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Model of a Cooperative Simulation Project

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Abstract: In this study, we present and define a model of cooperative simulation project. We divide this model into four cooperation modes. These modes were developed from the conduct method of a simulation project. For each mode, we propose a description of interactions using the Denver Model. We illustrate our study by presenting our experiment with BSCW system to implement such a model.

Key words: Simulation modeling, cooperative simulation, BSCW, CSCW, denver model

INTRODUCTION

We observe that an increasing number of enterprises and individuals are equipped with high-tech computers and various accessories (Web cams, scanners, earphones, etc.) Furthermore, democratization of Internet access has led users towards increasingly communitarian and geographically oriented working modes. Users become increasingly demanding and expect computer science tools to assist them in their daily work. One cannot henceforth consider a computer program like a single-station application to be used by an isolated user. The study that has consisted in the past in investing important sums to develop centralized single-user applications will not be economically profitable in a very near future. Today's tendency favors groupware applications. Many classic single-user applications, such as Text Editors and CAD tools are already available. It is also worth noting to underline that today, worldwide economy has become more interconnected and more competitive, leading to an increasing need for organizations to form joint design teams that collaborate for the life of a project.

This is particularly true in the field of modeling and simulation where a simulation project is merely the task of a team rather than that of an isolated person[1,2]. In this study the objective of our study is the adaptation of the results of the research originally from the domain of the Computer Supported Cooperative Work (CSCW) by general vocation, to a specific domain, the conduct of a simulation project. In the first part of this study, we define four cooperation modes developed from the conduct method of a simulation project. In the second part we characterize these cooperation modes using the Denver Model. In the last part we present our experiment for implementing a simulation groupware with the BSCW system.

SIMULATION AND COOPERATIVE WORKS

The group dimension of a simulation project: From an external point of view, analyst or engineer is often seen as the unique actor in conducting a simulation project. This is especially true if he or she masters well the simulation software that serves in programming the simulation model. Meanwhile, the practice has shown since a long time that in major simulation projects, a set of collaborators are generally implied (statistician, machine operator, workshop chief, engineer, programmer, client of the study, etc. . .)[2]. Such collaboration can be achieved by internal worker of the enterprise or by external consultants. Jerry[3], has noted that the demand of consulting in the simulation field has grown faster than the consulting offer since the demand could not be satisfied by local consulting companies or researchers. It is also commonly recognized that to be able to use correctly and intelligently simulation techniques, it is necessary to have more or less skills in various areas (probabilities and statistics, modeling, programming, etc.). Therefore, due to the diversity of expertise needed, a simulation project must be seen as the responsibility of a group of individuals, acting or not in a structured team where each member plays one or several roles even if the assignment of roles to members is not made in an explicit manner.

Conduct method of cooperative simulation project: Group work can theoretically be organized as per two extreme working modes: subcontracting versus partnership. The effective working mode often uses a combination of both[4]. In either study, the project authority breaks up the work to carry out into parts and delineates it as goals and constraints. He assigns subsets and provides context to each participant or team. Each participant works on his subset according to objectives and constraints imposed,

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then submits his work-results to the project authority who gathers the accomplished subsets, verifies their content, then merges the parts. In the subcontracting mode, all constraints must be clearly defined so that each participant may work autonomously. Cooperation is limited to regular interactions and the steps of validation and transmission of information. In the partnership mode, interactions between participants take place throughout the process. Interactions make it possible to detect and solve problems as they arise. Theoretically, when a work is done in cooperation with several people, the steps consisting of analysis, design and validation, can be conducted in a sequential way (pure or iterative), or in a concerted way. Of course, the partnership cannot be carried out as a purely sequential mode: there would be no possible interactions between the participants.

