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Reconsidering the Virtual Workplace: Flexible Support for Collaborative Activity

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Abstract: Despite the substantial corpus of research concerned with the design and development of media space, the virtual workplace has failed to achieve its early promise. In this paper, we suggest that a number of problems which have arisen with the design and deployment of media space, derive from their impoverished concept of collaborative work. Drawing from our own studies of video connectivity, coupled with analyses of work and interaction in real-world settings, we consider ways in which we might reconfigure media space in order to provide more satisfactory support for collaboration in organisational environments

> [The future of the telephone will mean]...nothing less than a reorganisation of society — a state of things in which every individual, however secluded, will have at call every other individual in the community, to the saving of no end of social and business complications, of needless goings to and fro, of disappointments, delays, and a countless host of great and little evils and annoyances which go so far under present conditions to make life laborious and unsatisfactory. (Scientific American, 1880 p.16)

> That's a funny kind of thing, in which each new object becomes the occasion for seeing again what we see anywhere; seeing people's nastinesses or goodnesses and all the rest, when they do this initially technical job of talking over the phone. The technical apparatus is, then, being made at home with the rest of our world. And that's a thing that's routinely being done, and it's the source for the failures of technocratic dreams that if only we introduced some fantastic new communication machine the world will be transformed. Where what happens is that the object is made at home in the world that has whatever organisation it already has.
> (Sacks, 1972 [1992] p. 548)

1. Introduction

In recent years we have witnessed the emergence of a growing body of research concerned with 'media space'. Both in Europe and North America, a number of laboratories have established audio-visual and computing networks which allowed individuals in distinct physical locations to communicate with each other both visually and vocally. So, for example, at PARC a video window was established which provided scientists with audio-visual access to a common area in a related laboratory in Portland (Olson and Bly, 1991). A similar videowindow facility was established at Bellcore (Fish, et al., 1990). Elsewhere, at EuroPARC in Cambridge, and at the University of Toronto, audio-visual infrastructures were developed which allowed individuals to scan and search various offices, form links colleagues based in other locations, and establish long term connections, often called 'office shares' (Gaver, et al., 1992; Mantei, et al., 1991).

In many cases these technologies were deployed in order to encourage informal communication between personnel and enhance collaborative work. It was hoped that these new technologies could go 'beyond being there' (Hollan and Stornetta, 1992). These various media spaces became increasingly sophisticated as additional facilities were added. For example, individuals were provided with the possibility of receiving multiple images of different domains so that could remain 'aware' of colleagues throughout the workplace, and, in some cases, auditory signals were added which could warn people of upcoming events and encounters (Dourish and Bly, 1992). Despite the extraordinary effort which has been directed towards research in media space, the energy and excitement seems to be on the wane, and we are still no nearer to actually deploying a usable and used media space within a 'real world' organisational environment.

In this paper we wish to suggest that the growing concern with media spaces to provide a 'working' environment derives from underlying assumptions or presuppositions concerning interaction and collaboration within the workplace. In particular, the principle concern in media space research with supporting (mediated) face-to-face communication, has inadvertently undermined its ability to reliably support collaborative work. Our growing recognition of the shortcomings of media space and the need to rethink the domain it aims to support, derives from a wide range of research concerning the nature of collaborative work. This includes:

- Naturalistic observations of the use of a media space (EuroPARC's in-house system; Heath and Luff, 1992b).
- Naturalistic studies of work, interaction, and technology in a range of organisational settings (Greatbatch, et al., 1993; Heath and Luff, 1992a; Heath, et al., 1995; Luff and Heath, 1993).
- Experimental studies aimed at extending the design of media spaces by providing multiple views of the remote space (Gaver, et al., 1993; Heath, et al., in press).

By drawing on this work, and the work of others, we consider the problems with the ways media spaces are currently conceived and configured. In considering these problems, we focus on the prevalence of the face-to-face view as the basis for most existing systems. Finally, we briefly consider an alternative conception of collaborative work and outline its implications for media space technologies.

