Global Virtual Teams and 3D Collaborative Virtual Environments

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ABSTRACT
Collaborative virtual environments for desktop PCs. are inherently interesting to use and to develop, and provide motivating and challenging capstone projects for capable students to undertake. From an educational perspective, collaboration in virtual three-dimensional spaces using avatars also adds some interesting dimensions to student learning. This paper reports upon a series of developments, in which collaborative virtual environments have been applied since 2001 to support research into global virtual teams. Specific insights relevant to educators and developers have been gained through a series of local and international collaborative trials, using these 3D environments.

Keywords
Global Virtual Teams, Electronic Collaborative Learning Groups, Avatars, Collaborative Virtual Environments, Java-3D, Web-Based GroupWare, Capstone Projects, Space and Place.

1. INTRODUCTION
A collaborative virtual environment (CVE) is " a type of virtual reality, which is designed to support co-operative activities…usually this means the use of a three dimensional user interface and a creation of a virtual environment in which people perform activities through their embodiments, avatars" [1]. Given the familiarity with computer games and virtual environments of the so-called "Nintendo generation" [2], developing 3D software applications and using 3D environments has the potential to provide motivating, challenging and interesting learning experiences for computing students.

Three-dimensional environments also add new considerations to the nature of learning when students work in global virtual teams to collaborate internationally. This paper reports on a long term action research programme into global virtual teams (GVTs), initiated at Auckland University of Technology (AUT) [3]. As one element of this work 3D collaborative virtual environments (CVEs) have been developed and applied. Key stages in this thread of the research programme have consisted of:

- Commissioning of a capstone project to develop a CVE to support global virtual teams (*Teamlink*) – sem 1 2001 – sem 2 2001 [4]
- Internal collaborative trial using *Teamlink* - sem 1 2002
- International collaborative trial between Auckland University of Technology and Uppsala University – sem 2 2002 [3]
- Commissioning of further capstone project to resolve performance problems and extend functionality of *Teamlink* – sem 2 2004 – sem 1 2005
- Internal collaborative experiment - sem 2 2005 & 2006

As can be seen from the timeline above, progress has been slow but gradual, with development based upon the two semester cycle of undergraduate capstone projects inevitably imposing delays. Nonetheless the *Teamlink* CVE would not have been developed without the capstone project work and this has proven a valid mechanism to extend the research efforts. It has also offered challenging capstone project experiences together with an opportunity to involve undergraduate students in an active research programme, and expose them to the challenges of working globally in 3 dimensional collaborative environments.

2. INITIAL *TEAMLINK* DEVELOPMENT
The goal of the *Teamlink* project was to develop a CVE which would support the introductory phases of Global Virtual Team collaborations. In earlier trials using 2D environments the limitations of text and 2D graphics had proven a barrier to forging initial relationships in the virtual teams [3]. It was hoped that the additional "telepresence" [5] afforded by the 3D environment would ease the process of initial introduction for the team members (students from AUT and Uppsala who had never previously met and thus were complete strangers to one another).

Therefore the *Teamlink* application was conceived as an asynchronous 3D environment, a rather counterintuitive concept for a CVE, but necessitated by the need to operate across a 12 hour time zone difference and support multiple sections of students collaborating cross locations, meeting in class and out of class at different times of the day and week.

The functionality incorporated: the ability to configure a personal avatar (a 3D lego-like figure with which to represent oneself) within a virtual room; a security subsystem to manage groups and access rights; a series of primitive actions the avatar could undertake (appear, disappear, look, walk, run); and emotions it could display (wave, smile); 4 camera views - 1st person, 2nd person, 3rd person and helicopter; a hierarchical activity structure from project, through thread, sequence, step (incorporating a primitive action, and an optional text chat-like message); the ability to replay actions to date within the team's project space and join in the 3D "discussion" as it continued to develop.

The design depicted in figure 1 below, was based upon a client-server architecture, with a 'fat client' hosting the virtual world on the local machine, and the server tracking actors and their

movements for later replay. The server was to be hosted in Auckland.

