Our research objectives and methodologies are declared at the end of the second section.
In the third section, we examine the diverse natures and sources of tracking data in TEL. To do so, we study at first different methods for tracking data collection and how each method can be beneficial to users and in which context. Later, we study the practical issues relating to both human and technology factors of each method. Our main goal is to gain a broader perspective on the existing methods and their application possibilities in our research design and development.

The fourth section presents a study on security and privacy concerns in learning environments. We address the major issues related to learners’ privacy protection and some research data on users’ satisfaction with current security and privacy in TEL. The main objective of this study is to focus attention on these issues, which are often ignored in the research efforts involving user tracking and personal data exploitation in the learning process.

In the conclusion of this first chapter, we summarize the importance of the study we make on the tracking process as well as the benefits of observing the participants’ activities on computer-mediated communication (CMC) tools.
1.1 Tracking data in Technology Enhanced Learning (TEL)

1.1.1 Introduction

TEL was initially known as “Computer-Assisted Learning” and later as “E-learning”, a research domain involved in improving learning processes by the use of technology (Scott & Vanoirbeek 2007). Its objective is to encourage the emergence of new learning models that are sustained by the context-aware use of technology and anchored in the practices of users. TEL covers countless research topics that place equal emphasis on all three elements: technologies, learning, and improvements in learning. It is obvious that TEL research is no longer in its infancy, but developing very rapidly in accordance with the tremendous technological progress being made.

As we progress, we witness a big change of research interests in TEL toward the learning process and the participants. More efforts have been put in to the improvement of technologies that better support participation and interactivity (Manson 2007). One of the noticeable trends is on the integration of tracking process in learning situations, is to enable a better understanding of the interactions between learner and systems (Komis et al. 2002), between groups of learners (Hardy et al. 2004), and between learners and teachers (Mazza & Botturi 2007). Using tracking systems to observe the learning process has been seen to be a reliable support to the participants. If we look at an example of a distance learning situation, the tutors are strongly interested in being aware of the students’ activities and in being able to effectively monitor the learning sessions. Thus, tracking the actions of students through E-learning environments, gives the tutors access to the information related to the activities being undertaken, and the resources being consumed by the students. The tracking data has yet to become a significant source of information that reveals not only the activities themselves, but also their outputs – e.g. the results of the activities that the students carried through the learning process (May et al. 2007).

1.1.2 Life cycle of tracking data in TEL

Nowadays, we are confronted with a new situation. Using tracking system in distance learning environments has been steadily increasing. One of the reasons for this phenomenon is the willingness of the researchers, pedagogical teams and other practitioners to make distance learning a high quality education. Indeed, the concept of using tracking system is recognized as a contributing factor to the high quality education in terms of teaching enhancement and learning guidance. As found in the study of Jermann et al. (2001), a review of a variety of systems that make use of learning traces to assist the learners in mirroring their activities and to guide them throughout the learning process. Further evidence can be found in the research work of Després (2003); a tracking system has been used to support the tutors in monitoring student’s activities while accessing the learning platform.
It allows the tutors to keep themselves informed of the whole activity of a student and its different phases being carried out during a learning session. The research effort of Després (2003) has demonstrated that using students’ tracking is one of the essential components of online teaching enhancement. It also appears to be a solution to facilitating teaching activities and to improvement of student monitoring as shown in Mazza & Dimitrova (2003). Both Mazza & Dimitrova argued that a good online teaching situation is when the tutors could be more aware of what the students are doing during the course – e.g. which concepts are known? Are students participating in discussions? Have they read the course material? And how well do they perform on quizzes, etc. This can be achieved by exploiting the tracking data gathered throughout the learning environments.

Exploiting tracking data in TEL refers to the whole process of using the collected data to satisfy users’ needs in a specific learning situation. It can be briefly depicted in figure 1.2, which includes the following aspects:

![Figure 1.2 Example of life cycle of tracking data in TEL](image)

(1) A study on learning environments and dedicated tools being employed by the users to perform their activities (e.g. following online courses, synchronous chatting, making discussions, etc.). This study is considered one of the crucial and challenging phases in exploiting tracking data in TEL. It mainly focuses on two important questions: What are we tracking and why? It generally results in
identification of the users’ needs in terms of keeping track of the activities and the objectives of using the collected data for each user (students, teachers, researchers, designers, developers …).

(2) The use of a tracking system for specific learning platforms (e.g. Course Management System, Virtual Learning Environment, Computer Mediated Communication tools, etc). In this phase, we are more interested in how to observe users while interacting with the learning environments, and how to produce tracking data that contain information on both the interactions and its outcome.

(3) A vast amount of tracking data to reference (e.g. data storage, transformation, modification …) is required. Dealing with tracking data with different natures can be very complicated which suggests the necessity of tools which provide not only the means to manage, but also to use this variety and quantity of data to respond to each individual demand. That is what we have been calling so far as “exploiting tracking data”. It can be varied from a simple data processing (i.e. computing data and displaying results) to more challenging operations such as data analysis and visualization (i.e. generation of multi-dimensional data in a graphical representation).

Thus far, every aspect mentioned above is a challenge. There are many factors to be taken into account when making use of tracking data in TEL. Furthermore, it is still a complex task for the participants in the learning process when it comes to practice. It requires both human competency and technological supports, particularly when tracking data represent multimodal Computer-Mediated Human Interaction (Dyke et al. 2009). Before going into any further discussion on this issue, we will be looking at the research context in which the latter is studied. The following section gives an introduction of our research effort and its important points. It starts off with a presentation of our research motivation, followed by the research questions that are expressed, based on two points of view – a researcher in TEL and a researcher in Information Technology. Our research objectives and methodologies are listed at the end of the section.

1.2 Tracking Computer-Mediated Communications: research overview

1.2.1 Actual observation

- Communication and computer-mediated communication in learning context
  For many reasons, communication is an essential component of the education. Primarily, it is vital to the development of the whole person in enhancing relationships to oneself, others, and society (Ford & Wolvin 1993). Further, communication plays an important role in improving specific skills and abilities
including critical thinking ability of the persons (Allen et al. 1999), media literacy and criticism (Metallinos 1992), leadership skills (Grace 1996), and family relational development (Pearson & Sessler 1991). Other reasons were given in the research work of Morreale & Osborn (2000). They show that introducing communication activity into the educational environment brings progress to the work of education in various disciplines, advances the interests of society, and bridges cultural differences. For example, Price (1991) and Garmston (1995) pointed out that communication activity is the key to successful collaboration in the educational environment and to intensify classroom instruction. Blumer (1983) suggested communication is crucial to the continuation of the society we live in and to erasing cultural boundaries. Blumer’s claim has been strongly supported by Herring (1990) and Potoker (1993), and they added that providing education through communication activity by making the participants interact between each other allows not only a development of skills and sensitivities that shape the social lives, but also a gain of better understanding of individuals from multiple cultures.

If we take a closer look at the communication activity in a learning context, it has undoubtedly always been an important part of the learning process. Whilst it usually creates opportunities for learning to take place, it also enables the sharing of information, the confrontation of ideas and thoughts which contribute to learning. In distance learning situations, communications are made on CMC tools and can be called as computer-mediated communication activities (i.e. CMC activity in short). Making CMC activity is not only to increase interaction between student and teacher, or interaction among students for an instructional purpose, but also to compensate the lack of face-to-face interaction within the distance learning. Also it helps in exchanging knowledge, inducing enthusiasm in learning and building positive relationships among the participants. More importantly, CMC activities positively influence the pedagogical process (Frantisek & Ig 2005). Evidence to back up such argument can be found in the research effort of Morreale & Osborn (2000) along with a thorough study of nearly one hundred articles, commentaries, and publications, which emphasizes the importance of communications in various contexts, from the contemporary life to the specific learning situations.

1.2.2 Research motivation

- **Using Computer Mediated Communication technologies to support participations and interactivities in distance learning**

As discussed in section 1.1, more research interests tend to focus on technologies that better support users in the learning process, particularly their participations and interactivities (Manson 2007). Those technologies include Computer Mediated Communication (CMC) tools, which are employed to extend the content and interaction of a class because of their advantage in providing users with a
great variety of ways to communicate between them. Hence, the study we present below aims at illustrating our research interest in Computer Mediated Communication technologies and how they can support users’ participations and interactivities (cf. figure 1.3).

![Figure 1.3 Using Computer Mediated Communication technologies to support user’s participation and interactivity in the learning process](image)

Berge & Collins (1995) pointed out that the CMC tool is recognized as an essential element in distance learning, as it promotes a type of interaction that is often lacking in the traditional teacher-based classroom. Firstly, CMC tools can be used effectively to facilitate collaboration among students, teachers and guests or experts from outside the classroom. Secondly, they allow students the freedom to explore alternative pathways to find and to develop their own style of learning. In addition, there are desirable characteristics CMC tools that allow us to acknowledge their roles in supporting user’s participation and interactivity in distance learning process. Those characteristics can be summarized as follows:

- **CMC tools increase accessibility and opportunities for interactions in distance learning**

Thanks to the availability of resources (e.g. learning platforms, CMC tools, Internet access ...), students and teachers can communicate at any time and at any distance (Groeling 1999). What is more, using communication tools such as discussion forums, instant messaging applications, blogs, conferencing tools, etc., can help create an atmosphere that mirrors face-to-face activities. It can also expand student and faculty interaction and reinforce learning experiences. For example, found in the research work of Yoder (2007), blogs are used by the tutors to communicate with learners, and to require learners to document their efforts in class, thereby encouraging interaction between tutors and students and encourage
the participation of learners outside classroom. Blogs can also be vehicles for voicing opinions, expressing creative and original thinking, and sharing resources within the learning community. Also conferencing tools, are of great assistance to online meetings, collaborative project hosting, online mentoring and tutoring, etc. As yet, CMC tools are used to support and at the same time to encourage interactivity between participants in the learning process.

- **Online communication can break down social barriers**

  As pointed out Harasim (1989), online discussion is considered a means to enhance student control over learning and make the educational experience “more democratic”. Computer-mediated discussion can also encourage the participation of students who are often less willing to participate in face-to-face discussion because of shyness, language problems, gender, etc. In any case, communicating through the medium of a computer can strip away many of the normal difficulties of face-to-face interaction.

- **Online communication fosters active learning, encourages more thoughtful and developed participation**

  Participation in face-to-face discussion is often viewed to be a valuable tool for engaging students in a more active form of learning. The simple act of attempting to communicate an idea to another person often presents a valuable opportunity for reviewing that idea. Therefore, moving the discussion online enables another dimension to this activity. An example given by Gillette (1996), in this regard, states that when discussions take place online (e.g. on a discussion forum), students become “active choosers” as they decide what to read and what to disregard. They also become “active investors” because discussions yield greater returns the more students invest in them. Moreover, when communication mode is asynchronous, participants can take their time ordering and composing their thoughts (McKeachie 1999). The same logic can also be applied to synchronous communication. In either synchronous or asynchronous communication, the resulting discussions become a significant source for learning, as claimed McCabe (1998).

- **CMC tools and their advantageous over other media in terms of supporting participation and interactivities in both traditional and online class formats**

  CMC tools play a very important role in knowledge sharing between the participants in the learning process. They provide an important learning opportunity for students and an increase in the ease of exchanging ideas for subject that are more discursive (Guzdial & Turns 2000). Furthermore, CMC has many advantages over other media in terms of combining group communication features of face-to-face communication; time and place independence and mediated communication features of distance education (Liu 2002). Besides, CMC tools have the potential to improve the teaching and learning experiences in traditional classroom formats as well as in distance learning (Corich *et al.* 2004).
Last but not least, there is a rich source of data accumulated in CMC activities compared with face-to-face interactions (Rice 1990), which makes the use of CMC tools in learning situation beneficial to the participants in either traditional or online class format.

To conclude, CMC tool is highly recommended for learning situations because from a technical perspective, computer-mediated settings enable joint activities like cooperation and collaboration by means of application sharing technologies. For example, learning objects can be manipulated in a workspace that is visible and accessible for all participants; documents can be viewed simultaneously and jointly edited by the students during the communication process, etc. Another potential benefit of CMC tools in learning environments, from a technical perspective, is in sharing learning resources as they offer the ease of circulating and archiving files and documents related to learning activities (e.g. teacher presentations, course materials, student assignments, etc.). From a personal standpoint, it would be a misunderstanding to see computer-mediated interaction in learning situation just as being inferior to face-to-face interaction, because of its restricted possibilities for non-verbal communication, transfer of emotional signs, turn taking, etc. Many research evidences proved that using CMC tools in learning situations increases the level of satisfaction of the participants in terms of achieving a better learning performance (Chou & Liu 2005), overcoming many traditional barriers of distance and times (Bromme et al. 2005), and gaining flexibility in online learning (Rovai 2001; Dutton et al. 2002), etc. Therefore, CMC should be considered as new opportunities for acquiring new valuable teaching and learning experiences as the participants have at their disposal an alternative way to accomplish their activities.

1.2.3 Research questions

- **Tracking CMC activities to support the participants in the learning process**
  
  Adding to what has already been presented in section 1.2.2 regarding the potential benefits of CMC in learning situations, using CMC tools, also enables the participants to carry out communication-oriented learning activities (cf. Figure 1.4). In other words, communication-oriented learning activities are sustained by peer interactions, strongly based on communications, and that can be realized either partially or entirely on a CMC tool. Thus, communicating and making discussion in a learning process should not be seen as optional or complementary activities, but a whole learning activity instead. To illustrate what we referred to as communication-oriented learning activity, we give an example on using a CMC tool in the educational science discipline.
The example of the interested activity takes place in a context of training students from a faculty of foreign languages to be English lecturers. Different groups of students are assigned to realize a project on creation of an English course material for non English-speaking people. From the beginning to the end of the project, students are requested by their tutors to work collaboratively and by using a discussion forum to fulfill their learning activities. The discussion forum is not only where the interactions between students and their groups are taking place, but also where the learning activities are being conducted. In addition, both student's activities and its products will be found on the discussion forum, including the final result of the project (i.e. English course materials). In this example, the learning activities of a student are mostly to communicate with the rest of the group members by posting, reading, and replying messages on the forum to discuss about creating an English course. In this case, the learning activities are carried out through the communication activities. In respect of learning outcomes, during the project students might have learned from each other and from the challenges they have encountered on how to create English course materials for non English-speaking people. In other respects, students might also have acquired, for example, new knowledge in their field of study or gained new learning experiences after achieving the project. At this moment we have come to the conclusion that communication activities are strongly correlated to the learning activities and what result from the former express the outcome of the latter.
Thus far, CMC tools have demonstrated a variety of benefits for the learning process and the participants. However, there are limitations in using CMC tools that we should recognize. When using CMC tool alone, there are insufficient possibilities for the participants to fully control their activities the way they do in a traditional learning situation. If we look back at the last example, while students are working in collaboration on their project on a discussion forum, the tutors are not aware of what is happening until they log on to the forum and read the students’ messages. Consequently, regular actions of a tutor such as observing the student’s activities, evaluating the resulting discussions, or assisting and guiding the students when needed, could be missed. As for the students, the only support for their learning activities is simply a discussion forum. For that reason, students will not receive assistance from their tutors the same way they would in a teacher-based classroom. As a matter of fact, in the previous example, the interaction between tutors and students are not person to person, but computer-mediated and online, which makes it difficult for the tutors to locate the problems encountered by the students, and to give the kind of intervention students really need. Besides, from a technological standpoint, discussion forums as well as other CMC tools were not originally built to allow the tutors, for example, to monitor the students’ activities, or to provide feedback to the students on the fly as they would expect. Therefore, there is an urgent need to deliver a solution to such issues and the question that needs to be answered is “how could we provide convenient support to the participants in distance learning situations while using CMC tools to fulfill their teaching and learning activities?”

There are several paths we could take, to explore the answers to the research statement. For instance, developing a new type of CMC tool that permits the tutors to overcome all the difficulties mentioned earlier could be one of the solutions. Unfortunately, such solution is far from being optimal while one specific CMC tool might not have been designed to support different contexts of communication activities, or to be dedicated to a learning situation where another genre of CMC tool is absolutely required, etc. In an attempt to investigate the solutions to this challenge, we have conducted a research project that involves tracking the students’ activities on CMC tools, and exploiting the collected traces to assist both tutors and learners, during and after their activities in a learning environment. The context of our research work can be overviewed via figure 1.5.

Figure 1.5 reveals major components of our research, which are:

(i) the type of participants we are particularly interested in (i.e. tutors and learners),
(ii) the context of the activities being performed by the participants within learning environments (i.e. communication-oriented learning activities), and
(iii) the kind of support that we seek to provide to the participants (i.e. tracking data exploitation tools and their utilities).
Since our research work has a strong implication in the field of Technology Enhanced Learning (TEL) and Information Technology (IT), we look at the research questions from different angles and they can be expressed based on two different standpoints despite their strong correlation. First, for a researcher in TEL perspective, using tracking systems to observe both learning and communication activities can be a reliable support to the participants as highlighted in section 1.1. Meanwhile, this makes us face the difficulty of identifying what kind of support it is and how to make use of it in an authentic learning situation. In this matter, the following research questions will be studied:

(1) What Computer-Mediated Communications in learning situation are we interested in? What kind of CMC tool are we using for our research application?
(2) What are the characteristics of the existing approaches for tracking and exploiting CMC tracking data?
(3) How could tracking data being gathered in the learning process contain semantic or learning aspects and not just information on computer-mediated user actions?
(4) How exploiting tracking data of learners’ activities on CMC tools enables the tutors to monitor the learners’ activities or to evaluate them? As for the learners, how could their interaction data captured throughout the learning/communication process enable self-assessment and self-awareness?
Second, from a researcher in IT perspective, our research questions are more concerned with technology-centered approaches from the fact that there are several challenges in making use of CMC tracking data. Prior to the data exploitation is a complex task for the users when it comes to practice; it strongly suggests the necessity of technological supports. Nonetheless, it is important to emphasize that our main focus is not on the development of software or applications, but on working very closely with the participants (i.e. tutors and learners) to propose our both supports and technological solutions. Our research attempts are to examine the following questions:

(5) How does using tracking solution on CMC tools affect the activities of tutors and learners in distance learning situations?
(6) What is lacking in the existing tracking systems? What are our propositions to improve upon their deficiency?
(7) What kind of tracking approach is for the CMC tools? How to make it explicit so that it can be applied to various types of CMC tools, both synchronous and asynchronous?
(8) How to design and develop the tracking approach with the purpose of continually improving it for further usages?
(9) What tools do the tutors and students need to exploit their CMC traces? How to design and build tools, in order that a non-specialist computer user could readily access them?

As illustrated in Table 1.1, the research questions stated above will be studied in different chapters of this thesis.

<table>
<thead>
<tr>
<th>Research questions (Q)</th>
<th>Chapter 2</th>
<th>Chapter 3</th>
<th>Chapter 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEL (Technology Enhanced Learning)</td>
<td>(Q1) and (Q4)</td>
<td>(Q2) and (Q3)</td>
<td></td>
</tr>
<tr>
<td>IT (Information Technology)</td>
<td>(Q5)</td>
<td>(Q6), (Q7) and (Q8)</td>
<td>(Q9)</td>
</tr>
</tbody>
</table>

1.2.4 Research objectives and methodologies

We realize the complexity of conducting this research, but nevertheless consider it a necessary approach to study the whole problem, as illustrated in figure 1.6, showing the main objectives and methodologies of this research.
Figure 1.6 Main objectives and methodologies of our research

(A) **Proposing an explicit tracking approach for CMC tools**

- Determine a learning context that we are particularly interested. Our main goal is twofold: (i) to study the characteristics of the computer-mediated communications in distance learning and of the CMC tool that is used in our research application, and (ii) to formalize the tracking mechanism according to the context of the CMC activities. By doing so, we demonstrate that the tracking solution is objectively designed for an authentic learning situation where there is a connection between learning activities and communication activities.

- Identify the issues in existing tracking approaches.

- Study different types of actions and interactions of a computer-mediated communication activity in order to propose an efficient tracking approach for CMC tools.

- Make the proposed approach explicit and capable of:
  - taking into account the learning aspects of the communication-oriented learning activities being conducted on CMC tools – e.g. by contextualizing the tracking process according to the context or modality of the communication activities, etc.,
real-time observing and capturing tracking data of user’s communication activities,

- efficiently tracking different types of actions and interactions between users and CMC tools (e.g. Human-Computer Interaction, Human-Human Interaction Mediated by Computer, Computer-Computer Interaction, …) ,

- producing tracking data that are not just a simple history of users’ activities, but containing substantive information such as the semantic aspects of the activities; and which can be useful to various users (e.g. both tutors and learners),

- Collaborate with tutors and learners who regularly use CMC tools in their tutoring and learning activities. Our major interest is to study their actual needs in terms of tracking CMC activities and to make the proposed tracking approach applicable to their actual practices.

- Design and develop tracking systems for Web-based CMC tools (e.g. discussion forum, chat, wiki, blog, etc.) for case studies and experiments.

**B) Exploiting CMC tracking data**

- Explore the properties of the CMC tracking data and study the main issues of their exploitation. The study covers the following points:
  - Data collection
  - Data storage and representation
  - Data analysis and visualization

- Propose a generic model of CMC tracking data. The objective is to provide a means to the CMC-tool users to (re)structure data being gathered from different CMC tools in a generic data model, thus making the data reusable in either data exploitation tools, or CMC tools that did not formerly generate the data, or do not share the same data properties. From a technical standpoint, the proposed model is an abstract model defining data elements, attributes and relationships among data elements, which describe how data is represented and accessed.

- Identify the needs of tutors and learners in exploiting CMC traces.

**C) Proposing tracking data analysis and visualization tools**

- Suggest different set of data indicators to both tutors and learners in order to assist them in the process of interaction analysis of communication and learning activities.

- Design and develop TrAVis (Tracking Data Analysis and Visualization tools) to enable users to:
  - manipulate the tracking data (e.g. data storage, modification, …) ,
analyze the tracking data (e.g. computing statistical data, generating synthetic information from traces, …),
visualize the tracking data in graphical representations and in different scale, etc.

• Make TrAVis accessible to both tutors and learners and provide them with functional tools to efficiently exploit the CMC traces.

Having specified our research objectives and methodologies, we now turn our attention to the two fundamental aspects that have an impact on the choice of our further research design and development. These two aspects concern:

(i) **natures and sources of tracking data** that respectively refer to the representations of tracking data and the method of how data are assembled (cf. section 1.3).

(ii) **security and privacy issues of tracking data**, which are both crucial factors to our research as it involves user tracking, and user’s personal data exploitation in learning environments. The study we made in section 1.4 aims at focusing our attention on these issues and at investigating the solutions to them.

### 1.3 Natures and sources of tracking data

The definition of tracking data (or trace) can be given either narrowly or broadly, depending on numerous factors including user’s point of view or the research context in which tracking data is defined, etc. Champin & Prié (2002) stated that “a trace of user activity is a temporal sequence of operations and objects used by the user while interacting with a system”. The representation of a trace of user activity can be complex and varies according to its original nature and source as well as to how the user interacts with the system. In any case, a trace of user activity is generally generated by tracking system in accordance with its defined trace format or model (Choquet & Iksal 2007). Meanwhile, we define a trace, at its broadest, as a mark (or imprint) left by a user in one place and at a given time.

Up to now, “tracking data” and “traces” are the two vocabularies alternatively used to describe digital information on users and Computer-Mediated Interactions that are produced, stored and manipulated by the tracking systems. Henceforward, other terminologies such as “log files” and “recordings” will be introduced in this thesis. Each single terminology will eventually be used in different manners to describe a common thing due to the fact that the research efforts we are referring to used one or another – e.g. “traces” instead of “log files” or vice versa. Moreover, when citing anything relevant to tracking data from other related works, the former word will be intentionally kept intact in our presentation. In regard to this matter, the meaning of “tracking data”, “trace”, “log file” and “recording” are assumed equal.
In this section, we study the natures and sources of tracking data by concentrating on how each method of data collection works, and in what kind of learning situation each method is used. Inspired by the research work of Hulshof (2004) on the methods of obtaining log files in TEL, our study particularly focuses on the three most widely used methods, which are “eye movement registration”, “think-aloud” and “computer-registered operations”.

**Table 1.2** Summary of the three most widely used methods of obtaining log files

<table>
<thead>
<tr>
<th>Method</th>
<th>Eye movement registration</th>
<th>Think aloud</th>
<th>Computer-registered operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interested characteristics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of participants</td>
<td>Single user</td>
<td>Small group of users</td>
<td>Both small and big group of users</td>
</tr>
<tr>
<td>Learning situation</td>
<td>Experimental situation</td>
<td>Experimental situation</td>
<td>Authentic learning situation</td>
</tr>
<tr>
<td>Application of method</td>
<td>Mostly local</td>
<td>Local</td>
<td>Both local and distance</td>
</tr>
<tr>
<td>Technology used to obtain data</td>
<td>Recording eye gaze and movement</td>
<td>Dictation</td>
<td>Computer program</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Audio-video tapping</td>
<td>Web-based application</td>
</tr>
<tr>
<td>Nature of tracking data</td>
<td>Video</td>
<td>Verbatim transcript</td>
<td>Computerized data format (e.g. XML, RDF, TXT, Database, etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Audio/video</td>
<td></td>
</tr>
</tbody>
</table>

The most important intention of this study is to identify the method that most effectively assists our research work. Hence, we address in this study the characteristics of each method and we subsequently take account of them in our research design. As a matter of fact, to provide one efficient tracking approach, we have to start with studying very carefully the limitations or more precisely the practical issues in both human and technology factors of each method. To do so, we summarize in table 1.2 (cf. previous page) the most interesting characteristics of each method. Via Table 1.2 we are able to make a side by side comparison of the methods by turning their characteristics into significant comparison criteria.
1.3.1 Data from eye movement registration

The eye movement registration method is commonly used in a particular learning situation where we are strongly interested in observing how much attention a user pays when performing a task (Duchowski 2003). It can be very advantageous in the creation of more effective interactions between E-Learning content and learners (Iqbal & Bailey 2004). As claimed Wang et al. (2006), eye-movement log files can be the key to achieve a more natural and friendly environment for learning. Merten & Conati (2006) seem to agree with this since they used the same type of information to try to assess learner meta-cognitive behavior during the interaction with learning environment, and to improve the quality of learning. Examples can be found in the research works of Hyrskykari et al. (2000) and Pivec et al. (2006), in order to facilitate learners in their reading online course, a study was made on how to dynamically capture their behaviors based on real-time eye tracking and to find eye-movement patterns while viewing online courses – e.g. reading, skimming through text, searching in text, etc. The main goal of both research efforts is to provide adapted assistance to the learners when they access to learning resources, based on both their eye movements and their history log files.

“Is eye-tracking approach a solution to CMC tracking in distance learning?” is the question that we have to answer. From a broader perspective, this method is far from being applicable in the learning situation that we are interested in, due to several practical issues in both technology and human factors as presented in the study below.

Eye tracking results in very detailed log files, especially when a task has a large visual component. It may provide us with more information than other methods of obtaining log files would. However, exploiting log files, being completely acquired from eye tracking can be difficult, which may deem the method less suitable for tasks in which high-level cognitive process are studied. In many practical applications for distance learning, it makes no sense to just measure eye movements. Such as in a learning situation where students are working collaboratively to solve a problem or where different groups of students are making discussions on CMC tools, etc.

Other limitations of eye-tracking approach can be determined from table 1.2. When using this method, the tracking process is limited to a single user at a time and is often carried out in a specific local site (e.g. university or a computer lab where user activity is taking place) from the fact that not every user’s terminal machine is equipped with a device for recording users’ eye movements (e.g. a user’s home computer). Another important point to be noted from table 1.2 is that eye-tracking approach is rarely used in real learning situations, but more often in experimental situations.
In regard to technologies used for tracking eye movements, Hallowell & Lansing (2004) mentioned that choosing eye-tracking technology for a research application is one of the major concerns. Even though several eye tracker manufacturers have provided software tools that allow users to easily record eye movements, concerns remain regarding the accuracy of eye trackers. From a technological standpoint, the accuracy of an eye-tracking system is considered fundamental. Nonetheless, the accuracy of the best current eye trackers is still limited, as claimed Robert & Keith (2003) and there are typically 10 to 20% of the users’ eye movements that cannot be tracked reliably. Developers of eye tracking systems have made great progress in improving the accuracy in eye tracking, but existing solutions are far from optimal.

Practical issues in eye movement registration are not limited to technology factor, but also human factor. Using eye tracker not only needs a strong cooperation of the participants, but also puts some restrictions on the participant’s freedom of eye, head, and whole body movement. For example, some systems require a fixed head position to separate eye movements from head movements for high spatial accuracy. To do so, the eye tracker will be firmly and uncomfortably mounted to the participant’s head. Such systems would be appropriate for young, healthy adults, who are highly cooperative and would tolerate restraints to restrict head movement. These systems may not be tolerated by adults with physical or cognitive impairments, some older adults, or very active young children (Hallowell & Lansing 2004). In this way, the need to constrain the physical relationship between the eye tracking system and the participant becomes one of the most significant barriers to incorporation of eye tracking in many learning situations, which includes the one that we are interested in.

1.3.2 Think-aloud data

Think-aloud data refers to talk that is produced continuously throughout the participants’ engagement with an activity. To obtain this type of data, think-aloud method is used by requesting the participants to keep on talking, speak out loud whatever thoughts come to mind, while performing the task at hand (Ericsson & Simon 1993). In many cases, as claimed van Someren et al. (1994), think-aloud is considered as a unique source of information on cognitive processes as seen in the research efforts of Crutcher (2006) in the field of cognitive psychology or behavior analysis of Austin & Delaney (1998).

The traces gathered by using the think-aloud method are also referred to as “verbalized thoughts” (Nakashima et al. 2006) and can be obtained by audio-recording and/or video-taping. Hulshof (2004) described in his research work that obtaining think-aloud data involves three steps: transcribing, segmenting and encoding. Transcribing refers to the process of typing in the verbal data. Segmenting a protocol means breaking it down into separate meaningful segments. Encoding is for categorizing each segment and developing a descriptive
behavioral model based on the sequence of categories. Segmenting and encoding processes influence each other, which means that the whole process occurs in cycles (cf. figure 1.7).

![Figure 1.7 Think-aloud method for obtaining log files](image)

Using think-aloud method is suitable when there is interest in higher-order cognitive processing and as when verbal data are used as important indicators of the thought processes that occur during a task. For example, we can use this method to investigate differences in problem solving abilities between people, differences in difficulty between tasks, effects of instruction and other factors that have an effect on problem-solving. Nevertheless, think-aloud is not meant to be used in the learning situation where we are particularly interested in tracking users CMC activities. Right below a synthetic study on the main issues related to think-aloud method and the reasons that the latter is avoided in our research design.

Even technology factor is not a problem when using this method, but human factor is. Discussed in the research work of Young (2005), user’s verbal abilities is a major concern. Young pointed out that when it comes to a learning situation, participants vary in their ability to articulate thought processes in order to produce useful think-aloud data. Indeed, as suggested by Wade (1990) that participants with high-level cognitive development will have available mental capacity to report on thinking. Alternatively, those participants who are less capable of expressing their own thinking will be less capable of reporting on it, thus the think-aloud data may underestimate their knowledge and abilities. Described in the research works of Wilson (1994) and Branch (2000), in an authentic learning situation, the participants usually have very brief or very procedural think-aloud – e.g. the participants shorten their words instead of expressing thoroughly their thinking. Branch (2000) denoted that when the participants having difficulties in thinking aloud, the usefulness of the collected think-aloud data is limited, as they will not necessarily reflect the participants’ abilities in successfully completing a given task. The same issue has been
commented in the research work of Keys (2000) that the think-aloud data do not always provide evidence of thought processes being engaged. For all the reasons mentioned, data of verbalized thoughts will not be a contributing factor to our research and can be safely ignored.

Since we are more interested in computerized data that represent the computer-mediated activities of the users in learning environment, what engages our attention at the moment is **whether or not think-aloud method can be applied to our research approach regardless its issues in human factor mentioned earlier.**

If we look very closely at table 1.2, think-aloud method appears to be only the most convenient to local and experimental situations. From table 1.2, other practical issues are also found to exist that make this method inapplicable in distance learning with computer-mediated settings, such as in our case. First, capturing think-aloud data requires the participant to continually speak aloud the thoughts in their head as they work. That process is more appropriate for small groups of participants and for environments where face-to-face interactions can easily be made. Second, the verbal data can take several forms including audio recordings, video images and verbatim transcripts, which turn its exploitation to be a challenging and time-consuming task. Examples of exploiting verbal data include audio-video tapping, transcribing the video images and speeches, segmenting, encoding, and analyzing verbal data, etc. In this case, one of the problems associated with exploitation of think-aloud data, as pointed out by Williams & Clarke (2002), is the interpretation of it. Last but not least, in distance learning situations where there is a total absence of face-to-face interaction and without which, verbal data can not easily be acquired, the think-aloud method will, no doubt, be a huge constraint in achieving the task of collecting the log files of the participants in the learning process. This is not to mention that most distance learning activities (e.g. browsing online courses, making discussion, etc.) often feature a big number of Computer-Mediated Interactions which require other tracking methods, such as “computer-registered operations” that focus more on user and machine interactions and not on users’ verbalized thoughts.

### 1.3.3 Computer-mediated interaction tracking data

Such types of data can be acquired by using “Computer registered operations” method that involves keeping track of Computer-Mediated Interaction, where interaction is defined as users-initiated behavior that leads to a change, visible or invisible to the computer program or which the interaction pattern is studied. In practice, this method is easier to use than the two previous methods as it is all carried out by registering mouse-button presses and keyboard operations that a user undertakes during a task. The schema we give below (cf. figure 1.8) presents the computer registered operation approach independent of the specific context in which the tracking process is taking place.
To better understand what is depicted in figure 1.8, we will now look at an example of the tracking process of a user’s interactions on a computer program to fulfill a “drawing a diagram” task. The computer program for drawing a diagram, also known as “Computer-based systems” in figure 1.8, consists of a number of “Interaction Objects” that enable users to compose graphical diagrams. Each interaction object (e.g. a square or rectangle diagram object) displayed on the program interface permits users to perform one or many actions, such as drag and drop them on screen. When the user clicks on an object and drags it on the screen, “click” and “drag” are referred to “User Actions” and every time an action is occurred, a “Computer Operation” is launched by the program to execute the user command. Each user action on an interaction object is registered by the tracking system and the obtained log files store information of both user actions (e.g. click, drag & drop) and interaction object (e.g. graphical component of the drawing program such as a square or a rectangle object, etc.). The computer-registered operation log files can be varied accordingly to how users interact with the computer program when conducting a task. That is why when tracking a user activity, different types of Human and Machine Interactions must be taken into account by the tracking systems (cf. discussed in detail in chapter 3).

Tracking users’ interactions in learning environments, as clearly expressed in Misanchuk & Schwier (1991, 1992), has three major purposes, which are: using captured information (i) for evaluation of instructional design; (ii) as tools for basic research into the instructional design of computer-based instruction and hypermedia; and (iii) as a means of monitoring usage of learning environments. Many researchers agreed with the first two cited reasons. Examples can be seen in the published works of Mills (2001), Maslowski et al. (2000) and Ingram (1999), the idea of using the log files resulting from the approach that is based on computer-mediated tracking system to evaluate instructional software.
The same approach has also been adopted by many other researchers, including Gay & Mazur (1993) and Tessmer (1993). They also made a point that a properly conducted evaluation can help researchers determine the effectiveness, efficiency, usability, and acceptability of educational software.

Log files of users’ interactions on a learning environment also serve as a foundation for users monitoring, as pointed out Mills (2001). Which statement followed the third purpose of tracking users’ interactions, mentioned earlier by Misanchuk & Schwier on monitoring usage of learning environments and its users. Indeed, monitoring the used learning environment becomes increasingly important as in many senses it helps reduce a large number of barriers and problems particularly encountered by the learners. As proved in the study of Galusha (1997) and later in Rivera & McAlister's (2001), the common problem in a distance learning situation is that learners may feel isolated due to lack of contacts with tutors or with other learners, can get lost in the course hyperspace, and often find it difficult to manage without institutional support. For all of these reasons, monitoring learners’ activities on a dedicated learning environment by tracking their interactions, allow the tutors to examine various aspects of learners and to take immediate actions to prevent or overcome learner’s problems and difficulties (Mazza & Milani 2004).

To sum up, we bring back the same question that appeared in the studies of the two previous methods (i.e. eye movement registration and think-aloud methods): Is computer-registered operation approach the answer to CMC tracking in distance learning? Our general findings reveal that this approach has reached great popularity in the TEL research community, for its benefit in providing means and technologies in implementing tracking systems for educational platforms. As a matter of fact, most distance learning environments are built upon Web-based technologies for the accessibility and flexibility reasons. Therefore, tracking users’ interactions in such environments can be done by a variety of Web technologies (Atterer et al. 2006), from Web-based mouse-movement registration (Mueller & Lockerd 2001) to World Wide Web tracking applications (Pirolli et al. 2002). Additionally, if we look back at table 1.2, there are two significant characteristics relevant to “the number of the participants” and to “the learning situation” that make the computer-registered operation approach the most advantageous and suitable for our research application.

For instance, this approach can be applied to multiple users simultaneously as the tracking process can be realized on different users’ machines and at the same time. This makes the approach practical and useful when the purpose is to obtain a global overview of the activities of an individual user or a group of users. What is more, with the existing technologies, both computer programming languages and World Wide Web applications, implementing a tracking system to capture interactions between user and the computer program becomes easier.
We have, therefore, come to the conclusion, that using computer-registered operation approach is the most appropriate solution for distance learning situations where user’s activities are largely conducted on computer-mediated environments (e.g. learning platforms, course management systems, communication tools, etc.) and when those activities appear as a major part of the learning process. However, if we look at this approach from a broader perspective, obtaining log files of user’s interaction demands more than tracking mouse-button presses and keyboard operations. The resulting log files would lack users’ reasoning behind the action they have performed, which makes interpretation a complex affair. Having said that, we discuss in chapter 3 that tracking user interaction in learning situations is a challenging task from a technological standpoint and it requires more research effort to build an efficient and explicit tracking approach.

While interpreting data of user interaction is a complex process, the collection of information on user interaction, and how it is structured also matter. For example, the information related only to user action is not substantial enough for the data interpretation. As highlighted by Williams & Dodge (1993), a log file on user interaction must display what action a user takes, where and when, which allow data analysis to determine the user behavior through user action. In other words, it should be possible to reconstruct the sequence of relevant user’s interactions from the log file to make the data analysis more pertinent. We could suggest that data interpretation is not the only issue we can discuss here while tracking user interaction and exploiting log files struggle with a huge number of difficulties in other aspects like data representation, storage, analysis, visualization, etc. The discussion that covers in detail all of these practical issues is presented in chapter 3.

### 1.4 Security and privacy issues of tracking data in learning environments

#### 1.4.1 Overview of the security and privacy issues

The security and privacy issues in learning environments are not new in Technology Enhanced Learning, but already cover plenty of research topics. Therefore, the study made in this section is not meant to address new challenges in this research field, but to express our attention on this matter. In the mean time, it should also be noted that tracking data of the participants in the learning process is one of the core items of our research and we readily acknowledge potential privacy threats and protection of their personal data in learning environment. As follows, we give a synthetic study on security and privacy concerns in TEL.

