Cultivating Interaction Ubiquity at Work

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Abstract: Since the invention of the electronic computer in the 1940s, technological development has resulted in dramatically increased processing power, storage capacity and communication bandwidth physically embedded in devices ranging from large mainframe computers to tiny radio-frequency identification (RFID) tags. Toasters, blenders, elevators, cars and an increasing range of other everyday objects embed computer technology. Over 4.3 billion phone connections have placed processing power, storage and communication bandwidth directly in the hands of around half of the World's population and a range of emerging technologies is expanding this further. Weiser (1991) created a conceptual clearing characterising this phenomenon as ubiquitous computing. He argued that pervasive access to information will lead to a more harmonious relationship where computing adapt to the human environment instead of the opposite. However, large-scale mobilisation of interaction implies the risk of a less that harmonious socio-technical relationship for the individual user of ubiquitous computing as the user actively engages with their surroundings. This paper therefore considers individual users' ongoing cultivation of interaction ubiquity – the continuous organisation of mediated interaction to suit individual needs and preferences. The paper asks the question: *What is the role of technologically embedded assumptions in the cultivation of ubiquitous interaction?* Two distinctions are forwarded characterising embedded support for: 1) Managing ongoing interaction relationships as opposed to the embedded assumption of a series of interaction encounters and 2) prioritising interaction versus complete user-management of interaction priorities. Combining these two sets of assumptions results in four distinct types of embedded technological support for cultivating interaction ubiquity: 1) Connectors offering unfiltered encounters; 2) filters supporting prioritisation of interaction encounters; 3) mediators supporting unfiltered relationships; and 4) coordinators supporting filtered ongoing relationships. These four types of embedded support are illustrated through case studies of technologies supporting mobile working. It is argued that successful cultivation of interaction ubiquity at work relies critically on a portfolio approach where the technology plays a more active role in the management of interaction than in the common example of a mobile phone simply supporting an unfiltered stream of voice- and text encounters.

1.Introduction

Computer technology innovation is an impressive technical story of increased processing power, storage capacity and communication bandwidth in packaged in a variety of form-factors from large mainframes to tiny RFID tags. A large part of everyday objects contain microchips and a growing proportion is able to interact with other devices or mediate interaction between the users (Bassoli, Forthcoming). One such technology dominates more than any other – the mobile phone. The GSM Association reported in 2009 more than 4.3 billion mobile phone connections globally, compared with around 1.5 billion Internet connections (Kluth, 2008; GSMA Mobile Infolink, 2009). The diffusion of mobile telephony has the past 20 years brought computation, storage and communication into the hands and pockets of more than half the World's population. Handset services and global infrastructures interact fuelled by the mass-adoption of mobile and digitally converged technologies

(Lyytinen and Yoo, 2002b). A growing body of research explores the role of mobile information technology (IT), for example, (Castells et al., 2007; Akiyoshi and Ono, 2008; Barendregt, 2008; Donner, 2008; Goggin, 2008; He, 2008; Ling, 2008; Ureta, 2008). The large majority of contemporary research of mobile IT in use is only concerned with one single technology, the mobile phone, general social contexts as the domain of use, and technical features conceptualised as a black box of possibilities. There are also ery few studies of portfolios of mobile- and ubiquitous IT used in the context of work (Sørensen, Forthcoming). Most studies assume technical possibilities limited to voice- or textual connections through mobile phone calls, short message service (SMS) messages, voicemails, emails, and multi media messages (MMS) and does not explore a diversity of technical support.

Weiser's (1991) groundbreaking article formulated the vision of ubiquitous computing and signalled the disappearing of the computer as a distinct entity and instead merging with ordinary objects and being embedded in physical environments. Ubiquitous computing is a powerful conceptual clearing that has been insufficiently cultivated over the years considering the extent to which computer technology is permeating all aspects of life. Weiser's argument that pervasive access to information will lead to a more harmonious relationship where computing adapt to the human environment, instead of the opposite, has merit but mainly when considering the technology as means for supporting individuals managing or processing information. Dourish (2001) proposes a shift in the study of ubiquity towards the broader concept of embodied interaction emphasising the ongoing maintenance of the coupling of user actions and their intensions. From a technical perspective, ubiquitous computing can be characterised in terms of addressing the three concerns of; natural interfaces, context aware applications and automated capture and access (Abowd and Mynatt, 2000). However, while much attention in the HCI (Human-Computer Interaction) field has been devoted to understanding relationships between individual users and the technological interface, little attention has here been devoted to the general understanding of real-life ubiquitous computing user-experiences (Abowd and Mynatt, 2000). In particular, there is very little research exploring how specific technological affordances relate to the everyday processes of rendering information and communication technology ubiquitous (Sørensen and Gibson, 2008).

