An Environment for Cooperative Learning over the Internet

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ABSTRACT

In this paper, we present a cooperative learning platform on the Internet. This platform is an environment and a distance learning system. It is made up of an educational server that allows access to the available courses on the site. The server is structured in pedagogical labs that respond to the user needs. It offers also a module for self-evaluation so that the user can evaluate his/her level. Trainers have created this facility very carefully to assure a detailed evaluation with very accurate solutions.

Based on the model of "telephone ring", the system proposes facilities for communication and collaboration in order to bring the trainers and the learners closer to each other. This forum of trainers and learners allow the users to exchange information and their experiences pedagogic. These experiences are acquired by the use of computer aided tools for virtual navigation through structured hypertext documents. The user actions during a learning or navigation session are analyzed.

Key words

Computer Aided Cooperative Work, Distance Learning, Navigation Map, Time Indicator.

INTRODUCTION

Among the potential of the advent of communication and information technologies, in the field of the tele-formation, is the development of environments that support distance co-operative training. Within this framework, we propose an experimental platform of a co-operative system. It gives the possibility to a group of users (learners, teachers, and tutors) to cooperate, to coordinate and to communicate in order to arrive to a better form of training.

DEVELOPMENT APPROACH AND PLATFORM ARCHITECTURE

There are a number of possible methods that can be used in the development of cooperative training systems. These methods can be classified into two groups. In the first approach, we define a logical architecture that takes in consideration, from the start of the design, the possible and needed tools for cooperation. This ideal way makes it certainly possible to build a flexible structure, which can rigorously apply the metaphor of cooperation.

But this approach is expensive. The realization of single users training systems is already sufficiently complex without adding other problems inherent to the cooperative work.

The second approach, which is more pragmatic, and in our opinion more economic in design effort, consists in enriching a preexistent system by a certain number of modules aiming at making the system more intelligent and co-operative. This pragmatism is based on two reasonable ideas. The first is the established fact that there are many operational systems available. The second stipulates that many works concerning co-operative work in other fields such as the co-operative edition of documents led to satisfactory results. Then, why shouldn't we benefit from their experience as suggested by Grudin [Gru 94]?

We adopted the second approach. We will describe its framework, through the software Architecture of a co-operative system. We start from a platform of teaching remotely that consists of an educational server, a synchronous module of communication, a dynamic tasks manager and an assisted navigation tool through the hyper-textual structure of the educational server.

On the basis of this methodology we conceived a system which is composed of:

- Remote database containing information that is at the disposal of the learners and made up of multi-media documents accessible from a distance.
- Networks connecting students' and teachers' workstations to the database.
- Communication procedures based on a new interaction metaphor called: "the telephone rings". This interaction makes it possible to create a form of dialogue and direct exchange between geographically distant interlocutors.
- A dynamic management module of the training activity in co-operative situation.

EDUCATIONAL SERVER

We have developed an environment to experiment with distance learning. The system offers to the users a set of courses and a graphical interface to access the system and communicate with each other and/or with the instructors. We designed the system based on the users' needs. The users access the server through Internet from their locations, which might be home, learning centers, public libraries, etc. The system is made up of a server for different educational activities (courses support, presentations, images for illustration, and exercises for evaluation) accessible to the general public. Trainee and tutor access the server, communicate and cooperate with each other.

The trainee has the facility to contact the teacher via electronic mail from any web page. The user can ask questions, access the questions frequently asked, and read the answers given by the instructors.

The educational server is structured in a set of practical sessions whose content is in accordance with the teaching of technologies for information and communication (data and documents management, Internet tools, multimedia, and web site development). Each course is composed of chapters, sections and paragraphs. Also for each course there is on line a table of content, a presentation page, access to the subject index, and the bibliographic reference list. The movement from one place to another is done using buttons. The educational server has to follow a graphical and pedagogic chart prepared before hand.

