It's all in the words: Supporting work activities with lightweight tools

Elizabeth F. Churchill
FX Palo Alto Laboratory, Inc.,
3400 Hillview Avenue, Bldg 4,
Palo Alto, CA 94304, USA
churchill@pal.xerox.com

Sara Bly
Sara Bly Consulting,
24511 NW Moreland Road,
North Plains,OR 97133, USA
sara_bly@acm.org

ABSTRACT
The development of tools to support synchronous communications between non-collocated colleagues has received considerable attention in recent years. Much of the work has focused on increasing a sense of co-presence between interlocutors by supporting aspects of face-to-face conversations that go beyond mere words (e.g. gaze, postural shifts). In this regard, a design goal for many environments is the provision of as much media-richness as possible to support non-collocated communication. In this paper we present results from our most recent interviews studying the use of a text-based virtual environment to support work collaborations. We describe how such an environment, though lacking almost all the visual and auditory cues known to be important in face-to-face conversation, has played an important role in day-to-day communication. We offer a set of characteristics we feel are important to the success of this text-only tool and discuss issues emerging from its long-term use.

Keywords
Virtual environments; interviews; distributed collaboration; presence; text-based communication; computer mediated communication

INTRODUCTION
Being separated from one's colleagues poses problems for the maintenance of ongoing work. In recent years much effort has been put into developing applications that allow colleagues to continue collaborating and coordinating work activities irrespective of time and geographic distance. There are various approaches and various configurations of technologies that have been brought into play in this enterprise. Examples include systems to support audio, video and textual communication between people [3,8], tools for coordination of work activities [11] and tools for the organization of serial and/or interleaved work procedures [12]. More recently, Web-based, virtual workspaces are on the increase [15]; some of these offer support for all of the above.

Information rich media for collaboration
When it comes to designing for synchronous communication, there are a number of beliefs about how to facilitate work-based interactions between non-collocated colleagues.

One clearly-stated belief is that interactions can be facilitated by structuring the virtual work space/environment to create a shared "landscape of work artifacts"[14]. Project-based applications [e.g.15,17] therefore provide support for the management of personal and shared workspaces and the sharing of work-related artifacts. A notion of shared spaces or "locales" [9] is also used to structure interactions between interlocutors.

A second belief is that for tightly coupled collaborations at least, the creation of a feeling of co-presence between non-collocated collaborators is crucial if computer mediated communication is to be successful. With reference to such communication technologies, Lombard and Ditton [13] state "an enhanced sense of presence is central to the use, and therefore the sense of usefulness and profitability of new technologies". Their argument suggests that a greater sense of presence is correlated with "a feeling of nonmediation", and that this will result in a greater quality of interaction.

This begs the question: how can a sense of co-presence and non-mediation be achieved? Lombard and Ditton [13] review a number of conceptions of presence; these can be divided into cognitive engagement, presence or immersion (as one might get when reading a novel) and sensory/perceptual presence which is characterized by provision of perceptual cues to create an illusion of 'being there'. The authors place considerable emphasis on the second characterization, arguing that an illusion of non-mediation involves "continuous real time responses of the human sensory, cognitive and affective processing systems" and stating that "objects and entities in such a medium should appear perceptually (if not socially) vivid and real". People should feel "that they and other users are sharing a real or artificial environment". Further, "the illusion of nonmediation will be more complete if the medium is

perceptually and psychologically immersive". The implication is through provision of rich, multi-modal cues one can create a mediated interaction that seems "real" or "direct; *more* cues result in greater presence, greater presence results in more fruitful communications.

Emphasis on the perceptual can be seen in the design of many applications for collaboration. Co-presence equates to a rich perceptual experience of the other. This can be seen in the recent development of (immersive and desktop) collaborative virtual environments (CVEs) and avatar-inhabited virtual worlds. In these virtual environments, virtual objects can be shared, and users are embodied in increasingly elaborate avatars with gestural capabilities [1]. The design model is drawn from the physical world; the aim is the recreation of physical-world style interactions in the digital arena. Co-presence is operationalized in terms of the communicative cues that enable the establishment of common ground in face-to-face interactions.

This drive to recreate face-to-face interactions has yielded a substantial body of work on the role of non-verbal cues in conversation in both virtual worlds and video-conferencing contexts. For example, in the context of video-mediated communication, Whittaker and O'Connaill [18] offer an analysis of cues for process coordination (turn-taking cues and availability cues) and content coordination (reference, feedback, and interpersonal cues). Typically such coordination comes from the ability to see another's gestures, artifacts, emotional stance, and gaze. The challenge for technology is to support the timely transmission of these cues, through audio and video channels.

The linking of perceptual cues, presence and collaboration is also evident in shared workspace applications. Often such applications provide visual icons that emphasize the metaphor of the physical world in structuring the virtual workspace. Icons for organizing activities and groups in the form of virtual desks and virtual tables are mixed with tools for interaction in the form of virtual post-its, virtual whiteboards and audio/video links. All of these populate virtual offices in the form of application windows or Web pages. In a similar push, MUDs, which have traditionally been text-based, have grown into multi-media and visually rich environments [3].

