Dealing with Mobility: Understanding Access Anytime, Anywhere

MARK PERRY
Brunel University
KENTON O'HARA
The Appliance Studio
ABIGAIL SELLEN
Hewlett-Packard Laboratories
BARRY BROWN
Glasgow University
and
RICHARD HARPER
University of Surrey

The rapid and accelerating move towards use of mobile technologies has increasingly provided people and organizations with the ability to work away from the office and on the move. The new ways of working afforded by these technologies are often characterized in terms of access to information and people anytime, anywhere. This article presents a study of mobile workers that highlights different facets of *access* to remote people and information, and different facets of *anytime, anywhere*. Four key factors in mobile work are identified: the role of planning, working in "dead time," accessing remote technological and informational resources, and monitoring the activities of remote colleagues. By reflecting on these issues, we can better understand the role of technology and artifacts in mobile work and identify the opportunities for the development of appropriate technological solutions to support mobile workers.

1. MOBILE WORK, MOBILE TECHNOLOGY

The rapid and accelerating move towards the use of mobile technologies has provided individuals and organizations with the ability to work in novel and previously unanticipated ways. Such developments are at both the level of emerging technological infrastructures for connectivity (e.g., WAP, Bluetooth, Sun's Jini, and HP's JetSend, location-pinpointing technologies, 3G, and GPRS) and mobile information appliances such as mobile phones, personal digital assistants (PDAs), and laptop computers. These have the potential to provoke even more radical changes in work practices and encourage an even greater level of mobile work and distributed collaboration.

Mobile work differs in many interesting ways from desk work. It can also present the business traveler with a unique set of difficulties. When people work in an office, they have greater familiarity and certainty about the environment and resources (i.e., technologies, information, documents, and people) available to them. People in offices know where technologies such as the photocopier and the fax machine are and that their personal equipment is set up appropriately. They structure the information and documents around them to suit their needs and they know who to ask for particular kinds of information. Such familiarity with their environment affords them greater freedom over the way they organize their work. Of course, systems break down and technology can go awry, but in general, when people work at their office desks, they know how to go about fixing their problems and finding what they need to perform the job at hand.

Contrast this resource-rich view of office work with the difficulties encountered by a mobile worker on a business trip who may experience a range of different contexts both in transit and at their final destination. Such contexts (e.g., clients' offices, hotel rooms, airports, and vehicles such as trains, aircraft, and cars) are likely to be more unfamiliar to the mobile worker in terms of factors such as available technology and communication infrastructures, available workspace, and noise levels [Lamming et al. 2000]. In addition, they do not have the access to colleagues or knowledge of who to seek to get support. The greater unpredictability—or *heterogeneity* [Krestoffersen and Ljungberg 1999]—of the contextual constraints within which mobile work must take place means that mobile workers have less control over the configuration of their environment, and therefore the way they manage their work.

In light of the particular difficulties encountered by mobile workers, one of the major premises of mobile technologies is to remove the bindings between a fixed space and a person's information and communication resources. By supporting access to these resources wherever they go, the argument is that uncertainty associated with the contextual constraints while mobile is removed. This is intended to give control back to the mobile worker over when and where they can do their work. As a rhetorical device for the promotion and sale of mobile technologies, the "access anytime, anywhere" construct serves an important function. However, in terms of understanding technology use in mobile work and informing design through this understanding, such a construct may not be quite so useful, since it misrepresents the reality of the difficulties faced by

mobile workers. Indeed, as other authors have argued (e.g., Churchill et al. [2001]), this and other rhetorical devices in the mobile technology industry "contribute to a common discourse of mobility" from which narratives are drawn. These narratives embody a set of simplistic assumptions about the nature of mobile work. In the absence of a real understanding of what constitutes mobile work, these narratives are the only fallback in justifying and shaping design decisions.

As Luff and Heath [1998] have shown, misunderstanding the nature of mobile work can be problematic and lead to technologies being used in unexpected ways. For example, they describe a situation in which a mobile device was introduced onto a building site to replace a paper allocation sheet used to record the amount of time workers spent on particular aspects of a job. The system was supposed to provide a mobile resource for the foremen to help them monitor problems as they were encountered and to support *in situ* discussions with other people on the site. What happened in actual use, however, differed from the intent. Instead of being used as a communication tool to support the mobility of the foreman around the site, it was primarily used as a data documentation device. That is not to say that it failed as a useful tool, but merely that it was not useful for its intended purpose. This occurred because the device actually impeded certain important features of collaborative work practices of the foremen and the other workers when on the site. For example, with the existing paper-based version of the allocation sheets, there was a brief hand-over of documents and a simultaneous discussion about the problems on site. During these discussions, the paper documents were dynamically positioned to render them "accessible" to the participants as the needs of the conversation dictated. With the new electronic mobile system, the size, shape, and screen intensity of the device made it difficult to access and share information among the collaborating participants. In practice, then, the system actually hindered mobile collaboration rather than supported it.

In response to some of these issues, we set out in this article to contribute to a deeper clarification of the rhetorical underpinnings of mobile work. In particular, rather than treating the three concepts of *access anytime*, *anywhere* as monolithic terms, we argue that each of these terms is multifaceted, each facet having different implications for the way we think about mobile work and the technologies designed to support it.

As an illustration, we simply look at one of the primary purposes of mobility itself. That is, one of the main reasons for being mobile is to have face-to-face interactions with others (e.g., Bellotti et al. [1996]; Henning and Bragen [1994]; Lamming et al. [2000]). It is well established that face-to-face access to colleagues is different, and usually much richer, than remote collaboration. Thus there are different kinds of access to people, and we need to look carefully at whether new technologies can deliver the necessary support for the task at hand. Similarly, if we look at access to documents and information, different kinds of tasks require different kinds of access. For example, the kind of access required to exchange a document as an email attachment is different from the level of access necessary to allow editing the document. In the first instance we do not really require visual access to the contents of the document, but

merely access to digital information that encodes the document so the bits can be emailed onwards.[1] In the editing instance, we require visual access to a modifiable document.

To illustrate the notion of "anywhere" in the same way: We can see that accessing or transporting documents between a desktop computer in an office and a laptop in a hotel room constitutes a different level of spatial granularity than the "anywhere" associated with Luff and Heath's [1998] document micromobility (the small shifts in artifact position and orientation in response to the ongoing demands of a particular task). The granularity differences in spatial shift in these two examples demand a different set of affordances from the information embodiments used to support them. So the laptop is able to receive a document anywhere that a network connection can be established with the computer back at the office. But once the document is received, the laptop cannot be spatially reoriented at the microlevel—for example, during a face-to-face interaction—in ways that a paper embodiment of the same document allows (e.g., Harper and Sellen [1995]; Luff et al. [1992]). This notion of "anywhere" also assumes a geometric notion of space, in which all places are assumed to be functionally equivalent. We can also look at the social facets of "anywhere" and consider space in terms of the different properties and social norms governing the kinds of activities that can take place there. For example, the kind of mobile phone conversation we can have in a public place surrounded by others is different from the conversation we could have in a different place with no one else around (cf., Churchill and Wakeford [2001]). In this instance, anywhere access is *possible*, but may not be *acceptable*.

Finally, as an illustration of the notion of "anytime," let us consider the task of writing a document on a laptop while needing to reference some information from a source document. The level of time granularity associated with a quick glance at a paper document adjacent to the laptop is very different from the time it takes to get exactly the same information by pulling the document over the Internet. The different embodiments of the information in these two instances offer very different values and properties in the way they can be drawn upon as a resource. To ignore these differences is to ignore the competitive ecology in which new mobile devices must operate. As with notions of space assumed in the rhetoric of "anywhere," the notion of "anytime" often assumes a linear notion of time, as opposed to the "anytime" characterized by the social norms and properties of time that affect information access and communication behavior. For example, many people might consider it inappropriate to make a phone call about work-related issues outside a mutually agreed understanding of "work time."

