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Defining the Mobile Work Domain

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Abstract

There is increasing interest in the application of ubiquitous computing concepts to the use of mobile and wireless technologies in business. This paper presents the results of a conceptual study of the literature in ubiquitous and mobile computing and related areas. The outcome of the conceptual study is a context model of an identified Mobile Work Domain (MWD) which is focussed on mobile commerce and the use of new technologies and approaches to business processes in the workplace. This framework and context model comprises existing domains of activity and research, including electronic commerce, computer mediated communication and computer supported collaborative work and the new domains emerging from the relationships between these domains. Specific issues regarding mobile business are also identified and discussed including work domains, usability, context, software and infrastructure.

Keywords

Electronic Commerce, Mobile Commerce, Collaborative Work Systems, Human Computer Interaction

INTRODUCTION

Increasingly the terms “ubiquitous computing” and “pervasive computing” are being used to describe the third wave of computing (Weiser, 1991). The first wave was characterised by a mainframe computer servicing many terminal users or a “one computer: many users” model. The second wave is characterised by networked desktop computers or a “one person: one computer” model. The third wave is characterised by single users having fixed or wireless networked access to many computers or other networks. This has been called the “one person: many computers” model (Weiser, 1991). The term ubiquitous computing is also being used together with the term “mobile computing” although mobile computing is neither the same as ubiquitous computing nor a subset or superset of it (Russell and Weiser, 1998; Weiser, 1993).

Ubiquitous and pervasive computing describes a philosophy where technology recedes into the background of people’s lives and activities, where computing technology is a part of life and is embedded in the environments in which human beings live and work. People operating in ubiquitous environments need “invisible”, unobtrusive computing and computing devices that are constantly connected, continually available, portable and intuitive. Nomadicity or nomadic computing is defined as the systems support needed for providing “*…computing and communication capabilities and services to nomads as they move from place to place in a transparent, integrated and convenient form*” (Kleinrock, 1997). Ubiquitous and nomadic environments include not only mobile devices such as mobile phones, PDAs and the like, but also wearable computers and smart buildings. In contrast, digital cameras and MP3 players are portable and digital devices but that does not make them necessarily part of an ubiquitous or mobile environment.

Some elements of ubiquitous computing require mobile technologies (including wireless, infrared, bluetooth, and microwave technologies) for implementation. None of these technologies on their own are necessary or sufficient for the implementation of ubiquitous computing environments as defined above. Future generations of communications

environments will consist of high speed, wired backbone and wireless LANs with extended coverage of broadband services providing ubiquitous network access to mobile users.

These developments have come about due to the increasing number of connected computers in the environment and also by the convergence of advanced communications, Internet and wireless technologies. This new environment based on a mix of wired and wireless technologies and the associated devices requires new protocols, new ways of building systems and new ways of interacting with systems. The purpose of this paper is to review current research in this new environment and provide a framework for future research in the area of mobile and associated technologies and approaches in business process environments.

Section 2 of this paper describes the research approach used in this study. Section 3 of the paper reviews early and related work undertaken in the area of ubiquitous and mobile computing including the evolution of a mobile environment. Section 4 defines the Mobile Work Domain and associated context model. Section 5 describes and discusses some of the research issues that need to be addressed in the mobile work domain.

RESEARCH APPROACH

Since research in the area of the application of wireless and mobile technologies in business and the workplace has so far been limited, there is a need to develop a framework for future research projects. The approach taken in this paper is to report a conceptual study of the literature. The outcome of the conceptual study is an identified framework called the Mobile Work Domain (MWD) and an associated context model.

The conceptual study research approach (Keen, 1991; Shanks *et al.*, 1993), also called the argumentative/ subjective approach (Galliers, 1992:152), *"...involves the articulation of subjective beliefs about an area of investigation"* (Shanks *et al.*, 1993:39) and is based *"...more on opinion/speculation than observation, thereby placing greater emphasis on the role/perspective of the researcher"* (Galliers, 1992). A conceptual study can be used to review existing bodies of knowledge as well as actual situations. Building a framework or conceptual model to represent a body of knowledge based on the researcher's interpretation of the literature can be considered a conceptual study (Webster and Watson, 2002) and this is the research method used in this project.

EARLY AND RELATED WORK

Early and related work in the area of mobile and ubiquitous computing is worthy of examination to help understand where the technology has come from and help predict its future. A number of early and related projects are described below.