TEXT-BASED VIRTUAL ENVIRONMENTS

In this paper we present observations from a recent interview study on the use of a representationally simple, text-based MUD to support successful work collaborations. We have been studying use of this MUD for over 3 years; results from interviews carried out two and a half years ago are described in an earlier paper [2]. Our studies indicate that visually oriented media richness is not a prerequisite for the creation of sufficient social co-presence for maintaining collaborative relationships. Such social co-presence seems to reside in shared goals and understandings which derive from conversations around a common focus.

In the next sections we offer some illustrations of the way in which the MUD is currently being used to support communication between collaborators, and comment on how that use has changed over time. Before presenting the results of our analyses, we offer a short introduction to MUDs and MOOs.

Communicating in text-based virtual worlds

MUDs are multi-user, end-user extensible, low bandwidth, and distributed network accessible virtual environments. Within such environments, people can converse with others through text. In comparison to distributed multi-media and 3-D graphical environments, MUDs are technologically lightweight and low bandwidth. They are also cognitively lightweight for users; once an account has been set up, a user can begin interacting with others who are present in the MUD with only a small amount of instruction.

MUDs embody a "spatial" metaphor; activities take place within interconnected rooms wherein other users and objects are located. In this regard MUDs differ from chat rooms and talk channels like IRC and instant messenging applications. Further, as a result of their gaming roots, MUDs offer far more programming capability than chat rooms and talk channels. By issuing commands it is possible to navigate between rooms and to create, move and alter objects. MUDs are also easily extensible from within – it is relatively simple to create new rooms. Many different communication modes are also possible; one can whisper private messages, issue broadcast messages to all MUD rooms and page individuals who are in different rooms. It is also possible to issue commands which provide activity logs in the MUD; such logs can give one awareness information about who is where, what activity is currently occurring, what activities have occurred in different rooms and so on.

Communication flexibility, activity awareness tools and navigation tools are typically not available in chat rooms. There are also differences between MUDs and other synchronous chat applications in conventions of use. Unlike IRC channels and chat spaces, MUD users experience virtual rooms through textual descriptions; such descriptions contain information about objects and other users who are present in the room.

Although powerful, there are some drawbacks with MUDs. A primary drawback is that they require considerably more set-up and maintenance than most chat rooms; usually an administrator or MUD manager oversees the MUD. As a MUD's population grows, this workload can grow. Once set up, MUDs are simple to use for end-users, and although they are programmable, programming is by no means a necessary requirement for using the MUD to communicate.

Researching MUD use

As noted earlier, MUDs have traditionally supported multi-player Internet gaming and social chat. Indeed, most of our knowledge of the use of such environments comes from studies of gaming, education and social contexts wherein

loosely coupled groups, often comprised of people who have never met face to face, can meet and interact. Studies have shown that the characteristics of MUD use vary according to the kinds of people who inhabit them. Gamers, for example, require rich room descriptions and fictional character representations. Social MUD spaces which are inhabited by people who are drawn to meet peers tend to focus on communication. Interlocutors are less likely to use fictional character names and there is less emphasis on rich room/object descriptions [2,16].

In recent years, more research has focussed on the use of such environments in the support of work activities [2,5,6,7]. However, whilst illustrating the affordances of MUDs and MOOs for certain activities within particular communities, few papers detail the *long-term* use of text-based MUDs in supporting communication and coordination activities within work environments. Our work spans long-term use of a MUD.

In previously reported work, we presented analyses of interviews carried out when the MUD had been in use for two and a half years. Our findings from the first set of interviews demonstrated that the MUD was one of the main means of communication between collaborators, providing a lightweight way for collaborators to keep in touch with each other. Social and work interactions were interleaved. The dynamic objects and rich descriptions of the gaming MUDs were not in evidence, and users preferred to use character names that allowed them to be easily identified. We posited a number of factors that we believed were crucial for the success of the environment at that time, including its technological affordances, the work practices of the division members and the organizational set-up whereby the use of the MUD is sanctioned.

In this paper we report observations from a second and recent visit to the field site. The MUD is now in its sixth year of use. Our intention with this visit was to build on our earlier work by investigating whether the MUD is still in use, and, if so, how it is currently being used, to note whether that use has changed over time, and to explore ideas for ongoing developments to the MUD.

In the next sections we present some background to the interview study and our observations. We then offer some discussion of our observations and reflect on the relationship between presence, informational richness, awareness, evolving usage patterns and the support of work activity.

STUDY

All interviews and observations were carried out at Argonne National Laboratory (ANL) in the Mathematical and Computer Science Division (MCS). Within MCS internal and external collaborations are commonplace. Project groups can be made up of individuals from many parts of the organization as well as from other organizations. Individuals can belong to multiple groups, and groups often do not have stable membership over time, as people join and leave projects according to expertise and requirements. All interview participants either worked in the division itself or collaborated with others who did. Project products are software, journal/book/conference papers and technical reports.

