

# Access Grid Environments as Spaces of Mixed Spatial Interaction

*The Third International Conference on e-Social Science*

*October 7-9, 2007, Ann Arbor, Michigan, US*

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**Abstract.** Using Actor Network Theory, the paper investigates the relationships between people and technology and the way these relationships construct social spaces in Access Grid (AG) environments. This investigation challenges prevalent perceptions about the dominance of technology in driving innovative research practices, and proposes a cyclic relationship between people, the technology and other artefacts used in the course of AG sessions. The paper highlights the various elements comprising AG communications, and finds that these generate a unique setting of mixed spatial environments in which the physical and the virtual coincide as if residing in the same space to create an almost seamless flow of interactions and exchanges. However, the paper -shows that the seamlessness is occasionally disrupted by a 'virtual divide' generated sometimes by technology, the people, or the interactions between people and artefacts such as cameras, microphones, or furniture. The paper outlines a process which identifies assemblages of factors conducive to the creation of mediated collaborative research environments and the construction of globally accessible spaces of collaborative knowledge creation.

## Introduction

Toffler (1990) argues that the Knowledge Economy introduces a paradigm change in the way manufacturing processes are perceived, accentuating the interdependencies of the production process rather than celebrating its distinct phases as occurred in the industrial era. This paradigm shift heralded a growing demand for teamwork and collaboration across expertise. Moreover, Roger and Geisler (1997) found a growing complexity in the products, projects, and services offered in today's knowledge driven economy, hence further necessitating collaborative activity between and across disciplines incorporating specialists to create multidisciplinary and cross disciplinary teams of research and development. This growing need for collaboration highlighted a requirement for researchers to communicate with colleagues based at various institutions on a national and international level. The geographical dispersion of research teams resulted in what Wainfan & Davis (2004) refer to as the increase in virtual collaborative activities. This increase in virtual collaboration implies a growing dependency on electronically mediated rather than face-to-face (F2F) collaboration. This dependency is becoming increasingly important in the New Zealand context, because the country's geographic remoteness from the major centres of research threatens to disadvantage researchers in their ability to collaborate and share resources with

colleagues, and compete as equal partners in the global knowledge economy. Successive New Zealand governments acknowledge that for the country to resume its position in the top half of the OECD (Lewis & Thorns, 2005; NZGovt, 2005; Oxley & Thorns, 2007), it needs to enhance its ICT infrastructure and implement powerful technologies such as Advanced Network and the Access Grid to support its scientific research activities. The recently<sup>1</sup> launched high-speed internet connection KAREN<sup>2</sup> links all of the country's universities and Crown Research Institutes enabling international connections to academic and research institutions across the US and Europe offering a more robust infrastructure for interactions.

The paper recognises the potential of virtual collaboration to trigger changes in the current research arena; however, it proposes to challenge a common assertion (Castells, 1996; Hine, 2003; Jarvie, 2004, 2005; Machlup, 1962) which argues for the dominance of the technology in driving research innovation and changes in practice. Adopting a Latourian (Latour, 1999, 2005) approach the paper suggests that if indeed changes are occurring they are made possible through constant cyclic movement among researchers, between them and technology, and the interdependent assemblages these cyclic movements create. The paper investigates virtual interactions facilitated by Access Grid (AG) infrastructure and outlines a process which identifies assemblages conducive to the creation of collaborative globally accessible mediated knowledge creation spaces

Collaboration is about '*working together*', sharing a mutual space in which people and associated technologies are present and in the presence of others, all of which requires an ability to communicate. Prevalent perceptions about face-to-face (F2F) interactions suggest that they provide the richest and most effective medium for communication, providing verbal and non verbal cues (Billingshurst & Kato, 1999; Daft & Lengel, 1986; Daft & Wiginton, 1979), while at the same time creating a sense of 'being there' in each other presence, sharing a space (Goffman, 1963; Heeter, 1992; Schroeder, 2006). The paper attempts to establish whether the interdependencies of assemblages interrelating in cyclic movement among researchers interacting with, and through the AG infrastructure provide circumstances similar to F2F communication and hence hold the potential to facilitate collaboration, in a way that will go beyond fast and robust transfer of data, to facilitate the creation of new knowledge. As social scientists investigating the emergence of collaborative practices conducted in technologically mediated environment, we choose to engage in reiterative discursive analysis of processes emerging in the constantly evolving assembling and disassembling cycles of socio- technical interactions comprising our data.

