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December 2005

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### Recommended Citation

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<http://aisel.aisnet.org/acis2005/87>

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## Technology Portfolios: A Metaphor for Users' Technology Selections while Mobile?

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### Abstract

*Humans employ metaphors to understand, communicate and appropriate new, complex or perplexing aspects of their lives. This paper suggests that the rapid diffusion and widespread acceptance of mobile technologies have not been accompanied by a rich set of metaphors. Apt metaphors might help us to make sense of these technologies and the new practices that are emerging around them. The metaphor of a technology portfolio is proposed for users' selections and deployment of technologies while mobile. Three case studies examining users' technology selections while mobile are described. Observed practices can be understood and explained using the technology portfolio metaphor. The metaphor is particularly valuable given the changing nature of mobile technologies and the resulting difficulties in envisioning likely future needs and practices*

### Keywords

Metaphor, technology portfolio, mobile technologies, technology appropriation, sense making

### INTRODUCTION

Humans employ metaphors and symbols to help in understanding, communicating and appropriating new, complex or perplexing aspects of their lives. Metaphors have long been used in the information systems (IS) domain to explain innovations, communicate complex concepts and appropriate challenging technologies.

The widespread acceptance of mobile technologies has not been accompanied by the generation and circulation of a rich set of metaphors through which the user, practitioner and research communities can make sense of these technologies. On the one hand, the presence of mobile technologies is becoming mundane. In 2003, 533 million mobile phones were sold worldwide (The Australian Financial Review 2004). In Australia, the number of mobile phones exceeds land lines (The Age 2004). The use of mobile phones in the street, public transport, cafes and meetings illustrates their acceptance. The increase in cheap and widely available mobile technologies has been accompanied by radical changes in users' practice. These changes have led to dissolution of the boundaries between personal, social, educational and workplace activities (Carroll, Howard, Peck and Murphy 2002). On the other hand, the place of mobile technologies in our lives, the ways that people are using technologies to transform their everyday practices and the social impacts of these changes are poorly understood. It appears, therefore, that there is room for additional metaphors in the mobile domain. This paper seeks to identify a suitable metaphor for technology selections and use while mobile.

The metaphor of a 'technology portfolio' is proposed as a rich and useful means of understanding and communicating users' selections of technology while mobile. The portfolio metaphor has recently been applied in marketing (Hill, Ettenson and Tyson 2005), IT project management (Armour 2005), and education (Barrett and Wilkerson 2004). Its application to mobile technology use provides an alternative viewpoint in the debate about mobile technology trends. Current metaphors are polarised between the vision of a single all-in-one 'converged device' and multiple, single-function 'information appliances' that are implicit in Weisner's concept of ubiquitous computing (Norman 1998; Weisner 1991).

Empirical research was undertaken to examine people's practices with technologies—both electronic and non-electronic—that support their activities while mobile. The two metaphors representing future visions for mobile technologies—information appliances and a converged device—were applied and found wanting. In contrast, the technology portfolio metaphor captures the salient aspects of the research findings. This metaphor provides leverage for explaining the participants' technology selections while mobile. It is also valuable given the transitory nature of both mobile technology and practices and the resulting difficulties in predicting or envisioning likely future needs and practices (Carroll 2004b).

The paper is structured as follows. The next section of the paper explores metaphors, outlines their application to mobility and presents the metaphor of a technology portfolio. The third section describes the research design of the empirical work that investigates users' selections and uses of technology while mobile. The findings are

then provided. Next, the application of the technology portfolio metaphor to the research findings is evaluated. The paper concludes with an assessment of the significance of the contribution of this metaphor for research into use of mobile technologies and indications of areas for future research.

## BACKGROUND

A metaphor is the “application of name or descriptive term or phrase to an object or action to which it is not literally applicable” (Concise English Dictionary 1976). A symbol is similar but employs images rather than words. Humans employ metaphors for a variety of purposes. Metaphors are a way of making the unfamiliar familiar, of communicating that for which no descriptions exist, and of taking possession of that which appears alien or unattainable. Metaphors may also generate new perceptions, explanations or inventions by providing new ways of understanding the familiar (Schon 1983). The power of metaphors rests in highlighting similarities between disparate objects or actions. We make sense of the world through such similarities: “A metaphor is essentially a way of understanding and experiencing one kind of thing in terms of another” (Hirschheim and Newman 1991:37). People who share a connotation system may draw similar understandings from metaphors or symbols (Mingers 1995). Therefore, metaphors are not just a literary or academic device but an integral part of human sense-making: “Our ordinary conceptual system, in terms of which we both think and act, is fundamentally metaphorical in nature... The way we think, what we experience, and what we do every day is very much a matter of metaphor” (Lakoff and Johnson 1980).

