TOWARDS COLLABORATIVE SIMULATION MODELLING: IMPROVING HUMAN-TO-HUMAN INTERACTION THROUGH GROUPWARE

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Abstract: Collaborative simulation modelling, as defined by the GROUPSIM Network, involves the study of human-to-human interaction, computer-to-computer interaction, and synergies between the two, to support simulation modelling practices. This paper investigates the improvement of human-to-human interaction through the use of groupware. Interaction is introduced as C3, a combination of communication, coordination and collaboration. Simulation modelling introduces from the perspective of the roles that people take in a simulation study and the tasks that these roles must perform. The paper then presents results from an evaluation of NetMeeing groupware in the support of human-to-human collaboration. Several novel areas of future research are suggested.

Keywords: Simulation, Groupware, Collaborative Simulation

1. INTRODUCTION

Advances in distributed systems technology have created new possibilities for innovation in simulation modelling and the creation of new tools and facilities that could improve the productivity of simulation. Collaborative simulation modelling (CSM) is a term introduced by the GROUPSIM Network (www.groupsim.com) to refer to the many possible forms of human and computer collaboration that exist in simulation modelling.. Research topics focus on the support of human-to-human (H2H) interaction (computer supported cooperative work/groupware and simulation) and support of computer-to-computer (C2C) interaction (distributed simulation, parallel and distributed simulation, and web-based simulation), and the synegies between the two. Figure 1 shows the current overview diagram of CSM. As can be seen the diagram is developed on the basis of H2H interaction and C2C interation through the simulation model. C3 is used to denote that the interaction is made up of communication, coordination and collaboration activities. The distinction between the three activities is useful: we define communication as the exchange of information, coordination as the balanced and effective interaction of actions, and collaboration as the joint working with another or others on a shared project.

Looking to the future we see, in terms of H2H C3 distributed computing technology in the form of groupware facilitates interaction between simulationists (individuals and teams) and stakeholders (see the discussion on roles in section 2). For example, communication can be supported in various ways by using audio, visual, text, etc. over conventional or novel (wireless, PDA) technologies; shared diaries, shared activity planning, model version control and such like can facilitate coordination; and novel approaches to collaboration such as online application sharing can improve collaboration. Individual models are built and simulated in the same organisation, or multiple models are built

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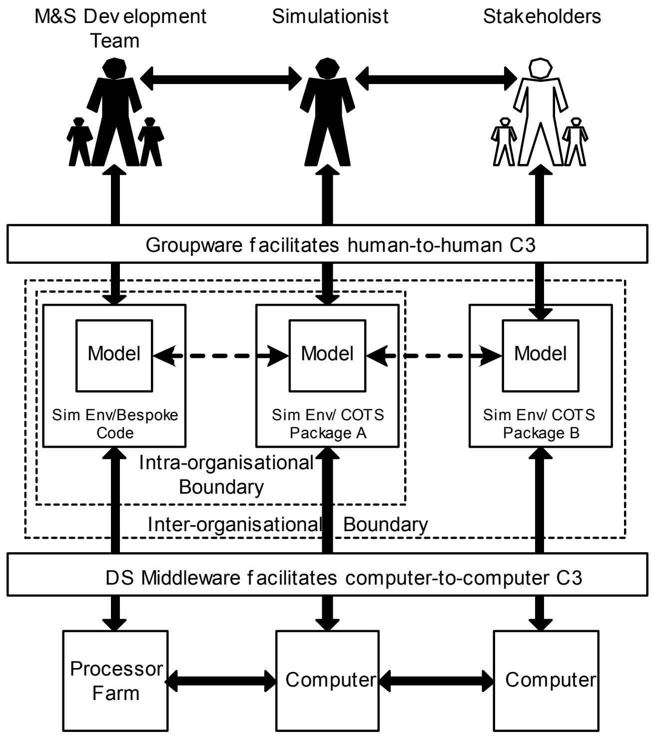

Figure 1: The GROUPSIM View of Collaborative Simulation Modelling.

that cross inter- and intra-organisational boundaries. Models can be software engineered in general purpose development environments or dedicated commercial-off-the-shelf (COTS) simulation packages. Distributed computing (in this context more commonly known as distributed simulation) middleware allows multiple models to interact over the Internet (or intranets) and to use processor farms to execute replications and experiments at high speed. The HLA-CSPI Forum (www.cspif.com) is dedicated to the development of C2C distributed simulation solutions that support C3 interaction between COTS simulation packages. Other aspects of this work are the focus of workshops that will take place this year (and will be reported in future publications available from the GROUPSIM website). In this paper we consider one facet of CSM, the results of introducing one type of groupware to simulation modellers.