When a user engages with technology supporting the mobilisation of interaction through a range of mobile IT is not guaranteed to lead to the harmonious relationship Weiser anticipated. Practically, the technology will support the user but also impose demands, for example, of everyday maintenance tasks, for back-ups to be made, ensuring that batteries are charged, that all necessary cables and connectors are brought along, and perhaps occasionally to install firmware upgrade (Sørensen and Gibson, 2008). Considering the relationship between the technology and the user, there are also more substantial conflicts at play. The individual user is through their mobile IT, for example, both free to roam and at the same time instantly available for interaction requests (Arnold, 2003). Understanding the processes of adaptation between technological affordances and human activities is a complex arrangement of mediated and body-to-body interaction (Fortunati, 2005). Closing the physical gap between the user and their computational support for interaction increases the complexity of the relationship as mediated interaction gains immediate access to an individual's personal context of conflicting demands, purposes and preferences. In the context of work, additional constraints and opportunities emerge, for example, relating to the negotiation of interdependencies between distributed colleagues, performance measurement, and the degree of individual discretion in decision-making.

Mick & Fournier (1998) reflect upon the paradoxical relationship between consumers and technology in general, and this is applied by Jarvenpaa & Lang (2005) to the analysis of mobile IT. The mobile phone can, for example, simultaneously fulfil the need for instant contact with someone else and create further need for contact. This complex and paradoxical relationship between user and technology results in the user cultivating their own individual coping mechanisms in order to resolve everyday conflicts (Mick and Fournier, 1998; Jarvenpaa and Lang, 2005). The user may decide to look at their mobile phone display before accepting a call to decide if they wish to engage in the conversation. When confronted with the conflicting demand of not disturbing in a meeting and yet remain available for interaction, the mobile phone may bet set to silently vibrate, and the user may here choose to interact through text messages instead of calls.

This paper is concerned with *individual cultivation of interaction ubiquity at work*, which is the ongoing changes in the relationship between a worker and the technological possibilities offered to this individual implemented in order to ensure that interaction with remote individuals, groups or interactive systems best match the individual user's personal preferences, the requirements of the situation and other constraints. Arnold (2003) argues, in the context of everyday technology use, that such cultivation must be considered as contrary, and not linear, performances based on technical affordances. However, he does so representing the technology as a closed black box of affordance, i.e., possibilities for action (Schneiderman and Maes, 1997; Dourish, 2001). These possibilities for action are evoked in a context of contradictions, tensions and uncertainty and thereby rendering the technology multi-faceted. This paper assumes that increased complexity in cultivating interaction ubiquity follows as the user increases their use of mobile and ubiquitous IT. It also assumes the need to further understand the diversity of technological support for the cultivation of interaction ubiquity and asks the question: *What is the role of technologically embedded assumptions in the cultivation of interaction ubiquity at work?*

In order to analyse this question, two distinctions are forwarded characterising technological choices: 1) The technology offers embedded support for managing ongoing interaction relationships as opposed to the technological assumption of a series of interaction encounters, and 2) the technology offers embedded support for prioritising interaction versus complete user-management of priorities. Combining these two sets of assumptions about the diversity of possibilities for technologically supported action results in four distinct types of affordances. Each type characterises a distinct type of embedded technological support for individuals cultivating interaction ubiquity: 1) *Connectors* offering support for unprioritised encounters; 2) *filters* supporting the prioritisation of encounters; 3) *mediators* supporting unfiltered relationships; and 4) *coordinators* supporting filtered ongoing relationships. These four types of affordances supporting the cultivation of interaction ubiquity are illustrated through the analysis of empirical studies of mobile working.

The analysis demonstrates the diversity of technical affordances supporting individuals cultivating interaction ubiquity in the context of mobile working. It is argued that successful cultivation of interaction ubiquity at work relies critically on a portfolio approach where the technology plays a more active role in the management of interaction beyond the simple standardised technical connection explicitly or implicitly assumed in the majority of research on the social aspects of mobile IT. Whilst the simple connections can be appropriated into complex interactive process, a discussion disregarding diversity in affordances will over-emphasise the social and neglect the role of explicit technological support in the cultivation of interaction ubiquity. Jarvenpaa & Lang (2005) call for further research on technology support for individuals managing interaction, and this paper aims to contribute to such a research endeavour.