2. The Informal Turn

With the best of intentions, one of the motivations which drove the development of media space within a number of laboratories derived from the growing recognition that the informal organisation of the workplace was an important if not critical aspect of collaborative work. It was argued in particular that 'informal sociability', passing conversations and the like provided the gel to the organisation, and the means through which decisions are made and work gets done. In the scientific domain it was suggested that some of the most innovative ideas and work derived from informal conversations which happened to arise around the work place, often in areas such as lunch rooms, coffee lounges or common rooms (cf. Fish, et al., 1990; Kraut, et al., 1990). At EuroPARC, for example, where the office building straddles three floors and inevitably reduces the possibility for informal contact between particular scientists, it was felt that an audio-visual infrastructure could provide a virtual environment which allows personnel to be 'aware' of each other, and provided opportunities for 'unmotivated encounters'; that is chance meetings and conversations. At EuroPARC, various devices were built into the media space to facilitate awareness and informal contact, whilst of course being careful to preserve a sense of privacy amongst the personnel. A similar emphasis on 'informal sociability' permeated the development of other media spaces, not surprisingly at PARC, but also at Bellcore, the University of Toronto, and to a lesser extent perhaps at Hewlett Packard (UK) (Abel, 1990; Gale, 1994; Gaver, et al., 1992; Kraut, et al., 1990; Mantei, et al., 1991).

It was an inspired and sophisticated decision to deploy a technology within the workplace to support the informal rather than formal organisation. At EuroPARC, individuals were provided with cameras and monitors in their offices and within public domains which, through a complex computing infrastructure, supported awareness, context, and conversation. It was assumed correctly, that most users would simply place the camera and monitor on their desk close to their workstation, and thereby be able to see and establish contact with colleagues. At EuroPARC and elsewhere, it was largely taken for granted that the access that one would like of the other(s) was to see their face, their head and shoulders. In consequence, in almost in media spaces, it has become the practice to provide 'users' with a (mediated) face to face view of each other. In some cases, it was assumed that if users need an

alternative view, then they could negotiate a shift in the position of the camera and monitor and physically re-site the equipment.[1]

It is interesting to note that the location of camera and monitor in their respective domains were treated as largely unproblematic in most media spaces. Indeed, despite the emphasis on peripheral awareness and sensitivity, it was assumed that a head and shoulders view of the other would provide the relevant information. The forms of access that the user required once they had established contact was given less emphasis, so that, for example, the idea that another might be engaged in object focused task, like making notes on a paper pad, did not feature as important for the design. In part, this relative lack of concern with task-focused collaboration may have derived from the decision to support informal sociability where one would not properly assume it being relevant to provide access to the working domain and the wider environment of the person with whom one is conversing. It seems then, that the concern with providing support for sociability and (mediated) face-to-face communication throughout a variety of media spaces may help to explain why such sophisticated technological environments have largely failed to support individuals' access to each others activities and working domains.

It would be an exaggeration to suggest that the commitment to support sociability is solely responsible for the relative failure of media spaces. Nonetheless, it is the case that, despite the desire to engender new forms of human sociability, there is little evidence to suggest that media spaces, throughout the various organisational environments in which they have been deployed, have served to establish new interpersonal relations and relationships. Moreover, given the restricted access that they provide to users, the media spaces with which we are closely familiar have not generally provided an environment for collaborative work. Indeed, in the cases where individuals do, for example, try to write to paper together using the media space, or provide advice on the use of new software, the inability to see and share objects and shift ones views of each other domains causes frustration and difficulty for those involved. The evidence suggests that media spaces are instead used as a new form of communication for personnel in more 'formal' settings (e.g. in video-conferences), when they are already known to each other, or to demonstrate to others the nature of existing interpersonal relationships (Kantarijev and Harper, 1994). The technology therefore has served as a resource for those who already know each other, but rarely led to new forms of collaboration or 'sociability'.

