Mobile Information and Communication Technologies: integrating technology for practical use

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INTRODUCTION

The decreasing cost of mobile technologies and telecommunications service provision has revolutionised the take-up of mobile communications technology. Complementary to this rapid proliferation of mobile technologies, we have recently seen the beginning of a convergence of mobile communications and data technologies alongside a variety of newly designed standards, protocols and technologies that allow the more flexible interconnection of handheld information appliances. As evidenced by these proposed standards and technology developments, there is now an increasing interest by the telecommunications industry into supporting mobile data connectivity in addition to voice-based communications. This goes far beyond supporting simple voice and modem based communications. Whilst data transfers are currently possible, these proposed technologies will support increased levels of flexibility, speed and processing power for data communications.

These new developments and research into the area have been largely technologically driven. Human factors research has largely focused on the design of small screens and interface navigation. Little research has been conducted on the 'use' of devices in collaboration and other work activities. As a consequence, we can only guess how these new standards, protocols and technologies will change work patterns or will be integrated together into task-centred suites of technology (either as designed, or developed by users in an *ad hoc* fashion). We need to investigate the design and the deployment of mobile information and computing technology (MICT) from a user-centred perspective and understand how information is used where people are no longer fixed to permanent or semi-permanent locations.

Recent changes in both work and communications technologies have led to a shift in working patterns, so that across a range of organisations, a model of work where the employee has a desk and a rich, fixed set of informational and technological resources is no longer appropriate. However, with a few honourable exceptions, few studies exist that tell us much about how mobile workers operate, the sort of work they perform and the problems that they encounter. If we are to develop appropriate technologies to support mobile work, we need to understand the tasks that users are engaged in, the access to information that they have, and how they collaborate with their colleagues (who may be mobile or static). We need to motivate a research programme that will expose the collaborative and informational requirements of mobile workers and to show how mobile technology can be effectively designed to support their needs.

THE DESIGN AND USE OF MICT

The definition used here of MICT includes remote hand-held computing, networked computing, and wireless communications technology (audio, fax, voicemail) to operate. It is distinct from either mobile computing or mobile communications, because it integrates the communications and computing elements together, providing capabilities that neither can offer alone. Similarly, designing user-centred MICT devices will be different to the design of any of its stand-alone component parts, because of their tight integration and use in novel environmental settings.

Human computer interaction (HCI) and computer-supported co-operative work (CSCW) have long examined how to support interaction with devices and communication with other people through the use of appropriate technologies. A large body of research now exists in journals and conference proceedings that systems designers can make use of when designing technology. However, this research has been done in very specific environments and where users have a particular set of resources with which to work. Because of the physical constraints of mobile systems (e.g. weight, screen size, battery consumption, connectivity failures) and the nature of mobile work (distributed and highly dynamic), interaction designers need to review their development techniques and methodologies for this new generation of computing devices.

In terms of activity, mobile work has been described as *heterogeneous* (Kristofferson and Ljungberg, 1999) in that its context is constantly changing as people interact and reorient themselves to their environments. Little existing research and few of the MICT systems developed have directly applied themselves to such work settings. This is perhaps strange when numerous studies of work have shown that people spend much of their time working away from desks and offices (e.g. Bellotti and Bly, 1996).

Users of mobile devices are confronted with a situation in which technologies and services are being designed

without a detailed understanding of what contexts these systems are being used in and what their users' informational requirements are. This is similar to the situation that desktop computer systems were in 20 years ago, yet it appears that little is being done to address the situation. Neglecting this in the design and implementation of MICT systems could lead to an increased workload or even a contrary requirement for non-mobility. For example, Luff and Heath (1998) showed how a mobile data recorder used for record keeping did not support the kinds of collaboration that was possible using paper records. As a consequence, workers recorded their data twice - once onto paper and again into the 'mobile' computer system at a later time when they were back at their office desk. Had the designers of the device understood or accounted for the collaborative nature of the work, they could have presented a design more appropriate to the requirements of these workers.

MEDIA, CO-ORDINATION AND COLLABORATION

Research findings from a previous study (Perry *et al.*, unpublished) have demonstrated strategies through which mobile workers make use of the resources that they have available to them. To effectively make use of the time that they have when travelling, mobile workers can co-opt the resources that they find available to them, but they can also plan ahead to take things with them that they may require. This *preplanning* for contingency is often an essential feature of the work. Mobile workers also needed to keep up with their ongoing background work activities, rather than only working when they had a complete office infrastructure. The flexibility of the mobile telephone allowed them to distribute this workload and to work in otherwise '*dead time*'. The other resources that allowed them to do this were pen and paper - a technology with a low interactional overhead that could be used in a wide variety of environments. The mobile telephone also allowed its users to operate other technologies by *proxy*. When they were in resource-poor surroundings, the mobile workers used the mobile telephone to access external devices (e.g. fax machines, email) and documents. They could also use the mobile telephone when they were away from their home base to *monitor activity* back in their main office, something that they tended to do in dead time. Technologies could be built to support these strategies more effectively, linking the different technologies and integrating them more closely with their work practices.