Guide of Educational and Graphical Design

The quality of an educational site depends mainly on the organization of textual and graphical information, the browser flexibility and the level of interactivity. The guide of educational and graphic design containing a design plan and a set of recommendations is provided to simplify the task of the site designer. This guide is elaborated based on our own experience in sites development and the analysis of several web sites available on the Internet.

The teaching design is used to structure the contents of pages in order to facilitate the training. This will make it possible to achieve the teaching goals and to attenuate the problems raised by the users. The teaching design of a course is carried out through several stages. First the identification of the training specific objectives and aimed goals must be defined. Second the content must be structured logical training units. Third a complete scenario of the site is implemented. Four the complete navigation flow chart and the logical links of the site must be designed in order to allow the user to build a mental structure of knowledge. Finally, model pages are produced. A prototype is built to make it possible to standardize the presentation of the semantic units of the site (typography, page presentation, title, graphical elements placement, etc).

COMMUNICATION METAPHOR

The process of communication is carried out by the interaction of three elements: a transmitter that sends messages, a channel and a receiver. The complexity of this process depends on the number of people involved and the technique used as mean of communication.

The communication within the group requires from the data-processing point of view not only the recovery of information of a distant source but also to be able to quickly access this information once found. The requirement for an immediate storage at low cost of objects being used led to the definition of workspace concept. This space constitutes an environment in which the available resources are refined according to the needs of the process that is using them. We should explore the metaphors of the real world and exploit the visual signs as well as the graphic possibilities to carry out a considerable advance in the field of the man-machine interfaces.

The use of the metaphors of interaction makes it possible to facilitate the design phase. By copying the operation of an application on that of a current element of the real world, one discharges the user from the phase of training [Eri 90]. The telephone is the example most usually used in Man-Machine-Man communication systems. Thus, the implementation of the communication model is based on a new design metaphor called " the telephone rings ".

Principal Characteristics

The "telephone rings" is a rather long connection and which can be stopped, by a double opposition to the glance used amongst other things in system CRUISER of BelleCore laboratory [Fis 92]. The " telephone rings" makes it possible to establish a communication with a correspondent. The correspondent attention is drawn by the sound of the telephone ringing (and possibly by the display of the call number). The " telephone rings" is a reciprocal connection between two or several users, one is the caller but the called ones must give their agreement so that the communication is established. It is thus a metaphor close to OfficeShare used in the system RAVE, and the mediaspace of RANK XEROX [Gav 92].

We have established three principal characteristics with the metaphor of the " telephone rings":

- Reciprocity: any user who can call must be able to be called. This reciprocity is not necessarily total, someone who can call, does not have to be called (restricted station...).
- The feedback information about who and when is given to the called.
- The protection of privacy can be done quite simply by disconnecting the telephone (busy or does not answer). Thus it can not be contacted. This protection can be done via a filtering mechanism of calls by means for example of an answering machine.

System Operations Based on the Metaphor

The system architecture is organized in layers around a server that manages connections (like a telephone switchboard): a software layer on the top of the server manages the access control and another layer manages the information feedback. This decomposition in layers adheres to the principle of distinction between mechanism and the usage policy. Some principles of the system operations are described next:

- A request for co-operation can take place when the telephone rings.
- The caller formulates a request and sends it to the receiver. The caller is the server and the others are the clients.
- In the absence of call, each user can carry out a work for him or the community independently.
- In the same interval of time (communication time), two people cannot call each other.
- Based on the telephone technology, we will suppose initially that one cannot call somebody who is already on another line. In a forthcoming phase, one will suppose that a user can speak in alternation with several other users and to even establish a multiple connection between several users as in system CAVECAT of the university of Toronto [Man 91].
- Each process updates locally its interface widgets, which are not distributed. For example somebody may increase the sound of his telephone set.
- The fact that the object is distributed, the feedback of the user is simple. All the changes in the objects are automatically propagated with the other users' processes.