In this article, then, we present a user study of mobile workers traveling on business in order to further understand what it means to be mobile and to work in different places at different times. We hope to learn from observation how mobile workers currently use the resources they have to think systematically about what they might need in the future. For example, we hope to be in a better

---

[1]It is recognized that we might want visual access to the document to confirm that the correct document is being attached and sent. For purposes of this illustration this is not important, and so is not included.)

position to answer important emerging design questions such as how and why wireless communications should be incorporated into mobile devices (such as PDAs). What new data services might be useful to access via mobile phones? What document-handling facilities should be incorporated into mobile devices? In addition to informing new design directions for mobile technologies, it is also about developing an understanding into the rationalities of existing artifacts in real-world practice, from which we can begin to infer how emerging technologies will compete in the ecology of existing communication and information artifacts.

2. PREVIOUS RESEARCH

Much of the research on mobility has dealt with issues such as limited battery life, unreliable network connections, varying channel coding, volatile access points, risk of data loss, portability, and location discovery [Wiberg and Ljungberg 1999]. However, as a number of authors have commented, user centered research on collaborative mobile work is now beginning to emerge as an important field in its own right (e.g., Berqvist et al. [1999]; Luff and Heath [1998]). A growing number of studies exist on mobility in collaboration that offer findings and observations about the actualities of mobile work. Some of these findings can be recast to inform our particular concerns about "access anytime, anywhere" and form the foundations on which our own study of mobile work can build.

In one of the earlier studies in the area, Whittaker et al. [1994] carried out an in-depth study of two mobile professionals. One was primarily mobile in the local office environment, the other was mobile in both the local office and also remotely (within the local metropolitan area). The primary focus of Whittaker et al. was on informal communication rather than on mobility *per se*, but they also looked at the role of mobility in enabling access to colleagues. This occurred through chance encounters with colleagues facilitated by mobility, like bumping into someone while roaming as well as planned office visits. The extent of mobility away from the desktop led to difficulties in reaching colleagues successfully (two-thirds of attempted phone calls failed because the other person was not at his or her desk). The study also highlighted how different spatial locations varied in perceived intrusiveness. For example, in "on the move" serendipitous informal interactions, the caller does not interrupt the recipient in the same way as calling the recipient at the office. The subtly different social properties of these instances influence the duration of the collaborative activities.

Local mobility (defined as within easy walking distance of the office, walking between rooms or buildings at a local site) is further examined in an ethnographic field study of a distributed design team by Bellotti and Bly [1996]. The particular theme of the study was how local mobility is important in supporting communication and awareness, highlighting the importance of connecting with a colleague to get a richer level of access than is possible by using telecommunication from the desktop. The mobility also gave a certain level of access to colleagues that made people aware of what was going on elsewhere in the workplace. However, one negative consequence of local mobility was that,

as in the Whittaker study, telephone access by remote colleagues was made more difficult.

Awareness and communication are also discussed in Luff and Heath's [1998] mobility studies. One example comes from their observations of staff and management at the London Underground. In this case, many of the information and communication resources required for the staff to perform their work were located in the Ops room. When a member of staff was mobile and away from this room, they were unable to access the ongoing changes taking place in it: the staff member no longer had continuous visual and auditory access to colleagues and information gained by inadvertently overhearing conversations and phone calls. In the Ops room, access to this information is ongoing and unplanned—we cannot predict when a particular piece of eavesdropping will become an important resource for a particular activity. Since remote access must be initiated deliberately, the form of access that many mobile technologies (such as mobile phones) provide is not equivalent to that allowed by *being* in the Ops room.

As we discussed earlier, Luff and Heath's [1998] paper talks not just about the mobility of people but also about the mobility of artifacts (micromobility) and the way they are configured in an ongoing manner within collaborative activity. By giving examples of different configurational needs, they point to the varying facets of "access," "anytime" and "anywhere" that we address in this article. In particular, they discuss how the properties of different forms of representation of the same information impact micromobility. For example, when talking about the role of documents in mobile conversations (cf., Whittaker et al. [1994]) they point to the ecological flexibility of paper compared with conventional computer systems or even laptops, which are regarded as "cumbersome and rigid" during conversation.

The role of documents and access to documents in mobile work is further developed in a series of studies by Eldridge et al. [2000] and Lamming et al. [2000]. These studies examine mobility both within a local area and beyond a metropolitan area using a variety of quantitative and qualitative approaches to data collection. These studies are important in characterizing some of the particular features and problems of mobile work, such as the unfamiliar environments, in which people often find themselves, unanticipated document behavior, the difficulties in "accessing" remote documents and the frequency of face-to-face interactions in which paper documents play a key role (cf., Luff et al. [1992]). Findings from these studies informed the design of a new system, called Satchel. The Satchel system allows document tokens to be carried on a mobile device. When these tokens are instantiated—for example by beaming them to another device (e.g., a Satchel-enabled printer)—the actual document is pulled across the Internet to the recipient device. Some of Satchel's design features are clearly based on the need to think about different facets of information access. For example, Luff et al. talk about the need to beam a document token to a printer to create access to the document appropriate for face-to-face interaction. They regard this as different from the type of access necessary to simply beam a document token to another mobile device.

There is less discussion of the concepts of *anytime* and *anywhere* in the Satchel papers; but there is an important point to be raised here. Many features

of the Satchel system depend on place and time being defined by the presence of Satchel-enabled devices. This is not a criticism of Satchel *per se*, whose value has been demonstrated through extensive field trials (e.g., Lamming et al. [2000]), but is intended to illustrate the different features of different places, defined by the technological ecology of that place. Perhaps these issues will become clearer if we consider some findings of O'Hara et al. [2001] on relationships between mobile phone conversations of mobile professionals and their document activities. For example, one study participant was driving his car and received a phone call about some information on a spreadsheet on the caller's PC in the office. While the caller was able to give a certain level of "access" to the information by describing it verbally to the driver, the driver really needed to see the document to truly engage in the conversation. The point is that while a mobile technology could allow access to the document by transmitting it to the mobile phone in the car, this would not be suitable for the situation at hand. Additional technology would be necessary to allow the appropriate level of visual access to the document. In this particular situation, the characteristics of the place (the car) were such that this additional technology was not available, and hence "access" was not possible. Similarly, the particular time (i.e., while driving) that the person received the phone call meant that visual inspection of the document was dangerous.

Lack of awareness of a recipient's activities, time, and place, which impact the types of possible access, can lead to disruptions in what Churchill and Wakeford [2001] call the "reciprocity" and "rhythm" of collaborative interactions between mobile workers and colleagues. Reliable rhythms, they argue, are necessary for ongoing collaboration to work effectively. Churchill and Wakeford observed that breakdowns in reliability, caused by the particular difficulties of mobile work and technological problems, can lead to the subsequent abandonment of particular communication and collaboration media for mobile workers. In relation to these issues, their fieldwork also points to the problems caused by the functional asymmetries between devices that purport to allow access anytime, anywhere. For example, they talk about access asymmetries between email sent from a desktop machine to a mobile device. The mobile device was restricted in its ability to view attachments as well as access to the embedded hyperlink URLs. But sender expectations were that the email was being read with all the levels of access available at the desktop. Since this was not so, there were mismatches in rhythm, leading to problems in ongoing collaborative activity.