There are, of course, some examples where media space has provided individuals with a useful environment in which talk to each other, share ideas and undertake collaboration. At EuroPARC for example, two scientists established an 'office share', an open video connection, through which they maintained contact, conversed and worked together (Dourish, et al., 1994). It is interesting to note that

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1 An interesting exception to this is Bill Buxton's 'fly-on-the wall' camera at the University of Toronto which is designed specifically for the purpose of glancing and is positioned above the office door.

an 'informal' set of practices emerged between the two scientists to enable them to cope with some the limitations of the technology. For example, they soon learned to differentiate looking at the camera to establish mutual gaze, as opposed to looking directly at the other in the monitor, so as to deal with the distortions that are necessarily introduced when a camera is placed above or to one side of the monitor. They also learned to cope with the problems which emerged when it only appeared that they may be alone, since part of each others' office were out of range of the respective cameras. In general however, at EuroPARC as with other media spaces, the infrastructure did not give rise to new forms of sociability or interpersonal relationship, and it was relatively rare for individuals to collaborate with each other in the virtual workplace.

3. Support for focused, collaborative work

Whilst media spaces are undeniably an innovative and exciting concept that have done much to advance the interconnection of audio-visual and computing technologies, they have largely provided 'users' with conventional (mediated) face to face views with which to work together. Indeed, even in the more sophisticated examples of media spaces, we find that users are provided with access to each other which does not differ significantly from the arrangements found with conventional video-phone and video-conferencing technologies. It is assumed, or presupposed, that single view is adequate and that the most important view of the other for a range of purposes, is a head and shoulder, face to face image. Most commercial video-phones and video-conferencing equipment, for example, provide this as the built-in view. It is assumed that if users wish to discuss any 'physical' object such as a document, then this can be adequately supported either by exchanging documentation prior to establishing video-mediated contact or by switching over to an alternative 'document view'. In such cases, participants necessarily lose sight of each other.

There are of course one or two important exceptions. These tend to be restricted to prototypes in research laboratories. For example a number of researchers have begun to provide users with shared work space as well as audio-visual link through which they can collaboratively work on text or diagrams (Olson, et al., 1990; Smith, et al., 1989). However, even in these more innovative cases, the audio-visual infrastructure is primarily designed to provide a face-to-face view rather than to allow participants to vary their access to each other with respect to ongoing demands of the tasks in which they are engaged.

Whilst it might be thought that in cases of focused collaborative work such as meetings, it is unnecessary to provide individuals with anything more than a head and shoulders view of each other, it is not at all clear that even in these relatively restricted and formally organised applications, that the conventional media space is satisfactory. For example, the remote participant(s) are often presented on a fairly

small monitor (14" or so). The image is perceived 'en bloc', and distorts our ability to discriminate the relative weighting of the other's conduct, so that for example, gestural activity and even major bodily rearrangements, pass unnoticed to the remote participant(s) (Heath and Luff, 1992b). Moreover, the image does not appear to provide participants with the ability to monitor the other on the periphery of their visual field, outside the direct line of their regard. They sometimes notice gross changes in the image, as when someone sits down or places a hand over the camera, but relatively small changes in the other's comportment, which subtly display changes in the ways in which they are participating in the activity at hand, pass unnoticed to the remote 'user'. These 'problems' are exacerbated by video configurations which preclude one participant seeing the other in relation to their activity or local environment, so that, for example, an individual's engagement in a document, or happenings within their office, are hidden to the remote participant. Focused collaboration, like other forms of interaction, rests upon people's ability to remain 'peripherally aware' of the other and to be sensitive to actions and events outside the direct like of their regard. Media space, and its predominant concern with providing (mediated) face to face views, undermines the ordinary resources upon which individuals rely in working together and coordinating their activities with each other.

Almost all media space therefore, like more conventional video-conferencing and video-phone facilities, provide 'users' with a restricted and severely delimited choice of views. The problem is not simply that media space tends to provide (mediated) face to face views, but rather that it is assumed that access between participants does not need to vary with respect to ongoing and shifting demands of a particular task or activity. It is this static and inflexible notion of collaborative activity which has inadvertently hindered media space research, and undermined its ability to provide a useful environment to enable people to work, or even socialise with each other. In consequence, it is difficult to imagine that current media space research constitutes the first brave steps towards 'beyond being there', rather people are provided with a poor and inadequate approximation of co-presence in which it is difficult to accomplish even the most simple collaborative tasks.