All of the factors noted above had a technological component that the mobile workers made use of. However, the infrastructures and compatibility issues thrown up in their use of the technology often frustrated users. These are clearly areas requiring support. There also appear to be a variety of ways in which people integrate their use of telecommunications and documents (O'Hara *et al*, 2000). The data suggest regularities in the use of the combined document and telephone, particularly their use in *negotiation and discussion* (documents triggering phone calls, and document discussion during a phone call), in providing an *audit trail* (phone confirmation of document receipt, and conversely, the document as a record of a phone call), and in *elaboration* (phone calls that elaborate on a document, and documents to elaborate on a phone call). Documents generated from phone calls could be taken as notes (semi-synchronously), or as a larger, more formal follow-up document (asynchronously). Here, flexible access to documents and integration with voice-based communication would be of enormous benefit to mobile workers.

Mobile communications technologies need to support a range of different types of activity, between the mobile user and their offices, between several mobile users, and between the range of devices that the mobile user carries with them. When deconstructed, the notion of mobility or 'mobile work' - perhaps unsurprisingly – is a diverse one. Whilst mobility can be related to occupation, it can differ within an individual's working day. Mobility can be described as being of many kinds - working at multiple (but stationary) locations, walking around a central location, travelling between locations, and working in hotel rooms, on moving vehicles, or in remote meeting rooms. Mobile workers have described their activities involving some or all of these types of work (Perry *et al*, unpublished), each having their own particularities, constraints and access to resources. These are important features of mobile work that should influence the design process; they provide a wide set of different requirements, and technology developers need to understand and take account of them.

NEW TECHNOLOGIES, NEW OPPORTUNITIES

The range of recent and emerging technologies will vastly increase the computing power and connectivity available to mobile workers. The 'next generation' of communications devices will build on developments in distributed systems, such as the use of Suns' Java and Jini, Hewlett-Packard's JetSend, and XML (eXtensible Markup Language), and in mobile computing, such as WAP (wireless application protocol) and Bluetooth, time-difference-of-arrival location processing (TLP) or tracking GPS, 3G and GPRS. Simple explanations of the less known technologies and standards are given below.

Supporting collaboration at a distance. 3G ("third generation") and GPRS (General Packet Radio Services) are technologies that provide an infrastructure for a high bandwidth (broadband) data channel for mobile communications devices. They will provide users with a faster and consequently more synchronous medium for data communication than at present, enabling a more flexible form of collaboration around documents and data than is currently possible. TLP is a system that allows location pinpointing by triangulating the signal from a mobile telephone between its reception at different

position-fixed receivers. Currently, pinpointing technology is inaccurate (within 125m), but future generations of the technology will allow relatively precise positioning. These technologies potentially enable users of mobile information and communication systems to become more autonomous as the sender is able to retrieve location-specific information and the receiver can be made aware of the sender's geographical position.

Supporting local interactivity. Bluetooth is a technology specification that provides short-range radio links between devices. When Bluetooth-enabled devices come into range with one another, they automatically detect each other and establish a network connection. JetSend is a communications protocol that allows devices - printers, scanners, handheld computers, digital cameras and others - to interact without user intervention using a radio or infrared connection. Similarly, and complementary to JetSend, Jini-enabled devices (based on Java technology) allow devices to dynamically connect to impromptu networks automatically, without planned installation or human intervention. Devices identify themselves to the network and offer their services to it, for example allowing a digital camera to locate a printer, and to print over a network connection without the need for configuring a network address or loading a printer driver into the camera. Bluetooth, JetSend and Jini-enabled devices will be able to build local information services around the user supporting enhanced flexibility for information access and technology appropriation.

A RESEARCH AGENDA FOR FUTURE COMPUTING

Current approaches to designing mobile information devices follow a model of work that attempts to reproduce tools from the desktop environment onto a small hand-held device with limited communications bandwidth. Rather than taking a technology-centred perspective, we need to push the user-centred perspective. If we understand the nature and context of mobile work better, devices that are matched to the work, and not existing (and perhaps inappropriate) design paradigms, could be developed. To achieve this, developing considered approaches to the integration of mobile devices with one another and to other networked information sources will be of paramount importance.

We need to explore and develop hybrid devices to augment the mobile activities uncovered from real world data from the field studies. This development effort will necessarily have to differ from more traditional HCI and CSCW approaches, building both software and developing hardware in the form of hybrid devices (linked information and communications appliances). An example (although *not* one we would propose developing without supporting field data) of such a hybrid device might be to use a handheld computer fitted with a modem linked to a mobile telephone and a digital camera. The handheld computer could be used to send an email enclosing a digital image from the camera over the mobile telephone, whilst also keeping a record of the communication that could be accessed later. In this case, software and hardware are tightly integrated and cannot sensibly be seen as independent from one another. We expect development efforts to focus on integrating technologies that allow users to manage distributed information from mobile settings, and in providing context-relevant information appropriate to their needs.

As a community, we need to develop a more thoughtful approach to the design of MICT systems. There are very few published studies of, or standard approaches to, the development of handheld MICT devices (with exceptions, see Kiljander, 1999). New, or adapted evaluation techniques will be needed to examine how mobile workers integrate mobile technology into their work practices, how appropriate the technology is to their work, and where the technology changes that work. Our challenge is to integrate this technology for *practical* use.

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