Existing technologies used in learning environments have increased security and privacy problems, which leads to a situation where security and privacy protection are becoming essential for the participants in the learning
process. Weippl (2005) raises our awareness that security issues are important in the context of education. Yet understanding the security models in learning situations help the participants to avoid security threats as well as to improve protection of both participants and their learning environments. In TEL, according to Klobucar et al. (2007), privacy issues concern learning technology providers, learning service and content providers, and the participants in the learning process, particularly the learners. For example, the crucial tasks for learning service and content providers are to secure learning environment and to secure storage of learner data. As for the learners, they are mainly concerned with trust assessment of learning environments they are using, and with protection of their sensitive personal data (Anwar & Greer 2006). It is important to mention that security and privacy levels differ in various learning environments and depend on types of learning activities being conducted by the participants. For instance, in a collaborative learning situation where interactions between several participants are inevitable and their exchanges of both personal and collaborative data are intense, a strong protection of participant’s privacy could only be done on a particular environment that is specifically built for such situation. As found in the research works of Borcea-Pfitzmann et al. (2005) on establishing a privacy-aware collaborative learning environment and Skinner's (2007) on multi-dimensional privacy protection for digital collaborations, allowing users to perform collaborative learning activities with a high-level protection of user privacy.

To have an overview of some issues of privacy and security in learning technology as well as learners and their protection provisions, we will look at some research data taken from the published work of Klobucar et al. (2007). Klobucar and his research group collaborated with a network of excellence in the field of Technology Enhanced Learning, PROLEARN (http://prolearn-project.org/) (Wolpers & Grohmann 2005) and have conducted a research on different topics related to security and privacy issues in TEL. Right below, table 1.3 reflects the urgency of different protection provisions of the following issues: personal data protection, anonymous use of learning services, address and location privacy, single sign-on, seamless access to learning resources, authenticity of learning resources (LRs), digital rights management, legislation and awareness raising. Figure 1.9 depicts the average of the privacy issues protection provisions. The synthetic information in both table 1.3 and figure 1.9 is computed from a questionnaire data on people’s satisfaction with current security and privacy in TEL, a view on future TEL security and privacy, and urgency of different protection measures. A total of 147 people responded to the questionnaire, among which 66% represented universities and higher educational institutions. 67 participants are learning technology and service providers, 38 are learning content providers, and 42 are end-user organizations.
Table 1.3 Security and privacy issues in TEL: Urgency of different protection provisions
(Klobucar et al. 2007)

<table>
<thead>
<tr>
<th>Protection of personal data</th>
<th>Non relevant</th>
<th>Nice to have</th>
<th>Relevant</th>
<th>Urgent</th>
<th>Very urgent</th>
<th>I don’t know</th>
<th>No answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anonymous use</td>
<td>10%</td>
<td>16%</td>
<td>45%</td>
<td>23%</td>
<td>6%</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td>Address and location privacy</td>
<td>5%</td>
<td>10%</td>
<td>37%</td>
<td>22%</td>
<td>22%</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td>Single sign-on</td>
<td>3%</td>
<td>12%</td>
<td>37%</td>
<td>26%</td>
<td>16%</td>
<td>2%</td>
<td>5%</td>
</tr>
<tr>
<td>Seamless access</td>
<td>1%</td>
<td>10%</td>
<td>33%</td>
<td>33%</td>
<td>17%</td>
<td>1%</td>
<td>5%</td>
</tr>
<tr>
<td>Authenticity of LRs</td>
<td>2%</td>
<td>14%</td>
<td>25%</td>
<td>32%</td>
<td>24%</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td>Digital Rights Management</td>
<td>15%</td>
<td>11%</td>
<td>33%</td>
<td>25%</td>
<td>16%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Legislation</td>
<td>7%</td>
<td>13%</td>
<td>52%</td>
<td>18%</td>
<td>5%</td>
<td>1%</td>
<td>3%</td>
</tr>
<tr>
<td>Awareness raising</td>
<td>5%</td>
<td>10%</td>
<td>26%</td>
<td>24%</td>
<td>33%</td>
<td>1%</td>
<td>2%</td>
</tr>
</tbody>
</table>

Figure 1.9 Average values of urgency of different protection provisions
(Klobucar et al. 2007)

Interesting information can be retrieved from table 1.3 and figure 1.9. Examples include user data protection and anonymity that are strongly relevant to privacy concern in learning environment (cf. second row of table 1.3 and second horizontal bar of figure 1.9). Besides personal data protection, learners requested to be able to control the visibility of their sensitive data such as their learning traces, and their profiles, etc. That is why various privacy-enhancing technologies are proposed by Senicar et al. (2003) and El-Khatib et al. (2003) for privacy protection at both learner side and provider side (i.e. learning service and content provider). Those technologies include identity protectors, anonymous communication systems, cryptographic mechanisms, etc. Regarding the tracking process of learner’s activity in learning environments, Klobucar et al. pointed out that 55% of end-users perceive user tracking as a big or very big threat.
Interestingly, we have found similar results in the study of Fox et al. (2000) that user tracking is not welcome even when users receive personalized content in return. Similar results were obtained for unsolicited profiling (45%) and personalization (40%) in the research work of Klobucar et al. (2007).

To wrap up, the study in this section enables us to gain an insight of the most important aspects regarding the security and privacy concerns in learning environment: the awareness of users when being tracked and the protection of their personal data. It also inspires us to explore a proper solution for our research. The following section presents some existing solutions to the security and privacy concerns along with their limitation and compromise.

1.4.2 Solutions to the security and privacy concerns: limitation and compromise

To get the better of privacy concerns is not only about using technological solutions to keep users safe from any threats, but also about “trust” – a word that people constantly use to mean different things in different circumstances, and in different scenarios (e.g. trust between parties, trust in the underlying infrastructure, etc.). According to Handy (1995), trust is a confidence in someone’s competence and his or her commitment to a goal. Trust, in learning situation is also a crucial enabler for meaningful and mutually beneficial interactions that build and sustain learner collaboration (e.g. collaborative learning) and community (Anwar & Greer 2006). As yet, privacy is a natural concern at the same time that trust is an important factor in learning environment because in practice, privacy and trust are circularly related. For example, in a closed learning environment, where all learning services are provided internally (e.g. from a university or a trusted source) learners can have higher confidence that their personal data and learning traces will be treated properly. Thus, their learning tasks such as working collaboratively with other learners could be effectively conducted upon trust (Nickel & Schaumburg 2004; Mason & Lefrere 2003). On the other hand, in an open learning environment with unknown providers such as private or external learning service providers, privacy concerns are higher and the trust level of learners will be influenced by the level of perceived privacy offered by those providers. So finally, privacy and trust complement each other, and together they can make for a more stable learning community (Steel 1991).

Regarding the solution to the discussed issues, we have two different perspectives. From a technological perspective, the solution to the security and privacy issues is still heavily reliant on technological approaches. We are convincing that better privacy protection tools are required in learning environment to manage and safeguard learning traces and personal information of the participants. The solutions, as pointed out Davison et al. (2003) will involve the development and integration of Privacy Enhancing Technologies such as identify protector (van Blarkom et al. 2003), shield privacy (Skinner & Chang 2006), and privacy protector (Gritzalis 2004). Those technologies are largely used
in some manner to help protect user personal information and to secure learning
environments. From a researcher in TEL perspective, what is important is the fact
that learner personal data benefit from any type of exposure in any circumstance.
Nevertheless, a compromise between tracking learners and protecting their
privacy is still needed. For example, allowing learners to anonymously access to
their learning environments for a privacy reason is feasible from a technological
standpoint, but somehow limited from the fact that a learning application aims at
assisting learners and so they can not act in full anonymity (Pfitzmann & Hansen
2005). For that reason, we suggest that learning application researchers, designers,
developers and administrators should be aware of privacy requirements in their
applications, from both legal point of view and as a way of ensuring learners’
concerns on their data protection.

To conclude, tracking CMC activities in the context of our research
should not be seen as a threat to learners for the following reasons. First of all, we
always raise learner’s awareness of any tracking process when they access
learning platforms or use CMC tools to perform their communication activities.
Second of all, only on approval of learners that any tracking process can take
place. Besides these two principal reasons, there is always an acknowledgement
from our part on the protection of learners’ personal data and their entity privacy.
On top of that, learners also have a full control on their traces and especially they
have the right to make their traces accessible or not by any type of participants
including their tutors. Last but not least, every use of the learning traces we
acquire in this research is strictly for educational purpose only and in an objective
to support both tutors and learners in their tutoring and learning activities on
CMC tools.

1.5 Conclusion

In this chapter, we presented a general study of tracking data in Technology
Enhanced Learning (TEL) and an overview of our research work. Throughout the
study, we placed our emphasis on the participants and the supports needed in
order to sustain their participations and interactivities within the learning process.
From an actual observation, we pointed out that using technologies like
Computer-Mediated Communication (CMC) tools can better support participation
and interactivity of both tutors and learners. The reason being is that CMC tools
are employed not only to encourage the exchange between the participants, but
also to promote the communication-oriented learning activities. This is not to
mention about the possibilities CMC tools have to offer to the participants to
easily access learning resources (e.g. the results or the products of the CMC
activities) or to reinforce learning experiences via communications, etc. While
CMC tools demonstrated a lot of advantageous to both the learning process and
the participants, we also acknowledged the importance of integrating tracking
systems in the learning environments as well as the benefits of observing the
participants’ activities on CMC tools. That is why we studied different tracking approaches and justified the one that is the most appropriate to our further research design and development. In addition, we also studied the important issues regarding to the security and privacy concerns, which are often neglected in the research efforts that implicate user tracking in learning situations.

In the next chapter, we present a study on the characteristics of the Computer-Mediated Communications and a specific learning context where our research work is situated. A particular CMC tool that is used in our research application is also presented. Three research statements presented in this chapter (cf. section 1.2.3) will be discussed in the next chapter along with the aspects that emerge in response to them. The discussion will concentrate on the tracking solution that we are suggesting for the CMC tools and on the use of the collected CMC traces in various learning contexts.
Chapter 2

Tracking Computer-Mediated Communications in distance learning
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Chapter 2 at first glance

This chapter is dedicated to a study on tracking computer-mediated communications in distance learning.

![Figure 2.1 Logical schema of chapter 2](image)

The study, as summarized in figure 2.1 starts off with a presentation of the characteristics of CMC and the chosen CMC tool in the context of our research. In section 2.1, we give an overview of different techniques and modes of CMC. Later, we present a specific learning context in which our research work is situated – using CMC tools in foreign language teaching and learning. In the last part of section 2.1, we present Confor (CONtextual FORum), a particular CMC tool that has been used in our research application.

The rest of the study concentrates on the aspects that emerged in response to the following research questions (already posed in chapter 1, see section 1.2.3):

- **How does using tracking system on CMC tools affect the activities of tutors and learners in distance learning?**
  Presented in section 2.2, is a study undertaken to investigate the positive effects of using tracking systems on CMC tools and the outcomes that contribute to online teaching and learning enhancements. First, we express in this study the
reason why we adopted the tracking solution. Later, we fix our attention on “data indicators” of communication activities, which result from the tracking process and are exploited as useful artifacts to support the participants in the tasks of teaching and learning via CMC.

- **How exploiting tracking data of learners’ activities on CMC tools enables the tutors to monitor the learners’ activities or to evaluate them?** As for the learners, how could their interaction data captures throughout the learning/communication processes enable self-assessment and self-awareness?

The state of the art of different platforms and applications for exploiting learning traces is presented in section 2.3. Our main goals are twofold: (i) to study a variety of possibilities of transforming CMC traces into a tool to assist the participants in the learning process, and (ii) to acquire a clearer perspective on what trace exploitation tools can be provided to the tutors and the learners to respectively enhance their tutoring and learning tasks on CMC tools.

The conclusion of this chapter will cover our broader perspective on the three important aspects in relation to:

(i) a tracking solution to the production of good quality data indicators. We will point out what has generally been overlooked by the existing research efforts regarding the tracking approach for CMC tools and why we pay extra attention to it.

(ii) the existing tracking data exploitation tools that are specifically addressed to one particular user group, such as teachers or researchers; while learners consistently request more assistance be given for the task of learning CMC traces.

(iii) The proposed data indicators that are built with less pertinent information and usually ignore the behavioral aspects of the activity although they are substantial to the analysis process.
2.1 A general study on Computer-Mediated Communication

2.1.1 Characteristics of computer-mediated communication

Computer Mediated Communication (CMC) represents an alternative approach to human communication, and has been described as an “altered state of communication,” including altered physical environments, altered time and space, and altered structures in communication (Vallee et al. 1975). CMC, according to Santoro (1995) can be defined narrowly or broadly, depending on how we define human communication. At its narrowest, CMC simply refers to computer applications for Human-to-Human Communications. Examples include computer-based applications such as electronic mail, chatting systems, asynchronous discussion forums, etc. At its broadest, CMC can encompass virtually all computer uses, which include using computer as (i) communication device, (ii) data management system, and (iii) support in educational settings. In addition to Santoro’s suggestion on CMC, Liu (2002) added that CMC has been employed in many other fields, including political forums (Hill & Hughes 1997), educational computer conferencing (Iseke-Barnes 1996), cooperative research (Walther 1997), organizational communication (Steinfield 1992), social support communication (Weinberg et al. 1995), and interpersonal communication (Kraut et al. 1998).

Rapaport (1991) divided CMC into four elements: Information retrieval, electronic mail, bulletin boards, and computer conferencing. These elements do not explicitly correspond with the types of CMC tools, but with the characteristics of CMC built into the four clusters of techniques of one-alone, one-to-one, one-to-many and many-to-many (cf. figure 2.2).

The one-alone techniques (cf. part A of figure 2.2) can be characterized by learners performing a learning task on computer-mediated settings, without engaging in communication with other learners. An example of one-alone technique is information retrieval: where a learner can access a learning platform to consult online courses, or to retrieve learning resources. The one-to-one techniques (cf. part B of figure 2.2) as presented by Moore (1991) can be conducted by e-mail applications or instant messengers. Examples of one-to-many techniques (cf. part C of figure 2.2) include online classroom or electronic lecturing (Paulsen 1995) where tutors can easily share learning resources with the learners, and e-mentoring (Bierema & Merriam 2002) where different types of CMC tools such as chat groups and conferencing applications are employed to reinforce the online mentoring process. The many-to-many techniques (cf. part D of figure 2.2), provide answers to the problems that limit communication between the participants in a larger scale (Wilfried et al. 2004). The reason being, that the many-to-many techniques found in standard CMC tools; such as discussion forums or in other particular learning environments such as Moodle1, Dokeos2.

---

1 Moodle official web site : http://moodle.org/
2 Dokeos official web site : http://www.dokeos.com
Claroline\textsuperscript{3}, etc., allow collaboration between the participants, as well as co-operative learning.

Each technique mentioned earlier, offers alternative communication possibilities that can be divided into two main kinds: Synchronous and Asynchronous.

**Synchronous communication** is a real time event. It means that both participants have to be present at the same time. This form of communication is mainly based on text, voice and audio-video transfers (Bucko et al. 2005). Synchronous communication can be accomplished by basic Internet applications; including instant messenger service (e.g. chat), or special software programs related to computer conferences, which allow multiple users to have a simultaneous conversation (Warschauer 2001). It is also feasible in one-to-one and one-to-many techniques, allowing, for example, a tutor to share a message with an individual, a small group of learners or the whole class.

\footnotesize{\textsuperscript{2} Dokeos official web site : http://www.dokeos.com} \textsuperscript{3} Claroline official web site : http://www.claroline.net
Asynchronous communication, on the other hand, is performed in different time. In other words, participants may communicate in different time slices for the reason that there is always a certain time span between sending a request (i.e. a message) and receiving a response. A typical example and probably the most obvious form of asynchronous communication is e-mail. Other possibilities of asynchronous communication are newsgroups, bulletin boards, discussion forums that allow messages to be threaded, thus facilitating easier access to particular parts of long, complex discussions among many participants.

2.1.2 Computer-mediated communication and the learning context concerned

The studies in the previous section unveil a diversity of CMC techniques and modes. To which, CMC has been adapted to a large number of disciplines, including art, culture, psychology, communication sciences, information technology, languages and didactics, and many others. Due to this diversity, CMC can take different forms in each learning context, and which we have to clearly specify to which form our research work is attached. It is important for us to do so, in order to carry out our research work in an authentic learning situation, and to determine a context in which the learning and communication activities to which we are referring, are taking place.

Throughout this research work, aside from our research colleagues, we have been working with the tutors and students from the Stendhal University of Grenoble 3(4), a French university located in Grenoble, a city of France. They are from the faculty of Science of Languages and Linguistics, where one among proposed online courses and trainings is French as Foreign Language (FFL). FFL also refers to FLE in French for Français Langue Etrangère. FFL is a two-years-professional-master course that aims at providing students a solid education based on theoretical concepts as well as their implementations in teaching practices. This means that students who follow this course are trained to be teachers, specialized in French language teaching. The learning contents of FFL are organized into different themes that include: educational concepts and observation of classes, literature and intercultural approaches, analysis of language and speech, and use of ICT (Information and Communication Technologies) in class. An important part of FFL courses is the design of educational programs and materials by taking into account the target learners and the resources (learning medium, supports, etc.). FFL can be characterized as Computer Supported Collaborative Learning (CSCL) where most activities are being conducted by students, separated in to small or big groups and supervised by tutors on a dedicated E-learning platform. While students are neither in the same locations nor time zones, CMC tools are largely employed to fulfill their collaborative learning tasks, assignments, and projects. For instance, discussion forums, chat, blogs, and wiki are among the most used CMC tools by both tutors and students to sustain the online tutoring and learning processes.

4 http://www.u-grenoble3.fr
It is worth mentioning that the research interests we have for the domain of Foreign Languages and Didactics had been strongly influenced by two important factors. First of all, being a part of the team who work on different research topics in TEL (Technology Enhanced Learning) and particularly in CMC as learning technology, allows us to gain a better and broader perspective on our research. As a result of our collaboration with different colleagues, we are able to constantly diversify our interests and to enlarge application possibilities of our research approach. This is thanks to the approach which is objectively designed to be generic and applicable to a variety of CMC in educational settings (discussed in chapter 3).

The second factor is more related to our actual findings on the strong implication of CMC in foreign language acquisition and didactics. Presented as research evidence by Warschauer (1997); Leh (1999); Ramzan & Saito (1998); Sutherland-Smith (2002); Saito & Ishizuka (2005); Freiermuth (2002) and Kitade (2000); shows that CMC plays an important role in foreign language learning and teaching, with its obvious advantages in reaching the learners, based in different locations (e.g. school, work place, or home, etc.) and times, to communicate between them in a quick, easy, and inexpensive way. Leh (1999) added that both tutors and learners are usually in favor of using CMC in educational context. Furthermore, along with the widespread use of Internet access, technological and pedagogical developments make CMC an innovative way to online language teaching and learning (Warschauer & Healey 1998). As reported by Xiao & Ru-Hua (2006), CMC supplies tutors with more effective and enjoyable teaching situations and provides learners with more opportunities for learning through communication, and collaboration, etc.

2.1.3 Contextual Forum: the chosen computer-mediated communication tool

It is very important to mention that our research work covers a variety of CMC tools such as discussion forum, chat, blog, wiki, and other tools from the same family, either synchronous or asynchronous. However, the principal CMC tool that has been used in our research application is discussion forum. We have adopted a particular discussion forum named Confor (CONtextual FORum) (George 2003), which was found suitable for the learning context to which our research is attached (i.e. FFL, presented in the previous section). Confor has been introduced to our research colleagues, and particularly the tutors and learners of FFL with whom we have collaborated during this research. Confor can be seen as another type of CMC tool capable of supporting users’ communications. Moreover, it has a unique feature that allows users to organize their communication activities according to their learning activities, structured in a form of learning contents, tasks or scenarios.

Figure 2.3 illustrates the principal view of Confor. The upper part of the window contains a learning activity that can be represented by (i) an online...
course, (ii) a set of learning tasks with descriptions, or (iii) a learning scenario with different learning phases. In figure 2.3, we can see in the left panel a structure of the activities of an online course (A), and in the right panel, the content of the course (B). Immediately under, is the interface of the contextual forum (C), which is integrated in the same window. Such interface enables a contextual display of all the communication activities that are related to a learning activity.

Figure 2.3 Principal view of Confor (George 2003)

For instance, from the principal view of Confor, shown in figure 2.3, a learner carries out the activity number 2 (i.e. Activités 2) of the second course module (i.e. Module 2). The discussions that are connected with the current activity number 2 are displayed in the interface of Confor (C). While the left panel of Confor displays the list of the discussions, structured in a tree of messages; the right panel displays the content of the selected message. The list of the discussions in Confor will be automatically changed when a learner changes from one activity to another, or from one course module to another.

To sum up, the biggest advantageous of using Confor instead of other forums is that users do not have to switch from a learning platform to Confor to perform any discussion on their learning activities. This is due to the most practical feature of Confor that links both the learning and communication activities and displays them in one single window. Also, Confor has other essential qualities for the learning situation where communication activities play an important role; as found in the study of George (2004), Confor is a type of forum that not only promotes communication activities between users, but also
encourages them to make their communications more relevant to their learning context.

2.2 Tracking learning and CMC activities

2.2.1 Tracking solution for teaching and learning enhancements

Online learning with computer-mediated communications requires a significant investment of resources, and involves considerable effort from various participants, particularly the tutors. As such, they bear a great responsibility in fostering the learning process with effective pedagogical concepts and strategies. For example, it is extremely important for a tutor to encourage the interactions between the learners, supervise, moderate and animate their discussions, etc. Meanwhile, with the current support of CMC tools that are often limited to communication means, the tutors are compelled to neglect other important facets of tutoring, such as student assessment or evaluation when they are in a remote learning situation.

Regarding learning evaluation, it is traditionally performed using methods such as tests, ethnographic observation (objective in terms of the students but subjective in terms of the teachers), or student’s attitude (oral or written) toward various learning aspects (Ravid et al. 2002). Online learning, on the other hand, generally requires learner evaluations on the observable interactions on technology-based learning environments and their outcomes (Zaiaine & Luo 2001; Ben-Zadok et al. 2009; Ceddia et al. 2007). Indeed, from a teacher standpoint, the learning evaluation could be carried out based on the results from learner activities on CMC tools including homework, report, assignment submissions, etc. However, the lack of information on how those activities were realized (i.e. the processes of the activities) might make the evaluations less effective or biased in some circumstances (e.g. subjective instead of objective).

Acknowledging these limitations, providing an extra means to the tutors to keep track of ongoing actions of learners during their CMC activities would effectively participate in the task of examining and evaluating learners. For this reason, we address the importance of the tracking process of CMC for the benefits of learning traces to online tutoring and learning enhancements. We also suggest that learning traces should be among the core items to be exploited by both tutors and learners, to seek for “data indicators” that support their activities (discussed further in section 2.2.2).

The proposition of tracking solution could be explained as follows. For example, while standard CMC tools fail to provide effective support to the tutors in performing learner monitoring, acquiring awareness of the learning process or making an evaluation on learner activities can be a challenging task for the tutors.
In addition, the consequences of insufficient learner monitoring have many negative effects on online learning. Examples highlighted by Rivera & McAlister (2001); Valentine (2002); Hara & Kling (2000) include high learner drop-out rates, learners’ feeling of isolation, and difficulties with finding help from tutors and peers, etc. To overcome such barriers, regular learner monitoring is strongly suggested for the reasons cited by Galusha (1997); Ragan (1998) that it can reduce both online learning problems and the tutors’ difficulties in the tasks of online tutoring. **Because of that, we value the idea of tracking CMC and exploiting the collected traces in order to produce data indicators that allow the tutors to better supervise and evaluate their learners.** The idea can be illustrated in figure 2.4.

![Figure 2.4 Data indicators to support users on CMC tools](image)

To be more precise, our needs and interests regarding CMC tracking and traces exploitation are directly related to the attainment of three main types of assistance of data indicators: (i) **awareness**, (ii) **appreciation/assessment**, and (iii) **evaluation** of learning activities, outcomes, effectiveness, etc. We suggest that these indicators are important elements to online learning. Considering an example of awareness data indicators, they enable the tutors to monitor the ongoing activities undertaken by the learners. Mazza & Dimitrova (2005) and Mazza & Botturi (2007) pointed out that awareness data indicators are needed in order to assist the tutors in taking actions while observing their students, diagnosing a problem, so that they can take immediate actions to overcome that problem; or to provide more appropriate synchronous interventions related to particular situations, etc.
“Awareness” is crucial to the online learning process and is not limited to the monitoring activities of the tutors, as raised by Barros & Verdejo (2000). From a learner standpoint, awareness also contributes to the improvement of learner collaboration on CMC tools. Brooks et al. (2006)’s general findings claimed that awareness is the key to successful collaboration and provides a potential to increase learner performance and satisfaction. Regarding awareness data indicators, they are dedicated to support learners’ meta-cognition and diagnosis during the collaborative learning. They enable learners to (self) evaluate in an operational way, both the learning processes/outcomes and the quality of CMC activities (Dimitracopoulou et al. 2004). Furthermore, awareness data indicators are recognized to be beneficial to the self-regulation process of the participants while interacting with computer-mediated learning environments (Mary & Lyn 2006). As raised by Dimitracopoulou (2008), they usually feature substantial information relevant to complex cognitive and social phenomena that occur during the participants’ CMC activities, thus allowing them to regulate their behavior.

The discussions in the following sections, give an overview of data indicators and a first look at their utilization as useful artifacts to support the participants in the learning process.

### 2.2.2 Overview of data indicators

Data indicators can be referred to a piece of information, usually presented in a visual form and may feature, according to Dimitracopoulou (2005),

(a) the mode or the process of the considered “cognitive system” learning activity (task related process or quality),

(b) the characteristics or the quality of the interaction product,

(c) the mode, the process, or the quality of the interaction being performed on a technology-based learning environment (e.g. CMC tools).

Data indicators provide means of abstracting, synthesizing, inferring, and visualizing the information that they feature (Dimitracopoulou & Bruillard 2006). Obtaining data indicators is a complex process. As shown earlier in figure 2.4, it involves many phases including:

- observing CMC tools to gather the traces of user activities,
- exploiting the collected traces to generate data indicators, and
- displaying the indicators to support users in information visualization process.

Therefore, we consider each data indicator as substantial output produced by a specific traces exploitation tool, or in other words, by an **Interaction Analysis** tool (IA), a terminology introduced by Dimitracopoulou et al. (2004).

A dedicated IA tool for learning environments (cf. figure 2.5) plays an important role in filtering, processing, and representing the data in an appropriate format (e.g. textual or graphical) to provide an insight on the past or ongoing activities of the users. Thus, the data indicator generally consists of valuable
information that allows the user not only to realize on a cognitive or meta-cognitive level his/her own activity, but also to analyze it. Additionally, it can feature a collection of information in relation to various aspects of the activity. It is also susceptible to be interpreted in distinctive manners according to some obvious factors such as user’s point of view, level of complexity of the indicator, characteristics of the information it contains, etc. For these reasons, an IA tool is usually designed to allow users, via a GUI (Graphical User Interface), to customize the visualization of data indicators. An example given by Dimitracopoulou et al. (2004) specified the possibilities for IA-tool users to alter the values of the indicators to be viewed, or to choose the desired model of the indicators (e.g. predefined models of an IA tool) to help users interpret the meaning of the indicators values.

![Diagram of a Learning Environment with data filtering, pre-processing, and interaction analysis tool](image)

**Figure 2.5** Generic Interaction Analysis tool (AI) (Dimitracopoulou 2005) in the report JEIRP of Kaleidoscope Network of Excellence

The production of data indicators is based on the information collected during the interactions between users and the computer-based environments they are using (e.g. learning platforms or CMC tools). Also, the indicators can refer to diverse concepts of user interactions depending on how they were performed and/or on other contextual conditions (e.g. tracking mechanism, data collection method used). Considering a CMC activity in a collaborative learning situation, learners can interact with a CMC tool in either stand alone or collaborative mode.
Hence, with regard to how the data indicators are constructed by an IA tool, they may refer to (i) learners individual actions and/or their products, or (ii) the actions and/or products of a number of learners who participate in the collaborative activity. Such indicators could assist the learners in the process of interactions analysis to acquire a conceptual understanding of their collaborative activities.

To conclude, data indicators give considerable assistance to both tutors and learners in online learning situations, whilst IA tools are essential for them to visualize, analyze, and interpret the information that each data indicator features. As argued by Dimitracopoulou & Bruillard (2006), an IA tool can be considered as “awareness tools”, supporting participants on a level of awareness, related to their own actions, or the actions of others within the learning and communication processes. An IA tool can also be an “assessment tool” that offers necessary elements to the participants to assess their individual or collaborative activities.

In order to better understand the type of assistance of data indicators, the next discussion focuses on the nature of “interaction analysis indicators” and its potential involvement in online teaching and learning activities.

2.2.3 Interaction analysis indicators

The type of assistance an indicator has to offer to AI-tool users relies upon its nature and can be characterized by different attributes as illustrated in figure 2.6. The study we present below places an emphasis on the indicators for the computer-mediated and user interaction analysis. It is a synthetic study of the research efforts of

- Dimitracopoulou (2004) on ICALTS (Interaction and Collaboration Analysis supporting Teachers and Students Self-regulation), a deliverable version D.26.1 of Kaleidoscope Network of Excellence,
- Martinez Mones et al. (2004) on state of the art on Interaction Analysis Indicators, produced by the research members of JEIRP (Jointly Executed Integrated Research Project) of Kaleidoscope Network of Excellence,

The study helps us explain better the interaction analysis indicators along with its principal attributes as follows:
Figure 2.6 Interaction analysis indicators’ attributes (Dimitracopoulou 2005)

(A) Indicator concept
Each interaction analysis indicator is characterized by its main concept. Thus, the indicator concept is referred to different aspects of users’ interactions that a data indicator represents (e.g. participant personal progress, the collaboration between the participants, etc.).
(B) **Indicator purpose**
The general purpose of the indicator could be described as being:
(i) **cognitive**: the cognitive operations of the participants on the process and production on an interaction
(ii) **social**: the communication or cooperation of the participants
(iii) **affective**: emotional dimension of the participants

The indicator purpose is directly related to the indicator concept. As yet, it has to be further determined whether an indicator can contribute to promoting awareness, assessment or evaluation. In practice, the possible exploitation of data indicators may be varied to different conditions according to the indicator concept and user intention. For example, a teacher could exploit a social data indicator on awareness of actions within a group for inferences on collaborative aspects of the group activities. Meanwhile the same indicators can also be exploited for interpreting the managerial aspects of the participants. This is due to the information that indicates a change of group members during the collaborative activity or a new participant joining the group, etc.

(C) **Indicator values**
Data indicators take values and the presentation of the values usually takes a proper visual form, from textual to graphical one, and is directly accessible by the IA-tool users via a specific interface. The form of the value is a significant attribute and it often concerns (i) the variation of the values of the indicator in relation to an independent variable (e.g. time), or (ii) the values of another indicator. As for the status of the value, it refers to whether the interaction analysis output gives only a value, a calibrated value or an interpreted value.

(D) **Validity field**
The validity field of each indicator is defined by different factors including the type of learning environment, the content of the activity, the profiles of the participants and many more. It is recommended that the validity field as well as the range of this validity should be thoroughly explored and defined. In terms of technical aspects, an IA tool can have a more or less restricted validity field according to the learning environment or specific domain of activity (cf. Dimitracopoulou (2005)). For instance, an IA tool can be learning environment dependent in the case where it is directly integrated in the learning environment – e.g. an existing component or a built-in piece of software of the learning environment.

(E) **Participants of a technology-based learning environment**
An indicator refers to the participants of a technology-based learning environment (i.e. learning platforms, CMC tools, etc.). There are a variety of participants in the learning process that could be identified by their roles, their activities and the community of which they are part. The participants could be a teacher, an administrator, a student, a group of students, or a wider virtual community.
(F) **Interaction Analysis Indicator (IAI) intended users**

It should be reminded that even if the indicator concept could be the same, the value form or status may be different depending on the intended user. The IAI are designed for IA-tool users with different profiles. Those profiles are:

(i) **participants of the learning activity**: individual students, a group of students, a whole community of students,

(ii) **observers of the activity**: teacher, administrator, researcher.

It is important to clarify that teachers are also considered as participants of the learning activity from the fact that they are sometimes involved in students’ activities. A typical example is when, in order to supervise a synchronous collaboration of a group of students, the teachers have to participate in the students’ communication activities. In general, the indicators generated by an IA tool are intentionally dedicated to each one of the users’ profiles. However, the same indicators could be re-used by both of the two profiles mentioned above. For instance, an indicator that is initially addressed to students can also be used by teachers despite some information missing, or every indicator addressed to teachers can be reused by researchers, even if the latter would need supplementary information in order to make sense of the indicator.

(G) **Time of use of IA indicator**

The use of IA indicators can be either on the fly or post-hoc. The first case can also be called as “online use of IA indicator” where the participants can observe their activities, and eventually exploit on the fly the information provided by the indicator values. For example, the online IA indicators for “workspace awareness” allow users to be aware of their own and other users’ interactions who share the same workspace in a social environment. The second case of IA indicator utilization is post-hoc, which means that the IA-tool users will only access the output of the indicators at the end of an interaction session. It is usually in favor of the assessment and/or evaluation of the interaction product. In addition, the post-hoc use often signifies that the data indicators can not be calculated during the interactions, or the IA tool itself has limitations in data processing and is unable to display the information of the ongoing interactions. Such limitation can be explained by the fact that computing and generating data indicators during a session of synchronous interaction are a great deal more complex in a real-time mode than in a post-hoc one.

(H) **Variable dependencies**

The variable dependencies in which we are interested are both time dependent and independent indicators.

(i) **Time dependent indicators** are to describe aspects that evolve during the interaction process. In fact, most of the cases in communication activities data indicators are strongly related to the time. As we can note that the indicators such as user participation rates, activity of a user in the
discussions, activity in a discussion thread, etc., can be measured in both smaller and larger time intervals (e.g. minutes, hours, days, weeks, months…). The time dependent indicators are often in graphical representations and are displayed with time variation of their values.

(ii) **Time independent indicators**, on the other hand, are usually computed at the end of the interaction sessions, and are used to describe global aspects of the final product, or of the whole process of the interactions. Such types of indicators are useful for users to assess the quality of the process, the quality of the interaction, or the collaboration product, etc. For that reason, it is not necessity to calculate them in short time slots. Nonetheless, the temporal aspects are not to be overlooked even for the time independent indicators. As pointed out Dimitracopoulou (2005), each interaction indicator must always register information regarding the time period during which it was calculated. This is to allow a better interpretation of user interactions that took place in various time slots.

To conclude, the discussion we made in this section gave an answer to the question of how using tracking system affects the activities of tutors and learners in distance learning. Further, our study on ICALTS helps us demonstrate in an indirect way the positive effects of tracking system and its contributions to online teaching and learning enhancement. The study concentrated on “interaction analysis indicators”, which are reliant on tracking system. In fact, the latter holds a responsibly in producing tracking data that serve as input for IA tools to output “interaction analysis indicators”.

### 2.3 Exploiting learning and CMC traces

We have shown in the previous section the nature of data indicators and the types of assistance it provides to the participants via IA tools. However, the exploitation of data indicators in authentic learning contexts has not yet been discussed. Therefore, this section is specifically dedicated to a synthetic study of tracking data exploitation tools (or IA tools) and their services in supplying data indicators of learning and communication activities. Table 2.1 displays a compilation of traces exploitation tools along with the three main types of data indicators (i.e. awareness, assessment and evaluation) and their target users. For each type of indicator, we will only describe the tools that are particularly devoted to user interaction analysis and visualization, and that are the most relevant to our research.
### Table 2.1 Compilation of tracking data exploitation tools

<table>
<thead>
<tr>
<th>Nature of indicators</th>
<th>Tools/Indicators concepts</th>
<th>Target users</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Awareness</strong></td>
<td>ARGUNAUT</td>
<td>Teacher</td>
<td>De Groot <em>et al.</em> (2007) and Van Diggelen <em>et al.</em> (2008)</td>
</tr>
<tr>
<td></td>
<td>iHelp</td>
<td>Teacher, Student</td>
<td>Brooks <em>et al.</em> (2006)</td>
</tr>
<tr>
<td></td>
<td>Discourse structure analysis</td>
<td>Teacher</td>
<td>Gerosa <em>et al.</em> (2004)</td>
</tr>
<tr>
<td></td>
<td>Mining groups’ activities</td>
<td>Teacher, Student</td>
<td>Reyes &amp; Tchounikine (2005)</td>
</tr>
<tr>
<td></td>
<td>DIAS</td>
<td>Teacher, Student, Researcher</td>
<td>Bratitsis &amp; Dimitracopoulou (2005)</td>
</tr>
<tr>
<td><strong>Assessment</strong></td>
<td>i-Bee</td>
<td>Student</td>
<td>Mochizuki <em>et al.</em> (2005)</td>
</tr>
<tr>
<td></td>
<td>Temporal participation indicators</td>
<td>Teacher</td>
<td>Dringus &amp; Ellis (2005)</td>
</tr>
<tr>
<td></td>
<td>DIAS</td>
<td>Teacher, Student, Researcher</td>
<td>Bratitsis &amp; Dimitracopoulou (2005)</td>
</tr>
<tr>
<td></td>
<td>Automatic Message Assessment</td>
<td>Teacher</td>
<td>Wu &amp; Chen (2006)</td>
</tr>
<tr>
<td></td>
<td>MTRDS</td>
<td>Teacher, Student, Researcher</td>
<td>Gibbs <em>et al.</em> (2006)</td>
</tr>
<tr>
<td></td>
<td>Assessing online discussion</td>
<td>Teacher</td>
<td>Shaul (2007)</td>
</tr>
<tr>
<td></td>
<td>PeopleGarden</td>
<td>Researcher</td>
<td>Donath <em>et al.</em> (1999); Donath (2002)</td>
</tr>
<tr>
<td><strong>Evaluation</strong></td>
<td>CourseVis</td>
<td>Teacher</td>
<td>Mazza &amp; Dimitrova (2004)</td>
</tr>
<tr>
<td></td>
<td>DIAS</td>
<td>Teacher, Student</td>
<td>Bratitsis &amp; Dimitracopoulou (2005)</td>
</tr>
</tbody>
</table>
2.3.1 Awareness data indicators

- **Awareness of argumentative discussion with ARGUNAUT**

ARGUNAUT is An Intelligent Guide to Support Productive Online Dialogue (De Groot et al. 2007; Van Diggelen et al. 2008). It is a computerized system that supports teachers in their endeavor to increase the quality of synchronous discussions in collaborative learning situations. One of the principal functional tools of ARGUNAUT is to allow users to carry out analytical discussions by using graphical discussion tools (cf. figure 2.7).

