Spontaneous Interaction in Virtual Multimedia Space: EuroPARC's RAVE System

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ABSTRACT

Increasingly, multinational corporations sponsor projects in which the participants must work closely together, even though they live in different countries and in different time zones. Many technologies, including phones, faxes and electronic mail, may make it possible to attempt such collaborations. But they are difficult. Why? People who work in the same place have many chances for informal communication. They can often resolve problems based on chance encounters, rather than waiting until the problem reaches a crisis. People who work together may share various interests and develop a sense of community. When people are separated geographically, most of the informal knowledge about each other disappears and communication becomes much more formal.

We are interested in designing tools to support people who work together on design problems, even though the people are distributed geographically. We have chosen to explore the notion of a media space, in which participants have video cameras and monitors in their offices and can choose a variety of ways of viewing or being viewed by others in the organization.

Unlike most uses of networked video, such as video conferencing and video phones, which support focused collaboration, the RAVE media space can also support casual interactions and chance encounters. People can glance informally at each other or set up long-term connections between offices. They can maintain a shared awareness of the others in the building or use a system called Portholes to keep in touch with people in a lab on another continent. Other tools support focused collaboration, such a shared drawing. The goals are to provide a sense of shared community among the members of the lab and to enable them to shift smoothly from peripheral awareness of each other to focused collaboration and back again.

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INTRODUCTION

Successful working groups within a single location rely on a variety of forms of communication, ranging from unplanned, spontaneous interactions to planned, formal meetings. People who work together in the same building may run into each other in the hallway and learn something new or find out about something going on in the organization. Even with formal meetings, much of the useful work is done informally, at the breaks or after the meeting.

People in groups located far apart have a more limited range of communication options. One of the goals of the media space research at EuroPARC is to learn about how people at the same site work collaboratively and provide similar kinds of access to people who work together, but at a distance.

The RAVE project (Ravenscroft Audio Video Environment) is designed to support a range of activities from focused collaboration on shared design problems to helping people maintain a peripheral awareness of each other. the goals include reducing the cost of quick communications, supporting spontaneous, unplanned interactions, permitting long-term sharing of virtual office space and supporting tutoring and distributed expertise. RAVE consists of a computer-controlled network of audio-video equipment in which each office contains a video monitor, camera, and microphone, all positioned by the user and completely under the users' control. The setup is similar to other "media spaces' being explored elsewhere (e.g. Stults, 1986, Root, 1988, Buxton and Moran, 1990, Mantei et al., 1991, Fish et al., 1991).

What makes the EuroPARC media space unique?

The ubiquity of the video network: Every member of the laboratory, including researchers and administrative staff, participates in the media space. It is not simply used by the subgroup of researchers who are working on the project.

Privacy issues: We have explored ways of providing participants in the media space with privacy while taking advantage of the benefits of the media space's ability to provide unobtrusive awareness. Privacy issues are multidimensional and are greatly affected by the culture of the organization in which the media space is placed and the purposes for which it was created.

Research issues: We are concerned with supporting collaboration over its entire range from casual awareness about the whereabouts and activities of each other to the more focused and planned work of shared design and problem-solving. The design of the RAVE environment includes a user-tailorable interface and users have been able to modify the system to support this range of activities. In this way, some of the most important research issues have emerged as a function of the use of the system.

Research strategy: EuroPARC researchers include sociologists, computer scientists and psychologists. These researchers work together collaboratively to examine work habits and how they are influenced by the computational environment and the media space. Software is based on observation of users and users reactions to that software influence the design of subsequent applications.

THE RAVE AUDIO VIDEO ENVIRONMENT

EuroPARC was founded in 1987 and there are currently about 30 research and administrative staff members, plus students and part-time researchers. The building is called Ravenscroft House and has 27 rooms and 5 open areas on 4 floors. The lab is laid out on four floors, with two physically separated "pods" to each floor. Within a pod, people can see each other as they come and go, but people in different pods may go all day without seeing each other. So, despite the small size of the lab, the layout causes a surprising degree of separation, making the building effectively a collection of isolated sites. Although this arrangement is not the same as if these small sites were located far away from each other, it begins to simulate some of the problems of an environment in which people must work together but are physically separated.