Metaphors are used in organisational studies where we talk of ‘glass ceilings’, ‘flat’ structures and ‘unfreezing’ in order to change. Morgan (1986) uses a range of metaphors to present different views of organisations including organisations as machines, brains, cultures and political systems. Similarly designers, researchers and users of information and communication technologies (ICTs) employ a rich set of metaphors to understand, communicate and explain these technologies and associated practices (Hirschheim and Newman 1991). Some widely accepted metaphors include ‘desktop’, ‘mouse’ and data ‘warehouse’. ICT-related activities involve a user ‘scrolling’ through screen content, performing ‘knowledge’ management or ‘architecting’ an information infrastructure. These metaphors have been used to communicate unfamiliar functions, concepts and activities and to assist the non-technical in accepting new technologies. They have provided a layman’s language for discussing and sharing activities around ICTs. Metaphors also assist researchers in interpreting people’s ICT-related activities. For example, Hirschheim and Newman (1991:30-31) apply symbolism in the form of myth, metaphor and magic as “an analytical approach to understanding the behaviors of participants” in information systems development. The effects of metaphors, however, are not always positive. Undesirable or unintended similarities highlighted by a metaphor can mislead. The metaphor of information systems development as an engineering activity underplays the situated and social nature of information and the importance of people in creating, sharing and interpreting information systems (Goguen 1994).

Much of the new language surrounding mobile technology appears to be grounded in literal rather than metaphorical terms; for example, the use of ‘texting’ for sending a text message. We lack a rich and evocative set of metaphors in the mobile technology domain. The Personal Digital Assistant was an attempt to harness a metaphor but rapid abbreviation to PDA offset the potential benefits. The ‘smart’ phone implies that the device is clever enough to satisfy all of users’ technological needs. Labeling users of mobile technologies as nomads (Dahlbom 1998) gained wide currency in the early days of mobile studies but limited similarities (moving from place to place) and clear dissimilarities (nomads’ lack of access to technology and established infrastructures) curtailed its popularity. ‘Pranking’ is a more playful metaphor, capturing the elements of mischief involved in young people’s attempts to avoid the high costs of mobile interaction.

There are two established but contrasting metaphors for future mobile technologies. ‘Information appliances’, similar to mundane household appliances such as stoves or fridges, are single-function devices that provide or access information (Norman 1998). Information appliances incorporating sensors, intelligent agents and e-gadgets (Kameas and Mavrommati 2005) are the building blocks of ubiquitous computing; this trend appears to be driven by the visions of futurists and researchers (see Weisner 1991). A ‘converged device’, where multiple features, functions, media or applications are brought together in the one device, provides for all of a mobile user’s needs. Converged technologies appear to be driven by the desire of technology producers to gain competitive advantage through the accumulation of functions on a ‘killer’ device. The trend towards convergence is visible in the current range of smart phones that aim to combine the features and functionality of both a mobile phone and a PDA. Other interesting examples of this trend include the BlackBerry (combining email pushed onto the device, along with phone and PDA functionality) and the addition of image capacity to the iPod.

The metaphor of a technology portfolio is proposed as an alternative to information appliances or the converged device. It is applicable to users’ current rather than envisioned future selections and deployment of technologies while mobile. A portfolio is defined as both a case for keeping loose sheets of paper and a list of investments held by person or company (Concise Oxford Dictionary 1976). The metaphor of a portfolio is widely used in

finance and investment. A portfolio approach involves diversification, where risk is spread over a number of options and the weaknesses (high risks) in one area of the portfolio can be offset by strengths (low risks) in other areas. The investor then concentrates on the overall performance of the portfolio and views each individual investment as a part of the whole. The aim of a portfolio strategy is to maximise benefits through an appropriate mixture of high-risk, high-return and low-risk, low-return investments. This metaphor has been applied to IT project management where individual project risk is assessed as part of an overall portfolio of projects (Armour 2005). The metaphor has also been applied in education, where students construct a portfolio of artifacts that represent their learning. The portfolio is a dynamic collection of resources that can be reviewed and adjusted to meet different needs (such as assessment, job hunting, documenting personal learning) (Barrett and Wilkerson 2004).