Travel is a core component of mobile work. Wiberg and Ljungberg's [1999] ethnographic study of mobile telecommunication engineers in Sweden examined how the work they did was dependent on both time and place. Their results show that travel could not easily be avoided because the workers had to visit places where their physical presence was required (e.g., telephone poles, network routers, locations where new cables needed to be drawn, as well as customer homes). The timeframe in which work had to be conducted was also often not negotiable; for example, customer service had to be provided within 24 hours, rebooting parts of the telephone network had to be done at night. Another important finding was the problem of knowledge sharing among technicians. Since they worked alone in their cars most of the day, they faced the

very real problem of finding out about ongoing developments in other projects. Wiberg and Ljungberg [1999] conclude that the practical limitations of their work made it impossible for the mobile service engineers to conduct knowledge-sharing "anytime, anywhere." Whether this is the case for other types of mobile workers is debatable, but an examination of these issues is long overdue if we are to design really effective mobile technologies.

What we see in these studies is a move toward examining the nature of mobile work. However, this research area is still not populated with a large enough corpus of information to undertake any kind of theory building. The area is further complicated by the increasing adoption of new technologies and organizational work practices. Nevertheless, understanding the nature of the problems that mobile workers face and their artful use of the resources that they have access to *can* provide a rich resource to designers in scoping the design space they will need to work in. The purpose of the current study is therefore to further understand the nature of mobile work by looking at mobile workers' activities carried out before, during, and after business travel. Within this study of mobile workers *in situ*, we focus on how these workers manage information through documents and mobile communication technology.

3. METHOD

From previous work, such as segmentation studies of mobile professionals (e.g., Ablondi and Eliott [1993]), it is evident that there is great diversity in the work that mobile workers do, their modes of travel, and their document and technology use. We therefore felt it important to recruit a sample of mobile workers representative of this diversity. To do this, 17 mobile workers from the UK were chosen from a range of professions. Participants were prescreened to represent different levels of mobility in terms of typical duration of business trips (overnight, day), distance travelled (e.g., within local area, national, or international), type of transport (e.g., plane, train, car), and the extent to which they worked collaboratively. Professions included a variety of management personnel from a range of industries, sales staff, consultants, medical workers, civil servants, and the media. For a summary of the participants, their roles, resources, and patterns of mobility, see Table I.

We were particularly keen to represent frequent air travelers to destinations outside the UK, as well as regular road or train travelers moving within a local area and other parts of the country. For this reason, we did not examine working from home (as a form of mobile work). All participants, bar three, worked in different organizations. The relatively small number of participants meant that we could afford to explore the rich details of their activities, using interviews in which they were able to show us the resources they had described and sometimes even demonstrate their use. The study was not designed to provide a complete survey of mobile behavior, but was intended to be interpretive rather than statistical. Thus, we do not discuss statistics or frequency data here, but examine use-practices and situated activities.

In order to collect rich and detailed information about the interviewees and their work practices, we felt it was important to gather many different

Table I. Details of the Mobile Workers in the Study

Role	Gender	Distance Travelled	Mode of Transport	Duration of Diary Trip	Artefacts Carried on Diary Trip
Regional manager for a market research company	F	Local region	Car	2 days	Mobile, paper notes, paper forms
Corporate relations manager for a communications firm	M	National	Train	Daytrip	Mobile, paper project files, notebook
Regional operations manager for telecoms company	M	National	Car	3 days	Mobile, laptop, filofax
Software sales manager	M	International	Air, Car	1 Week	Laptop, mobile, Psion organiser, phone card
Managing director of an Italian import company	M	International	Air, Train	1 Week	Mobile, product samples, paper notes (on A4)
Account development manager for a major brewery	F	National	Car	Overnight	Laptop, Mobile, filofax, paper agenda, paper presentational material
Business and sales manager for a lab equipment supplier	M	National	Car	Overnight	Equipment samples, mobile
PR consultant	F	National	Train	Daytrip	Mobile, logbook, 'glossy' magazines
Medical research co-ordinator in a large hospital	F	Local region, International	Bus, Train, Subway	Daytrip	Tape recorder, mobile telephone, medical records, paper
International customer services manager for a telecoms company	M	International	Air, Car	2 days	Laptop, notebook, mobile, camera, filofax
International marketing director	M	International	Air, Car	Week	Laptop, mobile, notebook
Civil servant (Executive Officer for Procurement)	M	National	Car	Overnight	Notebook
Sales/marketing manager for a software company	M	National	Car	Overnight	Mobile (borrowed)
Production manager for a television company	M	National	Car	1 Week	Mobile, spare phone batteries, filofax, working folder
Strategic account manager for the product support division of a computing company	M	International	Air, Car	3 days	Mobile, laptop, working files
Business Development manager of a research lab	M	International	Air, Car	3 days	Laptop, papers
Project manager in an e-business application department	M	International	Air, Car	1 Week	Paper project folders

kinds of situated data, and to gain our understanding, as far as possible, from observation and interviews in the actual work settings. This involved gathering a comprehensive set of data covering the full range of communication and document activities of these mobile workers. Interviews alone did not suffice, as people are necessarily selective in what they describe or think is important to discuss. The solution involved using a combination of diary techniques, interviews, and analysis of the artifacts (technologies and documents) used during specific business trips. This grounded the study in real activities and provided a means to unearth the detailed contextual backdrop of the participants' information and communication activities.

We decided the best way to gather grounded data was to plan our interviews around actual business trips, both before and after these trips. In this way, we hoped to gain a longer-term understanding of what happened during travel—from the kinds of preparations made prior to travel, to the minutiae of what actually took place over the whole travel episode. This helped us gain a deeper understanding of the context surrounding the mobile workers' activities. To aid the contextual nature of the interview and to support the interpretation of the data, where possible, interviews were conducted in the participants' usual (static, i.e., nonmobile) workspaces. The workspaces were located in and around London and Bristol, and took place over three months in mid-1999. Approximately 43 hours of interviews were conducted in all, which were tape-recorded and later transcribed. Where appropriate, artifacts were also photographed. A follow-up study was conducted between November 2000 and February 2001 to see how patterns of activity had changed in the meantime; this study examined another five mobile workers from the same profile in terms of their mobility. The study involved a single one and a half-hour interview following a business trip (similar to the second interview of the primary study). No major differences were noted in the behavior and use of technology, other than in increased use of text messaging for personal reasons (mostly to co-ordinate meetings and to send playful messages). Their data is not included in this report, as it did not involve the full interview schedule, and so is not directly comparable—although it is interesting to note that after one and a half years, very little has changed in the activity patterns of mobile workers.

A first interview prior to the trip helped to inform us about the context surrounding the mobile workers' activities—why they traveled, what preparations they made, who they would see and what they were taking with them. This was conducted as close as possible prior to the departure date for the next upcoming business trip—in the majority of cases, two working days or fewer (cancelled trips making up the remainder). The interview was around an hour long, and its purpose was to build up a general background about the participants' work and home life. We explicitly asked questions regarding their positions and responsibilities in the workplace, who they worked with, and the nature and frequency of this collaboration; we then asked for descriptions of "typical" days, so that we were made aware of the difference between their office- and travel-based activities. We also asked for further information about the frequency and type of typical travel. So that we could understand their information, communication, and technology requirements, we asked about their family and social networks,

existing technology infrastructure at home and office, and the availability and use of technologies while they were mobile. The participants were then asked specifically about the upcoming business trip, including the purpose of the trip, its duration, its destination, and whom they were expecting to meet. In terms of information and communication, we enquired about the kinds of information they were expecting to pick up while traveling, the preparations they would have to make before traveling, such as planning presentations (e.g., photocopying, MS PowerPoint slide creation), preparing documents to take with them (and why). Finally, we enquired what technologies they were taking with them (and why). At the end of the interview, the participants were asked to bring any materials (e.g., email, paper, and electronic documents) generated or collected while away to the second interview.

