Identifying Coordination Agents for Collaborative Telelearning

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HAL Id: hal-00197381
https://telearn.hal.science/hal-00197381

Submitted on 14 Dec 2007

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Abstract. This paper deals with *identifying roles* for coordination agents in a future collaborative telelearning environment. The current practice of students participating in a net-based simulation marketing game on-campus, is studied with an eye on designing a future collaborative telelearning environment where this same net-based simulation game will be central. The work described in this paper is situated within the theoretical foundations of computer supported collaborative learning (CSCL). In particular Salomon's writings on *genuine interdependence* in CSCL, and work on *coordination* from a computer supported cooperative work (CSCW) perspective provide the view on collaborative telelearning. Viewing collaborative telelearning from a coordination theory perspective offers a means of understanding the inter-relationships between actors and entities and how these relationships can and should be supported. In this paper an extended definition of coordination is given and a set of actor (inter)dependencies and related coordination processes for collaborative telelearning is proposed. Then, coordination agents are suggested as a means of managing and supporting the identified (inter)dependencies and examples of possible coordination agent roles are given.

INTRODUCTION

This paper deals with *identifying roles* for coordination agents in a future collaborative telelearning environment. The current practice of students participating in a net-based simulation marketing game on-campus, is studied with an eye on designing a future collaborative telelearning environment where this same net-based simulation game will be central. Human-computer interaction researchers, Liam Bannon and Susanne Bødker argue for studying artefacts in use, for studying how they mediate use, how they are incorporated into social praxis as the basis for designing future use situations. In their inspiring article (Bannon & Bødker, 1991), they argue for an activity theory[1] (Leontiev, 1978) framework for designing computer systems for human use. They describe their quest for designing more usable computer artefacts and claim that *"If our quest is to actually design more usable computer artifacts, then a better knowledge of the "users" is required as a part of our analysis; one that sees people acting in a situation, with motives, and intentions, in interaction with others and the environment* (p. 248)*".* Design in this human activity framework is *"a process in which we determine and create the conditions which turn an object into an artifact of use. The future use situation is the origin for design, and we design with this in mind ... To design with the future use activity in mind also means to start out from the present praxis of the future users* (p. 242)*".*

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[1] Leontiev expanded Vygotsky's cultural-historical theory to an activity theory approach to human interaction where reality consists of "mediated, social, hierarchically organised, developing, internal and external, object-oriented activities (Kaptelinin, 1995)". For Leontiev the unit of analysis was extended to include the collective activity, something done by a community with a motive (which need not be consciously recognised), but composed of individual actions which were directed toward a goal. The individual's mediated actions could still be analysed, but there was now a social dimension (being part of a collective activity) which could be used to understand the individual's actions (Wasson, 1996).

The work described in this paper is situated within the theoretical foundations of computer supported collaborative learning (CSCL) which focuses on the use of information and communication technologies (ICT) as a mediational tool within collaborative methods of learning (e.g., peer learning and tutoring, reciprocal teaching, project- and problem-based learning, simulations, games). It is an approach to ICT in education that emphasises an understanding of language, culture and other aspects of the social setting (Scott, Cole & Engel, 1992). Bannon and Bødker's reasoning applies nicely within this paradigm and it can be argued that designing CSCL environments requires an understanding of current praxis as a basis for future use.

Salomon's (1992,1993) writings on *genuine interdependence* in CSCL, and work on *coordination* from a computer supported cooperative work (CSCW) perspective provide the view on collaborative telelearning taken in project OCCT[2] (Orchestrating Collaboration in Collaborative Telelearning). The net-based simulation game is part of a course on strategic management, and is used to engage the students in strategic decision-making. Teams of students compete against one another for market shares. Studying the current practice while focusing on how the students, instructors and simulation facilitators coordinate their efforts has lead to a first proposal for a set of interdependencies and coordination processes that will need to be managed and supported in a collaborative telelearning environment. Thus, the roles for coordination agents identified in this paper, are based on empirical studies of praxis — students, instructors and simulation facilitators interacting to support the students learning about strategic management. The paper does not, however, discuss how these agents will be built, nor how they are to be integrated into an architecture. This paper takes a first step in the design process only. The suggested agents are seen as only a part of the entire learning environment that will support collaborative telelearning praxis. Furthermore, the paper can be seen as an argument for a reflection on how the CSCL systems we design and implement are part of a current learning praxis that will be changed by the introduction of new mediating artefacts. Such a reflection should emphasise how an evaluation of the current praxis, including the social context, can provide a window to the future use situation.

The paper begins by defining collaborative telelearning and discussing the theoretical foundations on which this work is built. Then an illustration of how coordination theory has facilitated an identification of actor (inter)dependencies in collaborative learning scenarios is provided. First the methodology used for documenting (Wasson, 1997) three collaborative telelearning scenarios used in the strategic management curriculum at École des Hautes Études Commerciales in Montréal (HEC) is given and an overview of a knowledge model of one of them is used to highlight some of the inter-activity dependencies as specified by Malone & Crowston (1994). Then an enumerated set of actor (inter)dependencies and examples of possible coordination processes for managing them is presented. Finally an extended definition of coordination for collaborative telelearning is given. The paper concludes with a discussion of the implications of this research for the design of agents as coordination facilitators and coordination managers.

THEORETICAL FOUNDATIONS

This section highlights the aspects of CSCL and coordination theory that are relevant for our research. Throughout the description, three research challenges are identified. The section begins, however, by discussing collaborative learning perspectives and by giving a working definition of collaborative telelearning.

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[2] Project OCCT is a sub-project of the Canadian Telelearning Program (http://www.telelearn.ca) project 6.2.3: *Instructional Design Methodology for Computer-Supported Collaborative Learning* (principal investigators J. Bourdeau & J. Vasquez-Abad).

COLLABORATIVE LEARNING

Collaborative learning can be seen as a collection of perspectives based on principles of interpersonal interaction (Sorensen, 1997) that emphasises an understanding of language, culture and other aspects of the social setting (Scott, Cole & Engel, 1992). Traditionally methods such as peer learning and tutoring, reciprocal tutoring, project- or problem-based learning, simulations and games have been used to engage learners in collaboration. Collaborative learning also refers to notions of "socially shared cognition" (Resnick, Levine & Teasley, 1991), of "distributed cognition" (Salomon, 1993) and of "jointly accomplished performance" (Pea, 1993), which emphasise that cognitive development occurs through interactions between students, as well as between students and rich or knowledgeable environments. Fjuk (1998) identifies three perspectives of collaboration that place emphasis on different goals including joint construction, joint negotiation and using teachers and peers as resources. These perspectives can be found within the CSCL community as indicated below:

1. Joint construction of knowledge (e.g., joint problem-solving by mutual refinement). For example, see the work on CoVis (Pea, R., Edelson, D., & Gomez, L., 1994). On the web at http://www.covis.nwu.edu/.
2. Joint negotiation of alternatives through argumentation, debate and other means. For example, see the work on Belvedere (Suthers & Weiner 1995). On the web at http://advlearn.lrdc.pitt.edu/belvedere/index.html.
3. Student reliance on students and teachers as a resource to support their own learning and for external feedback. The computer serves as a mediational tool to support collaborative efforts. For example, see the work on CSILE (Scardamalia et al., 1989). On the web at http://www.ed.gov/pubs/EdReformStudies/EdTech/csile.html.

Each of these perspectives can be supported in a collaborative telelearning environment.

WHAT IS COLLABORATIVE TELELEARNING?

The term *telelearning* is used to designate new forms of distance or of computer mediated learning, where the distance is not only distance in space or time as in traditional distance learning, but the mediation of learning activities served by information and communication technologies such as multimedia shared workspaces, communication (e.g., chat boxes), or servers. Distance learning evolved from a need to ensure equal access to education for all students even when there are obstacles for them to access school or campus (Bourdeau & Bates, 1997). The main features of distance learning are the time and space co-ordinates, where students and professors do not all meet at the same place at the same time. Individual learning, individual tutoring and asynchronous communication are typical features of a distance learning situation, requiring extensive macro- and micro-instructional design, and a strong student support system. These features, however, do not dominate in telelearning. Many variations of telelearning can be found in terms of presence, telepresence, meeting in virtual spaces, interactivity with rich multimedia environments and extensive human interactions in a virtual world with no limits except access and language. These variations afforded by advances in multimedia ICT, increase the potential for on-campus learning systems to incorporate flexibility and variety in time and space from where learning can occur. In addition, it enables hybrid solutions of on-campus and distance learning systems (Bourdeau, 1996; Romiszowski, 1996).