This analysis indicates that a portfolio has four main characteristics. It is:

- purposeful. A portfolio is constructed with the purpose of satisfying specific purposes (for example, minimising risk or maximising profit).
- diverse. A portfolio approach distributes strengths and weaknesses amongst diverse resources in the portfolio. For example, diversification in an investment portfolio provides a mixture of high-risk and low-risk investments. A learning portfolio may contain diverse types of learning artifacts.
- holistic. A portfolio approach aims to maximise benefits by taking an overall or holistic view and balancing competing options (such as high versus low risk). Therefore, the emphasis of a portfolio is on integration of complementary options rather than accumulation of contents.
- flexible. The contents of a portfolio are not fixed but may be added to, removed or re-ordered.

Applying these characteristics to mobile technology use enriches the metaphor of a technology portfolio that:

- is constructed for the purpose of meeting the needs of a particular user while mobile.
- contains a diverse mixture of resources, both electronic and non-electronic.
- takes a holistic approach, where the portfolio contains technologies that can accommodate a range of needs and use situations. Each technology has particular strengths and weaknesses. Over time, these diverse technologies can be ‘mixed and matched’ in various combinations, as the user draws on the contents of the portfolio to maximise the support and satisfaction gained from technologies while mobile. Thus, a technology portfolio is not merely an accumulation of disparate resources but rather a thoughtful and integrated selection of complementary technologies.
- is flexible so the contents of the portfolio will be appraised, updated and applied in different ways as the user’s needs change.

## RESEARCH METHOD

Examining users’ technology selections and use while mobile raised two definitional issues. Firstly, technology was interpreted in a broad sense to include fixed computer-based technologies such as personal computers (PCs), mobile technologies such as mobile phones and non-electronic technologies such as pens and paper. Secondly, the established metaphors of the information appliance and converged device suggest that a fine-grained analysis was necessary, where the notion of a mobile technology is decomposed into its components. In this research, mobile technologies are viewed not as completed devices with given functions but rather as “sets of loosely bundled capabilities [that] can be implemented in many different ways” (Gutek, Bikson and Mankin 1984). Accordingly, they are composed of features, functions, media and applications. Features are built-in attributes such as a speaker phone or camera. Functions are the activities that are supported such as making a phone call or sending a message. Mobile technologies employ a range of media that capitalises on digital content such as voice, text, video and images. Applications are the software programs that users may select to provide functionality. In use, these components of a mobile technology are explored and some components may be rejected while others are adopted and applied in different ways in different use situations (Carroll et al. 2002). Consequently, the ways that the components of a technology are selected and used in order to provide support for people while mobile were investigated. This provided understanding of users’ current practices with the components of mobile technologies as well as other technologies – both electronic and non-electronic – that are accessed while mobile.

Intensive studies of a small number of participants were chosen in order to provide depth of understanding of mobile technology users’ perceptions and practices. Such studies provide for analytic rather than statistical generalisations (Miles and Huberman 1994). A multi-method approach was employed; the research methods included focus groups, questionnaires, participant observation and semi-structured interviews. These methods provided data about what participants say about their needs, do in their everyday routines, and what they do with available resources (adapted from Spradley 1979). Also both contextual (in context) and a-contextual (out of context) methods were employed so that the influence of context on mobile technology use was addressed. Thus the participants were observed in their everyday situations of use, immersed in the sounds, issues, purposes and

needs that drive their interactions with technology. These observations attempted to capture the technological aspects of the world in which the participants act, unreflectively and routinely, in their involvement with the 'ready-to-hand' (Heidegger 1962). The participants' use of diverse technologies, mobile and fixed, connected and stand alone, electronic and non-electronic was studied. They were also interviewed out of context so that they could focus reflectively on specific issues away from these contextual distractions. Three case studies were undertaken. Each study examined a different user cohort. Two studies involved young people, selected because they are viewed as 'early adopters' or indicators of the trends that may be followed by the rest of the market. The third cohort were IT professionals, selected because of their exposure to cutting edge technologies and expertise in applying technology in different settings.

All data were transcribed, coded and categorised. The following section presents the findings from this analysis. The technologies that were 'to hand' (Heidegger 1962) to the participants are listed and classified as follows. Devices are computer-based technologies, both mobile and fixed; Digital media are used by this cohort; Applications are software programs; Other resources include non-electronic technologies; and Other media are non-digital media used by this cohort. The Findings sub-sections contain descriptions of each cohort's technology practices while mobile, the accessible technologies and their perceptions of current and future technologies.

## CURRENT PRACTICES

### Sixteen year old young people

The research involved intensive study of a pre-existing group of six 16 year olds over one month (November-December 2003); the group comprised four males and two females.