The paper is structured as follows. In Section 2 we review C3 in simulation modelling and the roles and interactions that might be taken during a simulation study. Section 3 introduces groupware and one example, the net-conferencing tool NetMeeting. Section 4 presents some results of a survey and study of the use of NetMeeting to support H2H interaction in simulation. Section 5 concludes the paper with some novel areas of research.

2. C3 IN SIMULATION MODELLING

To consider how one might support communication, coordination and collaboration in simulation modelling, it is useful to consider the general roles that people might take in a simulation study. Ormerod (2001) conveniently provides a useful characterisation in the definition of various groups in operational research interventions (amongst which simulation modelling is a key technique):

- *The doer*: in this case the simulation modeller
- *The done for*: the clients
- *The done with*: members of the simulation modelling team
- *The done to*: those from whom information and data are obtained
- *The done without*: those not involved, but nevertheless with a vested interest in the outcome

Table 1 shows this in the context of a simulation study. In other words, a person may take on more than one role, or many people may be required to share a single role – the real world is not a tidy place (a modeller is often the project manager and the model user, in that he/she performs the experimentation). There may, however, be a number of people tasked with being data providers. A model user can be both a *done for* and a *doer* (a model user begins as a client and then becomes a doer as they use the model to provide information to the organisation).

The first three categories have direct involvement in the project team, while the latter two have little or no involvement. A wide group of people may need to be interviewed in order to obtain information about the system being modelled, but they do not need to have direct involvement in the simulation project. There may be a great many beneficiaries of the project, some of whom are even unaware of its existence. Workers in a factory are probably not aware that a simulation model has been developed to improve the level of production. They are, nevertheless, beneficiaries (or possibly a victims!).

2.1 C3 BETWEEN THE ROLES

The simulation modelling process can be described as a number of stages, as shown in figure 2. Four key stages are performed in an iterative manner: conceptual modelling, model coding, experimentation and implementation. In parallel with each of these are various verification and validation processes. The level of C3 required in a simulation study is now discussed by considering the process set out in figure 1 in the context of Ormerod's groups.

The nature and level of C3 between the simulation modellers and each of these groups will vary, and will depend upon the stage of the study that has been reached. Generally, the *doer* performs the simulation study with the *done for*. Where additional help is needed from subject matter experts and for supporting the modelling effort, the *done with* become involved. Interaction is also required with appropriate *done to* groups to gain relavent information and data. The *done without* are not involved (their role and their effect on the simulation study is outside the scope of this paper).

During the simulation study the frequency with which the groups interact is determined by the stage of the study. Consider a manufacturing system where a client wants to investigate the cost of manufacturing a new product with current production facilities. The client has enlisted a simulation modeller to help him or her make a decision (i.e. we assume a single modeller and not a team). To begin the simulation study the real world problem must be identified and a conceptual model of the system being studied must be built. In this case the problem is to evaluate the cost of production. A conceptual model is needed to identify what system elements (scope) and detail (depth) must be simulated to investigate the problem. Conceptual modelling is an intensive activity as the modeller must develop an understanding of the system being studied. The modeller and the client, as well as any appropriate information sources (i.e. personel involved in the production

Doers	Project manager	Responsible for managing the process; may not have specific modelling skills
	Modeller	Develops the model (conceptual and computer)
	Model user (in later stages)	Experiments with the model to obtain understanding and look for solutions to the real world problem
Done for	Clients	The problem owner and recipient of the results; directly or indirectly funds the work
	Model user (in early stages)	Recipient of the model
Done with	Data providers	Subject matter experts who are able to provide data and information for the project
	Modelling supporter	A third party expert (software vendor, consultant or in-house expert) provides software support and/or modelling expertise
Done to	Those interviewed for information	A wide group of people from whom information is obtained
Done without	Management, staff, customers	Beneficiaries of the project, but not involved; in some cases they are not aware of the project