This overall work-group setting can apply perfectly to the simulation field. Indeed, a project in this domain consists of a set of tasks, each of which requires specific skills. Some of those tasks cannot be accomplished before others are finished. These tasks are accomplished by a work-team placed under the responsibility of a Project Authority and working together on this project in view of obtaining a defined result, that is both known and measurable. This work-team, in its size and configuration, varies from a project to another. This variation depends greatly upon the cost and size of the project and is linked to its complexity in both technical and functional aspects; thus, the simulation of a plane requires dozens of specialists and skilled professionals, while the simulation of an electric motor requires few workers in most cases: a programmer and an electro technician. Generally, the team responsible for the realization of the simulation project is composed of: computer specialists (Engineer, Analyst, Programmer, data entry operators, etc.), the main field specialists (Design engineers, Technicians, etc.), the mathematicians (Statistics and Probabilities) and the consulting experts (experts in simulation, experts in professions).

A simulation project can be subdivided into parts and studies of subsets whose complexity is more easily controllable as they have shared relations and constraints[3]. The subsets correspond to possibly different techniques (modeling, statistics and probability, programming, field-trades). This cutting into parts and controllable subsets is essential for its management, its planning and thus to its satisfactory outcome and success. It also enables different scenarios of cooperation between the doers of the project.

The implementation of a simulation project is graded in several stages each of which needs to be followed with the greatest care. It starts with measures taken towards

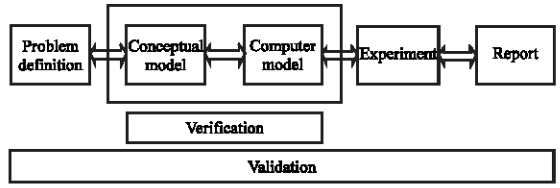

Fig. 1: Simple simulation project[5]

the formalization of the objectives and the terms of references. Next comes the planning (delays, finance, etc.), as well as the acquisition of the computer material and software, the recruitment of highly skilled professionals and the submission of the subsets and objectives entrusted to each one. In the process, the study is upheld by coordination and follow-up of the teams and work, which can take place through supervision and collaborative work.

Figure 1 shows a simple simulation project. A simulation project is usually initiated as result of a need to analyze a real world problem with a view to decision making in a system that cannot be studied directly due to cost or danger. The study usually begins by defining the problem in as much detail as possible. The next step is to form a conceptual model of the physical system in which the problem exists. Diagrammatic techniques are typically used (activity cycle diagrams, event graphs, flow charts, block diagrams, etc.). Consideration must also be given to how time advances in the system (time stepped, next event, continuous), to whether or not system activities take deterministic or stochastic time and to how the system changes state (discretely, continuously, or both).

Once there is agreement by the involved parties that the conceptual model is an adequate representation of the physical system (validation), it is translated into a computer model, which is then tested (verified) to determine if it conforms to the computer model (although with modern simulation environments the conceptual and computer modeling are often merged). The computer model is then combined with experimental data to attempt to discover more about the problem under investigation. Validation is carried out at all stages of the simulation study to ensure that the various models used do not deviate from the physical system being studied. Statistical analysis of experimental results can either result in recommendations as to how to solve the real world problem, or in further refinement of the problem (as more is discovered about the real world system).

FOUR COOPERATION MODES

It is necessary in order to create a group application to first identify the cooperation modes through which members could interact with the application and communicate with one-another. On the whole, a group application must support several communication channels that will ensure, respectively[2]:

- A Human to Machine communication with classic software used locally by each member (Text Editors, Spreadsheets, etc). There must necessarily be a modeling and simulation tool among these applications.
- A Human to Machine communication which involves team cooperation and whose fundamental aim is the coordinated handling of divided objects by the group members, in a true multi-user mode.
- A Human to Human communication which offers to group members several conversation modes: Mail, Chat, stick-up, videophone.

Based on a method for conducting a simulation project as presented hereinabove, we attest that this may be done according to various cooperation modes:

Asynchronous cooperation: The asynchronous cooperation equates the autonomous working mode. In this cooperation mode, members work at the same time but in an autonomous way. Each member works individually but it is not excluded that a member use the work of another.

Cooperation in session: Cooperation in session involves presence within the organization. In this co-operation mode, members of the group work at the same time, but in an autonomous way. They are available to debate (in Co-temporality) but without sharing data visually.