#### *Technologies to hand*

Devices	mobile phone, PC, digital camera, MP3 player
Digital media	voice, text, image
Applications	SMS, email, chat, address, games
Other resources	diary, pen & paper
Other media	face to face

#### *Findings*

The main purpose of technology use was communication rather than information gathering or retrieval. Major influences on the type and amount of use were cost and convenience. The participants were either unemployed or school students dependent upon allowances from parents; the two girls had part-time jobs. Many workarounds were observed in mobile technology use to reduce cost including selective activation of voicemail, use of SMS rather than voice and 'pranking' (making a brief call to others' phones so they ring back in response to a missed call, thus passing on the cost to the receiver). Convenience was also important. Text messaging is quicker and easier than email: "*cos you don't have to turn on the computer, open up all the programs*" and "*you can get a response straight away*". One young male is selective about the medium used: "*usually I use SMS when I have to say something quick*" but for more complex activities he uses voice because there is less chance of misunderstanding. The Internet is used to download songs and play games rather than communication.

The participants expressed general satisfaction with existing technology. One stated that "*I think a phone is a phone. It doesn't have to have all the magic gadgets.*" He was not interested in playing games on a phone because the screen is too small and he would not want to interrupt the game when a call came through. Another participant bought a particular phone because "*I wanted to have MP3 and the phone at the same time*"; however the phone is large and cumbersome to carry around. A third male participant had a picture phone "*and that was fun*" but he passed it on to his father. Asked whether new phones with more features are good, he replied "*more buttons [are] more confusing.. it's fine how it is now.*"

The mundane nature of technology within the participants' lives was clear. Technology is just an accepted part of everyday life. The participants had adapted and combined technologies to meet their needs. The participants' technology practices change effortlessly according to context (school, work, at home, with friends, travelling away from home) and who they communicate with (there was agreement that they would not SMS a teacher). A mobile phone is always 'to hand' though it may not be a personal phone (it may belong to friend, parent or sibling). There was a loose coupling between mobiles and individuals (who might lose, swap, barter or share phones). For example, when one girl's phone was confiscated by her parents due to the size of her bill, her parents rang her boyfriend's phone to contact her. Further, although a mobile may be to hand the user may not be available to others: the mobile may not be turned on, may not be answered, or it may not be their own phone.

### Young people aged over twenty

The research involved 11 post-graduate IT or IS students at two universities; all except one was in their twenties. There were seven female and four male participants. Data were collected over five months in 2004.

#### *Technologies to hand*

Devices	Mobile phone, laptop, PDA, PC, digital camera, iPod, MP3 player, USB key
Digital media	Voice, text, image
Applications	SMS, email, chat, scheduler, address, games
Other resources	Diary, notes, pen & paper
Other media	Face to face

#### *Findings*

These participants had access to a wider range of devices and applications than the younger cohort. For most of the participants, the dominant purpose of a mobile technology was communication. Cost was less of a constraint on technology use, although participants stated that cost influenced their selection of SMS rather than voice calls.

Convenience was important to them. The proliferation of mobile technologies has led to a need to reduce the number of devices that are carried or mastered. This is epitomised by one female's situation: "*My bag, it's got all my laptop stuff and it's got the PDA, all those things. Diaries, appointments, new USB port, digital camera, cell phone, laptop, all these mobile devices and I chuck them all in my bag*". A male participant expressed the desire to reduce complexity: "*If you have too much technology in your life, you get reliant on it.. I think all of them, a nightmare...Just try to keep to one device.*" The physical constraints on future device convergence, such as the small screen on a mobile, means that "*maybe you can't consolidate all of the laptop's functionalities*".

The mobile phone was usually selected in situations where participants could only carry limited resources. The exceptions were two dedicated users of PDAs. A female participant in her early thirties stated that her PDA is more useful than a mobile phone: she stores pictures of her pet rabbit, all her thoughts are stored there as well as her schedule, work things and fun things. Her PDA "*has a name... this is my friend.. I use this far more than my mobile anyway.*" A younger male described how he was very disorganised until his parents gave him a PDA: "*since then my life's just turned around. It just became so easy... Cos all of a sudden I'm always on time, I never forget things... I'm just so organised*". The PDA contains his calendar, address book, list of greatest movies ever, funny quotes: "*it doesn't matter, it's all there. It doesn't change.. it's always 2 inches by 3 inches by half an inch, no matter how much I put on it, it's never going to get bigger.*" Both participants use their devices to store information: PDAs are examples of converged information devices. Their usefulness rests on providing access to important information at any time and any place. Both PDA owners access other technologies for communication.