Table 1: Roles in a Simulation Study

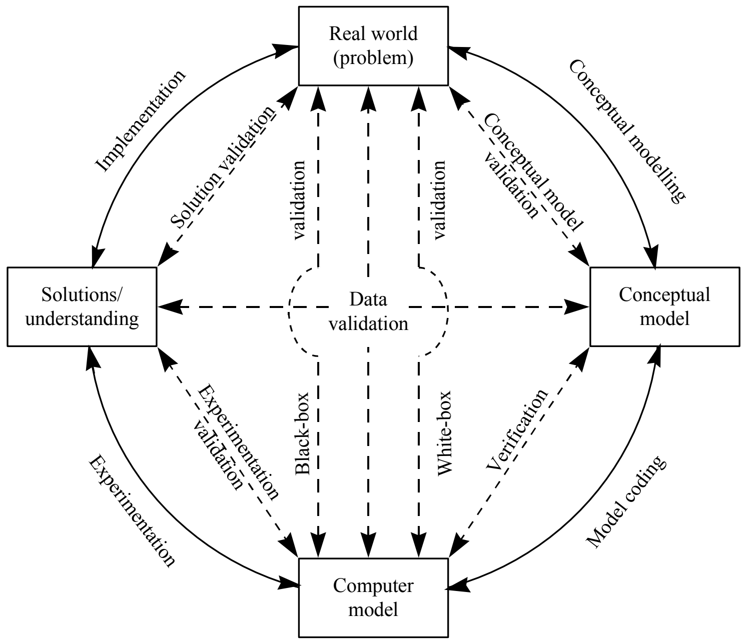

Figure 2: The Simulation Modelling Process (Robinson, 1999).

process), must therefore interact frequently so that the modeller can accomplish this. The *doer* must interact frequently with the *done* for, done *with* and the *done to*. Indeed, it is during conceptual modelling that the level of C3 needs to be at its highest.

In model coding the need for interaction is reduced. The modeller spends much time developing the computer model away from the eyes of the other parties. Verification is performed largely in isolation, since the modeller checks the model against the design stated within the conceptual model. That said, white-box validation (a detailed check of the computer model against the real world) is performed at regular stages during model coding, and so the model needs to be presented to the other parties for critique. The same is also true for black-box validation, which can only be performed once the model is believed to be complete. In terms of our study, the modeller would meet less freqently with the groups involved in the manufacturing system. The *doer* interacts moderately with the *done with* and the *done to.* Interaction with the *done for* is probably greater, since it is necessary to keep them appraised of progress.

Once the computer model is completed, the model user performs experiments with the clients to develop an understanding of how the complex relationships in the system being studied impact on the problem. In our case, experiments are performed with the computer model of the manufacturing system to understand the probable cost of the new product. Significant interaction is required between the model user and the clients in order to share the understanding gained from the experimentation and to direct the continuing experimentation. It is expected that there will be much C3 between the *doer* (now the model user) and the *done for*. The *done with* and certainly the *done to* will be needed to a much lesser degree, although the need for help and information is not completely removed during experimentation.

The final stage (of a cycle) in the study is to implement the solutions and/or understanding that have been developed from the experimentation. Apart from fully explaining the results from the experimentation, the *doer* often has little involvement in implementation. That said, it is sometimes necessary to maintain the model or to provide results from further runs. C3 are often at their lowest at during the implementation stage.

Figure 3 summarises the discussion above, indicating the level of C3 at each stage in the simulation modelling process. It shows that there is a changing requirement for C3 as a simulation study progresses.

The volume of C3 required for successful simulation modelling add to the cost of performing a simulation study. This is further exacerbated if the groups involved in the study