Collaborative telelearning emphasises the collaborative interaction between students and between students and supporting actors in a telelearning environment (Wasson, 1997; Wasson & Bourdeau, 1998). Support for collaborative telelearning focuses on the design of artefacts that mediate the learning. Providing artefacts that mediate collaborative learning between distributed learners can be seen as facilitating a distributed collaborative community. "…a distributed collaborative learning community is a *'place'* that is created by the individual

students through their individual and collective actions, …The designers' role is to *support the students' work of creating that community*, and in such a way that the computer systems become integrated parts of the students' activity (Fjuk, 1998, p. 70)".

The fluid mediation of collaborative learning activity is a major challenge for telelearning. Mechanisms to support synchronisation, exchange and sharing of information or documents, and access to tools and services, need to be as transparent as possible to avoid hindering learning. An environment capable of supporting collaborative telelearning needs to be knowledgeable about organising and supporting the collaboration. Viewing collaborative telelearning from a coordination theory (Malone & Crowston, 1990, 1994) perspective offers a means of understanding the inter-relationships between actors and entities and how these relationships can and should be supported. Influenced by the coordination theory approach, project OCCT aims at developing an interdependence model for collaborative telelearning (Bourdeau & Wasson, 1997ab; Wasson, 1997; Wasson & Bourdeau, 1998). We envisage (see figure 1) that such a model will inform a) the instructional design of learning scenarios, b) the specification of the technological design comprising the telelearning environment configuration as well as the tools and services available, and c) the design of intelligent agents to mediate, or to support the mediation of, the time, space and collaborative learning activity distance between students and between other supporting human agents (e.g., an instructor, an animator). In this view, the use of agents is one way to include needed knowledge about organising and supporting collaboration.
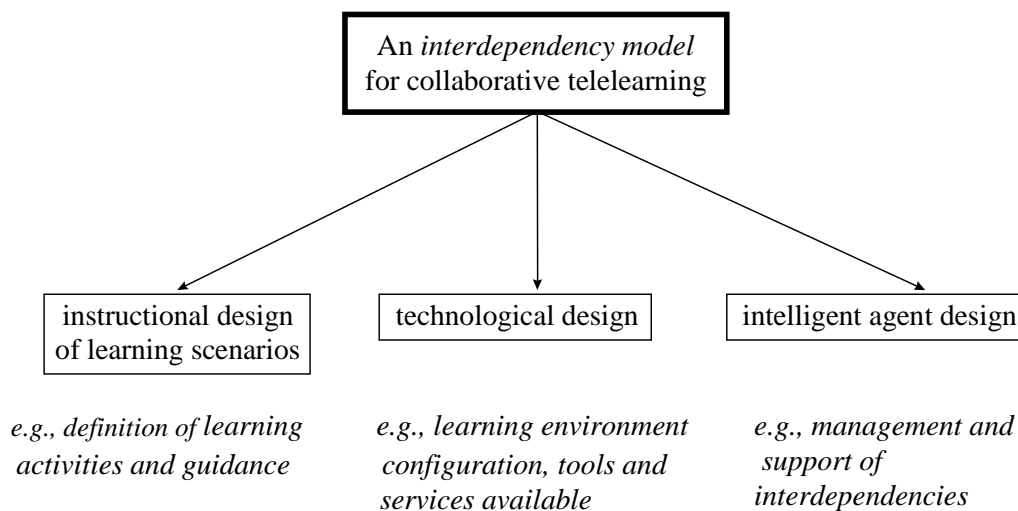

Figure 1. The uses of an interdependency model for collaborative telelearning

In her research on CSCdistanceL (Computer-Supported Collaborative distance Learning), Fjuk (1995, 1998) has carried out a number of studies of two different learning situations in which the computer system has crucial but different roles. For example, one relatively traditional distance learning situation (with highly individual and independent learning) used the computer as a medium for correspondence. A second learning situation was based on alternative didactics (Illeris, 1974) or problem-oriented project-based learning. In this situation the computer is used not only to distribute text, but also to articulate individual contribution and to mediate interaction between collaborating students (Fjuk, 1995). Focusing on the interconnection between human actions directed towards the collaborative learning process and human actions directed towards the computer application, Fjuk has developed an analytical framework (figure 2) for both understanding CSCdistanceL and for designing computer applications to mediate human actions of collaborative learning.
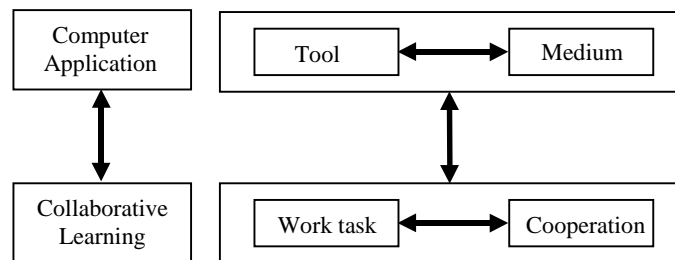
Figure 2. The analytical framework of CSCdistanceL (from Fjuk, 1995)

The results of her research show that CSCdistanceL as a learning phenomenon implies a dialectical contradiction between these two aspects which results in a requirement that computer mediation needs to mediate human actions directed towards both individual work and cooperation. Furthermore, she feels that the relationship between these two aspects distinguishes and characterises CSCdistanceL from other forms of learning. As a consequence of this dialectical contradiction, Fjuk concludes that CSCdistanceL application needs to have both a mediating role between the individual learner and the peer-students **and** between the individual learner and her learning tasks. Thus, collaborative telelearning can be understood as a medium for inter-human interactions and articulation of individual work. Similar conclusions are made by Rubtsov (1993; see Wasson (1996 for a description)).

Aim for *Effects of* computer supported collaborative learning

Computer supported collaborative learning (CSCL) gives insight into what collaborative telelearning can be. Salomon's work on CSCL (Salomon, 1992, 1993) provides one of the most complete approach to the study of CSCL in that it is built upon learning theories, relies on observations, raises strong design issues and gives methodological tools for educational research. Salomon (1992) distinguishes between the *effects with* a tool and/or collaborating peers and the *effects of* these. The first, the effects with, are the changes or results afforded during the use of a tool or in collaboration with a partner (i.e., the group can achieve more together than individually). The second, the effect of, is the aim Salomon advocates for education and is the lasting changes, or cognitive residue, that are a consequence of an intellectual partnership. To achieve long-term cognitive residue requires mindful engagement on the part of the learner. Helping the learner reach this level requires that "*the whole learning environment, not just the computer program or tool, be designed as a well orchestrated whole. This includes curriculum, teachers' behaviors, collaborative tasks, mode of peer collaboration and interaction, tasks, learning goals, and the like* (Salomon, 1992, pg. 64)".

Genuine interdependence

Salomon's research focus is on mediation in CSCL, which is a key issue in collaborative telelearning. Salomon (1992, 1993) states that CSCL's success depends *on mindful involvement* and *personal responsibility* on the part of the individual learner and *interdependencies* between learners. Of primary importance is interdependence; i.e., the sharing of information, meaning and goals, a division of labour, and joint thinking. In this view, instructional design issues become, for example, to orchestrate these interdependencies and the shared activities, while maintaining personal responsibility and mutual involvement (Bourdeau, 1996).

Furthermore, Salomon argues that effective collaborative learning requires much and well orchestrated interdependence. To avoid group phenomena such as the "free rider" effect (Kerr & Brunn, 1983), the "sucker effect" (Kerr, 1983), the "status sensitivity" effect (Dembo & McAuliffe, 1987) or the "ganging up on the task" phenomenon (Salomon & Globerson, 1989),

the interdependence must be genuine. Genuine interdependence is characterised by Salomon (1992) as:

- the necessity to share information, meanings, conceptions and conclusions;

- a division of labour where roles of team members complement one another in a joint endeavour and the end product requires this pooling of different roles;

- the need for joint thinking in explicit terms that can be examined, changed, and elaborated upon by peers.

Salomon's emphasis on *genuine interdependence between team members* raises the first specific challenge:

Challenge 1:   How can such interdependencies be specified and supported in collaborative telelearning situation?

Coordination theory

Schmidt (1997) argues that the investigation of artefacts for coordinative purposes is a crucial and fertile area for CSCW research. For CSCW researchers, cooperation is defined as communication plus coordination (Olson *et al.*, 1993). For collaborative learning based on a definition of genuine interdependence, both are certainly essential. Add collaborative learning to a telelearning environment and this requirement for coordination is magnified. Coordination entails the meshing, allocating, relating, and scheduling of activities, actors and resources with respect to each other (Strauss, 1985; Schmidt, 1994). Furthermore, the coordination of group activities requires awareness information (Dourish & Bellotti, 1992). Awareness is *"an understanding of the activities of others, which provides a context for your own activity* (Dourish & Bellotti, 1992, p. 1)".