Application to the Training Cases

The different remote training cases in our platform are grouped in three classes:

- Star Training: the trainer leads remotely the training of several learners at the same time. Synchronization points are necessary in order to make it possible for learners to catch up with each

other. Learners do not communicate with each other. The trainer does not send any common message to all.
- Training via interpersonal communication: the trainer sends the same problem to each one of learners who are able to interact with the trainer and to use a set of documents that are at their disposal (personal initiative). At certain moments, the trainer can send the same message (public space) to all (advise, document, problem, example, etc.). He can also authorize in certain cases a communication or exchange of information between learners.
- Collective solution of problems: it is a real co-operation situation. The trainer proposes a problem to a set of learners who will cooperate to solve it. The co-operation is free where all learners have the same status a priori. Each one has pre-established roles.

We are aware that the choice of training cases will depend on the structure of the group in the process of training. A mechanism to analysis the different cases, is designed to help the members of the group to make the best decision. The system must thus have tools to manage the shared resources, individual and collective knowledge and suitable communication devices. The problem to be solved has a significant influence on the users' final choice.

DYNAMIC MANAGEMENT OF TRAINING ACTIVITIES

We differentiate in a co-operative training activity several steps corresponding to the individual production phases and the synchronization/decision co-operative phases. The various users involved work independently from each other during the production phases but now and then they synchronize their progress in order to have a coherent activity.

The implementation of such a solution in the system requires a decomposition of the problem. This decomposition can either be present in the problem statement or agreed on by the people involved in the development phase (role distribution, task division, etc).

The needs for co-operation are not always foreseeable a priori: one learner can thus be blocked in the solution of a problem, which was delegated to him, so he needs the assistance from other learners. In this case he can either ask one of the trainees of his choice or leave it to the training system, which tries to find a learner who may be able to help, or one of the available trainers.

The possibilities of interaction within a group allow the individuals who compose the group to correlate their behaviors in an adaptive way to face various situations. This functional correlation implies the existence of a common cause: the problem to be solved. The co-operative resolution is a cyclic process, which stops at the time the goal is reached and which passes by the following stages:

- Decomposition of the initial problem in a set of tasks
- Distribution of the tasks among the members of the group
- Solution of the individual tasks
- Combination of the partial solutions

This way of looking at the problem allows a great flexibility, because no solution is imposed. The space-time modification of the environment involves in return the modifications of the group behavior, which can thus adapt to the new environment. It allows also a greater robustness, because the individual error is not excluded, on the contrary it helps the group not to fall into erroneous configurations. The feedback mechanism allows the coordination of the individual behaviors.

For a better coordination, a user must be able " to visualize " his state with respect to the task to be carried out by the group, which enables him to predict his future actions. This also makes it possible to inform the users of their state and the tasks on standby [Abh 96].

The tasks involved in the management of the workflow and the learners' repetitive tasks would be delegated to virtual assistants equipped with certain intelligence. An assistant is software that achieves the mission, which was entrusted to him in an autonomous way at the convenient period, even remotely if there is a need. Such an assistant must take all kinds of decisions (important or not) without claiming ceaseless approvals. The characteristics of such an assistant are:

- the assistant must be autonomous, once started by the user or by an event, it acts without the least external intervention

- It is self-adapting; it is able thus to learn in contact with the user and to develop its capacities progressively with time
- It must function in the background without obstructing the user
- And it has finally, a conditional intelligence. Thus, in complex and changing contexts, it is able to make decisions instead of the user.

The internal architecture of the assistant is based on an approach, which combines at the same time rules defining its task and an intelligent function to observe users' actions and work habits. To model this function, we used techniques based on the production rules and the probabilistic reasoning.

The assistant observes the user and when it locates a behavior, an action that is repeated, compares it with its database of knowledge. If there is a strong probability of a link between the located behavior and knowledge of the assistant, then it proposes to automate the sequence of actions. The user can either accept or reject the assistant recommendations and the delegation of responsibilities. The user can constantly intervene, not to modify the programming of the assistant but to direct its deductions. There is a need to find a simple technique to allow interaction between the assistant and the user.