In order to overcome this limitation of the building, a complete data, audio, and video network, controlled by a central computer-controllable switch, was installed, connecting every office and common room in the building (see Buxton & Moran, 1990, for details). Each room has an audio-video “node," consisting of a camera, monitor, microphone and speakers. Users have complete control over the placement of these items and can turn them on and off at will, either physically (by putting on a lens cap or unplugging the equipment) or through the computer system which controls everything. People can display the views from various cameras on their desktop monitors; set up two-way audio-video connections, etc. Thus, the members of EuroPARC live and work in both they physical workspace and a media space. This paper describes a set of applications developed within the RAVE environment to support various user activities.

GODARD: Controlling RAVE

Users control the RAVE environment via a program called Godard (Dourish, 1991). Godard is built on top of *iiif* (Buxton & Moran, 1990) which provides the underlying protection mechanism to control device plugs so that no connections can be made without its permission. Godard mediates all connection requests, which makes it easy to define and control explicit6 services. When a user or a computer application requests a service, Godard uses information previously obtained from potential recipients to determine whether or not to perform the service. If necessary, Godard will request input interactively to request permission for individual connections or to resolve conflicts. If permission is given and all relevant plugs are available, Godard creates a record of the pre-existing connections, so that it is easy to return to the pre-existing state, and then makes and protects the appropriate connections.

One of the chief benefits of this architecture is that it allows privacy control to exist at the level of specific services rather than individual plugs. People can decide in advance who has permission for specific kinds of services. For instance, Figure 1 shows a "glance control panel". The panel presents a complete list of people at EuroPARC and allows users to select those who will or will not be given permission to glance at them on their video monitors. Similar control panels exist for video phones, office share connections, and other services.

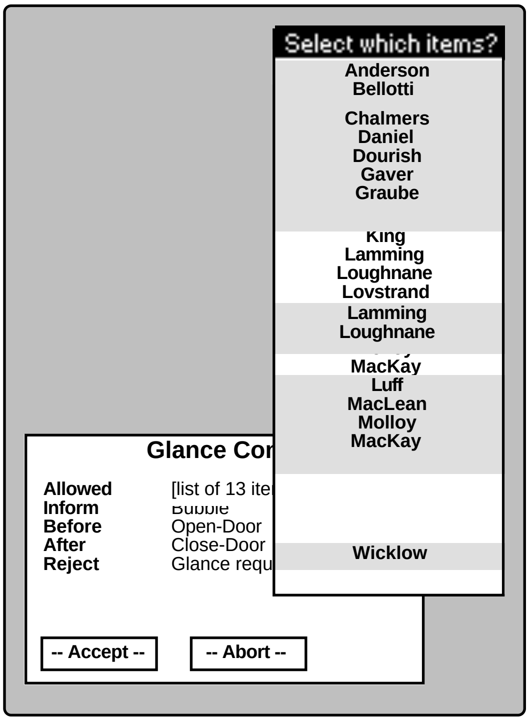

Figure 1: *Control panels allow users to give permission to specific individuals for specific services.*

Godard allows participants to interact with the RAVE environment in terms of high level services rather than simply low level physical connections. Each service includes a notion of the initiator's intentions, which makes it easier to make judgments about whether or not to allow the connection, maintaining the tradeoff between privacy and access.

THE RAVE BUTTONS

The RAVE environment was designed to be tailorable by users, partly because it was not clear in advance how audio-video connectivity would extend current work practices. Instead of dictating a fixed set of functions, users were able to tailor on screen buttons, such as those in Figure 2.

Buttons are the product of research both at Xerox PARC (Henderson & Card, 1986) and at EuroPARC (MacLean et al., 1990). Users interact with an on screen graphical object to run small programs without having to enter the relevant commands explicitly. Users may tailor their on-screen locations, modify their appearances, and copy or Email them. Many buttons can be parameterized so that application-specific variables can be changed easily, and their encapsulated code can be edited. This flexibility allowed users to explore the RAVE media space and develop the services that were most useful to the staff.

The RAVE buttons evolved from providing relatively low-level functionality, e.g. allowing a particular connection to be made or broken, to higher-level tasks that users wished to accomplish. The current version includes the buttons shown in Figure 2.

The RAVE buttons illustrate a range of collaboration types and reflect varying levels of engagement among the participants in the interaction.