Schmidt & Simone (1996) identify the understanding of how computer systems can aid in reducing the complexity of coordinating cooperative activities as a major research issue in CSCW. They argue that this issue was identified and defined early in CSCW history by Holt (1985). He wrote *"Whatever has to do with task inter-dependence — coordination — is left to the users to manage as best they can, by means of shared databases, telephone calls, electronic mail, replies to which multiple users have access, or whatever ad hoc means will serve (Holt, 1985)"*. Carsten & Sørensen (1996) point out that although many have explicitly addressed and modelled coordination work (Holt, 1988; Malone & Crowston, 1990, 1994; Kaplan et al, 1992; Fitzpatrick et al., 1995), these studies have not been based on empirical studies of artefacts introduced in order to cope with the complexity of the coordination work the actors must handle. In their own field studies (Carsten & Sørensen, 1996) they found that actors themselves chose to increase the fomalisation of work processes, despite the problems of increased rigidness and possible loss of control of the work.   Mechanisms were invented and adpoted to support coordination to deal with complexity.

Malone & Crowston (1994) describe coordination theory as an emerging research area focused on the interdisciplinary study of how coordination can occur in diverse kinds of systems. Coordination theory provides a means for specifying (inter)dependencies between, and among, actors, goals, activities, and resources by identifying a *dependency type* (e.g., shared resource) and a *coordination process* (e.g., group decision-making) for managing the dependency. In their work, coordination is defined *as managing dependencies between activities* (Malone & Crowston, 1994). In particular, actors face coordination problems because of dependencies between their activities, and as such, Malone and Crowston have focused on dependence between activities.

Drawing on ideas about activity coordination in complex systems from disciplines as varied as computer science, linguistics, psychology, economics, operations research and organisation theory, they present a first version of an analysis that characterises the basic

processes involved in coordination. Table 1 gives a taxonomy of dependencies between activities and possible coordination processes for managing them.

Table 1. Dependencies between Activities (from Malone & Crowston, 1994)

Dependency	Examples of coordination processes for managing dependency
Shared resources	"First come/first serve", priority order, budgets, managerial decision, market-like bidding
Task assignments	(same as for "shared resources")
Producer/Consumer relationships	
Prerequisite constraints	Notification, sequencing, tracing
Transfer	Inventory management (e.g., "Just In Time", "Economic Order Quality")
Usability	Standardisation, ask users, participatory design
Design for manufacturability	Concurrent engineering
Simultaneity constraints	Scheduling, synchronisation
Task / Subtask	Goal selection, task decomposition

For example, two activities are dependent if they *share a resource*. Resources include actors, tools or information. A *first come/first serve* coordination process would allow the first to ask for a resource (be it, for example, an actor or a computer processor) to receive the resource. Another possibility is that a *managerial decision* decides who gets the resource, or a *market-like bidding* process takes place. *Task assignment* is a special case where an activity needs to be assigned to an actor and the same coordination processes that applied for a shared resource apply here. Another example is that two activities are dependent if there is a *prerequisite* constraint between them. In this case some kind of explicit *sequencing* and *tracking* processes are needed. The *usability* dependence implies that the product of one activity must be useable by the consuming activity and this can be ensured by a *standardisation* process.

A *simultaneity constraint* dependency exists if two activities need to occur at the same time. For example a meeting requires *scheduling*. The *task/subtask dependency* often surfaces when a goal is decomposed into subgoals or activities. Coordination process *goal selection* is choosing a goal while *goal decomposition* is the process of choosing activities.

Such a taxonomy of dependencies and related coordination processes serves several purposes. First, the taxonomy serves as a way to organise coordination mechanisms. This will enable others to determine if identified dependencies or coordination mechanisms have already been recognised, and if not, to add the new dependency type or new coordination mechanism. Second, if you can identify a dependency, then you can consult the table to find out what coordination process is needed to manage that dependency. The coordination process itself can be broken down into a number of activities as is shown in table 1 where the *generic resource assignment* coordination mechanism is represented as a four step process comprising: identify necessary resource, identify available resources, choosing resources and marking resources in use (i.e., assign resource).

Malone & Crowston's emphasis on *dependence between activities* raises the second challenge:

Challenge 2: Which of these dependencies arise in a collaborative telelearning situation, and what coordination processes are needed to manage them?

Adoption of Salomon's definition of genuine interdependence in our research has lead to a focus on the ponderation of *(inter)dependencies between actors* such as individual students, teams/groups of students, instructors, tutorial assistants, or experts. Thus the third challenge becomes:

Challenge 3:   What (inter)dependencies arise between actors in collaborative telelearning and what coordination processes are needed to manage them?

Although Malone & Crowston (1990, 1994) include actors in their theory, the major emphasis is on the role of actors as a resource (an actor is assigned to an activity). The coordination processes they identify deal with managing the dependencies where it is a goal to minimise the number of dependencies in a complex system. In collaborative telelearning, on the other hand, interdependence between learners is desirable, and we design tasks that will create actor interdependence.

SUMMARY

Collaborative telelearning focuses on the collaborative interaction between distributed learners. In order for collaborative learning to be effective, Salomon argues that we need genuine interdependence between the learners. Thus we need to design learning tasks that require interdependence between the learners. Supporting the interdependence between learners in a collaborative telelearning environment is a major challenge. CSCW researchers have been and still are addressing coordination issues. Viewing collaborative telelearning from a coordination theory (Malone & Crowston, 1990, 1994) perspective enables the identification of (inter)dependencies that need to be managed and supported. The next section describes how collaborative telelearning scenarios have been modelled from an (inter)dependence perspective.

MODELLING COLLABORATIVE TELELEARNING SCENARIOS

Several collaborative telelearning scenarios that are in use in the teaching of Business Administration at HEC, École des Hautes Études Commerciales have been documented in detail (Wasson, 1997). One documented learning scenario has been modelled using a knowledge modelling tool developed at the LICEF Research Centre at Télé-université, called MOT (modélisation par objets typés—modelling with object types). This MOT model provides a representation of the learning scenario where some of the (inter)dependencies as defined by Malone & Crowston (1994) can be identified. In addition, several actor-actor (inter)dependencies have been found.

This section discusses the methodology for documenting and modelling the learning scenarios. First, however, the distributed software used in the learning scenarios is described. Then, a MOT model of an overview of the learning scenario for the undergraduate course is presented. The section concludes with a focus on actor (inter)dependencies and gives an extended definition of coordination for collaborative telelearning.

The Netstrat learning scenarios

The Strategic Management curriculum at HEC in Montréal has been using a distributed simulation game, called Netstrat (http://cetai.hec.ca/netstrat/welcome.htm), to engage the students in strategic decision-making in real time. The various uses of Netstrat as a team-based collaborative activity in the strategic management curriculum has provided access to a number of collaborative telelearning scenarios that can be documented. In the "semi"-telelearning on-campus configurations, students attend an instructor lead briefing session and then break into teams that will compete against one another in a Netstrat simulation game for market shares.

Each team develops a shared vision and a business strategy that guides their decision-making. Between 5 and 7 decision-making rounds are run. During each round, the teams submit their decision. The decisions from each of the teams are then compiled by the simulation engine and the results given back to the students. At the end of the 5-7 periods, the team with the most shares had won. A debriefing session is held by the instructor. The main Netstrat screen can be seen in figure 3.
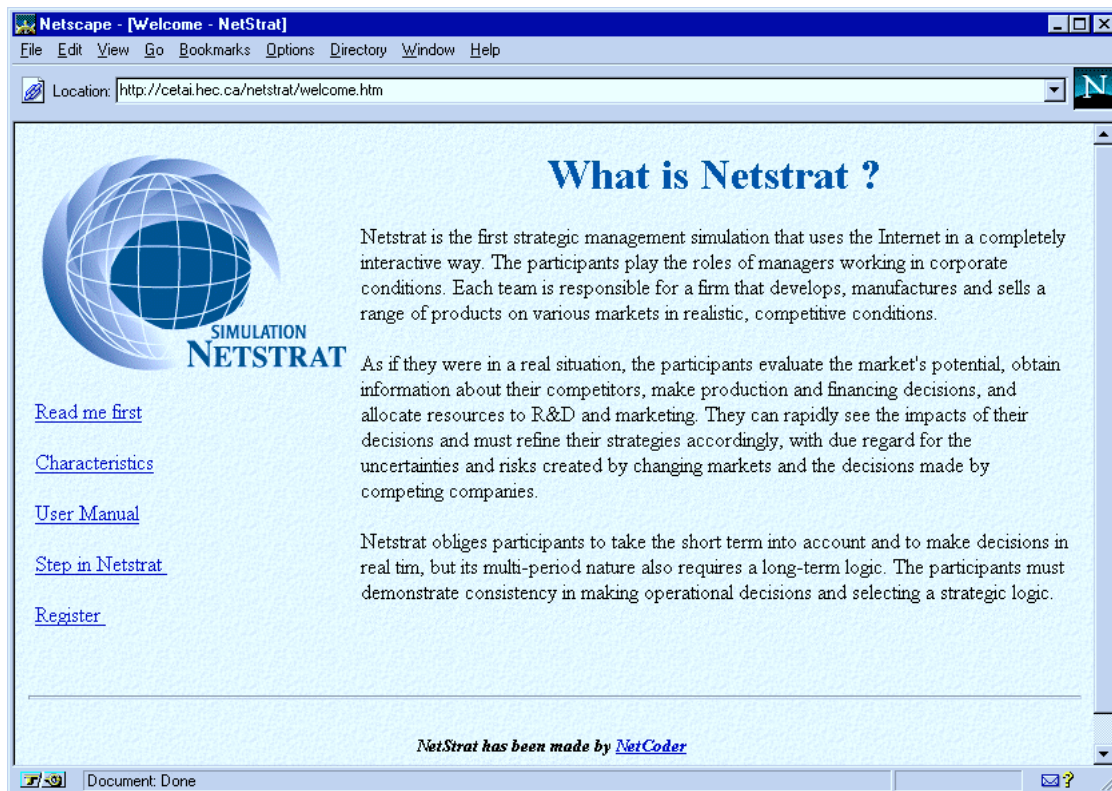