The following section discusses the concept of ubiquity. Section 3 characterises the diversity of affordances supporting individual cultivation of interaction ubiquity in terms of the support for ongoing relationships and prioritisation. Section 4 uses this perspective in the analysis of four cases of mobile interaction at work. Each of the cases illustrates portfolios of technological support for the cultivation of interaction ubiquity. Section 5 discusses the results. Section 6 concludes the paper.

2.Ubiquity

Already in the late 1960s and early 70s, Alan Kay and others from Xerox Parc formulated the conceptual design of the Dynabook, which in essence was a notebook- or tablet computer. The Dynabook represented a conceptual leap in the understanding of how computers ought to support human activities. Another Xerox Parc researcher, Mark Weiser (1991), was later on the first to formulate a vision of ubiquitous computing implying the social embedding of portable and pervasive technology. Weiser's proposition of multiple computers for each person, and with the computers disappearing into everyday objects, marked a dramatic departure from famous predictions about electronic computers. IBM's Chairman, Thomas Watson, stated in 1943 "*I think there is a world market for maybe five computers.*" The founder of DEC, Ken Olson, predicted in 1977 "*there is no reason for any individual to have a computer in his home.*" Even Bill Gates' statement that "*Microsoft was founded with a vision of a computer on every desk, and in every home*" is now a conservative vision when considering the range of everyday computing experiences (Yoo, 2009). Harold S. Osborne's prediction from 1954 now seems much more lucid. He foresaw that each individual would possess a device similar to the mobile phone with video connection and a phone number given to the owner at birth and following him or her to their death (Ling, 2004). This prediction was, however, purely technical and with less concern for the wider socio-technical implications.

Mobile and wireless technologies such as laptops, notebooks, mobile phones, PDAs and smart-phones provide users access people and information sources whilst on the move. Ubiquitous computing is most often used merely to signify omnipresence of technology, for example (Mccullough, 2004; Ahonen, 2008). Lyytinen & Yoo (2002a) characterise ubiquity in terms of the level of mobility and pervasiveness. Wireless connected portable technology has led to a shift from traditional stationary- to mobile computing. Developments in telecommunications infrastructures and sensor technology has led to increased pervasive computing, i.e., technology embedded within and interacting with the user and their surrounding environment utilizing environmental and contextual information in the services offered. Whilst it is possible to carry around portable computers, they do not necessarily constitute ubiquitous technology unless they contain pervasive capabilities by relating to and using information about their surroundings. Similarly, some pervasive technologies may not be mobile, for example, stationary sensors feeding data to a central computer (Lyytinen and Yoo, 2002a).

From the mid-90s, both Europe and South East Asia saw a growing installed bases of mobile phones connecting people through global telecommunications infrastructures and the beginning of the 21st Century signalled the era of expanding network connectivity. In 2001 the 358 million European mobile phone subscribers superseded the 330 million fixed line subscribers. In 2009 the 4.3 billion mobile phone connections globally almost tripled the 1.5 billion Internet connections (Castells et al., 2007; Kluth, 2008). Personal Area Network (PAN) technology, such as Bluetooth and Zigbee, offers device interconnectivity in close proximity. Local area network (LAN) standards such as WiFi (IEEE 802.11.a/b/g/n) provide medium-range wireless connectivity. Wide area network (WAN) standards such as, GSM, UMTS, WiMAX, and Long Term Evolution (LTE), provide wireless connectivity across large distances. Broadband Internet access is brought to the mobile phone in addition to the existing services of voice, SMS, and email. Such rapid development of network technology has expanded the reach of computers around the globe, while at the same time bringing it ever more intimately into everyday computing. Weiser's prediction of several computers for each person has definitely been accomplished in large parts of the World.

A variety of research efforts have been concerned with ubiquitous computing. Research programmes such as The Disappearing Computer (www.disappearing-computer.net); research conferences, e.g., Ubicomp; and academic journals such as Journal of Personal and Ubiquitous Computing, have been established to focus research on this subject. Much of this research has been quite technical, see for example (Hansmann et al., 2003; Baresi et al., 2004). However, there has also been some effort invested in understanding ubiquitous computer use from a broader social and organisational perspective. Dourish (2001), for example offers a very comprehensive phenomenological analysis of what he coins embodied interaction.