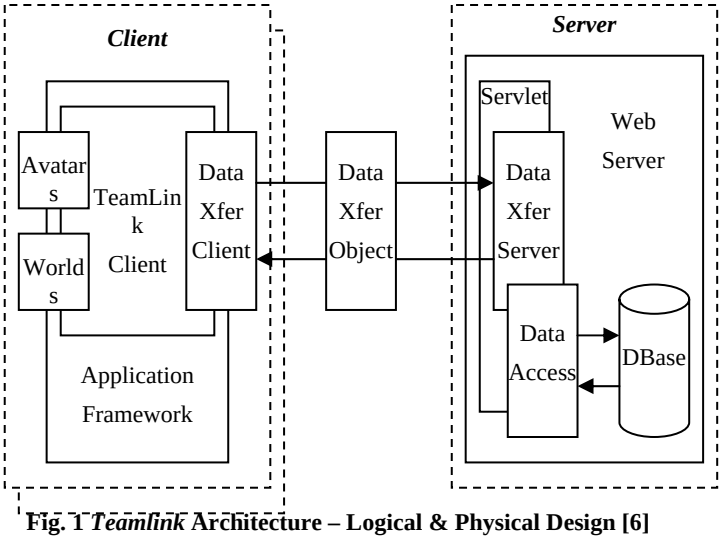

Fig. 1 *Teamlink* Architecture – Logical & Physical Design [6]

3. INTERNAL COLLABORATIVE TRIAL

This trial conducted at AUT offered the first opportunity to test out the *Teamlink* application. It was conducted between three sections of students studying an Intelligent Business Systems course and involved some 61 participants across seven virtual teams. The collaboration involved students using a combination of 2D and 3D software to accomplish a common goal – namely to introduce themselves online using an assigned icebreaking option (either 2D or 3D with *Teamlink*) and evaluate their experiences (anonymously), which would then be visible to all participants, through the 2D groupware. The trial was scheduled over a four week period.

Although approximately half of the overall participants completed the exercise, for avatar based group members the completion rates had reduced to a third of the participants, so there were clearly some issues. However we had achieved a proof of concept, and the trial although mixed had proven of some value. A few comments from students are given below:

> What went well: *"The initial sequence (gestures, etc) went well, but after that the server became really slow and it took more than two minutes to execute each step in the seuqence, hence the exercise took too long and it became frustrating.*
>
> *However, I was sitting next to my team memeber and one of them wasn't having too much trouble with the server and he was having a lot of fun."*

4. INTERNATIONAL *TEAMLINK* TRIAL

The lessons from the internal trial led us to work with the university's internal IT support group to ensure a more robust install for the 3D client software. The application itself had appeared robust and the logs had not reported application level errors. So we optimistically proceeded to install the application at AUT and Uppsala and extend the internal trial activity with a set of global virtual teams.

This trial was designed with both learning and research related goals. From a learning perspective the trial aimed to give students exposure to collaborative applications in a context in which they worked with global virtual teams to span cultural, geographical and temporal boundaries. The research focus related to engaging with students as co-researchers in exploring the differences between 2D and 3D icebreaking techniques in global virtual teams.

The 3D environment was provided by "*Teamlink*". Students were required to configure personal avatars through which to represent themselves, and collaborate with other group members (local and remote) within their own rooms of a virtual world resident on the local client. Movement, conversation and configuration data for groups and avatars in the virtual rooms was in turn accessed from a central server hosted at the Auckland location.

In the initial stage of the collaboration, students were required to become acquainted with their remote team members using one of two modes of cyber icebreaker (a 2D Lotus Notes™ forms based icebreaker and the 3D avatar based icebreaker). The forms based icebreaker was so designed that students worked through a linear process on line involving a guessing game about their characteristics, which they had hidden but revealed obliquely through clues. Given the large time difference between sites, both icebreaker treatments had been designed to operate asynchronously.

The exercise involved some 125 students from both locations. Upon completion of their icebreaking phase, students were required to conduct an evaluation in which they indicated their preference for the 2D or 3D icebreaker mode. The Lotus Notes collaborative application then collated their findings for display and online review.

As reported in [3] students appeared to have a preference for the mode of icebreaker which they were assigned, but "the 3D application appears to have injected an element of fun and excitement into student learning, and show some promise as an approach for initiating new members into a virtual team" [3]. However the performance and infrastructure issues continued to be problematic, but diagnosing the cause of the problems – mostly evidenced by very slow response times would prove difficult without a diagnostic suite.