Figure 3. Main Netstrat Screen

Netstrat consists of an engine containing heuristic rules for compiling decisions, of an html user interface that displays dynamic text and graphical data that provides the students with rapid response to information requests. Students can evaluate the market's potential, obtain information about their competitors, make production and financial decisions, and allocate resources to R&D and marketing, and send email within and between teams. For example, the decisions interface in shown in figure 4.

The distributed aspects are multifold: given the client-server IP architecture, clients can interact from any IP connection in the world; student teams can be scattered, and can interact with the instructor and each other on-line; team members themselves can be at a distance and work asynchronously. Currently the briefing and debriefing sessions are held live and team members interact with each other and the instructor through face-to-face meetings and through the Netstrat communication system. Inter-team alliancing also occurs both face-to-face and electronically. The future vision[3] is that both briefing and debriefing, as well as tutoring can happen at a distance and be supported by interactive telepresentation software and multipoint videoconferencing.

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[3] Trials of running a simulation game with teams spread around the world were to be undertaken in 1998. Interested parties can sign up on the web site!
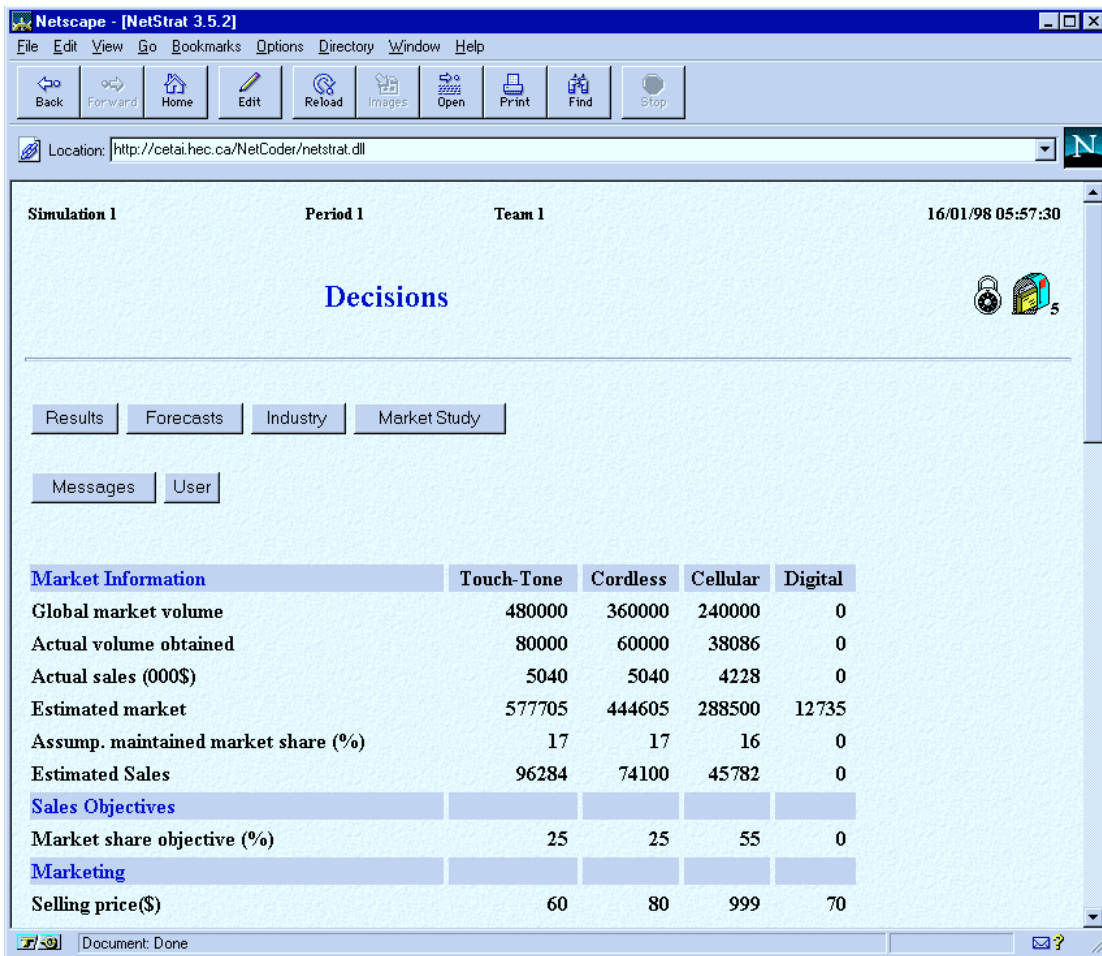
Figure 4. The Enter a Decision interface for Netstrat

Documenting Netstrat Learning Scenarios

Empirical studies consisting of structure diaries, computer trace files, video recording and semi-structured interviews have been carried out in order to document the collaborative learning scenarios for various versions of the strategic management curriculum given at HEC. The part of the courses that the learning scenarios document are exercises utilising Netstrat. Each learning scenario (documented in Wasson (1997)) includes a short description of the course and the role of Netstrat. Then the main activities are listed with the roles of each actor (or set of actors) made explicit. Actors involved include the instructor, the students (sometimes divided into teams and simulation groups) and an animator whose role it is to support the simulation game, part of which entails running the simulation software and monitoring the progress of the competition.

The Netstrat simulation game is used in 4 different course variations of strategic management at HEC. There is a 3rd year undergraduate BAA course, an MBA graduate course, a 3-day Executive course for managers, and a 1-week tailored course for a particular industry. In each variation, the Netstrat simulation game is central, but its role and implementation varies. For example in the 3rd year BAA course, a month long Netstrat competition is held half way through the course and serves to give the students a chance to practice the strategic management skills they have been learning about over the past three years. The MBA students, on the other hand, are welcomed to their program with an intensive week long Netstrat session that serves as an orientation exercise to highlight just how much they have to learn.

Student interaction in the Netstrat exercise meets all the criteria Salomon specifies for genuine interdependence: sharing, division of labour, and joint thinking. In a Netstrat

competition, groups of students work in teams preparing themselves for a competition for market shares. In order to make a strategic decision for each of seven rounds, the students need to come to a consensus about a shared vision, determine a team strategy and implement this strategy in the form of decisions about market stocks. To make informed decisions, the teams will need to divide the work into complementary tasks and pool their ideas. Joint thinking is required to make a team strategy and team decisions.

The 3rd year BAA learning scenario

The BAA strategic management course is a 3rd year optional course for BAA students. The students have 6 or 7 courses behind them and this course is presented as a process of applying their knowledge. A Netstrat competition in particular provides the opportunity to see how well the students can synthesise the concepts and knowledge they have been accumulating during the past 3 years. They are to apply analytical tools to make decisions. The learning scenario for the 3rd year BAA course (Wasson, 1997) documents the course goals, the Netstrat goals, the evaluation scheme and student, instructor and a simulation animator's participation in the Netstrat competition. Aspects of this learning scenario are described below.

The course runs over 1 term and there is a 3-hour meeting once a week. During the first 8 weeks of the course the students attend lectures, read (about 2 articles per week), and do case study analyses (about 12) relating to strategic management concepts and principles. In particular topics covered during the lectures include: role of leaders, visions, sector analysis (Porter model), internal organisational analysis, portfolio analysis (BCG model), and new trends and strategies (e.g., internationalisation, globalisation, learning organisation). A midterm exam falls at about week 9. The Netstrat competition begins after the midterm and lasts about one month.