![Figure 2.7 The ARGUNAUT teacher’s interface (credit: http://www.argunaut.org)](credit: http://www.argunaut.org)
ARGUNAUT was mainly designed to help teachers in discussion administration practices. It shows that teachers can monitor and moderate the discussions without disrupting the flow of the on-going collective arguments. ARGUNAUT currently consists of a shared workspace based on a concept-mapping interface, which enables synchronous, textual talk through mediation of geometrical shapes that represent different dialogical moves (cf. figure 2.7). Its most salient features are:

- awareness tools that provide immediate representations of aspects of online discussions between users (i.e. students and teachers),
- automatic alerts on discussions,
- a remote control intervention panel from which the teacher can send textual comments and imagery to an individual or a group of students, and
- tools for off-line reflection (annotations and keyword searches).

Along with these features, the system provides awareness data indicators to describe the discussion activities, which are among others:

- Student presence: online users, active or inactive users
- Student participation: number of contributions per student
- Responsiveness: social network diagrams, numerical indicators of connectivity on discussion map-level, frequency of responses/questions.

**Collaboration and awareness acquisition in iHelp**

Developed by Brooks *et al.* (2006), iHelp supports the users in making both synchronous and asynchronous discussions in collaborative learning situations. iHelp is a light weight environment that has the capacity to track users communication activities and visualize the collected information to support user collaboration and awareness. Regarding the collaboration aspects in iHelp environment; students can share their artifacts with an instructor, teaching assistant or peer helper. This is due to iHelp’s ability in workspace sharing that enables students to work simultaneously on the same learning content (e.g. document, programming code). In addition, iHelp also displays indicators every time there is a change in the workspace to keep the students informed of other students actions. Those indicators include the participation of new students in the workspace, their actions when editing the learning content, and their annotations on the workspace.

The awareness features of iHelp are more relevant to the communications between the users in a shared environment. Figure 2.8 displays a sociogram of students’ discussions, which is an example of the iHelp awareness indicator. The nodes in the sociogram represent individual learners, and the directed edges between nodes indicate some form of interaction – e.g. viewing or replying to a message in the forum. Dark nodes indicate facilitators (e.g. instructors, teaching assistants), while lighter colored nodes indicate learners.
Figure 2.8 Sociogram of communication activities on a discussion forum
(Brooks et al. 2006)

In this sociogram, there are three different groups of learners:

(i) **Active users**: those individuals who have written messages, either on their own or as replies to other messages. An active user is connected to another user in a directed fashion if the first has replied to the second.

(ii) **Lurkers**: those individuals who have read postings but have not written any. Lurkers have no edges between themselves and other nodes. However, they are situated either closer to the centre of the sociogram if they have read many postings, or closer to the outside edge of the sociogram if they have read few postings.

(iii) **Delinquents**: those individuals who have neither read nor written a message.

Each group of learners was placed into their own sociogram that aligned nodes along the exterior of a circle. The different sociograms were then layered on top of one another, such that the delinquents were farthest from the centre of the screen, the participants were closest to the centre of the screen, and the non active learners were in between (cf. figure 2.8). This corresponds well both with the perceived participation rate of individuals, as well as a group of users.

- **Awareness of discourse structure**

Being aware of the discourse structure is important to the teachers to coordinate the communication process and to supervise the participants. Indeed, discourse structure-like message chaining, message date and categorization are essential to the teachers to moderate educational communication tools, such as discussion forums. Based upon these aspects, Gerosa et al. (2004) proposed a set of awareness indicators on discourse structure with an objective of assisting the teachers in monitoring discussion evolvement and in coordinating the communication activities of the students.
Figure 2.9 indicates the discussion depth, where messages are structured hierarchically in a tree format. Observing the form of this tree allows teachers to interpret and infer the level of interaction among students which are established by message chaining. In fact, the depth level of a discussion tree usually provides views on how a discussion is taking place. Also, by analyzing other attributes of a message (i.e. its categorization and date), it is possible to obtain extra information with respect to the type of message per level, how fast the discussion thread grows, which types of messages are answered more quickly, etc. In addition, message categorization adds meaning to the way messages are connected. It helps teachers identify the accomplishment of tasks and the direction the discussion is taking.

### 2.3.2 Assessment data indicators

- **Basic assessment tools**
  Existing forums possess basic methods for assessing users’ communication activities (Shaul 2007). For instance, by simply counting students postings, the teachers could assess the participation rate of that student. In addition, because most forums automatically record posting history of the participants, and store their log files on internal forum databases, exploring assessment indicators could be quite easy. As shown in figure 2.10, a user control panel on a forum phpBB\(^5\) displays an indicator of the number of messages posted by the user. This type of indicator could help a teacher, for example, determine how often a student interacts with others on a discussion forum.

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\(^5\) http://www.phpbb.com
Figure 2.10 User control panel on a discussion forum
(credit: http://www.phpbb.com)

- **MTRDS to appraise online discussions**

While most discussion forums organize the visualization of messages by thread, topic and/or time and hierarchically, users find it difficult to examine discussions as well as evolving temporal norms, especially when the numbers of messages increase. For that reason, MTRDS (Mapping Temporal Relations of Discussion Software), designed and developed by Gibbs et al. (2006), aims at supporting researchers, instructors and students in managing online discussions. An essential function of MTRDS is to generate visual representation of discussions based on hour and date. It has an objective to help users analyze the temporal and spatial dimensions of online discussions. Users have to compile discussion board messages in a text file and then upload the file to MTRDS by using a Web browser. The indicator created by MTRDS is rendered in a form of discussion activity map (cf. figure 2.11).
The X and Y axes in figure 2.11 denote day/date and time, respectively. Each discussion message is represented by a color-coded circle (message node) and a line (link) that connects a response node to the originating message. An originating message (i.e. the parent), when replied to, will have one or more child messages. A line with a single arrow pointing backward represents the linkage between a response node (child) and its originating message (the parent). Such illustration contains a number of indicators allowing users to observe the pattern of responding, including individuals who contributed consistently over time and those who contributed sporadically. These indicators are also helpful to users for assessing some discussion characteristics such as messages clustering, concentration links, temporal norms, and the degree of participation.

- **Self-assessment with i-Bee**
  Making assessment of communication activities is not explicitly a teacher’s task. Students acquire interest in self-assessment when engaging in collaborative discussion. Mochizuki *et al.* (2005) suggested that messages exchanged during the discussion are substantial to the self-assessment process. In support, Mochizuki *et al.* (2005) proposed i-Bee software (Bulletin board Enrollee Envisioner) with a purpose of helping students visualize assessment indicators of their interactivities and their exchanged messages. i-Bee’s indicators are designed by using a metaphor: *bees* as students and *flowers* as message keywords. Such metaphor is meant to support the content-wise visualization of the communication (cf. figure 2.12). It displays a mapping of co-ordinates that indicate how strongly each student relates to each keyword in his/her messages. Additionally, it also allows students to reflect over their discussion, to understand the condition, and to reorganize their commitment in a discussion.

![Figure 2.12 i-Bee principal interface and communication structure](image)

*(Mochizuki *et al.* 2005)*
Figure 2.12 illustrates participating students (bees) and message keywords (flowers) selected by teachers. Each bee and flower is drawn with its name, which represents what is being described. i-Bee refreshes the indicators, either when the student joins the discussion or when the student accesses every discussion topic. While visualizing the coordinates, i-Bee displays each bee turned toward the flowers as an indication of the number of times a learner uses the corresponding keywords (chosen earlier by teachers). Thus, students could recognize their current status and involvement in the discussion, which instantly allow them to reflect over their attitude (in a discussion) in a content-wise manner and mostly to appraise it.

### 2.3.3 Evaluation indicators

- **Evaluating social aspects of student discussion with CourseVis**

  Mazza & Dimitrova (2003) claimed that evaluation of student discussion is the most important aspect in discovering general tendencies and phenomena about social aspects of students during the course activities. Hence, they proposed CourseVis, a course visualization tool that externalizes student tracking data from Course Management Systems (CMS) and to generate graphical representations of students’ activities. CourseVis is particularly useful to teachers who wish to evaluate social aspects of student discussion and other aspects of course activities. Figure 2.13 shows an example of data indicators of student communication on a forum. Depicted in a 3D scatter plot, the visualization of these indicators can be manipulated by teachers brushing, zooming and rotating the scatter.

![Figure 2.13 Data indicators of student discussion represented in a 3D scatter plot](image)

Data indicators shown in figure 2.13 have three dimensions: time, discussion topic, and student. An additional dimension is the length of the discussions, illustrated in sphere shape. The size of the sphere represents the number of follow-ups in a discussion (i.e. the bigger size the longer discussion thread). The given indicators enable the analysis of the discussion threads opened...
by each student during the course. They also offer information to evaluate certain social characteristic of students. For instance, the active students who dominated in opening discussion threads (e.g. francesco and massimo from figure 2.13) and those that dropped out the discussion (e.g ada from figure 2.13).

- **DIAS to evaluate asynchronous discussions**

Discussion Interaction Analysis System (DIAS) is mainly developed to offer extended interaction analysis support to various participants in the learning process (Bratitsis & Dimitracopoulou 2005). The main concept of DIAS is to exploit the recorded data from discussion forums to produce a wide range of interaction analysis indicators for various users (individual students, groups, teachers or even researchers). DIAS has an interesting dual purpose. It supports not only the teachers in monitoring the students’ activities, but also the students in visualizing their own actions and those of others (Bratitsis & Dimitracopoulou 2006). Regarding the evaluation of communication activities, DIAS provides a number of interaction analysis indicators that include:

- **User classification indicator**
- **Relative activity indicator**
- **Contribution indicator**
- **Activity indicator**

Credit: Bratitsis & Dimitracopoulou (2005)
(i) **User classification indicator** (cf. figure 2.14): the X-axis represents the amount of user contribution and the Y-axis represents the amount of interaction by the users. The X-coordinate is calculated by the number of messages of an individual user as a percentage of the total messages. The Y coordinate is used in calculating as the percentage of the available messages viewed by a user.

(ii) **Relative activity indicator** (cf. figure 2.15) is useful for the students as it provides information concerning their classification within the group activity. Each bar represents the activity of the users for the selected time duration as a percentage of the total activity.

(iii) **Contribution indicator** (cf. figure 2.16): A polar chart contains bullets representing four users. The distance from the circumference of the circle is proportional to the contribution status of the user, subsidizing the initiation of discussions. The size of the bullet corresponds with the number of messages of each user.

(iv) **Activity indicator** (cf. figure 2.17) is shown in a chart with the number of contributions (X-axis) and the number of messages (bullet size). The Y-axis represents the mount of other users’ messages viewed.

The given indicators reflect several dimensions on which the DIAS users can evaluate their interactions and discussions. Three among the five dimensions mentioned by Henri (1991) (via Bratitsis & Dimitracopoulou 2005) that correspond with the DIAS indicators are:

(a) **participative**: the counting of numbers of messages can measure the user participation in the discussion (cf. contribution indicator in figure 2.16),

(b) **social**: the social dimension is important since it reflects the implication of the participants in the discussion community (cf. relative activity indicator in figure 2.15), and

(c) **interactive**: the interactivity between users during the discussion can be described by the exchanged messages. It can be measured by looking at, for example, the responses of a message in a discussion thread (cf. user classification indicator in figure 2.17 and activity indicator in figure 2.14).

**GISMO tool for evaluating participation in discussion forums**

GISMO (cf. figure 2.18) is a Graphical Interactive Student Monitoring tool, designed and developed by Mazza & Botturi (2007). Among the main functions of GISMO is the visualization of behavioral and social data of student’s activities on a discussion forum. Its objective is to help the teachers evaluate the involvement of the students in the communication process during the course activities on a learning platform (e.g. Moodle). Mazza & Botturi (2007) pointed out that the evaluation of discussion participation covers an important position in the instructional process. Nevertheless, without a visual interface for a teacher to monitor and visualize the discussion between the students, evaluating participation requires a huge amount of work, and consumes a great deal of time. GISMO, as commented by the authors, does not provide a complete solution to
that issue, but is an indication of the discussion that allows teachers to evaluate the participation and the quality of contributions.

**Figure 2.18** Indicators of student discussion generated and visualized by GISMO

(Mazza & Botturi 2007)

Figure 2.18 shows a chart where teachers may have an overview of all the discussions in which students participated. For each student, the chart indicates the number of messages posted (represented in a square shape), number of messages viewed (represented in a circle shape), and the number of discussion threads started by the student (presented in a triangle shape). The visualization given by GISMO allows the teacher to identify at once every student who posts and views messages. It allows the teacher to observe the students who posted more often in the forum, and made the most relevant contribution to the discussion, etc. Plus, it also helps the teachers identify different behavioral aspects of the students and evaluate them depending on the evaluation criteria. For example, the teacher could give a good grade to a student who posted and viewed many messages. Also, the teacher could give a better grade to another student who is more reflective and contributes with few postings while regularly reading forums and browsing all available content.

### 2.4 Conclusion

In this chapter, we discussed tracking the computer-mediated communications, and the support it has to offer to the users of CMC tools in distance learning situations. Throughout the discussion, we placed special focus on the aspects that emerged in response to the research questions regarding the importance and the
contribution of tracking solution to online teaching and learning enhancements. First, we pointed out the beneficial outcomes of the tracking process on CMC tools, which are directly related to the acquisition of useful data indicators of communication activities. Later, we demonstrated, with research evidence, how those indicators could support the participants in the learning process in terms of awareness, assessment and evaluation of their activities and productions. Finally, we presented a synthetic study of different tracking data exploitation tools and their use in favor of better analyzing and visualizing user interactions on CMC tools in learning contexts.

To conclude, the study we made in this chapter allows us to gain a broader perspective on three important aspects in relation to:

1. Tracking CMC activities to obtain interaction analysis indicators
   As briefly mentioned in section 2.2.2, obtaining data indicators of CMC activities involves a complex procedure that starts with a tracking approach. Indeed, tracking approach is crucial to the whole data gathering process and always has an impact either directly or indirectly on the production of data indicators. It determines:
   (i) the tracking mechanism to observe both the users and the CMC tools, and
   (ii) the data collection method that participates in the formation of a great quality data indicators (e.g. substantial and useful for various users).

   However, most research efforts seem to overlook these two elements, despite their strong correlation to the indicator generation process. As we have noted from the relevant study presented in this chapter, some research works focused only on the existing data, captured by a built-in tracking system of CMC tools (e.g. user’s browsing or posting history on a discussion forum). Some other research works preferred extracting raw data from e-learning platforms (e.g. Moodle) to seek for available interaction indicators. Consequently, in both cases, the obtained indicators usually lack the semantic aspects that cover, for instance, the context, modality, condition, or even behavior of user activities on CMC tools. This subsequently appears to be one of the main difficulties for a user to give more sense to the information that each indicator features when it comes to the analysis process. Having encountered these issues, there is a need to focus our attention on the tracking approach and the related issues (e.g. data collection, storage, exploitation, etc.). The discussion in chapter 3 will pinpoint the main issues regarding CMC tracking by referring to the research statements already addressed in the previous study (cf. section 1.4.2 of chapter 1). It will be followed by a proposition of a tracking approach along with the answers to the studied problems.

2. Tracking data exploitation tools
   Our observations regarding the current tracking data exploitation tools, are that most of them are exclusively dedicated to the teachers. As revealed in our
synthetic study (cf. table 2.1), while some tools are also accessible by the researchers, only a few are accessible by the students. Moreover, students are usually allowed minimal access to the tool functionality due to their restricted user rights, as well as their roles in the learning process. As a result, students always receive less support in visualizing and analyzing their traces during their learning and communication activities. For that reason, we propose a tool, named TrAVis (Tracking Data Analysis and Visualization) that is objectively designed and built not only for the teachers but also for the students. TrAVis will be discussed in detail in chapter 4.

3. **Proposed data indicators**

Our major observation is on the characteristics and the assistance of the proposed data indicators. In fact, a communication activity consists of a variety of user interactions and contents exchanged over a CMC tool. Therefore, it needs to be described with adequate and pertinent information to help users define, for instance, the behavioral aspect of the activity and the context in which it took place. However, most indicators we presented in section 2.3 focused more on what resulted from an activity (i.e. final product) but less on the actions taken to produce the result (i.e. process). Considering an example of an indicator that displays the participation rate of a student in a discussion forum. As we have seen in iHelp, DIAS, CourseVis, GISMO, etc., it has always been calculated by counting the number of student postings. Yet, such indicators do not contain the information on how each posting was made or what was its content. Thus, it would make less sense for a teacher to assess or evaluate the participation level of a student by only making reference to the number of postings. Due to this fact, we suggest that a tracking system should observe the **process** of the posting (e.g. user actions taken to write a message, duration of a message composing, etc.) as well as the **product** of the posting (e.g. message content, attachment files, etc.). Thus far, tracking solution proves itself once again superior to the production of significant indicators of user communication activities on CMC tools. This finally emphasizes the first conclusion we made earlier regarding **tracking CMC activities to obtain more substantial and useful interaction analysis indicators.**
Chapter 3

Proposing an explicit tracking approach for CMC tools and a generic model of CMC traces
Chapter 3: Proposing an explicit tracking approach for CMC tools and a generic model of CMC traces
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Chapter 3: Proposing an explicit tracking approach for CMC tools and a generic model of CMC traces
Chapter 3 at first glance

The study we made in this chapter can be overviewed via figure 3.1.

The study concentrates on the research questions of tracking CMC in distance learning situation, already posed in chapter 1 (see section 1.2.3 of chapter 1).

- What are the characteristics of the existing approaches for tracking and exploiting CMC tracking data?
- What is lacking in the existing tracking systems? What are our propositions to improve upon their deficiency?

Since these two research questions are strongly correlated, they will be studied together in section 3.1. Throughout the study, we focus on the fundamental characteristics of the existing approach for tracking CMC and their deficiencies that, from our standpoint, limits using them in our research. More precisely, we pinpoint the lack of existing tracking systems and the main issues in exploiting CMC tracking data, including (i) data collection, (ii) data structuring and storage, and (iii) data analysis and visualization. The study in section 3.1 also covers our presentation of an improved technological solution to overcome the encountered issues.
• **What kind of tracking approach is for the CMC tools?** How to make it explicit so that it can be applied to various types of CMC tools, both synchronous and asynchronous?

• **How could tracking data being gathered in the learning process contain semantic or learning aspects and not just information on computer-mediated user actions?**

These two research questions will be studied together and presented in section 3.2 of this chapter. We present our research methodology and explain the two different steps to build our tracking approach: (i) studying the CMC activity in an authentic learning situation and (ii) applying the Human-Computer Interaction approach in the design of a tracking system for CMC tools. Our main objectives are:

(a) to identify a set of parameters that describes a CMC activity in a learning context (e.g. objective, context, and product of the activity, etc.), and

(b) to use the identified parameters in building the tracking mechanism, allowing its application in a diversity of CMC tools, both synchronous and asynchronous. Moreover, each parameter is a contributing factor to the production of the tracking data that reflects the semantic aspects of both the communication and learning activities (i.e. communication-oriented learning activity), and not just simply computer-generated user actions.

• **How to design and develop the tracking approach with the purpose of continually improving it for further usages?**

The answer to this research question is heavily reliant upon the development technologies adopted by the researchers/developers in their individual practices. Consequently, we choose a discussion forum as a reference CMC tool and we focus on the development of a tracking system with a purpose of using it in a variety of discussion forums. We present in section 3.3, the tracking system architecture and our research effort in the development of its different components.

In the conclusion of this chapter, we summarize (i) the important aspects of our proposition to improve upon the deficiency of the existing tracking approaches in terms of tracking data collection and (ii) the technological solutions to overcome the issues regarding tracking data structuring.
Chapter 3: Proposing an explicit tracking approach for CMC tools and a generic model of CMC traces

3.1 Proposition of a solution for tracking CMC and exploiting traces

We address in this section three main key issues related to tracking learner’s communication activities on CMC tools and to the use of CMC traces in learning environments. Our objective is twofold:

(i) pinpoint what is lacking in the existing approaches, and
(ii) subsequently take into account the studied issues and propose an explicit approach for tracking CMC together with the solution to the problems relating to CMC traces, from the production to the visualization of the traces.

3.1.1 Observing learner’s communication activities

In order to efficiently track learners’ communication activities on CMC tools, the tracking system must closely follow the activities taking place. However, in the existing tracking methods, most systems were designed to observe the users activity only on the server side (e.g. where the communication platform is hosted). The user interaction on the client side (e.g. user web browser) is often ignored. In this method, the granularity of the traces should be rather large, as the information from the trace analysis may not be accurate enough to reflect the complete activities of users during their communications. It is known that information gained from the client side is often incomplete. This can determine the behavioral aspect and/or the process of user interaction during an activity. It is worth mentioning again that the collected traces are essential elements to the production of good quality data indicators of CMC activities. They should contain significant information that describes both the process and the product of the activity, enabling users to acquire a pertinent analysis and visualization of the activity-related information.

An attempt has been made to investigate the problem, “how to make tracking systems capable of producing traces that are not just a simple history of users activities, but containing substantive information that can be useful to various users?” Also “while using the tracking system, how to produce traces with semantic or learning aspects of the users activities?”. The proposed tracking approach (described later in section 3.2) focuses on the observation of users activities on both client and server sides, thus keeping track of (i) Human–Computer Interaction, (ii) Human–Human Interactions Mediated by Computer, (iii) Computer-Computer Interactions, (iv) Non-Computer Mediated User action, and (v) Computer action without user action. This allows us to have various compositions of traces with finer granularity in which user interactions and semantic aspects of the communications can both be found.

Another important observation we made about the existing tracking systems; is that the activities of “lurkers” on CMC tools have rarely been tracked down. If we consider an example of a discussion forum, a lurker is a type of user
who is inactive with respect to their communications with other users and who is not “visible” to other users when online. Lurkers might log on to the forum to view other users’ discussions, but have no intention of exchanging any messages with the discussion groups. However, lurkers are recognized as an important part of discussion community, as mentioned by Smith (1999). Hence, tracking lurkers’ activities, and analyzing their traces provide a better understanding of lurkers’ behavior and their influences in distance learning environments (Takahashi et al. 2003). In the context of our research, lurkers appear to be as important as other active users. From a personal standpoint, lurkers are no different from other active user in terms of making discussion on a forum, except for the fact they observe the discussion but do not contribute to it. For that reason, aside from the idea of tracking communication activities on both client and server sides, we are also interested in tracking lurkers with an objective to increase user awareness of other users activities, including lurkers.

3.1.2 Structuring tracking data

Since each choice of collecting and structuring traces was made to match each individual need, traces of users activities stored on existing CMC tools are often carried out in an ad-hoc manner, which either limits the reusability of data in different purposes or makes data exploitation difficult (i.e. traces can show varying by different tools). We also noted from our general findings that most tracking systems still used text log files to keep track of users’ communications on CMC tools. Consequently, the traces stored in log files have rarely been exploited by the users (tutors and learners) either because of the ignorance of their existence, or because the traces do not match the demands of the users. The first case can be found in most of distance learning environments where users are neither informed about the tracking process nor given access to their traces. On the other hand, the second case is more connected to the actual need of users in terms of traces exploration. For example, a learning platform like Moodle enables access to the tutors to view the history log file of learners’ actions on a forum, but the tutors might leave the log file unexplored because they find the latter less important to their tutoring activities.

The problems of data structuring also cause other technical constraints in exploiting the data. If we look at the structure of traces in a log file, it usually varies from one CMC tool to another, due to differences in how it was generated. Yet, there is eventually a lack of semantic aspects for traces stored in some types of log files. For instance, a pure text log file (i.e. TXT extension) does not store data with their types and semantic relations. In addition, data are often formalized in different models, represented in different computerized formats, and stored on different physical media, etc. These constraints do not favor the reuse of existing traces, particularly by users who have limited technical skills (e.g. non computer specialist).
To avoid situations of this kind, two crucial points must be taken into consideration in the phase of structuring CMC traces. In the first case, the repository type that stores the traces should be independent of the platforms that access it. In the second case, the representation of CMC traces should be in a generic model from which standard or specific models can be created; and used for various communication tools. The main advantage of formalizing a generic model is to allow users to represent the identical traces in different computerized formats that remain consistent to a unique model. In addition, we need to consider the possibilities of enriching the recorded traces; which can be modified by adding more substantial information to the original representation and restructuring it. Examples include adding new fields to describe the relationship of different items in the traces or transforming the existing traces into another format that can be reused in other types of CMC trace exploitation tool. The proposed model of CMC traces is presented in section 3.4.

3.1.3 Analyzing and visualizing tracking data

CMC traces are generated from specific information which can only be interpreted by the CMC-tool users, with the assistance of the specific tools. Interpreting traces is a complex process that involves other processes, such as traces analysis. This can be done with quantitative or qualitative analysis methods, depending on user intention. Nevertheless, the major problems that are usually encountered stem from the effectiveness of the method used and the quality of the results returned from the traces analysis. In fact, the analysis cannot be done efficiently if the recorded traces are not descriptive enough, or when there is a lack of information that is necessary for the analysis. Despite the support of a specific tool, the collected traces are still the core items of the analysis process, as they are important to the quality of the results (e.g. indicators calculated, synthetic information extracted, etc.). Thus, the root of the problem seems to have a higher degree of correlation to the collection of CMC traces that we studied earlier in section 3.1.1.

With regard to the traces visualization, various visual forms of traces are considered: Textual, histogram or graph with multi-dimension. In order to help users in visualizing traces, the visualization tools must be equipped with a friendly graphic user interface (GUI) components, by which users could easily interrogate the trace repository by simple formal query and transform traces, into data indicators, represented in graphical representations. However, some visualization tools provide only the overview of users’ activities, often in a unique form. To improve upon the deficiency of such tools, we put our research effort into designing TrAVis, a Tracking Analysis and Visualization tool in order to assist users in analyzing and visualizing the traces of users’ activities on CMC tools. Presented in chapter 4, TrAVis also enables users to visualize the same traces in different visual representations as well as in different scales.
3.2 Proposing a tracking approach for CMC

3.2.1 Research methodology

We built our approach with the participation of researchers and specialists from different disciplines including Information Technology, Sciences of Education, Human Computer Interaction (HCI), and E-learning. The adopted research methodology can be explained in two different steps: (i) studying the CMC activity in an authentic learning situation and (ii) applying the Human-Computer Interaction approach in the design of a tracking system for CMC tools.

Our first studies were based on both synchronous and asynchronous CMC tools and their uses in an authentic learning situation context, to which our research is attached (cf. already presented in section 2.1.2 of chapter 2). Later, we identified different parameters, as well as their connections that characterize the communication-oriented learning activities. Table 3.1 presents the parameters and their descriptions.

Table 3.1 Parameters of learning and communication activities to be taken into account in the formalization of the tracking mechanism

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>User</td>
<td>Users can be identified by their profiles or roles (tutors or learners) and by their activities during the communication process. It should be noted the tracking process can be carried out in different manners according to user profiles so that the collected traces can be as representative as possible of users’ activities.</td>
</tr>
<tr>
<td>Objective</td>
<td>Depending on the context of a communication activity, the objective can be either predefined or emerging. A predefined objective refers to the main objective of an activity, usually fixed by the tutors or learners before commencing the activity. An emerging objective, on the other hand, is determined during the activity and can be altered alongside the progress of the activity. An objective that emerges over time can eventually affect both the activity that has already been realized and any further activity. Therefore, the tracking process should be able to produce the traces of an activity that includes temporal aspects as well as other variables that link the past and the upcoming activity together.</td>
</tr>
<tr>
<td>Context</td>
<td>Context is extremely important to the tracking process as it clarifies the activity (i.e. adding more sense to it). Even though</td>
</tr>
</tbody>
</table>
the context of an activity can not be easily described by the traces, the tracking process should capture as much as possible, the most intuitive information related to the activity, to enable users to identify the context in which it is undertaken. For example, when a user posts a message in a forum, the information that enables the user to recall the context of his/her activity could be:

(i) in which forum the message is posted and whether the forum is dedicated to the learning activity, or to some other casual discussions

(ii) the objective of the message and whether or not the message is learning-related.

### Process

The process of an activity is fundamental as it covers various aspects of the activity that describe, for instance, the actions taken by a user, interactions between a user and a CMC tool, or even interactions between two users. For that reason, tracking the process of an activity adds more semantic aspects to how an activity is carried out.

### Product

The product of an activity refers to what resulted from an activity realization. For example, a message posted by a user in a forum is a product of his/her activity.

The benefit of studying these parameters is two-fold:

(a) these parameters are essential to the contextualization of the tracking process. In other words, each parameter represents a characteristic of communication-oriented learning activity; and according to which a tracking system must adapt in the observation and data generation processes,

(b) these parameters are contributing factors to the production of tracking data, as their combination represents not only the whole communication activity, but also its semantic aspects (e.g. objective, context, and product of the activity).

The next step of our research methodology is the choice of applying Human-Computer Interaction (HCI) approaches in the tracking system design and development. Such choice is due to the fact that a communication activity on a CMC tool consists of a large part of both Human and Computer Interactions, which are technically the “observable objects” traceable by the tracking system. Therefore, we studied the Human and Computer Interactions of a CMC activity and gathered them into two types of actions and three types of interactions, as shown figure 3.2.
Figure 3.2 Different types of actions and interactions of a CMC activity

We give below the explanation of the tracking approach in a general context. We focus on what, where, when, and how to track a user communication activity on CMC tools. Discussion forum is once again used as example of CMC tools to which we refer.

3.2.2 What and where to track?

As illustrated in figure 3.2, during a CMC activity, two types of actions and three types of interactions could be observed during a communication activity:

1. **The Human–Computer Interactions (HCI)** refer to the user’s actions while using the GUI (Graphic User Interface) of CMC tools to communicate with other users. If we look at an example of an activity “writing a new message”, the interactions between a user and a CMC-tool interface can be: “edit” message title or message content, “move” vertical scrollbars upward or downward, “drag and drop” smileys into the message, etc. All of these interactions occurred only in the user interface. Considering a Web-based application such as a discussion forum, these interactions occur on the user Web browser, without sending any request query to the server where the discussion forum is hosted. Indeed, tracking HCI on the client side, means to follow very closely user's actions that occurred during a CMC activity. The main reason of doing so is that HCI on the client side represent a big part of the whole CMC activity and the HCI tracking data are compulsory for the process of rebuilding successive user’s actions and events of the past activity (e.g. what did a user do to write a new message). Furthermore, HCI tracking data are also beneficial in identification of user’s behavior while using a discussion forum to perform a communication activity.
(2) **The Human–Human Interactions Mediated by Computer (HHIMC)** refer to the content of the exchanges between users. With the same example of “writing a new message” on a discussion forum; all the written text as well as the attachments will be submitted to the server so that the message can be read by other users. To do so, the user has to click on “send” or “submit” button on the forum interface. The message is being sent via a request query to the server where the message must be stored. The collected tracking data of HHIMC will be exploited along with those of HCI to make the data more descriptive and to enable an awareness of both the process of an interaction (e.g. how a user writes a new message) and its product (e.g. what the message is about). The fusion of HHIMC and HCI tracking data leads to an identification of a general context of the communication activity, describing the successive sequence of user’s interactions (i.e. actions in message writing), but also the content of the interactions (i.e. written message), which both represent the semantic aspect of the activity.

(3) **The Computer–Computer Interactions (CCI)**: keeping track of meaningful events means to track also the computer input and output processes while a communication takes place. The tracking data of Computer–Computer Interactions serve two main purposes: (i) evaluation of the quality of the computer processes in exchanging the communication data and (ii) monitoring the CMC-tool performance. Most of the time, the results are very useful for the designers and developers who seek to improve the CMC tools; and for the researchers who are involved in development experiences. For example, developers commonly use the CCI tracking data to debug problems related CMC tools and to strengthen the security of the communication, etc.

(4) **The Non–Computer Mediated Human Action (HA)**: this covers all user’s other actions outside the computer environment (e.g. a user makes a phone call during the learning session). In some circumstances, particularly in remote situations, it is not sufficient to track only the computer-mediated activities of the users. Hence, video and audio recorders are more practical in observing what cannot be observed by the computer-mediated tracking system. It is important to mention here that despite the fact we do not particularly focus on the audio-visual data in the development phase of our tracking approach, we acknowledge their multipurpose usage, among which is the analysis of user behavior while working individually or collaboratively.

(5) **The Computer Action without Human Action (CA)**: there are many computer actions that occur automatically without the action of the user. Examples include a popup message indicating to the user that his/her session in the chat room will expire in 5 min, or a jingle to alert that a new member has logged in to the forum. Tracking such computer actions can be done on both the client and server sides. On the client side, we can capture most of events that occurred and showed up on
the user interface. On the server side, the events will be captured once the request query has been launched and executed. The tracking data of computer action usually detect what else happens besides the HCI. That is why such data is often used as supplementary information to complete the tracking data of actions and interactions presented earlier.

### 3.2.3 When and how to track?

Since there are a great variety of CMC tools in web-based learning environments, the wisest solution is not to build a tracking system for each single tool. The most appropriate solution is to study the common points and the peculiarities of each tool, and to propose tracking system architecture, which is applicable to a variety of CMC tools. For example, it is recognized that every CMC tool provides a functional tool for “writing a message”; that is the common point. The dissimilarity is the possible ways a user can employ it to write a message. The particularities of CMC tools are mainly about the user interfaces and the types of HCI available in each tool – when a user writes a message in *forum 1*, placing the written message into a thread category which is feasible through a multi-selected drop list. The user would do that otherwise in *forum 2*, because instead of multi-selected drop list, *forum 2* proposes a set of checkboxes for the thread categories. The final results of that activity are the same in terms of message posting; however, the way the user interacts with the two forums is different. Therefore, we started to formalize the use models to describe the way users employ each functional tool to perform their communication activities. A use model is formalized to (i) define the context of a user’s activities and (ii) identify every user action on the interaction objects and its associated events. As shown in figure 3.3, the identification of:
(a) the different user actions,
(b) the interaction objects, and
(c) the associated events of the activity “write a message”.

Formalizing a use model starts with the separation of the Human-Computer Interactions (HCI) from the whole activity to obtain a clearer view of:
(i) what action a user can perform on a CMC-tool interface,
(ii) what kind of action/interaction it is, and
(iii) what happens when there is an action/interaction.

The main advantage of doing so, is to make the tracking system able to observe every HCI (e.g. a user clicks on a button) and the associated event (e.g. what happens when a user clicks on a button), and to finally generate tracking data with pertinent information related to every action and interaction which occurred during an activity.
Chapter 3: Proposing an explicit tracking approach for CMC tools and a generic model of CMC traces

**Figure 3.3** An example of the identification of users actions, interaction objects, and the associated event of an activity “write a message”

**Figure 3.4** An example of a Use Model for an activity “post a new message” in a discussion forum
To better understand *when* and *how* to track a CMC activity, an example of a use model for the activity “post a new message” in a discussion forum is given below (cf. figure 3.4). On figure 3.4, the interaction objects in the context of this activity could be a “post new” button, a “form for a new message”, and a “submit” button, which users employ to post a new message. The arrow (1) represents a sequence of events that happens when the user clicks on the “post new” button to open the “form for a new message” in order to write a new message. This form includes several other interaction objects, in this example, a “submit” button. When the user clicks on the “submit” button (arrow 2), there is another event called “send message”, representing the action that the user’s message is being submitted to the server.

To sum up, the identification of the interaction objects, and the successive events to be observed, allows the tracking system to take into account every user’s action, and to simultaneously produce the tracking data in accordance with its defined use model. In this way, each use model indicates how to observe, when to capture the user’s actions and/or interactions, and what to generate as tracking data.

### 3.3 Design and development of tracking system

#### 3.3.1 Overview of tracking system for Web-based CMC tools

In the previous section, we presented a tracking approach that features explicit characteristics of tracking mechanism for user’s communication activities. Meanwhile, the presentation of the approach that focused on “*what*, *where*, *when* and *how* to track”, demonstrates it being explicit in terms of approach implementation regardless of the modeling and development languages. In this section, we present a case study where the proposed approach is applied in the development of a tracking system for discussion forums. The tracking system will be later used in a particular discussion forum Confor, which has been used in an authentic learning context, to which our research work is attached. (cf. sections 2.1.2 and 2.13 of chapter 2).

We implement a tracking system with the purpose of continually improving it for further usage in a variety of discussion forums, which are the most used Web-based CMC tools in distance learning environments. To do so, we first studied the development technologies that are largely used by the developers of both learning platforms and discussion forums. Technically, we chose the programming languages that are compatible to the existing platforms to which we would like to integrate our tracking system (e.g. PHP for most CMS and forums). Subsequently, we developed different components of the tracking system in a way that they can be independent of the platform in which they are integrated.
Figure 3.5 presents our tracking system architecture. In the following sections, we describe the two principal components of the system which are:

(a) the **observation component**, composed of different “traces collectors” on both client and server side,

(b) the **trace repository** that structures and stores the traces generated by the observation component.

![Diagram of tracking system architecture for Web-based CMC tools](image-url)

**Figure 3.5** Tracking system architecture for Web-based CMC tools
3.3.2 Observation component

The observation component was specifically designed with a number of “traces collectors”, which ensure the observation of different Human and Computer Interactions on both client and server side. The observation component is attached with a number of use models (cf. section 3.2.3) which describe how each communication activity on the CMC tool can be performed by a user, and how the trace collector generates instantaneously the tracking data representing the actions/interaction of users and the associated communication content.

Via figure 3.5, we look at an example of a tracking process, showing how an activity “post a new message in a discussion forum” is being tracked and how the tracking data are being generated and stored. In order to easily understand the given example, we only focus on tracking Human–Computer Interactions and Human–Human Interactions Mediated by Computer. Similarly, the tracking process of other types of actions/interactions is based on the same concept.

The user’s interactions on the forum interface (i.e. HCI), such as “typing a message”, “drag and drop smilies into the message”, “moving the scrollbar up or down” will be captured by traces collectors on client side. The tracking data will be generated and temporarily stored on the user machine (i.e. via user Web browser). When the user clicks on the “submit” button, there is a HTTP server request query to submit the message content to the server. The trace collector on the server side captures that request query, and generates simultaneously the tracking data to represent the communication activity, (i.e. user posted a new message) as well as the content of the activity (i.e. written message and other message attachments if there are any). At each HTTP request, the temporary tracking data, previously stored on user machine, will be submitted to the server. The submitted data from client side will then synchronized with those on the server, structured, and stored in the trace repository.

We had developed the trace collector on the client side by using JavaScript and AJAX (Asynchronous JavaScript and XML). The choice of development technologies was largely based on the technical capacities of the technologies, and their application possibilities in a diversity of Web-based CMC tools. Indeed, JavaScript is a lightweight scripting language which is executed on user’s Web browser (client side) and supported by any type of Web browser. AJAX, it is a cross-platform technique usable on many different operating systems and Web browsers as it is based on open standards such as JavaScript and XML. These technical capabilities make the two chosen technologies the most appropriate for the development of the trace collector on the client side for the discussion forums. One the other hand, the trace collector on the server side was developed with PHP, the server scripting language that is largely used to implement Web-based communication tools, including the discussion forum.
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Confor. The code sample of trace collector on both client and server side can be found in annex A.

Thus far, it is important to clarify that we are not developing any spyware-type application and we do not need to install any tracking application on the user machine. By simply using AJAX technologies, we are able to make our Web-based tracking system more flexible in terms of manipulating the tracking data directly at the client side. More precisely, the generation and submission of the tracking data to the server are executed in the background and without interrupting the user’s navigation. In addition, the predefined use model of each communication activity allows the traces collectors on both client and server sides to exchange the information and to make the information coherent. In this way, the trace collector on the server side is capable of synchronizing the tracking data that is being submitted from clients, with those on the server.