Xerox PARC

The ubiquitous computing movement started in the Electronics and Imaging Laboratory of the Xerox Palo Alto Research Centre (Xerox PARC) in the late 80s (Weiser *et al.*, 1999). In 1987 the ubiquitous research program began with the development of large, wall-sized, flatpanel computer displays from silicon sheets which it was hoped could also act as input devices similar to scanners. This work led to the development of the "LiveBoard" based on rear screen projection. This development coincided with anthropological work being done at PARC by Lucy Suchman (Suchman, 1985) about the situational use of technology particularly how computers were embedded in the social framework of daily activity. Developments at PARC continued with the development of the ParcPad, a book sized computer and forerunner of the Personal Document Reader and e-books and the palm sized ParcTab forerunner of the Personal Digital Assistant. According to Weiser *et al.* (1999) these developments staked out a new conception of what computers could be, and feel like. Adverse reaction to a perceived idea of "big brother in the office" created by this environment led to a restructuring of the research at PARC to emphasise "calm computing" as the goal of ubiquitous environments. That is, the user is in a state of mind that allows the actual hardware configuration of the system to "disappear" and become invisible so that the user is in control rather than the computer system.

Other Projects

Project Aura (Project Aura, 2002) based at Carnegie Mellon University emphasises "distraction-free" ubiquitous computing where the most precious resource in a computer system is identified as user attention and the goal is to *"…provide each user with an invisible halo of computing and information services that persists regardless of location*." This halo would encompass wearable, handheld, desktop and infrastructure computers.

Planet Blue (Planet Blue, 2002) is an IBM Research Centre project that aims to *"…understand how people will interact with the emerging world of the wireless Internet*." The philosophy is to *"…create and deploy a technology-assisted immersive environment used by knowledge workers in their daily lives, in which individuals and teams can create, learn, use, and share knowledge with few limitations or disruptions, regardless of physical location or context. We are trying to remove the technology from the consciousness of users*."

The MIT Project Oxygen (Project Oxygen, 2002) aims for an environment where *"…computation will be freely available everywhere, like… oxygen in the air we breat*he." The goal is a system that is pervasive, embedded, nomadic and eternal, based on an infrastructure of mobile and stationary devices connected by a self-configuring network.

The common characteristics of all these projects are that their aim is to develop technology that frees the user from the desktop, extending the reach and application of computing technology.

An evolutionary view of mobile work environments

Figure 1 presents a model, grounded in the literature, of the evolution of a mobile work environment from the initial concepts of ubiquitous computing through infrastructure and application environments to emerging practice which we will call the mobile work domain (MWD).

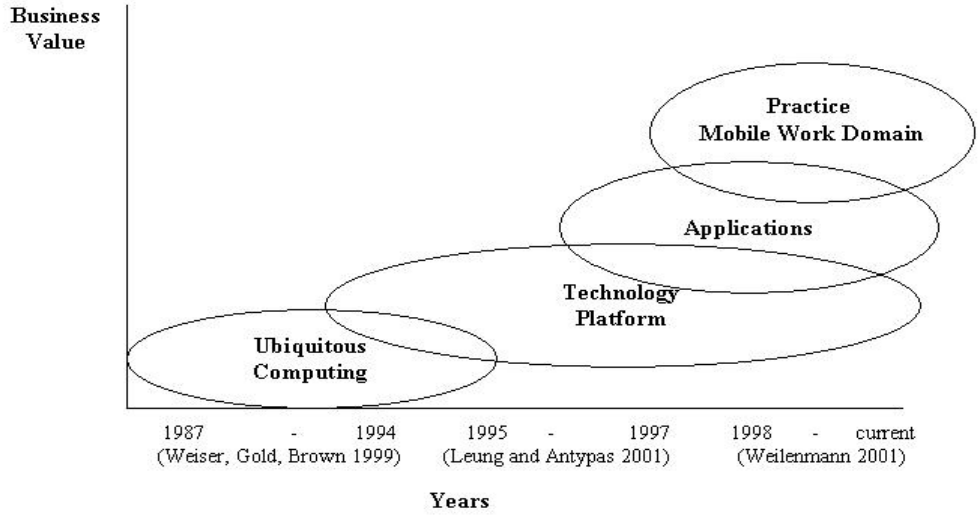

Figure 1 Stages of Evolution of the Mobile Environment

In the early years of ubiquitous computing, beginning in the late 1980s, there was little by way of technological infrastructure to support the philosophy that was being espoused by Weiser and his colleagues. It was not until 1994 that the researchers at PARC produced infrastructure to support their "ubi-comp" (Weiser *et al.*, 1999). Further technological developments during the 1990s produced platforms that enabled the development of applications that could be delivered via mobile phones. In particular it was the development of the Wireless Application Protocol (WAP) and radio wireless technologies such as Bluetooth that enabled the wide spread use of limited applications via mobile phones (Leung and Antypas, 2001; Myers *et al.*, 2000). The term "mobile commerce" was initially defined as electronic commerce based on mobile telephony (Lawrence *et al.*, 2000). Early applications allowed mobile phones to connect to a limited number of (WAP-enabled) Internet websites