Our data consists of the deconstructed elements of AG spaces, through which we search and investigate similarities between F2F and technologically mediated contexts. The investigation is formed around three key criteria. The first is the richness of communicative features relayed throughout the AG medium. The second is the sense of presence, co-presence created through interactions between human participants and interdependencies between humans, technology, and other artefacts in AG environments. The third is the sense of shared social space in the mixed spatial AG environment where physical and virtual are blurred.

## Scope of Study

The paper summarises a pilot study of 17 AG sessions conducted between the second half of 2006 and the first half of 2007, and also provides a preliminary look at the first phase of a

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<sup>1</sup> February 2007

<sup>2</sup> KAREN- Kiwi Advanced Research and Education Network

two-year project funded by the BRCSS<sup>3</sup> Network, and REANZ<sup>4</sup> Capability Building Fund. The data comprising the studies described here consists of observations conducted during Access Grid sessions. The participants of the study included staff and postgraduate students attending virtual seminars broadcast via Access Grid across NZ universities, BRCSS network management meetings, collaborative teaching across two universities and a collaborative project debate involving various community representatives.

## Method of Study

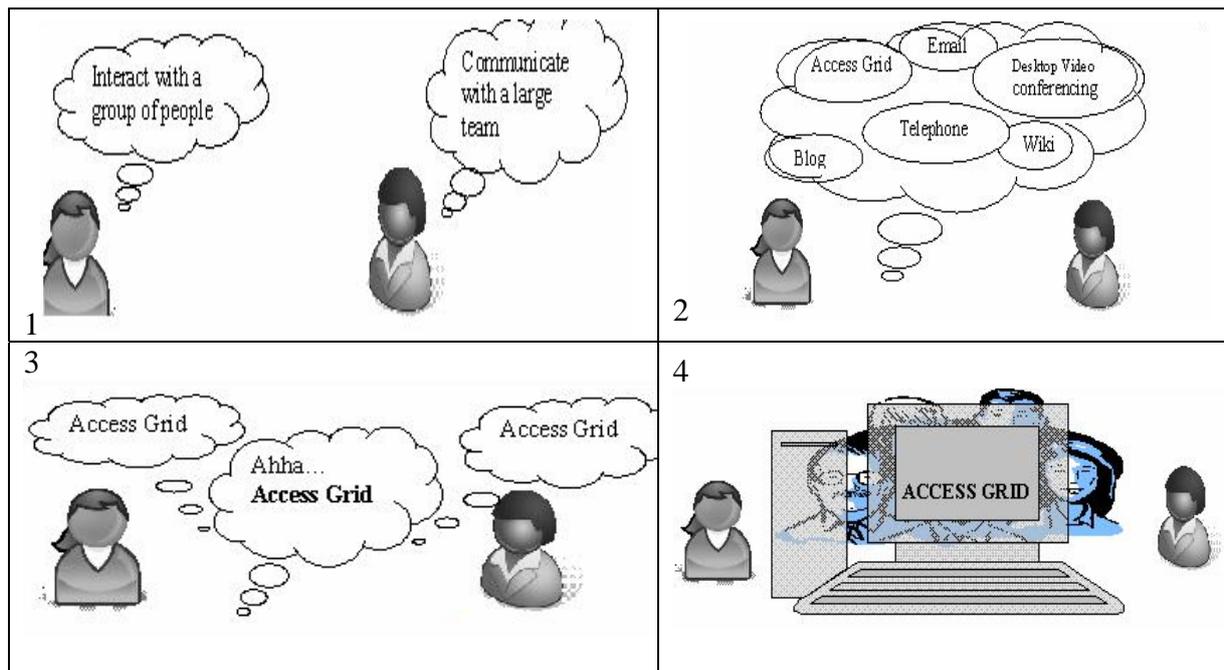
The method of study is ethnographic in the sense that the researchers collected data through participation and observation of Access Grid meetings. The data consists of manual annotation of Access Grid (AG) sessions, seminars and cross-site teaching sessions. Note taking, was the only option for recording and documenting due to two major technical setbacks. First, the bandwidth available to us prior to the implementation of KAREN in February 2007 could not support any type of recording, archiving, or the operation of computer based annotating middleware. Only when KAREN's robust bandwidth became available, were we able to begin exploring recording and annotating tools. Having evaluated a number of options we have discovered a gap between the tools available, and our research needs. We are currently attempting to develop our own set of tools with the help of our project partners from HIT Lab NZ. The technical restraints limited the amount of information we were able to obtain. The manual note taking consisting of text alone could not capture or fully represent aspects such as body language and facial cues. Therefore, the study primarily focuses on aspects that could be noted down manually in real time observation.