The main goal of the Netstrat competition is to build a sustainable competitive advantage at the enterprise level through: diagnosing strengths and weaknesses of companies within a competitive environment, applying strategic concepts and developing and implementing a coherent strategy.

A typical semester will see about 140-200 students taking the strategic management course. The course is divided into several sections with each section assigned an instructor and about 30-40 students. An instructor may have several sections. A simulation game (or industry) comprises 5 or 6 teams of students referred to as companies. A company has between 4 and 6 students. Thus one industry (a simulation competition) has between 20 and 36 students divided into 5 to 6 teams and in one semester there will be between 4 and 6 competitions.

The Netstrat competition is worth 30% of the course grade. Of this 30%, a team's strategic plan is worth 10% (a written document handed in between two of the decision rounds), the final stock value 5% (each team begins with equal stock values), and a written report (includes both a team report and a one page report from each team member) and an oral presentation 15%. The major activities in which the actors are involved (although with varying roles) include:

- Briefing
- Decision-making (7 rounds of team decision-making in the simulation game)
- Debriefing
- Report writing
- Team presentations
- Evaluation

Each of these activities consists of a number of sub-activities some of will be described in more detail in the next section when the MOT model of the learning scenario is presented.

Modelling the 3rd year BAA learning scenario

The documented 3rd year BAA learning scenario has been modelled using MOT[4]. MOT (http://206.167.88.162/anglais/real/mot.htm) is an object-oriented modelling tool for developing graphical knowledge models for learning environments. The MOT editor enables easy creation of graphs that represent knowledge objects and the links between them making the nature and structure of a learning system explicit. MOT is most often used in conjunction with MISA (http://206.167.88.162/anglais/real/misa.htm) a learning systems engineering method used to produce a learning system which is characterised by a knowledge model, a pedagogical model and a media model. The model presented in this section is a pedagogical model that specifies the learning processes.

MOT provides the modeller with a set of knowledge types (concept (rectangle), procedure or activity (oval), principle (rectangle with diamond ends, or fact (rectangle with missing corners) and links (**C**: component, **S**: specialisation, **P**: precedence/prerequisite, **I/P**: input/output, **R**: regulates/governs, **In**: instance of). The modeller can also create new link types or shape objects to represent other types of objects. For example, in modelling the collaborative telelearning scenarios a shape object for a goal (an **oval with no shadow**) was added, and the use of shadowed objects to indicate either a collaborative goal or activity, or a concept/resource that has been produced collaboratively was adopted. In addition, link types **simultaneous** and **G-A**: Goal-Activity have been added. In addition, an attribute on each object was included to indicate which actor was carrying out the procedure or activity.

Figure 5 gives an overview of the MOT model of the 3rd year BAA scenario emphasising the student view where collaborative team work plays a significant role. The full model can be found in Wasson (1997).

In this overview model, only the first three activities, briefing, decision making and debriefing are included. In the model actors are indicated as: an instructor (I); 200-250 students (S); an animator (A); teams of 5-6 students (Tx); and simulation groups (SG-x, i.e., a set of 5-6 teams). The following discussion highlights aspects of this overview and ties some of the visible dependencies to those identified by Malone & Crowston (1994) and listed in table 1. In some instances description of areas of the overview model are embellished with full examples from the complete MOT model.

The top node of the model indicates that the instructor, the students, and the animator share an overall goal "A,I,S: to have all students experience a competitive market through a simulation game". This goal is decomposed into three subgoals one for each of the actor roles. The instructor will meet the overall goal by "I: guiding and assessing the students in their learning objectives"; the students will meet the overall goal by meeting their learning objectives of which the overall objective is "S: learning to build a sustainable competitive advantage at the enterprise level" and the animator will meet the overall goal by "A: supporting the students in meeting their learning objectives.

Each of these subgoals is linked to a shared activity "A,I,S: participating in the Netstrat simulation" by a goal-activity link (G-A). Three simultaneous activities "I: guiding and assessing the students' participation", "S: competing in the Netstrat game", and "A: supporting the Netstrat simulation game" illustrate both the *task/subtask* and *simultaneity constraint dependencies* identified by Malone & Crowston (1994) and listed in table 1.

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[4] MOT was developed at LICEF and is the tool of choice for LICEF projects concerned with designing learning systems.
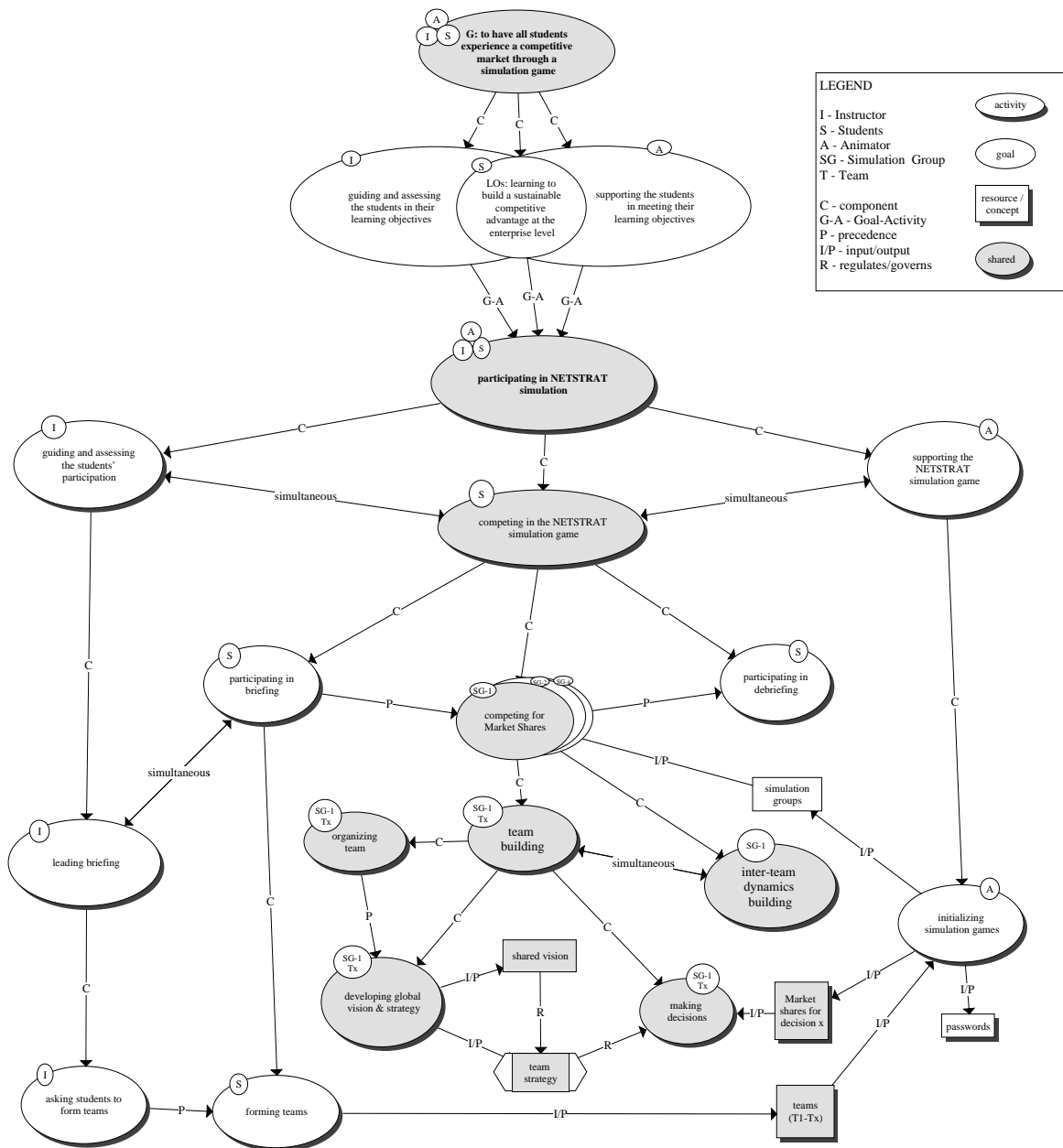
Figure 5. An overview of the MOT model of the 3rd Year BAA learning scenario

Following the student activity, three sub-activity nodes, "S: participating in the briefing", "SG-x: competing for Market Shares" and "S: participating in the debriefing" are met. There is a *prerequisite constraint dependence* (table 1) between these activities indicated by the precedence (P) link. In the complete model each of these nodes has a sub-model but for brevity only the highlights are shown here. Notice that in the second activity the students (S) have been divided into simulation groups (SG-x) and it is a SG-x that competes in one simulation game.