The MUD

The MUD at ANL is called Waterfall Glen (hereafter WFG), and uses version 1.8.0r5 of the LambdaMoo server code. The MUD has been operational for over 5 years, with approximately 290 people receiving accounts during that time. These accounts are predominantly for researchers, systems administrators, student interns and work collaborators, although a few have been set up for close relatives and friends of the primary users. It was reported that during an average week in Spring 1998 eighty-two people had been present in the MUD; an informal survey of names revealed that these were regular MUDders. Ninety-three people had been active in the MUD during the previous month and 164 had been active between early 1997 and early 1998. It was reported that usage was on the increase. Since our first interviews in 1996 there has been a steady increase in the number of users, indicating the *ongoing* success of the MUD.

The MUD has many rooms (in informal conversation one person stated there were over 200 rooms), many of which are no longer used. Some in fact have never been used as virtual meeting places; creating a new room appears to be a favorite activity for "newbies"[1] as part of learning to use and program in the MUD. In our interviews approximately six rooms were mentioned regularly. Most people used an EMACS window for their MUD connection; only one person used a more sophisticated client.

Study participants

Eight interviewees were asked about their work activities and their use of communication technologies, with a primary focus on the use of WFG. Details about our interviewees can be seen in Table 1[2].

All of our interviewees with the exception of Mitch have offices in the same building. Three of our interviewees, Greg, Shirley and Chris, are systems administrators. They have offices on the same floor and corridor. Most of their work-related communications are with researchers in the division, with hardware and software vendors and with their colleagues on the system administration team. Five of our interviewees are research scientists, with backgrounds in chemistry, computer science and applied mathematics. Their work-related communications are primarily with domain colleagues on and off-site and with the systems administrators. Three of our interviewees, Lily, Lucy and Marv were interviewed on our previous visit [2]; all three are research scientists.

[1] New MUD users.

[2] All interviewee names have been changed.

Name and occupation	Background and MUD expertise
Chris, Sys admin.	Computer science training Expert MUD programmer
Shirley, Sys admin	Computer science training MUD user, does not program the MUD
Greg, Sys admin	Computer science training MUD user, does not program the MUD
Marv, Researcher	Background in chemistry, research into applications for internet collaboration between chemists MUD user, limited MUD programming
Lily, Researcher	Background in applied math MUD user, can program but says she does not need to for her current use of the MUD
Lucy, Researcher	Background in applied math MUD user, does not program
Mitch, Researcher	Background in chemistry MUD user, limited programming in the MUD
Peter, Researcher.	Background in computer science MUD user, does not program the MUD

Table 1: Interviewees and their characteristics

MUD programming expertise varied; one of our interviewees, Chris, is an expert at programming in the MUD, whilst most of the others consider themselves "users" rather than environment builders. However, Lily had experience of setting up a different MUD and most had tried creating objects and rooms at some point.

CHARACTERISTICS OF USE AND SUCCESS FACTORS

These recent interviews concerning the use of WFG suggest that many of the factors we identified in our earlier interview studies are still in evidence. However, there have also been a number of changes. In the following sections we outline the current status of the MUD as it is used at ANL and offer some reasons for its continuing success.

Observations

Representational simplicity

In contrast to the above-noted drive for perceptual richness we have observed in the design of many communication tools, the MUD at ANL remains representationally simple. There has been little in the way of movement toward more visually sophisticated clients over the past 2.5+ years. Where tailoring of the technology has occurred it also has been limited. There has, however, been "tailoring" of the social practices of groups.

An example of this is the way in which activity and availability awareness is achieved. Current research in explicit and tacit awareness mechanisms places much emphasis on provision of rich perceptual cues that can be mapped to activity levels and types. The MUD offers only simple activity awareness cues for colleagues. One is seeing text scrolling by in the MUD window indicating that activity is taking place. New since our last visit are an auditory cue that lets one know one has been paged and a set of social conventions that have grown up in the form of explicit actions MUDders take to signal availability. For example, two of our interviewees, first Lily and then Shirley, talk about "blinking". Blinking is a statement typed to the MUD which signals one has arrived at work and is available for contact. Other MUDders see this in their logs as, for example, "Shirley blinked".

> [My colleague] comes on in the morning and I see that he's blinked and I know that he's there working on the stuff, because the only time he logs onto the MUD is when he's working on the project we have together.
>
> When you first come in in the morning, you blink on the MUD … that tells people that you're awake and available for comment or to be 'poked', which means they're trying to get your attention.

Also new since our last visit is the implementation of a means of directing messages to people for them to pick up later. By "poking" people you can leave a special indicator that you have been trying to contact them. When they return to their desks, they can issue a command to tell how many times they have been poked and by whom – an easy summarisation of salient points in the logs and the facilitation of asynchronous communications.

Notably, we saw no evidence to suggest that more visually sophisticated mechanisms were required for the maintenance of this group's activities. Concerns around saving screen space and maintaining a quiet working environment with non-intrusive cues seemed paramount. We also got the impression that most people were not concerned with spending time programming the MUD – but rather, the current functionality appears to be sufficient to their needs, and, in the few instances where the MUD is not able to support effective communication, other complementary tools are available.