## Relationships - People and Technology

Geographically dispersed interlocutors need technological mediators that enable communication. However, the presence of the technology itself does not insure communication, it is up to the human agent to utilise the technology and initiate communication and interaction with another human. This creates a relation of interdependency between human and non-human. Establishing a communication link facilitates interactions, the nature of which will be determined through the interdependency between the human agent and the technology, as well as through the purposes, intentions, motivation, and goals the human participants aim to achieve by choosing to use a certain technology. The storyboard in *Figure 1* illustrates some of the processes that occur in the interaction between people, their intentions and their choice of technology as they seek to communicate across distance using an AG as the connecting medium.

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<sup>3</sup> Building Research Capabilities in the Social Sciences  
<sup>4</sup> Research & Education Advanced Network NZ Ltd



**Figure 1. Media Selection**

While this choice facilitated the goal of linking a large group, it also contributed to the nature of the communication resulting from the features and structure of the technology. This interdependent relationship highlights a cyclic movement between the actors and systems or structures surrounding them, creating a reciprocal rather than dichotomous or hierarchical relation in which one party is perceived as dictating the roles and interplays among communicating human and non-human members (Latour, 1999). Latour's Actor Network Theory (ANT) enables a systematic recording of the world-building abilities, and procedures which render actors, (human and non-human) the ability to negotiate their ways through one another's activity. This approach allows us to investigate the practices applied in the Access Grid environment without the constraints of fixed roles allocated to either the technology or the participants, and opens the way for us to establish how, and in what ways collaborating through technology may be changing practices of human interaction, perception of, and relationships with the technology. In this approach the participants in the relationship, human and non human alike are called *actants*. These according to Latour (1987) are not simply characters in a story, but an integral structural element upon which the narrative revolves.

## Collaborating at a Distance

Communication between people is an essential prerequisite for facilitating any form of sharing and collaborative activities. Physical proximity allows people to engage in F2F interactions, which provide the highest richness of information, divulging what Mehrabian (1971) called the "3 Vs" ( Verbal, Vocal, and Visual). Furthermore, people participating in a F2F situation experience what Heeter (1992) refers to as '*presence*' a feeling of '*being there*' and '*co-presence*' a sense of 'being there together' (Goffman, 1963; Schroeder, 2006). These notions entail a sense of being aware of each others actions, of coming together, and being 'somewhere', in a common space.

Access Grid (AG) is a collection of resources put together for the purpose of supporting human collaboration across the Grid<sup>5</sup>. Because the Access Grid is based on the Grid infrastructure it has the potential to allow for sharing dimensions that were not available using internet technology. Furthermore, AG technology is presumed to overcome the lack of presence, and co-presence associated with other virtual communication modes, (Fielding & Macintyre, 2006), and so contributes to providing a near real face-to-face experience, in which people can experience *'being there'* in a shared space. In this paper we examine the ways in which interactions in AG environments explore the potential embedded in the technology, and the ways in which the various *actants* interact and construct socio technical, communicative narratives.