or provided secure mobile payment environments for banking and bill-paying (Lawrence *et al*., 2000). The underlying philosophy was that eventually there would be a single "workstation" based on a mobile phone available to all users of computer networks and the Internet. This philosophy is similar to the ubiquitous computing environment philosophy. Most of the developments, however, up to the late 1990s provided little value for business. The focus of this paper is on the next wave of mobile technology and how mobile technology provides value for business, defined here as the Mobile Work Domain. The following sections outline the major concepts, domains and relationships that require definition.

DEFINING THE MOBILE WORK DOMAIN AND ASSOCIATED CONTEXT MODEL

The basis for most of the activities in the mobile work domain is founded in mobile systems and electronic commerce. The Mobile Work Domain also draws on two other existing areas of activity and research: computer supported cooperative work (CSCW) (Dryer *et al.*, 1999; Weilenmann, 2001) and computer mediated communication (CMC) (Dryer *et al*., 1999; Kakihara and Sorensen, 2001). These domains and the relationships between them are described below:

Electronic Commerce is defined by Kalakota and Whinston (1996) as "…the buying and selling of information, products and services via computer networks today and in the future, using any one of the myriad of computer networks that make up the Internet." The definition used in this paper and this research project extends this definition to include the exchange of information, products and services and thus implying the participation of not-for-profit organisations as well as for-profit organisations in electronic commerce. Also included in the working definition here is the concept of any network not just the Internet thus including fax, phone, EFT etc.

So, the working definition used in this paper and research project is:

> "…The buying, selling or exchange of information, products and services via computer networks today and in the future, to support the business activities of a for-profit or not-for-profit organisation using any one of a myriad of computer networks including the Internet."

Computer Supported Cooperative Work (CSCW) can be described as the use of computer technologies to support collaborative activities. The 2000 ACM Conference on Computer Supported Cooperative Work (CSCW, 2000) suggests that topics within CSCW include culture and community, proximate and distant collaboration, remote guidance, mobile work and technology, awareness and attention, collaborative instruction and distance learning, managing expertise, video technologies, collaboration infrastructures, privacy, instant messaging, consistency management, and new interaction paradigms.

The Usability First website (Usability, 2002) describes CSCW as the study of how people work together using computer technology. Typical applications include email, awareness and notification systems, videoconferencing, chat systems, multi-player games, and realtime shared applications (such as collaborative writing or drawing).

Computer Mediated Communication (CMC) refers to human communication via computer technology and includes using computers as tools to exchange text, images, audio and video. CMC can include e-mail, network communication, instant messaging, text messaging, hypertext, bulletin boards, online shopping, distribution lists and videoconferencing. John December (2002) defines CMC as:

> *…The process by which people create, exchange, and perceive information using networked telecommunications systems (or non-networked computers) that facilitate encoding, transmitting, and decoding messages.*

Mobile Systems can be defined at the device level. Mobile systems provide the infrastructure that supports wireless and mobile devices such as mobile phones, Personal Data Assistants and hand held or pocket computers. Nomadic work performed by people such as consultants, sales people, healthcare workers, police officers, and emergency-care specialists require workers to be mobile and contactable. Mobile systems allow users to

physically move around while using a device. Wireless networks and mobile infrastructure allow real-time access to network, communication and computer resources while moving between physical locations.

Mobile systems also allow mobile devices and users to be part of larger wired networks or to collect data in a mobile or wireless environment and upload the data later to databases (Fraunholz, 2002).

Relationships in the Mobile Work Domain

Considering the domains described above and the relationships that exist between them leads to the identification and definition of some new domains of interest in the Mobile Work Domain context. Some of these identified relationships include:

The concept or domain of **mobile commerce** arises from the application of mobile systems in electronic commerce (Kalakota and Robinson, 2002).

The area of study of **virtual communities** (VCs) arises from the interaction of (often) not-for-profit electronic commerce and CMC particularly computer networks. **Virtual Offices** can be identified as a subset of VCs where groups of people who work together as teams can establish a working environment based on mobile technology in which each individual may be physically and geographically remote from other team members.