Ongoing support of work collaborations

A central observation is that WFG, more than 5 years after its introduction, continues to be used in support of work. Whilst the MUD is still not an "official division tool" as Marv expressed it, all systems administrators are actively encouraged to use it, and it is viewed as a primary means of communication for them. We observed that users have one or more WFG windows constantly up their screens, and noted that this practice has not changed over the years. The MUDders have a continuous presence in the MUD. Literally, if you need to find a systems administrator, you can always find them in the MUD. This "knowing where to find people" is a point we pick up on again later.

Comments from several of our interviewees suggested that although social and work related interactions interleave seamlessly in WFG, its *primary* use within the groups to which our interviewees belong is for work-related interactions[3]. Since our earlier interviews, this use of the MUD for explicit work interactions has increased. Indeed, there was considerable evidence that more people have begun using the MUD *because* of the increased work focus. This increase in work use seems to have been accompanied

[3] Although we were told that there are other groups who utilise rooms in WFG for primarily social purposes.

by a reduction in social chat in the groups we interviewed. Greg says[4]:

> For the first year or so, I'd experiment on it a little bit, but I really didn't find it very useful. A lot of that came from the fact that there was an awful lot of just chatter and -- It was too much information a lot of times … It was useful to the people that brought it up and a few others, but it wasn't encompassing an area that I was really interested in … And then once there got to be enough people in Systems [a room in WFG where the systems administrators can be found] or enough other people that the MOO was able to fragment, I guess, into areas of commonality, that it became a lot more useful. And that's why I started spending a lot more time or paying a lot more attention to it.

This was expressed as a reduction in the "signal-to-noise" ratio. Greg expressed current use of WFG in this way:

> There are times where it's 100% signal because a small group of us will go off and we'll be concentrating on a problem and work. You know, the only thing that will go on in that is technical.

Whilst the systems administrators represent an obviously tightly-knit, established and stable group who collaborate on a daily basis, the researchers we interviewed continue to use the MUD to maintain weak and strong work ties with local colleagues and within their often geographically dispersed research communities. Lucy, who continues to use the MUD for many of her collaborations, explained that the MUD has enabled her to have multiparty project meetings whilst team members are distant. She also makes a clear case that the MUD enables the maintenance of relationships with colleagues long after the main collaboration has officially ended.

> It used to work well because we had a lot of people working on the project together, and it [the MUD] worked well for us because we were able to have a group discussion, even though at one point … these are students that I kept working with me even after they'd left … So we were able to have a meeting with, you know, John was in Iowa, I was here, Jeff was in California, and Dave was here. So we were able to have a meeting of the four of us discussing actively some project, even though we were not together.

As time goes on and more MUD-supported collaborations come into being, this group of MUD-based collaborators is obviously growing. We saw more evidence of these maintained relationships than during our previous visit, and were interested to notice that the mode of choice for continuing conversations and, often for locating people and reestablishing contact, was the MUD.

Related to this work-related activity has been a move since our last visit toward "quieter" rooms which are contrast with many of the more social MUD spaces. Thus, while our interviews 3 years ago showed "The Very Cool Hangout Room" as the main center of action with multiple conversations overlapping and interleaving, our recent interviews indicated that (1) there is no central social room that *everyone* attends regularly, and (2) more people spend most of their time in project rooms. In these project rooms most communications occur using 'whispers' which are directed at specific individuals and which do not get broadcast to the whole room. Lucy stated of her relatively recently created new project room:

> Well, now I'm spending most of my time there. Prior to that I did in a different room that focused on another software project ....So within that room is where I tended to communicate with people who worked as my closest collaboration historically, but now I'm heavily involved in this other project, so I'm hanging out in this other room to encourage other people to talk about things. It's working.

This suggests people tend to go where the work conversations are.

Project rooms were surprisingly different from one another; each had its own 'atmosphere'. This room atmosphere was surprisingly strong given the fact that only textual representations and communications are used. Room atmosphere was no longer as associated with room descriptions but now explicitly associated with room use: how many people spend time in the room; who those people are; the relationships between those people; what kinds of conversations are ongoing (primarily social "banter" or primarily work exchanges); what times of day the room is busy; how much people whispered rather than talked to the whole room; what level of description the room has; what objects are in the room; and how stable the membership was. Given the lack of visual cues, it is clear that such an atmosphere develops out of the practices and interactions of people who "hang out" in the rooms; it evolves over time rather than being explicitly tailored. Over time the atmosphere of the Very Cool Hangout Room has transformed from that of a lively café to an empty corridor.

The move to more project rooms does not, of course, preclude MUDders going to the more social rooms. The ease of movement through MUD rooms has far more of the feel of an open-plan office environment than the more partitioned, page-based project spaces of Web-based projects spaces (e.g. [15]). Marv, a researcher, states that his primary MUD collaboration group is small, however:

> I also take advantage of my being on the MUD, so for example I communicate with systems people and with [another lab's] people.