4. Working Together

Whilst there are significant technological constraints which currently shape the ways in which we might develop media space, we would like to suggest that many of the difficulties which arise with the deployment of current systems derive more from the assumptions which inform their design, than the limitations of the technology. It is not simply that we have misconceived the activities we are attempting to support, but rather that media space research has been informed by an impoverished conception of interaction and collaboration. This may be a consequence of conflating the organisation of informal conversation with the

demands and complexities of focused, cooperative work. Or it may be that we have sought a compromise between technical practicalities and the demands of collaboration. In any case, the inadequacies and limitations of offering a single and fixed, face-to-face view become even more apparent when we consider the organisation of collaborative work in more conventional, organisational environments.

We believe that examining the ways in which people ordinarily work together can direct our attention towards requirements for more satisfactory systems. This is not to suggest that the design of innovative systems should simply be based on the status quo, or be shaped to support current working practices, but rather that in developing new technologies we need to take into account the complexity of even the most mundane tasks, and the richness of the skills and competencies utilised by participants in doing what they do. A more thorough understanding of how people do what they do in organisational life, and in particular accomplishing collaborative work, can provide resources not only to evaluate our ideas and concepts, but to envisage more radical solutions to conventional problems.

In this light, alongside our research on media space, we undertook a series of interrelated, naturalistic studies concerned with the organisation of work, interaction and technology in a variety of organisational environments such as control rooms (Heath and Luff, 1992a), medical consultations (Greatbatch, et al., 1993), architectural practices (Luff and Heath, 1993) and news agencies (Heath, et al., 1995). Whilst the settings encompass a broad range of tasks and technologies, there are some findings which generalise. These can be summarised as follows:

- Cooperative work involves the ongoing and seamless transition between individual and collaborative tasks, where personnel are simultaneously participating in multiple, interrelated activities.
- An individual's ability to contribute to the activities of others and fulfil their own responsibilities relies upon peripheral awareness and monitoring; in this way information can be gleaned from the concurrent activities of others within the "local milieu", and actions and activities can be implicitly coordinated with the emergent tasks of others.
- Much of the interaction through which individuals, produce, interpret and coordinate actions and activities within co-present working environments is accomplished using various objects and artefacts, including paper and screen-based documents, telephones, and the like. The participants' activities are mediated and rendered visible through these objects and artefacts.
- Both focused and unfocused collaboration is largely accomplished not through direct face-to-face interaction, but through alignment towards the focal area of the activity, such as a document, where individuals coordinate their actions with others through peripheral monitoring of the others involvement in the activity "at hand". For example, much collaboration is undertaken side by side where the individuals are continuously sustaining a

shared focus on an aspect of a screen or paper-based document, such as a section of an architectural drawing.

- Collaborative work relies upon individuals subtly and continuously adjusting their access to each others' activities to enable them to establish and sustain differential forms of co-participation in the tasks "at hand".

These observations stand in marked contrast to the support that media space provides for collaborative work. It becomes increasingly apparent, when you examine work and collaboration in more conventional environments, that the inflexible and restrictive views characteristic of even the most sophisticated media spaces, provide impoverished settings in which to work together. This is not to suggest that media space research should simply attempt to 'replace' co-present working environments, such ambitions are way beyond our current thinking and capabilities. Rather, we can learn a great deal concerning the requirements for the virtual office by considering how people work together and collaborate in more conventional settings. A more rigorous understanding of more conventional collaborative work, can not only provide resources with which to recognise how, in building technologies we are (inadvertently) changing the ways in which people work together, but also with ways in which demarcate what needs to be supported and what can be left to one side (at least for time being). Such understanding might also help us deploy these advanced technologies.

5. Preliminary designs: the MTV Studies

Perhaps the most important lesson for the design of media space, drawn from studies of collaborative work in more conventional environments, is the ways in which participants utilise and rely upon their ability to continually shape their access to each other and the activities in which they are engaged. It is not simply that a face-to-face orientation is inappropriate for the accomplishment of certain types of cooperative task, but rather that face-to-face is just one amongst a variety of orientations that participants rely upon in working together.[2] In thinking, therefore, of developing a virtual environment to support collaborative work, it is necessary to explore ways of providing users not simply with alternative views of the other, their work space and their local environment, but with ways of flexibly and even 'seamlessly' varying their access to each other.