## Mediated Shared Spaces

A project called “Dancing beyond Boundaries”(Oliverio, Quay, & Walz, 2001) used Access Grid to connect dancers, choreographers, musicians, and engineers across North and South America, and collaboratively create a dance piece while being separated by thousands of miles. The artists from different spaces created original music and dance as though they were sharing the same physical space. Video captures of music and dance were simultaneously transmitted to all four collaborating locations. One could argue that the collaborative piece was created in the interconnection between the four physical locations and that this connectivity created a ‘fifth place’, a virtual space (Oliverio et al., 2001). Mediated spaces challenge our perception of *space* as being a physical entity. “Dancing Beyond Boundaries” created a fluent continuum between physical spaces to create something that is beyond them, reflecting the physical, yet residing in the interconnection between them.

Blurred boundaries between the physical and the virtual is referred to as *mixed reality* (Florins, Trevisan, & J., 2005), where the ‘real’ may include video display of physical objects, whereas the *'virtual'* has no existence in the physical world, and is computer generated (Milgram & Kishino, 1994). ‘Dancing Beyond Boundaries’ created a sense of “*same space flow*”, between the physical spaces and their representations by creating a *virtual space* in the interconnections between the physical spaces. We suggest that the Access Grid calls for a redefinition of the ‘virtual’ to include the video displays representing the physical world, and refer to AG environments as *'mixed spatial environments'*. The creation of ‘space’ in the interconnections denotes *'space'* as a socially constructed entity (McGregor, 2004), with social processes influencing the structure of space (Castells, 1996; Francke & Ham, 2006). Allan (2005) argues that *'space'* is not only created through interactions, but that their dynamics define the nature of the *'space'*. Using visualisation technologies Allan was able to study visual representations of the dynamics of interactions. Her study found that chain like interactions illustrated negotiations and mutual meaning making processes implying collaborative activities.

## Findings and Analysis

### Simulating Face to Face Interactions- The Media Richness of Access Grid

In our observations we attempted to investigate whether the social spaces created through the Access Grid convey the media richness entailed in face-to-face (F2F) interactions. In order to

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<sup>5</sup> The Grid – a computing and data management infrastructure that provides electronic underpinning for a global society in all walks of life. Grids integrate networking, communication, computation and information to provide a virtual platform for computation and data management in the same way that the internet integrates resources to form a virtual platform for information (Berman, Fox, & Hey, 2003) ( p.9)

do so we listed the features involved in F2F as well as those comprising mediated interactions. The F2F features included: physical proximity, posture, orientation, language and speech, patterns of looking at the other (Gaze) bodily movement; facial expression (Argyle & Kendon, 1967). Access grid mediated interactions included: images of F2F interactions; camera movement; microphone/s, furniture in the AG/VC facility, room décor, and group size. *Table I* illustrates how features of face-to-face were translated to the mediated environment. The table notes the interaction between people, the technology, and various artefacts present in AG environments, and the ways in which the use of these indicated the construction of social status and roles.

**Table I-from physical to virtual**

	Face –to- face	Mediated (Mixed Spatial) Reality	
		<i>Physical</i>	<i>Virtual</i>
Physical proximity	Distance between self and others Choice of seating arrangement	Choice of seating arrangement, use of furniture i.e. high/low tables, distance	Choice of distance from microphone and camera distance in virtual
Posture-revealing status and hierarchy	Relaxed posture=higher status Formal sitting= lower status (Goffman in Argyle and Kendon, 1967)	Similar to F2F Choice of furniture- higher status – coffee table lower status – desks	Choice of prominence of positioning in front of camera
Orientation	Angle in which people relate to each other, and also positioning the furniture they are using	Angle in which people position themselves in relation to people in the room	Positioning in relation to visual images of people in other nodes
Gaze	Looking at each other – a social act Seeing each other offers important information about one another	Gazing at other people in the physical node	Gazing at the camera transmits one’s gaze to the mediated environment, creating sometimes unintentional ‘meeting of the eyes’

Because of the inability to record, we are only referring to these aspects and have left out the features of language and speech, bodily movement, and facial expressions.

Communication in the virtual, as in the physical is reliant on the ability to see and hear each other. The means of achieving this differs between the physical and virtual, the former requiring an assemblage made of only the F2F features, whereas the latter requires a double layered assemblage of both F2F and mediated features. We propose that the physical assemblage reflects social interactions, whereas the virtual assemblage reflects socio-technical interactions.