The simulation group activity "SG-x: competing for Market Shares" has two sub-activities "SG-x,Tx: team building" and "SG-x: inter-team dynamics building". Note that the simulation group has been split into teams (Tx) for the team building activity. Under "SG-x,Tx: team building" there are three sub-activities "organising team", "SG-x,Tx: developing global vision & strategy" and "SG-x,Tx: making decisions". These activities (of which there are *precedence order dependencies*) are the heart of the collaborative team activity and will be described in more detail in the following section on student activities.

Output (indicated by the I/P link) from the "SG-x,Tx: developing global vision & strategy" activity is a "shared vision" and a "team strategy". The shared vision is input into the team strategy which in turn governs (or regulates (R)) the "SG-x, Tx: making decisions" activity. This means that the team strategy has an influence over how team decisions are made and illustrates a *producer-consumer dependence* between activities as listed in table 1. The final item to be highlighted is the "Market shares for decision x" concept. This concept represents the value of the Market Shares for which the teams within a simulation game are competing. The Market changes after each decision thus feeding new values into the next decision making round. The Market updates are released by the animator (not shown in figure 5, but to be found in the complete model in Wasson (1997)) after a set criteria is met (e.g., all decisions have been entered by time x and no team will be out of the competition).

Student activities

The main student activities in the BAA learning scenario, shown in figure 6,　include: participating in the briefing, competing for Market Shares, participating in the debriefing, writing a report, and participating in presentations.
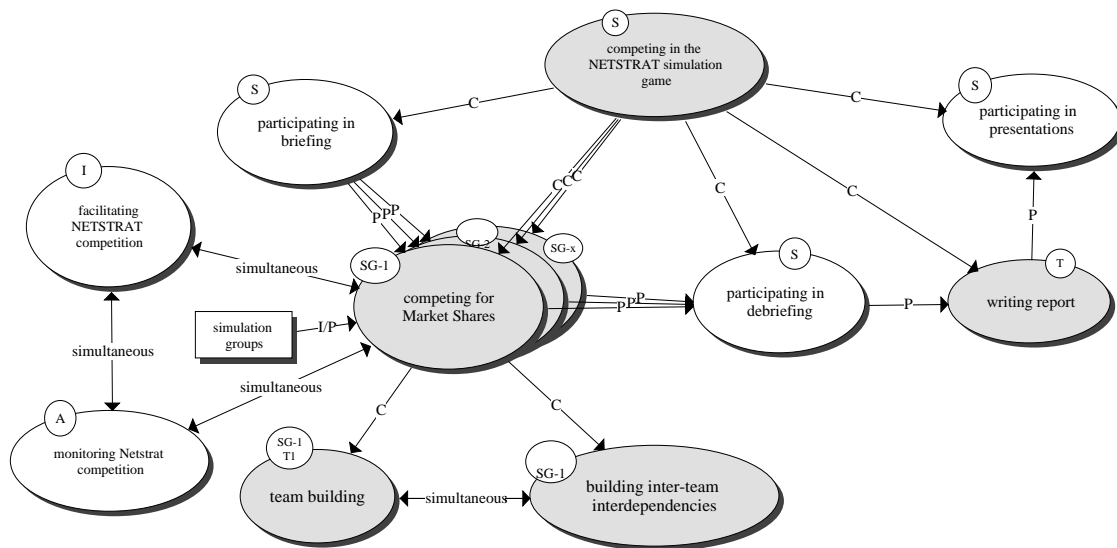

Figure 6. Main student activities from BAA model

Each of the subactivities comprise several other activities as follows:

Participating in briefing is one of the two activities that satisfies the goal "I,S: preparing for competition" and it occurs simultaneously with "I: leading briefing (see figure 5). The subactivities complement the "I: leading briefing" subactivities (not illustrated here). The student activities include: hearing about learning material (hearing about Netstrat, watching Netstrat simulation demo), interacting with Netstrat demo, forming teams, and receiving schedule and passwords.

Competing for Market Shares has two components, team building and building inter-team interdependencies.　 Team building is described below. Building inter-team interdependence is included because it is possible for teams to build alliances between them, to borrow money from one another etc. Alliance building is not stressed at the undergraduate level so this tends not to happen often.　As can be seen in figure 6, competing for market shares occurs simultaneously with "I: facilitating Netstrat competition" and "A: monitoring Netstrat competition".

Team building comprises three activities: organising team, developing shared vision and strategy and making decision x.　The complete model in Wasson (1997) documents the activities involved in organising team as including: specifying tasks, allocating tasks, arranging

meetings, time, communication and determining decision-making rules. These are the activities that coordinate the interactions of team members. Developing shared vision and strategy, shown in figure 7, is a key activity in the team collaboration. Together the team members must come to a consensus for a shared vision (i.e., setting a goal for the team) and work toward a team strategy (i.e., planning how to meet their goal) that will influence their company's actions towards the market. Two characteristics of genuine interdependence can be seen here as the students need to share information, meanings, conceptions and conclusions which will require joint thinking to come to a vision and strategy for their company. This strategy can be examined, changed, and elaborated upon by the team members throughout the decision making rounds (the vision ought to stay the same) as indicated by the recursive arc on the node.
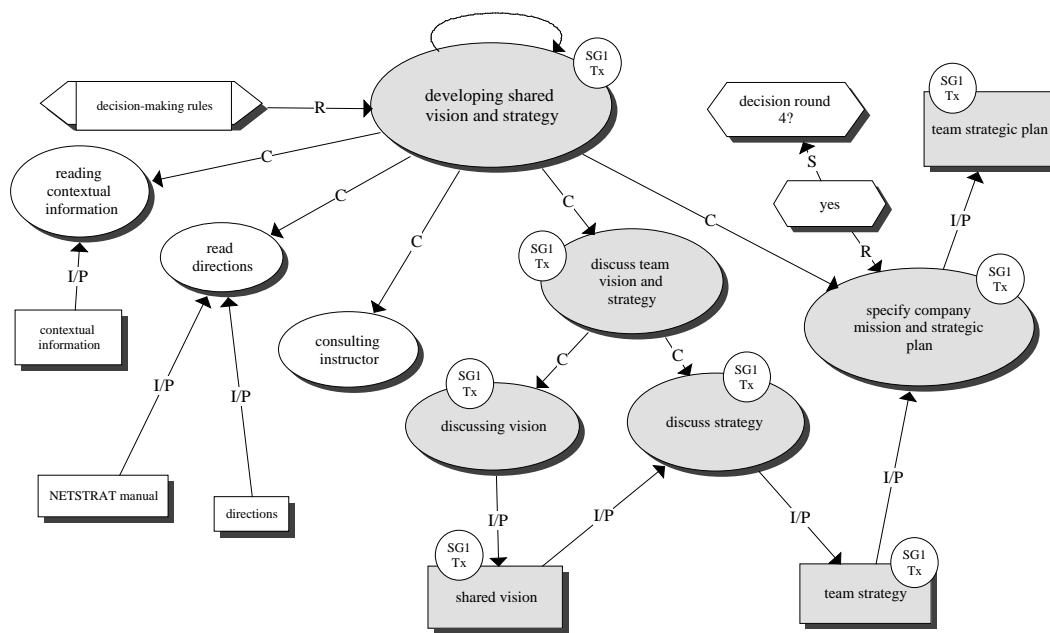

Figure 7. Developing a shared vision and strategy from the BAA model

Making decision x, as illustrated in figure 8, is the heart of the competition where the teams are seeking and sorting information (according to the division of labour they agree upon — the third characteristic of genuine interdependence) that is then pooled and moulded into a "what if" decision. This decision can be tried on the Market as it stands after the previous round. The team discusses the result and if satisfied can submit the decision. If not, then they can try again. This can continue until the end of the decision period where the last entered decision stands as the team's decision for that round. The results of the trial decisions show only the effects of the individual teams' decisions and not the results of the other teams' trials. The market is only actually updated after the decision deadline is reached (this will be evident below in the section on the animator actions).

Participating in the debriefing occurs, as described simultaneously as "I: leading debriefing" and involves the students in listening to the instructor's summary, asking questions, answering questions, and engaging in a discussion with other teams in their industry (i.e., a single competition).

Writing reports involves writing a team report that is due the day of the oral presentation. The team report consists of a collaborative team report and a one page individual evaluation of each team member's participation. This individual evaluation includes a self-evaluation.