NAVIGATION HELP

Navigation help takes primarily two forms:

The first form relates to the design of Web sites. It is a question of adopting a method, which facilitates the access and the traversal of the site by the user. For example, we propose to be restrictive by limiting to four levels, the in-depth decomposition of the various pages (what corresponds in fact to three nodes activable in sequence). Moreover, in each screen, an average of five possible links appears to be the most adequate. In order to be clear and efficient priority is given to links to the general levels that conation the direct ideas (1st and 2nd). This will facilitate the reference. This method of construction deals with the traditional tools of realization of hypertext. It should make it possible to obtain hypermedia that has less complex and more effective structure. This new approach forces the designer to divide, for example a course, in several sections exploitable separately. An interrelationship between these sections is possible between but indirectly.

The other form consists in providing the customer assistance to enable him/her to better navigate with his/her preferred browser. The available navigation software such Netscape Navigator or Microsoft Internet Explorer propose functionalities like the history and the bookmarks. But these technical functions have proven to be of limited help to the kind of troubles encountered by the user. Moreover, the point view and understanding of a hypertext system vary significantly from one user to another. A significant number of computer aided systems for navigation are proposed in the literature: Nestor [Zei 97], Broadway [Jac 98], FootPrints [Wex 97], Hypercase [Mic 96] and Letizia [Lie 95].

Help System Description

We developed a computer aided tool virtual navigation on the Web called NaVir to help the user to locate where he/she is with respect to time and space during a navigation session. NaVir can be used with any navigator (Netscape Communicator, Internet explorer or other). The principal screen is composed of several windows. Its kernel is made up of two significant modules: a module to extract URL addresses and a module to construct and interact with the navigation map. The second module manages the navigation time [DJO 99]. The user has also the possibility to access a glossary containing the terms frequently encountered on Internet and likely to be misunderstood by beginner "surfers". A help window on how to use the software can also be opened.

In order to guarantee the system independence from the navigator, the solution adopted for recovery of the visited addresses consists of an active agent (proxy server). The proxy server is interceded between Web clients and information servers using various protocols, it is used as relay. Each user request is sent, by the software installed on the client side, to the proxy server, which will answer it, directly if it has information in its cash. Otherwise the proxy send itself the request to the destination server. A copy of each document thus relayed by the proxy server is kept in the cache memory of the proxy (for a variable amount of time). If a document already in the cache is requested from the proxy server, then it is not requested from the distant server. The cache is configured in a way to make it possible to define the cache management according to certain parameters: date of last update of the document, maximum lifespan of the documents in the cache, and the time expired since the last use of the document. This system, transparent to the user (except at the time of initial installation), thus offers answers much faster for data available in the cache. It takes more or less the same time, as other system, to get data that is not in its cache. So in general it reduces the traffic over network in a significant way.

The proxy server receives the requests from the navigator, recomposes them if necessary, and sends them to the map creation module. The server is installed locally on each user computer to serve as HTTP requests. The navigator must be configured to use this proxy. Each HTTP request is intercepted and transmitted by the proxy which extracts and preserves necessary information (requested address and elapsed time since the last request) and preserves them. It stores the data in a file, which will be used later on by the map creation module.

Graphical Navigation Map

The use of graphical map as a device to assist the user navigates the Web is based on a study of the cognitive processes that are involved during the navigation of distributed hypermedia. It gives a graphical representation of the conceptual and geographical search path that a user follows in the information space, in agreement with the cognitive navigation maps. The card of navigation, which we conceived is inspired largely from the principles used in the conceptual cards [Gai95].

A conceptual map is a mean of representing the existing relations in a set of knowledge as well as the nature of these relations. It is thus a map representing links between concepts of the same topic. It must be able to evolve at the same rate as the acquisition of knowledge by the learner.