### Access Grid technology for creating a sense of presence, co-presence

When investigating the ability of Access Grid environments to provide a sense of presence and co-presence, the observations followed Heeter’s (1992) approach which suggested that there are three different types of presence: personal presence- the extent to which a person feels part of the environment; Social presence- the extent to which others (human and non-human) exist in the environment; Environmental presence – the extent to which the environment acknowledges and interacts with the participants. *Table II* illustrates how presence was played out in AG sessions

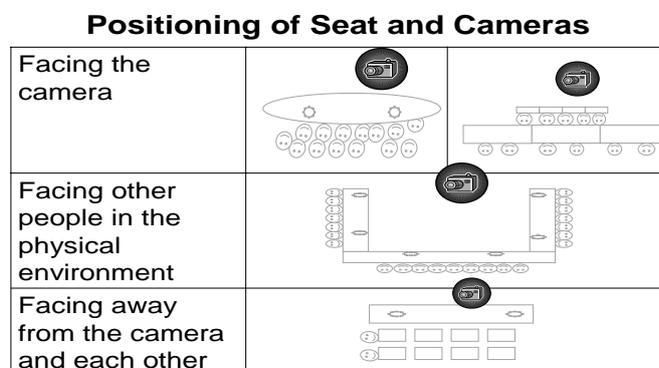
**Table II presence**

Type of Presence	Presence in AG Sessions
<i>Personal presence</i> - the extent to which a person feels part of the environment	Visual image of self - when local node's image was projected people felt part of the environment. When image was not projected participants noted that they felt excluded
<i>Social presence</i> the extent to which others (human and non-human) exist in the environment. Sometimes referred to as <i>co-presence</i> , a situation in which participants experience a mutual awareness of each other through interaction. Both <i>social presence</i> , and <i>co-presence</i> describe a situation of <i>being present</i> , in an environment which includes another, as ' <i>being there together</i> '(Rettie, 2005; Schroeder, 2006). -	<p>1)When microphones were muted people perceived the social presence to be that of their physical /local space</p> <p>1a) Muting of microphones was perceived by participants as a way of becoming 'invisible' and became unaware of the effect their body language and facial expressions may have on people sitting in other nodes</p> <p>2) Some presenters used the muting of microphones for creating a local social presence, working in local groups</p> <p>3) when self image was not available, some very informal behaviour appeared, i.e. yawning, or leaving the room with no reference to the projected nodes, frequent attention to person present in the room but invisible to the camera for example participator talking to node operator sitting off range of camera</p>
<i>Environmental presence</i> – the extent to which the environment acknowledges and interacts with the participants	<p>1) The introduction of the participants of each node to the other nodes created an environmental presence.</p> <p>Example: On occasions where one node was active and the rest were invited to listen in, no introductions were made, as if obscuring the environment surrounding the active node.</p> <p>2)Control over camera when given to chair person – camera movement acknowledged changes in the session and was made to respond accordingly</p>

## Social spaces created in Access Grid

Our observations revealed that the interactions among people and between human and non-human artefacts created spaces in which physical entities such as furniture and cameras, became *actants* in the communicative activities among people, and so contributed to the creation of social spaces embedded in the physical. The positioning of furniture, as showing in *Figure 2* created and narrated the forms for interaction among the people sitting in the physical node, those located at remote nodes represented through video images on the screens, and the interactions between the physical nodes and their video representations.