### 3.3.3 Trace repository

Figure 3.6 illustrates the entity-association schema of the trace repository and table 3.2 presents the data dictionary of the trace repository.

![Figure 3.6 Entity-association schema of the trace repository](image-url)
### Table 3.2 Data dictionary of trace repository

#### User
This table contains user information and user tracking option

<table>
<thead>
<tr>
<th>IDU</th>
<th>Int</th>
<th>User identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>User</td>
<td>String</td>
<td>User name (login)</td>
</tr>
<tr>
<td>Trace</td>
<td>Byte</td>
<td>User has the right to enable or disable the tracking system.</td>
</tr>
<tr>
<td>0: tracking system enabled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1: tracking system disabled</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| IDTypeU | Int | Reference identifier that links tables User and Typeu |

#### Typeu
This table stores information of user profile

| IDTypeU | Int | User type identifier |
| Title | String | Label of user profile. For example: |
| 1: registered member |
| 2: guess without password |
| 3: guess with password |
| 4: anonymous/lurker |

#### Activity
This table contains information of user actions and interactions on the CMC tool during a communication activity

| IDAct | Int | Activity identifier |
| Title | String | Label of an activity |
| TypeAct | byte | Type of action/interaction that occurs during an activity. For example: |
| 0: Human-Interaction |
| 1: Human-Human Interaction Mediated by Computer |

| IDCat | Int | Reference identifier that links tables Activity and Category |

#### Category
This table stores different categories of communication activities

| IDCat | Int | Category identifier |
| Title | String | Label of the category |

#### Transition
This table records traces of user actions and interactions within a communication activity
Chapter 3: Proposing an explicit tracking approach for CMC tools and a generic model of CMC traces

<table>
<thead>
<tr>
<th>IDTran</th>
<th>Int</th>
<th>Transition identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Note: a transition refers to a record that is stored in the trace repository and a combination of different transitions represent a complete activity</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>User</th>
<th>String</th>
<th>User name (login)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Title</th>
<th>String</th>
<th>Label of an action/interaction</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Attribute</th>
<th>String</th>
<th>Attribute of an action/interaction. This field stores additional information of an action/interaction. For example, if a user posted a message a forum, the additional information to be stored is the identifier of the posted message and the identifier of the forum in which the message is posted</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Date</th>
<th>Date of an action/interaction</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>Time</th>
<th>Time of an action/interaction</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Duration</th>
<th>Time</th>
<th>Time span between two actions/interactions</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>RefTran</th>
<th>Int</th>
<th>Reference identifier that links one recorded transition to another</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Comment</th>
<th>String</th>
<th>Comment of an action/interaction</th>
</tr>
</thead>
</table>

**Userfiles**

This table contains information regarding user files and other types of multimedia that users share during a communication activity

<table>
<thead>
<tr>
<th>ID</th>
<th>Int</th>
<th>File identifier</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>User</th>
<th>String</th>
<th>User name (login)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>IDForum</th>
<th>Int</th>
<th>Forum identifier (i.e. in which forum the file is posted)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>IDMsg</th>
<th>Int</th>
<th>Message identifier (i.e. the message that the file is attached to)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Filenameo</th>
<th>String</th>
<th>Original file</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Filenamer</th>
<th>String</th>
<th>Renamed file</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Filetype</th>
<th>String</th>
<th>File type</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Filesize</th>
<th>Float</th>
<th>File size</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Dateupload</th>
<th>Date</th>
<th>Date of uploaded file</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Timeupload</th>
<th>Time</th>
<th>Time of uploaded file</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Date_la</th>
<th>Date</th>
<th>Last date access of uploaded file</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Time_la</th>
<th>Time</th>
<th>Last time access of uploaded file</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Nbdownload</th>
<th>Int</th>
<th>Number of downloads</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Filestatus</th>
<th>Byte</th>
<th>File status</th>
</tr>
</thead>
<tbody>
<tr>
<td>0: approved by the administrator</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1: not yet approved by the administrator</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The trace repository was implemented as a centralized database server with MySQL. The SQL script for creating trace repository can be found in annex B. The trace repository, as shown in figure 3.6, contains the meta-data that are used to structure the tracking data from the traces collectors of both client and server sides. We made a choice of using a relational database such as MySQL for storing CMC tracking data for the following reasons:

(i) traces are structured in a rich format as the relationships between tables as data in each table, can be easily defined,

(ii) traces can be easily restructured and transformed into another computerized format such as XML, RDF or TXT, and

(iii) the operations for traces manipulation, such as insertion of multiple records or data modification in the synchronization processes, etc., can be easily performed with simple SQL queries.

### 3.4 Proposing models of traces for CMC tools

#### 3.4.1 Overview of model of traces

We have pointed out in section 3.1.2 the main issues regarding the individual representations of the CMC traces and the difficulties in their exploitations. We also advanced the idea of using a generic model for CMC traces in order to:

(i) enable a common representation of CMC traces,

(ii) transform the existing CMC traces into different representations that remain faithful to the same model of traces, and

(iii) enrich the existing CMC traces by adding supplementary information to the original representation, with a purpose of increasing the reusability of the traces in various CMC tools (e.g. in both standard discussion forums and specific contextual forum like Confor).

Therefore, we are proposing a generic model for CMC traces with an objective to make it a contributing factor in the CMC traces exploitation, **both conceptually and practically**. The proposed model is implemented to describe the **structure** of CMC traces, their **types** and **relations** in a high level of abstraction.

The significant benefits of a generic model can be summarized as follows:

- **Data structuring:**

  Identical CMC traces can be represented in a diversity of computerized formats that are still consistent with one single model. In other words, data can be easily transformed from one representation to another without having to redefine the data model (i.e. data fieldnames, types, relations, etc.). For example, we can export data from a MySQL relational database into an XML file by keeping the same data model and values, although their representations will be changed from MySQL tables and columns into XML elements and attributes.
• **Interoperability:**
  Traces that are produced by various CMC tools can be interoperable as long as the same model of traces is used. Considering an example of CMC traces represented in XML formats. One XML file can be expanded or merged with another if the two files have the same data structure and are validated by the same DTD (Document Type Definition) or XML Schema.

• **Reusability:**
  Existing traces generated by a CMC tool can be reused in another tool without requiring users to make data conversion, mapping or transformation. For example, if two CMC tools that used XML files to store CMC traces and adopted the same model of traces, each XML file would share the same element and attribute names, thus enabling its reusability in either one CMC tool or another.

The proposition of a generic model of CMC traces was preceded with a choice of (i) a reference computerized format of CMC traces and (ii) a language to formalize the model. Our choice was made on XML and XML schema for the following reasons:

- While XML file is a computerized format largely used in numerous CMC tools to store structured traces, XML schema is used as a description of XML file to define the structure, types, and relations of the traces stored in the XML file.
- XML schema is an XML-based alternative to DTD, except that it is richer and more powerful in terms of data structuring. This makes XML schema more advantageous in practical use when CMC traces are represented in XML format.
- XML schema supports data types for elements and attributes that structure the CMC traces stored in XML files. Hence, using XML schema allows us to define data facets (e.g. restrictions on data), data patterns (e.g. data formats), or to easily convert data between data types.
- XML schema is extensible, allowing us to reuse one schema in another or to reference multiple schemas in the same XML file. This means that we are able to add new elements and attributes to the existing XML file to extend it.
- XML schema can be transformed with XSLT (EXtensible Stylesheet Language Transformation), which enables us to easily alter the representations of the data in XML files.
- XML schema supports “namespace” that provides us means to mix or combine different XML schemas together and by avoiding the conflict of element names used in each schema. On top of that, with XSLT, a combined schema can be again transformed into a specific representation that fits each individual user need.
3.4.2 Model of traces for Human and Computer Interactions in a communication activity

Inspired by the tracking approach, presented earlier in section 3.2, we first identified the compulsory elements to describe various Human and Computer Interactions within a CMC activity. These elements are indeed the composition of the CMC traces. Later, we used the XML schema to describe the structure of the identified elements as well as their attributes, data types, and relations in order formalize the model of CMC traces.

We present below our proposed model and the description of the principal elements that appear in the model. A complete description of the model in pure XML schema along with detail documentation can both be found in annex C. Figure 3.7 illustrates the graphical view of the XML schema of the proposed model for CMC traces. Table 3.3 documents the elements of the model and their descriptions.

Figure 3.7 Graphical view of the proposed model of CMC traces
### Table 3.3 Identification of elements to describe the model of CMC traces

<table>
<thead>
<tr>
<th>Identified elements</th>
<th>Description of the identified elements</th>
<th>Elements in XML schema</th>
</tr>
</thead>
<tbody>
<tr>
<td>User</td>
<td>Information that can be used to reflect user role and involvement in a CMC activity (e.g. a user name).</td>
<td><code>&lt;User&gt;</code></td>
</tr>
<tr>
<td>Action or Interaction</td>
<td>Multiple actions and interactions between a users and a CMC tool during a CMC activity. Each action/interaction is described by <code>&lt;HCI&gt;</code> element.</td>
<td><code>&lt;Activity&gt;</code> <code>&lt;HCI&gt;</code> <code>&lt;Title&gt;</code></td>
</tr>
<tr>
<td>Interaction object</td>
<td>Tools and objects that a user interacts with to perform a CMC activity.</td>
<td><code>&lt;Tool&gt;</code> <code>&lt;Object&gt;</code></td>
</tr>
<tr>
<td>Attribute of an action or an interaction</td>
<td>Extra information to characterize an action/interaction, making it more descriptive and specific to each CMC activity. An attribute of an action/interaction can contain a set of information described by pairs of attribute names and values; all placed in the <code>&lt;Attribute&gt;</code> element.</td>
<td><code>&lt;Attribute&gt;</code></td>
</tr>
<tr>
<td>Content of an action or an interaction</td>
<td>The end result of a CMC activity. It is also considered as a product of a CMC activity depending on the type of the action/interaction that occurs during the activity.</td>
<td><code>&lt;HCIContent&gt;</code> <code>&lt;Content&gt;</code> <code>&lt;ContentAttribute&gt;</code></td>
</tr>
<tr>
<td>Timestamp</td>
<td>Timestamp is imperative to the description of an activity as it measures not only times, but also intervals of both actions and interactions occurred throughout an activity. Timestamp has been divided into two categories: (i) date and time of the activity, represented by <code>&lt;date&gt;</code> and <code>&lt;Time&gt;</code> elements, (ii) time of each action/interaction represented by <code>&lt;TimeHCI&gt;</code> element.</td>
<td><code>&lt;Date&gt;</code> <code>&lt;Time&gt;</code> <code>&lt;TimeHCI&gt;</code></td>
</tr>
</tbody>
</table>

Figure 3.8 gives an example of the CMC traces of different activities represented in XML format, which is consistent to the proposed model of traces.
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Figure 3.8 An example of CMC traces presented according to the proposed model

- <FormatHCI>
  - <TraceHCI id="1">
    <Tool>Forum</Tool>
    <Activity>Write a new message</Activity>
    <User>Madeth</User>
    - <HCI id="1">
      <Title>Type message title</Title>
      <Object>Input</Object>
      <TimeHCI>12:04:40 PM</TimeHCI>
      <Attribute>Objectname=Title</Attribute>
    - <HCIContent>
      <Content />
      <ContentAttribute />
    </HCIContent>
  </HCI>
  - <HCI id="2">
    <Title>Click</Title>
    <Object>Button</Object>
    <TimeHCI>12:05:03 PM</TimeHCI>
    <Attribute>Objectname=send</Attribute>
    - <HCIContent>
      <Content />
      <ContentAttribute />
    </HCIContent>
  </HCI>
  <Time>12:06:07 PM</Time>
  <Date>10/03/2007</Date>
  <Comment>New message</Comment>
</TraceHCI>
- <TraceHCI id="2">
  <Tool>Forum</Tool>
  <Activity>Read a message</Activity>
  <User>Madeth</User>
  - <HCI id="1">
    <Title>Click on a hypertext link</Title>
    <Object>Link</Object>
    <TimeHCI>12:07:20 PM</TimeHCI>
    <Attribute>IDMsg=3, IDForum=2</Attribute>
    - <HCIContent>
      <Content />
      <ContentAttribute />
    </HCIContent>
  </HCI>
  <Time>12:07:24 PM</Time>
  <Date>10/03/2007</Date>
  <Comment />
</TraceHCI>
- <TraceHCI id="3">
  <Tool>Forum</Tool>
  <Activity>Send a new message</Activity>
  <User>Madeth</User>
  - <HCI id="1">
    <Title>Write message content</Title>
    <Object>Input</Object>
    <TimeHCI>12:09:10 PM</TimeHCI>
    <Attribute />
    - <HCIContent id="1">
      <Content>Hello there, how are you doing?</Content>
      <ContentAttributes>IDMsg=7, IDForum=4</ContentAttributes>
    </HCIContent>
  </HCI>
  <Time>12:15:30 PM</Time>
  <Date>10/03/2007</Date>
  <Comment />
</TraceHCI>
</FormatHCI>
Three different user’s activities can be found in the example of CMC traces shown in figure 3.8, encapsulated by the element `<Activity>`. Each activity contains several actions or interactions placed between the `<HCI>` element, which contains other elements, including `<Title>`, `<Object>`, `<TimeHCI>` and `<Attribute>` respectively representing the title of the action, the object that the user interacted with on the CMC tool, the time of the action, and other supplementary information of the action. If there is any content produced from an action/interaction during an activity, it will be appeared inside the `<HCIContent>` element.

### 3.4.3 Model of traces in practical use

Figure 3.9 gives an overview of the possibilities of putting our proposed model of traces into practice.

![Diagram](image)

**Figure 3.9** Different possibilities of using the proposed model in CMC tools

While viewing figure 3.9 we are examining an example of two use cases of the proposed model. The first use case is when both tools (Cf. CMC Tool 1 and CMC Tool 2 from figure 3.9) accept the unique model of traces from the very beginning of the trace generation process. The generated traces in this case will be
structured in a common format, which enables their reuse in one tool or another. Contrary to this, the second case is when the two CMC tools use their own formats, and there is need to structure the traces issued from each tool in a common format. This use case requires a definition of XSLT (EXtensible Stylesheet Language Transformation) to entirely transform the two formats into one single unit, which is inherited from the proposed model and reusable in both CMC tools. Technically, using XSLT is an alternative way of modifying the existing trace format at the end of its generation process instead of modifying the code of the first CMC tool to make it accept the trace format of the second or vice versa. This also means that using XSLT is an efficient way to transform diverse trace formats originally used by each individual CMC tool, into one common format that is always consistent to the proposed model.

The use of the proposed model is not limited to the two use cases given in the example earlier. Indeed, the proposed model is formalized in XML schema which is flexible in terms of structure and data manipulation. In addition, the XSLT is a convenient technical support for the practical use of the proposed model in different circumstances. For example, it allows the model to be:
- extended to create a more specific trace format which is suitable for other types of CMC tool (e.g. forum Confor),
- merged with other models to output the existing traces in a richer and more appropriate format for each particular CMC tool, or
- transformed to alter the representation of the traces (e.g. mapping fieldname by using namespace, data type conversion, etc.)

### 3.5 Conclusion

In this chapter, we studied the main issues related to tracking computer-mediated communications and exploiting the collected traces in distance learning situations. Our study focused on the existing approaches and their limitations of (i) traces collection, (ii) traces structuring, and (iii) traces analysis and visualization. To improve upon these limitations, we have proposed:

1. **An explicit tracking approach** to efficiently track users communication activities on CMC tools. The proposed approach concentrates on different Human and Computer Interactions to be tracked throughout a communication activity and on both the granularity and the semantic aspects of the collected traces.

2. **A generic model of CMC traces** to answer to the problems of CMC traces structuring, interoperability and reusability.

Along with these two significant propositions, we also presented in this chapter our effort in:
(i) the development of a tracking system for Web-based communication tools, which, later on, is used in our case studies and experiments in an authentic learning situation (presented in chapter 5),

(ii) the implementation of the model of CMC traces that required a thorough study on technologies that allows the formalization of the model and the possibility of putting it into practice.

The next chapter will cover our research approach related to the traces exploitation, or more precisely, the traces analysis and visualization, which have only been highlighted in this chapter (cf. section 3.1.3). A more in depth study will be made to explore solutions to overcome the difficulties in making use of the CMC traces in the learning situation, to which our research is directed. The study will mainly focus on our platform TrAVis (Tracking Data Analysis and Visualization), a technological solution we are proposing to both tutors and learners to support them in the task of exploiting their CMC traces.
Chapter 4

TrAVis (Tracking Data Analysis and Visualization tools)
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**Chapter 4: TrAVis (Tracking Data Analysis and Visualization tools)**

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- TrAVis design approach
- TrAVis' indicators design
- TrAVis design guidelines

## 4.2 TrAVis Development
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- Database
- Tracking component
- Interface component
- Data processing component
- Data analysis component
- Data visualization component

## 4.3 Analyzing and Visualizing CMC Tracking data with TrAVis
- Overview
- Visualize user communication activities
- Visualize in real time user activity on discussion forum
- Visualize user level of interaction of a communication activity

## 4.4 Conclusion
Chapter 4 at first glance

This chapter is dedicated to a presentation of the platform TrAVis, which we design and develop to support both tutors and learners in traces analysis and visualization practices. TrAVis is a technological solution that answers our research question:

- **What tools do the tutors and learners need to exploit their CMC traces?**
  The presentation of TrAVis will also cover the technical aspects of the development process. Hence, it allows us to develop a solution to the problem:

- **How to design and build tools, in order that a non-specialist computer user could readily access them?**

Figure 4.1 gives an overview of how we structure this chapter.

![Diagram of chapter structure]

**Figure 4.1** General structure of chapter 4

In section 4.1, we give an overview of TrAVis by concentrating on the design approach. We also present in the same section our proposition of data indicators of CMC activities that will be specifically computed by TrAVis.

The presentation of TrAVis development is given in section 4.2. It focuses on the technical aspects of TrAVis and the development technologies needed to build the multi-component architecture therein.

In section 4.3, we present three visualization tools of TrAVis and different sets of data indicators in graphical representation.

In the conclusion of this fourth chapter, we summarize the three important aspects in relation to TrAVis and the proposed data indicators.
4.1 Overview of TrAVis (Tracking data Analysis and Visualization tools)

4.1.1 Objective of TrAVis

As already highlighted in the previous chapter, TrAVis (Tracking data Analysis and Visualization tools) is a technological solution that we are developing, to assist CMC-tool users in the task of exploiting the CMC traces. TrAVis enables users to:

- Directly access to the traces repository via a GUI (Graphical User Interface)
- Manipulate the traces (e.g. data storage, modification, …)
- Export the traces into different computerized formats (e.g. from MySQL to XML)
- Compute the data indicators from traces
- Visualize the data indicators in different forms and in different scales.

In the research context in which we are involved, TrAVis is designed and built with an objective to support the tutors and the learners in their online tutoring and learning activities. Example of how include:

- **For tutors**, TrAVis offers different tools to visualize in real-time the traces of learners on CMC tool. With TrAVis, the tutors could monitor individual or group of learners and at the same time increase their awareness of the ongoing communication activities. In addition, TrAVis provides means to transform the learners traces into graphical representations which serve as indicators for the assessment and/or the evaluation of different aspects of the learners (e.g. social, cognitive, behavioral aspects, etc.).

- **For learners**, TrAVis is a “reflexive tool” that helps them increase their consciousness of the learning and communication activities being carried through. More precisely, what we mean by a reflexive tool is a guide that assists learners to gain an insight on their activities via their traces, thus allowing them to self-monitor or to self-assess. A reflexive tool can be employed by the learners to acquire an overview of their personal learning progress, their participation rate in social interactions, or other statistical data from their communication activities, etc.

4.1.2 TrAVis design approach

We have adopted a mixture of iterative and participative approaches in the design of TrAVis. Different versions of TrAVis were built during the progress of our research. The major changes in each build have particularly involved the visualization of CMC traces. In fact, the latter is one of the principal tools of TrAVis and it focuses on:
(i) the production of **data indicators** from CMC traces, and
(ii) the **graphical representations of the indicators** that match the demands of tutors and learners.

The approach for the design of TrAVis can be described as follows:

1. We conduct a preliminary study on the existing indicators of CMC activities that are the most appealing to the tutors and learners in the learning context in which we are interested (see section 2.1.2 of chapter 2). The study leads us to compile a variety of indicators that might subsequently be implemented in TrAVis.

2. The identification of the actual needs of users in terms of data indicators and their visualizations is a complex affair. The reason is that users, on the one hand, often encounter difficulties in expressing their real needs due to the lack of prior interest on CMC traces and their exploitation. On the other hand, users who are not familiar with the type of tools like TrAVis, usually have trouble in perceiving the real advantages of using it. Acknowledging these practical issues, to begin with, we introduce TrAVis to the users (tutors and learners) with a purpose of demonstrating its benefits in their actual practices. Our main goal is to study the feedback of users on how TrAVis could, or could not, be of use to them. Later, we request the users to evaluate the proposed indicators obtained from the previous study (cf. step 1) according to their pedagogical or learning objectives.

3. The proposed indicators that respond mainly to the needs of users, are later implemented in TrAVis and accessible according to their profiles (tutors or learners). Case studies and experiments are conducted to bring users closer to the authentic tutoring and learning situations wherein they are invited to use TrAVis, to visualize data indicators as well as to manipulate the rest of TrAVis’ functions. In each case study and experiment, TrAVis is dedicated to assist the monitoring and reflexivity of user CMC activities.

4. Users are requested to evaluate TrAVis according to a set of criteria, including the ease of use, utility, pertinence, relevancy of TrAVis, etc. They are also requested to specify their needs on indicators to be generated by TrAVis and the visualization of those indicators. Both online questionnaires and face-to-face interviews are included in this step. An example of questionnaire of TrAVis is presented in annex D.

5. The procedure comprising the four steps above is repeated every time that TrAVis is proposed to other types of users or other learning contexts.

### 4.1.3 TrAVis’ indicators design

From a user standpoint, exploiting CMC traces is a time consuming task as it consists of different phases, starting with the traces collection, to the visualization of traces. There are other technical factors, such as constructing the visual forms
of the indicators from CMC traces, which could present a more challenging process for the users. For example, an indicator of a CMC activity with a complicated visual form might not facilitate both the visualization and the interpretation of the information that it features. Consequently, the indicators might not always be any help to users. This then, suggests that not only the construction of more intuitive, representative and compelling indicators are required, but also the necessity of increasing the ease of use in their visualizations. Therefore, we have concentrated on the design of data indicators that particularly focus on (i) the conceptual level of the indicators and (ii) the visual form of the indicators:

(i) The conceptual level of the indicators:
We refer to the research efforts of Dejean & Mangenot (2006) and Mangenot (2008) that focused on different levels of user interactions during CMC activities in learning situation. More precisely, Dejean and Mangenot distinguished the four levels of interaction – aggregation, discussion, cooperation and collaboration, which reflect the form or the modality of a communication activity. For instance, while the Aggregation level refers to the activities of an individual user, the Collaboration level refers to the collaborative activities of a small group of users. Our main objective is to propose different sets of data indicators to support the visualization and analysis of each level of interaction. Accordingly, we identify at first the significant information describing the latter and how it is represented in a visual form easily interpretable by the users.

Another crucial aspect of data indicator design at the conceptual level is that every single indicator from the inferior levels can be reused in the superior levels (cf. figure 4.2), thus enabling TrAVis to compute additional indicators.

![Figure 4.2 Four levels of data indicators](image)

For example, every indicator in the Aggregation level is found in the Discussion level and the combination of indicators from both Aggregation and Discussion levels are included in the Cooperation level; and so on. We present in section 4.3.4 the proposed data indicators with example of visualization.
(ii) **The visual form of the indicators:**

We employ various data visualization techniques to construct the visual forms of the indicators (presented in section 4.2.7). The visualization of the indicators is shown in a form of **“user control panel”** that varies from statistical data in tabular format, to synthetic information in graphical representations. Meanwhile, we also add **“visualization variables”** that allow the transformation of the indicators, depending on their type, from one visual form to another. More precisely, the visualization can be technically varied according to the following variables:

(a) **User**, refers to the number of users that appear in the representation of the indicator. For instance, this variable enables indicators of an individual user, or multiple users, to be visualized either separately or together.

(b) **Scale** or the scope of information that an indicator covers. For instance, an indicator of a CMC activity can either describe the global overview (high level) or the detail of the activity (low level).

(c) **Chronology** or the temporal aspect of an indicator that allows users to display data indicators with a specific date and time or even within a period of time (i.e. an interval of time) – e.g. displaying every interaction of a user on CMC tool between *day 1* and *day 2* and from *Time 1* to *Time 2*.

4.1.4 TrAVis design guidelines

TrAVis is dedicated to users with different backgrounds and experiences in using computerized systems. Hence, it is crucial for us to consider a guideline in the design of TrAVis in order to make it more accessible and customizable to users with limited technical skills. However, the development of TrAVis should also be guided by a number of rules that lead to an achievement of good quality engineering process in relation to the architecture design, or the evolution of TrAVis for further usage, etc. Therefore, the design and development of TrAVis, is realized with the following guidelines:

- **Web-based platform**

  For the reasons of flexibility and accessibility, TrAVis is developed with Web-based technologies. Our main objective is to share TrAVis with the TEL community, a part of which, regularly seeks additional technological solutions to support traces analysis and visualization practices. It is worth mentioning that Web-based technologies are very well sustained and fostered by a strong community of researchers and developers. This means that we can easily access many technical resources, freely available (i.e. open source software, plug-in, applications ...) and indeed, share our contribution among the community.

- **Ease of use**

  Users could be non-computer specialists who often request technical support in using a particular tool to analyze and visualize traces. In view of this, TrAVis is designed with a friendly Graphic User Interface (GUI) that allows users to easily
access and manipulate it at ease. Also, users who often use Web-based platforms, will not have trouble in using TrAVis as it is equipped with the same type of interface elements (e.g. input forms, buttons, links, etc.) with which they are familiar.

- **CMC tool independence**
  TrAVis is an independent platform, designed to be applied to a wide range of CMC tools to support users in the tasks of analyzing and visualizing CMC traces. What makes TrAVis independent of the CMC tool is the capacity of accepting CMC traces with the formats that are consistent to our proposed model (Cf. section 3.4.2 in chapter 3). As a matter of fact, the latter serves as a technical solution for restructuring the existing traces into a common format exploitable by TrAVis.

- **Multi-component architecture**
  TrAVis architecture, as presented in section 4.2, consists of various components developed to handle specific tasks. The significant advantage of such architecture is that each component can be individually modified. Moreover, it is practical for us to be able to add extra features or new functions to improve a particular component without having to alter the whole architecture of TrAVis. For example, we can add new data analysis methods to compute new types of data indicators, or we can expand the graphics library in order to generate new visual forms of data indicators.

- **Evolution perspective**
  From a researcher/developer standpoint, the evolution of TrAVis is not negligible. TrAVis is built upon iterative and participative approach, and from which the progress is made in accordance with user feedback. It is important for us to continually improve TrAVis at the functional level in order to make it more efficient and more responsive to the needs of users in further usage. Therefore, a tracking component is implemented in TrAVis to observe user interactions when it is in use (cf. section 4.2.3). While the collected information is mainly used in the study of the behavioral aspect of users on TrAVis, it also serves in the process of debugging and ameliorating the latter.

### 4.2 TrAVis development

#### 4.2.1 TrAVis architecture

Figure 4.3 presents the multi-component architecture of TrAVis. It consists of a database and five major components including Interface, Data processing, Data analysis, Data Visualization, and Tracking component. The technical aspects of each component will be presented in the following sections.
4.2.2 TrAVis database

TrAVis is independent of CMC tools in terms of data management. It possesses a defined database, implemented with MySQL, to store metadata of its logical structure and extra information regarding:

(i) **user profiles**: users right set by their roles on CMC tool (e.g. tutor, learner, administrator). This information can be either duplicated from CMC-tool database or manually inserted by TrAVis administrator.

(ii) **user visualization options**: preferences of each individual user in the visualization process. Each preference consists of a triplet of parameter name, value and description. It enables users to control how to visualize data indicators. For instance, users can change the view mode, visual form or scale of an indicator according to its available visualization parameters (Cf. presented in section 4.1.3). New parameters can be gradually added into the database when new indicators are computed.
(iii) **user notes**: user personal notes created and shared among others. For example, it is practical for a tutor to take notes on important information of an indicator of a learner activity while visualizing it, and share with other tutors.

(iv) **user log files**: Human–Computer Interaction and Computer–Computer Interaction captured while a user accesses to TrAVis and manipulates it.

Having a proper database allows TrAVis to run in conjunction with various CMC tools and CMS without having to alter their existing database structure and data. In other words, TrAVis will only access to CMC-tool database to retrieve essential information for the traces exploitation process. Figure 4.4 presents the entity-association schema of TrAVis database whilst table 4.1 describes the data dictionary of the latter.

![Figure 4.4 Entity-association schema of TrAVis database](image-url)
Table 4.1 Data dictionary of TrAVis database

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>User</strong></td>
<td>This table contains user personal information</td>
</tr>
<tr>
<td>IDUser</td>
<td>Int</td>
</tr>
<tr>
<td>Name</td>
<td>String</td>
</tr>
<tr>
<td>Surname</td>
<td>String</td>
</tr>
<tr>
<td>Email</td>
<td>String</td>
</tr>
<tr>
<td>Login</td>
<td>String</td>
</tr>
<tr>
<td>Password</td>
<td>String</td>
</tr>
<tr>
<td>Type</td>
<td>Int</td>
</tr>
<tr>
<td>Comment</td>
<td>String</td>
</tr>
</tbody>
</table>

| **Typeu**| This table stores information of user profile                              |
| IDTypeU | Int                           | User type identifier                                              |
| Title   | String                        | Label of user profile. For example: 1: Administrator 2: Tutor 3: Learner |

| **User_param**| This table contains visualization parameters of each individual user        |
| IDParam       | Int                           | Parameter identifier                                              |
| Username      | String                        | Reference identifier that links table User_param and User         |
| ParamNameX    | String                        | Parameter name where X is parameter order. For example, ParamName1 is the first parameter |
| ParamValueX   | String                        | Parameter value where X is parameter order. For example, ParamValue1 is the value of the first parameter |
| DescriptionX  | String                        | Parameter description where X is parameter order. For example, Description1 is the description of the first parameter |

| **User_notes**| This table stores user personal notes                                    |
| IDNote       | Int                           | Note identifier                                                   |
| Username     | String                        | Reference identifier that links table User_notes and User         |
| Share        | Byte                          | Note shareable status                                             |
### User_sharenote
This table records information regarding users and their access to the shared notes.

<table>
<thead>
<tr>
<th>IDShare</th>
<th>Int</th>
<th>Share identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Username</td>
<td>String</td>
<td>List of user names who have access to the shared note</td>
</tr>
<tr>
<td>IDNote</td>
<td>Int</td>
<td>Reference identifier that links table User_sharenote and User_notes</td>
</tr>
<tr>
<td>Dateshare</td>
<td>Date</td>
<td>Date of a shared note</td>
</tr>
<tr>
<td>Lastaccess</td>
<td>Date</td>
<td>Last access date of a shared note</td>
</tr>
</tbody>
</table>

### User_log
This table contains the traces of Human–Computer Interactions on TrAVis.

<table>
<thead>
<tr>
<th>ID</th>
<th>Int</th>
<th>Log identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDTraces</td>
<td>Int</td>
<td>Reference identifier that links table User_log and Tool_log</td>
</tr>
<tr>
<td>User</td>
<td>String</td>
<td>Reference identifier that links table User_log and User</td>
</tr>
<tr>
<td>HCI</td>
<td>String</td>
<td>Title of a Human–Computer Interaction</td>
</tr>
<tr>
<td>Tool</td>
<td>String</td>
<td>Title of TrAVis functionality accessed by the user</td>
</tr>
<tr>
<td>Date</td>
<td>Date</td>
<td>Date of HCI</td>
</tr>
<tr>
<td>Time</td>
<td>Time</td>
<td>Time of HCI</td>
</tr>
</tbody>
</table>

### Tool_log
This table stores the traces of Computer–Computer Interactions occurred when a user interacts with TrAVis.

<table>
<thead>
<tr>
<th>ID</th>
<th>Int</th>
<th>Log identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDTrace</td>
<td>Int</td>
<td>Reference identifier that links table Tool_log and User_log</td>
</tr>
<tr>
<td>HTTPQuery</td>
<td>String</td>
<td>Raw data of a HTTP query sent and received when a user interacts with TrAVis</td>
</tr>
<tr>
<td>Date</td>
<td>Date</td>
<td>Date of a HTTP Query</td>
</tr>
<tr>
<td>Time</td>
<td>Time</td>
<td>Time of a HTTP Query</td>
</tr>
</tbody>
</table>
4.2.3 Tracking component

TrAVis is integrated with a tracking component, developed specifically to register the traces of use, or more precisely, the Human–Computer Interactions (HCI) and Computer–Computer Interactions (CCI) throughout the traces exploitation process. It should be noted that the tracking component of TrAVis is independent of the one we developed for the CMC tools (presented earlier in section 3.3.2). Instead, its main goal is to:

(i) keep the traces of users when accessing to each tool of TrAVis. The HCI traces are indeed very beneficial to the study of the behavioral aspect of users on TrAVis. Their exploitation provides us not only a better understanding on how users interact with TrAVis, but also a better perception on what to improve in terms of functionalities and utilities in order to efficiently support users in their practices. Figure 4.5 gives an example of the HCI traces. For ease of view, the representation of the traces is transformed into XML format.

```
  <user_log>
      <ID>280</ID>
      <IDTraces>145</IDTraces>
      <User>
          <HCI>Visualize discussion indicators</HCI>
          <Tool>Menu of discussion visualization</Tool>
          <Date>05/04/2009</Date>
          <Time>15:05:42</Time>
      </User>
  </user_log>
```

**Figure 4.5** An example of HCI traces captured by TrAVis tracking component

(ii) monitor the input/output processes when there is an exchange of HTTP query between TrAVis and the trace repository. The CCI traces contain raw information on how TrAVis sends and receives HTTP queries during the data visualization process. From a personal standpoint, CCI traces are extremely beneficial to the improvement of TrAVis. For example, we regularly use the CCI traces to debug technical problems of TrAVis and to optimize its performance in executing multiple HTTP queries from users’ Web browsers. Figure 4.6 illustrates an example of the CCI traces, which are captured immediately after the HCI traces, presented earlier in figure 4.5 (see IDTraces tag in both examples).
Figure 4.6 An example of CCI traces captured by TrAVis tracking component

From a broader perspective, tracking the use of TrAVis contributes to our investigation of the impact of TrAVis in the learning situation where the participants have to visualize and analyze their traces. As a matter of fact, we are particularly interested in studying whether or not, using TrAVis leads to a change of the participant behavior during the communication and learning process.

The development of TrAVis tracking component is based on the same development concept of the tracking system, presented in the previous chapter (see section 3.3.2). AJAX and JavaScript are used to develop the traces collectors to observe on the client side the Human–Computer Interactions on TrAVis. On the server side, the traces collectors that capture the HTTP queries (i.e. Computer–Computer Interactions) are developed with PHP scripting language.

4.2.4 Interface component

Developed with Web-based technologies that include DHTML, CSS, AJAX and JavaScript, the interface of TrAVis is not only functional but also flexible, allowing users with limited technical skills to easily manipulate it. For example, users have choices between manually filling the visualization parameters and selecting them from a preset list. Figure 4.7 shows a screenshot of a tool, among others, currently available to TrAVis users.
While viewing figure 4.7 we explain why such interface offers users flexibility and ease of use in the task of exploiting CMC traces.

(A) TrAVis principal menu
This gives user access, according to their profiles, to different functionalities of TrAVis, including traces visualization tools and user personal settings. Each menu can be briefly presented in table 4.2 below.

**Table 4.2 List of menus of TrAVis**

<table>
<thead>
<tr>
<th>Menu</th>
<th>Menu title</th>
<th>Description</th>
<th>Accessibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A0)</td>
<td>Home</td>
<td>Access to the front page of TrAVis</td>
<td>Tutor, learner and administrator</td>
</tr>
<tr>
<td>(A1)</td>
<td>Login</td>
<td>User login page</td>
<td>Tutor, learner and administrator</td>
</tr>
<tr>
<td>(A2)</td>
<td>Trace repository</td>
<td>Transform and export traces from MySQL relational database format into XML or TXT formats (the two exportable formats implemented in TrAVis for the time being)</td>
<td>Administrator</td>
</tr>
<tr>
<td>(A3)</td>
<td>Visualization tool 1</td>
<td>Visualize the fundamental communication activities on a discussion forum (see section 4.3.2)</td>
<td>Tutor, learner and administrator</td>
</tr>
<tr>
<td>(A4)</td>
<td>Visualization tool 2</td>
<td>Visualize in real time every user action on a discussion forum (see section 4.3.3)</td>
<td>Tutor, learner and administrator</td>
</tr>
<tr>
<td>(A5)</td>
<td>Visualization tool 3</td>
<td>Visualize the levels of interaction of communication activities (see section 4.3.4)</td>
<td>Tutor, learner and administrator</td>
</tr>
<tr>
<td>(A6)</td>
<td>User options</td>
<td>Access to user profile, personal settings and preferences (visualization parameters)</td>
<td>Tutor, learner and administrator</td>
</tr>
</tbody>
</table>
(B) **Filling in user name**

User names can be either filled in manually or selected from the list, as shown in figure 4.8, the list for a single or multiple selected users.

![Figure 4.8 Panel of single and multiple selected users](image)

In practice, it is very convenient for the tutors to be able to visualize and analyze the CMC activities of an individual or multiple learners with different perspectives. For instance, the tutors can analyse the *aggregation* level and at the same time the *collaboration* level of a CMC activity of an individual learner in relation to a group of learners or vice versa. Learners, can view other learners activities in addition to their own, which allow them, for example, to compare their personal progress with others.

(C) **Visualization options**

Depending on the types of data indicators, users have options to view them differently. For example, figure 4.9 presents some visualization options for the indicators that display user activities on CMC tool (further discussed in section 4.3.3). Those options include display order of the activities, color filters, time interval, and scrolling speed of the indicators.
Figure 4.9 An example of visualization options of data indicator

(D) **Date picker**
Date is one of the essential visualization parameters that allow TrAVis user to display data indicators with a specific date or between two dates. Users can enter a date manually or use the date picker panel to choose one.

(E) **Time select**
Time parameter complements the visualization of data indicators with the temporal aspects. User can combine date and time parameters to view and to navigate each indicator in different time slots. In terms of ease of use, a floating analog clock is proposed to users to select a desired time whilst they can do manually.

(F) **Activity filter**
Users can simply select from the activity list what to visualize (e.g. reading, posting messages, browsing forum, etc.). They can also add new types of activities that are not featured in the list from the traces repository.