Reasons for success

Support for lightweight interactions

In part due to the factors described above regarding the representational simplicity of the MUD, use of the MUD continues to be quick and lightweight. This lightweightness is both in terms of initial set-up and in terms of ongoing interactions that people have through the day. Being able to engage in quick interactions is clearly a function of the continuous presence in the MUD of collaborators (noted above), as well as due to the fact the tool affords swift exchanges. Through continuous (peripheral) monitoring of these windows, MUDders are always aware when some activity is occurring in a relevant MUD room, and they can jump in is as needed. Lily says:

[4] Where details have been removed a summary is offered in square brackets, or in the case of less relevant commentary, a section is replaced with three periods.

> I definitely like immediate interaction with one or more people. I definitely like the, yeah, the connections that you can just maintain via communicating with people, even if it's just a word. That's a short amount of time on a daily basis, so it's worked very well for me to be in touch with Dave and what he's doing, and what he's up to, even if it's just to say hello. I know that he's there, I can talk to him if necessary. So that's very nice. It has enabled me really to work very well with remote students, in a way that I was unable to do before.

Quick interactions were also in evidence between people who are geographically distant. Marv said:

> The post docs here are working on the same problems as the post docs at [a distant university], and they say "Gee, I don't know if so-and-so got his part done yet. I need to call him." And instead they start bantering good morning and so forth, and say by the way, how are you doing on the basis function. And they bridge that social transition to a technical level. That's occurred with the graduate student in France as well.

Lily, similarly says:

> I had for a time been not here physically all the time [not based an ANL]… so the MUD has been a nice tool to help us have sort of consistency in daily informal communication.

This feature means also that unplanned, impromptu collaborations can happen; if a problem arises one can simply ask people who happen to be present in the MUD.

This ability to check in and easily make contact, combined with the *potential* for synchronous communication clearly creates a sense of co-presence, and a feeling of intimacy with one's colleagues. If quick responses are crucial for a feeling of engagement with one's collaborators in synchronous communication, it is worth noting that whilst video and audio links provide richer data, interactions are often disrupted due to transmission lags. Lags in communication in the MUD can also occur, and arguably these also disrupt any feelings of co-presence, but they result in asynchronous messaging. Lags in audio and video communications more often result in lost data.

Know each other and shared culture

The way in which the MUD is used is also affected by the fact that the individuals who are using it know each other. "Know each other" can be broadly interpreted. Either colleagues have met face-to-face and may have collaborated over time, or just being members of the same research community meant there was sufficient shared ground and shared culture to provide familiarity. Chris states:

> I think it boils down to, for example, with Waterfall Glen, with the MUD here, the room can fall very idle or it could be very busy, but I know everybody in it, I interact with them regularly. So if while I'm talking to you guys 10 pages of stuff happens, I can actually sit there and read it and be interested in it afterwards. When I'm on another MUD I may not know everybody.

For this reason, he says, his use of more recreational MUDs has dropped since he began work at ANL.

This sense of shared culture and sense of identification spans organizational boundaries; we saw many instances of collaborations in the MUD between people from different organizations, and observed that such interactions were seamlessly integrated with the communications with one's local collaborators. Crucially, no change of tool or interaction with multiple menus and dialogue boxes was needed, and in some instances not even the initiation of a new window. MUDders could simple issue a command and move to a different, now relevant, room.

One of the biggest surprises which illustrates the group nature of these environments was the fact that one of our interviewees predominantly used not WFG but a *different* MUD for interactions with *his* main collaborators who inhabit a different virtual space. Peter stated:

> Well, I don't use Argonne's MUD. NCSA has a MUD, and that's what this is right here. [indicates an open window on his screen] … Mostly people will throw out questions if they're working on something and they get stumped. They'll throw out a question and maybe someone else can answer pointing to the right direction.

Peter has used WFG on occasion, but stopped because:

> Just that since I don't really work with those people, there didn't seem to be a reason for me to connect in. I mean, I don't know most of the people on there, or if I know them, I don't know them very well. … It's not like an Internet chat room where you go in there to meet people. This serves a really functional purpose.

Complement to other tools

It was clear that the MUD acted as a complement to other tools. Users themselves determine which communication medium is the most appropriate for their current needs.

The MUD is used to carry out certain communications that otherwise would not be possible, or rather would be possible in a more cumbersome manner, using other tools. The seamless move from synchronous to asynchronous without users needing to initiate any technical modality change through deliberate actions on their part is highly valued. Peter said:

> The thing about e-mail, through, well, the e-mail is what I'd call strictly asynchronous, where I send off the question and I have to wait for a response. The MOO can work, or the MUD can work in either mode. Now, I can ask a question and if someone's paying attention and they see my question come up and they know the answer, they can type it in right away and I can see it right away. But at the same time, if later someone comes by, has a comment or, so it can work in both modes. It's not strictly asynchronous, and it's not necessarily synchronous.

He also said that unlike a phone call, in the MUD one can paste relevant output into each other's text windows and speed the problem solving process:

> It's a good way to exchange information. We can paste things back and forth, so if I have a question or if I wanted to show someone in the group something I see, I can paste it.