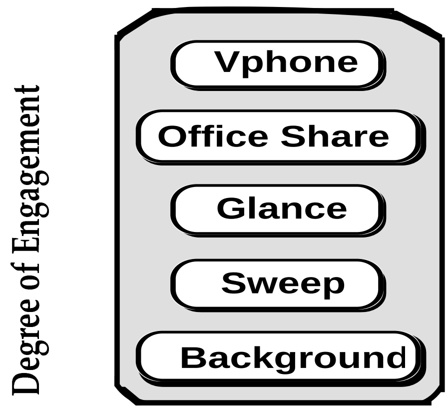

Figure 2: *RAVE buttons provide different services that reflect varying degrees of engagement.*

Vphone: A video phone call is a highly-focused form of interaction with two-way audio and video connections. Vphone connections are initiated and accepted like traditional telephone calls: one party must explicitly initiate the call and the other must explicitly accept the connection.

Office share: An office share is technically identical to a vphone connection, except that the participants decide in advance to set up the connection and then do not explicitly initiate or terminate specific calls. People who work together closely may thus establish long-term links with each other, for hours, days or even months. The effect is of sharing an office, but because audio volume can be controlled (or left off) and the video image is relatively small, the presence of the other party is less intrusive. So, rather than the highly focused interaction evident with vphone calls, an office share provides a range of interaction from passive awareness to highly focused interaction.

Glance: If given permission in advance, a user can look at another person with a brief (3-second) one-way video connection. The person being glanced at hears an audio cue prior to the glance and another cue when the glance is complete. Some people also choose to hear the name of the person who is glancing at them. Glances are used as a quick method of finding out whether or not a person is currently busy. The effect is similar to walking by somebody's door and glancing in: general information about a person's presence and activities can be obtained with little intrusion of privacy.

Sweep: People can quickly glance at remote locations in the building, using short (1 second) one-way video connections to pre-authorized nodes within the building. Users can customize their own sweep patterns, to include the most useful public (and, if authorized, private) nodes. Typically this is used to find out who is around and what they are doing (c.f. Root, 1988).

Background: Since the video monitor is always on, people usually choose a "background" connection. For some people, this is the same as an office share, since they have a pre-agreed upon arrangement to connect to another person's office. But most people like to view a public area, such as the camera that displays the view from the roof (popular for people in offices without windows) or the EuroPARC commons. The latter is the most popular, since it provides a peripheral awareness of who is in the building (since most people go there to check their mail or get coffee) and when informal gatherings (such as afternoon tea) have started.

The use of the commons as a background connection has had a perceptible effect on the behavior of the members of the lab. For example, people usually wait until a critical mass of people have assembled in the commons before going up there in person. The result is that usually very few people arrive, then when 4 people appear, suddenly everyone else arrives all at once. Thus people can work as late as possible and still be assured of arriving when the meeting actually starts. Another use that evolved was the 'broadcasting' of one's availability. By sitting in the commons area in view of the camera, a researcher is letting his or her colleagues know that it is OK to come up and chat. Interestingly, when members of the administrative staff do the same thing, the message is the opposite. For them, sitting up in the commons means that they are on a break and it is not acceptable to come and ask them to do something (although it's fine to come and chat). Note that the commons is set up with a "video free" section as well, so that people who want to avoid being seen may do so easily and naturally. The overall effect is that of having the common area right outside one's door, but without the noise. Whenever this connection breaks down (such as when the equipment is being upgraded or there is work on the building), the members of the lab report a sense of being out-of-touch with what's happening in the lab.

These five RAVE buttons emerged through a process of integrated use and design supported by an interface system that affords flexible tailoring. The resulting functionality supported by these buttons reflects the range of shared work from general awareness to focused collaboration to a remarkable degree. However, it is worth addressing a common set of concerns about the RAVE system.

WHAT ABOUT BIG BROTHER?

George Orwell's book, *1984* , describes a world in which "Big Brother" uses video cameras everywhere to keep close watch on the individuals in the novel. Our accounts of cameras in every office, one-way glance connections, long-term monitoring of public spaces, etc. can have Orwellian overtones: it was clear that despite the possible advantages of an integrated audio-video environment, it was also essential to protect each individual's privacy.