A second interview was carried out as soon as possible after the trip (again, for the majority of interviewees, within two days of return), and was based around the schedule of events that had taken place on the trip in terms of information and communication activities. This interview lasted about an hour and a half on average. Our approach allowed us to ground the study in real activities and to use the trip diaries and existing artifacts to unearth a detailed context for the interviewees' documents and communication. We began the interviews by focusing on an overview of what had happened during the entire trip. The participants were then asked to identify a typical day of the trip in order to unpack it in more detail. This "typical" day was determined in concert with the interviewee: this allowed the participants themselves to highlight the *everyday* nature of their work, rather than the interviewers picking out unusual episodes. A schedule was then constructed of the whole day, from waking to sleeping, framed in terms of travel-, information-, and communications-related activities.

The participants brought material they had generated or collected during the trip to the interview, and discussed it in relation to their activities, goals, and motivations. They were asked what they planned to do with the material, which formed the basis for a discussion on the use and purpose of this material (with respect to their activities, goals, and motivations). To support data collection and its subsequent analysis, a document and communications inventory was taken during the interview. The document inventory involved the compilation of a list of the data (e.g., text, document, scribble, sound, scene) used by the participant prior to the trip, during the diary day, and during the rest of the trip, how the data was acquired or produced, and how it was (or was expected to be) used; e.g., reading the information, distributing it to another person, storing it for later use, and so on. The communications inventory recorded communication episodes (for example, phone calls, email, and fax) during the diary day, the purpose and nature of this communication, and its subsequent use. The inventories collected in these interviews allowed us to investigate the extent to which documents were used in conjunction with communication episodes in the analysis. In a final set of questions, the participants were asked if they had experienced any particular problems in relation to their document-related and communication activities while traveling—these too were recorded in an inventory.

4. FINDINGS

It is no surprise that there was great diversity in the nature of mobile work among the 17 people in this study, and in the ways in which they appropriated tools to accomplish their work. Even the notion of "mobile work" itself was not uniform. The participants in this study were mobile in many different ways, echoing the findings of Dahlbom and Ljungberg [1998]—they worked at multiple (but stationary) locations, walked around a central location, traveled between locations, worked in hotel rooms, worked on moving vehicles and in remote meeting rooms. Participants described their activities involving some or all of these types of "mobile" work, each with its own particularities, constraints, and sets of resources.

Rather than consider each of these kinds of work in turn, we sought to identify common themes or features in the behavior that bound them together. We discovered four key findings about the way in which mobile technologies (both "high tech" devices such as mobile phones and "low tech" artifacts such as paper) were used by mobile workers to maximize flexibility and access to information while on the move. These findings can be summarized as follows:

—preparation for a trip and planning for the unpredictable ("planful opportunism");
—effective use of "dead time" by mobile workers;
—use of the mobile phone as a "device proxy"; and
—use of technologies for remote awareness monitoring.

These four topics are used to explore key notions of resource and task flexibility, how mobile workers make effective use of their time, how they maintain awareness about remote activities, and how they are able to access remote information and devices. While other authors have discussed some of these findings in some form or other, we attempt to explore the issues surrounding them. We demonstrate *how* these activities are used to support mobile work and the ways in which they are interdependent and intertwined both with and within other activities. In the sections that follow we consider each key finding in turn.

4.1 Planning Opportunistic Access to Information

As we have indicated, one of the characteristic difficulties of mobile work is that there is less predictability and more restricted access to information and artifacts. Hence, one of the important features for mobile workers is how to deal with this by planning prior to the trip to make sure the information can be used when and where it is required. We may see this as a paradox, in the sense that planning can be ill-suited to unpredictable circumstances. However, this is to overload our use of the word planning: What we mean is that, in order to flexibly adapt to a situation, mobile workers had to generate workarounds through *ad hoc* activities with the resources that they were able to co-opt at the time. When people know they are going to encounter situations in which they cannot know exactly what is required, they can plan by collecting and carrying particular technologies, documents, and resources. We call this

"*planful opportunism*," in contrast to "opportunistic planning" [Hayes-Roth and Hayes-Roth 1979] in which people make plans spontaneously, reacting to circumstances as they happen.

This planning activity centered on making sure that documents and information are available in the appropriate form when and where needed. Much of the focus was on participants collecting paper documents in a project, or trip, file. Files on particular topics (for example, client records) were printed, photocopied, or collected from filing cabinets. In paper form they could be collated in a common format and then the contents could be selected and configured to conform to the situation at the remote site. To quote one of the participants,

> "So there's about a dozen folders in plastic wallets on my desk and I'll probably be taking about three of them in their current form and probably another one which has sort of components of two or three of those other wallets. So I'm going over with information in my hand…"

The reasons for gathering paper into a single format file is that paper has important characteristics (see Harper and Sellen [1995]) that make it useful for opportunistic appropriation by the mobile worker in a range of circumstances, both predictable and unpredictable. The planned activity and use context are important in making decisions of where, when, and how the information is going to be used. For example, in mobile meeting situations, small amounts of paper were portable enough to be taken to meetings and were immediately viewable for *ad hoc* reference and referral. This permitted the participants to distribute the documents to others for use there and then,[2] and afforded a high level of micromobility Luff and Heath [1998] at the meeting, which made the documents a useful conversational resource. Likewise, paper was frequently used for *ad hoc* reading, as illustrated by the number of participants who printed documents out or deliberately carried paper documents to read if they had any spare time or had to work in places where they could not do other types of work (due to lack of resources). Paper is ecologically flexible, and thus by choosing it as a medium, the participants knew that it could be accessed in contexts where other technologies would be awkward. Ecological flexibility means that carrying paper was perceived as a reliable option. Paper use was not hindered by the complications of technological incompatibility or breakdown, and so was sometimes carried as a backup to electronic documents.

Planful opportunism was also observed in the use of digital technologies, with some particularly elaborate strategies being employed to ensure that access to information in different places and different times would be in appropriate and useful forms. As the following extract from a project manager in an e-business department illustrates, these combined media strategies also highlight the kinds of potential breakdowns in access to and use of information by the mobile worker:

---

[2]Permitted in the sense that no common technological infrastructure was assumed, although conversely, they were also restricted because multiple copies might be required for *ad hoc* distribution, in which case paper can be less flexible than electronic documents.

> "I'll be sending out the slide set which will drive the meeting next Thursday. My feeling is that I'll have good access to cc mail once I'm over there but I may not access to the other information that is on the shared drive.... I'll be moving round from one desk to another and that my experience is that I can't actually log on as myself over in another county because it messes up all the NT settings on the other person's PC so the best I can do is log on to my cc mail on their PC.... I've asked if I can have a lap-top during the week just so that if I do need to do any work in the evenings and I have that capability.... What I'll do is I'll probably [take] a diskette over with me too with the most important documents and just so that I know that I've actually got the information, the electronic information with me. Particularly the slide set you know, the most important documents, I'll probably take both in paper form and electronically because my design session I'll want to be using the electronic version rather than the paper version.... I've e-mailed myself with all my bookmarks so that if I need to get hold of a URL during the week and I can't remember was it on e-mail or did I stumble across it or whatever then I can go into just one e-mail message knowing that the attached file contains all my bookmarks.... I even e-mail myself at home as well so that if I need to do any work in the evening then I've got the right documents there, electronically sent to me...."