The communication niche that the MUD fills is also illustrated in the following statement from Chris.

> It's primarily inter-group communication, is what I see as the primary use for it. When I am downstairs trying to solve something and I know Mark has the answer I'm looking for, I can pick up the phone and call him, but, you know what, I don't know what Mark's extension is. I never use the phone here. I can send him e-mail. John may not check his e-mail. John's not the fastest on e-mail. I could walk upstairs and ask him, but then I'm no longer at the computer and I can't apply it. So, I go to my laptop and I poke him and I say can you help me with this, and we'll talk

back and forth, and if it needs a face-to-face, then we arrange it on the MUD.

There are also practices around the use of different tools and a perception that certain protocols grow up around those tools. For example, the MUD is not seen as an official route for requesting help:

> We encourage that above all else, number one, because it's e-mail that goes to everyone who should care about it; and number two, because it's a permanent record. We do not consider the MUD, regardless of how long you've been keeping your scroll-back around, we don't consider the MUD to be a permanent record, nor is it trackable. … So, we don't consider it a reliable. But if you come in and you ask can someone help me with this, I think the official line on it is yeah, if we can we will, but don't get upset if no one's there to help you because it's not an official method of support.

Different communication media are used to structure work activities. The following quote illustrates that Lily and her collaborator distinguish between email and the MUD and use the two in distinct ways in their interactions.

> And then he'll always tell me [in the MUD] when he's leaving to go to class, and so I know when he's gone. Whereas in e-mail, you're right, it's much more -- Our e-mails, my e-mail with Nick at any rate has always been here's an update from Nick versus my here's what I'd like you to work on next. So it's always very much project-driven, with very descriptive, informative stuff, as opposed to "Gotta go to class, I'll see you tomorrow."

The choice of technology was, as Greg put it, on a "case-by-case basis", and is down to the particular practices of these individuals and their exploitation of the technology affordances.

Organizational support

The use of the MUD is still not officially recognized within the division. However, the organizational support for the use of the MUD comes not only in the tolerance of its use, but also manifested more concretely in the technological infrastructure that is provided, and the recognition that many collaborations cross organizational boundaries. This means that an open system where many people can have accounts in WFG is possible.

Nature of work

Although there were notable differences between the researchers and the systems administrators we interviewed in terms of the structure and location of their primary work contacts, there were also commonalities in their work practices which meant that for both groups the MUD serves a central role. This fact and the structure of the MUD mean these groups inhabit the same virtual space in a way that may not otherwise be the case. For all our interviewees much of their work is done collaboratively, they are all computer literate, happy with typing and usually at their desks. As Lily put it:

> I also think it works so well here because we're always here at our computers and it's one of our, you know, we're very, very comfortable with our computers. We are always interacting with our computers. It's always right in front of our faces.

In considering the successes and failures of technology mediated communication we are aware of the need to match the particulars of the work activity to the explicit and latent affordances of the technologies.

Ubiquitous

Perhaps the single most important factor in the MUD's success, apart from its lightweightness and low cognitive overhead, is that it is persistent and ubiquitous. That is, the MUD is always available. It offers a persistent place or set of places that users can go to as desired without requiring much entry overhead. This ease of entry to a MUD and how that plays into its continued (and continual) use has been also noted by Curtis with regard to use of social MUDs [4]. For our interviewees it seems that the MUD is not associated with any physical place, machine or person as far as the users are concerned. Marv notes this ubiquity and the constant presence it affords users:

> We have examples in our division and again we get it from other people, and we have people who travel with ricochet modems on their laptop and you have no idea where on the planet they are. And there they are on the MUD.

It appeared to us that the MUD rooms have become a more "real" place in terms of collaboration than the physical offices that users inhabit. MUDders sense of location or "presence" is in the interactions they are having with colleagues. There is an expectation that if people are ever near a computer, they are on a MUD; this availability adds to that notion that people are 'there for each other' even if they are not physically present. Chris states:

> There are times when I am in this office from the time I arrive to the time I go home, and then there have been weeks when I have not been upstairs to the second floor of this building. I come in. I go into the machine room. I sit down because whatever project I'm working on is so immersive that I've got my laptop, my laptop's up, and I've got my MUD window. So, I'm more reachable that way. I mean, I was [away] over the weekend with my wife's family for Thanksgiving and I was on the MUD everyday … I'd pick up my laptop, connect to the lab over the modem, and chat with whoever happened to be around.

Greg states:

> It's becoming more acceptable that you will find people in the MUD, where you may not find them -- I mean, they may not be in their office, they may not be at home, they may not be wherever, but chances are if they're anywhere near a computer, they've got their MUD window up. And if their MUD window is up, they're accessible that way. So it's an easier way to deal with people. You're spending less time trying to track them down.

This feature of ubiquity, persistence and easy access stands in contrast to all other technologies, which aim to provide a sense of co-presence for colleagues. Often such environments are technically heavyweight, and over time as systems develop, problems of interoperability are an issue. With the MUD all one requires is a telnet connection and an account; then, a set of interconnected interaction spaces becomes available. Notably, technically simpler chat spaces also reputedly offer some limited sense of co-presence. However, in this case, there is no sense that the social or collaborative space will endure despite one's absence. In fact, their existence is predicated upon one having a live

connection. Unlike WFG, when the connection dies so does the communication space.