A significant part of research in ubiquitous computing relates to the design and usability of technology, for example, Greenfield's (2006) excellent presentation of 77 principles for understanding what he calls "everyware"; most of Ishii's work on remote collaboration and on tangible bits (Ishii and Ullmar, 1997); and Norman's (1999b) work on invisible computers and information appliances. Mitchell (1995; 2003) and Mccollough (2004) consider broader relationships between people, ubiquitous computing, and the built environment in terms of the changing role of the city and the individual inhabiting this world of merging architectural and informational elements. Mann & Niedzviecki (2002) explore the social implications of ubiquitous computing based on Steve Mann's more than 20 years of experience with wearable computing. Warwick (2002) takes the concept of embodied interaction literally and experiments with RFID (Radio Frequency ID) chips operated into his body and sensors enabling him with his hand to remote control a mechanical hand via an Internet connection. Within the Information Systems field, very little effort has been invested in understanding ubiquitous computing. Notable exceptions addressing the research agenda for ubiquitous computing in organisations are: Lyytinen & Yoo (2002a; 2002b); Lyytinen et al. (2004); Sørensen et al. (2005); and Kourouthanassis & Giaglis (2008). Albrecht & McIntyre (2006) offers a techno-political exposition on the relationships between individuals as consumers, commercial organisations and RFID technology. Furthermore, the substantial body of HCI research in ubiquitous computing has largely devoted little attention to understanding unfolding real-life user experiences with the technology (Abowd and Mynatt, 2000; Sørensen and Gibson, 2008).

3.Interaction

Ubiquity is traditionally discussed as an inherent property of a particular type of technology, for example, in terms of being compact, mobile, pervasive, and provide capabilities of embedded computation. Ubiquitous computing relates to a range of socio-technical phenomena from individual technologies to ambient information spaces and shared public displays. Furthermore, the term ubiquitous computing most often simply implies ever-present and embedded computation. The aim of this paper is, however, to explore ubiquity as an ongoing relationship between the individual and the technological possibilities offered to this individual. Interaction ubiquity is the particular aspects of this relationship directly related to interaction with remote individuals, groups or interactive systems so as to best match the individual user's personal preferences, the requirements of the situation and other constraints. This paper considers the cultivation of such interaction ubiquity in the context of the individual engaging in mobile working. This section will in more detail discuss interaction in order to characterise the diversity of support for individual cultivation of interaction ubiquity.

Ubiquity and Interaction

The characteristic most commonly associated with ubiquitous computing is the disappearing of the computer as a dedicated device and processes of computation instead being integrated into appliances, clothes, walls etc (Norman, 1999b). The clear-cut classification of activities into those requiring the use of a computer and those that do not is blurred as computation becomes integral to a broader range of activities, and Yoo (2009) characterises this everyday use of computing as “experiential computing.” Weiser’s (1991) vision has been powerful in shaping the understanding of the technical possibilities but it also engenders the notion of ease of use, harmony, and computation merging into the fabric of life. The shrinking physical size of a computational device makes it easier for the computer as an independent device to be carried in hands, pockets, and handbags, and to form integrated features of tables, toasters, and walls. The features of the technology simultaneously inform patterns of use, and are appropriated through use. Socio-material assemblages are “*constitutively entangled in everyday life*” (Orlikowski, 2007, p.1437) and are best conceived as complex, paradoxical, and conflicting relationships (Mick and Fournier, 1998; Arnold, 2003; Jarvenpaa and Lang, 2005).

When ubiquitous computing technology supports remote connections with individuals, groups, or interactive systems, the user’s individual process of cultivating ubiquity can be shaped by actions of these remote entities, and can equally in turn shape other users’ remote contexts. The use is here informed by individual-, social- and organisational norms. Interaction ubiquity is an emerging relationship between the user and the technology supporting the person. For example, the decision of whether or not to pick up a specific mobile phone call will be informed by a whole range of possible factors. Is it possible to discover the caller’s identity? Who is calling? What is the recipient’s physical and emotional situation? What image does the recipient wish to display to the caller and what is the relationship between the two people? The rhythms of coupling and uncoupling technology from social action can vary across individuals, situations, tasks, and over time (Dourish, 2001, p. 138ff; Green, 2002; Sørensen and Pica, 2005). The user experience of ubiquity is therefore complex and an emerging property of the situation, and is shaped by a variety of factors ranging from practical matters of technology (Sørensen and Gibson, 2008) and situation (Ljungberg and Sørensen, 2000) to fundamental issues of the person’s emotional state (Ciborra, 2006).