A separate issue manifested itself during this collaboration. Space precludes a fuller discussion of these aspects, which have been elaborated in [7], but the key issues revolved around: the appropriate behaviour of avatars in cyberspace, the implications of physical proximity, what might constitute "harassment" and what behaviour protocols should be stipulated for students collaborating with CVEs.

5. SECOND CAPSTONE PROJECT

Instability of the software and the fat-client restriction to a single classroom in which the software had been installed proved a barrier to its use, so subsequent trials in the research programme have proceeded with 2D applications which have been browser based, and thus offer more student flexibility

This second capstone project therefore had the goal of implementing a diagnostic suite so that potential performance issues could be clearly pinpointed as they arose. For instance it was unclear whether the University's network was part of the

problem, or if it was an application bug where the precise performance bottleneck lay. A second goal for the project was to enhance the functionality of the application to enable it to offer more structured activities and spaces to support collaboration and make fuller use of the "3D'ness" of the application. Students in previous collaborations had complained of lack of structure in the 3D space, and uncertainty about what they were to do once they arrived there.

The key distinction between "space" and "place" pointed out by [8] gave the theoretical insight into the problem. While the 3D virtual world provided a room, this bland room really only constituted a "space", in which there were no accompanying social structures or rules of behaviour. This virtual world needed to be transformed into a "place" "invested with understandings of behavioural appropriateness, cultural expectations and so forth" [8]. Therefore the application needed to take the leap from "space… the opportunity" to "place…the understood reality" [8]. The challenge as project sponsor was how to envisage a design for "places" which would have meaning and fruitfully use the 3D features of the application.

The final solution involved the notion of an "activity" taking place within a scene, as a context within which icebreaking could be conducted.

An activity would have a duration, enable named objects to be placed in the space, and have a focusing instruction, which would require avatars to locate themselves in the physical space in relation to one another and/or the placed objects. Thus a form of "sociometric readout where group members physically display their connections with each other" [9] could be supported within the application, and avatars would be able to orient themselves relative to one another based upon an icebreaking activity.

Upon completion of the activity, a feedback question for each team member to complete would give a snapshot of the group's internal dynamics after performing the activity.

This project finished having completed several of its goals. Some bottlenecks were identified and removed, the latest Java versions, removed some instabilities, and the activity functionality required to support physical graphing was implemented.

6. INTERNAL *TEAMLINK* EXPERIMENTS

These experimental activities conducted at AUT with graduate classes in collaborative computing in 2005 and 2006, provided opportunities to exercise the physical graphing functionality of the extended *Teamlink* application. Groups of students undertook group assignments in which they were to devise suitable activities to be conducted in the *Teamlink* application (e.g. icebreaking tasks for their groups which would involve some form of sociometric readout based upon avatars locating themselves in relation to one another). Given the general desire to test the suitability of the CVE for developing trust within global virtual teams, a pre-test post-test design was applied in which students were to indicate their feeling of belonging to the group both before and after the icebreaking activity. This required them to identify suitable criteria and questions to be posed by *Teamlink* to operationalise this understanding.

The group struggled with installing the application in different environments, with java virtual machine versions and possibly firewall restrictions appearing to cause difficulties.

Eventually the groups decided to meet face to face and conduct the experiment together in the graduate lab where the software had been successfully installed. This was not wholly compatible with the asynchronous design of the application, and the one day minimum duration of an activity caused some further delays.

Nonetheless students did complete their activities, an example of which is given in figure 2 below. The teams decision to conduct the trial as a synchronous rather than asynchronous activity, and in a face to face mode as opposed to remote, all acted to confound the experimental question of whether the group members were "closer" after this quasi-experiment. Student answers to their questionnaires suggested that the groups had developed stronger bonds, but perhaps these were forged through jointly working to overcome adversity in performing the task required for their assignment.

Therefore as one student concluded:

> *"The hypothesis, that ice-breaking activities in TeamLink increase trust among virtual groups could not be verified or falsified".*

7. DISCUSSION

7.1.1 Research Process

Collaborative computing is an inherently complex research area. When investigating aspects of 3D CVEs, it involves both complex software developments, and a multiplicity of research questions to which attention could be given. Configuring the necessary software environments in multiple locations and managing the logistics of moderate scale collaborative trials with students from different universities, or even different classes, has also proven to be far from trivial work, and needs careful planning.