This example shows the level of uncertainty associated with mobile work and the different forms in which information is carried and delivered to make it accessible in the appropriate form in the range of places where it will be used for a range of different tasks. The participant quoted above was unsure as to whether he could take a laptop, unsure about whether there would be sufficient reliable email in both the hotel room and the office he was visiting. It is interesting that the ability to send information electronically did not exclude the need to take it on paper.

One of the participants commented that the laptop and mobile phone provided him with access to unanticipated documents, either from the hard drive or via mobile phone, and thereby reduced the need for some preplanning activities. This is indeed an important potential benefit of mobile technologies, and illustrates an interesting relationship between the need for preplanning and the flexibility provided by mobile technologies. However, it is also interesting that, in reality, the participant also carried various paper documents, some available electronically on his laptop. This also applied to a number of the other participants with laptops. There were various reasons given for this: e.g., the possibility that the paper documents would be used as an impromptu conversational resource at meetings or for reading when traveling. The point is that if a document were needed for a discussion it would be to hand in paper form—paper was regarded as being more appropriate in the context of unanticipated use.

Planning behavior, then, is not simply about what documents are needed but also the form in which they are needed to allow appropriate access. For various reasons, laptops do not support the same type of impromptu document access as paper, despite the fact that in theory they offered the potential flexibility to open unanticipated documents from the hard disk or over a network connection. Generally, laptops were not regarded primarily as "casual use or carry devices".[3]

---

[3]The level of casualness varied among participants. One of the subjects, for example, who had a laptop and a mobile phone, downloaded his email at the airport while waiting for his flight.

Impromptu information retrieval via connected laptops was hindered because laptops themselves were subject to planning (should they be taken or not?) While approximately 70% of the participants we studied had access to a laptop, only about half actually took them on trips (most involved an overnight stay). Furthermore, taking a laptop on a trip did not necessarily imply that it would be taken to meetings. What is important here is that this form of laptop-carrying behavior conflicts with potential use in supporting *unanticipated* document and communication needs.

4.2 Working In Dead Time

While it is possible to talk about the purpose of business trips, the nature of work undertaken during these trips is highly varied. The work cannot be usefully characterized simply in terms of the specific purpose of the trip, such as the need to meet face-to-face with a client. To do so would be to ignore the large amounts of time spent outside the trip's scheduled activities (this is characteristic of much business travel). This time was described by participants as "dead" time, "travel" time, "spare" time, or "wasted" time. The common factor was that this time occurred between tasks and between meetings, in which the participants usually had little control over the resources available to them. Work during dead time could take place in a variety of locations (e.g., cars, trains, buses, airplanes, hotel rooms, airports, and office buildings), each constraining the kind of technology that could be used, and hence the kind of work that could be done. Examples include time spent in transit, or in waiting, e.g., in airport lounges or railway stations. When participants knew that they would have periods of dead time, they would often plan ahead to make good use of it:

> "On a completely dead day like I had on Wednesday, I can check some voice mail, check some e-mail but otherwise have an uninterrupted, quiet day in my hotel room. I can just focus. I spent a lot of time sorting loads of notes in my bag. Sorting it in to stuff I could file. This was stuff I had taken away with me. Before l left I knew the Wednesday was going to be clear so my briefcase was full of all these notes I had accumulated and never prioritised the time in order to rationalise them and get them sorted."

In addition, many of the business trips described by the study participants were characterized by multiple meetings for multiple purposes to exploit geographic propinquity (thus saving time, money, and effort). The accounts manager for the brewery, for example, had a management meeting one day, and decided to stay overnight because she had a training meeting next day in the same part of the country. Her overnight stay created a period of dead time in the evening. Likewise, many overseas trips were characterized by multiple meetings spread over several days with long periods of time between meetings.

The need to work during dead time was recognized as increasingly important for mobile workers in managing the growing number of tasks waiting for them at the home office. If the workers wait until they return to complete these tasks, they will have a heavy backlog to catch up with. Working during dead time allows them to distribute some of this workload:

> "It's convenience, to keep on top of it, because if you don't, it will be full and be completely out of control by the time you come back.... Travelling is just part of the job as opposed to a rare event. I'm travelling 2 or 3 times a month so it's part of the job. Staying in touch is important, both from a management of the workload perspective, to make sure there's not this enormous pile, and secondly to be in touch if there is anything that comes up that needs a quick response."

From a design perspective, being explicit about how dead time is used is important because it appears to be a key element of mobile work, with its own distinct characteristics. It is very different from the kinds of activities and contexts in which the more scheduled, face-to-face activities occur during business travel. This can have implications for understanding the different levels of information access required or possible in the particular situations and places where mobile workers find they have some dead time. For example, for those who spend time in cars, the only real work possible had to be done by mobile phone, hands-free or otherwise. Access to information and documents in these instances is not limited by technology only, but by the limitations of human information processing (cognitive loading, attention, memory, etc.) and the physical inability while driving to read and process document-related information.

The exact form that dead time takes for mobile workers can be difficult to characterize due to the range of circumstances in which it occurs. There is a huge variety in, for example, the time scales for certain types of dead time. For example, the time of a break in a meeting is different from the time spent in a hotel room, and the utilization of time in a particular situation requires a particular resource and technology set. Short time periods between meetings or during breaks was conducive to doing work such as making a phone call or checking voice mail on the mobile phone. We found that activities were rarely organized according to priority or urgency, but according to the context in which dead time ocurred and the technological resources available. The work was fit in as and when possible. Hence, the ecological flexibility of a technology is an important part of this activity, the mobile phone and paper being particularly useful in giving access to a variety of resources. As one of the participants said about his use of a mobile phone to access voice mail:

> "It's more accessible because you can do it from far more places geographically than you can email—car, airport lounges, home—as opposed to which email needs to be in the office most of the time. It's also quicker both to connect and to listen to and to respond to."

When time permitted, a few of the participants who had laptops would also use them during dead time to check their email or, very occasionally, create new documents. As the following example illustrates, a participant took advantage of a delay in his flight to engage in some email activity. What is interesting here is the way this was done: the participant utilized a period of dead time in the hotel room to access his email and download it to his laptop, but not to read it. This allowed him to exploit the delay at the airport to immediately read his email messages and write responses to them.

> "Called to see if I could get hold of my wife to say hello, wasn't there, left a message on voice mail and then headed off to LA and sure enough the flight

was delayed so sat in the airport and worked and got through some of those e-mails that had been piling up that I hadn't been able to get to. . . Just basically took my laptop out."

Other types of dead time were less constrained by the time available and more by the environment, in terms of physical and network resources. For example, dead time on the plane was often utilized to read paper documents. This was partly because paper is easy to read and use (as noted above), but also because many of the participants liked to use (and planned for) this uninterruptible time for quiet, reflective reading and annotation. In addition, constraints on available space can impact the type of work that can be done to make use of this time, and therefore the level of document access required. For one of the participants, the work that he could do with a laptop would generally require access to other documents to refer to while manipulating an electronic document on the laptop. The fact that he could not use his laptop and simultaneously access documents from his briefcase meant that he had to restrict dead time to reading paper documents:

"I read a few things on the plane. I don't use laptop on plane. In the back of the plane there is not enough room to use a laptop and have access to your briefcase."