The past 20 years’ global diffusion of mobile telephony has, for example, led to emerging social practices (Licoppe, 2004; Ling, 2008). The individual user’s ongoing relationship with ubiquitous computing technology can contain elements of control, harmony, interruptions, and overload. When the user and their immediate ubiquitous technology entirely define the situation, the user may indeed still perceive the relationship as problematic – this is the subject of much HCI research and a valid concern. The particular technology and the user are, however, the only immediate factors directly influencing the interaction. When the technology mediates remote interaction, other individuals, groups and interactive systems can play an active role in the user’s perception of ubiquity in their relationship with the technology. This paper specifically focuses on this latter aspect where the individual user is seeking to cultivate their everyday use of technology so as to ensure that their interaction with remote entities are experienced as ubiquitous interaction, i.e., interaction deemed appropriate, suitable and desired in the specific context. Interaction overload characterises the user experiencing a significant mismatches between their individual preferences and the actual interaction (Ljungberg and Sørensen, 2000; Mathiassen and Sørensen, 2008). Interaction ubiquity characterises the user experiencing a symbiotic relationship with the supporting technology in their interaction with remote individuals, groups or interactive systems.

Interaction ubiquity relates to Arnold et al's (2008, p.49) argument that "*things do not speak*" as the telephone, for example, easily disappear from our attention when we recall having spoken with a friend on the telephone and recall this as having spoken to the friend and not spoken through the telephone with a friend. However, this scenario assumes that the telephone is not perceived as a disturbance, and does not invite interaction to occur in situations deemed inappropriate. Whereas things may not speak, they can still call and disturb. It is the mobile phone ringing until the identity of the caller is established, thus shifting the issue of the phone disturbing towards the discretionary decision of engaging or abandoning the request for interaction. It is no longer possible to rely on the assumption of clear boundaries allowing simple categorisation of activities and matching these against specific use of particular technologies. Whereas the telephone traditionally inhabited fixed pre-defined places, the opportunity for voice calls now follows users wherever they are. Adding to this, a range of additional means of interaction has been included, for example, SMS messages, emails, voicemails, MMS messages, and the communication of availability through presence-services. For example, when a user reveals their mobile phone number to others is an act that at some later point may result in calls, and if the coupling and uncoupling of technology is the ongoing relationship between intention and action (Dourish, 2001, p. 138ff), then mobile phone callers are remotely seeking to influence the intentions of those they call, if nothing else, then to pick up their phone.

The technological complexity not only involves interaction mediated by standardised connections, such as the telephone system simply providing point-to-point connections, where the user is entirely responsible for managing the interaction. Ubiquitous technology can provide support for the management of interaction, for example providing the user information about requests for interaction, supporting the management of information about others, providing an audit trail of past interaction, by supporting the prioritisation and filtering of interaction (Ljungberg, 1999), and even the negotiation of availability (Wiberg and Whittaker, 2005). This type of support for the individual managing their own interaction can be compared with the use of coordination mechanisms in collaborating groups. Coordination mechanisms serve the purpose of managing part of the complexity of negotiating mutually interdependent activities (Carstensen and Sørensen, 1996; Schmidt and Simone, 1996). The cultivation of interaction ubiquity at work implies coordinating mutual interdependencies in the context of the multiple interests of the individual user, immediate team members and the rest of the organisation.

Latent- and Perceived Affordances

The remainder of this section discusses the diversity of affordances offering possibilities for the user to cultivating interaction ubiquity. The aim is to provide the background for a discussion of how the diversity technological choices can shape the socio-technical relationship of the user cultivating their interaction ubiquity.

Arnold (2003) characterises the use of technology as affordances subjected to simultaneously contrary performances in contrast to the traditional assumption of the affordances serving as simple means of achieving a purpose. Mobile computing technology will, for example, most often both follow the user and offer access to instant connections with others, and through this both facilitates the user's mobility and provides an uniquely fixed point of contact (Arnold, 2003, p.243). Technology performances are results of technological affordances – possibilities for action – meeting inherently contradictory situations. Arnold does not offer a specific definition of technology affordances other than rejecting their place in a linear performance achieving a specific purpose and instead exploring the role of affordances in the situated and contradictory use where they are evoked.