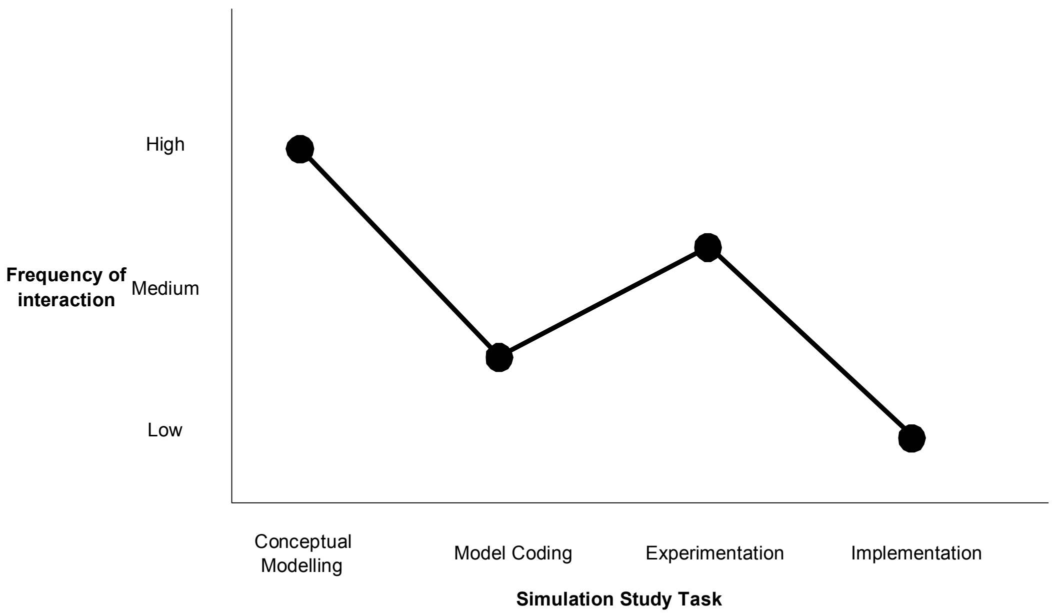

Figure 3: Frequency of interaction in the Simulation Modelling Process

are inconveniently or distantly located. In the next section we present a possible technological approach to reducing this cost.

3. GROUPWARE

The previous section highlighted the need for communication and collaboration in a simulation study. The field of Computer Supported Cooperative Work (CSCW) is a multi-disciplined research area that draws on expertise from both social and technical disciplines including distributed systems and internetworking, multimedia, communication, computer science and socio-organisational theory (Borghoff and Schlicter, 2000). Research in CSCW has led to Groupware, the practical application of CSCW research, a technology that pervades (often without the user knowing) many computing applications (for example IBM's Lotus Notes and Microsoft Office products have several examples of groupware). There are specific Groupware technologies to support specific tasks. These can be characterised as systems that support cooperative meetings or work as categorised on the basis of a simple two dimensional time/location matrix. The matrix divides groupware on the basis of time and location. During some task, people may meet at the same time, at different but predictable times (shift working on a project) or at different and unpredictable times (drop in team rooms). Similarly, people may meet in the same place (a room), in different but known locations (different offices) or different and unpredictable locations (mobile workers). Note that many Groupware technologies support activities that fall simultaneously into many of the groups.

Conveniently Microsoft's NetMeeting is a groupware tool that combines various aspects of tele- and video-conferencing (only two users) with information sharing applications such as text chat, whiteboard, file transfer and application sharing. The product is reported (principally in Microsoft's press) as being used for applications such as remote training, collaborative design, augmenting existing software applications, virtual team support, accessibility, user support and many other situations where the emphasis is on reducing travel costs and saving time. NetMeeting works acceptably on a laptop connected to the internet via a normal modem (faster communications are preferable for ease of use). NetMeeting is accessed either though the Start menu, via a menu in a Microsoft Office application, or through Run by typing conf in the dialog box. The actual choice depends on the version of Microsoft Windows being used.

Text chat allows users to interact via a text conversation. The Whiteboard application allows users to draw various shapes on a shared drawing space (effectively shared Microsoft Paintbrush). Another application is File Transfer. This appears in a similar form to text chat; a menu of participants lists allows the user to choose to transfer a file to another single participant or to the entire complement of participants. The final, and possibly most powerful feature of this package is the application sharing feature. This allows a participant in a NetMeeting session to share any application running on his or her computer. For example, a simulation package can be "shared" by selecting application sharing and selecting the simulation package from a list of running applications that NetMeeting can find on that participant's computer. Once the package has been shared, all participants receive an image of the package as if it were running locally on their computer. Each participant can see the shared package and the results of any manipulation performed by the owner of the package. For example, the owner may communicate to the other participants (by text chat for example) that s/he is going to run the model to demonstrate how a part of the model works to the other participants. The owner runs the model as normal and the other participants will see the model animation as if the package were running on their own computer (with the caveat of communication speed). If one of the participants wanted to point out a model feature, or indeed stop the model and change some aspect of the model, the participant could request control from the owner. If control is granted, then all participants will see the mouse arrow annotated with the ID of the participant. The participant is then in *direct* control of the package running on the remote machine of the owner and may modify the model as they wish. See Taylor (2001) and Taylor *et al,* (2002a) for more details on this technology.

4. EVALUATION

The approach taken for evaluation was in two stages. The first stage invited participants to take part in a "standard" demonstration of NetMeeting and then follow up with a questionnaire that invited participants to consider how potentially useful they might find this application in their role as a simulationist. The second stage was then to visit the participants two to three months later to see how (if any) adoption of the software was progressing. During the two to three month gap staff at Brunel University provided user support in the implementation of NetMeeting facilities at a participant site. Staff were restricted to the user support role. Care was taken to ensure that staff did not introduce new ideas and experience into the process – our objective was to examine the individual innovation made by a participant and not that given by shared experience.