Cooperation in meeting: The concept of meeting adopted by cooperation in meeting precisely relates to that of a specific project. Clearly identified members work and communicate in Co-temporality while sharing data and discussions. They are assigned roles in connectedness with the aim of the meeting. The organization of their mediation is governed by a policy of "speech turn".

Close cooperation: Close cooperation involves a more precise vision of the cooperation. This form of cooperation resembles the concept of cooperative work on the board. Members can work, communicate and interact in real time on all shared project data. Resulting consequences of the group's interventions are directly managed at the level of the data handled. Next, we apply the Denver model to characterize these cooperation modes, from the point of view of interactions, situations and protocols.

DENVER MODEL

The Denver Model is offered as a framework with which to plan or evaluate the capabilities associated with a particular groupware application. This model was the output of 14 participants at the two day workshop on Designing and Evaluating Groupware, held at CHI'95, Denver Colorado[6]. The Denver Model is a nested collection of models describing the generic elements of any groupware application. The first model consists of three submodels describing three aspects of constructing and reviewing groupware applications: Goals and requirements, design and technology. The design submodel illustrates a framework for groupware as well as identifying those characteristics that uniquely define groupware applications as separate from single use, single user applications. Groupware applications can be characterized by five categories related to:

People: this category refers to the characteristics of people (names, appearance, voice, addresses, phone numbers, primary language, signature, their culture, their business, their interests, etc). The roles people play in a group include their business status, cultural status, their technical expertise, their operational expertise with respect to the groupware application, etc. As pertains to design, users interact with each other and with the system depending upon their role in the group. More importantly, people assume different roles in different groups. The characteristics of groups include the following, which range from stable and homogenous to unstable (changing) and heterogeneous: represented disciplines, group versus individual goals, stage in project/project cohesion, company(ies) represented, culture(s) and language(s) represented, group size, order and status in the group.

Artifacts: This category refers to those objects produced or consumed during the interaction. There are five generic artifact types: text, sound, temporal image, static image and computational elements. Compound artifacts may be constructed by combining elemental artifacts. Artifacts may also exhibit certain generic attributes, such as: cotemporality, revisability, reviewability and quality. In addition, artifacts can possess attributes associated with ownership. For example, conceptual models, operational models, experimentations and project documentation constitute the product of the project teams.

Tasks and activities: This category presents the characteristics of tasks and activities workable by the groupware. Four levels of Tasks and Activities represent