Chris offered an interesting anecdote that illustrates this expectation of the MUD being always available.

> When I was down in Orlando for this big conference, the lab took a power hit, and all the computers there went down. We had our network in Orlando, and we had our little net running, and all of a sudden the MUD wasn't there, and we couldn't talk back and forth. My pager went off, so I picked up my phone and I called [a colleague] and said, "What's going on?" He said, "Oh, we had a power hit." Blah, blah, blah. And I went, "Oh wow, all right, well, is there anything we can do?" "I'm not sure, I don't think so." So as soon as I got off the phone, I bring up my Jay's window, my Jay's House[5] window and he's alert there, and we start coordinating there trying to get Waterfall Glen back up so that we can have that channel of communication. But, you know, we're using this other MUD that's a completely different site for that, and it was just handy because it -- Like one of the things that I say I like about the MUD is I'd say to [my colleague], you know, try this, and he may leave the computer to go try something, and then while he's gone I'll say oh, maybe you should do this, maybe you should do this, or maybe you should do this. And when he comes back, he will see what I said, but if he lays down the phone to go do something, I can't start talking and he can't come pick up the phone and see what I've been saying while he's been gone. So it's kind of nice to have that method of communication open.

This anecdote illustrates the extent to which the MUD has increasingly become part of the working practices of this group, and its central role in maintaining a perception of co-presence. A second point from this anecdote which was not apparent in our earlier investigations was that WFG sits in a matrix of MUDs, and being a MUD user gives one expertise to access to a number of social environments. Thirdly, text-based MUDs are accessible wherever you are, and with little specialized equipment. Finally, the seamless move between synchronous and asynchronous communication is of great benefit, as the tool allows concentrated tightly-coupled collaborations as well as looser collaborations without requiring collaborators to shift tools.

DISCUSSION

The ongoing success of WFG suggests that there is a greater potential than is being realized for low bandwidth tools to fill a niche in conversational gaps for people who are not always collocated. Our observations suggest several factors that are important in making WFG so useful: the now well-established ability to support ongoing work; the quick and lightweight access; the underlying shared culture and familiarity with one another; the ability to exchange short, casual communications; the way it complements other tools; the organizational support for WFG; the nature of the work itself; and the ubiquity of access.

One surprising thing is that the MUD use has not changed substantially, but has changed in subtle ways over time. The number of MUDders has increased, the number of "non-expert" MUDders has increased, and the use of the MUD has become a much more personal or group-specific activity. To a far greater extent than in our previous field visit, the MUD has become an integrated tool rather than being associated with an "in-crowd" or "clique". New features have been introduced but these features are not universally used (not everyone was familiar with the "poke" command for example) – rather, their use moves along social communication lines. We have observed some customising of the tools over time.

There is also evidence that people feel connected or co-present with each other despite the representationally simple nature of the MUD. Our observations suggest that the text environment is adequately "immersive" when communication and conversation are the main requirements. As Curtis noted with regard to typing text versus manipulation of graphical interfaces, text-based interaction is able to succeed on his "metric of believable detail per unit of effort expended" [4].

Further, in contrast to video and audio connections, the fact that one actually cannot see or hear what is *really* going on in others' offices offers a significant advantage to the MUD. The impression a participant wants to share with others is *determined by that participant* and not by the physical or audible context. The MUD offers cognitive co-presence but not physical or visual co-presence.

In addition, the seamless move between synchronous and asynchronous communication lets one interact with another whether or not both are present, and at the convenience of each. Messages can be left in a place where one knows another will be. Chris states:

> Unlike e-mail, it's real-time in that if I'm paying attention to it and the other person pokes me, we can talk back and forth. But, unlike in person or face-to-face, if I don't want to pay attention to it, I don't have to. If someone walks into my office, I can't sit here and ignore them while they're talking to me. I can on the MUD if that needs to be the case. But, unlike e-mail, because you have that real-time and because MUD is not just like an IRC client, it's not just named text, because you can actually -- it's just more expressive because you can actually simulate actions.

However, these factors that make WFG so powerful also lead to problems. One particular issue poses challenging design issues for such a tool. This is in part as a result of the increasing numbers of MUDders in this distributed MUD community, and can be characterized as the clash between availability and privacy in such an online environment.

Availability and Privacy

One of the big benefits of WFG is that one can almost always find someone they need there. In fact, it requires a critical mass to make such a tool "work". However, now that WFG is a mature environment in the working life, the ease of access to MUD rooms and thus to others' conversations has led to problems. Firstly, administrators can quickly become overburdened with queries. This phenomenon has been noted also for those involved in "work" in social MUDS [4]. Secondly, people find themselves unable to have quick exchanges with a restricted audience. For example, with easy access to all rooms, individuals from other groups

[5] Jay's House is a social MOO.

often 'drop by' and 'hang out'. Given this situation occurs and sometimes conversations can be sensitive or misconstrued when taken out of context, how do you ask someone to leave a team room when the discussion turns to more sensitive topics. Further, drop-in conversants can mean difficulty in keeping conversations focused. There is a clear tension between the advantages of openness and accessibility that WFG provides and the fact that information needs to be presented in appropriate ways for different audiences.