However, providing safeguards that balance the trade-offs between protection of privacy and provision of functionality is a non-trivial task. At one extreme, the audio and video equipment could be removed all together: but this would clearly do away with any and all services it offers. More subtly, privacy might be ensured by enforcing symmetrical connections, so that seeing or hearing somebody implies being seen or heard oneself (indeed, this strategy has been taken at BellCORE; Root, 1988). This approach is similar to 'real life', in which people who see each other can (usually) also be seen by each other. Yet the members of the EuroPARC community found that one-way connections had advantages that they are unwilling to give up. *Glances* allow people to maintain awareness of colleagues without actually engaging in interaction with them and, not incidentally, bothering or annoying them; they can be a valuable prelude to communication. For example, I might look into an open doorway to check if another person is busy before knocking on the door. Similarly, I might *glance* at the person before *v-phoning* them. Video provides an excellent means to gain general awareness unobtrusively; enforcing symmetry for the sake of privacy would undermine this functionality.

So how can people feel comfortable with a media space, without losing the benefits? We have identified four primary issues that must be disentangled:

- *Control*: Users to control <u>who</u> can see or hear them at any time.
- *Knowledge*: Users want to know <u>when</u> somebody is in fact seeing or hearing them.
- *Intention:* Users want to know <u>what</u> the intention of the connection is.
- *Intrusions*: Users want to avoid connections that disturb their work.

The trade-off between privacy and functionality involves a conflict between the desirability of control and knowledge and the intrusion implied by activities needed to maintain them [cf. Fish et al., 1991]. Explicitly acknowledging every connection would provide control, but the requests themselves would be intrusive. Similarly, if every glance results in seeing someone's face on the monitor, it would demand some sort of social response and might well disrupt previous connections. Having to specify and be informed of the intention of various connections would likewise transform a light-weight, unobtrusive process into a relatively effortful and attention-demanding one. The challenge of safeguarding privacy, then, is not just one of providing control and notification, but doing so in a lightweight and unobtrusive way.

Privacy protection depends greatly on social convention. Initially, EuroPARC's culture was the only protection: it was assumed that people would use the system with “good” intentions and not seek information with the intent of using it against others. At the same time, people were encouraged to control their own equipment: Individuals were (and still are) free to turn their cameras to face a wall or out a window; they could turn off their microphones and so forth.

This initial strategy allowed the issue of privacy to become a research issue: what could be handled through social norms and what needed to be added to the software architecture? Explicitly relying on trust established clear social norms about the use of the media space. Instead of building software on the assumption that privacy would otherwise be invaded, it was assumed it would not be and people were expected to behave accordingly. As the equipment became ubiquitous in the lab, it became important to explore specific techniques for supporting privacy. The general approach is to provide *services* rather than simply connections. Each service, e.g. *glance*, includes the initiator's intention as an implicit feature of the connection. Others can then respond based on both the connection and the intention. The following sections describe how users can control these connections and receive notification as they occur.

PROVIDING NOTIFICATIONS: AUDITORY CUES

Feelings of privacy are not only supported by control over who can connect to one's equipment using various services, but by feedback about when such connections are actually made. Because Godard knows about connections to recipients' audio-video nodes at the service level, it facilitates the provision of such feedback. Several kinds of feedback can be requested by users in current instantiations of interface software, including text messages displayed on their workstations and spoken messages played over the audio network. Less obvious are *auditory cues* used to provide information about system state (Gaver, 1991).

For example, when a glance connection is made to a camera, Godard triggers a sound (the default is that of a door opening) before the connection is actually made. When the connection is broken, another sound (typically that of a door closing) is triggered. In addition, different sounds indicate different sorts of connections (and thus the intentions behind them). A knock or telephone bell indicates a vphone request; door sounds indicate glances; footsteps might indicate sweeps; and a camera whir indicates that a frame-grabber has accessed one's node. Thus auditory cues provide information about what kind of connection is being made, over and above information about the existence of a connection alone.