The notion of dead time is problematic and difficult to pin down. We use it because it is analytically useful and because it was frequently used by the participants themselves. What makes it hard to define is its fragility: mobile workers actually make use of this time, so it is not strictly unusable in terms of actions that can be conducted within it. Rather, when workers expect to spend a period of time without communication or the full set of resources to do their work, they use devices and preparation strategies to (at least partially) revive this time. In practice, however, we found that dead time was rarely used as efficiently as it could be. Here then lies a challenge for developers: design devices and services to allow mobile workers to make full use of dead time, taking into account the diversity of environments in which it occurs and the paucity of available resources.

4.3 The Phone as a Device Proxy

One of the main uncertainties that emerged in our study of mobile work is when and where people could have access to technologies and documents such as fax machines and email connections. As it happened, helping to deal with or work around these uncertainties turned out to be the key benefit of the mobile phone. The flexibility of the mobile phone (in terms of where it could be used and its use in problem-solving discussions) allowed participants to access equipment and documents back home or at another location *by proxy*. For example, one of the participants was in his car where he had an hour of dead time available. So he made a call on his mobile phone to a customer about some equipment he was trying to sell. While he was able to give the customer enough overview information to get him interested, the customer wanted full written details before he would commit to buying. Here, the phone call was not sufficient to make the sale because the customer needed time to look through the details

more closely and in his own time. Hence, there was a need to support verbal communication with some form of paper-based visual information to meet the customer's needs. The solution was to fax this information to the customer in support of the phone call. But the participant did not have access to a fax machine in the car, nor did he have the information in a document at hand, so he made a call on his mobile phone to his office requesting that they find the necessary document and fax the full details to the customer.

This example is interesting because the participant did not have access (in the sense of being able to forward the information to the client) to the information necessary to complete the demands of the phone call. Predicting the need for taking the document along was not possible due to the ad hoc nature of the phone call during what was otherwise dead time in the car—not only was the technology not available to send the fax, neither was the document. So while a mobile faxing device would have been useful in situations like this, it should also be understood that the mobile worker will often not have the information to compose the fax.

Other examples of the phone as a device proxy include dictating letters and accessing and responding to email:

> "I could ring up the office normally and speak to my secretary, she does shorthand and she can type it as quick as I can say over my mobile phone, you know, letter to so and so, really urgent, must go out, dear Mr so and so reference our conversation, I have pleasure in quoting you for this blah, blah, blah, that's the price Linda, you know, and she'll end and whatever it, and I'll say nip in my drawer and get the technical information, get it in the post this afternoon, he's really chasing it. You know, that sort of thing happens but I can do that on the phone. I can do most things verbally."

In another instance, a participant who was unable to connect remotely phoned his office to get someone there to log into his email account and read any newly received email aloud. He then dictated his reply over the phone, it was typed up and sent off as an email. However, although the telephone can act as a device proxy, it is not always ideal for the job:

> "I mean I use a mobile telephone probably because I haven't got a mobile fax, it would be nicer for me because I find myself ringing up one person in the office and I might ring him up ten minutes later to say I'd forgotten something so if I could sort of you know during the day jot down everything I had to tell one person in the office and send off a fax then you've also got the written record and so it's safer."

While it may not be the perfect tool, the phone allows the mobile worker to achieve important goals without investing a lot of effort in locating or carrying specialized information or communication appliances with them. In this respect, the mobile phone provides a workaround to help reconstitute in a flexible manner some of the resources normally available to the office worker as and when the need arises, by allowing operation from a remote location, if not by directly operating them remotely. Thus, mobile workers do not need to carry their offices with them, but do carry the means by which they can access (at least a degree of) their functionality.

4.4 Remote Awareness Monitoring and Access to Colleagues

Maintaining informal awareness of what is going on in the office and building a sense of community are important features of work. Evidence for this is seen in the workplace design literature (e.g., Tanis and Duffy [1999]) and in studies of informal communication [Heath and Luff 1991; Whittaker et al. 1994]. In the office, information that may or may not be useful to the worker is picked up incidentally throughout the course of a normal work day, by, for example, bumping into people in the corridor or being interrupted by someone.

One of the problems faced by mobile workers away from the office is how to maintain this informal awareness of what is going on back at the office and also how to maintain a sense of community at work. Mobile technologies can potentially help support these aspects of work, and, we saw some evidence for this in our study. Workers who took laptops on business travel were able to maintain some sense of connection with the workplace via email. However, email activity typically took place at the end of the day in a hotel room, when there was time to download it and network access was available.

Use of the laptop (and thus access to email) was much less frequent than that of the mobile phone. For many of the study participants, inability to access email anytime was partially ameliorated via use of mobile telephones to touch base and keep up-to-date with developments at the home office. They found it useful to phone the office just in case anything urgent had arisen, so that they could monitor developments. They also used the mobile telephone to keep abreast of general contextual issues that could impact their understanding of situations, and therefore their jobs. This was important not just for dealing with issues while away, but also to help with the catch-up period on returning to the office.

In practice, obtaining this information was not always a matter of urgency, and could be done at convenient points during the day. The kind of information the study participants required was not something that could be specified easily and was not predictable in terms of what it was needed for and when. Such requirements were met by the synchronicity of phone communication, adding to the value and consequent ubiquity of mobile phones within the mobile worker community. Such phone calls also had an element of social banter that helped to maintain the social connection at work while the callers were away from the office:

> "We've always had a habit keeping ourselves, keeping one another up to date as the day goes on… if he's down in London I would say you know OK we've had a brilliant day or we've had a bad day you know we've just got a habit of doing that… sometimes it's just social banter you know: he'd say he had a good day, he had a bad day that type of thing, and by the way I bumped into so and so, do you remember him you know we saw his project a year ago when it crashed, you know ooh wasn't it good you know just that type of thing. He rang me a couple of times just to say yes that order he had expected to come off had happened or it hasn't."

Being called, as opposed to calling out, on the mobile phone also worked as a personal locator—a continuous contact point that was equally important

in keeping the mobile worker informed of general information and of unpredictable, important information throughout the day.

5. DISCUSSION

While we have focused on mobile work as a phenomenon in its own right, we do not argue that it is the mobility, *per se*, that motivates much of what mobile workers do. Rather, the evidence suggests that much of what determines what they do can be explained in terms of the limited resources available to do their work, as well as the ways in which these resources change depending on the context of the work. Taking this as a starting point, we can begin to see how activities are related to different settings (while traveling, in meetings, between offices, and so on) in which mobile work is done. We can also begin to see how uncertainty about available resources, and the contexts in which mobile workers find themselves, determines their activities.

For example, some of the strategies engaged in by our mobile workers centered on ways to ensure flexibility and adaptability, such as planful opportunism and the use of versatile artifacts such as paper and mobile phones. The need to support flexibility is why the notion of *access anytime*, *anywhere* has become such an important mantra in the development of mobile technologies. When thinking about design issues in relation to mobile technologies, however, the terms, as they stand, are too abstract to be useful. To be truly useful, it is necessary to use empirical findings (such as those in this article) to unpack exactly what these terms mean.

Information "access" is not simply about having the capability to pull the appropriate document across a network. From the perspective of the mobile worker, the notion of access needs to be extended to include *how* the document is used and whether it is in the appropriate form for viewing and interaction. As an illustrative example, connected laptops allow "access" to documents, in that they allow the mobile worker to pull documents over a network. However, for certain tasks, such as reading and understanding long documents, the laptop may be an inappropriate medium. Here access to the document is inappropriate in that it fails to support the same kinds of interaction or "getting to grips" with a document as paper does [O'Hara and Sellen 1997]. The issue of restricted access becomes even more important when considering the emergence of PDA and phone-based data and document access facilities on the Internet, which offer immediate, but even more constrained, viewing facilities than does a laptop. There will be situations where hand-held devices are fine for exchanging documents with other hand-held appliances, but without appropriate devices to support viewing (such as a display or a printer), they offer limited access for practical use. The point here is not to criticize the utility of these devices, for they clearly offer the mobile worker increased access and flexibility, but to show that they may not offer the ideal level of "access anytime, anywhere" initially promised.