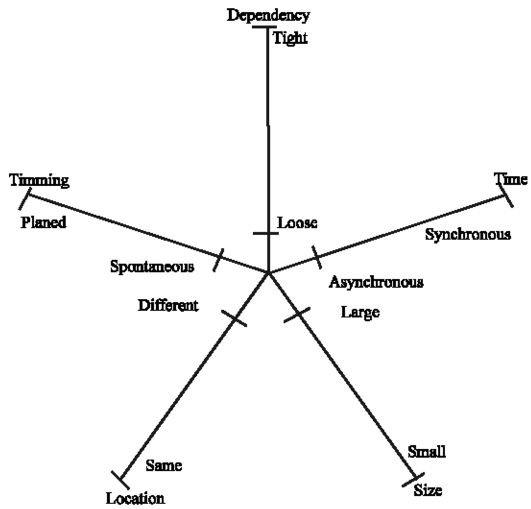

Fig. 2: Interactive situation model

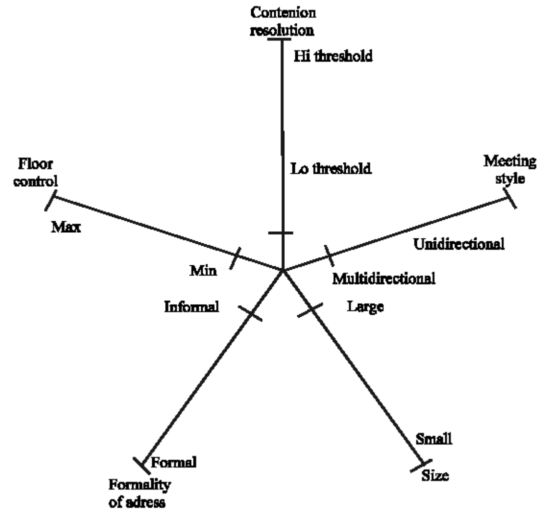

Fig. 3: Interactive social protocol model

this category: Goals, Tasks/Scenarios, Activities and Operations. Goals refer to high level work goals that guide all behaviors in the workplace and to a large extent can determine culture and specific characteristics of products that might work well in that environment. In the simulation context, objectives are for example "the performance evaluation of a production system", "to be cost and time-effective, with guarantee of study quality", etc. On a lower level, tasks are for example "design a model", "validate a document", etc. The activities combine to form tasks: "update its base of models", "coding models" and "exchange ideas" are examples. Finally, the operations are elementary handling on artifacts.

Interactive situations: An interactive situation is defined as the relationship of participants to themselves, time and space. The authors of the model represent them by a with five's axes star which correspond respectively to five concepts: Dependency, timing, time, location and group size. Thus, the groupware characteristics make it possible to give the position of five points belonging to each one of these axes (the degree of maximum entropy is located at the center of the star). The five points obtained, connected to each other, form a figure of five sides that is one of the groupware "signatures".

Interactive social protocols: A social protocol refers to the allowable sequence of exchanges of signals and information that determine and identify resolutions and conflicts. The interactive social protocol model is analogous to the interactive situation category. Here the axes correspond to the meeting style, contention detection and resolution, group size, floor control and formality of address. Meeting style refers to unidirectional or mostly unidirectional exchanges. The characteristic entitled "contention detection and resolution" describes the groupware capacity to discover the possible contention in the broad sense; the contention is a situation of competition or opposition of the participants and the moment of their resolution. Floor control refers to the competition among participants for the ability to control the interaction. Formality of address refers to just that, how formally participants are to be addressed.

INTERACTIVE SITUATIONS

Each polygon of Fig. 4 represents a cooperation mode: Asynchronous, in session, Meeting and close. The interaction situations clarify the differences between modes. All situations have in common the group size and members localization (Same/different). Differentiation, is on the level of the three axes "Timing", "Time" and "Dependency"

Timing: The cooperation in meeting Fig. 4 c and close cooperation Fig. 4 d correspond exactly to those which exist within the project framework (meeting and work on the board), i.e. planned. While an asynchronous cooperation Fig. 4a is spontaneous, it is a response to a request of another member or a spontaneous offer to a member. Between the two, the cooperation in session Fig. 4b is semi-planned, i.e. is planned from attendance sake only.

Time: The three cooperation modes in session, in meeting and close Fig. 4a, to 4d require the connection or the presence of the members, i.e. synchronous as opposed to asynchronous cooperation mode Fig. 4a.