Actually building a media space that fulfils these requirements is not straightforward. It is not only difficult to provide individuals with flexible access to each other's, and their respective settings, but in so doing one can exacerbate problems which haunt even the most basic media space, namely the perspectival incongruities of the different participants. Nonetheless, we believe that it is only by

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2 Adopting an alternative orientation for video that focuses on the activity at hand may alleviate some problems associated with face-to-face views (Nardi, et al., 1993). However, such a proposal still restricts participants to a single view with no suggestions on how to implement more variable forms of accessibility.

building and evaluating technologies 'in use', no matter how simple, that the benefits and problems of alternative configurations can be uncovered.

In collaboration with our colleague Bill Gaver, our first attempts at reconfiguring media space began with a series of experiments at EuroPARC called the MTV (Multiple Target Video) experiments. The purpose of the experiments was to explore ways of offering users an expanded view of the remote space. We did this by wiring up two offices at EuroPARC to simulate what might happen in a distributed work situation.

In the first experiment (MTV I), we provided participants with an environment which offered four different views. These views consisted of: a conventional face-to-face view; a 'desktop' camera to focus on the details of any activities on the work surface; a wider 'in-context' view providing an image of the co-participant in relation to their work; and a "bird's eye" view giving access to the periphery of a colleague's environment (Figure 1). Participants were also given a single monitor to view their co-participant, and could change their view on the remote site by turning a simple rotary switch. Thus, each participant could select for display on their monitor only one view at a time, doing so by sometimes momentarily passing through other views. To give information concerning which view their colleague was connected to, each participant was also given a 'feedback monitor' showing which view one's co-participant had currently selected of them.

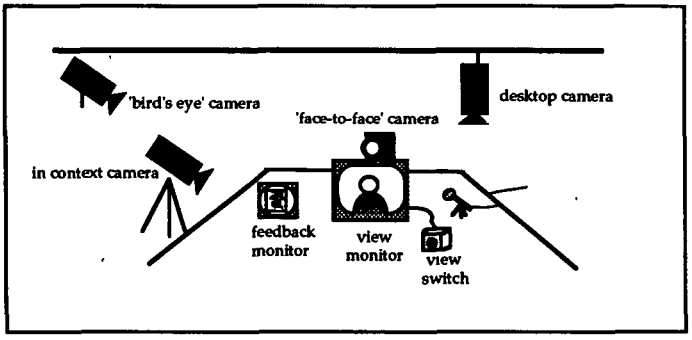

Figure 1. Configuration of the MTV I system using multiple cameras and a single monitor for each participant.

Pairs of users were asked to perform two experimental tasks. In the first, participants were each asked to draw the other's office. In the second, they were asked to carry out a collaborative design exercise where they had asymmetrical resources; one could manipulate a model to present possible solutions whilst the other drew the design. The results of these experiments, (described more fully in Gaver, et al., 1993), revealed how little the face-to-face view was used in the accomplishment of either task. Instead, participants mainly switched between the in-context, model, desk and bird's eye views. Given the nature of the design task it is perhaps not surprising that most participants who were doing the drawing focused on the view showing most details of the model. On the other hand, the

participants in the offices with the model appeared to utilise the in-context and bird's eye cameras for allowing them to assess their colleague's orientation and to make sense of particular aspects of visual conduct, for example, gestures pointing to objects. Finally, some participants appeared to take advantage of the different views to track their colleagues as they moved around the room.

However the system generated difficulties for the participants. These difficulties arise in the use of any media space, but become increasingly severe when you provide individuals with the ability to select between alternative views of each other, and their respective domains. Whilst participants presuppose that their own activity and domain is visible to the other, they discover, that within the developing course of the interaction, their conduct and their local environment may not be accessible, or inaccessible in the ways in which they have assumed. They presuppose a 'reciprocity of perspective' or 'interchangeability of standpoint' (cf. Schutz 1962, and Cicourel 1972), organise their conduct with respect to such assumptions, only to find that establishing and sustaining a mutually compatible frame of reference can prove deeply problematic. In MTV I, whilst we increased the relative access that participants had to each other (and their respective domains), we exacerbated the difficulties in participants knowing what was available to the other, and what the other was currently able to see. In consequence, the experiment reveals numerous instances in which the subjects are attempting to clarify and reconcile each other's perspective.