This programme of research has deliberately involved students as co-researchers, with the goal of changing the relationship between teacher and student since we are jointly enquiring into the unknown. Thus the work has been informed by both a research and a teaching strategy.

The primary research goals have been concerned with how to more quickly develop trust and rapport between members of global virtual teams, operating across significant time zone boundaries and whose members have never met. In service of this goal, and also in support of the secondary goal of motivating students with challenging and interesting development projects, the particular contributions of CVEs to breaking the ice online have been investigated.

7.1.2 Research Results

Software development students have had the chance to undertake challenging and interesting capstone projects and have performed creditably in bringing the work to this stage. Likewise other groups of students have had interesting if somewhat frustrating collaborating experiences.

Active collaborations, albeit troubled by numerous technical issues, have been conducted with some encouraging results, suggesting that the CVE environment has inherent motivational potential for at least some student participants. The challenge is to make the participation in the 3D context a natural element of the exercise. As with much groupware research [10], choice of a well designed task appears to be one key to a successful outcome.

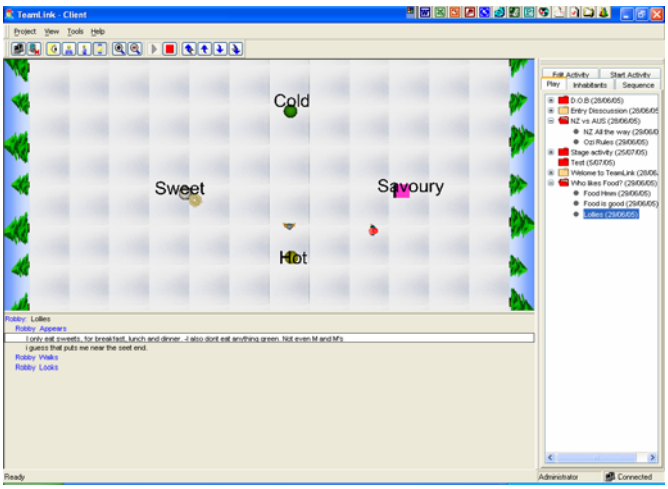

Fig. 2. Who likes food? Sociometric readout.

Insights from Phil Carter's work with action methods, and the value of "sociometric readouts" [9] has proven very helpful as it signposts a way to creating meaningful, culture bound activities that turn the rather bland "spaces" of the 3D rooms, into 'physically inhabited' and productive "places" as highlighted in [8] for conducting icebreaking activities.

An example of a student proposed icebreaking activity supported by the application is demonstrated in the helicopter view of figure 2 above. This activity required participants to position themselves relative to four poles related to their food preferences. The resulting picture showed hot, savoury and sweet food preferences for this group.

7.1.3 Unresolved Issues

As noted in section 4 above there is a need to define acceptable standards of behaviour in such environments, to avoid the darker side of 3D environments evidenced in forms of "avatar abuse" [7]. Whether *Teamlink's* use of more structured icebreaking activities will address this issue without specific guidelines and policing mechanisms, remains an open question.

The specific value of 3D environments requires further investigation. Pekkola comments that "3D is mainly used by novices (or teenagers) who are fascinated by the graphical interface" [1], whereas frequent users used other more appropriate media. In the educational context this may however be a plus. For instance, in [3] the Uppsala students preferred the *Teamlink* application, over their Auckland counterparts. However, the Uppsala students were younger and more technically focused. In section 6, the critique of the worth of the 3D view was made by a graduate student, in the context of an experiment in which the virtual aspects had been solidly confounded by face to face activity. Nonetheless the *Teamlink* CVE now offers a useful test bed for experimental activities in which the merits of different icebreaking tasks (whether with local or global virtual student teams) can be formally assessed.

8. CONCLUSION

Research in three dimensional collaborative virtual environments (CVEs) raises some interesting challenges, exacerbated when involving global virtual teams of students. The research programme reported above has been conducted on a shoestring with student support. Since 2001 we have been engaged in developing and investigating 3D CVEs, and their effectiveness in supporting icebreaking activities for global virtual teams whose members have never met. Current designs have been informed by action methods, and group process techniques which have introduced mechanisms to make effective use of the 3D features afforded by the application. The work has had a degree of success, measured from a learning teaching and research perspective, but challenges have been met in technical, logistical, design and cultural dimensions.

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