In terms of "anytime" access there are also important distinctions from the users' perspective highlighted by findings from the study: for example, when a mobile worker is in a meeting and needs a document to refer to in a conversation. The need for that document is short-lived, creating a small window

of time during which access is appropriate. In these circumstances, the cost in time to access the document over a network, for example, is of the wrong order of magnitude. So while from a technological perspective it is possible to access the document anytime, from the perspective of the mobile worker there are practical limitations. Further examples of distinctive notions of "anytime" can be seen in some of the communication practices in the data. Mobile workers were able to use small amounts of time between meetings to make phone calls or access voice mail and respond accordingly. Compare this to the email communication while mobile, which was typically checked and responded to at the end of the day, due in part to costs in time and effort. From the perspective of the mobile user, both of these mobile communication technologies operate at different orders of magnitude of time. That is, a mobile phone is useful during smaller units of time, so it could be used "anytime" a small unit of time becomes available. Downloading and checking email with a laptop, however, take up longer units of time, so typically could only be carried out "anytime" a larger unit of time becomes available. Obviously, longer time units are less frequent than smaller ones, which are more exploitable by the mobile phone. As a consequence of operating at indifferent orders of time, the various communication devices provide different values to their users (such as the speed at which they could communicate while on the move).

The understanding of "time" in "anytime" can be further complicated by what Jauréguiberry [2000] described as "simultaneity": the superimposition of activities on top of one another, so that multiple activities can be performed at the *same* time. This can be seen in the simple example of someone who both drives and uses the mobile telephone; this would not have been possible prior to the introduction of the mobile, single-hand telephone. Here, "One is not substituting one activity for another, or dealing with a task more quickly" (ibid., p. 257). This complicates the rather simplistic notion of working *anytime*. The layering of work on top of other work and intertwined with that other work (driving to a meeting and simultaneously arranging its location) means that technology designs based on the one-dimensional notion of *anytime* will not be focused on the very work that the designers want to support.

While time and place are inextricably linked in many ways, it is nevertheless useful to unpack the notion of *anyplace* by itself. Places can be described at many levels of granularity, each of which is important from the perspective of portable technologies and artifacts. For example, laptops were sometimes transported from city to city, but not necessarily carried from meeting to meeting at the same location. Likewise, large briefcases full of client files were easily transported from city to city in a car, but it would be inappropriate to take them all into a meeting. The physical form of these objects does not facilitate "casual" carrying and prevents them from being ubiquitously available to the mobile worker— so that in unexpected circumstances their use is limited. Further, within a meeting room, there are finer levels of granularity in terms of how documents and artifacts are moved to support conversation (cf., Luff and Heath's [1998] notion of micromobility).

For mobile workers there are other findings in the data that illustrate additional distinctions between places in relation to infrastructure issues. Consider,

for example, study participants who sent files to both personal and work email addresses because each was easier to access from either a hotel or office, respectively. Firewalls complicated access to email outside the office increasing the potential for access difficulties from the hotel. Thus, for this participant, the personal email address provided the easiest way to access information from the hotel.

These distinctions in the meaning of the terms above have particular importance when we consider that mobile work is not just about the primary purpose of the trip (e.g., a meeting), but also about the related dead time activities. The depiction of dead time in the data points to the different forms of access, over a variety of times and places, required by the mobile worker. A range of resources and strategies are used by the mobile worker to achieve different types of access, constrained by where the workers are and the time available to them. Understanding the values of new and emerging technologies partly depends on understanding how they are co-opted by mobile workers during dead time. For example, understanding the various levels of access to a document for a particular dead time activity can explain why that document is taken on a trip in a particular medium. A mobile worker may choose to take a document in paper form so that it could be read and reflected on during time spent on a journey. Alternatively, an electronic copy may be taken in order to manipulate a document in a hotel room for later use as a report or presentation.

Perhaps one of the most interesting findings of the study is how mobile workers use other, remote, co-workers to access information and devices. Work becomes explicitly collaborative as the mobile worker attempts to co-ordinate events in his or her local environment with remotely accessed resources. Talk is central to mobile work, and the telephone is the key supporting technology. By themselves, data-enabled mobile devices and miniaturized desktop technologies may not create more effective mobile workers. Unlike the futuristic image of a "road warrior" who carries a range of technologies around with him, we see a leaner individual, more adaptable to changing circumstances and to manipulate the environment and collaborate with others to carry out work. As we have seen in this study, mobile workers frequently make use of the flexibility built into the technology to do things that it was not explicitly designed to do. Perhaps, as designers, we should design tools that can be co-opted flexibly to meet the unexpected contingencies of mobile work. "Designing for unexpected use" is not a novel idea [Robinson 1993], but in a development environment in which targeted mobile device functionality is accelerating, we need to reconsider the benefits that such technologies bring.

In terms of direct implications for the design of technology, this study may inform the development of a number of possible avenues. The technologies that would have supported the behavior of several mobile workers we interviewed would have the following properties:

- Be lightweight and highly flexible, rather than highly specific, integrated systems. Technologies that could be adapted to a variety of situations would be more useful than highly complex and powerful, but single-use, devices. There is a clear demand by the participants for tailorability in the

information and device sets that they carry around with them, particularly while traveling.

- Allow more effective planning of activities and flexible allocation of resources. Technologies such as shared group calendars that could be accessed and updated remotely would be useful, in that they would allow workers while mobile to co-ordinate with others in their organization.
- Support effective use of dead time to plan for upcoming mobile activities and catch up with nonmobile work. An important fact in respect to dead time is that it is often (although not always) short—making "instant on" devices that do not require lengthy boot-up times essential. Also, much dead time is only available when mobile workers are engaged in other activities (e.g., while driving), and thus cognitive and physical demands need to be minimized. Voice (for information access and data entry) in these environments would be particularly useful due to the low demand on the user's visual attention.
- Allow the location, use of, and access to locally available resources (e.g., through Bluetooth). This might involve a system through which local technologies could be "captured" by a mobile telephone or mobile data device, to print, scan, and otherwise access or make available information from a remote source (perhaps paid for by some kind of micropayment).
- Allow monitoring of remote activities more easily, perhaps through radio, or reduced-bandwidth mobile voice over IP ('VoIPoMo'), carrying sounds from the office (over GPRS or another 3G system; see also Mynatt et al. [1998] "audio aura"), or the use of subscriptions to text-based office information (see, for example, Fitzpatrick et al.'s Elvin [1999]), broadcast over WAP, or SMS/text messaging.

The data show a demand for immediate and easily accessible information, and there are obvious links with the high bandwidth, "always on" technologies of GPRS (General Packet Radio Service), and 3G (3rd generation) data telecommunications technology. However, much of the material that the participants required was already available to them (albeit nonoptimally, and requiring some effort to access and transform into a useful form) through social networking and the telephone. How much users, or businesses, would pay to access additional information on top of what they were already able to access is, of course another question. But the additional utility that they would (ostensibly) benefit from is also questionable. In many cases, the workarounds that the participants employed appeared to be acceptable to them, with minimal weight and size overheads, and at the same time were flexible enough to be useful in a range of different situations.