These difficulties are not solved by the provision of the feedback monitor; indeed users did not intuitively realise that the smaller 'vanity' monitor showed the other's view of themselves, despite instructions. Participants presupposed that an object or gesture was visible to the other, only to discover that it was unavailable or not available in the way that he or she believed. For example, it was quite common for one participant to point to the other's document on their monitor in an attempt to refer to something, when the feedback monitor showed that such gestures could not possibly be seen by the other. At other times participants expressed uncertainty about what the other could see, and together, pairs of subjects often had difficulty not only determining what each other could see, but actually attempting to align their 'perspectives' with each other in order to establish, if only temporally, a mutually compatible frame of reference.

In the second experiment (MTV II), we attempted to address some of these difficulties by providing a more stable configuration which allow access both to the other and the workspace. Rather than providing access to the various views via a switch, each participant was provided with several monitors, so that all the views from the cameras were simultaneously available. The monitors provided three views: a face-to-face view, a 'desktop' view and an 'in-context' view; the latter giving access to the periphery of the colleague's environment (see Figure 2). The three monitors were arranged in each rooms in a similar fashion with the face-to-face monitor and camera positioned in the middle. This meant that a orientation towards the face-to-face view would also appear to a colleague as a reorientation

away from their in-context or desktop view, and *vice versa*. As both participants had access to all views simultaneously, there was no need for a feedback monitor. The tasks the users were asked to perform were the same as those used in MTV I

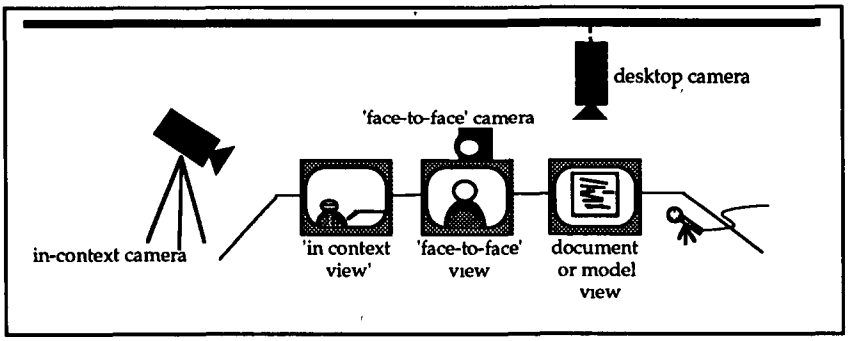

Figure 2. The configuration of the MTV II system using multiple cameras and multiple monitors for each participant.

Although preliminary observations reveal that participants used all three views and 'switched' views more frequently than they did in MTV I, as in the first experiment, participants mainly focused on the view displaying the most details of the model or the drawings. Participants glanced at the face-to-face view more frequently than in MTV I, but only for short durations, appearing to utilise the view, sometimes with the in-context view, to assess their colleague's involvement in the ongoing activity.

A further brief trial was carried out which provided a closer side-by-side orientation, mimicking that found in co-present environments. While the results were inconclusive, it appeared that the participants in this trial were particularly sensitive to this repositioning, perhaps due of the increased access it gave to the colleague's orientation to their activity.

The simultaneous availability of views appeared to increase the ease with which participants could flexibly vary their access to the remote space and did not require them breaking from the activity 'at hand' to switch the view. However, despite having similar access to their colleague's domain and this access remaining stable, limitations remained. As with MTV I, separate, fixed cameras failed to offer complete access to the remote space, there being gaps in the views offered. Moreover, participants still had little access to the actual document or artefact on which their colleague was focused. Perhaps more importantly, participants still encountered difficulties ascertaining what aspects of their own conduct and environment were visible to their colleagues. Although the co-participants had available, at the same time, similar views, and were also able to simultaneously monitor shifts in colleagues' shifts in orientation, there are still instances in which participants attempt to reconcile each other's perspective.