(G) **Extra tools**
For the time being, a sticky note (cf. figure 4.10) and a shout box (cf. figure 4.11) are implemented in TrAVis as extra tools to support user in making personal notes and chatting.
4.2.5 Data processing component

Data processing also refers to access and manipulation of data that are stored in the traces repository. While the latter is implemented with MySQL (as already presented in section 3.3.3), processing data is completely done with SQL queries. Developed with PHP, data processing component is mainly a library of SQL queries formalized to perform different operations, among which two are fundamental:

(i) retrieve visualization parameters from the interface component (i.e. filled in by users), insert those parameters in the predefined SQL query in order to interrogate the traces repository,

(ii) extract the necessary data that serve for the construction of indicators. For instance, to count the number of messages posted by a user in a discussion forum, all data in the trace repository that are relevant to the activity “post a new message”, “reply to a message”, or “start a new discussion thread”, will be extracted and sent to the data analysis component (presented in section 4.2.6 below).
4.2.6 Data analysis component

This component consists of a number of predefined data analysis methods that are dedicated to the production of indicators. Technically, the analysis methods are coded in PHP as a set of functions with parameters, dynamically changed according to the data received from data processing component. The main advantages of doing so are:

(i) the possibilities of adding new functions to compute new types of indicators without having to modify the source code of other components of TrAVis, and

(ii) the ease of reusing each function either recursively or in other functions without having to redefine a new one when only the parameter names and types vary.

For example, a generic function that counts the number of messages can be called to output the number of messages posted in a particular forum. In this case, the used function only needs an extra parameter, which is the identifier of the forum. Additionally, the same function can also be reused to compute similar types of indicators by simply adding new parameters. As shown in table 4.3, the possible indicators that are obtained from the aggregation of user, date and time parameters.

Table 4.3 An example of computing different data indicators by using a predefined analysis method that counts the number of messages

<table>
<thead>
<tr>
<th>Extra parameters</th>
<th>Example of possible indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>User</td>
<td>Number of messages posted by an individual user</td>
</tr>
<tr>
<td>Date</td>
<td>Number of messages posted by an individual user in a specific date or between two dates</td>
</tr>
<tr>
<td>Time</td>
<td>Number of messages posted by an individual user in a specific date and time or within a time slot</td>
</tr>
</tbody>
</table>

New analysis methods can be gradually added to the component to generate new indicators that response better to the needs of TrAVis users.

4.2.7 Data visualization component

For the present, this component contains two graphics libraries and various visualization techniques coded in PHP as a compilation of functions, to display the data indicators in graphical representations. While we chose pChart (http://pchart.sourceforge.net/), an open source PHP class oriented framework for the development of this component, we also designed a proper Graphics Library, called TrAVis-GL, to ensure a large part of data indicator construction in TrAVis. Below we explain the technical aspects of TrAVis-GL and pChart.
• **TrAVis-GL**
  While each indicator should be pertinent, allowing a better interpretation of information it features, its ergonomic aspects regarding shapes, size, colors, etc., are also crucial to the visualization process. Therefore, TrAVis-GL is specifically implemented and dedicated to TrAVis with an objective to produce **original data indicators** for CMC activities and to provide an increase in the ease of both information visualization and analysis. Figure 4.12 describes the workflow of TrAVis-GL.

![Figure 4.12 Workflow of TrAVis-GL in the generation of data indicators](image-url)

(A) TrAVis-GL contains a library of images in JPG format that **we manually drew with graphics editor software**. Each image is created to represent a specific type of data indicator in a way that its height and width can be customized when it is displayed on TrAVis user interface. This means that the graphical representations of data indicators are constructed by a combination of several images.

(B) After having initialized TrAVis-GL, we choose a visualization technique by filling in the necessary parameters, which are the data retrieved from the analysis component. In other words, we call a function to select images from the graphics library that correspond with the given parameters.

(C) The selected images are outputted to TrAVis user view screen.

(D) Each image will be applied with the CSS (Cascading Style Sheets) to adjust its size, position and display style, etc. For example, an image can be animated, illustrated with tooltips or mapped to create clickable zones.

• **pChart**
  pChart is an open source framework, designed to create aliased charts with data retrieved from MySQL database, CSV files or manually provided. It uses the GD library to create PNG, JPEG and GIF images among other formats. The greatest advantage of using pChart in the development of TrAVis is the capacity of instantly transforming data indicators in images and outputting them directly to user interface. Even more convenient, pChart provides a large number of predefined graphics, charts, thumbnails, etc., which facilitate the production of data indicators in different visual forms and scales. Figure 4.13 presents the workflow of pChart in the creation of images.
As shown in figure 4.13, using pChart consists of three main steps after having initialized the graphics library. The input data presented in the workflow refer to the data we retrieve from the data analysis component to render the images. pChart allows us to customize the image properties such as changing image size, display position, background color, or adding image title and legend, etc. While each image rendered by pChart is sent out to TrAVis user view screen, it is also locally stored on the platform that hosts TrAVis, allowing us to reuse it in other visualization processes. We give an example code of using pChart to create an image in annex F. In the following section, we present examples of indicators generated by both TrAVis-GL and pChart.

### 4.3 Analyzing and visualizing CMC tracking data with TrAVis

#### 4.3.1 Overview

In this section, we focus on our proposition of data indicators that feature both quantitative and qualitative information regarding user communication activities on discussion forum. Computed by TrAVis, different sets of data indicators we present in the following sections can be seen as a demonstrator, in particular to:

(i) give examples of how collecting traces with finer granularity (see the discussion of our tracking approach in chapter 3) contributes to the production of pertinent data indicators,

(ii) demonstrate how TrAVis provides a new experience in visualizing and analyzing user actions and interactions on discussion forums,

(iii) emphasize the originality and novelty of the proposed data indicators and their potential benefits to both tutors and students in their online tutoring and learning activities.
Before having a look at the proposition of data indicators and how TrAVis supports the users in exploiting them, we give below two examples of the recorded traces of CMC activities on a discussion forum, which are extracted from our case studies (presented further in chapter 5).

**Figure 4.14** An example of CMC traces of an activity "Reply to a message in forum"

**Figure 4.15** An example of CMC traces of an activity "Display a message in forum"
The examples give a first glimpse of the CMC traces with finer granularity. We have mentioned in section 3.3.3 that CMC traces are originally stored in MySQL database server (i.e. trace repository). Consequently, for the sake of comprehension, the CMC traces in the two examples, respectively shown in figure 4.14 and 4.15, are exported and transformed into XML format with a minimum of essential data elements and attributes. Meanwhile, it should be noted that for privacy concerns, the user name figured in the examples has been changed to “Lucas”, a nickname we picked at random.

The traces of each communication activity are described by a set called “activity”. The “attribute” and “duration” properties are the two major compositions of traces in which we are interested. The “attribute” property describes the data attributes associated to each individual communication activity. It contains the information that links to other types of traces which are not eventually recorded in the trace repository (e.g. audio, video or other attachment files). The “duration” property represents the duration of an activity, or in other words, the total time a user spent when performing an activity.

If we look closely at the given examples, we can spot some significant information that reflects user activity as a whole. For instance, the CMC traces in figure 4.14 show the complete information on Lucas activity when replying to a message in a forum. If we focus on the “Attribute” tag, we can extract necessary indications regarding which message Lucas wrote (i.e. IDMsg=263), the parent message it replied to (i.e. IDMsgParent=68) and the forum in which it is posted (i.e. IDForum=4586). Additionally, in the “Duration” tag, we can find out that Lucas spent 4 minutes and 39 seconds to write the message.

Figure 4.15 shows an example of CMC traces for an activity “display a message in forum”, which feature information of user interactions on both client and server side. As found in the record HCI=8096, Lucas’ interaction on the server side when he accessed the forum server to retrieve a message in order to display it. In the same record, we have an indicator that Lucas spent 3 minutes and 26 seconds to display the message before performing another activity. Subsequently, due to the records HCI=8097 and HCI=8098, we are able to determine that Lucas moved the vertical scrollbar to reach the bottom of the message. These records represent Lucas’ actions on the client side (i.e. on his Web browser).

We will now look at our proposition of data indicators of communication activities on discussion forum by concentrating on their graphical representations and their visualizations with TrAVIs.

4.3.2 Visualize user communication activities

The first set of data indicators we are proposing refer to the fundamental CMC activities such as browsing the discussion forum, reading and posting messages.
CMC traces of the participants from our case studies and experiments (presented further in chapter 5) will be used in our presentation in this section and the next. Therefore, it is important to mention that we have permission from the participants to use their traces in the upcoming examples of data indicators. Particularly, a participant, Tdelille whose username was not blurred out in every example, has signed a consent form (see annex G).

- **Reading a message in forum**
  “How do we know whether or not a displayed message in a forum is read?” This question has been frequently asked, particularly by the tutors who regularly use discussion forums in their teaching activities. We are not pretending that we can prove if a message was really read by the user who displayed it, but we can tell if a message has not been entirely read. For example, if a user has only rapidly displayed the message (e.g. less than 3 seconds) without touching or moving the vertical scrollbar downward the bottom, the displayed message must not have been entirely read by the user. Back to the CMC traces shown in figure 4.15, the user (Lucas) might have read to the end of the message, since he has not only displayed the message, but also moved the vertical scrollbar twice downward and to the bottom of the message (see the records HCI=8097 and HCI=8098). As a matter of fact, knowing if Lucas moves the scrollbar after displaying a message would emphasize a hypothesis that Lucas might have read the message. Also, he has spent 3 minutes and 26 seconds on the message (i.e. the window that displayed the message remained active and Lucas did not perform another activity within 3 minutes and 26 seconds).

Figure 4.16 gives an example of data indicators in graphical representation that allow TrAVis users to easily visualize and interpret information on an activity “reading a message in a discussion forum”.

![Figure 4.16 Data indicators for an activity “reading messages in a discussion forum”](image)

Each sphere shown in figure 4.16 represents an activity of displaying a message and the diameter of the sphere is proportional to the time spent by each user reading the message. The distance between two spheres represents the time
gap between two different readings. A sphere can be one of the following four colors: orange, blue, green, or grey.

- The **green** sphere notifies us that the user read the message by having moved the vertical scrollbar downward to the end of the page (reading till the end of the message).
- The **orange** sphere indicates the fact that the user has simply displayed the message without touching the scrollbar.
- The **blue** sphere signifies that the user has displayed the message and has moved the vertical scrollbar downward, but not to the bottom of the page (i.e. partial reading).
- The **grey** sphere indicates that the window displaying the message has been left inactive – e.g. user minimizes the window leaving the message unseen.

The same data indicator for the activity “reading messages” can also be transformed by TrAVis into another visual form, as shown in figure 4.17, except that the vertical bar presents the reading activity of a user and the bar height corresponds with the time a user spent on a message.

![Figure 4.17 Data indicators for an activity "reading messages in a discussion forum" in another visual form](image)

With both views, when we move the mouse cursor over the sphere/vertical bar, an information tag (i.e. tooltip) fades in with brief information on the reading activity. If we click on the sphere/vertical bar, a pop-up window is displayed to detail (i) the date, time, duration of reading, etc., and (ii) the message content as well as its attachment files, if there are any.

The presented data indicators are not limited to a single user or message. More interestingly, they are reusable for other types of activities which share the same characteristics. For example, user activity such as viewing online courses, wiki pages, or blog postings, can be represented in the same manner.

- **Posting a message in forum**
  Data indicator for an activity “posting messages in a discussion forum” is shown in figure 4.18. Illustrated in two different types of icon, a posting can be either a brand new message or a reply to other messages. The distance between two icons
represents the time gap between two postings. Each icon has a tooltip, allowing users to access to more detail information regarding who wrote the message, how long user spent to write a message, in which forum does it belong, etc. The message content and the associated attachment files can be visualized by clicking on the icon.

![Figure 4.18 Data indicators for an activity “posting messages in a discussion forum”](image)

Such indicator with detail information is objectively designed to provide the tutors with detail information on the learner communication activities. In fact, it could be of great assistance to the tutors to observe how often a learner participates in exchanging ideas on a certain discussion topic, and whether the posted messages are for seeking help, debating or arguing on a learning topic, etc.

- **Summary of a user activities**
  Figure 4.19 presents an indicator that features the statistical data related to four different activities of a user on a discussion forum. The main objective of such indicator is to provide an overview of the following activities:
  (i) reading messages  
  (ii) viewing course materials or assignments that are posted in the forum  
  (iii) posting new messages (or starting new discussion threads)  
  (iv) replying to messages

![Figure 4.19 Data indicators for an overview of user activity on a discussion forum](image)
In practice, the tutors would be very interested to know more than just how many times a learner has visited the forum where they posted their online courses. The substantive data indicators to be provided to the tutor should be able to describe which learner clicks on which course and when, whether or not the learner has viewed the course, and for how long he/she spent to read it, etc. While the data indicator shown in figure 4.19 serves as a control panel that summarizes the quantitative information of the four main activities of a learner (Tdelille), it also allows the tutors to access to more detail information regarding each activity. For instance, when the tutor clicks on the link [detail], situated under the label “Number of displayed messages”, another data indicator of the activity “reading messages” will be displayed (see figure 4.16).

Thus far, it is important to mention that TrAVis offers users the possibility to customize each data indicator according to a variety of visualization parameters, directly accessible via TrAVis user interface (see figure 4.7). For instance, data indicators of a reading activity can be set to be specific to:
(i) an individual or a group of users,
(ii) a particular message, blog posting, wiki page,
(iii) a particular forum, a course content, or
(iv) a period of time.
What is more, users can also combine the different parameters to compose the data indicators that match better their needs in terms of visualization and information analysis.

4.3.3 Visualize in real time user activity on discussion forum

The second visualization tool of TrAVis is called “Time Machine” due to the technical capacity of retrieving the CMC traces from the traces repository and computing data indicators on the fly. This makes it a particularly efficient tool for users like tutors and learners who wish to observe in real time the ongoing activities on the discussion forum. Furthermore, Time Machine has a flexible GUI (see figure 4.7) that enables user to:
(i) select the desired activities from the “activity filter” or to add new types of activities that are available in the traces repository (see part (F) in figure 4.7),
(ii) specify the date and time of the activities to be viewed, and especially
(iii) navigate among the past and the current activities with or without a specific time slot.

Figure 4.20 illustrates the view screen of Time Machine with the list of the activities of a user (Tdelille).
Chapter 4: TrAVis (Tracking Data Analysis and Visualization tools)

FIGURE 4.20 List of user activities displayed on Time Machine view screen

With this view, we can move up and down the activity list and update it in order to get the most recent activities performed by Tdelille on the discussion forum. Each activity is represented as a horizontal bar and in a unique color. When we select an activity by clicking on a bar, the detail information of the activity is displayed at the right part of the screen with an “extra menu”, allowing us to view other activities that are related to the current selected activity. For example, in figure 4.20 above, we are viewing an activity of Tdelille while reading a message “Outil et mode de collaboration” (IDMsg=2898) in the forum “Scénario de communication” (IDForum=362). The extra menu for this activity, as shown in figure 4.21, gives us three choices to:

FIGURE 4.21 Extra menu of Time Machine
(i) view other reading activities of Tdelille in the forum “Scénario de communication” (i.e. every other messages in this forum that are viewed by Tdelille)
(ii) view Tdelille’s reading activities on this message “Outil et mode de collaboration” (i.e. a message can be viewed multiple times by Tdelille, but in different dates and times), and
(iii) view who else reads the same message that Tdelille is reading.

Once again, temporal parameters are available in this extra menu to make the visualization more specific to date and time. The extra menu is dynamically shown according to the type of the activity (e.g. reading, posting, replying messages, etc.), thus enabling us to view other information related to the latter on the same view of Time Machine. Figure 4.22 gives an example of Time Machine view screen updated with data indicators of reading activities of every other user who is viewing the same message that Tdelille is currently viewing. The new added data indicators feature the same visualization characteristics as the ones that we presented earlier in section 4.3.2.

Time Machine is also considered unique to each individual user, for the reason that the latter can configure how the activities should be visualized. Figure 4.9 (in section 4.2.4) presents the configuration panel of Time Machine with a number of visualization options that allows user to:
(a) change the graphical representations of the activities (both forms and colors),
(b) sort out the activities in chronological order (or reverse),
(c) choose the intervals of time for the activities, and
(d) set the scrolling speed when user moves up and down the list of the activities.

Each change made to the configuration panel comes into effect instantaneously, whilst Time Machine updates simultaneously the view with new visualization options.

Time Machine also provides us with another possibility to observe in real time user activities on discussion forum. Indeed, instead of viewing every single activity in a sequential list, as previously shown in figure 4.20, we can choose to view the whole activities at a global level. The main objective of this second view is to support a quick perception of essential ongoing activities and to enable time-dependent analysis of several aspects in relation to activeness of user, personal progress or participation rate on the discussion forum, etc.

Figure 4.23 Visualizing ongoing activities at a global level

As illustrated in figure 4.23, each vertical white bar refers to a set of activities and the bar height represents the density of the activities, calculated by the number of the activities within a specific time slot. The blank space between two vertical bars indicates that there is either no activity going on or the activity is not being tracked (i.e. a user views a Word document outside the discussion forum). From the view, we can adjust the scale by increasing or decreasing the interval of time (see Time Interval Indicator in figure 4.9). We can also zoom in any set of activities figured in a particular time slot by clicking on it. Plus, the zooming allows us to easily switch back and forth between the global view and the sequential list view of the activities.
4.3.4 Visualize user level of interaction of a communication activity

We have discussed in section 4.1.3, our proposition of data indicators, which are dedicated to support the analysis of different levels of interaction between users during a communication activity. Each level of interaction reflects a form of the latter, distinguished into four categories: aggregation, discussion, cooperation and collaboration. The third visualization tool of TrAVIs, as shown in figure 4.24, is built to enable users not only to view the proposed data indicators, but also to customize them.

![User interface of the third visualization tool of TrAVIs](image)

**Figure 4.24** User interface of the third visualization tool of TrAVIs

Presented in a radar graph, each indicator features multivariate data of the process and outcome of a communication activity, to facilitate the visualization of user’s level of interaction. A radar graph is a convenient visual form, providing simultaneous observation and analysis of different aspects of user activity. More importantly, a radar graph can be illustrated dynamically with an arbitrary number of variables where the values can be both quantitative and qualitative information of an individual or a group of users’ activities.

For the time being, TrAVIs offers a list of variables that facilitates the composition of data indicators in radar graphs. The list is presented in table 4.4 below.

**Table 4.4 List of variables for composing data indicators in radar graphs**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>User</strong></td>
<td>Indicators related to user’s activities</td>
</tr>
<tr>
<td>Connection frequency</td>
<td>Number of connections</td>
</tr>
<tr>
<td>Subscribed forums</td>
<td>Number of subscribed forums</td>
</tr>
<tr>
<td>Replied messages</td>
<td>Number of messages posted to reply to other</td>
</tr>
</tbody>
</table>
We give below examples of aggregation, discussion, cooperation and collaboration levels in radar graphs, formed by combining different variables from the list above.

- **Aggregation**
  Data indicators at this level reflect the users’ activities being performed for mutual benefit. They are commonly used to describe the activities of each individual user but in the context of pooling the resources in the discussion group. Aggregation data indicators are divided into three categories:

  (i) **User profile**: indicators on user personal progress in the communication activities.
  (ii) **Pooling resources**: indicators on user contribution to the group that participates in the communication activities.
  (iii) **User navigation**: indicators on user browsing history on CMC tool.

  Figure 4.25 gives an example of aggregation data indicators of a user Tdelille.

<table>
<thead>
<tr>
<th>messages</th>
<th>messages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posted messages</td>
<td>Number of total messages posted</td>
</tr>
<tr>
<td>Cited messages</td>
<td>Number of messages quoted when replying to other messages</td>
</tr>
<tr>
<td>Read messages</td>
<td>Number of messages read</td>
</tr>
<tr>
<td>Started threads</td>
<td>Number of discussion threads created</td>
</tr>
<tr>
<td>Uploaded files</td>
<td>Number of files uploaded</td>
</tr>
<tr>
<td>Downloaded files</td>
<td>Number of files downloaded</td>
</tr>
<tr>
<td>Chat history</td>
<td>Number of chat messages recorded</td>
</tr>
<tr>
<td>Browsing history</td>
<td>Number of records of user browsing history on the discussion forum</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Forum</th>
<th>Indicators related to the discussion forum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forum access</td>
<td>Number of accesses of a particular forum</td>
</tr>
<tr>
<td>Threads</td>
<td>Number of threads created in a particular forum</td>
</tr>
<tr>
<td>Messages</td>
<td>Number of messages posted in a particular forum</td>
</tr>
<tr>
<td>Participants</td>
<td>Number of users participated in the discussion in a particular forum</td>
</tr>
<tr>
<td>Files</td>
<td>Number of files uploaded in a particular forum</td>
</tr>
</tbody>
</table>
The five data points of the radar graph represent the following activities of Tdelille in a discussion forum:

(i) **Connection frequency**: the number of connections showing how often Tdelille log on to the forum.

(ii) **Threads started**: the number of new discussion threads created by Tdelille in the forum.

(iii) **Messages posted**: the total number of messages posted by Tdelille in the forum. It is calculated by a sum all postings.

(iv) **Message replied**: the number of messages posted by Tdelille to reply to other messages.

(v) **Message quoted**: the number of messages quoted by Tdelille. A quoted message can be either Tdelille’s old message or other user message.

The spoke of radar graph is marked by a number from 1 to 6, representing the magnitude of the data points. The magnitude value is automatically calibrated according to the number of data points and their corresponding values. The numbers figured right under the label of each data point represent the statistical data of each activity. For instance, the label “Threads started (68)” refers to the sixty-eight discussion threads started by Tdelille.

With this third visualization tool, as already mentioned earlier, users can customize the radar graph by deleting or adding new data points. If we look back at the earlier example, the data point “Connection frequency” can be replaced with another, such as “Uploaded files” or “Downloaded files” (see table 4.4) to show the number of files uploaded and downloaded by Tdelille. Another important feature of this visualization tool is the ability to generate simultaneously, several radar graphs (i.e. data indicators of multiple
users) and display them on the same view, thus enhancing the analysis of information from an individual or a group of users’ perspective.

- **Level 2: Discussion**
  The proposed indicators at this level feature the discussions between users. Such indicators refer to quantitative information regarding user interaction (e.g. number of messages posted in a discussion forum) and to the content exchanged throughout the communication activities (e.g. message content, document, etc.).

![Figure 4.2](image)

*Figure 4.26* An example of data indicator for discussion level

As shown in figure 4.26, the level of user interaction in a discussion can be expressed by several indicators, among which:
- the number of forum participating,
- the number of messages read and posted in the forum,
- the number of messages exchanged in a chat room, etc.

In practice, analyzing the discussion indicators leads to an identification of the level of social interaction and the activeness of a user during the
communication activities. For example, from figure 4.26, the number of forums a user participated could reflect the interest of the user in making discussions in the forums, which belong to other groups or are dedicated to other discussion topics. Meanwhile, the number of messages a user read and posted in the forum could reveal how active the user was in interacting among other users.

- **Level 3: Cooperation**

The proposed indicators at this level feature specific exchanges of a small group of users. They are commonly used to identify the activities of individual users who participate in the discussion for a common purpose or benefit. For example, the cooperative data indicators enable a user to identify the part of his/her contribution comparing to the rest of the group.

Figure 4.27 is an example of data indicator for cooperation level. This indicator gives an overview of the interactions of a small group of users.

![Figure 4.27 An example of data indicator for cooperation level](image)

From figure 4.27, we give two examples of analyzing the cooperative aspect of group activities. The first analysis is based on an individual user perspective, where we make a comparison of each individual user in terms of participation level and contribution to the group. The user participation level, as shown in figure 4.28, is determined by:

1. First user
2. Second user
3. Third user
4. Fourth user
Figure 4.28 Indicators for calculating user participation level

(i) 20% of forum browsing: activeness of a user on the forum,
(ii) 60% of message posting: exchanges between an individual with the rest of the group, and
(iii) 20% of message reading: viewing messages of other users in the same group.

The contribution of a user to the group, on the other hand, can be identified by a set of quantitative data indicators, including user new postings (i.e. New messages), documents realized and shared among the group throughout the cooperative task (i.e. Files uploaded).

The second analysis is based on a group of users’ perspective where we are interested in how users cooperate with one another. To do so, we attempt to identify each user profile in relation to the rest of the group. For instance, we can observe in figure 4.27 that the fourth user (Tdelille) is a lot more active than other users in “almost” every aspect. Moreover, judging from the total number of postings, it appears that Tdelille is also the most significant contributor. In this way, Tdelille, in relation to the group, has a profile as the leader and who initiates most of the discussions (see indicators Thread started and New messages) as well as animates them (see indicators Quoted messages and Replied messages). As yet, the important aspect of the cooperation level can be then determined by the divergence between user profiles – e.g. the larger difference between users’ activities in terms participation and contribution means the lower cooperation level among the group. Having that said, the analysis of the cooperation level can still be done in different manners according to user analysis perspective.

Level 4: Collaboration

The collaboration level of a communication activity refers to the group activity being carried out to reach a common goal. There are few differences between cooperative and collaborative data indicators from a technical standpoint with respect as to how they are computed and displayed. Users are to judge with their own personal points of view the collaborative aspects of an activity. However, the collaborative data indicators focus on the product of communication activities of a group of users within a defined time span. Due to this condition, the analysis of collaboration level of a communication activity is time-dependent and usually realized from a group of users’ perspective.
Figure 4.29 illustrates an example of collaborative data indicators of a group of five users in three different forums.

![Radar graph illustrating collaborative data indicators](image)

**Figure 4.29** An example of data indicator for collaboration level

The radar graph, as depicted in figure 4.29, gives a quick perception of the forums that have the most participation and productivity rates. In addition, it is accompanied by statistical data of each forum, which give further indications of the outcomes of users’ activities (see the table right below the radar graph). Each of the indicators featured in the radar graph presents a characteristic of the collaboration in the group activity. For instance:

(i) **Forum access** or the frequency of user connection to the forum signifies the activeness of the group,

(ii) **Number of threads** and **Number of messages** indicate the density of the communications within the group to realize the collaborative task,

(iii) **Participants** refers to the number of users participating in the group discussions,

(iv) **Number of files** reflects the number of documents elaborated during the collaborative task.

Thus far, it should be noted that a collaborative indicator features every single indicator from the three previous levels (i.e. aggregation, discussion and cooperation), allowing its visualization flexible, showing a global view of the activities of a single user or of a group of users, as already shown in figures 4.25,
4.26 and 4.27 along with the examples of analysis. More interestingly, the visualization of collaboration level of a communication activity is not limited to a single group of users. Figure 4.30 gives an example of visualization of two groups of users on three forums that have the same structure, dedicated to the group discussion on the same type of collaborative task.

![Figure 4.30](image)

**Figure 4.30** An example of data indicator for collaboration level of two groups of users

The analysis of data indicators illustrated in figure 4.30 can be carried out, for instance, to (i) compare the participation and productivity rates of both groups during the collaborative task, or (ii) to evaluate the level of collaboration of one group in relation to another.

### 4.4 Conclusion

This chapter is dedicated to a presentation of TrAVis, a technological solution that we are proposing to the participants in the leaning process with an objective to enhance their skills in analyzing and visualizing CMC traces. The presentation covered three important aspects in relation to:

(i) **TrAVis design approach** that mainly focused on the design guidelines and on our proposed data indicators of users’ activities on discussion forum,

(ii) **implementation of TrAVis**, which illustrated our choice of building a multi-component architecture, and the development technologies to build the latter,

(iii) **visualization of CMC traces** in different forms and scales with the assistance of TrAVis.

The presentation in this chapter also showed our reasoning in proposing:

(a) a variety of data indicators in order to support the analysis of users’ communication activities on discussion forum,
(b) original graphical representations of data indicators to make their visualizations in TrAVis a great assistance to users in interpreting the information of both the process and the product of a communication activity.

In the next chapter, we will discuss our case studies and experiments, where the participants were able to test TrAVis. Indeed, our main objective is to make an evaluation of TrAVis (data indicators included) with the feedbacks from the participants, particularly the tutors and the learners who use TrAVis in an authentic learning situation. The data obtained from case studies and experiments will be presented along with our quantitative and qualitative analysis.
Chapter 5

Case study, Experiment and Results Analysis
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Chapter 5 at first glance

This chapter is dedicated to a presentation of the three case studies and an experiment we have conducted during this research work. In section 5.1, we give an overview of the case study and experiment setup.

We present the three case studies in section 5.2. Our main objective is to evaluate the technical aspects of the tracking approach and the usability of the first prototype of TrAVis. At the end of this section, we discuss both quantitative and qualitative analysis of the three case studies.

Section 5.3 is dedicated to a presentation of our experiment in an authentic learning situation. The experiment focuses on the use of TrAVis to support the tutoring and learning activities in a context of FFL (French as Foreign Language or Français Langue Etrangère). Our main objective is to evaluate the utility of TrAVis and the proposed data indicators from the points of view of both tutors and learners of FFL. The results analysis and the assessment of the experiment will also be discussed.

We conclude this chapter with a broader perspective we gain from both case studies and experiment.
5.1 Introduction to case study and experiment

5.1.1 Overview

What we refer to as a case study, is a preliminary test or a semi-controlled experiment that particularly focuses on the Web-based tracking system and the first prototype of TrAVis. The participants are not necessarily our target users, but research colleagues, lecturers and students from different disciplines. However, they are requested to play roles as tutors and learners, whose activities are guided by a scenario, specifically designed to attain the objectives of the case study (presented further in section 5.2.1). On the other hand, an experiment focuses on the use of TrAVis in an authentic learning context of FFL (already presented in section 2.1.2 of chapter 2). The objectives of the experiment are declared in section 5.3.2.

5.1.2 Case study and experiment setup

The setup of the case study and experiment shared the same technical characteristics. Figure 5.1 illustrates the multi-tier architecture of the setup.

![Multi-tier architecture setup for case study and experiment](image_url)
While viewing figure 5.1, we give a brief description of the components of the architecture.

(A) Moodle, a Web-based CMS was installed on an individual server\(^6\) to manage the personal data of the participants (e.g. user profile) and other contents related to their learning activities (e.g. enrolled courses).

(B) Confor server, developed by our collaborators, a research team from LICEF research center\(^7\) of Télé-université of Québec, Canada, as a Web service of contextual forum (see section 2.1.3 for further discussion on Confor). Confor possesses its own database that stores the profile data of the participants (duplicated from Moodle database) and their discussions (forum structures and messages). Confor server is also hosted by LICEF and accessible via a Web service client\(^8\).

(C) Confor client, developed by our research team as a Web service client with the capacity to be integrated in a diversity of Web-based CMS, including Moodle. It allows the participants to structure their communication activities according to their learning activities (see example in figure 5.2 below). In both case study and experiment, the discussions among the participants were done entirely on Confor and not on the Moodle built-in forum.

(D) Tracking system, built with a number of traces collectors (Cf. section 3.3.2) and integrated in both Moodle and Confor, to observe the activities of the participants.

(E) Trace repository, a centralized database (Cf. section 3.3.3) implemented on an individual server, locally situated at our laboratory\(^9\). It is to store all the CMC traces submitted from different traces collectors.

(F) TrAVis, hosted on the same server as Moodle to allow the participants to visualize and analyze their CMC traces in real time.

The multi-tier architecture as shown in figure 5.1, provides us with significant advantages among which, the independence of each component and the reusability of the setup in a variety of CMS and CMC tools. For example, the forum structures and contents are stored on Confor server database and not on Moodle’s. It is then possible to transfer them to another CMS (e.g. Dokeos, Claroline, etc.) that supports the integration of Confor client. Furthermore, the traces repository is separated from Moodle, which enables TrAVis to access to the recorded traces without having to reconnect to the latter.

Figure 5.2 is a screenshot of Moodle and Confor from our experiment (presented further in section 5.2). It gives an example of a structure of learning

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\(^6\) Moodle is hosted on http://www.madethmay.com

\(^7\) LICEF Web site: http://www.licef.teluq.uquebec.ca

\(^8\) List of available Web services: http://poseidon.licef.teluq.uquebec.ca:8080/confor/services/ConforWebService?wsdl

\(^9\) Laboratoire d'Informatique pour l'Entreprise et les Systèmes de Production (LIESP), Web site: http://liesp.insa-lyon.fr
activities on Moodle and the related discussions, carried out by a group of learners on Confor client.

![Diagram of Moodle and Confor](image_url)

**Figure 5.2** A screenshot of Moodle and Confor

(A) The learning activities on Moodle are structured hierarchically in a tree format. Each activity has a dedicated forum, in which all the discussions related to it will be conducted.

(B) The Confor client is integrated in Moodle in a form of a floating window, allowing the participants to view on the same screen, both their learning and communication activities.

(C) The communication activities are presented in a list of discussion threads, displayed on the left panel of Confor client. The list is automatically updated and contextually displayed when a learning activity in Moodle is selected.

(D) The messages of a discussion thread are displayed on the right panel of Confor client.
Chapter 5: Case study, Experiment and Results Analysis

5.2 Case study

5.2.1 Objectives of the case study

Three case studies were conducted with the following objectives:

- Evaluate the proposed tracking approach by concentrating on its technical aspects:
  - Feasibility of the tracking system with multiple “traces collectors”,
  - Effectiveness of the trace collector in simultaneous observation of the CMC activities on both client and server side,
  - Synchronization process of CMC traces,
  - Quality of the collected traces
- Introduce the first build of TrAVis (prototype) to the participants and demonstrate the benefits of using it in their actual practices (see section 4.1.2 for further explanation),
- Identify both technical and practical issues related to TrAVis to be taken into account for further improvement,
- Study the feedbacks of the participants while using TrAVis to visualize their CMC traces,
- Investigate the real needs of the participants in terms of tracking CMC activities and exploiting CMC traces with TrAVis.

5.2.2 Progress of the case study

In each case study, two different use scenarios (see example in annex H) were prepared to guide the participants on Moodle and Confor. To make the communication activities more relevant to the learning activities, a random course was picked by our research team and integrated in Moodle. Therefore, the participants were invited to carry out their discussions on different topics regarding the course contents, assignments, quizzes, etc. The two use scenarios consist of the following activities:

1. Browsing the forum structure,
2. Viewing course content (in Moodle),
3. Posting new messages in the forum,
4. Replying to messages in the forum, and
5. Reading message in the forum.

The first use scenario was distributed to half of the participants, and the second scenario to the other half. The main idea of having two use scenarios is to make sure that a large number of participants will not do the same actions, on the same things, or at the same time. In addition, it is more interesting for us to analyze the collected traces and attempt to identify different behaviors of the participants with the assistance of TrAVis.

While the participants follow the given use scenario, they also get access to TrAVis to visualize the traces of their ongoing activities.
At the end of each case study, the participants were requested to fill in a questionnaire (see annex I) to evaluate TrAVis at its first stage of development. They were also invited to express their needs in terms of tracking the communication activities and using a tool like TrAVis in their online teaching and/or learning practices.

5.2.3 Results analysis

Table 5.1 summarizes the quantitative data of the three case studies.

<table>
<thead>
<tr>
<th>Number of case study</th>
<th>Number of participants</th>
<th>Number of messages</th>
<th>Duration (minutes)</th>
<th>Number of records</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
<td>62</td>
<td>30</td>
<td>1037</td>
</tr>
<tr>
<td>2</td>
<td>26</td>
<td>83</td>
<td>45</td>
<td>1399</td>
</tr>
<tr>
<td>3</td>
<td>26</td>
<td>147</td>
<td>45</td>
<td>2421</td>
</tr>
</tbody>
</table>

The analysis of the data from the three case studies is separated into two parts. The first, focuses on the interpretation of the recorded traces to assess the technical aspects of the tracking system. The second part, is more relevant to a qualitative analysis of responses of the questionnaire on the first build of TrAVis.

(1) Tracking system assessment

- **Effectiveness of tracking system**
  
  To assess how effective our tracking system is in terms of data collection, we can refer at first to the quantity of the collected data. Since Moodle, the CMS used in our case studies, also keeps track of user navigation (user activity on course modules as well as the HTTP queries exchanged between Confor client and Confor server), it is interesting for us to look at the traces captured by both Moodle built-in tracking system and our integrated tracking system.

  In the first case study, with only 8 participants and within 30 minutes, our tracking system registered 1037 records where one record represents an action or interaction of a user on Moodle (e.g. user clicks on a link). This number is almost two-thirds higher than the records in Moodle internal log files as for the same amount of user actions and interactions, only 375 records are registered. This is due to the fact that our tracking system is capable of observing user activity on both client and server side, thus resulting in a production of a large quantity of records. In addition, each record has a finer granularity (see example in figure 4.16 in section 4.3.1 of chapter 4), to which a first conclusion can be drawn that there is (i) an efficient data synchronization process between multiple traces collectors and (ii) a low data loss rate.
- **Traces analysis**
  Another interesting analysis of the recorded traces from the case studies, is to verify whether or not, two distinctive behaviors corresponding exactly to the two use scenarios can be identified.

  In the second and third case studies, there is a big difference in the number of records, although the two were conducted with the same number of participants and within the same amount of time. This can be explained by the fact that in the third case, the participants exchanged a large number of messages. This type of behavior usually happens when there are interesting postings on a particular discussion topic. By looking at the recorded traces, we found that the participants conducted other activities, which are not described in the given use scenario. Since every user action is tracked, it is usual to find out at the end of the third experiment, a high number of records generated. In fact, there are almost 73 percent of extra records comparing to the second case. Additionally, interesting information can be extracted from these records. Two different communication behaviors corresponding to the two given scenarios were identified in the second case study. Meanwhile, we also found out that more than 80 percent of the participants from the third case did not correctly follow what was specifically described in the use scenario.

  To conclude, the tracking system demonstrates its efficiency in collecting pertinent information of user CMC activity, which is beneficial to analysis of the activity. As a matter of fact, with the support of TrAVis, we are able to easily identify not only the two expected behaviors corresponding to the two use scenarios, but also another behavior, from the third case study, which does not correspond to either of the two use scenarios.

**(2) User feedbacks on TrAVis prototype**

- **Questionnaire and response rate**
  Table 5.2 displays the number of participants categorized by title and sorted by the number of responses we received.

<table>
<thead>
<tr>
<th>Participants (total number)</th>
<th>Number of responses received</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student (25)</td>
<td>13</td>
</tr>
<tr>
<td>Lecturer/Researcher (16)</td>
<td>8</td>
</tr>
<tr>
<td>Professor (11)</td>
<td>5</td>
</tr>
<tr>
<td>Engineer (8)</td>
<td>2</td>
</tr>
</tbody>
</table>
28 out of 60 participants responded to the questionnaire on TrAVis prototype. We consider such response rate a success and sufficient for our study for two reasons. First, there is a good variety of participants among the 28 who are specialized in the fields of Information Technology (IT) and Technology Enhanced Learning (TEL). This makes the data from the questionnaire more significant to our study. Second, the data showed a great interest by the participants in TrAVis. Indeed, 19 of them expressed their willingness to use the proposed tracking approach and TrAVis in their academic activities. More interestingly, the participants evaluated the first build of TrAVis according to their expertise and experiences in the research context that is close to ours. For this reason, their feedback is a key enabler for us not only to determine what needs to be improved in the next version of TrAVis, but mostly to explore new concepts for traces analysis and visualization.