Another example of the trend towards convergence is the iPod. Originally a music storage and player, the iPod is being used for other activities. One participant uses her iPod to store PowerPoint presentations: "*you can use it like a USB key, so I've got a presentation that I'm doing this afternoon on PowerPoint at the moment it's on there... cos it's 20 G worth of space, it's a lot more useful than a USB key...*" The multi-functional iPod may render the mono-functional USB key obsolete for this person. However the use of diverse devices for similar tasks has led to management issues such as version control (files are on the iPod, a USB key and email).

There were diverse views about convergence of applications. A male Mac user dislikes convergence: "*I really hate that. I want my email program to be email. I don't want it talking to MS Word: that's a word processor, that's something different*" He wants control of any interactions between programs rather than occurring automatically. Another participant believed that adding applications to PCs slows down loading time and leads to system crashes. A third suggested that "*Some interaction between contacts and the address book would be good, and it would be good if you could choose when to use it but to have all the stuff interacting when you don't want it overly complicates the programs*".

Thoughtful selections of appropriate media for activities were observed. An international student emails her boyfriend every day but she views emails as "*.. not personal. Well they are personal but when you talk there's so many interactions that you can say and do, you're just restricted to typing in an email... You can't keep a relationship alive over email, you've got to talk on the phone.*" Further, within the one medium (text), alternative applications (SMS, chat and email) provided for nuanced communication. An example related to making and maintaining friendships. Although voice (face to face or by phone) was preferred, it was viewed as acceptable to email or chat with people that you have not met. However there was broad agreement that you should not SMS someone that you have not yet met. This is summed up by a male participant: "*With new people I prefer to use a voice call than SMS. It's a bit more personal and it's too unsighted: SMS. So if they don't really know you and you just SMS them, its not really gonna help. You need to actually have a conversation. And it's better in person than down the phone.*" A female added: "*I think phones to me are more about maintaining*

*friendships whereas you can use the Internet to make them... I use email, ICQ or MSN to make friends and SMS to maintain it". An older female added: "I'm very old fashioned. I don't use SMS... I have to meet somebody and talk to them... Using technology to meet somebody makes no sense to me at all".*

At times, ICTs are discarded for other resources. There was agreement amongst the female participants that private information or gossip is chiefly communicated face to face: *"Email leaves a trace: it's a bit too concrete"*. In addition, being present physically allows you to gauge the receiver's reactions *".. and you can be there also to do damage control."* Also, not all participants use ICTs for scheduling or recording their activities. One male participant keeps appointments in his head (he was late for the initial focus group). Others prefer paper diaries as they are more reliable (they do not have batteries) and more personal. They suit to a participant's preferences: *"And I very much like the pen and the paper aspect... I just prefer it that way."*

### **IT professionals**

The research involved a study in 2003 of seven IT professionals (six male and one female).

#### *Technologies to hand*

Devices	Mobile phone, laptop, PDA/IPAQ, MP3 player, hands-free kit for the car
Digital media	Voice, text, image
Applications	Addresses, calendar and task lists (schedule), SMS, MSWord, Project and Excel, email (a company standard), PDF Writer, Internet browsers, specialized prototyping tools (Visio, PowerPoint)
Other resources	Exercise books, pen and paper
Other media	Face to face

#### *Findings*

The participants accessed a wide range of devices and applications for both communication and information purposes. As they move around, both within the city and between states, they carry these technologies (typically a mobile phone, PDA, laptop and paper resources). The mobile phone is the primary resource for these participants because *"the convenience of the phone is too good."* Sensitivity to the affordances and constraints of materials was apparent, between devices, applications, media and between electronic and paper-based resources. One participant stated that he wants the correct technology and information for the task. He uses a laptop at work and home and a PC at home. He uses a mobile phone for voice and a Palm for email, notes and calendar: he *"flip flops from each other"*. He synchronises the Palm and laptop but not the Palm and mobile phone. When he travels interstate he takes the Palm not a laptop – he uses the Palm as a reference but not for writing (this is for the laptop).

Fewer nuances of media selection were noted than in the post-graduate cohort. Voice was preferred for coordination of both colleagues and clients. When privacy is an issue, text rather than voice is used. SMS and chat are viewed as suitable for colleagues but not clients; email should be used for clients.