6. Flexible Access for Collaborative Work

By observing the use of both conventional media spaces and experimental configurations, it is possible to envisage ways in which more advanced technological support could be given to support remote collaboration. Noting that access to a remote space is problematic even when participants are provided with multiple fixed cameras and monitors, it may be worth considering more mobile solutions, for example, developing systems that allow a participant to 'rove' around a colleague's remote environment (cf. Gaver et al. 1994). However, such solutions do not address the key problem faced by participants in media spaces or subjects in the MTV experiments, that of reconciling their own perspective with their co-participant's. Instead, systems that automatically track a person's movements in order to provide images of a colleague's domain may well exacerbate the problems facing a colleague when trying to establish a mutual frame of reference. An alternative approach would be investigate how our understanding of collaborative work could suggest requirements for 'virtual environments'.

For example, our studies of work in real-world settings have revealed a resilience of the paper document that is perhaps surprising in the light of the various sophisticated computational facilities that are available (Luff, et al., 1992). Much collaborative work is mediated and rendered visible through objects and artefacts, including both paper and screen-based documents, where individuals co-ordinate their actions through peripheral monitoring of the other's involvement in the activity "at hand". Such flexible forms of collaboration are not supported by those current CSCW systems that simply place various facilities on the screen of the workstation and allow participants to refer to and operate on electronic copies of a shared document.

With its emphasis on providing computational support within current work spaces and existing artefacts, like documents, many of these concerns do appear to be shared by those exploring the possibilities for 'ubiquitous computing' and 'augmented reality' (e.g. Weiser, 1991). One direction these efforts have taken has been to explore the possibilities of extending work surfaces so that, for example, electronic documents can also be manipulated on them (Wellner, 1992). Although, the size and orientation of innovations, such as the DigitalDesk, do appear to provide resources for supporting the alignments to artefact-focused collaborative activity found in real-world settings they currently, as yet, provide no explicit support even for co-present collaboration. The attempts at supporting remote collaboration, by projecting images of co-participants through the work surface, for example, appear to have largely ignored the orientations through which collaborations through which collaboration is ordinarily accomplished (Ishii and Kobayashi, 1992; Tang and Minneman, 1991b). Thus, it may not be surprising that providing co-participants with a face-to-face view of a colleague whilst they engage in focused collaborative work, has been found to be intrusive and inflexible, (Ishii personal communication).

What it may be useful to consider is how to support different forms of, and orientations to, collaborative work, allowing co-participants not only to move seamlessly between individual and collaborative activities (cf. Ishii, 1990), but also to allow co-participants to adjust their own access to another's activity. So, for example, one could explore how to allow for the many ways in which individuals can be aligned to a focal area of an activity and for transitions between these orientations to be made easily. In order to explore these requirements in more detail and to suggest ways in which they could be integrated into a common design, it is perhaps worthwhile envisaging a more concrete example of a system to support more flexible access to collaborative work.

At present, in collaboration with David Travis of the Centre for Human Communication at British Telecom, and with Bill Buxton of the University of Toronto, we are developing a system that aims to support different orientations to focused collaborative work. This system consists of two prototype video desks and is a preliminary attempt at providing the variable access into another's domain by integrating the capabilities of video, computer and digital tablet technologies.

As with MTV II experiments, the requirement for the system to support variable access into a remote space can be met by providing co-participants with multiple views from multiple cameras, these views displaying the co-participant and the co-participant's in the context of their work. However, it is important for co-participants to be able to make fine adjustments to the positioning and orientations of cameras and monitors in order to tailor the environment to the demands of particular activities. Providing multiple views simultaneously and allowing some flexibility in their placement also makes it feasible to reconfigure desk to support other kinds of collaborative arrangements, for example, between several users at several remote sites, or with several users at a particular site. However, in these configurations participants have less variety and flexibility in their access to their colleagues. In order to reduce the problems of separating cameras from the image, the views are provided by 'through the screen', adjustable cameras (cf. the 'Hydra' system Sellen, 1992; Sellen, et al., 1992). A feedback monitor being available for each view to give participants access to the views their colleagues can see. Moreover, each different view is accompanied by an audio speaker for sound from the appropriate camera, thus providing a further resource for participants to monitor the orientation and participation of their colleagues. Most importantly, perhaps, the views will be configured in such a way to support the alignments most commonly found when individuals engage in collaborative activities; not only is it possible to present one view at the side of the user (to support side-by-side collaboration) but also the appropriate orientation of the image will be displayed (i.e. with the relevant height-width ratio).