Mobile Supported Cooperative Work is a logical consequence of applying mobile systems infrastructure to computer supported cooperative work making MSCW a subset of CSCW.

These are only some identified relationships that have emerged from an analysis of the Mobile Work Domain. Other interactions and relationships may be identified and studied as research projects progress.

The following concepts address the identification and definition of the communities and characteristics of workers operating in the Mobile Work Domain**.**

Device-level communities are defined as environments where wired and wireless networks continually connect various types of mobile and wireless devices to one another.

User-level communities are defined as environments where users are able to communicate using device level communities (and wired and wireless networks). These communities are often communities within organisations such as work teams, departments, business units, etc, but can also represent supply chain communities of interrelated suppliers and customers.

Nomadicity is defined as that characteristic of a worker who, as a member of a user level community, conducts his/ her day-to-day work activities by moving from place to place in a virtual office supported by device-level communities. Nomadic workers require access to data and services independent of location.

The Mobile Work Domain Context model (Figure 2) represents the elements and relationships described above in diagrammatic form. The elements and relationships embody the concepts of device-level communities, user-level communities and nomadicity.

RESEARCH ISSUES IN THE MWD

Work Domains

The Mobile Work Domain as defined in Figure 2 represents a starting point for research in the area as it relates to business and the workplace. Kakihara and Sorensen (2001) identify three dimensions of mobility that will impact on the work domain of users: spatial mobility, temporal mobility and contextual mobility. Spatial mobility is not just the movement of people, but also the mobility of objects (such as mobile devices), symbols (such as images) and space (use of the Internet). The use of mobile devices will increase the mobility of objects, symbols and space. For example a nomadic worker will be able to use a mobile device and access images through the Internet anywhere and anytime.

Temporal mobility refers to the acceleration of work and saving time. The introduction of information technology has an impact on the temporality of social life and work life. Barley

(1988) (drawing on Hall's (1959; 1962) work) uses two contrasting terms to describe the organisation of temporality: monochronicity and polychronicity. Monochronicity refers to the organisation of work in time slots – where people do one thing at a time. Polychronicity refers to a divergence of structural and interpretive attributes of the temporal order of work. Polychronicity refers to people doing more than one thing at a time. The concepts of monochronicity and polychronicity have been researched in relation to information technology by a number of researchers (for example: Bellotti and Bly (1996); Dix and Beale (1996)). Information technology impacts the organisation of work and will further impact the organisation of the work that individuals do. Mobile devices will additionally impact on both monochronicity and polychronicity. Contextual mobility refers to the particular context that frames and is framed by human activity. In the case of mobile devices the technology goes to the place of work that is not necessarily adapted for it.

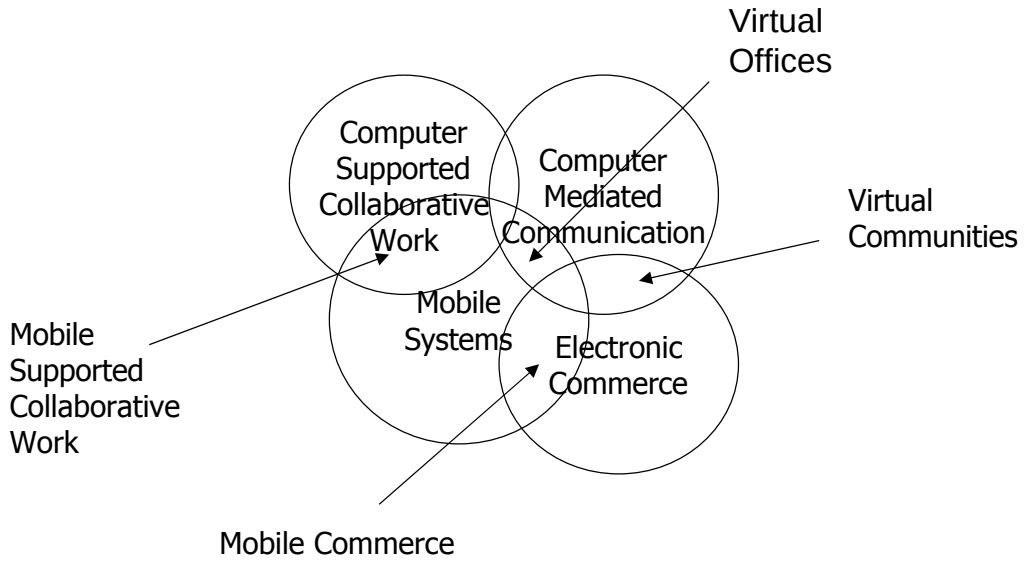

Figure 2 – The Mobile Work Domain Context Model

The three dimensions of mobility and the possible impact that mobile technology will have on the work domain forms the background for identifying the aspects of interest for the Mobile Work Domain. The literature and studies to date have explored a number of issues and the following identify those we believe are key in the context of the model and will be the focus of future research and are key to widespread adoption of the technology.