Gibson's (1977; 1979) original definition of affordances denotes latent action possibilities independent on perception. Norman (1988) popularised the concept in the discussion of the design of everyday objects and here, as opposed to Gibson, emphasised perceived affordances (Gaver, 1991; Norman, 1999a). Whereas Gibson's original definition emphasises possible usefulness of a technology, Norman's perceived affordances emphasises the usability of a technology (Gaver, 1991). As this paper is not concerned with issues of technology usability, the properties of ubiquitous computing artefacts are only characterised in terms of affordances – latent possibilities for future action.

The following two sections each consider a category of technological affordances and the third combines the two categories into a framework characterising diversity of possibilities for cultivating interaction ubiquity.

Encounter and Relationship Affordances

This paper draws on the distinction between technological affordances implementing encounters where memory of the interaction is not supported by the technology, and those mediating ongoing relationships through recording aspects of the interaction (Mathiassen and Sørensen, 2008). Encounters imply the technologically embedded assumption of algorithmic codification, whereas the mediation of relationships places importance in the cultivation of data (Wegner, 1997). Distinctions between encounters and relationships of various kinds have been discussed widely, for example: Wegner's (1997) distinction between algorithmic codification and ongoing interactivity in computing; problem solving method assumptions of transformation or interactivity (Mathiassen and Nielsen, 2000); organisational information services supporting encounters or relationships (Mathiassen and Sørensen, 2008); understanding market relationships as transaction- or relationship economics (Zuboff and

Maxmin, 2002); services as encounters or relationships (Gutek, 1995), and marketing as transactions or relationships (Coviello and Brodie, 2001). In the context of this paper, encounters and relationships specifically relate to technology affordances supporting the individual user managing their interaction with remote individuals, groups and interactive systems.

As an example, consider the core affordance of a standard mobile phone, the possibility of establishing connections with other mobile phones, either synchronously through a voice call or asynchronously by SMS or MMS messages. Each such connection is by the phone treated as an instance of an encounter between the two telephones and no specific assumptions are made regarding relationships between individual connections other than their chronological ordering and their type – incoming or outgoing. This core affordance defines the mobile phone as a device for encounters with little or no support for memory managing an ongoing relationship consisting of multiple such encounters (Mathiassen and Sørensen, 2008). Messages are organised in separate folders for sent and received messages. Each of these folders lists messages by their time-stamp as a record of the stream of encounters. Opposite to this approach, the Apple iPhone implementation of SMS messaging draws on an instant messaging metaphor. SMS messages are organised as a series of ongoing interaction relationships. The iPhone organises sent and received SMS messages as conversations between the phone user and contacts in their address book. Although this organisation of messages does not fundamentally alter the core mobile phone affordance to provide possibilities for encounters, it offers the additional affordance of encounters being organised as a series of relationships. By assuming that encounters indeed are part of ongoing interaction relationships, the technology can provide affordances supporting the management of these relationships. This basic example illustrates the essential distinction between affordances offering encounters as opposed to those supporting ongoing relationships. Encounter affordances implement the assumption of atomic, unrelated, interaction instances. Relationship affordances implement memory of aspects of the interaction.

Interaction Symmetry and Asymmetry

The assumption of ubiquitous computing developments leading to technology receding into the background and generally taking part in a harmonious relationship with the user is questionable if the technology mediates user interaction with remote people and systems. The technology will here enable the user-technology context to be penetrated by remote requests for interaction, messages, alerts, etc as well as extend the user's ability to equally engage in remote interaction with others (Ljungberg and Sørensen, 2000; Kakihara and Sørensen, 2001). In the simple case of a mobile phone call, anyone possessing the unique telephone number associated with a specific SIM (subscriber identity module) card will be able to instigate a call, which the recipient can decide to accept or reject. If the call is accepted, a simple connection is established allowing the two people to engage in a conversation.