The conceptual map can be also a navigation tool, making it possible for a hypertext reader to see the titles of various information units as they are displayed on the screen. The links connecting these units in a form of a traffic network are also displayed. The map is drawn with a goal, within a framework of reference well defined and according to a graphical representation suitable to navigation problem.

Choice of Graphical Representation

The navigation map makes it possible to keep track of the path followed by the user while he/she is surfing the Web. The map is a form of a directed graph whose nodes consist of the page (URL) address, the page topic or title and the time spent connected to this page. The map is visualized at the user request. The request can be made at any stage of browsing.

The map representation as a directed graph is adapted for its visualization. The visited page name and information are shown on each node. It is obvious that this information should be kept to the minimum so that it does not affect the clearness and readability of the graph. The information present in each node is primarily the duration spent while visiting a page This information can be used to evaluate the running time of Internet resources and the HTML page name. It is necessary also to connect the nodes by a link (or arc of the graph) indicating the fact that the user has moved from one page to another.

The question is to how to show the nodes of the graph on the screen without covering other nodes by minimizing arcs intersections.

For the choice of the best map representation, we considered the various techniques to represent maps suggested in the literature. Also, we took in consideration the characteristics of the navigation graph and the operations carried out. We thus adopted the circular graph method. This method consists in placing all the nodes of the graph on the same circle. Because the nodes do not overlap and moreover are distributed uniformly on the circle, the graph is readable. The arcs will inevitably cross each other but the intersection is concentrated toward the center of the circle. The arcs going out or coming to a node can be very easily followed. Moreover, the implementation of such a representation remains relatively simple. Thereafter, the user has the possibility of modifying this representation by a direct interaction on the map.

Map Manipulation

In addition to the automatic graphical map generation representing the visited pages, the system allows the drawing of the map from a list of identifiers of pre-selected pages. Also, the user can follow the map evolution by creation, deletion of any link or reorganization of the graph, or do only a read of the map for a simple task. All actions that are performed and amount time spent on each page are saved and used for evaluation. This information can be shared among a group of users.

The navigation notion through the web can take another meaning if we make a space correlation between the graph containing the web addresses and a geographic map. The zooming idea starts from here. We propose many zooming levels to make correspondence between different extension of Internet addresses (.com, .edu, .fr, .ae, etc) and countries on the geographic map. Different sites having the same extension represent states, pages of the same site represent cities of the same state. This leads to a better comprehension of the Internet hierarchy and helps the user to locate himself within the network. Also, the same way we keep track of the time spent during a navigation session can be done for a page, a site or a set of sites with the same extension. The cognitive overload problem is solved by the possibility to do a map zoom (or part of the map) to be able to hide or unhide different details. Also, the user can display many graphs corresponding to different zooming level: extension graph, graph of visited sites, graph of pages of the same site, etc.

The graphical map can be displayed in three different modes to simplify the comprehension of Internet navigation. The first is *extension* mode used to group sites according to their extension. The nodes of the graph represent all extensions of sites visited. The other two modes are *site* mode and *page* mode. They are accessible by clicking on the desired node. If we wish to see all sites visited that have the extension <<.fr>>, we just click on the corresponding node. The graph displayed represent all sites visited and which have extension <<.fr>>. Each node of this graph represents a site. If we want to visualize all the visited pages of a particular site, we click on the corresponding site. The nodes of newly displayed graph represent the pages.

At any moment it is possible to go backward by clicking on back button. When we are in *page* mode, we can recognize the complete address and title of a node by simply clicking on it.

Actually, to make the comprehension easy a coloring system is adapted. The node colored in green represents the first site (page if we are in *page* mode) visited by the user. A node colored red represents the last site visited. The intermediate sites are colored orange. If the first site visited is also the last site, then it is colored in gray.

The user has also the possibility to save, print or reopen the map constructed during a navigation session. He has also access to the log report during a session that will allow him to do a self-evaluation and to be able to follow his progress during a training period or a search for information. It is also possible to have report indicating the daily interactions and the time spent connected to each site. The graphical map can be used to share information within a group of learners in a cooperative learning environment [Zei 97] [Jac 98]. Each user can benefit from the experience of the other members of the group.