The participants clearly articulated a desire for a converged mobile device. One stated: *"a converged device is what I want"*, combining the IPAQ and phone (that is, information and communication capabilities). Another described how he has been waiting for 'the best' device for over a year; he wants a combination phone/PDA with graffiti input, addresses, calendar (with his tasks listed), MP3 player and a Speaker Phone that is fully integrated with other technologies such as his laptop. At the end of the research another participant said: *"Once you've invented all these things, could you could send them to me?"*

The participants were sensitive to the physical constraints placed on a converged device. Usability and size were important: *"not as big as a laptop but larger than a PDA."* They agreed that the PDA was too small, required constant scrolling and made reading and writing difficult: *"I have an IPAQ, I find it quite difficult to type, I don't like typing in for too long."* This participant writes information about each client in a separate notebook; these notebooks accompany her to meetings. The notes are not transcribed so she cannot access the notes electronically. Easier input to a device would allow such access. In addition, accessing maps or images from the Internet require a larger screen: *"... this is why you need the bigger device. If you're looking at a map with public transport, road, you need to have a big enough area to see the context of that information."*

The participants expressed a desire for simpler access to applications. One participant said a converged interaction management application is needed, so that people do not answer mobile calls during meetings. They expressed the need to access the organisational intranet while mobile. The issue of control was important: information overload is common and the participants expressed dissatisfaction with having information or advertising pushed onto devices: *"I'd prefer to be able to search for stuff that's around me and me connect to it rather than it being automatic and sensing stuff. I want to limit the information coming in... I get too much information coming in as it is."*

## DISCUSSION

### Similarities and diversities of practice

Mobile technologies are an accepted part of everyday life for all cohorts. Most participants nominated the mobile phone as their principal technology but the 'mobile phone' used by the sixteen year olds was different to that used by the post-graduates or the IT professionals. Similarly, MP3 players and music devices were appropriated in different ways: some participants used them for listening to music while others also used them for file storage.

Convenience is important. For most participants, technology is a tool that must be quick and easy to use, available when needed and not intrusive. The physical limitations of mobile technologies, including clumsy input and output mechanisms and inadequate screen size, influenced their selection and use.

Similarities of technology selections and use within each user cohort were observed, but diversity was apparent between cohorts. The main purpose of technology use for the sixteen year olds was communication. Technology selections were strongly influenced by cost and convenience. The participants always had a mobile phone 'to hand' through the practice of sharing, swapping or trading phones although there was a loose coupling between mobiles and individuals. The post-graduate students had access to a wider range of devices and applications than the younger cohort. They prized convenience and simplicity but were less cost-sensitive than the younger cohort. The IT professionals had access to a wide range of devices and applications. They currently carry many resources and wish to reduce this load.

This diversity of practice indicates the need for care in generalising about technology selections and use when mobile. Such diversity reinforces the argument that metaphors, in highlighting similarities between dissimilar entities, may be useful in explaining or communicating users' technology practices while mobile. Which, if any, of the metaphors helps us to understand or explain these current practices is explored in the next sub-section.

### Application of metaphors

Two well-established metaphors seek to represent future trends of mobile technology design and use. The metaphor of information appliances indicates that multiple, single-function devices linked into an all-encompassing ubiquitous environment are the technology for the future. In contrast, the metaphor of a converged device indicates that users will select a single multi-functional device that meets all their needs while mobile. A third metaphor, that of a technology portfolio, is proposed in this paper. A technology portfolio is constructed from diverse technologies and contains a user's preferred technology options for a particular activity in a given context. The technologies may be combined to meet users' real-time situated needs for support as they move from place to place. These metaphors are applied to the research findings and their value in capturing key aspects of the research observations is assessed.

Neither the information appliances nor the converged device metaphor appear to help understand the practices of the youngest cohort. The main purpose of technology use for the sixteen year olds is communication. Their favourite technology is the mobile phone, supplemented by a small number of other technologies (MP3 players, PCs for gaming and pen and paper). Some participants had used multi-functional smart phones and rejected them (they were sold, bartered or passed on to family members). Access to the internet and video while mobile was not prized. Also, multiple single-function devices were not favoured. An exception was a participant who had a digital camera; she had a strong interest in photography and preferred the higher quality photographs produced by the camera. The participants indicated that they were content with their current technologies: lower-model mobile phones with a limited set of functionality (voice, text and perhaps a camera) were effective for communication. The technology portfolio metaphor describes the technology selections of this cohort. They have appropriated a limited set of technologies that meets their needs as they move around within a narrow geographical area (from home to school, local mall and sports grounds). They adapt and combine technologies in a creative way, especially where reducing costs was the outcome. Their use of media (primarily voice or text) was driven by cost and convenience. A striking characteristic of technology use in this cohort was the absence of a one-to-one relationship between technology and individual: PCs were accessed at the local internet café and mobile phones were shared, borrowed, swapped and bartered. Ownership of components of their technology portfolios was not personal but extended to family and friends.