One of our interviewees stated that the use of WFG to type comments means they "communicate as if we were all sitting in the same room typing on computers, as if when I type to someone I'm talking to them, you tend to discuss things the same way you would face-to-face". The problem is, in contrast to physical spaces where it is obvious when someone is present, in a MUD room, someone could be "lurking" and privy to all conversation in the room. This is akin to the room being "bugged".

One resolution is to create a private, "locked" room for group discussions, a decision that has political import and negative impact. This may result in reducing the easy availability that is so much a feature of the MUD in its current formation. Further, if users are required instead to monitor both a public and a private room, then the work overhead becomes an issue. This need for privacy manifested itself in a number of ways, including an increase in private project rooms, greater amounts of whispering and considerable discussion about access to rooms. Of particular interest is the clash between the requirements for privacy and the original philosophy of the more social MUDs where such constraints are not considered acceptable. The different rooms are indications of the evolution of different work worlds in this virtual domain. However, unlike other tools that are aimed at supporting teams, the boundaries between different projects domains are not fixed. Thus as a user I can roam into your project domain should I wish to and sit in on your conversations. The model here is of open plan offices and total access, in contrast to closed doors and separate offices or buildings.

The issue of availability versus privacy remains open at this time, with no obvious solution readily available. As one of our interviewees put it, it is a "balancing of advantages versus disadvantages, because there have been times when it's been very advantageous that this person hangs out here."

CONCLUSIONS AND FURTHER WORK

In this paper we have presented observations from our second interview study at Argonne National Laboratory where a text-based MUD has been operational for over 5 years. Our first interview study took place over 2.5 years ago [2]. Perhaps the single most notable observation from this recent study is that the MUD continues to play a long-term central role in the activities of members of the division and their collaborators. This stands in contrast to many other communication tools that have been deployed [10]. Further, the fact that the MUD remains so representationally simple and yet still supports sufficient cognitive and social co-presence to maintain close working relationships flies in the face of many theories of media richness. In this instance perceptual presence cues are not a prerequisite for *cognitive* and *social* presence.

We believe that the Waterfall Glen success is due not to the fact that the MUD provides an environment for interactions. Rather, it provides the infrastructure for support of multiple social groupings and social interactions, and the easy continuance of relationships, wherever people are physically located and without necessitating conscious effort when no apparent reason exists. MUDers know they will see each other in the MUD at some point soon so they don't need to make a special, explicit effort to keep in touch. The fact that any computer and any client can offer access to a virtual space shared with colleagues is a clear bonus.

The representational simplicity also means that considerably less screen space *has* to be dedicated to the MUD window(s). The MUD does not try to replace familiar tools and practices but simply to complement them. We saw no evidence that more visually sophisticated clients were desired by our interviewees, the programmable aspects of the MUD are used by few people except in regard to the creation of new MUD rooms. Possibilities for integrating the MUD with other communication tools (e.g. pagers) were discussed but, again, were not generally available or desired at this point.

Before concluding this paper, we wish to offer a compelling illustration that the MUD supports sufficient co-presence to enable complex collaborative problem solving in difficult circumstances. This was the incidence of a hacker attempting to break into one of the machines. On discovery of the attempted break-in, three systems administrators were working together.

> Well, when we started out, we were all working in the machine room side by side. I mean, we were in various places. Physically we were all sitting side by side, but we got to a point where it's like okay, now we have at least minimal control over this and it's getting late and, you know, let's go somewhere else. So I think [my colleague] went to his office. I went to my office first then later on home. One of the other guys went home. And I mean, it was basically we used the MUD as if we were still sitting side by side. So, when we'd find something, we'd paste it in, or have you checked here, have you checked there.

The three of them continued working together even though they had moved physically apart. They worked in a quiet MUD room so as not to be disturbed by others. One person had a presence (a character) in this room and another character in the general Systems room. In the Systems room he kept interested parties informed about their progress by typing updates and answering questions. This kept the problem solving room free from extraneous chat whilst keeping communication open with the 'outside world'. By pasting things into the MUD window they were able to share test output even though they were 25 miles apart.

This anecdote illustrates how the MUD aids flexible contact between people and supports work activities. Sufficient co-presence is established for work collaborations to be maintained in a single virtual place that is ubiquitous and persistent even when people's physical locations are changing. Whilst there is clearly truth in the fact that impoverished cues can hinder communication, it is also the case that communication does not always require the richness of face-to-face interactions. It is also not always the case that few cues and a lack of multimodality equals an unsuccessful communication product. An interesting issue is to determine when and under what conditions these relatively impoverished communication tools are perfectly sufficient, and when higher bandwidth visually rich environments are necessary for establishing a feeling of co-presence and getting the job done.

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