Playing sounds such as opening and closing doors may seem frivolous, but there are several reasons that it is a particularly effective way to provide feedback about connections:

- Sound indicates the connection state without requiring symmetry; providing information without being intrusive.
- Sounds do not require the kind of spatial attention that a written notification would.
- Non-speech audio cues often seem less distracting and more efficient than speech or music (although speech can provide different sorts of information, e.g., *who* is connecting).
- Sounds can be acoustically shaped to reduce annoyance (see Patterson 1989). Most sounds involve a gradual increase in loudness to avoid startling listeners.
- Finally, caricatures of naturally-occurring sounds are an intuitive way to present information. The sound of an opening and closing door reflects and reinforces the metaphor of a glance, and is thus easily learned and remembered (cf. Gaver, 1986).

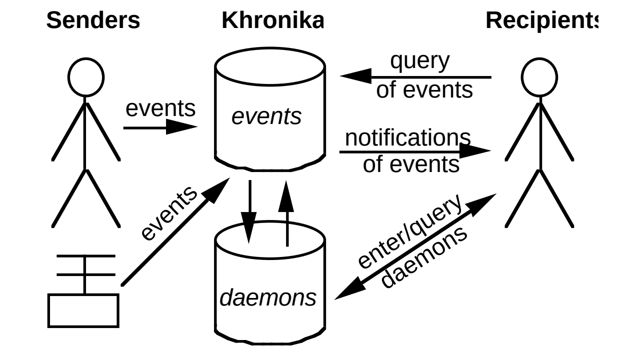

Figure 3: *Khronika maintains a database of events entered both by people and other systems. Daemons watch for specified events and post notifications when they are detected.*

These sorts of auditory cues have provided an flexible and effective way to unobtrusively inform people that somebody is connecting to their node, and thus serve as another means of safeguarding privacy. More generally, Godard, with auditory cues, provides control, feedback, and intentionality, three prerequisites for privacy, at very little cost in terms of intrusiveness. Big Brother would have a difficult time at EuroPARC, both because his access is restricted and because users can hear him coming.

KHRONIKA: AWARENESS OVER TIME

Khronika (Lövstrand, 1991) is a software "event notification service" that supports selective awareness of *planned* and *electronic* events. Khronika is related to on-line calendar systems, but supports a more general notion of events than most. It announces when a video connection has been made, reminds users about upcoming meetings, provides information about visitors, and can even be used to gather people to go to the pub.

Khronika is based on three fundamental entities: *events*, *daemons*, and *notifications* (see Figure 3). Events are defined in terms of their class, their start time, and their duration. Examples of events include conferences, visitors, local movies, and arriving Email. Because they are represented as objects in a hierarchical classification structure, they can also be manipulated in terms of more abstract classes such as "professional," "electronic," and "entertainment."

Event daemons watch for specified event types and produce notification events when they are detected. Daemons are created by users as a set of constraints, so recipients choose the information about which they wish to be informed. For example, a user may create a daemon which watches for all seminar events occurring in the conference room with the string "RAVE" as a part of their description. They can then instruct the daemon to generate notifications five minutes before relevant seminars are due to begin.

A number of interfaces to the Khronika system have been explored, including buttons which allow users to browse the event database and to create new events and daemons. One of the more interesting and useful interfaces is the *xkhbrowser*. The browser serves as an on-line calendar, with events shown as fields extending over their relevant times. But the event database may be displayed at varying levels of specificity, from the most encompassing ("event") level to more specific ones such as "meetings," "visitors," or "sound." In this way, the xkhbrowser provides a general and powerful mechanism for exploring the database of events.

Notifying Users About Events

Khronika is the mechanism with which Godard generates feedback about audio-video connections. When a request for a connection is made, Godard enters an event into Khronika; an appropriate daemon (created using the various privacy controls already described) then triggers the requested notification.

Notifications can be generated by daemons in several different forms – for instance, a daemon watching for meetings might send out an Email message the day before, display a message on a workstation window, or generate a synthesized speech message. Nonspeech audio cues are commonly used to inform users about the state of the audio-video system; there are also a number of cues which inform users about other events (see Gaver, 1991).

For example, upcoming meetings are signalled by the sound of murmuring people gathering together, followed by a gavel sound. This sound acts as a memorable stereotype of naturally-occurring meeting sounds and is thus quickly learned and immediately recognizable. In addition, the sound is designed so that it grows in amplitude quite slowly, so that it is less intrusive. Finally, the sharper gavel sound at the end lends a sense of urgency to the sound. Sounds like these are effective yet unobtrusive reminders about remote events – as evidenced by the fact that approximately 50 sounds a day are requested from the Khronika system.