Navigation time

According to [Per 96], people do not manage the time the same way while using a media to learn or to just get information. Some users manage their time efficiently, but others do not. In this regard people act in different ways. There is a huge difference in the estimation of time spent browsing from one person to another. Certainly, our interest in the message being read and our motivation for browsing the Internet play a major role in our time estimation but there are other factors related to the communication tools which also influence our intuition. These observations suggest a dual notion of the time. On one hand each media has its own internal clock, on the other hand the users have their own notion of the time based on the interaction with this media.

Actually, there are two kinds of speed (which imply that there are two amounts of time for this execution) related to the execution of any phenomena. The first time is the universal time measured by our watches. This is the real time. The duration of the execution of phenomena is equal to the difference between its start and completion times. The second time is the time estimated by the user. This time does not have any mathematical base. It is related to the user's cognitive activity and his perception of the real time.

Our mathematical values loose their significance because we have a deformed perception of time. We can not define a response time in an absolute way, but we define it based on the time that we perceive. While using a graphical interface, the manipulation is done in a direct way via the interface objects (keyboard, mouse, etc.) in

response to these actions the represented objects change to inform the user that the event has taken place. These requirements are generally taken in consideration by the software developers. But the time dimension is rarely considered by most applications such as the available web browsers.
In order to give to the user, the ability to be aware of the time spent during a browsing session, we added panel on which the time is displayed. When the user starts the system, he will be asked to enter the expected time to be spent. Once the time expires the system will inform the user by displaying a message. Then the user can decide what to do next. The choices are continuing the browsing, save the information find so far, or quit. Actually, the user can request the system to display the total time spent on each node. In addition, the user can display the cumulated time spent on each node.

EXPERIMENTS

The tools proposed were designed to answer certain problems. It is necessary to test these tools with the participation of learners. We have tested the developed platform in real practical sessions in cooperation with a teacher and his students. This testing was done in a course about the new information and communication technologies in general and about the web in particular. There were about 100 second year university students, aged from 19 to 22 years. Their major is earth science, and all had some experience with some browser. They used the Internet to search for information before. This is a limited experience because we have only the strict minimum needed equipment. Also, the connection equipment is not suitable for heavy use.

The experimental environment is made of:

1. Free access to the educational server (self-learning mode) as a complement to the course taken in a regular class.
2. A guided access to the course according to a plan, prepared by the teacher, which is made of a set of documents on the educational server and some links to public documents available on the web.
3. The collection of information about a particular topic from the Internet and the structure of this information into a personnel or group document will be submitted to the teacher using the browsing map.
4. The time panel is used with the browsing map to limit the time of search and access of information.

The use of the browsing map has given the students the possibility to structure their knowledge, recognize their limitation and to have a graphical support that can be used to prepare the plan how to search for the needed information. The proxy architecture made it possible; while using the tools, to display on the screen the browser on one window, the sequence of site and the navigation map on another. This solution helps to reduce the cognitive overload of the users.

For the teacher the graphical map can be considered as a tool to analyze the content of what is being taught, to have a better structure of the programs and manuals, and to build a plan for the course. The preparation of a guided tour with comments helps to get the new learner to start. These guided tours allow a simple browsing without limiting the freedom of exploring. They include some public documents available over the Internet and some local documents prepared for pedagogical purpose.

CONCLUSION

We designed and implemented a platform that helps to solve many problems pertinent to distance cooperative teaching. But it seems that it is necessary at this stage to tackle questions related to the use and the control process that a learner must exert on its own training activity. We plan to design a platform that allows a group of teachers to conceive in a co-operative way intelligent tutoring system [Tal 00]. Also, another aims of ours is to evaluate the system in a cooperative training environment either remotely or locally. This evaluation will make it possible to measure the user's opinion about the integration of the co-operation and the availability computer aided tools within the framework of training via Internet.

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