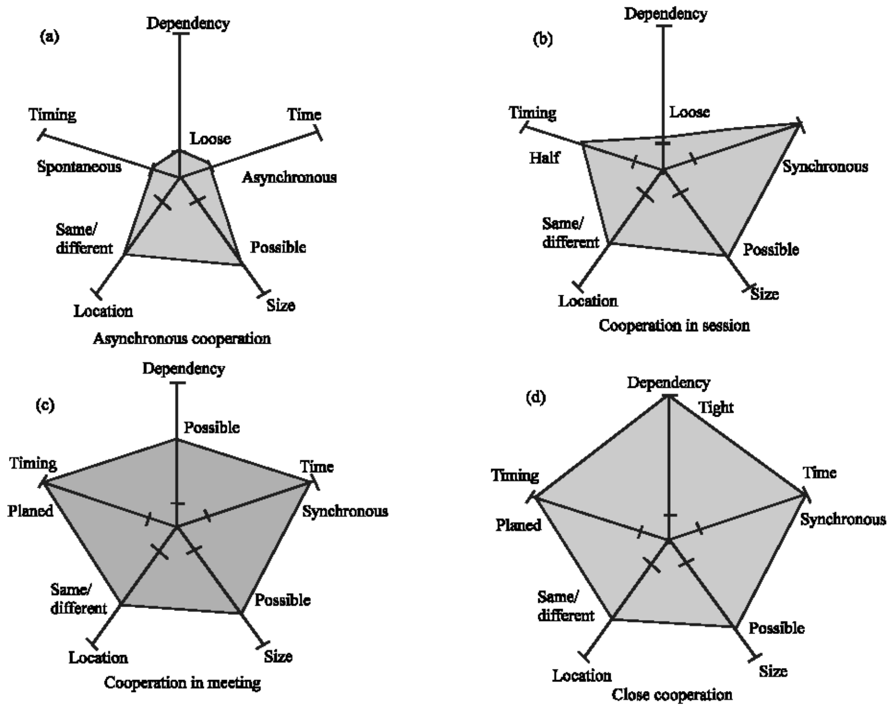

Fig. 4: Interactive situation of the four cooperation modes

Dependency: The tight dependency is that of the close cooperation Fig. 4d. In this cooperation mode, it is the project chief who decides what to do. In fact, the production of an object is carried out here by the chief's reasoning. While, in the asynchronous mode and cooperation in session the dependency is loose; everyone works in an equivalent and independent way. The dependency is possible in the cooperation in meeting Fig. 4c.

INTERACTIVE SOCIAL PROTOCOLS

With regard to the interaction protocols, each polygon of Fig. 5 represents a cooperation mode: Asynchronous, in session, meeting and close. All have in common, the characteristic group size. Differentiation is on the level of the three other axes.

Contention resolution: In asynchronous cooperation and cooperation in session Fig. 5a,b everyone works in an equivalent and independent way. Members are free to solve possible contention; this justifies the low value assigned to this characteristic. The close cooperation mode Fig. 5d is the opposite of these two last modes, the value assigned to t his characteristic is high. For the cooperation in the meeting mode Fig. 5c the value assigned to this characteristic is average, this is justifies by the fact that this mode does not include tight contention.

Meeting style: the value assigned to this characteristic in the cooperation in meeting mode Fig. 5c and close cooperation mode Fig. 5d is unidirectional, this it justifies by the fact that these modes are controlled and animated by the project chief. While, the other modes: asynchronous Fig. 5a and in session Fig. 5d are multidirectional.

Formality of address: In asynchronous cooperation and cooperation in session Fig. 5 (1), (2)) the participants work in an independent way, this supposes the existence of certain formality of communication between them. In the other modes, communication between the participants is less formal; for example an electronic mail is more formal than a note written on Post-It.

By applying the Denver model, we characterized the four cooperation modes, from the point of view of interactions, situations and protocols. Next, we present our experiment with BSCW system to implement a groupware of modeling and simulation that instance these four cooperation modes.