The Khronika systemm in conjunction with audio reminders, enhances the general awareness of ongoing events and thus promotes collaboration. Khronika blurs the boundaries between the electronic and everyday worlds, allowing information to be entered from and disseminated by both. Finally, it allows for a great degree of user customization and, like all EuroPARC systems, is in a continual state of evolution guided by use.

POLYSCOPE AND PORTHOLES: AWARENESS OVER LONG DISTANCES

EuroPARC maintains a close association with another research lab (Xerox PARC, in California in the United States) which also has a media space. Unfortunately, the cost of directly connecting the two media spaces, with full functionality, would have been prohibitive. Rather than trying to duplicate all of the features of RAVE, this project concentrated on one of the most useful aspects: the ability of lab members to maintain a shared awareness of each other. By sharing still images selected from each media space, members of both labs can stay in touch with very little effort.

Polyscope (Borning and Travers, 1991) was developed to distribute digitized images within the building approximately every 5 minutes. The resolution of the display is not very high -- only 200 by 150 bits, with no gray scale. Nonetheless, people and objects in their environments are usually visible. In addition, a simple animation facility is available, in which a few images are digitized successively and looped on display. Although such animations are often jerky (and sometimes deliberately frivolous, as when one researcher arranged to periodically transmogrify into Elvis Presley), they make movement obvious and are an effective way to disambiguate scenes. Moreover, Polyscope acts as an interface to the audio-video network. Buttoning an image produces a pop-up menu which allows glance or vphone connections to be initiated.

Portholes, (Dourish and Bly, 1991) was developed collaboratively between the lab in England and the lab in the United States. Lab members may see people in both buildings, even though they are 6,000 miles (10,000 kilometers) apart. This connection not only supported awareness, but has also helped to create and maintain a *research community* within EuroPARC and PARC. Some researchers who have never met in person speak of "knowing" each other through their experience with Portholes.

Both Polyscope and Portholes allow several remote locations to be presented simultaneously, affording passive awareness of distributed workgroups without the necessity of explicitly setting up video links and so on. This facilitates smooth transitions between general awareness and more focused engagements. In addition, the spatially-distributed but asynchronous functionality offered by systems like Portholes and Polyscope complements the synchronous but single-channeled video services quite well. Perhaps most importantly, Portholes allows users to extend this awareness out of the building to colleagues at geographically distant locations.

RAVE: REALIZING A VIDEO ENVIRONMENT

This paper describes RAVE and several of the related systems used to support shared work at EuroPARC and how they work together to form an integrated environment. As in many labs, the division between designers and users is often blurred. Even so, the group can be divided into technical and non-technical staff, and much of the development is guided by the experiences and input of non-technical users (see MacLean et al. 1990). In addition, a number of users have been keeping diaries of their experiences with various systems. These anecdotal accounts are a valuable source of insight about audio-video mediated collaboration.

A more formal study is reported in Heath & Luff (1991) who observed how lab members used the RAVE environment over a period of time. They found that video can undermine the effectiveness of subtle communicative gestures, which led to further changes in RAVE. Another recent study assessed the utility of a shared text editor called ShrEdit and the effects of shared video on its usefulness (Olson and Olson, 1991). A third study found that nonspeech audio feedback changed both participants' perception of a complex collaborative system and their tendency to collaborate while using it (Gaver et al., 1991). Finally, ongoing research on participatory design has involved the installation of a limited audio-video link in a London architecture firm; it has become clear that technology interacts with existing work-practices in subtle and complex ways (Carter and Harper, 1991).

A new media space, with limited RAVE functionality, is being set up between an engineering design group in England and a corresponding manufacturing site in the Netherlands. (This is part of the EuroCODE ESPRIT project.) The participants in the study are not researchers, but members of a distributed project team responsible for creating a new Xerox copier. The current situation involves large numbers of people moving between the two sites, sometimes as often as every week. The goal of the project is not necessarily to reduce travel, although this would benefit both the individuals and lower costs, but to identify new kinds of interactions that may be possible with a distributed media space and help to better understand the problems and potential for distributed cooperative work.

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