Usability

Universal acceptability of mobile devices and other ubiquitous computing devices is critical to acceptability and adoption of these devices particularly in the workplace. One of the major issues has been the usability of the devices. Huang *et al.* (2001:108) note that: "*in reality, users are often unable to accomplish even the simplest tasks with the new digital devices*", usability is the major hindrance often driving users away from new technology. Further, Huang *et al.* (2001:109) note "*This usability problem does not end with the devices. To extract the data from these devices, users must often deal with installing, configuring, and learning how to use new software on their PCs or handheld devices.*"

The major usability issues can be classified under the following headings.

Interface design and size

The design approach taken for standard desktop software interfaces cannot be applied to mobile devices (Myers *et al.*, 2000). The size of the display requires a rethinking of what is possible in terms of interface design. The range of mobile devices also has an impact on the design of interfaces. Some devices such as PDAs display a touch screen keyboard; mobile phones have a numeric keypad; and wall displays have touch sensitive screens. Such variety means that the design of each interface depends on the device on which it will be

displayed. Myers *et al.* (2000) argue that where developers are designing an application to run on a variety of platforms the task is more difficult.

Pham *et al*. (2000) also note this as a problem and suggest that in the future small screen mobile devices will have greater capacity and high-resolution displays. Myers *et al.* (2000) suggest in the future it might be possible and desirable for people to determine their own interfaces. For example the user might prefer a textual output and in other circumstances speech.

Manual dexterity and other skills are required for interacting with mobile devices. It cannot, however, be assumed that everyone has the same level of skill, particularly when thinking about elderly people and children (Myers *et al.*, 2000).

Input devices

The variety of input devices used with hand held equipment must be considered when interfaces are designed. Myers *et al.* (2000:18) argue that: "*We expect to see substantially more use of techniques such as gestures, handwriting, and speech input and output. These are called recognition-based because they require software to input stream from the user to identify the content*." How interfaces are therefore designed will be dependent on the input device.

Abowd and Mynatt (2000) argue that natural interfaces are needed for mobile devices. They suggest that: "*to ease the development of more applications with natural interfaces, we must be able to handle other forms of input as easily as keyboard and mouse input*" (2000:33). The major limitation they note is the problem with the size of the devices.

Consideration must also be given to the context in which the user is interacting with the device; it cannot be assumed that the person is sitting down and has two hands available to operate the device (Myers *et al.*, 2000).

Device design issues

A major issue identified by Huang *et al.* (2001:110), is the issue of data. For business users the ability to move data seamlessly between devices is an imperative. This should be accomplished without users having to think about where the files are stored, what format they are in, nor how they will be displayed. "*One consequence of this principle is that the traditional notion of a file should become invisible to the user; this means that the file's actual location and format is hidden from everyday users. After all, using only simple, single purpose data appliances, everyday users should not be expected to deal with a file system hierarchy or incompatible file formats. In practice, this means that file routing and format transformation are hidden from the user.*"

Another problem facing designers of digital devices is how to build in sufficient functionality so that the problem described above is overcome. The difficulty, argue Huang *et al.* (2001:110), is that the devices then become more complex that they need to be and therefore more difficult to use. "*The tasks become harder because of the screen interface limitations on such devices.*"

Additionally, Dryer *et al.* (1999) developed a model outlining the influence the design of the mobile device has on human behaviour, social attributions and how these affect the outcome of the interaction. The basic starting point for the model is the mobile device design, which refers to aspects such as accessibility, familiarity with the device, whether the device allows sharing of input and output information and the usefulness of the device within its context of use. Human behaviour refers to the actions individuals take while interacting with the mobile device. Factors that are included in this aspect are whether the device makes the user appear awkward, interferes with interaction, distracts the non-user and whether the device changes the control between the partners. Social attributes refer to judgements that are made by a person about a stakeholder's disposition, traits, roles and group membership. Interaction outcomes refer to the outcome of the interaction between stakeholders. It includes situations in which the interaction has been successful, unsuccessful and whether the interaction will be desirable in the future.