4.1 Stage 1

In the first stage, the demonstration was given at nine different sites to approximately seventy subjects (one site involved a GROUPSIM workshop led by the Simulation Study Group of the UK Operational Research Society). Eleven returns were made from users in industry, defence, and academia. The results are presented here therefore as an indication rather than exhaustive evidence.

The demonstration took the form of an example collaboration between two users (the modeller doer and the system owner done for). A laptop with NetMeeting was connected via a standard modem to a global NetMeeting server. Each of the groupware features were demonstrated in turn with application sharing left for last. The application was loaded at Brunel University (UK) and local and remote interaction was demonstrated. The communication mechanism used was telephone (mobile) rather than the audio feature of NetMeeting. This was due to feedback when audio was placed on external speakers (necessary for the demonstration). The evaluation of audio was therefore on the basis of telephone (in two cases conference calls). The most unpredictable element of the exercise was making the modem connection as various methods were used each time to find a working phone point. The video was shown – the image was quite jerky and it was pointed out that this was smooth if a network connected to the Internet was used.

Each participant was asked to rate each of the demonstrated features of NetMeeting according to how potentially useful they found the feature on a scale of 1 to 5. Figure 4 shows the results from the evaluation. Ranks 1 to 5 indicates the perceived value of a feature with 1 indicating a low perceived value and 5 a high value. Relatively speaking, audio shows favourable results. Video performed moderately. Whiteboard performed well. Text chat performed poorly. File transfer also returned well. However, without doubt, application sharing performed the best and was considered an outstanding feature. Although the cross-section of the simulation modelling community was small, there is an indication that some aspects of this conferencing groupware are useful. Audio was (possibly obviously) useful to communicate with participants. There might be some confusion concerning the use of computer-based audio; most demonstrations used telephone/conference call rather than the application's audio (which was feedback prone). Video was liked by some but was observed several times to be a "novelty." The information sharing applications were the most popular. The ability to conveniently document shared conversations via the text chat application was well liked. The whiteboard was also liked and, in several cases, it was observed to be a convenient "brainstorming" tool. The file transfer utility was found to be useful as it was considered helpful by some to transfer files to all participants by a click of a button rather than having to use email attachments. Application sharing, however, was evaluated as the outstanding feature of the groupware. Many different uses of this facility were discussed. All oriented around the ability for multiple users to take control of another's application to demonstrate various points on-line.

industrialists were singled out as innovators in the use of NetMeeting in their simulation modelling activities. Overall, in terms of interaction with the various groups involved in a simulation project experience with the use of this tool has seen the augmentation of regular communication between the doers and the done for. Our returnees emphasised that this technology must not replace face-to-face meetings with remotely led net-conferences. However, since it appears that meetings can significantly contribute to the cost of a project, several modellers have commented on the use of net-conferencing to replace *some* meetings. Their innovative uses of NetMeeting are outline below.