While mobile, the post-graduates used technology for both communication and information purposes. They were keen consumers of technology and stated that they valued convenience. They had accumulated a wide range of technologies and applied them in thoughtful and innovative ways, such as using an iPod for storing files. Rapid changes in mobile technologies, curiosity about innovations and changing needs as they managed work and post-graduate studies led to several participants having a proliferation of multi-functional devices whose features and functionality overlapped. This is epitomised by the female participant carrying a laptop, PDA, mobile phone, USB port, digital camera as well as paper-based resources. These participants were highly



sensitive to the strengths and weaknesses of their technologies. They articulated clear reasons for selecting media (voice, text, image, face to face) and applications (email, SMS, voice call) to a particular activity. Compared to the sixteen year olds, there was less sense of satisfaction with existing technologies and more clarity about desired future technologies. The post-graduate cohort expressed the preference for a converged device for practical reasons: to reduce the number of technologies that they needed to hand, as well as to reduce complexity. At present they had a number of ‘converging’ devices: that provide some convergence of features, functions, media and applications such as a PDA, camera phone or iPod. Several participants used information devices that provided some convergence of features, functions, media and applications such as PDAs and iPods. However, sales of PDAs are decreasing worldwide as smart phone sales increase (The Australian Financial Review 2004). This indicates that demand for convergence across purposes is more popular than within the one purpose, that is, the convergence of information and communication technologies is preferred to convergence of information technologies. In addition, the participants acknowledged the physical constraints on the convergence of information and communication devices, particularly size. It was clear that no one currently available converged device met this cohort’s needs. Multiple single-function devices, represented by the information appliance metaphor, were neither attractive nor feasible for these users.

The focus of technology support for the IT professionals was work-related: gathering, storing and accessing information and communicating with others. They carried many technologies and accessed a broad range of applications in their everyday work. Media selection was simple. Voice was preferred for coordinating others while text was used when privacy is important. Choice between applications is thoughtful and reflects perceptions of professional behaviour. This cohort had strong opinions about use of the correct technology for a particular activity. Like the post-graduate cohort, they articulated a desire for a converged device for practical reasons: they wished to reduce the load of technologies currently carried (including a mobile phone, PDA, laptop and paper resources). This indicates that the information appliance metaphor did not describe current or likely future technology selections. At the same time, they are very much aware of size constraints on any converged device. Analysis of the interview and observational data suggests that a small number of devices (one small multi-functional device and a second with a larger screen and keyboard) would be preferred to an ‘all in one’ converged device.

The information appliance metaphor provides little leverage in describing, understanding or explaining the participants’ technology selections or use. The converged device metaphor is of some use in explaining observations of the post-graduates and the IT professionals. Both cohorts clearly expressed their desire for a converged device that provides for both information and communication. However, their actions in using mobile technologies indicate that ‘best of breed’ performance from purpose-built devices is desired for some activities whereas a converging device that involves a compromise on performance is acceptable at other times. This gap between expressed needs and observed actions reflects the difference between espoused theory (‘I want a converged device’) and ‘theory in action’ (‘I use multiple devices to meet my needs’) (see Argyris and Schon 1996). The participants articulated desire for convergence was driven by practical reasons: carrying and managing many devices added complexity where they wanted simplicity and convenience. The participants’ actions, in persisting with multiple technologies, reflected the greater importance of usefulness of the resources ‘to hand’: they provide the desired features and functions for the participants’ activities while mobile. Extrapolating future needs from articulated desires (espoused theory) rather than everyday actions (theory in action) can be misleading: it is the values and beliefs that underpin our actions that will influence future technology choices.

In contrast, the technology portfolio metaphor is valuable in capturing the essential details of the technology selections and use of the three cohorts. Users construct a portfolio of technologies to support their changing needs while mobile. All participants had accumulated a rich and diverse set of technologies that could meet their needs as they move from place to place undertaking various activities. The contents of their portfolios are selected from the vast array of available devices, media, applications and non-electronic resources according to their personal preferences, those of their peer group, their perceived needs and purposes for different activities in likely situations of use. The findings indicate that the participants were careful and discriminating in their technology selections. The portfolio can provide tailored technological support to the user and be adapted as needs change.