Context

Mobile computing has changed the nature of computing particularly with regard to the context in which devices are used. Traditional desktop computing typically allows interaction with technology one user at a time, in a fixed location. The move to mobile devices has allowed users to move away from the desk and in some cases away from the workplace. As the context of use has changed this has brought with it new challenges for designers and users of the technology.

Ark and Selker (1999:504) identified four factors that they believed needed to be addressed for pervasive computing to appeal to the general public. These were: *"Computing is spread throughout the environment, Users are mobile, Information appliances are becoming increasingly available, Communication is made easier – between individuals, and things, and between things."*

To some extent a number of the factors identified by Ark and Selker (1999) have been addressed in the design of the current PDA technology. With this however has come the need to design devices that have a sense of where the user is located and the context in which they are working.

The work of Pham *et al.* (2000) has involved developing a mobile computing communications system that they call "Situated Computing Framework (SCF)." Within this they are looking at a system that will provide access through mobile devices to multimedia services and content. The approach Pham *et al.* (2000:326) have taken it is to develop a "composite device" approach. "*That is to use the PDA as mobile and unique access interface to request structured multimedia information and services. The request performance is outsourced redirected to the most appropriate element(s) of the composite device available in the close user's vicinity to fulfil. The focus is to avoid having to use a single PDA perform all tasks.*"

Mark (1999) in his discussion of handheld devices discusses what he calls "mediated space". He suggests that people move around their environments working with different people in different contexts. Current desktop computing requires users to remain in one place as well; computers are unaware of where the user is or who they are. Mark (1999:678) sees a shift in the relationship between humans and computers *"from a fairly static single-user location-independent world to a dynamic multiperson situated environment."*

Software and infrastructure

"Furthermore, as people increasingly distribute their own computations across devices in their office, their home, their car, and their pocket, there will be an increasing need for people to communicate with themselves on different devices" (Myers *et al.*, 2000:17). This, Myers argues, will impact on the software available for supporting collaborative work. Mobile devices mean that it cannot be assumed that people working collaboratively are using the same technology and so are able to support the same software.

Scheepers and Steele (2002), based on the work done by Dryer *et al.* (1999), further indicated that the information system available on the mobile device also impacts on the use of the mobile device as well as the interaction between people. Issues such as the response time of the software, the type of information available on the mobile device and the grouping of information play an important role in mobile device use. A specific issue is when the mobile device is a mediator between different stakeholders such as a sales person and a client.

The implementation of mobile devices by organisations will impact on a number of issues such as the type of device made available to users, the training of users, help desk, as well as policies and procedures. Personal and organisational domain of mobile device use are overlapping and can be utilised by the organisation in speeding up the adoption of mobile devices (Scheepers, 2002) A further factor that can accelerate the adoption of mobile devices relates to ownership. In contrast with static information technology, users feel that the mobile device is their "personal" property; they can take it with them everywhere and use it for private purposes. Although the convergence might have a positive effect on the adoption it will impact on the standardisation of the type of mobile device in organisations.

Standardisation on the type of device that will be supported by the organization is preferable in order to save on supporting a diverse number of devices (Gold, 2000). However, the personal relationship that a user develops with their handheld might be of such a nature that an organisation will necessarily have to support a number of different devices.

A further implication of the overlapping of the two contexts is that the organisation need not necessarily engage in expensive and elaborate training for mobile devices such as mobile phones and personal digital assistants (PDAs). At the same time, organisations should carefully consider support systems in mobile use scenarios. The mobile worker should have enough knowledge to know how to help him/ herself or should be able to get the necessary information from someone. In typical office environments co-workers and the support staff are on hand to provide assistance. Mobile workers rely on themselves or e-mail or the telephone. The provision of a help desk or similar resources specifically geared towards mobile support needs to be researched.

CONCLUSION

This paper presented a conceptual study of the literature in ubiquitous and mobile computing and related areas which produced a framework and associated context model of an identified Mobile Work Domain (MWD). This framework provides a focus for research in the use of new technologies and approaches to business processes in the workplace.

Future research projects based on the Mobile Work Domain framework and context model will aim to understand how mobile and wireless environments are being used, can be used or adapted and improved in a specific work environment. Studies of the implementation and use of systems which incorporate mobile and wireless technologies and approaches by individuals, teams and organisations will assist other organisations in the selection and application of mobile and wireless technologies and devices for the implementation of business processes.

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