In order to support greater access to the focus of any activity 'at hand' it is necessary to allow for the manipulation of both paper and electronic documents so that co-participants can have resources collaboratively to refer to, discuss and manipulate. Although electronic documents can be transmitted in the conventional

way, to support more flexible forms of collaboration a more sophisticated approach is required. This could be accomplished by integrating camera and projection technologies so that paper documents are scanned from, and electronic documents are projected to, the work surface (cf. 'DigitalDesk', Wellner 1992) However, a simpler solution that does not require complex calibration of the document could be adopted that supports some mobility of the paper document. This requires that the relative position of the document and the camera be kept fixed.

The importance of providing access to both paper and electronic documents is further revealed when considering the requirements for providing participants to establish and sustain different forms of participation to collaborative activities. In particular, the need to provide users with the ability to see each other and to be able to change orientation to the other, there is also the requirement to see each other in relation to the relevant documents and artefacts (cf. Tang and Minneman, 1991a). In part, this can be achieved by viewing, or 'peripherally monitoring', the side-by-side view of the co-participant. However, access through video allows for another possibility - displaying the images of gestures as they pass over the document so that a co-participant can see details of visual conduct, such as gestures like pointing, in relation to a remote document, whether it be electronic or paper.

An implementation of the above environment is currently being developed and, needless to say, there are many technological issues to be overcome in its design; not least coping satisfactorily with the problem of multiple images of participants, artefacts and gestures. The particular system description above aims to be a more concrete way of illustrating the requirements that have been derived from our studies and experiments. What is important is the requirements not only provide participants with different forms of access to another's domain and activities, but also bring closer the ways tasks and interaction are supported; support that has largely been considered distinct within CSCW.

7. Discussion

It is perhaps an understandable ambition that in designing new technology we hope conventional ways of working will be replaced by more efficient and innovative practices, relieving us of past incumbencies and burdens. In the case of media space there is little evidence to suggest, however, that we likely to achieve our brave new world. We are now perhaps at a stage where we need to reconsider both the technology and the activities that we are attempting to support.

In this paper we have attempted to show how the design of media space has been founded on limited, if not mistaken, assumptions regarding both the nature of collaborative work and the ways in which technology can be deployed to facilitate informal interaction in organisational environments. In identifying some properties of work and collaboration in more conventional environments in order to inform the requirements for innovative systems, we are not suggesting that new technology

should simply support current social organisation (though that would be indeed an extraordinary achievement), but rather that an understanding of even the most simple, collaborative activities reveals the richness and complexity of working together, and that our systems should not impoverish what individuals do in their day to day working lives. We should at least attempt to support some basic aspects of collaborative activity, and unless we can, it is unlikely, even with most persuasive marketing strategy, that our heart felt innovations will have a significant impact on the organisation of work. In the case at hand, it remains to be seen to what extent the system we are currently developing comes even a small way to actually provide individuals with a useful environment in which to work together. It is only through building, deploying, and evaluating the prototypes that we can begin to identify their limitations and possibilities.

Ethnographic studies of workplace activities might not only serve to identify some properties of collaborative work which could inform the requirements of complex systems, but also provide resources though which we can begin to reconfigure key concepts in CSCW and HCI. As we have suggested elsewhere (see for example Heath and Luff 1992, and Heath et al. forthcoming) we need to develop an understanding of concepts such as 'task', 'collaboration' and 'user' which charts a course through the potentially polarised distinctions of the 'individual and the group', the 'cognitive and the social', HCI and CSCW. A glance at the details of workplace activities, reveal ways in which 'tasks' are embedded in interaction, 'users' include a range of individuals who may not be directly involved with the system, and participants are seamlessly and continuously moving between the individual and the collaborative as they mutually accomplish the 'business at hand'. A more thorough going reconsideration of many of the key concepts in HCI and CSCW in terms of an understanding of the workplace is not only of theoretical importance, but of practical significance to the ways in which we think about design and technological support for collaborative activity. Indeed, such theoretical respecifications and the burgeoning body of empirical findings concerning workplace activities, might not only provide the resources for developing more 'suitable' technologies for conventional organisational environments, but also inform the design of more innovative and exciting systems for collaboration and communication.

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