6. CONCLUSION

While there are some more obvious solutions for the design of technology, the point of this discussion is not to advocate particular designs for particular devices. Rather, the aim is to encourage reflection about work and technology from the perspective of the kinds of resources mobile workers need access to, and how those needs change depending on where the workers are, the time they

have available, and what they are doing. For example, examining these issues can help us understand why paper continues to play such a key role in mobile work, due to the type of access it supports across a wide range of timescales and places. But examining these issues also shows some of its drawbacks in terms of access across distance. Similarly, it can help us to understand what has made the mobile phone so important in terms of time and place and its ability to mimic different levels of access by proxy. Understanding the kinds of access the mobile phone does not support, such as visualizing information, can help us to judge the potential value of emerging data and document services. It can also help us to think about what might be required of a wider technology ecology to support documents and data services such as ubiquitous displays and printer technology for viewing information.

In addition to this analysis, this article also highlights the *mechanisms* by which mobile workers organize their actions, both as individuals and in order to co-ordinate their activities with others. In many ways, it is not simply interesting to note that various artifacts played into different activities, but it is especially useful to know *how* they were used in the organization of work. In particular, we can see both the mobile aspects of the work and how its everyday or nonmobile aspects intrude into the mobile component of work. The two appear indivisible, and technology that only supports the mobile component will not support a large component of its users needs.

In this article we have illustrated some of the unique characteristics of mobile work in terms of its unpredictability and uncertainty. A key feature of mobile work lies in the strategies used to create the necessary flexibility and adaptability necessary to operate in the context of the uncertainties faced by mobile workers. Understanding these strategies and their underlying motivations depends on more than simply saying they want access to information anytime anywhere. We hope to have shown that only by unpacking these terms more systematically from the perspective of the user can we begin to understand the role of certain key technologies and artificats in mobile work and to have shown where potential opportunities may exist for new mobile technologies and services.

ACKNOWLEDGMENTS

REFERENCES

ABLONDI, W. F. AND ELIOTT, T. R. 1993. Mobile professional segmentation study. In *BIS Strategic Decisions*.

BELLLOTTI, V. AND BLY, S. 1996. Walking away from the desktop computer: distributed collaboration and mobility in a product design team. In *1996 Proceedings of the Conference on Computer-Supported Cooperative Work* (Boston, MA, Sept. 17–20), ACM Press, New York, NY, 209–218.

BERQVIST, J., DAHLBERG, P., LJUNGBERG, F., AND KRISTOFFERSEN, S. 1999. Moving out of the meeting room: Exploring support for mobile meetings. In *1999 Proceedings of the Conference on Computer Supported Cooperative Work*. ACM Press, New York, NY, 81–98.

CHURCHILL, E. F. AND WAKEFORD, N.   2001.   Framing mobile collaboration and mobile technologies. In *Wireless World*: *Social and Interactional Implications of Wireless Technology*. Brown, B., Green, N., and Harper, R. Eds., New York, NY, Springer-Verlag.

DAHLBOM, B. AND LJUNGBERG, F.   1998.   Mobile informatics. *Scandinavian J. Inf. Syst. 10*, 227–234.

ELDRIDGE, N., LAMMING, M., FLYNN, M., JONES, C., AND PENDLEBURY, D.   2000.   Studies of mobile document work and their contributions to the satchel project. In *Personal Technol. 4*, 102–112.

FITZPATRICK, G., MANSFIELD, T., KAPLAN, S., ARNOLD, D., PHELPS, T., AND SEGAL, B.   1999.   Augmenting the everyday world with Elvin. In *Proceedings of the 6th European Conference on Computer Supported Cooperative Work.* Bødker, Kyng and Schmidt, Eds. (Copenhagen, Denmark, Sept. 12–16), Kluwer, Netherlands, 431–450.

HAYES-ROTH, B. AND HAYES-ROTH, F.   1979.   A cognitive model of planning. *Cognitive Sci. 3*, 275–310.

HARPER, R. AND SELLEN, A.   1995.   Collaborative tools and practicalities of professional work at the International Monetary Fund. In *Proceedings of the CHI '95 Conference on Human Factors in Computing Systems* (Vancouver, B.C.). ACM Press, New York, NY, 122–129.

HEATH, C. AND LUFF, P.   1991.   Collaborative activity and technological design: Task coordination in London Underground control rooms. In *Proceedings of the 2nd European Conference on Computer Supported Cooperative Work* (Amsterdam, the Netherlands, Sept. 25–27). Bannon, Robinson and Schmidt, Eds. Kluwer, the Netherlands.

HENNING, J. AND BRAGEN, M.   1994.   Mobile professionals in focus. *BIS Strategic Decisions.*

JAUREGUIBERRY, F.   2000.   Mobile telecommunications and the management of time. *Social Sci. Inf.* (*Information sur les Sciences Sociales*), *39*, 255–268.

KRESTOFFERSEN, S. AND LJUNGBERG, F.   1999.   Making place to make IT work: Empirical explorations of HCI for Mobile CSCW. In *GROUP'99*: *Proceedings of the International ACM SIGGROUP Conference on Supporting Group Work* (Phoenix, AZ, Nov. 14–17), ACM Press, New York, NY, 276–285.

LAMMING, M., ELDRIDGE, M., FLYNN, M., JONES, C., AND PENDLEBURRY, D.   2000.   Satchel: Providing access to any document, any time, anywhere. *ACM Trans. Comput.-Human Interaction*, *7*, 3, 322–352.

LUFF, P., HEATH, C., AND GREATBATCH, D.   1992.   Tasks in Interaction: Paper and screen based documentation in collaborative activity. In *Proceedings of the CSCW '98 Conference on Computer-Supported Cooperative Work* (Toronto, Canada), ACM Press, New York, NY, 163–170.

LUFF, P. AND HEATH, C.   1998.   Mobility in collaboration. In *Proceedings of the CSCW '98 Conference on Computer-Supported Cooperative Work.* ACM Press, New York, NY, 305–314.

MYNATT, E. D., BACK, M., WANT, R., BAER, M., AND ELLISS, J. B.   1998.   Designing audio aura. In *Proceedings '98 Conference on Human Factors in Computing Systems* (Los Angeles, CA), ACM Press, New York, NY, 566–573.

O'HARA, K., PERRY, M., SELLEN, A. J., AND BROWN, B. A. T.   2001.   Exploring the relationship between mobile phone and document use during business travel. In *Wireless World*: *Social and Interactional Implications of Wireless Technology.* Brown, B., Green, N., Harper, R., Eds. Springer-Verlag.

O'HARA, K. AND SELLEN, A. J.   1997.   A comparison of reading paper and on-line documents. In *Proceedings '97*, *Conference on Human Factors in Computing Systems* (Atlanta, GA). ACM Press, New York, NY, 335–342.

ROBINSON, M.   1993.   Design for unanticipated use..... In *Proceedings of the Third European Conference on Computer-Supported Cooperative Work.* De Michaelis, Simone and Schmidt, Eds. (Milan, Italy, Sept. 13–17). Kluwer, the Netherlands, 187–202.

TANIS, J. AND DUFFY, F.   1999.   A vision of the new workplace revisited. In *Site Selection.*

WHITTAKER, S., FROHLICH , D., AND DALY-JONES, O.   1994.   Informal workplace communication: What is it like and how might we support it? In *Proceedings '94 Conference on Human Factors In Computing Systems.* ACM Press, New York, NY, 131–137.

WIBERG, M. AND LJUNGBERG, F.   1999.   Exploring the vision of anytime, anywhere in the context of mobile work. In *Knowledge Management and Virtual Organizations*, Y. Malhotra, Ed. Idea Group Publishing.