What we analyze
We aim at making a first evaluation of TrAVis by focusing on the following practical aspects:
(i) usability and flexibility of user interface: the ease of use of TrAVis for users with and without limited technical skill,
(ii) functionality of the visualization tools: the accessibility of the tool in the traces visualization process and the convenience of manipulating each tool,
(iii) representation of traces: the graphical forms of traces (data indicators) and their usefulness to the information analysis.

Below, we present a qualitative analysis of responses from the questionnaire to identify what the participants appreciate, and what needs to be improved within TrAVis regarding the practical aspects mentioned above.

What the participants appreciate
The design of TrAVis user interface received the most positive evaluation. Most participants appreciated the clean interface, which is intuitive and at the same time, practical for them to access different tools of TrAVis. To give an example of the first hands-on impressions of the participants on TrAVis, we quote some of their comments as follows:

- **Participant 1**: “Belle réalisation, l'interface est fluide et intuitive”, which means “the interface is well implemented, smooth and intuitive”.

- **Participant 2**: “L'interface est très jolie, cela donne envie de revenir c'est déjà pas mal, ensuite les informations sont claires et après l'avoir fait une ou deux fois, c'est facile à refaire et utiliser donc c'est encore bien.”, which can be translated as “The interface is beautiful, which incites me to reuse it. Additionally, the information is clear and after using it a couple of times, it is getting a lot easier, which is even better”.

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- **Participant 3**: “l'interface, c'est agréable à utiliser”,
  that simply refers to
  “the interface is pleasant to use”.

- **Participant 4**: “Interface originale, claire et très bien présentée”,
  which means
  “Original interface, clean and well presented”.

Regarding the evaluation of the first data indicators, available during the case studies (see examples in section 4.3.2 of chapter 4), most participants acknowledged the originality of their visual forms and the pertinent information they feature. Particularly, the participants appreciated
(i) the control they had over the visualization process by adjusting the scale and temporal parameters of data indicators, and
(ii) the flexibility of the visualization with a possibility of switching back and forth between the detail and the global view.

Moreover, despite the lack of real tutoring and learning objective in the three case studies, the participants gave a view on how the proposed data indicators can be exploited in a real learning context. For example, the comments we quote below reflect how the participants perceived the utility of TrAVis in distance learning.

- **Participant 1**: “TrAVis pourrait être utile pour l'analyse des échanges réalisés sur les forums associés à des plate-formes de formation à distance en vue de déterminer des profils d'utilisateurs”,
  which can be translated as
  “TrAVis can be useful to the analysis of exchanges between users to identify their profiles on the forums, associated to distance learning platforms”.

- **Participant 2**: “C'est un bel outil de comparaison de profils”,
  or in other words,
  “It is a nice tool for comparing user profiles”.

- **Participant 3**: “Permet une lecture assez intuitive des données représentées graphiquement”,
  which also means
  “It enables a view of the data in an intuitive graphical representation”.

- **Participant 4**: “Pour le suivi pédagogique, pour aider l'étudiant à évaluer son implication”,
  that refers to
  “To support the pedagogical monitoring and to help student evaluate his/her implication (in the communication activity)”.
Chapter 5: Case study, Experiment and Results Analysis

What needs to be improved

While most of the participants did not find any difficulty in using TrAVis for the first time, some suggested we:

- add tooltips on each button to display the function of the tool
- provide an alternative means to fill in the information on TrAVis user interface to facilitate the visualization, and
- document the functionality of each tool.

It is considered that these comments did not have any significant negative impact on the use of TrAVis as used now. Nevertheless, the improvement of TrAVis is a part of both our near and long term intention. That is why the current version of TrAVis, presented in chapter 4, has been implemented with a new interface component, which increases the ease of use in the traces visualization process. For instance, while the essential information needed to visualize the data indicators can be now either manually inserted or selected from a preset list (see section 4.2.4), a user’s guide has also been created for users who might eventually need technical support in manipulating the visualization tools of TrAVis (see annex E).

Another important aspect that most of the participants mentioned in the questionnaire, is the possibility of visualizing CMC traces of multiple users at the same time. We recognize the importance of the requested feature and how advantageous it is in practice. Consequently, a new visualization tool has been implemented in TrAVis (already presented in section 4.3.4) along with new visualization techniques to enable users to compute data indicators containing:

(i) a number of activities of a single user,
(ii) a number of activities of a group of users, or
(iii) a number of activities of different groups of users.

5.2.4 Assessment of the case study

As an overall evaluation from a technical standpoint, we could say that the tracking approach was successful in achieving its goals. In addition, the web-based tracking system that we implemented for the case studies has not only proved the feasibility of the approach, but also justified the reason why we need tracking data with finer granularity in order to produce substantial data indicators of CMC activities.

The results from the three case studies are very encouraging. We received a great deal of positive feedbacks from the participants on our web-based tracking system, as well as on TrAVis prototype. Aspects the participants particularly appreciated, were the proposed data indicators in original graphical forms, the significant information they feature, and their potential utility in supporting the analysis of CMC activities in learning situation. In addition, the first evaluation we made on TrAVis resulted in a positive manner. It therefore encourages us to continue our research direction, by placing our emphasis on the improvement of TrAVis at both practical and functional levels to match better the needs of our target users.
5.3 Experiment in an authentic learning situation

5.3.1 Context of the experiment

Our collaboration with the research colleagues from LIDILEM laboratory\(^\text{10}\) of Stendhal University of Grenoble 3, gives us a privilege to conduct our experiment on a FFL online course “Computer Supported Collective Learning”, where learners are obliged to use CMC tools to perform their learning tasks. FFL, already presented in detail in section 2.1.2 of chapter 2, is a two-years-professional-master course to train learners to be tutors, specialized in French language teaching. Our experiment took place with one of the course modules, titled “Creating Pedagogical Scenario” during which the learners worked together with the support of Moodle and Confor to create a learning scenario for a French class. Separated into groups, the learners were supervised by tutors. Each group had several learning tasks undertaken by group discussions in a collective manner – e.g. the discussion on the organization, negotiation and distribution of the tasks among the group members, etc. At the end of the course module, the learners were evaluated by their tutor as a group and individually. Table 5.3 summarizes the context of the experiment.

### Table 5.3 Summary of the experiment context

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of learners</td>
<td>13</td>
</tr>
<tr>
<td>Number of groups</td>
<td>3 (1 group of 5 learners and 2 groups of 4 learners each)</td>
</tr>
<tr>
<td>Number of tutors</td>
<td>3 (1 tutor for each group of learners)</td>
</tr>
<tr>
<td>Start date</td>
<td>12(^{th}) of February 2009</td>
</tr>
<tr>
<td>End date</td>
<td>30(^{th}) of April 2009</td>
</tr>
<tr>
<td>Learning platform</td>
<td>Moodle</td>
</tr>
<tr>
<td>Communication tool</td>
<td>Discussion forum Confor and Moodle built-in chat</td>
</tr>
<tr>
<td>Traces visualization tool</td>
<td>TrAVis (accessible by both tutors and learners)</td>
</tr>
</tbody>
</table>

5.3.2 Objectives of the experiment

The main objectives of our experiment are to:
- Evaluate the functional level of TrAVis from the point of view of the tutors and learners,
- Study the impact of TrAVis in an authentic learning situation like FFL,

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\(^{10}\) Laboratoire de linguistique et didactique des langues étrangères et maternelles. Web site: http://w3.u-grenoble3.fr/lidilem/labо/
Chapter 5: Case study, Experiment and Results Analysis

- Evaluate the design approach of the proposed data indicators according to the pedagogical and learning objectives of the participants,
- Explore new concepts of traces visualization and analysis to better support online tutoring and learning practices.

5.3.3 Progress of the experiment

We present below the fundamental steps of the experiment, in which our implication is significant in terms of providing the participants with both our supports and technological solutions.

- **Collaborate with the tutors**
  Throughout the experiment, we have been working very closely with the tutors on two important aspects. The first is related to the use of Confor to enhance the tutoring activities in the context of FFL. We demonstrated the benefits of Confor in relation to other standard discussion forums, by emphasizing the technical capacity of Confor in increasing the ease of supervising the communication activities between learners. The second aspect is our exchange of ideas with the tutors, on how TrAVis can be of great assistance to them in the tasks of evaluating the learners.

- **Moderate the experiment**
  The setup of Moodle and Confor for the experiment is presented earlier in section 5.1.2. A “user’s guide” on how to use this setup can be found in annex J. Alongside the progress of the experiment, we had been acting as administrator, providing the participants with our technical supports related to their activities on Moodle. For example, we helped the learners:

(i) create new or alter the structure of their learning activities on Moodle.

![Figure 5.3 An example of a structure of learning activities on Moodle](image-url)
Figure 5.3 illustrates an example of how different activities of a group of learners are organized in a tree structure. The title of each tree node corresponds with a context of the communication activities. For instance, the node “Tâche I” is dedicated to the group discussion to fulfill the first task while the node “Tâche Finale” is for the final task, and so on.

(ii) create new or modify the existing contextual forums. Indeed, while the communication activities evolve in terms of the learning activities, the structure of the contextual forums is also regularly updated. This can be done on the request of the learners.

- **Setup TrAViS**
  During and after the experiment, both tutors and learners were granted access to different tools of TrAViS according to their profiles. While tutors had full access to the traces of each learner, some restrictions on traces visualization can be made conforming to the request of learners. For instance, a learner could at any moment request to set his/her traces inaccessible to either a tutor, or other learners who are not in the same group.

- **Evaluate TrAViS**
  The crucial step at the end of the experiment is the evaluation of TrAViS from the point of view of both tutors and learners. To do so, we created a questionnaire (see annex K) that covers two major aspects:
  
  (i) the functional level of TrAViS, which mainly focuses on the user interface and its usability, and
  
  (ii) the data indicators computed by TrAViS and the level of their utility in the context of FFL.

### 5.3.4 Results analysis

In this section, we present the data of the experiment and the result analysis of the questionnaire.

(1) **Some data from the experiment**
Table 5.4 summarizes the quantitative data of the communication activities of the three groups of learners.

<table>
<thead>
<tr>
<th>Table 5.4 Quantitative data of the communication activities from the experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of contextual forums</td>
</tr>
<tr>
<td>Number of discussion threads</td>
</tr>
<tr>
<td>Number of messages</td>
</tr>
<tr>
<td>Number of files</td>
</tr>
</tbody>
</table>
Table 5.4 reveals a very interesting aspect related to the intensity of the communication activities of the learners. Notably, within a period of less than three months, 330 discussion threads were created in 28 forums and over 2804 messages were exchanged among the learners. It shows that, on average, 36 new messages were posted per day and each user posted around 215 messages throughout their learning activities.

(2) Data from the questionnaire
Regarding the questionnaire of TrAVis, we have received 6 responses from the learners, and 1 response from a tutor. Below, we present a qualitative analysis of the data from the questionnaire by focusing on our main objectives – evaluating TrAVis in terms of:

- **Usability**
  As in the three case studies, previously presented in section 5.2, TrAVis user interface received, once again, the most positive evaluation. Of interest, despite the fact that most of the learners are non-specialist computer users, they find TrAVis easy to use and handy, as mentioned in the comments below:

  - **Learner 1**: “Je trouve l’interface très enjouée et colorée. Il y a beaucoup de boutons mais ils paraissent tous nécessaire, et permettent de cibler un point spécifique d’une quelconque recherche”, which can be translated as “I found the interface very cheerful and colorful. There are many buttons but they all seem to be necessary to enable the information searching at a specific point”.

  - **Learner 2**: “L’outil est très maniable, au début, on réussit assez bien à le faire fonctionner un peu, même instinctivement, sans mode d’emploi”, which means “The tool is very handy. I can instinctively use it from the beginning and without a user’s guide”.

The comment from the second learner is very interesting for the fact that it points out that even without a user’s guide, the learner could easily operate TrAVis. From a developer standpoint, it is important for us to ensure TrAVis the most practical to the users so that they will not have to spend time exploring how to use it, but start to exploit immediately, its functionalities and services.

Some other learners expressed in a few words to give their appreciation on the interface design of TrAVis and its usability. As found in the two following comments,

- **Learner 3**: “The presentation is awesome” (this comment was originally written in English)
Learner 4: “Interface est très agréable”, which refers to “The interface is very pleasant to use”.

Besides the good evaluation scores and positive comments on using TrAVis, some minor difficulties were also stated as follows:

Learner 5: “J’ai eu un peu du mal à comprendre les finalités des différentes fonctions au début”, which also means “At the beginning, I had a little difficulty understanding the purpose of each tool”.

Learner 6: “Même si j’ai apprécié l’interface, et l’ai bien noté, il m’a fallu un peu de temps pour comprendre le fonctionnement du projet” that can be translated as “Even if I appreciated the interface, and gave it a good score, it took me a while to understand the functionality of the project (TrAVis)”.

We recognize that some practical issues might eventually occur when users get to experience TrAVis for the first time. That is why we created a user’s guide (see annex E) to assist the users in the process of visualizing traces with different tools of TrAVis.

Utility of data indicators
The second part of the evaluation of TrAVis places a special focus on the utility of the proposed data indicators. More precisely, we aim at evaluating the data indicators at a conceptual level (i.e. design approach). Below, we quote the comments of the tutor and learner, reflecting how they perceived the utility of the proposed data indicators and the impact of using TrAVis within their online tutoring and learning practices.

Tutor 1: “Les indicateurs Lecture et Envoi de messages me semble très utiles”… “Visualisation des discussions : ces indicateurs sont très intéressants lorsque l’on compare les résultats pour plusieurs étudiants”… “Les indicateurs sur les profils sont très intéressants”… “Les indicateurs Discussion sont intéressants lorsqu’il y a eu des échanges sur chat sur forum”, which means “The indicators of Reading and Sending messages seem very useful”… “Visualizing the discussions: these indicators are very interesting for the comparison of the results of many students”… “The indicators on the profiles are very interesting”… “The indicators Discussion are very interesting if there were exchanges in the chat and in the forum”.

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• Utility of data indicators
The second part of the evaluation of TrAVis places a special focus on the utility of the proposed data indicators. More precisely, we aim at evaluating the data indicators at a conceptual level (i.e. design approach). Below, we quote the comments of the tutor and learner, reflecting how they perceived the utility of the proposed data indicators and the impact of using TrAVis within their online tutoring and learning practices.

□ Tutor 1: “Les indicateurs Lecture et Envoi de messages me semble très utiles”… “Visualisation des discussions : ces indicateurs sont très intéressants lorsque l’on compare les résultats pour plusieurs étudiants”… “Les indicateurs sur les profils sont très intéressants”… “Les indicateurs Discussion sont intéressants lorsqu’il y a eu des échanges sur chat sur forum”, which means “The indicators of Reading and Sending messages seem very useful”… “Visualizing the discussions: these indicators are very interesting for the comparison of the results of many students”… “The indicators on the profiles are very interesting”… “The indicators Discussion are very interesting if there were exchanges in the chat and in the forum”.

□ Learner 4: “Interface est très agréable”, which refers to “The interface is very pleasant to use”.

Besides the good evaluation scores and positive comments on using TrAVis, some minor difficulties were also stated as follows:

□ Learner 5: “J’ai eu un peu du mal à comprendre les finalités des différentes fonctions au début”, which also means “At the beginning, I had a little difficulty understanding the purpose of each tool”.

□ Learner 6: “Même si j’ai apprécié l’interface, et l’ai bien noté, il m’a fallu un peu de temps pour comprendre le fonctionnement du projet” that can be translated as “Even if I appreciated the interface, and gave it a good score, it took me a while to understand the functionality of the project (TrAVis)”.

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The comment from the tutor shows not only how interesting the data indicators are, but also how they can be useful in the tutoring activity. For example, the tutor pointed out that the data indicators for the discussion level (see section 4.3.4) enable the analysis of the exchanges among the learners in chat and in forum, as well as the comparison of their results. The tutor also added that

“Je suis certaine que plusieurs d’entre eux seraient très utiles dans le cadre d’un cours pour lequel l’enseignant-tuteur aurait à évaluer (voire à noter) précisément le travail réalisé par chaque intervenant au cours d’une discussion et/ou d’une activité collaborative.”, which also means

“I’m sure that many of those indicators would be very useful in a course where the tutor will have to evaluate (or to give a score) the task being conducted by each learner during a discussion and/or a collaborative activity.”.

Regarding the evaluation made by the learners, we noticed that it was based on both tutor and learner perspective. In fact, some of the learners have already been practicing their teaching activities alongside their FFL training courses. Therefore, their comments, as presented below, reflect their appreciation on TrAVis from different standpoints.

- **Learner 1**: “... it allows the teacher to analyze and evaluate the identify dynamics and practices of its students. Besides the frequency of connections, the 4 indicators (aggregation, cooperation, discussion, collaboration) allow the online tutor to evaluate the engagement and the learning motivation of each participant.”... “TrAVis allows visualizing the trajectories of practices so the tutor can proceed to an instructional adjustment in a realistic situation.”... “I am positive about the innovative learning approach that the use of TrAVis may imply.”... “It gives me a whole new perspective on practice, learning, identity dynamics and motivation.” (the comment was originally written in English)

Such comment drew our attention to one crucial aspect regarding how the four levels of data indicators (see section 4.1.3 and 4.3.4) actually help the tutors not only to identify the different levels of interaction among the learners during their communication activities, but mostly to evaluate the engagement and the learning motivation of each learner

Another learner had been a little more specific on the use of the proposed data indicators from a learner perspective. As mentioned in the following comment, TrAVis can be an interesting tool or even essential for a learner or a tutor in monitoring at the same time an individual or a group of learners.
Learner 2: “Du point de vue d’un étudiant, mais aussi d’un tuteur, on peut suivre un groupe de façon technique et voir l’utilisation réelle des outils et suivre la participation de chacun. Quand on gère un groupe, la prise en compte du nombre, la participation de tous est difficile à gérer et peut être un facteur de non réussite d’un projet. Un outil comme TrAVis devient donc vite intéressant, et sûrement indispensable.”

that can be translated as
“From the perspective of a learner, but also of a tutor, we can technically observe a group of learners and their activities on the tool (i.e. forum) as well as monitor the participation of each individual. When we manage a group, taking into account the participation of the group is difficult, which can be a contributing factor to the failure of the project. Therefore, a tool like TrAVis could quickly become interesting and certainly essential.”.

The remaining learners did not give a very descriptive evaluation of how TrAVis data indicators could be used in their learning practices, as found in the two comments below.

Learner 3: “Je trouve tous les indicateurs intéressants.”,
that refers to
“I found all data indicators interesting”.

Learner 4: “Cela me semble un outil très utile, que j’aimerais utiliser si je devais travailler sur une plateforme pédagogique par exemple.”,
which means
“It seems a very useful tool that I would like to use if I happen, for example, to work on a pedagogical platform.”.

The evaluation of TrAVis also reveals some issues related to the representation of the data indicators. As expressed in the following comments, the visual forms of some data indicators cause some difficulties in the information interpretation, which obviously require the participants to spend more time on the visualization.

Learner 5: “Je dirais que ce n’est pas évident au premier coup d’œil. Il m’a fallu un bon moment, de la pratique et de la concentration pour voir ce qu’on pouvait utiliser d’un point de vue pratique dans chaque fonctionnalité.”,
that also means
“I would say that it is not obvious at first glance. It took me quite a while, and I need some practice and concentration to figure out what I could make use of each functionality”.
Learner 6: “Certains graphiques, comme pour les indicateurs Collaboration, sont pour moi un peu difficiles à comprendre (en même temps, je n’ai pas réellement utilisés.”,
Which refers to
“Some graphics, such as indicators for Collaboration, are for me a little difficult to understand (having said that, I only spent a few minutes to visualize those indicators and I have not actually used them.”.

5.3.5 Assessment of the experiment

From a global perspective, the experiment has been a great experience for our research team. It has also been a valuable opportunity for us to put our research approach into practice. While the experiment was a success, we also achieved our main goals – evaluating TrAVis and the proposed data indicators according to the pedagogical and learning objectives of the participants of FFL.

The evaluation we made on TrAVis turned out to be very positive. In fact, the data from the questionnaire showed good appreciation of the participants on TrAVis. Additionally, both learners and tutors clearly expressed their points of view on the utility of TrAVis in their online tutoring and learning activities. In addition, they also provided us with significant feedback on the issues related to TrAVis they encountered during the experiment, which are most helpful for the improvement of TrAVis in both technical and practical aspects. However, they did not provide us with information to evaluate whether or not the proposed data indicators reflect the reality of the CMC activity.

5.4 Conclusion

Both case study and experiment allow us to gain a broader perspective on the two important aspects:
(i) tracking CMC activity in distance learning strongly relies upon the tracking system with the technical capacities as described in our tracking approach (Cf. chapter 3),
(ii) exploiting CMC traces varies according to a number of factors, among which three are essential: the context of the CMC activity, the learning situation and the real need of the users.
To summarize, the case study and experiment we present in this chapter reflect the scientific approach of our research work in the phase of evaluating
(a) the efficiency our Web-based tracking system, and
(b) the type of assistance of TrAVis to the participants in the learning process.
Conclusion and Perspectives
Summary of this research

Our research started with an in depth study on
(i) the research interests in using Computer-Mediated Communication (CMC) tools to support the interactivities amongst the participants in the learning process, and
(ii) the positive effect of tracking solutions in distance learning environments.

In the study, we emphasized the contribution of tracking solutions to online teaching and learning enhancements. We demonstrated the beneficial outcomes of the tracking process, which are directly related to the acquisition of useful data indicators to support the participants in terms of awareness, assessment and evaluation of their CMC activities. In the same study, we also acknowledged the security and privacy concerns related to user tracking in learning situations, which are often neglected in research efforts.

We explored different tracking approaches to obtain a better perspective on the limitations of the existing tracking mechanisms, and of their application possibilities in our research. Therefore, we concentrated on the main issues regarding (i) traces collection, (ii) traces structuring, and (iii) traces visualization. To improve upon these studied issues, we have proposed:

- An explicit tracking approach to produce tracking data with substantial information of the process and the product of a user activity on CMC tools.
- A generic model of CMC traces to resolve the problems of CMC traces structuring, operation and re-use.
- A platform TrAVis to assist the participants in the task of analyzing and visualizing the CMC traces.

We implemented different components of the tracking system with the purpose of continually improving them for further usage in a variety of CMC tools. Technically, we chose the Web-based technologies that are largely used in most learning platforms and CMC tools. We also developed TrAVis with Web-based technologies that provide the users with the flexibility in visualizing the CMC traces. The development of TrAVis features two other important aspects in relation to:

(i) The design approach of data indicators: we concentrated our efforts on designing data indicators at the conceptual level. Our challenge has been how to design pertinent data indicators to allow a better interpretation of the information on CMC activities.

(ii) The visual form of data indicators: we demonstrated that the visual forms of data indicators play an important role in the visualization and analysis process. From both technical and practical standpoints, data indicators should be illustrated in graphical form, as they are not only intuitive and compelling, but mostly easy to visualize.
At the current stage of this research, three case studies and an experiment have been conducted. The main objective of the case studies was to evaluate the effectiveness of the tracking system and the ease of use of the first prototype of TrAVis. Each case study has been a success as the results were both positive and very encouraging. Indeed, we were able to gather enough data to conduct an overall evaluation of the technical aspects of both the tracking approach (i.e. collecting traces) and model of traces (i.e. structuring and storing traces). In addition, the three case studies also produced positive results, which led us to make significant improvements of TrAVis in terms practical use.

The three case studies had been considered an intermediate step to our experiment, which has been conducted in an authentic learning situation with the participation of both tutors and learners from FFL. The objective of the experiment was to evaluate TrAVis and the proposed data indicators according to the pedagogical and learning objectives of the participants. In terms of usability, TrAVis received a good evaluation along with a large number of positive comments. Both tutors and learners appreciated the accessibility of TrAVis and its technical capacity in generating data indicators in real time. Furthermore, the participants had clearly pointed out the utility of the proposed data indicators computed by TrAVis, in their actual practices. The experiment allowed us to validate the design approach of data indicators and their visual forms. It also gave us a broader perspective on making TrAVis more beneficial to other learning contexts.

**Contribution of this research**

Our research has made scientific contributions in several areas as presented below.

At the beginning of our research, we had studied the different nature and sources of tracking data in Technology Enhanced Learning, by concentrating on how each method of data collection operates, and in what kind of learning situation each method is used. The study presented a fundamental aspect that has an impact on the choice of designing and building a tracking approach for distance learning environments. It also covered the practical issues in both human and technology factors of each method. Therefore, the study is considered to be very useful to other research efforts involved in designing tracking approach for a specific learning situation.

While having addressed the main key issues related to tracking process on CMC tools, we also proposed an explicit tracking approach not only to improve upon the deficiency of the existing ones, but mainly to unveil new possibilities of tracking user activity on CMC tools. The proposed approach focuses on a tracking mechanism that observes simultaneously different types of
Human and Computer Interactions occurring during a CMC activity. Indeed, it can be beneficial to the researchers/developers who are interested in implementing a tracking system, to efficiently collect traces of users’ communication activities on a Computer-Mediated environment.

Another important contribution of our research effort is the solution to the problems relating to traces structuring or representation. We formalized a generic model of CMC traces, from which standard or specific models can be created; and used for various CMC tools. The proposed model aims at answering the technical problems of inter-operational and reuse of traces. Indeed, it enables a representation of identical traces in different computerized formats that remain consistent to a unique model, thus allowing the inter-operational and reuse of the existing traces.

TrAVis was developed with the objective to support not only the tutors, but also the learners in the task of visualization and analyzing CMC traces. For tutors, TrAVis offers a new experience in visualizing in real time, the traces of learners on CMC tool. For learners, TrAVis is a “reflexive tool” that helps them increase their consciousness of their activities in the learning process. Besides, TrAVis is a platform dedicated to be of great assistance to users when exploiting their traces during and after their activity, allowing them gain an insight on both their ongoing and past activities. TrAVis is also dedicated to the learning situation, as a guide that assists the participants to acquire an overview of their personal learning progress, their participation rate in social interactions, or other statistical data from their CMC activities, etc.

The design of data indicators of CMC activities is another important contribution of our research work. We proposed a different set of data indicators in graphical representations to increase the ease of use in analyzing the CMC activity. More importantly, those data indicators support the evaluation of the level of interaction (i.e. aggregation, discussion, cooperation and collaboration) of an individual or a group of users during a CMC activity. The proposed data indicators reveal an original concept of analyzing CMC activity in a learning situation.

**Perspectives**

We place a special focus on the improvement of TrAVis at the functional level. We are particularly interested in implementing a new tool in TrAVis, called “Editor of data indicators”, to enable the users to compose a new series of data indicators by using the existing ones. This means that instead of having one single indicator describing a unique CMC interaction; users can combine multiple indicators to compute new types of indicators, which are beneficial to the analysis of a sequence of CMC interactions. From a personal standpoint, such tools can be
of practical help to users, not only to customize the data indicators to match better their needs, but mostly to create a visualization that serves their specific analysis. Another significant advantageous of this tool is that it allows the users to perform an analysis of CMC interactions in different manners by just changing the combination of data indicators.

Since our research involves tracking CMC activities in general, we are interested in studying how our tracking approach can be used in other types of learning environments, in which the communication activities among the participants are performed on different tools and at the same time. For instance, we are willing to conduct an experiment in a learning situation where the participants share the same workspace to interact among each other instead of using standard communication tools such as discussion forum, and chat. Our main objective is to explore new types of communication activities that consist of more complex interactions, and that might suggest a new tracking mechanism to be used.

The experiment we have conducted in an authentic learning situation helps us gain a broader perspective on how TrAVis enhances the online tutoring and learning activities. Nevertheless, we aim at investigating both the positive and negative impact of TrAVis in the tutoring and learning process. For example, we are interested in studying whether or not, when using TrAVis, the learners change their behaviors in their group activities. We are willing to collaborate with both tutors and learners from other disciplines and to conduct more experiments.
Résumé de thèse en français

Sujet de thèse

Les traces des interactions médiatisées sont une source privilégiée d’information pour comprendre comment les apprenants pourraient « mieux » collaborer ou comment les enseignants pourraient « mieux » intervenir. Cette thèse se focalise sur les traces de discussions synchrones et asynchrones et, en particulier, sur les situations de discussions, négociations et argumentations entre apprenants à distance. L’objectif est d’étudier comment utiliser ces traces pour concevoir des outils réflexifs pour les acteurs d’une formation à distance (apprenants et enseignants-tuteurs).

Un des objectifs de cette thèse est de développer un formalisme pour la représentation des traces issues de communications médiatisées. Ce travail s’appuie sur l’élaboration de la « théorie de la trace » réalisée par la tâche T1 du projet EIAH du Cluster « informatique, signal et logiciels embarqués ». La création de ce formalisme spécifique sera utile pour dépasser l’état de traces brutes (corpus de discussion) et viser la construction de traces plus évoluées rendant possible une analyse de l’utilisation d’un outil de communication, voire une analyse croisée de plusieurs outils de communication ou d’outils d’apprentissage. Une question centrale concerne la collecte de traces à l’aide d’outils spécifiques structurant de manière plus ou moins souple les discussions.

En termes d’analyse de discussions de collectif d’apprentissage, une des volontés est la mise en évidence de marqueurs de l’activité collective dans les traces formalisées (allant par exemple de la simple mutualisation d’information à la collaboration forte). À ce niveau, le couplage avec des traces provenant d’outils de travail (partage de document, tableau blanc, etc.) est étudié.

Enfin, un autre volet de cette thèse concerne la visualisation des données provenant des analyses. Différentes techniques sont étudiées pour la conception d’outils réflexifs avec lesquels les utilisateurs finaux (apprenants et tuteurs) peuvent interagir.

La discipline première de cette thèse est l’informatique mais elle s’appuie aussi sur les sciences du langage en partenariat avec le laboratoire LIDILEM (Université Stendhal Grenoble 3).

Les enjeux et la problématique engagée

Dans les environnements d’apprentissage à distance, les outils de communications médiatisées (CMC en anglais pour Computer-Mediated Communication) sont fortement utilisés comme moyens d’échange inter-apprenants et entre apprenants et enseignants. Les outils CMC tels que les messageries instantanées ou bien les
forums de discussion, permettent aux apprenants d'explorer des moyens alternatifs pour échanger des idées sur les sujets d'apprentissage et développer leur propre style d’apprentissage. Ainsi les outils CMC synchrones et asynchrones font fortement partie des environnements d’apprentissage à distance.

Afin de fournir du soutien aux utilisateurs des outils CMC, particulièrement aux apprenants et aux enseignants pendant et après leurs activités de communication, nous menons une recherche qui se focalise sur le traçage et l’exploitation des traces d’activités de communication en situations d’apprentissage à distance. Nous nous intéressons à tracer les activités de communications entre les utilisateurs sur ces outils et à analyser les traces capturées afin :

- d’aider l'apprenant à prendre conscience de ses activités et à identifier le comportement des autres apprenants,
- d'aider l'enseignant-tuteur dans son activité de suivi de situations d'apprentissage collectif à distance. Il pourra ainsi prendre conscience du déroulement global des activités des apprenants et évaluer les aspects comportementaux, sociaux et cognitifs de chacun.

Nous avons étudié les caractéristiques du problème comme présentées ci-dessous.

Pour que les traces CMC soient utiles aux différents acteurs dans différents contextes d’usage, le système de traçage doit être capable d’observer les activités CMC et de produire des traces qui ne sont pas uniquement un simple historique de l’activité, mais qui contiennent des indicateurs signifiants permettant aux utilisateurs de prendre conscience de l’activité effectuée (aspect sémantique). Pour cela, l’observation gagne à être effectuée à l’endroit où se déroulent précisément ces activités. Cependant, la plupart des systèmes de traçage existants font leurs observations uniquement du côté des serveurs (l’endroit où se trouve la plate-forme qui gère les communications). Les interactions côté client (sur le poste des utilisateurs) sont complètement ignorées. Il y a ainsi une perte importante d’information sur ces activités réalisées par les utilisateurs et la granularité des traces générées par les systèmes est plutôt grande. Dans ce cas, l’exploitation des traces ne peut pas être réalisée d’une manière assez précise pour refléter la totalité des activités des utilisateurs.

En ce qui concerne la structuration des traces capturées, la plupart des outils CMC gardent des traces d’activités des utilisateurs dans des fichiers logs (e.g. des fichiers au format texte). Cependant ces fichiers sont peu ou pas utilisés par les apprenants et enseignants soit par ignorance de leur existence, soit parce que les données qu'ils contiennent sont trop brutes et ne répondent pas aux attentes et besoins de ces acteurs. Les logs peuvent prendre des formes très différentes d'un outil à l'autre du fait de l'absence d’une normalisation, ce qui rend
difficile la systématisation de leur exploitation. En outre, les traces stockées dans des fichiers logs sont dépourvues d'aspects sémantiques. Par ailleurs, les opérations sur les fichiers logs (visualisation, recherche, tri, etc.) sont contraignantes et laborieuses pour des non informaticiens. En ce qui concerne la structuration des traces capturées, les choix de représentation sont souvent effectués soit sans réflexion précise sur la finalité, soit pour répondre à un besoin souvent technique. Tout ceci rend les traces difficilement utilisables en dehors du système les ayant produites et peu exploitable par une personne n’ayant pas participé à leur définition.

Une fois les traces sauvegardées et structurées, différentes méthodes d'analyse (quantitatives et qualitatives) peuvent être utilisées en fonction des besoins des utilisateurs. Les problèmes survenant souvent à ce niveau concernent l’efficacité de ces méthodes et la qualité de rendu des résultats des analyses. A ce stade, nous estimons que le système d’analyse doit être capable d'extraire des informations synthétiques à partir des traces structurées afin d’apporter un véritable service aux utilisateurs du forum. Il est aussi important d’envisager à ce niveau des moyens pour enrichir les traces afin de les rendre utilisables pour d'autres types d'analyse.

Enfin, la visualisation des traces doit fournir aux utilisateurs des vues simples mais très représentatives des activités sur les outils CMC. Contrairement aux fichiers logs qui nécessitent un traitement analytique et rationnel, une représentation visuelle sera souvent plus pertinente en faisant appel à des capacités synthétiques, émotionnelles et spatiales. A ce niveau, les utilisateurs devraient pouvoir choisir la façon dont les traces sont visualisées (différents formes, différentes échelles, etc.). Par ailleurs, les utilisateurs devraient pouvoir manipuler facilement les traces, par exemple via des composants IHM pour effectuer des requêtes d’interrogation.

**Travaux effectués**

Les travaux de thèse effectués peuvent être divisés en 5 parties principales:

1) **Proposition d’une approche pour le traçage automatique des activités de communication médiatisée**

Après avoir finement étudié les travaux de recherche récents sur les outils de communications médiatisées et leurs caractéristiques (fonctionnalités, systèmes de traçage existants, modèles de trace, etc.), nous avons essayé d’apporter des éléments de réponse à la question de recherche fondamentale : « Comment tracer au bon grain les communications médiatisées en situation d’apprentissage afin de fournir des indicateurs pertinents aux acteurs de ces communications ? ». 

Pour tracer finement les activités CMC, nous proposons d’effectuer l’observation non seulement du côté des serveurs, mais également sur les postes...

2) Développement d’un système de traçage pour les outils de communications médiatisées

Pour mettre progressivement en application notre approche, notre attention s’est d’abord portée sur le traçage des outils de communication à base de Web tels que les forums de discussion, chat, wiki, blogs, etc. Nous avons ainsi défini une architecture informatique composée des modules suivants : appareillages d’observation (capteurs de traces), synchronisation des traces, sauvegarde des traces, analyse et transformation de traces, et enfin visualisation des traces.

3) Modélisation des traces CMC

Le modèle général des traces pour les outils CMC est l’une des propositions pour répondre à la question concernant la formalisation des traces CMC. L’un de nos objectifs est donc de définir un modèle général de trace pour les communications médiatisées, ce format pouvant être étendu pour y intégrer des informations spécifiques à chaque outil CMC (e.g. des outils structurant les communications par des ouvreurs de phrases). L’avantage d’avoir un format de traces commun à plusieurs outils CMC est de pouvoir proposer des opérations d’enrichissement et de transformation des traces. Dans ce cas, les traces deviennent des données réutilisables et exploitables indépendamment des outils les ayant produites.

4) Développement d’une plate-forme TrAVis

Nous avons développé la plate-forme TrAVis (Tracking Data Analysis and Visualization tools) permettant aux tuteurs et apprenants d’analyser et de visualiser en temps réel les traces d’interaction des apprenants capturées pendant leurs activités de communications médiatisées avec des outils CMC (e.g. discussion forums, wiki, etc.). La plate-forme TrAVis a été développée avec les technologies Web et est facilement accessible avec tout navigateur Web. TrAVis a pour objectif d’assister les tuteurs dans les tâches de suivi et d’évaluation des apprentissages et des communications des apprenants en leurs proposant différents outils pour construire et visualiser des indicateurs d’interactions. Nous avons proposé également un ensemble d’indicateurs qui a pour but principal d’identifier le degré d’interaction des apprenants pendant une activité de communication médiatisée. Les quatre degrés d’interaction sont : mutualisation, discussion, coopération, et collaboration.
5) Expérimentation en situation d’apprentissage réelle

Trois expérimentations semi-contrôlées ont été conduites en juillet et décembre 2007 pour évaluer à la fois notre approche, nos modèles et la plate-forme TrAVis (évaluation de l’utilité, de l’utilisabilité et de la pertinence de TrAVis). Ces expérimentations ont été réalisées avec des enseignants, des chercheurs et des étudiants en Master 2 ou en thèse provenant de différentes disciplines. A la fin de chaque expérimentation, des questionnaires ont été remplis par les utilisateurs pour donner leur avis sur notre système de traçage et sur TrAVis et indiquer des besoins réels en tant qu’étudiants et tuteurs. Nous avons également mené une expérimentation en situation réelle dans un cadre d’une formation française en langue étrangère (FLE) avec la participation des tuteurs et des étudiants de l’université Stendhal Grenoble 3. Cette expérimentation a duré trois mois. Notre objective principale est d’évaluer l’utilité de TrAVis et les indicateurs proposés en fonction des objectives pédagogiques et d’apprentissage des participants.

Perspectives

Nous mettons un accent sur l'amélioration de TrAVis au niveau fonctionnel. Nous sommes particulièrement intéressés à développer un nouvel outil, intitulé « Editeur d’indicateurs » permettant aux utilisateurs de composer une série d'indicateurs à partir de ceux existants. Cela signifie que les utilisateurs peuvent combiner plusieurs indicateurs pour construire de nouveaux types d'indicateurs, dédiés à l'analyse d'une séquence d'interactions CMC.

Nous nous intéressons à étudier comment l’approche de traçage pourrait être utilisé dans d'autres types d'environnements d'apprentissage. Nous nous intéressons également à évaluer l’impact de l’utilisation de TrAVis dans différentes situations d’apprentissage. Ainsi, nous envisageons de mener d’autres types d’expérimentation avec la participation de tuteurs et d’apprenants venant d’autres disciplines.
Tracer, analyser et visualiser les activités de communications médiatisées des apprenants

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RÉSUMÉ. Cette communication présente un travail de recherche qui se focalise sur le traçage automatique des activités de communication médiatisées en situation d’apprentissage à distance. Une partie de cette recherche s’intéresse à l’exploitation des traces capturées pour aider les acteurs d’une formation à distance (enseignants, tuteurs, et apprenants) pendant et après leurs activités de communication. Cette partie s’appuie sur l’analyse et la visualisation des traces. Trois aspects principaux sont abordés : (i) la proposition d’une approche permettant de tracer efficacement les activités de communication médiatisées, (ii) la conception d’une architecture de système de traçage pour les outils de communication, et (iii) les premières expérimentations de la plateforme TrAVis (Tracking Data Analysis and Visualization), suivi d’exemples de calculs et de visualisations d’indicateurs d’activités de communications.