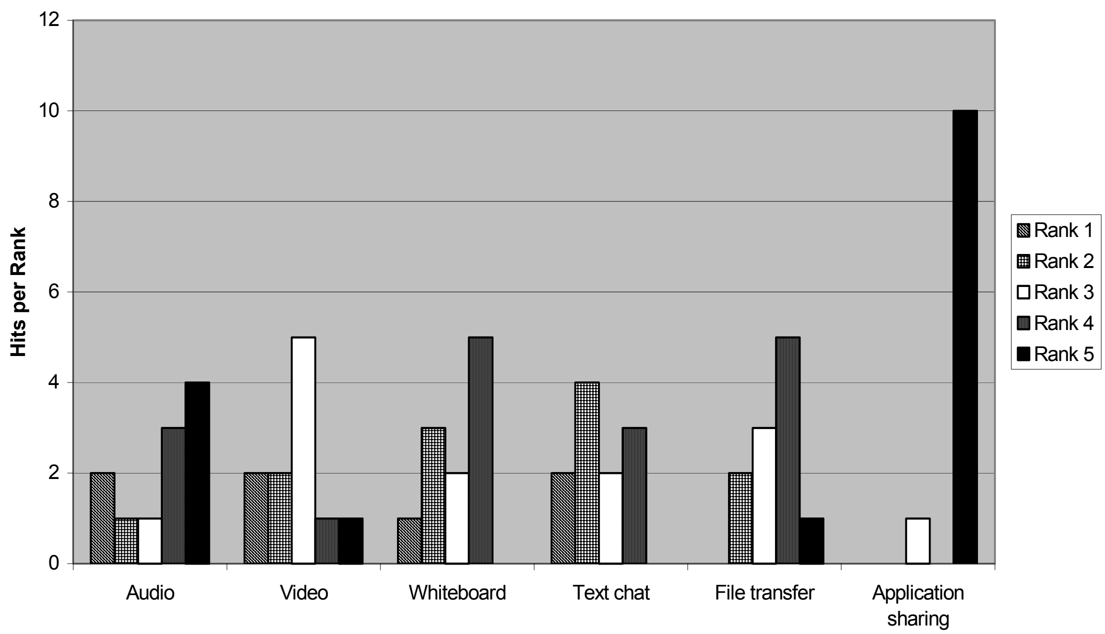

Figure 4: NetMeeting Features by Rank

4.2 Stage 2

This stage involved discussions on the use of NetMeeting with all returnees. The results were very black and white. Two to three months after the return the questionnaire, either the returnee did not use NetMeeting or they were now supporting some parts of the simulation modelling task. The only major difference between the users and non-users was the amount of modelling performed by returnee. In subsequent follow-up meetings to study the way in which NetMeeting was being used, three

Conceptual Modelling. As has been mentioned, in this activity the 'doers' require frequent and regular contact with the 'done for' and 'done with' in order to understand the nature of the problem situation, to define the modelling objectives and to define the conceptual model. In discussions specifically related to NetMeeting, the main application that has appeared is the use of the Whiteboard to collaboratively map out the boundaries and details of the conceptual model. In this situation, several computers have been networked in the same room, possibly with one being linked to a projected display. A discussion takes place about the model, usually run by a facilitator, and participants draw appropriate diagrams sharing the whiteboard. This is a computerised version of a flip chart with the bonus of being able to import figures and diagrams and interact between parties in real time. No specific use of NetMeeting has been identified for the 'done to' (the providors of the data necessary for the development of the model).

Model Coding (especially white-box validation). In this application face-to-face meetings are required to discuss whether or not a model is being coded correctly (although less than in Conceptual Modelling). Typically the 'doer' demonstrates the model to the 'done for' and to the 'done with' to determine correctness and to promote belief in the model. Several modellers are now using the application sharing feature of NetMeeting to replace some of the meetings. This combined with a phone call (or conference call) allows the 'doers' to interact remotely with the 'done for' and to the 'done with' by allowing both parties to interact with the modelling software. In addition to this, the text chat feature has been used to "formally" document the agreement between parties that a change in the model coding has been agreed. This has been used to add to the model documentation.

Support Tasks. In addition to Conceptual Modelling and Model Coding (and Validation), NetMeeting has found use between the "doers" and an unexpected group of members of the "done with." These are the support teams found in large simulation groups and simulation vendors. There are some project costs that come as a result of the need to install new simulation software (or software tools), training to use the software, and support on tool use problems (rather than on Validation). The ability to share a simulation application through NetMeeting means that simulation software can be installed remotely (in one case across two continents), can be used to augment (not replace) existing training strategies, and can make support on tool use completely remote. This point was reinforced by the insistance of one returnee requiring that the support on their simulation software was performed through NetMeeting. This has resulted in NetMeeting being integrated in the vendor's support package and is now being roled out to their customers.

5. CONCLUSIONS

This paper has introduced collaborative simulation modelling and has discussed how the introduction of groupware can assist H2H C3. It has reported on a two stage evaluation of one groupware technology. The results of this work have shown that this technology has been used in three novel ways amongst the different roles. This technology is now being used by three companies to good effect.

In a wider context, this paper has shown that one part of collaborative simulation modelling research carried out by the GROUPSIM Network is of major interest to the community. Technology assisted C3 can save project costs – an important contribution as simulation modelling is a costly technique. What is of interest is the following research topics that require futher study.

- techiques for effective communication, coordination and collaboration between the roles in a simulation study
- usability of groupware specifically within the above
- design of integrated COTS simulation package groupware tools
- the support of H2H C3 with C2C C3 distibuted simulation modelling techniques.

We hope that this paper will engender further research into the support of simulation modelling though technology. For more examples on the use of NetMeeting, see Ladbrook and Januszczak (2001) for a study of how groupware has changed work practices in a multinational company and Taylor (2000) for more details on the use of NetMeeting. For an introduction to the issues of C2C C3 see www.cspif.com and Taylor *et al* (2002b) and Taylor (2002).

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