### **Value of the technology portfolio metaphor**

One issue facing all technology users in times of rapid technological innovation is how and when to update current technologies that have been superseded by improved innovations. The information appliance metaphor indicates that users will simply replace an old technology with the innovation – an easy and low-cost solution; however, the research findings indicate that this metaphor does not capture current technology practices. The converged device metaphor indicates that updating a feature or function on a multi-functional converging device involves replacing it with a whole new device. This is a high cost strategy. The technology portfolio metaphor

indicates that the users will take a holistic view of their technologies, evaluate the innovation and then decide to add to, rather than replace, the contents of their portfolios. These partial changes to a user's technology portfolio are easy and fast. They capture the way that the participants updated their technologies.. For example, advances in entertainment technologies such as the iPod led some participants to add this technology to their portfolios. The iPod was then used for multiple purposes, replacing the single-function USB stick for some purposes (storage of large files) but not others (easy backup of smaller files while on the move). Thus, there is some redundancy in the technology portfolio, allowing for nuanced selections of appropriate technology components for specific purposes. At this time, when the capabilities of technology are changing rapidly, when users' practices are continuing to emerge and when our understanding of our needs for support are limited only by our imaginations, the portfolio approach evident in these participants' technology selections is practical and effective.

In addition, the construction of a technology portfolio can be seen as a way of completing the design process as users combine, adapt and select those components of existing technologies that meet the situated, real-time needs (Carroll 2004a). Understanding these technology portfolios and users' rationales for their choice of contents will enable designers to identify the technology features, functions, media and applications that can be combined to meet future needs. Insights into how, where and when technologies are used can provide understanding of both work and non-work practices related to mobility and the technologies that can support them. The diversity inherent in the portfolio metaphor suggests that designers and marketers who develop new mobile technologies should be very careful not to prematurely close down the design space. Nor should they over-generalise about the needs and practices of large segments of target populations. At this stage in the trajectory of mobile technologies, they would be better served by providing malleable technologies that can be adapted by users in their construction of personal or group portfolios to meet current and likely future needs. Similarly, managers and IT staff should support this 'mix and match' rather than a 'one size fits all' approach to mobile workers.

## CONCLUSION

This research examines technology selections and use by three user cohorts and applies three metaphors to the observations. Established metaphors that represent a choice between multiple 'information appliances' and a single 'converged device' do not capture the research findings. At times users may deploy 'best of breed' technologies; at other times they may compromise on performance for multi-functional convenience. While 'converging' devices with multiple features and functions were increasingly popular with the post-graduates and IT professionals, they do not appear to be replacing the most effective 'best of breed' technologies. These trade-offs are not one-off decisions but will frequently be reconsidered and renegotiated as technologies and user practices evolve and new needs emerge.

The metaphor of a technology portfolio is useful for picturing the participants' practices with technology. A portfolio contains a selection of technologies (electronic or non-electronic) from the vast array that is available. The selection can support the user for given purposes (communication, information and entertainment), activities, contexts of use, personal preferences, sensitivity to other's preferences and their needs (for convenience, cost and effectiveness of communication, for example). Different features, functions, media and applications are selected and combined with other available technologies as needed. Applying the metaphor of a portfolio to mobile technology use reflects the thoughtful choices made by users as they explore the available technological options and intentionally appropriate those aspects that most closely meet their needs. It also provides a warning to designers of converged devices. These users prized integration not accumulation of features, functions, media and applications. A selection of diverse components that serves users' overall purposes is preferred to an eclectic collection of unrelated features and functions.

The technology portfolio metaphor is valuable not just in capturing and explaining current practices. Metaphors are particularly useful given the immature state of mobile technologies, their rapid rate of change and the lack of stability of practices around them. Users' practices appear to be diverse and transitory, increasing the difficulties of predicting or envisioning likely future needs and practices. Portfolios provide a way of seeing similarities in diversity and perceiving general trends in times of rapid change. The future design, implementation practices and analyses of the social impacts of mobile technologies require conceptual and theoretical foundations. This research into metaphors provides one step in building these foundations. Further research is being undertaken to deepen understanding of the way that people construct and enhance their technology portfolios and to identify whether there are patterns apparent across user cohorts, technologies and influences on use (especially purpose, activity and context).

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## ACKNOWLEDGEMENTS

The assistance of Daniel Tobin, John Murphy and Elizabeth Hartnell-Young is gratefully acknowledged. The participants' enthusiasm and time was appreciated. Support was provided by a University of Melbourne Early Career Researcher Grant and Australian Research Council Linkage Grant LP0347459 with Novell.

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