### Constructing the physical



**Figure 2. positioning**

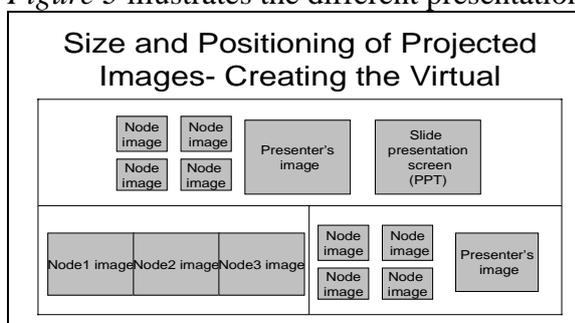
Different nodes used their physical space in different ways, positioning the furniture and the cameras in different arrangements. Furthermore, local institutional decisions and space

allocation also affected the way rooms were organised. Some institutions allocated an exclusive space for the use of Access Grid, whereas others opted for a multipurpose space that was used when required. These different physical features seem to have contributed to the ways in which participants through their interactions constructed social spaces. These findings corroborate Hall's(1963) findings, suggesting that the distance between people, their *Proxemic Behaviour*, reveals how people unconsciously structure micro spaces and construct hierarchies and levels of involvement. We argue that in mediated spaces, proxemic behaviour should be extended to the use of non human artefacts, and suggest that proximity to camera and microphones- reveal high level of hierarchy and involvement – for example, choosing to sit at the low table, positioned closer to the camera and microphones, and exposing full body rather than showing head and shoulder. These tables were chosen by people who expressed confidence throughout their interactions. They talked mostly addressing the screens (which include their own image), sometimes turning to the back to respond to people in the physical room. They were relaxed and exhibited informal, sometimes humoristic behaviour. In F2F situation this is interpreted as expressions of higher status. Having a large table at the AG room meant that only a single facet of it could be used without blocking the camera. When larger groups participated in nodes with a single large table, participants sat in multiple rows of chairs stacked one behind the other aligned with the single table facet facing the camera. This resulted in the exclusion of back rows from access to microphones and diminished their visual presence, hence diminishing their social presence. The horse shoe model created a wide exposed space in which even a large group could enjoy access to microphones and the cameras, and good visual connection with others in the physical space. Low levels of involvement were apparent in the proxemic behaviour of people who chose to shy away from the camera or the microphones, and sat far away from the microphones and out of the cameras range.

### Constructing the Virtual

Projecting different size images as showing in *Figure 3* narrated the direction of gaze and attention of the participants, and contributed to the structuring of the 'virtual' and the discourses it spawned. In some cases the presenter's image was enlarged, in other cases the presentation screen was enlarged alongside that of the presenter's. However, in other cases all screens representing each of the nodes were projected as adjacent one size screens. This created a feeling of standardisation of all the different nodes, merging them into an equalised single rather than fragmented virtual space, and creating a "same space flow" merging the different nodes. However, this model did not allow for distinguishing the current active speakers.

*Figure 3* illustrates the different presentations.



**Figure 3** positioning images

## Constructing Mixed Spatial Environments

The screen images not only construct the virtual, but also affect the interactions in the physical spaces, by focusing attention on different spaces and elements in the virtual. This cyclic momentum reiterates the construction of a mixed *spatial environment*, in which the virtual and the physical interrelate affecting the structures and dynamics of each other. This blurring of the boundaries created a need for people to feel co-presence in the virtual as well as in the physical. Seeing one's self is not something required in a F2F situation, however, to be included in this mixed and constantly flowing spatial environment, people expressed a need for a visual projection of themselves so as to experience embodied inclusion in the cyclic construction of the mixed spaces. In cases where no self image was projected, participants tended to lean towards the microphone as though funnelling their intention to the 'other reality'. Muting the microphones resulted in segregation of the different physical localities and disrupted the flow spaces. Furthermore the lack of self image diminished the feeling of co-presence, and participants expressed feelings of exclusion.

## Mixed Spatial Environments- Beyond the Technology

Our findings show, that the positioning of an interaction in the virtual or the local was not solely created by technology or geographic location, but was at times constructed through social dynamics. When people knew each other prior to the mediated encounter, a sense of mutual locality was created in the interconnection between spaces, to create something which is not embodied in any physical or virtual node, but in the minds of the participants. These instances occurred in events:

- When a group at one node spotted a colleague sitting at another node. This prior acquaintance formed a short informal hearty alliance. This alliance generated an atmosphere different to the one expressed by the rest of the participants
- When a physical meeting of participants from different geographical locations occurred the night previous to the Access Grid session. This prior meeting consolidated an inter- nodal group comprised of members from multiple physical locations which formed an alliance situated temporarily in a single physical location. The overnight links seem to have shadowed the connection with the originating geographical nodes. However, a note of caution should be made here. The inter nodal group was the largest in relation to other nodes, this in itself may have created a critical mass
- Locality was also created through the interactions with non human artefacts. Using printed hard copies of emails circulated prior to the Access Grid meeting created localities in the sense that people referred to their hard copy paper held in their hands, however, at the same time the local hard copy is an embodiment of a virtual communication through the email further virtualised by the discussions it triggers around the various AG nodes

Node operators, although obscured from the event happening in the forefront of the AG session are a crucial component in the system of interdependencies as they are the ones enabling the smooth running of the session. However, their involvement could be seen as residing in an adjacent cycle to the one involving all the other participants. Node operators maintained communication channels with their counterparts in other nodes, to ensure smooth running and solve problems. This connection created an additional space which is embedded in the physical and related to the technical infrastructure, while at the same time operating in an inter- nodal space.

## The creation of collaborative spaces of knowledge – a social dynamic process

Allan's (2005) study discovered a way of investigating the nature of Web Based interactions by identifying archetypes of visual patterns charted through communication exchanges. The study found that *Chain* like patterns of interactions indicate the existence of negotiation and mutual meaning making processes, *Star* shaped interactions indicated the exchange of structured or distinctly defined body of information, such as for example, the scheduled time of a meeting, or an exact location of an event. Identifying such dynamics would prove valuable in this current project, however, we needed a tool which will enable annotation and visualisation of interactions in AG environments. Our initial search for such a tool led us to the Memetic project developed by NCESS in the UK. The UK team collaborated with us in an attempt to solve the problems encountered when attempting to install the UK configured software to our NZ system. After long weeks of international collaboration and mutual attempts to solve the configuration problems we were able to install the Memetic software, only to find that it will not serve our purposes. In consultation with our project partners from HIT Lab NZ we have now decided to develop a suit of tools that will answer our investigative needs. The suit will include video streaming, capturing, annotating, and visualising tools, which will operate in seamless synchronisation. We are now in the process of developing the necessary tools.

## Conclusions

In this paper we set out to find whether Access Grid (AG) technologies facilitate a communicative environment that will simulate the richness of information conveyed in F2F interactions, and provide participants with not only verbal and non verbal cues but also with the experience of presence and co presence in a mutual space. Our findings outline the ability of the AG technology to provide information richness and support an almost true to life F2F experience in which participants use the microphones and cameras as ears and eyes. However, we would argue that this use of the technology is not a mere extension of human's physical abilities the way McLuhan (1964) may have concluded, but has created a complex system of interactions not only between humans, but between humans, artefacts and technology. These interactions create social structures which operate in blurred realities of physical and virtual spaces. Furthermore, these interactions create spaces which are not physical or virtual but exist in the interconnections between the real, the virtual, and the experienced. Furthermore, the interactions between human and non human *actants* created interdependencies. Whenever these were compromised, the system broke down. However, we would like to suggest that these breakdowns were not confined to the technology but that within the different spaces and the blurred mixed spatial reality lurks a '*virtual divide*', obstructing the seamless flow between the physical and the projected virtual. This virtual divide is a product of technological problems which are yet to be solved, but also emanate from our present limited perception of the possibilities and practices enabled by the new technological environment, and the collaborative potential these mixed spatial spaces offer. We anticipate that the new suit of tools we are currently developing will provide us with better understanding of the practices conducive for collaboration, and so enable us to facilitate the building of such capabilities in the research community in NZ and aboard.

The Latourian (Latour, 1999, 2005) approach guiding our study allowed us to view the complexities and interdependencies between humans, technologies, physical locations, and virtual embodiments in which '*actants*' and structures are engaged in a constant cyclic movement of acting and being acted upon. This notion dismisses any unilateral supremacy of any of the parties involved and challenges technological deterministic approaches. Looking

at the use of technology in this way heralds a new horizon for social science research, which looks beyond the study of the use of technology, to explore socio-technical interactions and the creation of socio-technical structures located at the interconnections between human and non human agency, and between physical and the virtual.

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