Participating in presentations includes preparing the presentation (discussing, preparing materials, practising presentation) as well as giving the presentation, listening to presentations,

and asking and answering questions. This activity occurs simultaneously as "I: orchestrating presentations" (not illustrated in figure 4).
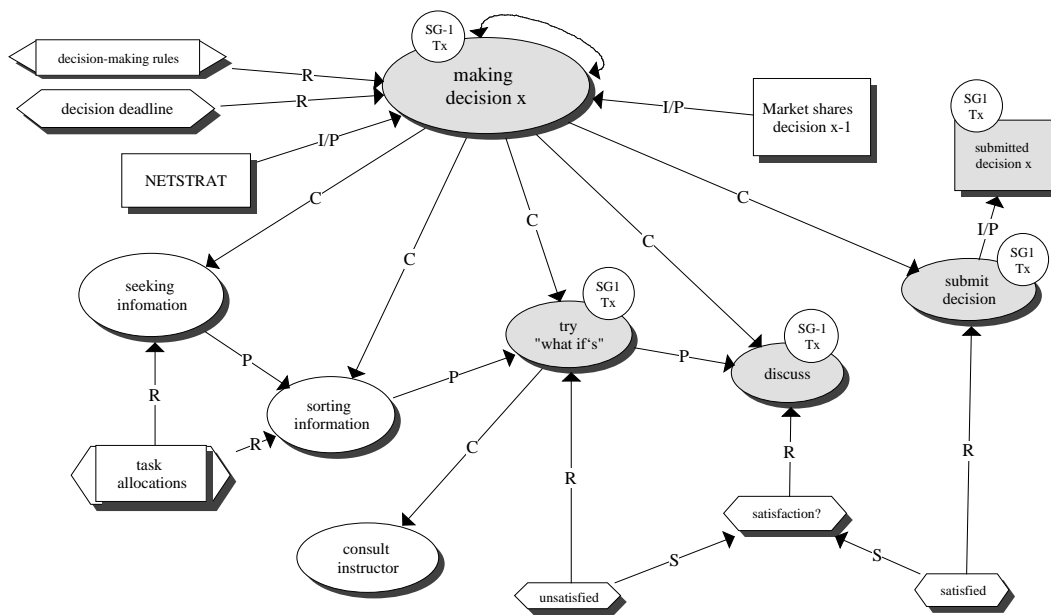

Figure 8. Making decision x from the BAA model

ACTOR INTERDEPENDENCIES AND COORDINATION PROCESSES

In analysing the dependencies between actors in the learning scenarios, the following observation has emerged (Wasson & Bourdeau, 1998). *Actors in a collaborative telelearning situation have the obligation or necessity to*:

- share Goals *to complete* Activities

- share Activities *to achieve* Goals

- share Resources *to complete* Activities

- share Activities *to produce* Resources

The first two are illustrated in figure 5 by the interconnection of the overall shared goal's subgoals to the shared activity "A, I, S: participating in Netstrat simulation". This illustrates a *collaborative interdependence through a shared activity*. The shared activity is sub-divided into three activities that have a *simultaneity constraint* dependency as identified by Malone and Crowston (1994) and listed in table 1. By carrying out these three activities simultaneously, each actor carries out their part of the collaborative activity which in turn satisfies the shared goal. The third obligation arises in the BAA learning scenario by the sharing of the actual Netstrat software to compete for the Market Shares. This *sharing of a resource to complete an activity* is illustrated in figure 8 where the Market Shares decision x-1 resource is input to the making decision x activity. The last obligation is illustrated in figure 5 and 7 by *the shared team activity* "SG-x,Tx: develop global vision & strategy" *production of the concepts/resources* "shared vision" and "team strategy".

Another aspect of this learning scenario that is worth noting is that there are both collaborative and competitive interdependencies and they are interlaced within each other. In figure 5, the *collaborative shared goal* "A,I,S: to have all students experience a competitive market though a simulation game" is achieved by a *collaborative shared activity* "A,I,S:

participating in Netstrat simulation" which includes a *competitive shared goal* "SG-x: competing for Market Shares" which comprises *collaborative shared activities* "SG-xTx: team building" and "SG-x: inter-team dynamics building". It is an interesting situation where students compete to fulfil a collaborative goal. There can also be a very powerful learning effect if, as Salomon (1993) posits, there is genuine interdependence between team members and as DeVries & Edwards (1973) suggest, high task interdependence. A deeper discussion of educational games and simulations can be found in Gredler (1996).

Dependencies between Actors

Table 2 presents an initial taxonomy of (inter)dependencies between actors and gives examples of coordination processes for supporting the (inter)dependencies. Both collaborative interdependence and competitive interdependence can manifest themselves through either a shared goal or a shared activity. Where they differ the most is in the coordination processes required for managing them. For example, the *competitive interdependence through a shared resource* is illustrated by the competition for Market Shares. This is a resource for which teams compete via a market-like bidding coordination process (from table 1).

Table 2. Dependencies between Actors

Dependency	Examples of coordination processes for managing dependencies
Collaborative Interdependence	
shared goal	team building
shared activity	team assignment; team building; division of labour; sharing of information, conceptions and conclusions; joint thinking; group decision making; planning; task assignment; scheduling; synchronisation; communication
Competitive Interdependence	
shared activity	scheduling; communication; monitoring; competition assignment
shared resource	same as in Table 1

An example of a *competitive interdependence through a shared activity* is the students sharing the activity "S: competing in the Netstrat simulation game". The students must adhere to a schedule, must communicate through the Netstrat software and need to monitor each others' actions (all example coordination processes). *Collaborative interdependence* is exemplified *through the shared* "A,I,S: to have all the students experience a competitive market through a simulation game" and *through the shared activity* "SG-x,Tx: making decision". The coordination process for these interdependencies has been designated *team building*. Team building is used to indicate that to satisfy a shared goal or activity, the team must, on the one hand, develop feelings of "caring", "trust" "respect", "acceptance" and, on the other hand, share complimentary skills, be committed to a common goal, set of performance goals and approach for which they hold themselves accountable (Katzenbach & Smith, 1993). In their research on incorporating motivation into CSCL, Issroff & del Soldato (1996), talk about the importance social affinity — developing a level of trust and a willingness to work together — has on the nature and effectiveness of interaction. In addition to *team building*, coordination processes *group decision making*, *planning*, *division of labour, sharing of information, conceptions and conclusions, joint thinking, communication, scheduling* etc. are all required. Several of the coordination processes are found in Salomon's definition of genuine interdependence.

New definition of coordination for collaborative telelearning

This work on modelling has lead to an extension of Malone & Crowston's (1994) definition of coordination to include the recognition for supporting the explicit (inter)dependencies between actors we have identified in our collaborative telelearning scenarios. This may seem an unnecessary detail, but from our point of view the distinction between designing to minimise interdependence and design for interdependence is extremely important. As Salomon (1992) argues, CSCL systems will only be successful if there is genuine interdependence between the learners.

Thus their definition of

<div align="center">

coordination as managing dependencies between activities

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<div align="right">

(Malone & Crowston, 1994)

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becomes

<div align="center">

coordination as managing dependencies between activities **and**
supporting (inter)dependencies among actors

(Bourdeau & Wasson, 1997b)

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This extended definition is particularly important in the view of collaborative telelearning as supporting a distributed collaborative learning community where the aim is to support the learners in creating that community.

COORDINATION AGENTS FOR COLLABORATIVE TELELEARNING

In the introduction agents were proposed as one way to include needed knowledge about organising and supporting collaboration in a collaborative telelearning environment. It was suggested that an (inter)dependence model for collaborative telelearning would inform the instructional design of learning scenarios, the technological design of the learning environment and the design of intelligent agents to mediate, or to support the mediation of, the time, space and collaborative learning activity distance between students and between other supporting human agents (e.g., an instructor, an animator). The goal of this paper is not to discuss in detail what an agent is or to define an agent-based architecture, or even to discuss agent languages (see Nwana (1996) and the collection of papers in Bradshaw (1997) for reviews of the last 20 years of agent research), rather it is a goal of presenting how viewing collaborative telelearning from a coordination theory perspective enables the identification of *agent roles* for managing and supporting (inter)dependencies that arise in collaborative telelearning. This section describes the agent roles that emerge from this perspective.

Coordination managers and coordination facilitators

Preliminary examination of the coordination processes listed in table 2, for example, leads to a suggestion of two general types of coordination agents: *coordination managers* and *coordination facilitators*.   Coordination managers mediate administrative aspects of collaboration such as scheduling, communication, access and control (of shared workspaces, conferencing tools, etc.), notification, booking, monitoring, information mining, etc. for both individual actors, groups and teams, while coordination facilitators support students involved in collaborative learning activities by mediating processes such as the development of shared goals and visions, planning, searching and sorting and sharing of information, team building, group decision-making, joint thinking, negotiation, etc. Some of these will be expounded below though examples from the BAA learning scenario.
Trying to put some order on the plethora of disparate research on artificial agents, Dillenbourg et. al (1997) propose three main categories of agents: sub-agents (autonomous

agents that carry out tasks for the user), co-agents (that can perform the same actions as the humans they interact with), and super-agents (that provide solutions and monitor actions of the users). Coordination agents, as suggested above, could fall into all three of these categories. For example, coordination managers would, most often, be sub-agents while coordination facilitators could be either co-agents (e.g., could act as a competitive team, or could collaborate on planning) or super-agents (e.g., a tutor for group-decision-making). The challenges in building the agents increase from sub-agents to co-agents to super-agents.