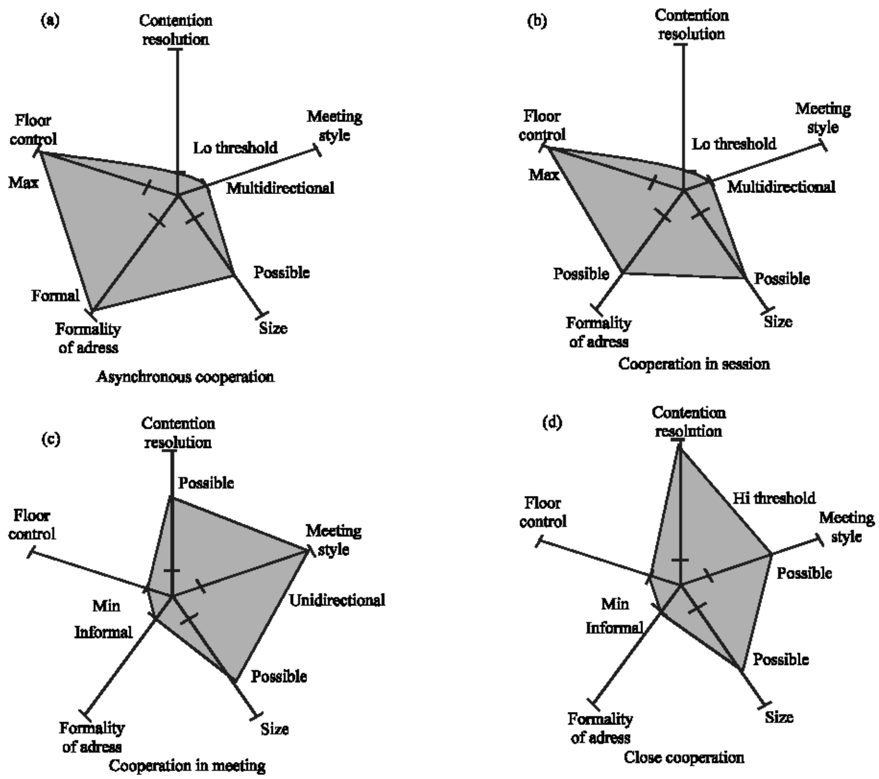

Fig. 5: Interactive social protocol of the four cooperation modes

IMPLEMENTATION

There is more than one approach to implement a groupware. One approach consists of using techniques and tools far less refined than those on the market. In this instance, we are confronted with the classic dilemma which consists of working with rudimentary and archaic tools. Another approach consists of using standard Computer Supported Cooperative Work tools that are more or less high-tech. The second approach seems to be simpler and easier to realize on the condition to find a standard and adequate tool for CSCW. Otherwise, we would be obligated to start the work from scratch.

A state of the art groupware capable to support the cooperative work of a team on simulation projects, allowed us to examine the latest and most crucial offers in the domain of the CSCW. Our choice of experimentation groupware was based on BSCW system (Basic Support Cooperative Work). This choice is justified by uncertainty about the available IT infrastructures of all project participants, as well as for its usability and the universality of its access. This solution exempts members from having to install specific customer software on the machines they want to use. It also enables them to work from different places.

The BSCW Shared Workspace System is an Web based groupware system. It is an extension of a standard Web server through the server CGI Application Programming Interface. The central metaphor of the system is the shared workspace. A BSCW server (Web server with the BSCW extension) manages a number of shared workspaces, i.e., repositories for shared information, accessible to members of a group using a simple user name and password scheme. Shared workspaces can contain various kinds of information such as documents, pictures, URL links to other Web pages, threaded discussions, member contact information and more. The contents of each workspace are represented as information objects arranged in a folder hierarchy. Of course, in addition to the normal download of information from a Web site, users can also upload information from their local file system into a BSCW workspace. The following are the main features of the system[4]:

Authentication: People have to identify themselves by name and password before they have access to BSCW workspaces.

Discussion forums: Users may start a discussion on any topic they like and the system presents the threads in a user friendly manner.

Fig. 6: A snapshot from the implementation: BSCW and NetMeeting and arena software in use

Access rights: The system contains a sophisticated access rights model which allows, for example, that some users may have complete control over an object in a workspace whereas others have only read access or no access at all.

Search facilities: Users can specify queries to find objects within BSCW workspaces based on names, content or specific properties such as document author or document modification date. Furthermore, queries may be submitted to web search engines and the result of the query can be imported into workspaces.

Document format conversion: These facilities allow users to transform a document into their format of choice, e.g., a proprietary document format into HTML, before downloading it.

Version management: Documents within a workspace can be put under version control which is particularly useful for joint document production.

Multi-language support: The interface of the system can be tailored to a particular language by straightforward extensions. Several languages (e.g., French, Spanish, Italian, Russian, Greek and Catalan) have been created by users of the system and are publicly available.

Event services: A cooperative system has to provide awareness information to allow users to coordinate their work. The event services of the BSCW system provide users with information on the activities of other users, with respect to the objects within a shared workspace. Events are triggered whenever a user performs an action in a workspace, such as uploading a new document, downloading an existing document, renaming a document and so on. The system records the events and presents the recent events to each user. In addition, users can request immediate email messages whenever an event occurs and so-called daily activity reports which are sent to them daily and informs them about the events within the last 24 h.