ABSTRACT. This paper presents a research work on tracking Computer Mediated Communication (CMC) activities in distance learning situations. A part of this research work is related to the tracking data exploitation. It focuses on tracking data analysis and visualisation to help the teachers, tutors and students during and after their communication activities. Three main aspects will be discussed in this paper: (i) an approach for efficiently tracking Computer Mediated Communication activities, (ii) the conception of tracking system architecture for CMC tools, and (iii) the experiments of TrAVis platform (Tracking Data Analysis and Visualization), followed by some examples of data indicators for CMC activities.

MOTS-CLÉS : traces, traçage automatique, activités de communication médiatisées, interaction homme-machine, analyse et visualisation des traces, indicateurs d’interaction

KEYWORDS: traces, tracking data, student’s log files, tracking system, computer mediated communications, human-machine interaction, data analysis and visualisation, data indicator

1. Introduction

Dans les environnements d’apprentissage à distance, les outils de communications médiatisées (CMC en anglais pour Computer-Mediated Communication) sont fortement utilisés comme moyens d’échange inter-apprenants et entre apprenants et enseignants (Corich et al., 2004). Selon Berge et Collins (1995), les outils CMC tels que les messageries instantanées ou bien les forums de discussion, permettent aux apprenants d’explorer des moyens alternatifs pour échanger des idées sur les sujets d’apprentissage et développer leur propre style d’apprentissage. Ainsi les outils CMC synchrones et asynchrones font fortement partie des environnements d’apprentissage à distance (Liu, 2002). Afin de fournir du soutien aux utilisateurs des outils CMC, particulièrement aux apprenants et aux enseignants pendant et après leurs activités de communication, nous menons une recherche qui se focalise sur le traçage et l’exploitation des traces d’activités de communication en situations d’apprentissage à distance. Nous montrons principalement une approche permettant de tracer des activités CMC et de produire des traces avec une granularité plus fine que celles des fichiers logs couramment stockés sur des serveurs.
La suite de l’article est structurée en quatre sections suivies d’une conclusion. La deuxième section présente une étude de la problématique du traçage et de l’exploitation des traces issues d’outils CMC, suivie d’une étude synthétique des approches existantes. L’approche proposée et l’architecture technique du système de traçage sont présentées dans la troisième section. La quatrième section présente la plateforme TrAVis (Tracking Data Analysis and Visualisation) qui a pour objectif de faciliter l’analyse et la visualisation de traces CMC. Les premières expérimentations ainsi que des exemples de calcul d’indicateurs à l’aide de TrAVis sont présentés dans la cinquième section.

2. Problématique de la recherche

2.1. Observation et production de traces CMC

Pour que les traces CMC soient utiles aux différents acteurs dans différents contextes d’usage, le système de traçage doit être capable d’observer les activités CMC et de produire des traces qui ne sont pas uniquement un simple historique de l’activité, mais qui contiennent des indicateurs signifiants permettant aux utilisateurs de prendre conscience de l’activité effectuée (aspect sémantique). Cependant, la plupart des systèmes de traçage existants font leurs observations uniquement du côté des serveurs (l’endroit où se trouve la plate-forme qui gère les communications). Les interactions côté client (sur le poste des utilisateurs) sont complètement ignorées. Il y a ainsi une perte importante d’information sur ces activités réalisées par les utilisateurs et la granularité des traces générées par les systèmes est plutôt grande. Dans ce cas, l’exploitation des traces ne peut pas être réalisée d’une manière assez précise pour refléter la totalité des activités des utilisateurs. Pour tracer « au bon grain » les activités CMC, nous proposons d’effectuer l’observation non seulement du côté des serveurs, mais également sur les postes clients. L’objectif premier est de produire des traces contenant des informations sur les différentes actions et interactions des utilisateurs avec l’interface de l’outil de communication. L’approche proposée est présentée dans la troisième section.

2.2. Structuration des traces

La plupart des outils CMC gardent des traces d’activités des utilisateurs dans des fichiers logs (e.g. des fichiers au format texte). Cependant ces fichiers sont peu ou pas utilisés par les apprenants et enseignants soit par ignorance de leur existence, soit parce que les données qu’ils contiennent sont trop brutes et ne répondent pas aux attentes et besoins de ces acteurs. Les logs peuvent prendre des formes très différentes d’un outil à l’autre du fait de l’absence d’une normalisation, ce qui rend difficile la systématisation de leur exploitation. En outre, les traces stockées dans des fichiers logs sont dépouvrues d’aspects sémantiques. En ce qui concerne la structuration des traces capturées, les choix de représentation sont souvent effectués soit sans réflexion précise sur la finalité, soit pour répondre à un besoin souvent technique. Tout ceci rend les traces difficilement utilisables en dehors du système les ayant produites et peu exploitables par une personne n’ayant pas participé à leur définition.

Pour éviter ce genre de problèmes, les traces issues des outils CMC devraient pouvoir être représentées dans un format standard. L’un de nos objectifs est donc de définir un format de trace générique pour les communications médiatisées, ce format pouvant être étendu pour y intégrer des informations spécifiques à chaque outil CMC (e.g. des outils structurant les communications par des ouvreurs de phrases). L’avantage d’avoir un format de traces commun à plusieurs outils CMC est de pouvoir proposer des opérations d’enrichissement et de transformation des traces. Dans ce cas, les traces deviennent des données réutilisables et exploitables indépendamment des outils les ayant produites.

2.3. Analyse et visualisation des traces

La visualisation des traces a pour objectif de fournir aux utilisateurs des vues simples mais représentatives des activités liées aux outils CMC. Contrairement aux fichiers logs qui nécessitent un traitement analytique et rationnel, une représentation visuelle sera souvent plus pertinente en faisant appel à des capacités synthétiques, émotionnelles et spatiales. À ce niveau, les utilisateurs devraient pouvoir choisir la façon dont ils veulent visualiser les traces, au minimum pouvoir les paramétrer (avec différents formes, différentes échelles, etc.). Par ailleurs, les utilisateurs devraient pouvoir manipuler facilement les traces, par exemple en effectuant des requêtes via des interfaces graphiques adaptées. Il est à noter que c’est au niveau de l’analyse et de la visualisation des traces que le contexte d’enseignement va se différencier des autres contextes. Les indicateurs et les visualisations seront spécifiés en fonction d’objectifs pédagogiques.

2.4. Travaux existants

Une trace d'activités est une séquence temporelle d’opérations et d’objets mobilisés par l'utilisateur en interaction avec un système (Champin et Prié, 2002). De notre côté, nous définissons une trace comme étant une empreinte laissée par un acteur à un endroit et à un moment donnés. La représentation d’une trace peut être complexe et varie selon son origine, son niveau et la manière dont l'utilisateur interagit avec le système. De manière générale, une trace est produite conformément à un modèle de trace défini pour chaque système (Choquet et Ikssal, 2007). L’étude de Gebers (2004) sur l’analyse des interactions des apprenants, a pour but d’observer l’ensemble des apprenants dans leur environnement d’enseignement et de faire un diagnostic adapté à la situation. Plusieurs méthodes d’analyse des traces d’interaction ont déjà été étudiées et proposées. La méthodologie OCAF (Object-oriented Collaboration Analysis Framework) de Avouris et al. (2003) est utilisée dans un environnement d'apprentissage collaboratif à distance qui a pour but d'analyser en mode synchrone des activités d’apprenants. CoAt (Collaboration Analyse Toolkit) (Komis et al., 2002) est un outil d’analyse qui permet au tuteur d’observer et d'analyser les activités de l'apprenant ainsi que sa propre communication avec les groupes d'apprenants. Les travaux de recherche de Fesakis et al. (2003) concernent plus particulièrement l’analyse des activités des apprenants en situation d'apprentissage collaboratif. Ces travaux s'appuient principalement sur l'observation des niveaux d'interaction des apprenants pendant leurs communications. En ce qui concerne les dispositifs de visualisation des traces, Riccando et Dimitrova (2003) ont proposé un ensemble d’outils permettant aux tuteurs de percevoir trois différents aspects des activités des apprenants (i.e. les aspects sociaux, comportementaux et cognitifs). Donath et al. (1999) ont mené une recherche sur la visualisation des activités de communications médiatisées. Les outils qu’ils ont proposés permettent aux tuteurs non seulement de visualiser mais également d’évaluer les activités de communication d’un individu ou d’un groupe d’apprenants. Les travaux de Hardy et al. (2004) ont abouti à des outils de visualisation sur des aspects comportementaux des apprenants en formation à distance.

Malgré le nombre de travaux existants, il existe un manque au niveau de l'observation du processus de communication (e.g. écriture, lecture), la plupart des systèmes s’intéressant avant tout au résultat (e.g les messages échangés). Ainsi, les actions fines des utilisateurs pendant une activité de communication (manipulation des messages, temps passé sur un message, …) sont souvent ignorées pour uniquement retenir le résultat final (i.e. ce qui est envoyé au serveur). Par conséquent, le traçage passe à côté de certains types d’interactions, tel que les aspects comportementaux d’un utilisateur pendant une communication médiatisée. L’approche présentée dans la partie suivante va tenter de répondre à ces manques.

3. Approche proposée pour le traçage des activités de communications médiatisées

La figure 1 présente les trois types d’interactions et les deux actions pour une activité CMC.
3.1. Les différentes actions et interactions d’une activité CMC


(2) Les Interactions Homme-Hommes Médiaïtisées par la Machine (IHHM) représentent le contenu des interactions échangées entre les utilisateurs. Revenons à l’exemple de l’« écriture d’un message ». Le contenu du message, y compris les éventuels éléments attachés, sera envoyé au serveur pour que l’ensemble du contenu soit sauvegardé et accessible aux autres utilisateurs. Tracer le contenu d’une communication permet de produire des traces d’un niveau sémantique. Les traces IHHM sont exploitées avec celles de IHM pour reproduire non seulement le processus d’une activité décrivant les actions successives d’un utilisateur (e.g. comment il rédige le message), mais également le contenu (e.g. de quoi parle le message).

(3) Les Interactions Machine-Machines (IMM) sont les processus d’entrées/sorties des machines lors d’une communication entre deux utilisateurs. Tracer les interactions Machine-Machines a pour but de tracer d’autres événements qui se sont produits lors d’interactions de plus hauts niveaux (e.g IHM et IHHM). Les traces des Interactions Machine-Machines sont principalement utiles pour observer la performance des échanges de données des outils CMC. L’exploitation des traces IMM est souvent effectuée par les chercheurs et les concepteurs-développeurs intéressés à faire évoluer les outils.

(4) L’Action d’un Utilisateur (AU) pendant l’utilisation d’un outil CMC est considéré comme une action non médiaïtisée. Il s’agit d’actions de l’utilisateur en dehors de l’environnement informatique. Par exemple, un apprenant reçoit un appel téléphonique pendant une session de cours ou s’absente pour un moment. Dans certaines circonstances, il n’est pas suffisant de tracer uniquement les interactions médiaïtisées. Des observations audio-visuelles sont utiles pour analyser les postures d’un utilisateur devant l’environnement informatique. Les traces AU peuvent être exploitées pour de multiples intentions, parmi lesquelles l’analyse de la réaction d’un utilisateur face à un message. Dans notre recherche, nous ne prenons pas en compte ce type d’action pour l’instant, mais nous trouvons intéressant de le placer dans notre approche globale.

(5) L’Action d’une Machine (AM) sans action d’un utilisateur : pendant une activité de communication médiaïtisée, il existe de nombreuses actions informatiques qui se produisent automatiquement sans être déclenchées par l’utilisateur. Par exemple, un message signalant qu’un autre utilisateur vient de se connecter est une action machine. Les traces de ce type sont essentielles pour compléter et situer les traces des autres types d’interactions.

3.2. Architecture du système de tracage

La figure 2 présente l’architecture du système de tracage. La conception du système de tracage pour les outils CMC a débuté par un travail de modélisation des activités de communication médiaïtisées et des processus d’observation (May et al., 2006). L’objectif de la modélisation est de proposer une architecture générique pour le tracage d’outils CMC. Sa conception a été présentée en détail dans (May et al., 2007). Pour mieux comprendre l’architecture du système et comment fonctionne le tracage en parallèle des côtés client et serveur, un exemple est donné ci-dessous. Cet exemple décrit un processus d’observation et de production des traces lors d’une activité « écrite un message dans un forum de discussion ».
Les actions des utilisateurs de l’interface du forum, telles que « éditer » le titre et le corps du message, « glisser et déposer » des smilies dans le message, « bouger » les barres de défilement vers le haut ou le bas, etc., sont capturées par des capteurs spécifiques côté client. Les traces de toutes ces interactions sont générées et sauvegardées temporairement sur le poste client. Lorsque l’utilisateur clique sur le bouton « envoyer le message », une requête d’interrogation de type HTTP (HyperText Transfer Protocol) est générée pour soumettre le contenu du message au serveur. A cet instant, le « capteur de traces » côté serveur a pris en compte la requête envoyée par le client. Il génère simultanément les traces pour représenter l’activité réalisée par l’utilisateur (i.e. écrire un message dans un forum de discussion) ainsi que le contenu de la discussion (i.e. le message rédigé). A chaque requête sur le serveur, les traces temporaires, précédemment sauvegardées sur le poste client, sont envoyées au serveur. Toutes ces traces sont ensuite synchronisées avec celles du serveur et sauvegardées dans une base de traces unique. Le modèle d’utilisation (May et al., 2007) qui a été pré-défini pour cette activité permet aux « capteurs de traces » d’échanger des informations et de les mettre en cohérence.

Pour simplifier, cet exemple décrit le traçage de deux types d’interactions (IHM et IHHM) mais le principe est le même pour la prise en compte d’autres types d’actions et d’interactions définis précédemment. Les capteurs de traces du côté client ont été développés en JavaScript et avec les technologies AJAX (Asynchronous JavaScript And XML). Ce choix a été fait pour rendre les « capteurs de traces » indépendants des plateformes dont l’utilisateur se sert pour réaliser les activités de communication. Il est aussi important de préciser que dans cette recherche, il n’y a aucune intention de développer des logiciels d'espionnage (spyware) et aucun besoin d’installation d’applications sur les postes d’utilisateurs.

4. Plateforme TrAVis

![Figure 3. La vue principale de plateforme TrAVis.](image)
TrAVis (Tracking Data Analysis and Visualization platform) a été développé pour assister les acteurs d’une formation à distance (enseignants-tuteurs et apprenants) lors de l’exploitation de traces CMC. La figure 3 présente la vue principale de la plateforme TrAVis. TrAVis fournit un certain nombre de fonctionnalités permettant aux utilisateurs d’accéder facilement à la base de traces, d’analyser et de visualiser les traces sous différentes formes ainsi qu’à différentes échelles. TrAVis est conçu pour être accessible non seulement aux enseignants-tuteurs, mais aussi aux apprenants (ce qui n’est pas le cas pour la plupart des outils existants). Ainsi, avec l’aide de TrAVis, les enseignants peuvent analyser des traces en construisant les indicateurs sur les interactions des apprenants. Quant aux apprenants, ils peuvent se servir de TrAVis comme outil réflexif donnant une visualisation globale sur leurs activités de communication en fournissant des indicateurs leur permettant de prendre conscience de leur propre comportement et celui des autres. Dans un but de partage avec les utilisateurs d’outil CMC dans les communautés académiques, TrAVis a été développée en utilisant des langages de développement Open Source comme PHP, JavaScript et AJAX. Ce choix nous a permis également de rendre TrAVis flexible et personnalisable pour chaque usage. Afin de rendre TrAVis capable d’exploiter des traces CMC produites par d’autres systèmes de traçage que le nôtre, le système a été développé sous forme de cinq composants indépendants :

- un composant **Interface** permet aux utilisateurs d’accéder aux fonctionnalités de TrAVis en faisant des requêtes de manière simplifiée,
- un composant de **Traitement de données** s’occupe d’interroger la base de traces avec les paramètres provenant du composant « interface »,
- un composant d’**Analyse de données** extrait et calcule les indicateurs en fonction des données soumises par le composant traitement de données,
- un composant de **Transformation de données** transforme les indicateurs calculés en une forme précise pour la visualisation,
- un composant de **Visualisation des données** représente les indicateurs calculés sous différentes formes graphiques et avec différentes échelles.

5. Premières expérimentations

5.1. **Conditions d’expérimentation**

<table>
<thead>
<tr>
<th>No.</th>
<th>Nombre de participants</th>
<th>Nombre de messages</th>
<th>Durée (minutes)</th>
<th>Nombre d’actions (utilisateurs et machines)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
<td>62</td>
<td>30</td>
<td>1037</td>
</tr>
<tr>
<td>2</td>
<td>26</td>
<td>83</td>
<td>45</td>
<td>1399</td>
</tr>
<tr>
<td>3</td>
<td>26</td>
<td>147</td>
<td>45</td>
<td>2421</td>
</tr>
</tbody>
</table>

**Tableau 1.** Informations sur les conditions d’expérimentation et le nombre de traces IHM, IHHM, IMM, et AM enregistrées

Trois expérimentations du système de traçage et de l’utilisation de TrAVis ont été conduites. La plate-forme Moodle et le forum de discussion CONFOR (George et Labas, 2007) ont été utilisés pour ces expérimentations. Il est à noter que ces expérimentations n’ont cependant pas été réalisées dans de vraies situations d’apprentissage. Il s’agit d’expérimentations semi-contrôlées destinées à évaluer l’approche pour tracer des activités de communications médiatisées et pour valider les premiers indicateurs de TrAVis. Le tableau 1 montre les données quantitatives de ces expérimentations. Dans chaque expérimentation, deux scénarios d’activités de communication ont été fournis aux participants. L’intérêt est de pouvoir vérifier si les comportements différents des deux scénarios se retrouvaient dans les traces (l’analyse est en cours). Après chaque expérimentation, les participants ont rempli un questionnaire pour donner leur avis sur TrAVis (utilité, utilisabilité, pertinence,...) et exprimer leurs besoins réels en tant qu’acteurs de formation (enseignant ou apprenant). Les résultats de ces questionnaires sont également en cours d’analyse.

5.2. **Exploitation des traces CMC avec TrAVis**

Les traces sauvegardées pendant les trois expérimentations ont été utilisées pour construire et visualiser des indicateurs à l’aide de plateforme TrAVis. Ils reflètent un des besoins réels des enseignants-tuteurs qui utilisent régulièrement les outils de communication dans leurs activités d’enseignement.

La figure 4 présente des indicateurs de traces pour une activité « lecture d’un message dans un forum de discussion ». Au lieu de donner uniquement des informations statistiques comme par exemple le nombre de fois...
qu’un message a été affiché, les indicateurs proposés décrivent (i) qui a affiché le message et quand, (ii) est-ce que le message n’a été lu que partiellement, et (iii) pendant combien de temps le message a été lu.

**Figure 4.** Indicateurs d’interaction de tous les utilisateurs qui ont effectué une activité « Lecture d’un message ».

**Figure 5.** Indicateurs pour deux activités « Poster un nouveau message » et « Répondre à un message ».

**Figure 6.** Indicateurs concernant le profil d’un utilisateur.

Sur la figure 4, chaque sphère représente une action de lecture d’un message par un utilisateur. Le diamètre de chaque sphère est proportionnel au temps passé par un utilisateur pour la lecture. La distance entre deux sphères représente le temps écoulé entre deux lectures. Une sphère peut être de quatre couleurs (orange, bleue, verte, ou grise). Une sphère verte signifie que l’utilisateur a ouvert un message en ayant bougé le « scrollbar » vertical vers le bas pour voir la totalité du message (on peut supposer dans ce cas que la lecture a été effectuée jusqu’à la fin du message, même si on laisse le soin à l’utilisateur d’interpréter cet indicateur). La sphère orange exprime le fait que l’utilisateur a seulement affiché le début du contenu du message sans toucher le « scrollbar ». La sphère bleue signifie que l’utilisateur a affiché le message, et qu’il a bougé le « scrollbar » mais sans aller jusqu’en bas (affichage partielle d’un message). Enfin, la sphère grise indique que l’utilisateur n’a fait qu’un passage éclair sur un message (moins de 3 secondes).

La figure 5 montre des indicateurs pour des activités « Poster un nouveau message » et « Répondre à un message ». Chaque icône indique si le message posté est un message qui aborde un nouveau sujet de discussion (symbolisé par un « i » pour « initiatif ») ou un message en réponse à un autre message (symbolisé par une flèche). Des informations sur la durée totale pour la composition d’un message, sur le temps écoulé entre deux écritures ainsi que sur le contenu du message sont également accessibles via ces indicateurs.

Les indicateurs présentés sur la figure 6 reflètent le profil d’un utilisateur. Ils contiennent des statistiques globales sur les activités de communication réalisées par un utilisateur et des liens pour accéder à des informations plus détaillées (messages envoyés ou lus, etc.). Dans le cadre d’une formation à distance, ces indicateurs ont pour objectif d’aider les enseignants à avoir une vue globale des activités d’un apprenant. En résumé, les indicateurs proposés dans les exemples ci-dessus donnent des informations plus fines que ce qu’on trouve habituellement dans des fichiers logs. Ceci est rendu possible par le tracage à différents types d’Interactions Homme Machine que nous avons présenté dans la troisième section.

6. Conclusion et perspectives de recherche

Ce travail de recherche porte principalement sur le tracage automatique des activités de communications médiatisées sur Internet en situation d’apprentissage. L’apport principal de cette recherche se situe dans la proposition d’une approche permettant de tracer efficacement l’utilisation d’outils de communications en effectuant des observations sur les différents types d’Interactions Homme Machine. Actuellement, le travail se focalise sur l’analyse des traces issues de trois expérimentations. Au delà de l’évaluation en terme d’utilité et d’utilisabilité, c’est l’expression de
besoins réels (analyses, indicateurs, …) que nous cherchons à faire ressortir. Ainsi, nous cherchons à faire évoluer TrAVIS de manière itérative et participative. Pour avancer sur tous ces travaux, des expérimentations en situations réelles de formation à distance seront prochainement réalisées afin de valider les premiers indicateurs de TrAVIS et d’en définir de nouveaux.
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Annex A: Example of code of traces collectors

A: Example of code of traces collectors

Different functions coded in PHP to save and update traces when there is a synchronization process.

- Tracecollector.php (on server side)

```php
<?php
// CONNECTION to trace repository
define("SQLHOST","localhost");
define("SQLLOGIN","xxxx");
define("SQLPASSWORD","xxxx");
//define("SQLPASSWORD","xxxx");
$db=mysql_connect(SQLHOST,SQLLOGIN,SQLPASSWORD);
if (!$db)
{
    die('Could not connect: ' . mysql_error());
}

$dbSelected=mysql_select_db("traceforum",$db);
if (!$dbSelected) {
    die ('Can\'t use database traceforum : ' . mysql_error());
}

//*** function to save trace of activity on server ******
function recordTrace($tracename,$tracevalue)
{
    //require_once('connection.php');
    $query="INSERT INTO transition1($tracename) VALUES($tracevalue)"
    //echo $query;
    global $db;
    $result=mysql_query($query,$db);
}

//*** function to update traces ******
function updateRecordedTrace($tracename,$tracevalue,$conname,$convalue)
{
    //require_once('connection.php');
    $query="UPDATE transition1 SET $tracename=$tracevalue WHERE $conname=$convalue"
    //echo $query;
    global $db;
    $result=mysql_query($query,$db);
}
function runSqlquery($function, $table, $function_op, $param, $conname, $convalue)
{
$query = "$function $table $function_op $param WHERE $conname=$convalue";
//echo $query;
global $db;
$result = mysql_query($query, $db);
}
?>

**Tracesubmit.js (on client side)**

```javascript
function submit(FILE, METHOD)
{
    var num = document.forms[0].elements.length;
    var url = "";

    //radio button
    var j = 0;
    var a = 0;
    var radio_buttons = new Array();
    var nome_buttons = new Array();
    var the_form = window.document.forms[0];
    for(var i=0; i<the_form.length; i++){
        var temp = the_form.elements[i].type;
        if ( (temp == "radio") && ( the_form.elements[i].checked ) ) {
            nome_buttons[a] = the_form.elements[i].name;
            radio_buttons[j] = the_form.elements[i].value;
            j++;
            a++;
        }
    }
    for(var k = 0; k < radio_buttons.length; k++) {
        url += nome_buttons[k] + "=" + radio_buttons[k] + "&";
    }
    //checkbox
    var j = 0;
    var a = 0;
    var check_buttons = new Array();
    var nome_buttons = new Array();
    var the_form = window.document.forms[0];
    for(var i=0; i<the_form.length; i++){
        var temp = the_form.elements[i].type;
```
if ( (temp == "checkbox") && (the_form.elements[i].checked) )
{
    nome_buttons[a] = the_form.elements[i].name;
    check_buttons[j] = the_form.elements[i].value;
    j++;
    a++;
}
}
for(var k = 0; k < check_buttons.length; k++) {
    url += nome_buttons[k] + "=" + check_buttons[k] + ";";
}
for (var i = 0; i < num; i++) {
    var chiave = document.forms[0].elements[i].name;
    var valore = document.forms[0].elements[i].value;
    var tipo = document.forms[0].elements[i].type;
    if ((tipo == "submit") || (tipo == "radio") || (tipo == "checkbox") )
    )
    else
    {
        url += chiave + "=" + valore + ";";
    }
}
var parameters = url;
url = FILE + "?" + url;
if (METHOD == undefined) { METHOD = "GET"; }
if (METHOD == "GET") { aah(url, 'previewmsg', '', METHOD); }
else { aah(FILE, 'previewmsg', '', METHOD, parameters); }
}

function aah(url, target, delay, method, parameters) {
    if (method == undefined) {
        if (window.XMLHttpRequest) {
            req = new XMLHttpRequest();
        } else if (window.ActiveXObject) {
            req = new ActiveXObject("Microsoft.XMLHTTP");
        }
        if (req) {
            req.onreadystatechange = function() {
                aahDone(url, target, delay, method, parameters);
            };
            req.open("GET", url, true);
            req.send("");
        }
    }
if ( (method == "GET") || (method == "get") )
{
    if (window.XMLHttpRequest) {
        req = new XMLHttpRequest();
    } else if (window.ActiveXObject) {
        req = new ActiveXObject("Microsoft.XMLHTTP");
    }
    if (req) {
        req.onreadystatechange = function() {
            ahahDone(url, target, delay, method, parameters);
        };
        req.open(method, url, true);
        req.send("");
    }
}

if ( (method == "POST") || (method == "post") )
{
    if (window.XMLHttpRequest) {
        req = new XMLHttpRequest();
    } else if (window.ActiveXObject) {
        req = new ActiveXObject("Microsoft.XMLHTTP");
    }
    if (req) {
        req.onreadystatechange = function() {
            ahahDone(url, target, delay, method, parameters);
        };
        req.open(method, url, true);
        req.setRequestHeader("Content-type", "application/x-www-form-urlencoded");
        req.send(parameters);
    }
}

function ahahDone(url, target, delay, method, parameters) {
    if (req.readyState == 4) {
        if (req.status == 200) {
            //do nothing
        } else {
            document.getElementById(target).innerHTML="ahah error: 
"+req.statusText;
        }
    }
}
Annex B: The SQL script for creating trace repository

Note: the names of the tables and columns are in French.

-- Database: 'tracerepository'
CREATE TABLE 'activity' (
  'IDAct' int(11) NOT NULL auto_increment,
  'Titre' varchar(120) NOT NULL default '',
  'TypeAct' tinyint(4) NOT NULL default '0',
  'IDCat' int(11) default NULL,
  PRIMARY KEY ('IDAct')
) ENGINE=MyISAM DEFAULT CHARSET=latin1 AUTO_INCREMENT=1 ;

CREATE TABLE 'categorie' (
  'IDCat' mediumint(9) NOT NULL auto_increment,
  'Titre' varchar(120) NOT NULL default '',
  PRIMARY KEY ('IDCat')
) ENGINE=MyISAM DEFAULT CHARSET=latin1 AUTO_INCREMENT=1 ;

CREATE TABLE 'transition' (
  'IDTran' bigint(20) NOT NULL auto_increment,
  'Usager' varchar(70) NOT NULL default '',
  'Titre' varchar(120) NOT NULL default '',
  'Attribut' varchar(200) default NULL,
  'Date' date NOT NULL default '0000-00-00',
  'Heure' time NOT NULL default '00:00:00',
  'Delai' time default NULL,
  'RefTran' bigint(20) default '0',
  'Commentaire' varchar(100) default NULL,
  PRIMARY KEY ('IDTran','Usager')
) ENGINE=MyISAM DEFAULT CHARSET=latin1 AUTO_INCREMENT=1 ;

CREATE TABLE 'typeu' (
  'IDTypeU' smallint(6) NOT NULL auto_increment,
  'Titre' varchar(70) NOT NULL default '',
  PRIMARY KEY ('IDTypeU')
) ENGINE=MyISAM DEFAULT CHARSET=latin1 COMMENT='Contient les informations de différents types d''utilisateur' AUTO_INCREMENT=1 ;

CREATE TABLE 'userfiles' (
  'ID' bigint(20) NOT NULL auto_increment,
  'User' varchar(70) NOT NULL,
  'IDForum' bigint(20) default NULL,
  'IDMsg' bigint(20) NOT NULL,
Annex B: The SQL script for creating trace repository

`Filenameo` varchar(70) NOT NULL,
`Filnamer` varchar(20) NOT NULL,
`Filetype` varchar(5) default NULL,
`Filesize` varchar(12) default NULL,
`Dateupload` date NOT NULL default '0000-00-00',
`Timeupload` time NOT NULL default '00:00:00',
`Date_la` date default '0000-00-00',
`Time_la` time default '00:00:00',
`Nbdownload` bigint(20) default '0',
`Filestatus` tinyint(4) default '0',
PRIMARY KEY (`ID`) ) ENGINE=MyISAM DEFAULT CHARSET=latin1 AUTO_INCREMENT=1 ;

CREATE TABLE `utilisateur` (  
`IDU` bigint(20) NOT NULL auto_increment,  
`Usager` varchar(70) NOT NULL default '',  
`Trace` tinyint(4) NOT NULL default '0',  
`IDTypeU` tinyint(4) NOT NULL default '0',  
PRIMARY KEY (`IDU`) ) ENGINE=MyISAM DEFAULT CHARSET=latin1 COMMENT='Informations d''utilisateur a tracer' AUTO_INCREMENT=1 ;
C: Documentation on XML schema of model of traces

Table of Contents

- Schema Document Properties
  - Global Declarations
    - Element: Activity
    - Element: Attribute
    - Element: Comment
    - Element: Content
    - Element: ContentAttribute
    - Element: Date
    - Element: FormatHCI
    - Element: HCI
    - Element: HCIContent
    - Element: Object
    - Element: Time
    - Element: TimeHCI
    - Element: Title
    - Element: Tool
    - Element: TraceHCI
    - Element: User

Schema Document Properties

<table>
<thead>
<tr>
<th>Target Namespace</th>
<th>None</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Element and Attribute Namespaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Global element and attribute declarations belong to this schema's target namespace.</td>
</tr>
<tr>
<td>- By default, local element declarations belong to this schema's target namespace.</td>
</tr>
<tr>
<td>- By default, local attribute declarations have no namespace.</td>
</tr>
</tbody>
</table>

Declared Namespaces

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Namespace</th>
</tr>
</thead>
<tbody>
<tr>
<td>xml</td>
<td><a href="http://www.w3.org/XML/1998/namespace">http://www.w3.org/XML/1998/namespace</a></td>
</tr>
<tr>
<td>xs</td>
<td><a href="http://www.w3.org/2001/XMLSchema">http://www.w3.org/2001/XMLSchema</a></td>
</tr>
<tr>
<td>wmh</td>
<td><a href="http://www.wmhelp.com/2003/eGenerator">http://www.wmhelp.com/2003/eGenerator</a></td>
</tr>
</tbody>
</table>

Schema Component Representation

<xs:schema elementFormDefault="qualified">
...
</xs:schema>
## Global Declarations

### Element: Activity

<table>
<thead>
<tr>
<th>Name</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>xs:string</td>
</tr>
<tr>
<td>Nullable</td>
<td>no</td>
</tr>
<tr>
<td>Abstract</td>
<td>no</td>
</tr>
</tbody>
</table>

### XML Instance Representation

```
<Activity> xs:string </Activity>
```

### Schema Component Representation

```
<xs:element name="Activity" type="xs:string"/>
```

### Element: Attribute

<table>
<thead>
<tr>
<th>Name</th>
<th>Attribute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>xs:string</td>
</tr>
<tr>
<td>Nullable</td>
<td>no</td>
</tr>
<tr>
<td>Abstract</td>
<td>no</td>
</tr>
</tbody>
</table>

### XML Instance Representation

```
<Attribute> xs:string </Attribute>
```

### Schema Component Representation

```
<xs:element name="Attribute" type="xs:string"/>
```

### Element: Comment

<table>
<thead>
<tr>
<th>Name</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>xs:string</td>
</tr>
<tr>
<td>Nullable</td>
<td>no</td>
</tr>
</tbody>
</table>
### Annex C: Documentation on XML schema of model of traces

#### Abstract

<table>
<thead>
<tr>
<th>Name</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagram</td>
<td><img src="image1" alt="Diagram" /></td>
</tr>
</tbody>
</table>

#### XML Instance Representation

```xml
<Comment>
  xs:string
</Comment>
```

#### Schema Component Representation

```xml
<xsd:element name="Comment" type="xsd:string"/>
```

---

#### Element: `Content`

<table>
<thead>
<tr>
<th>Name</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td><code>xsd:string</code></td>
</tr>
<tr>
<td>Nullable</td>
<td>no</td>
</tr>
<tr>
<td>Abstract</td>
<td>no</td>
</tr>
</tbody>
</table>

#### XML Instance Representation

```xml
<Content>
  xs:string
</Content>
```

#### Schema Component Representation

```xml
<xsd:element name="Content" type="xsd:string"/>
```

---

#### Element: `ContentAttribute`

<table>
<thead>
<tr>
<th>Name</th>
<th>ContentAttribute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td><code>xsd:string</code></td>
</tr>
<tr>
<td>Nullable</td>
<td>no</td>
</tr>
<tr>
<td>Abstract</td>
<td>no</td>
</tr>
</tbody>
</table>

#### XML Instance Representation

```xml
<ContentAttribute>
  type = string
</ContentAttribute>
```

---
<ContentAttribute> xs:string </ContentAttribute>

Schema Component Representation
<xs:element name="ContentAttribute" type="xs:string"/>

---

**Element: Date**

<table>
<thead>
<tr>
<th>Name</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>xs:string</td>
</tr>
<tr>
<td>Nullable</td>
<td>no</td>
</tr>
<tr>
<td>Abstract</td>
<td>no</td>
</tr>
</tbody>
</table>

XML Instance Representation
<Date> xs:string </Date>

Schema Component Representation
<xs:element name="Date" type="xs:string"/>

---

**Element: FormatHCI**

XML Instance Representation
<FormatHCI>
<TraceHCI> ... </TraceHCI> [1..*] </FormatHCI>

Schema Component Representation
<xs:element name="FormatHCI">
<xs:complexType>
<xs:sequence>
<xs:element ref="TraceHCI" maxOccurs="unbounded"/>
</xs:sequence>
</xs:complexType>
</xs:element>

---

**Element: HCI**

XML Instance Representation
<HCI id="xs:string [1]">
>Title> ... </Title> [1]
<Object> ... </Object> [1]
<TimeHCI> ... </TimeHCI> [1]
<Attribute> ... </Attribute> [1]
<HCIContent> ... </HCIContent> [1]
</HCI>

Schema Component Representation

<xsl:element name="HCI">
  <xsl:complexType>
    <xsl:sequence>
      <xsl:element ref="Title"/>
      <xsl:element ref="Object"/>
      <xsl:element ref="TimeHCI"/>
      <xsl:element ref="Attribute"/>
      <xsl:element ref="HCIContent"/>
    </xsl:sequence>
    <xsl:attribute name="id" type="xs:string" use="required"/>
  </xsl:complexType>
</xsl:element>

Element:HCIContent

<table>
<thead>
<tr>
<th>Name</th>
<th>HCIContent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Locally-defined complex type</td>
</tr>
<tr>
<td>Nullable</td>
<td>no</td>
</tr>
<tr>
<td>Abstract</td>
<td>no</td>
</tr>
</tbody>
</table>

XML Instance Representation

<HCIContent
  id="xs:string [0..1]">
  <Content> ... </Content> [1]
  <ContentAttribute> ... </ContentAttribute> [1]
</HCIContent>

Schema Component Representation
Annex C: Documentation on XML schema of model of traces

```xml
<xs:element name="HCIContent">
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="Content"/>
      <xs:element ref="ContentAttribute"/>
    </xs:sequence>
    <xs:attribute name="id" type="xs:string"/>
  </xs:complexType>
</xs:element>
```

---

**Element: Object**

<table>
<thead>
<tr>
<th>Name</th>
<th>Object</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>xs:string</td>
</tr>
<tr>
<td>Nullable</td>
<td>no</td>
</tr>
<tr>
<td>Abstract</td>
<td>no</td>
</tr>
</tbody>
</table>

XML Instance Representation

```xml
<Object> xs:string </Object>
```

Schema Component Representation

```xml
<xs:element name="Object" type="xs:string"/>
```

---

**Element: Time**

<table>
<thead>
<tr>
<th>Name</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>xs:string</td>
</tr>
<tr>
<td>Nullable</td>
<td>no</td>
</tr>
<tr>
<td>Abstract</td>
<td>no</td>
</tr>
</tbody>
</table>

XML Instance Representation

```xml
<Time> xs:string </Time>
```
Schema Component Representation

<xs:element name="Time" type="xs:string"/>

<table>
<thead>
<tr>
<th>Element: TimeHCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
</tr>
<tr>
<td>Type</td>
</tr>
<tr>
<td>Nillable</td>
</tr>
<tr>
<td>Abstract</td>
</tr>
<tr>
<td>Diagram</td>
</tr>
</tbody>
</table>

XML Instance Representation

<TimeHCI> xs:string </TimeHCI>

Element: Title

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>xs:string</td>
</tr>
<tr>
<td>Nillable</td>
<td>no</td>
</tr>
<tr>
<td>Abstract</td>
<td>no</td>
</tr>
<tr>
<td>Diagram</td>
<td><img src="attachment" alt="Diagram" /></td>
</tr>
</tbody>
</table>

XML Instance Representation

<Title> xs:string </Title>

Element: Tool

<table>
<thead>
<tr>
<th>Name</th>
<th>Tool</th>
</tr>
</thead>
</table>
Annex C: Documentation on XML schema of model of traces

<table>
<thead>
<tr>
<th>Type</th>
<th>xs:string</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nullable</td>
<td>no</td>
</tr>
<tr>
<td>Abstract</td>
<td>no</td>
</tr>
</tbody>
</table>

Diagram