Examples of possible coordination agents

Examples of possible coordination agents are presented in this section — these examples are speculative and are not meant to be an exhaustive list, rather are to stimulate thinking about the roles coordination agents can play. The roles have been identified by observing current collaborative telelearning praxis with an eye on designing a future collaborative telelearning environment that uses agent technology to manage and support dependencies.

For example, in the outline of their research on the nature of collaboration, Burton, Brna & Treasure-Jones (1996), suggest that collaboration is a composite skill which should be taught both explicitly and implicitly and argue for an approach supports students as *they learn to collaborate* and *collaborate to learn*. In collaborative telelearning when a situation arises where there is collaborative interdependence with actors sharing goals or activities and team building is the appropriate coordination process, *team building agents* can be used to support both learning to collaborate and collaborating to learn. For instance, a team building agent could support learning to collaborate by taking on an explicit tutoring or coaching role, or it could support collaborating to learn by assuming a more background implicit facilitative role.

The team building activity shown in figure 6 has three sub-activities: organising the team, developing a shared vision and strategy (see figure 7) and making decisions (see figure 8). Coordination processes involved in organising the team include communication and synchronisation as well as a division of labour, task assignment, planning, scheduling, and group decision making about decision-making rules. Similarly, developing a shared vision and goal include communication and synchronisation as well as coming to a shared vision (i.e., consensus), sharing information, ideas, etc., joint thinking and group decision making. How can team building agent support these coordination activities? One agent[5], a *group decision making assistant*, might know about group decision making tools available in the telelearning environment and how to use them, thus be able to point the team to these when need be and to provide help or assistance in using the tools. Another, a *decision-making tutor agent*, might know something about decision making processes and be able to advise the team on effective decision-making methods. These two agents would need to cooperate with one another and with coordination managers such as *schedule managers* and *synchronisation managers* that would support a team with administrative type tasks related to the use of a particular tool. The most challenging aspect of a team building process is the question of how to support the development of social affinity among team members[6] — is it possible to design a team building agent that can provide this support?

In another situation where there is either collaborative or competitive interdependence due to a shared activity that can be managed by team assignment, *a team assignment agent* can be utilised. For example, a team assignment tool has been designed and implemented (Winer, Wasson, Viola & Greer, 1997) that divides MBA students into teams according to a set of criteria. The instructor sets criteria (e.g., must share a common language, must come from different disciplines, must work in different industries, etc.) that the tool then uses to divide the students into groups using information the students provide when they register for the course.

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[5] The challenges in building such agents are as complex as for building tutoring components for ITSs.

[6] Awareness aspects in CSCW systems are one means to support social affinity. Having distributed teams of students play team-building games is another. The author has translated face-to-face team building games to distributed games played though a groupware system.

The results are then passed back to the instructor who inspects the teams and decides if any adjustments need to be made. This team assignment tool could be configured as a coordination manager agent that collaborates with the instructor by collecting the required information from the students, computing the teams, presenting this information to the instructor and then after the instructor accepts the teams or adjusts the teams, presents the information to the students and the animator.

Other possible agents include a *competition manager* which could be responsible for allowing all teams competing in one industry know when the competition starts, who they are competing against, which instructor is available and when, how to contact the animator, etc. and a *competition monitor* that can watch for decision deadlines and remind teams the deadline is approaching. Finally, a tailorable agent (Malone, Lai & Grant, 1997) that can be directed to collect information, such as a market study, would be of use to the individual student who is assembling information to support a decision for one of the decision making rounds. This type of agent, one that plays a mediating role between the individual learner and her learning task, is one example of the types of support for which Fjuk (1995) argues.

Related work

At this point it is premature to specify details of how agents would be incorporated into a collaborative telelearning environment, but the vision presented in this paper aligns with the principle of semiformal systems as defined by Malone, Lai & Grant (1997). In particular, we envisage a human-centred system where the roles for supporting (inter)dependencies that arise in the world of collaborative telelearning are shared — they can be assumed by either human or artificial agents, or by a cooperation between them. This upholds the principle of semiformal systems which means, in Malone and his colleague's words, that "the boundary between what agents do and the humans do is a flexible one (Malone, Lai & Grant, 1997, p. 110)".

Recently, multi-agent systems (Bond & Gasser, 1988) for collaborative learning have been proposed with the AI&ED community. For example, GRACILE utilises two types of intelligent agents, mediator agents and domain agents (Ayala & Ono, 1996) to support the application of domain knowledge and support effective collaboration inside a pre-established team of learners. The PHelpS project (Collins, 1996; McCalla et al., 1997) deals with a situation where one worker needs help from a peer who possesses the task knowledge to solve a problem the worker is facing. In this case, however, there is no collaborating team to support, rather the PHelpS Personal Assistant facilitates communication between the identified pair through the automatic transmission of problem summaries and the mutual capability of browsing knowledge profiles. Although PHelpS is not described as an agent, it is a model for peer helping that can inspire the specification of agent roles for collaborative telelearning. Within the Virtual Campus project (Paquette, Ricciardi-Rigault, Paquin, Liegeois & Bleicher, 1996) at LICEF, work is underway to define an architecture for a multi-agent system that provides intelligent advice for students collaborating in teams or groups. In COSOFT (Hoppe (1995), Ikeda, Hoppe & Mizoguchi (1995)), which is a system supporting students' collaborative problem solving, an agent can suggest peer collaborators for a new student. Dillenbourg et al. (1997) studied pairs of students using different communication tools while collaboratively problem-solving in a MOO. As a result they suggest a new type of agent, observers, which promote productive interactions by computing and displaying statistics about interactions to human or artificial tutors, or the students themselves. Future research will follow whether student pairs can use these statistics to modify their interaction behaviour. While each of these research efforts makes important contributions, and ideas for agent roles in collaborative telelearning can be gleaned from their results, none of them have focused on (inter)dependence as a means for identifying roles for agents.

CONCLUSIONS AND FUTURE WORK

This paper began by arguing that designing computer systems for human use is best served by studying current praxis as a basis for designing for future use situations. The research reported in this paper is based on empirical studies of current collaborative "semi"-telelearning scenarios with an eye on designing a future collaborative situation where all aspects of the learning scenario are distributed. Motivated by Salomon's work on genuine interdependence for effective CSCL, the empirical studies focused on identifying interdependencies between actors in the collaborative telelearning scenarios.

Taking a coordination theory perspective enabled progress on developing an (inter)dependence model for collaborating telelearning. This research, however, can only be viewed as a first step as the empirical studies were limited in scope and the distributed activity was focused through Netscape. The interdependencies that arose between the students and between the students and the instructor and animator were, however, real and many of them are not that different than ones that will arise in other pedagogical designs. In addition, many instances of the dependencies identified by Malone & Crowston (1994) were confirmed. Modelling collaborative telelearning from a coordination perspective facilitates an understanding of collaborative telelearning organisation, needs and vulnerabilities.

The research reported here has made progress in meeting the three challenges posed earlier. **Challenge 1:** *How can such interdependencies* (genuine interdependence as defined by Salomon (1992)) *be specified and supported in a collaborative telelearning situation?* Adopting Salomon's (1992) definition of genuine interdependence (the interdependencies referred to in challenge 1) and using ideas from coordination science (Malone & Crowston, 1994) has provided a means of identifying and representing actor-actor (inter)dependencies and the corresponding coordination processes. **Challenge 2:** *Which of these dependencies* (as identified by Malone & Crowston) *arise in a collaborative telelearning situation, and what coordination processes are needed to manage them?* The descriptions of the collaborative telelearning scenarios given above have pointed out instances of many of the dependencies identified by Malone & Crowston. In some instances, coordination processes to support the dependence were discussed, but further work is needed in this area (see below). **Challenge 3:** What *(inter)dependencies arise between actors in collaborative telelearning and what coordination processes are needed to manage them?* A first attempt at identifying the actor (inter)dependencies that arise in collaborative telelearning has been presented and some coordination processes for supporting these suggested. Again, more work is needed in this area.

As stated earlier, the identification of roles for coordination agents is at present only speculative. No discussion of the complexity of building such agents has been included, other than pointing out that some of the proposed agents require the same capabilities of tutoring components for ITSs. Many of the ideas reported in this paper are currently being tested out within project PALiTO (Pedagogical Agents for Learning and Training in Organisations) where agent technologies are used to facilitate collaboration by supporting both communication and coordination activities.

thank Svein-Ivar Lillehaug and my graduate student Frode Guribye for reading and commenting on various sections. Finally, I would like to thank the anonymous reviewers whose challenges to my presentation of the material resulted in what I feel is a much better paper.

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