The working philosophy of the BSCW system and these functionalities enabled us to implement perfectly the concepts and the various modes of possible cooperation of a simulation project. The implementation of the cooperation in meeting and the close cooperation is done only by the possibility of the use of the suitable external software (ex. MS-NetMeeting.). Figure 6 represents a participant's space who discusses the possibility of the use of the ARENA simulator in the current project with another member via the NetMeeting software.

The experimentation was conducted within the project framework of the end of studies to obtain a diploma in industrial computer science engineering at the University of first Author. The title of the theme was "Construction of a simulation model for the performance evaluation of a production system: Case of the national company of industrial gases ENGI. Two students, following their supervisor with the collaboration of two

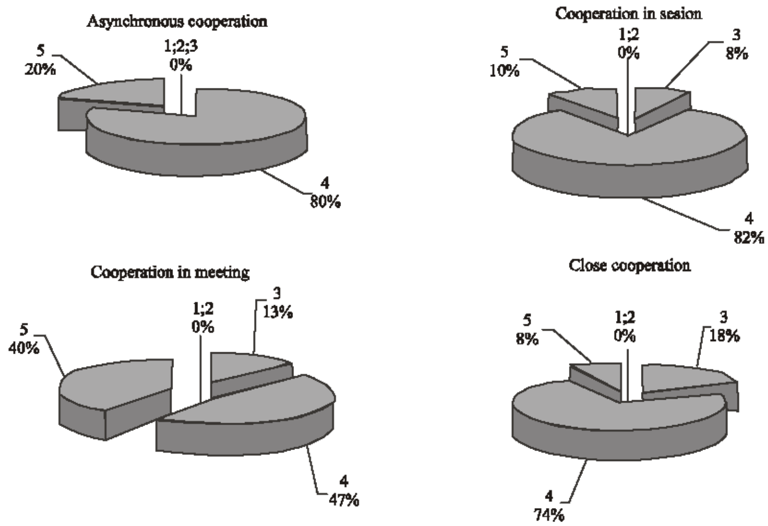

Fig. 7: Results of the participants' evaluation

other engineers and a specialist in probabilities and statistics, participated in the experiment. The experimentation project stretched out over six months.

The electronic outset of the project under the BSCW system was the subject of a reservation of a logical space managed by the project chief and of an analogous physical space. The project participants subscribe to this logical space. The logical space is organized as a tree structure of folders and files; chosen because it is a structure familiar to computer science users. In our implementation this folders structure has been used to structure logical space (ex: common space, team spaces, actors private spaces) and the creation of the project artifacts.

Rather than assuming that all features of BSCW and NetMeeting were useful, a short survey was conducted to elicit opinion of participants on the interpreted adequacy of this implementation. This led us to take a series of demonstrations and then follow up with a questionnaire.

Figure 7 shows the results of the evaluation. Each participant was asked to rate the groupware adequacy on a scale from 1 to 5 for each cooperation mode. Participants were also asked to weight their expertise of simulation and computer technology. Hindsight suggests that the 1 to 5 scale should have been broader (to present a wider range of options) and that expertise should have been evaluated against other factors rather than just a number. Although the cross-section of the simulation community was small, the result of this experiment is extremely clear.

CONCLUSION

In this study, we proposed a model of cooperative simulation project that includes four cooperation modes. These modes have been developed from the conduct method of a simulation project and different facets of cooperative work in the context of a simulation project. We then characterized them using the Denver model, then programmed within the BSCW system. The ideas proposed are not tied to a specific simulation tool and can be used with any tool. This study was carried out within the framework of a research project entitled «CSCW and Simulation: Toward a platform of analysis and design of production systems oriented group ». The object of this project is to analyze the cooperation practices during the conduct of a project of modeling and simulation of a production system, then to specify and develop a simulation groupware with an aim of adding the group dimension to simulation tools.

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