```
<Tool>
  xs:string
</Tool>
```

XML Instance Representation

```
<Tool> xs:string </Tool>
```

Schema Component Representation

```
<x:s:element name="Tool" type="xs:string"/>
```

---

**Element:** TraceHCI

XML Instance Representation

```
<TraceHCI
  id="xs:string [1]">
  <Tool> ... </Tool> [1]
  <Activity> ... </Activity> [1]
  <User> ... </User> [1]
  <HCI> ... </HCI> [1..*]
  <Time> ... </Time> [1]
  <Date> ... </Date> [1]
  <Comment> ... </Comment> [1]
</TraceHCI>
```

Schema Component Representation

```
<x:s:element name="TraceHCI">
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="Tool"/>
      <xs:element ref="Activity"/>
      <xs:element ref="User"/>
      <xs:element ref="HCI" maxOccurs="unbounded"/>
      <xs:element ref="Time"/>
      <xs:element ref="Date"/>
      <xs:element ref="Comment"/>
    </xs:sequence>
    <xs:attribute name="id" type="xs:string" use="required"/>
  </xs:complexType>
```
Annex C: Documentation on XML schema of model of traces

</xs:complexType>
</xs:element>

**Element: User**

<table>
<thead>
<tr>
<th>Name</th>
<th>User</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>xs:string</td>
</tr>
<tr>
<td>Nillable</td>
<td>no</td>
</tr>
<tr>
<td>Abstract</td>
<td>no</td>
</tr>
</tbody>
</table>

XML Instance Representation

```xml
<User>
  xs:string
</User>
```

Schema Component Representation

```xml
<xs:element name="User" type="xs:string"/>
```
D: Questionnaire 1

This questionnaire is created for participants to evaluate the level of importance of the data indicators. Our objective is to choose the most important data indicators to be implemented in TrAVis.

1. Généralité

Nous avons développé la plate-forme TrAVis (Tracking Data Analysis and Visualization) permettant aux tuteurs et apprenants d’analyser et de visualiser en temps réel les traces d’interaction des apprenants capturées pendant leurs activités de communications médiatisées avec des outils CMC (e.g. discussion forums, wiki, etc.). La plate-forme TrAVis a été développée avec les technologies Web et est facilement accessible avec tout navigateur Web.

TrAVis a pour objectif d’assister les tuteurs dans les tâches de suivi et d’évaluation des apprentissages et des communications des apprenants en leur proposant différents outils pour construire et visualiser des indicateurs d’interactions. Nous proposons un ensemble d’indicateurs qui a pour but principal d’identifier le degré d’interaction des apprenants pendant une activité de communication médiatisée. Les quatre degrés d’interaction sont : mutualisation, discussion, coopération, et collaboration.

Les indicateurs de niveau inférieur pourront être utilisés dans le niveau supérieur pour construire d’autres indicateurs. A titre d’exemple, tous les indicateurs du niveau Mutualisation sont retrouvés dans le niveau Discussion et la combinaison des deux types d’indicateurs de deux niveaux sont également retrouvée au niveau Coopération et ainsi de suite.

Chaque indicateur proposé est calculé automatiquement par TrAVis et peut être visualisé sous différentes échelles et formes, allant de données statistiques au format tabulaire à la représentation graphique des données. Différents paramètres sont aussi introduits dans la visualisation pour davantage de personnalisation. Par exemple, les paramètres temporels vont permettre aux tuteurs de visualiser les indicateurs d’une activité qui se déroule pendant une période de temps précise.

2. Questionnaire sur les besoins réels des tuteurs

Note d’évaluation sur le degré d’importance des besoins

<table>
<thead>
<tr>
<th></th>
<th>Sans avis</th>
<th>Pas du tout important</th>
<th>Peu important</th>
<th>Plutôt pas important</th>
<th>Plutôt important</th>
<th>Très important</th>
<th>Indispensable</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3. Questionnaire sur les indicateurs d’interaction

Note d’évaluation sur le degré d’importance des besoins

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Sans avis</td>
</tr>
<tr>
<td>1</td>
<td>Pas du tout important</td>
</tr>
<tr>
<td>2</td>
<td>Peu important</td>
</tr>
<tr>
<td>3</td>
<td>Plutôt pas important</td>
</tr>
<tr>
<td>4</td>
<td>Plutôt important</td>
</tr>
<tr>
<td>5</td>
<td>Très important</td>
</tr>
<tr>
<td>6</td>
<td>Indispensable</td>
</tr>
</tbody>
</table>

3.1. Mutualisation

Les indicateurs de ce niveau reflètent les activités des utilisateurs pendant une communication ayant pour but de mutualiser des informations au sein de la communauté de discussion. Ils sont également utilisés pour décrire les activités des individus pendant une activité de communication.
3.1.1. Profil d’utilisateur (un résumé pour chaque individu)

<table>
<thead>
<tr>
<th>Indicateurs</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>SA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fréquence de connexion</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Nombre de forums auxquels il participe</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Nombre de cours/activités d’apprentissage auxquels il participe</td>
<td>o</td>
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</table>

3.1.2. Mutualisation des ressources

<table>
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3.1.3. Parcours d’un utilisateur

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<th>SA</th>
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<tbody>
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Annex D: Questionnaire 1

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<td>○</td>
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<td>○</td>
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<td>○</td>
<td>○</td>
</tr>
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<td>○</td>
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<td>○</td>
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</tr>
</tbody>
</table>

3.2. Discussion

Tous les indicateurs du niveau *Mutualisation* sont retrouvés ici.

Les indicateurs proposés présentent une discussion entre utilisateurs.
3.3. Coopération

Tous les indicateurs de niveaux *Mutualisation* et *Discussion* sont inclus ici.

Les indicateurs proposés aident à l’identification des échanges entre les utilisateurs sur le forum. Ils sont également utilisés pour identifier les activités des utilisateurs qui participent à la discussion pour un but commun.

<table>
<thead>
<tr>
<th>Indicateurs</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>SA</th>
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<tbody>
<tr>
<td>Nombre de fichiers uploadés dans un forum particulier</td>
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<td>o</td>
<td>o</td>
<td>o</td>
<td></td>
</tr>
<tr>
<td>(tous les fichiers de tous les utilisateurs qui participent à la discussion)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nombre de fichiers uploadés dans un fil de discussion particulier</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
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<td>o</td>
<td></td>
</tr>
<tr>
<td>(tous les fichiers de tous les utilisateurs qui participent à la discussion)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
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<td>o</td>
<td>o</td>
<td>o</td>
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<td>(historique de téléchargement de tous les utilisateurs y compris ceux qui n’ont pas participés à la discussion)</td>
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</tr>
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</tr>
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<tr>
<td>(nombre de messages triés par heure, jour, mois)</td>
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</table>

3.4. Collaboration

Tous les indicateurs de niveaux *Mutualisation*, *Discussion*, et *Coopération* sont ajoutés ici.

Il n’y a pas beaucoup de différences entre les indicateurs de la coopération et de la collaboration d’un point de vue technique au niveau de calcul et d’affichage. Néanmoins, les utilisateurs pourront se servir de leurs propres raisonnements et d’une méthode d’analyse pour évaluer les aspects collaboratifs d’une activité de communication en faisant référence aux indicateurs proposés. Les indicateurs spécifiques à la collaboration sont :

<table>
<thead>
<tr>
<th>Indicateurs</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<th>6</th>
<th>SA</th>
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<tbody>
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</tbody>
</table>
Résumé d’un processus collaboratif
(nombre d’utilisateurs, fils de discussion, messages, fichiers uploadés, …)  

<table>
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<tr>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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</tr>
</tbody>
</table>

Nombre de fils de discussion créés pour une activité collaborative
(fils de discussion qui sont reliés à une activité collaborative, créés et structurés par les utilisateurs)  

<table>
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<tr>
<th></th>
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<th>2</th>
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Nombre de messages postés dans un fil de discussion pendant une période de temps
(de Date 1 au Date 2 et/ou pendant T1 et T2)  

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### 4. Questionnaire sur les indicateurs proposés

Note d’évaluation sur le degré d’importance des besoins

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<td></td>
<td></td>
<td></td>
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</tbody>
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**Questions**

1. D’une manière générale, que pensez-vous des indicateurs proposés ?

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<th>6</th>
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   7.1. Profil d’utilisateur

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   7.2. Mutualisation des ressources

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   7.3. Parcours d’un utilisateur

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   7.4. Discussion

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   7.5. Coopération

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<th>5</th>
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</tbody>
</table>

   7.6. Collaboration

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
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<th>4</th>
<th>5</th>
<th>6</th>
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</tr>
</thead>
<tbody>
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<td>o</td>
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</tr>
</tbody>
</table>
2. Est-ce qu’il est important pour vous de pouvoir visualiser les indicateurs d’interactions avec les paramètres temporels (mois, date, heure …)  

3. Veuillez nous indiquer d’autres indicateurs que vous souhaiteriez visualiser avec TrAVis

<p>| | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>3.1. Profil d’utilisateur</td>
<td>(champ de saisie)</td>
</tr>
<tr>
<td>3.2. Mutualisation des services</td>
<td>(champ de saisie)</td>
</tr>
<tr>
<td>3.3. Parcours d’un utilisateur</td>
<td>(champ de saisie)</td>
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<td>3.4. Discussion</td>
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</table>
É: TrAVis user’s guide

Manuel d’utilisation de TrAVis

Version : 1.0
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1. Présentation générale
1.1 Objectif de TrAVis

Nous avons développé la plate-forme TrAVis (Tracking Data Analysis and Visualization) permettant aux tuteurs et apprenants d’analyser et de visualiser en temps réel les traces d’interaction des apprenants capturées pendant leurs activités de communications médiatisées avec des outils CMC (e.g. discussion forums, wiki, etc.). La plate-forme TrAVis a été développée avec les technologies Web et est facilement accessible avec tout navigateur Web.

TrAVis a pour objectif d’assister les tuteurs dans les tâches de suivi et d’évaluation des apprentissages et des communications des apprenants en leurs proposant différents outils pour construire et visualiser des indicateurs d’interactions. TrAVis est également conçu pour aider les apprenants à prendre conscience de leurs activités sur les outils CMC (i.e. outil réflexif). Nous proposons un ensemble d’indicateurs qui a pour but principal d’identifier le degré d’interaction des apprenants pendant une activité de communication médiatisée. Les quatre degrés d’interaction sont : mutualisation, discussion, coopération, et collaboration.
1.2 Interface de TrAVis

- **Pour vous connecter :**
  - Cliquez sur
  - Saisissez votre login et mot de passe en précisant le type d’utilisateur
Pour visualiser les traces de communication :

- Cliquez sur

  - pour visualiser les traces des discussions sur le forum
  - pour visualiser toutes les activités d’un utilisateur sur le forum
  - pour visualiser le degré d’interaction d’un ou plusieurs utilisateurs pendant les discussions.

2. Visualiser les discussions

- Cliquez sur

  - Remplissez

Dans l’exemple donné, nous visualisons les activités « lecture des messages de xjmechain sur le forum ».
Indicateur : lecture d’un message

- Chaque sphère représente une lecture d’un message
- Taille de la sphère correspond au temps passé par un utilisateur pour lire un message
- Distance entre deux sphères correspond au temps écoulé entre deux lectures
- Sphère verte : utilisateur a lu jusqu’à la fin du message
- Sphère bleue : utilisateur a lu partiellement le message
- Sphère orange : utilisateur a ouvert le message et a laissé la fenêtre du message inactive
- Sphère grise : utilisateur a ouvert un message en éclair et a passé à d’autre message rapidement sans avoir lu le dernier

Indicateur : poster un message

- Chaque icône correspond à un message posté
- Distance entre deux icônes correspond au temps écoulé entre deux messages postés
- Deux types d’icônes : l’un représente le nouveau message et l’autre représente le message qui répond à un autre message

Indicateur : profil d’un utilisateur

- Le résumé des activités d’un utilisateur sur le forum
3. **Visualiser toutes les interactions sur le forum**

- Cliquez sur (outil nommé *Time Machine* permettant de visualiser en temps réel toutes les actions et interactions d’un utilisateur sur le forum)

- Remplissez

1. Saisissez le nom d’utilisateur ou cliquez sur l’icône pour en choisir un à partir d’une liste d’utilisateurs

2. Si vous souhaitez, précisez les dates. Remplissez-les manuellement ou cliquez sur l’icône pour choisir une date

3. Si vous souhaitez, préciser l’heure.

4. Cochez les activités que vous souhaitez visualiser
Annex E: TrAVis user’s guide

- **Indicateur : toutes les interactions d’un utilisateur sur le forum**

  **Liste d’activités**

  **Activité sélectionnée**

  **Cet icône est affiché en fonction de type d’activité. Cliquez cet icône pour afficher un menu supplémentaire pour visualiser d’autres activités qui sont reliées à l’activité sélectionnée.**

  **Chaque barre représente une activité sur le forum**
  **Différentes couleurs représentent différentes activités**
  **Cliquez sur la barre pour visualiser les informations détaillées**
  **Changer l’option de visualisation en cliquant sur le lien « Options »**

  **Trier les activités par ordre chronologique**
  **Afficher les barres en couleur ou non**
  **Indicateur de temps**
  **La vitesse de défilement de la liste d’activités**
4. Visualiser le degré d’interactions

- Cliquez sur

- Remplissez

1. Choisissez le type d’indicateur

2. Saisissez manuellement le nom d’utilisateur ou cliquez sur l’icône pour choisir un seul utilisateur ou sur l’icône pour sélectionner plusieurs utilisateurs à partir d’une liste.
This is an example of using pChart graphics library to create a radar graph.

Source: http://pchart.sourceforge.net

This example shows how to create a simple filled radar graph containing two data series. Data are manually set using the AddPoint() method of the pData class.

The first step consist in calling the drawRadarAxis() function to prepare the graph area by drawing the Axis. You can specify the MaxValue or keep the automatic scaling mode.

The second step consist in calling the drawFilledRadar() function to draw the radar graph over the Axis layer with a transparency of 60%. (default is 50%)

Running this script will create a « example.png » file in the current directory.

```php
<?php
  // Standard inclusions
  include("pChart/pData.class");
  include("pChart/pChart.class");

  // Dataset definition
  $DataSet = new pData;
  $DataSet->AddPoint(array(1,2,3,4,3),"Serie1");
```

Annex F: pChart graphics library

10. $DataSet->AddPoint(array(1,4,2,6,2),"Serie2");
11. $DataSet->AddSerie("Serie1");
12. $DataSet->AddSerie("Serie2");
13. $DataSet->SetAbsciseLabelSerie("Label");
14.
15.
16. $DataSet->SetSerieName("Reference","Serie1");
17. $DataSet->SetSerieName("Tested computer","Serie2");
18.
19. // Initialize the graph
20. $Test = new pChart(400,400);
21. $Test->setFontProperties("Fonts/tahoma.ttf",8);
22. $Test->drawFilledRoundedRectangle(7,7,393,393,5,240,240,240);
23. $Test->drawRoundedRectangle(5,5,395,395,5,230,230,230);
24. $Test->setGraphArea(30,30,370,370);
25. $Test->drawFilledRoundedRectangle(30,30,370,370,5,255,255,255);
26. $Test->drawRoundedRectangle(30,30,370,370,5,220,220,220);
27.
28. // Draw the radar graph
29. $Test->drawRadarAxis($DataSet->GetData(),$DataSet->GetDataDescription(),TRUE,20,120,120,230,230);
30. $Test->drawFilledRadar($DataSet->GetData(),$DataSet->GetDataDescription(),50,20);
31.
32. // Finish the graph
33. $Test->drawLegend(15,15,$DataSet->GetDataDescription(),255,255,255);
34. $Test->setFontProperties("Fonts/tahoma.ttf",10);
35. $Test->drawTitle(0,22,"Example 8",50,50,50,400);
36. $Test->Render("example.png");
37. ?>
This is the consent form created and signed by Tatiana. It allows us to use her personal tracking data in this dissertation.

To Whom It May Concern:

I, Tatiana Codreanu, hereby authorize Madeth May to release in his publications, the following information from my personal records: All log reports, records, notes and other data regarding my traces from TrAVis experiment since March 2009. I give my permission for this scientific information to be used for the following purpose: to use and analyze my traces in his Ph D dissertation and in any other publications related to his Ph D dissertation.

I do not give permission for any other use or for any further disclosure of this information.

Signature : Tatiana Codreanu
Date of Signature : Sep-27-2009
H: Use scenario for the case studies

Scénario d’utilisation pour CONFOR – Groupe 1

Adresse de connexion : http://www.madethmay.com/moodle
Login : insauser_
Pwd : insaUser_

1ère Partie (durée : 10 mn)

• Ouvrir une leçon dans le Module 1
• Lire les messages du forum correspondant à cette leçon
  ▪ Poster des messages dans cette leçon
  ▪ créer des nouveaux messages
  ▪ ou répondre à des messages existants

S’il vous reste du temps, vous pouvez refaire ces étapes dans d’autres leçons du module 1.

2ème Partie (durée : 10 mn)

• Ouvrir une leçon dans le Module 2
• Ouvrir des messages du forum correspondant à cette leçon en alternant :
  ▪ ouvrir un message sans le lire
  ▪ lire la moitié du message seulement
  ▪ lire le message jusqu’à la fin

S’il vous reste du temps, vous pouvez refaire ces étapes dans une autre leçon du module 2 ou répondre à des messages.

Scénario d’utilisation pour CONFOR – Groupe 1

Adresse de connexion : http://www.madethmay.com/moodle
Login : insauser_
Pwd : insaUser_

1ère Partie (durée : 10 mn)

(A) Ouvrir une leçon dans le Module 2
(B) Poster un message dans cette leçon
  ▪ créer un nouveau message
  ▪ ou répondre à un message existant
(C) Ouvrir des messages du forum correspondant à cette leçon en alternant :
- ouvrir un message sans le lire
- lire la moitié du message seulement
- lire le message jusqu’à la fin

S’il vous reste du temps, vous pouvez refaire l’étape A) et C) d’autres leçons du module 2.

2ème Partie (durée : 10 mn)

- Ouvrir une leçon dans le Module 1
- Poster des messages dans cette leçon
  - Créer des nouveaux messages
  - ou répondre à des messages existants.

S’il vous reste du temps, vous pouvez refaire ces étapes dans une autre leçon du module 1.

Détail des activités

- **Lire des messages**
  - Parcourez l’arborescence des activités dans Moodle
  - Parcourez l’arborescence des messages dans le forum Confor
  - Affichez les messages
  - Lisez les messages
  - Téléchargez les fichiers et vérifiez si le fichier est bien téléchargé et l’ouvrez pour voir s’il n’y a pas d’erreur (fichier ne peut pas être ouvert ou contenu affiche bizarrement, etc…)

- **Poster des messages**
  - Postez quelques nouveaux messages : merci de bien vouloir rédiger quelques messages longs et explicitement en français.
  - Répondez à des messages. Merci de suivre le même principe que « poster un nouveau message », c-a-d, message assez long et en français.

- **Uploader les fichiers**
  - Lorsque vous postez un nouveau message ou répondez à des messages, vous pouvez :
    -Uploader un fichier et l’attacher au message
    - Supprimer le fichier uploadé
    -Uploader les fichiers dont
      - le nom contient des espaces ou caractère français et/ou spéciaux (e.g : % ù * μ £, etc…)
      - le nom est long
Annex H: Use scenario for the case studies

- la taille est grande
- l’extension bizarre :) etc.

- Télécharger les fichiers
Lorsque vous lisez des messages, s’ils contiennent des fichiers attachés, téléchargez les et vérifier vos téléchargements
I: Questionnaire 2

This questionnaire is created for participants to evaluate the first build of TrAVis.

1. Votre nom et prénom (facultatif) :
   (Informations non traitées ni présentées dans les résultats)

2. Vous êtes :
   Professeur
   Maître de conférences
   Chercheur
   Thésard
   Ingénieur
   Étudiant
   Autres

3. Votre discipline :
   Informatique
   Sciences du langage
   Sciences de l'éducation
   Sciences de l'information et de la communication
   Mathématiques
   Psychologie
   Autre

4. Si vous êtes dans une autre discipline, veuillez la préciser :

5. Dans vos activités professionnelles (hors enseignement), utilisez-vous des forums de discussion ? :
   Jamais
   Rarement
   De temps en temps
   Souvent

6. Si vous enseignez, utilisez-vous des forums pour vos activités pédagogiques ? :
   Jamais
   Rarement
   De temps en temps
   Souvent
   Si vous n'enseignez pas, cochez ici

Questions générales sur TrAVis

7. Présentation générale de TrAVis :
   (Interface, icône, couleurs, graphiques,...) :
   Pas bien du tout
   Moyennement bien
   Plutôt bien
   Très bien
   Ne sais pas

8. Visibilité, clarté de l'interface :
   (message d'aide, texte, image, animation, ...) :
   Pas du tout clair
   Peu clair
   Plutôt clair
   Très clair
   Ne sais pas

9. Facilité d'utilisation :
   Très compliqué
   Assez difficile
Annex I: Questionnaire 2

Merci d’argumenter votre avis

10. Les fonctionnalités fournies par TrAVis :
(Gestion de base de traces, des utilisateurs, des paramètres de visualisation, visualisation des traces sous forme graphique, …)

Merci d’argumenter votre avis

11. Originalité de TrAVis :

Merci d’argumenter votre avis

12. De manière globale, avez-vous apprécié TrAVis ? :

Merci d’argumenter votre avis

Avis sur les exemples d’indicateurs et de visualisations des traces fournis par TrAVis

13. D’une manière globale, que pensez-vous des indicateurs fournis par TrAVis :
(Activité de communication sur le forum)

14. Les indicateurs "Affichage/Lecture des messages dans le forum" ci-dessous vous semblent :

<table>
<thead>
<tr>
<th>Indicateurs :</th>
<th>Pas du tout utile</th>
<th>Peu utile</th>
<th>Plutôt utile</th>
<th>Très utile</th>
<th>Ne sais pas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Le temps passé pour une lecture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Le temps entre deux lectures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indicateur d'affichage complet ou partiel du message</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Information détaillée sur un message

**15.** Que souhaiteriez-vous comme autres indicateurs pour une activité “Affichage/Lecture du message du forum”? Précisez au besoin pour quel type d’activité pédagogique.

<table>
<thead>
<tr>
<th>Indicateurs:</th>
<th>Pas du tout utile</th>
<th>Peu utile</th>
<th>Plutôt utile</th>
<th>Très utile</th>
<th>Ne sais pas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quel message, dans quel forum, par quel utilisateur, et temps de composition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Le message posté est-t-il un nouveau message pour aborder un nouveau sujet de discussion ou pour répondre à un autre message et à quel message il répond</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temps entre deux écritures de messages</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**16.** Les indicateurs “Poster/Répondre à des messages dans le forum” ci-dessous vous semblent :

<table>
<thead>
<tr>
<th>Indicateurs:</th>
<th>Pas du tout utile</th>
<th>Peu utile</th>
<th>Plutôt utile</th>
<th>Très utile</th>
<th>Ne sais pas</th>
</tr>
</thead>
<tbody>
<tr>
<td>la vue d’ensemble d’une activité d’un utilisateur (apprentissage + discussion)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Le taux de participation à la discussion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Le nombre de contenus de cours affichés</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**17.** Que souhaiteriez-vous comme autres indicateurs pour une activité “Poster/Répondre à des messages dans le forum”? Précisez au besoin pour quel type d’activité pédagogique.

**18.** Les indicateurs “Profil d’utilisateur” vous semblent :

<table>
<thead>
<tr>
<th>Indicateurs:</th>
<th>Pas du tout utile</th>
<th>Peu utile</th>
<th>Plutôt utile</th>
<th>Très utile</th>
<th>Ne sais pas</th>
</tr>
</thead>
<tbody>
<tr>
<td>la vue d’ensemble d’une activité d’un utilisateur (apprentissage + discussion)</td>
<td></td>
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<td>Le taux de participation à la discussion</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Le nombre de contenus de cours affichés</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**19.** Que souhaiteriez-vous comme autres indicateurs pour “le profil d’utilisateur”? Précisez au besoin pour quel type d’activité pédagogique.

**20.** Avez-vous d’autres types d’activités de communication médiatisées que vous souhaiteriez tracer? Merci de mentionner également vos objectifs pédagogiques dans ce cas:
21. Dans vos scénarios pédagogiques, en quoi un système comme TRAVIS pourrait vous être utile ?

22. Pensez-vous qu'une analyse automatique du contenu des messages pourrait être utile ? Précisez le type des résultats attendus pour ce type d'analyse :

23. Connaissez-vous d'autres outils d'analyse de traces qui ressemblent à TRAVIS ? Veuillez citer le(s) nom(s) ou les références de ces outils :

Autre commentaire, suggestion ou question : 
Ce guide rapide a pour but de vous présenter quelques principes simples d’utilisation de plateforme Moodle et du forum contextuel Confor. L’objectif est de vous familiariser avec les fonctionnalités du forum qui vous permettront d’effectuer efficacement vos discussions et avec une grande facilité.

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1. Généralité de la plate-forme

La plate-forme est disponible sous deux langues : Français et Anglais. Les navigateurs tels que Mozilla Firefox, Opera, Safari, Google Chrome sont fortement recommandés pour utiliser la plate-forme Moodle et les forums associés. Pour une raison de sécurité et de quelques problèmes techniques, le navigateur Internet Explorer n’est pas du tout recommandé. Je vous recommande vivement d’utiliser Mozilla Firefox ou d’autres navigateurs cité au-dessus pour cette expérimentation.

2. Connexion

Deux possibilités pour vous connecter à la plate-forme :

- Sur la page principale de Moodle, en haut à droite, cliquez sur le lien (Connexion)
- Sur la page principale de Moodle, en haut à gauche, dans le Menu principal, cliquez sur le titre du forum de votre groupe (Exemple : Group A est un forum de discussions pour les étudiants du groupe A)

3. Profil d’utilisateur

3.1. Changer le mot de passe

Une fois connecté, cliquez sur votre « nom – prénom » affiché sur la page principale de Moodle en haut à droite

Dans le premier onglet (Profil), cliquez sur le bouton (Changer le mot de passe) qui se trouve en dessous.

Note : il est conseillé de changer le mot de passe dès la première connexion

3.1. Modifier le profil d’utilisateur

- Cliquez sur votre « nom – prénom » affiché sur la page principale de Moodle en haut à droite
- Cliquer sur le deuxième onglet (Modifier mon profil)

4. Accès au forum

4.1. Liste des forums et droits d’accès

- Group X où X est l’indicatif du groupe (e.g. A, B, C …) : le forum spécifique à chaque groupe. Seuls les membres du groupe peuvent poster des messages dans leur forum, les autres utilisateurs peuvent uniquement consulter les messages.
- Forum administrateur est un forum qui vous permet de poster vos questions techniques, suggestions, demandes d’intervention à l’administrateur du forum. Ce forum est accessible à tout le monde.
- Demande de création de nouveaux forums : à tout moment vous pouvez demander la création d’un nouveau forum. Le nouveau forum peut-être créé à la racine donc accessible à partir de la page principale de Moodle ou un sous-forum du forum Groupe X. Pour cela, vous pouvez poster votre demande dans le Forum administrateur ou envoyer votre mail directement à madeth.may@insa-lyon.fr
4.2. Connexion au forum

Il est important de préciser qu’une fois connecté à la plate-forme Moodle, vous êtes automatiquement connecté au forum contextuel. Pour vous connecter au forum de votre groupe, suivez les étapes suivantes :

- Sur la page principale de Moodle, en haut à gauche, dans le Menu principal, cliquez sur le titre du forum de votre groupe (Exemple : Group A est un forum de discussion pour les étudiants du groupe A)
- Une description du forum est affichée avec un lien Forum Group X où X est l’indicatif du groupe (e.g. A, B, C …) et un bouton Entrer.
- Cliquez sur le lien (Forum Group X) ou le bouton (Entrer) pour accéder au forum

5. Discussion sur le forum

5.1. Barre de menu du forum

5.2. Partie gauche du forum

- **Parcourir les titres de messages** : les titres de message sont affichés sous forme d’arborescence. Vous pouvez déplier un fil de discussion en cliquant sur l’icône  qui se trouve devant le titre du message.
- **Afficher les messages dans un fil de discussion** : l’icône  qui se trouve à droite de l’icône  indique un début d’un fil de discussion. En cliquant sur cet icône tous les messages du même fil de discussion seront affichés les un après les autres, triés par date de création. Ainsi le message le plus récent se trouve en bas du fil de discussion.
- **Poster un nouveau message** : le bouton  qui se trouve en bas de l’arborescence des discussions vous permet de composer un nouveau message (début d’un nouveau fil de discussion). Ce bouton ne sera pas visible si vous n’avez pas le droit de poster dans le forum.
- **Cacher la partie gauche du forum** : vous pouvez à n’importe quel moment cacher la partie gauche du forum en cliquant sur la barre verticale qui sépare les deux parties du forum (c.f. voir l’image ci-dessous).
5.3. Partie droite du forum

- **Afficher un message** : en cliquant sur le titre du message son contenu et les éventuels documents attachés seront affichés à droite.

- **Afficher tous les messages d’un fil de discussion** : cliquer sur l’icône qui se trouve devant le titre de message qui débute un fil de discussion. L’affichage d’un fil de discussion est également possible en cliquant sur le bouton.

  ![expand thread](image)

  Ce bouton est visible lorsque vous affichez un message initiatif d’une discussion.

- **Afficher tous les réponses d’un message** : cliquez sur le bouton

  ![expand replies](image)

- **Afficher le message parent d’un message** : cliquez sur le bouton

  ![parent message](image)
5.4. Composition d’un message

<table>
<thead>
<tr>
<th>Bouton</th>
<th>Fonctionnalité</th>
</tr>
</thead>
<tbody>
<tr>
<td>![new]</td>
<td>Poster un nouveau message</td>
</tr>
<tr>
<td>![quote]</td>
<td>Poster un nouveau message en citant un message</td>
</tr>
<tr>
<td>![reply]</td>
<td>Répondre à un message</td>
</tr>
<tr>
<td>![Attach a file]</td>
<td>Joindre un fichier dans le message.</td>
</tr>
<tr>
<td>![Preview]</td>
<td>Afficher le message avant de poster</td>
</tr>
<tr>
<td>![Submit]</td>
<td>Envoyer le message au serveur</td>
</tr>
<tr>
<td>![Clear]</td>
<td>Effacer les contenus de message</td>
</tr>
</tbody>
</table>
This questionnaire is addressed to both tutors and learners who participated in our experiment. The objective of this questionnaire is to evaluate TrAVIs and the proposed data indicators.

1. Votre nom et prénom (facultatif) :

2. Vous êtes :
   - Tuteur/Tutrice
   - Étudiant(e)

Questions générales sur TrAVIs

3. Présentation générale de TrAVIs :
   (Interface, icône, couleurs, graphiques,...)
   - Pas bien du tout
   - Moyennement bien
   - Plutôt bien
   - Très bien
   - Ne sais pas

4. Visibilité, clarté de l'interface :
   (message d'aide, texte, image, animation, ...)
   - Pas du tout clair
   - Peu clair
   - Plutôt clair
   - Très clair
   - Ne sais pas

5. Facilité d'utilisation :
   - Très compliqué
   - Assez difficile
   - Plutôt facile
   - Très facile
   - Ne sais pas

6. Les fonctionnalités fournies par TrAVIs :
   (Visualiser les traces en temps réel, le détail d'interaction, les indicateurs des 4 niveaux d'interactions, etc.)
   - Pas du tout intéressantes
   - Peu intéressantes
   - Plutôt intéressantes
   - Très intéressantes
   - Ne sais pas

7. Originalité de TrAVIs :
   - Pas original
   - Peu original
   - Plutôt original
   - Très original
   - Ne sais pas

8. De manière globale, avez-vous apprécié TrAVIs ? :
   - Non, pas du tout
   - Non, assez peu
   - Oui, plutôt
   - Oui, beaucoup
   - Ne sais pas
Avis sur les indicateurs et de visualisations des traces fournis par TrAVis

9. D’une manière globale, que pensez-vous des indicateurs fournis par TrAVis :
   (Activité de communication sur le forum)
   Pas du tout intéressants
   Peu intéressants
   Plutôt intéressants
   Très intéressants
   Ne sais pas

10. Les indicateurs "Affichage/Lecture des messages dans le forum" ci-dessous vous semblent :

<table>
<thead>
<tr>
<th>Utilité d’indicateur</th>
<th>Pas du tout utile</th>
<th>Peu utile</th>
<th>Plutôt utile</th>
<th>Très utile</th>
<th>Ne sais pas</th>
</tr>
</thead>
</table>

Votre avis

11. Les indicateurs "Poster/Répondre à des messages dans le forum" ci-dessous vous semblent :

<table>
<thead>
<tr>
<th>Utilité d’indicateur</th>
<th>Pas du tout utile</th>
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<th>Plutôt utile</th>
<th>Très utile</th>
<th>Ne sais pas</th>
</tr>
</thead>
</table>

Votre avis

12. Les indicateurs "Profil d’utilisateur" vous semblent :

<table>
<thead>
<tr>
<th>Utilité d’indicateur</th>
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</tr>
</thead>
</table>

Votre avis

13. Les indicateurs "Time Machine permettant de visualiser en temps réel tous les actions/interactions d’utilisateur sur le forum" vous semblent :

<table>
<thead>
<tr>
<th>Utilité d’indicateur</th>
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<th>Plutôt utile</th>
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<th>Ne sais pas</th>
</tr>
</thead>
</table>

Votre avis
14. Les indicateurs "Mutualisation des ressources" vous semblent :

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<th>Plutôt utile</th>
<th>Très utile</th>
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</thead>
<tbody>
<tr>
<td>Votre avis</td>
<td></td>
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15. Les indicateurs "Discussion" vous semblent :

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16. Les indicateurs "Coopération" vous semblent :

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<th>Plutôt utile</th>
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</tbody>
</table>

17. Les indicateurs "Collaboration" vous semblent :

<table>
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<td>Votre avis</td>
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</table>

18. Les paramètres temporaux (date et heure) pour la visualisation des traces dans un intervalle précis vous sont utiles?

<table>
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<tr>
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<th>Plutôt utile</th>
<th>Très utile</th>
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</tr>
</tbody>
</table>
Votre avis

19. Ce que vous avez apprécié le plus et/ou le moins :

20. Votre commentaire, impression, suggestion, ou question :
L: List of publications


4) Madeth May (2008) Une approche pour tracer finement les communications médiatisées en situation d'apprentissage. Rencontre des jeunes chercheurs en EIAH 2008 (RJC-EIAH 08), Lille, pages : 71-76


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Rovai, A. A preliminary look at the structural differences of higher education classroom communities in traditional and ALN courses. Journal of Asynchronous Learning Networks, 2001, vol. 6, num 1


Senicar, V., Jerman-Blazic, B. & Klobucar, T. Privacy Enhancing Technologies – approaches


Wilfried, F., Ditte, L., Theo, W., Fred, A. & Wim, V. Computer-Mediated Communication Environments in Teacher Education: Computer Conferencing and the Supervision of Student


**FOLIO ADMINISTRATIF**

**THESE SOUTENUE DEVANT L’INSTITUT NATIONAL DES SCIENCES APPLIQUEES DE LYON**

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<table>
<thead>
<tr>
<th>NOM : MAY</th>
<th>DATE de SOUTENANCE : 04 Décembre 2009</th>
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<tr>
<td>(avec précision du nom de jeune fille, le cas échéant)</td>
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<tr>
<td>Prénoms : Madeth</td>
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<tr>
<td><strong>TITRE</strong> : Utilisation des traces comme outils réflexifs pour les apprenants et les enseignants à distance : application aux communications médiatisées</td>
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<tr>
<td><strong>NATURE</strong> : Doctorat</td>
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**RESUME** : Les outils de communications médiatisées (CMC en anglais pour Computer-Mediated Communication) synchrones et asynchrones font fortement partie des environnements d’apprentissage à distance. Ils sont utilisés comme moyens d’échange inter-apprenants et entre apprenants et tuteurs. Afin de fournir du soutien aux utilisateurs des outils CMC, particulièrement aux apprenants et aux tuteurs pendant et après leurs activités de communication, nous menons une recherche qui se focalise sur le traçage et l’exploitation des traces CMC en situations d’apprentissage à distance. Nous avons traité dans ce travail de recherche des problématiques autour de (i) la collecte des traces CMC, (ii) la représentation des traces CMC, et (iii) l’analyse et la visualisation des traces CMC. Les éléments de réponse à ces problématiques sont :

- Une approche de traçage pour les outils CMC :


- Modèle général de traces CMC :

  Le modèle général a pour but de répondre à la question concernant la formalisation des traces CMC. Le modèle proposé permet la représentation et structuration des traces CMC dans un format numérique commun indépendant des outils de communication. Ce format peut être étendu pour y intégrer des informations spécifiques à chaque outil CMC. L’avantage d’avoir un format de traces commun à plusieurs outils est de pouvoir proposer des opérations d’enrichissement et de transformation de traces. Dans ce cas, les traces deviennent des données réutilisables et exploitables indépendamment des outils les ayant produites.

- Plate-forme TrAVIs :

  Nous avons développé la plate-forme TrAVis (Tracking Data Analysis and Visualization) permettant aux tuteurs et apprenants d’analyser et de visualiser en temps réel les traces de communication. La plate-forme TrAVis a été développée avec les technologies Web et est facilement accessible depuis tout navigateur. TrAVis a pour objectif d’assister les tuteurs dans les tâches de suivi et d’évaluation des activités collectives des apprenants en leur proposant différents outils pour construire et visualiser des indicateurs d’interactions. Nous avons également proposé un ensemble d’indicateurs qui a pour but principal d’identifier le degré d’interaction des apprenants pendant une activité de communication médiatisée. Les quatre degrés d’interaction sont : mutualisation, discussion, coopération, et collaboration.

Trois études de cas et une expérimentation dans une situation de formation réelle ont été menées afin d’évaluer notre approche, notre modèle et l’environnement associé.

**MOTS-CLES** : Environnements Informatiques pour l’Apprentissage Humain (EIAH), Communication Médiatisé (CMC), Interaction Homme-Machine (IHM), Traces, Analyse et Visualisation des traces, Indicateurs d’interaction
Laboratoire(s) de recherche : Laboratoire d’Informatique pour l’Entreprise et les Systèmes de Production (LIESP)
Directeur de thèse: Patrick Prévôt et Sébastien George
Président de jury : Éric Bruillard
Composition du jury :

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Professeur (ENS de Cachan), Rapporteur

Mme. Angelique Dimitracopoulou  
Professeur (Université de l’Aegean), Rapporteur

M. Jean-Marc Labat  
Professeur (Université Pierre et Marie Curie), Examinateur

M. Riccardo Mazza  
Enseignant/Chef de recherche (SUPSI), Examinateur

M. François Mangenot  
Professeur (Université Stendhal Grenoble 3), Examinateur

M. Sébastien George  
Maître de conférences (INSA de Lyon), Directeur

M. Patrick Prévôt  
Professeur (INSA de Lyon), Directeur