Particularly interesting is the discussion of asymmetry in the situation between instigator and recipient as the request for interaction may be disruptive or the interaction itself may not suit the recipient (Ljungberg and Sørensen, 2000; Nardi and Whittaker, 2000; Wiberg and Whittaker, 2005). However, even if the interaction is deemed disruptive, it may still be perceived as beneficial (O'Conaill and Frohlich, 1995). The technological affordance offering one party remote access to another person raises the issue of interruptions, which has been researched extensively in the context of HCI (see for example the extensive list of references at www.interruptions.net). From the perspective of the recipient, this asymmetry can partly be caused by the combination of a technology affording interaction symmetry and the instigator of the interaction having limited or no insight into the recipient's general context and specific interaction preferences. Providing technological affordances for interaction asymmetry is, therefore, a possible means in redressing the situation. In the example above, the recipient may decide to reject the request for interaction based on information about the identity of the caller. The affordance of allowing the recipient to be informed about the identity of the caller, or indeed of the subject to be discussed, can be interpreted as the embedded assumption that this information matters for the decision to accept or reject the call (Ljungberg, 1999; Ljungberg and Sørensen, 2000; Wiberg and Whittaker, 2005).

The affordance of interaction symmetry implies that the technology offers all parties equal status in the interaction. Affording interaction asymmetry conversely means offering action possibilities prioritising interaction, for example through rules stipulating how interaction unfolds. SMS messaging affords interaction symmetry, as a text message sent is received, and as the technology does not prioritise messages, people, or contents. Instant messaging systems typically affords interaction asymmetry by providing rules regulating parts of the interaction, for example, requesting approval for a person to be included with the sphere of possible interaction (buddy list), and indeed the possibility to block existing members of that sphere. Technology offering interaction symmetry will leave the cultivation of interaction ubiquity entirely to the user, while technology affording interaction asymmetry supports the user in managing their interaction through supporting prioritisation.

Diversity of Interaction Ubiquity Support

The previous two sections categorised technology affordances supporting the cultivation of interaction ubiquity into two. The first category distinguished between the technological assumption of interaction as either unrelated encounters or as ongoing relationships. The second category distinguished between technology affording wither interaction symmetry or –asymmetry. In this section these two categories are combined into four types of technology affordances (see Figure 1) providing a diversity of possibilities for the individual to manage their interaction:

Connections offer possibilities of symmetrical encounters.

Filters embedded asymmetrical prioritisation of encounters.

Mediators afford symmetrical interaction in ongoing relationships.

Coordinators provide opportunities for interaction asymmetry in ongoing relationships.

The four types represent a diversity of affordances, which will be perceived and instantiated depending on the particular user's preferences, need and particular situation. The four types can each influence the extent to which the individual can cultivate interaction ubiquity to best suit their perceived needs. Figure 1 illustrates the four categories of affordances through examples. The following section uses this categorisation of affordances into four types as the analytical framework for a study of socio-technical practices in mobile working.

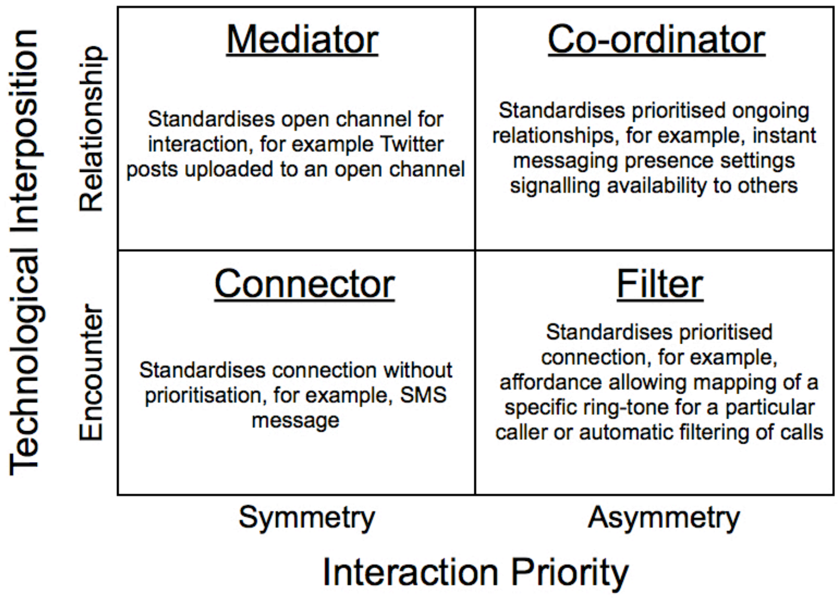

Figure 1: The diversity of affordances for interaction ubiquity defined in terms of assumptions about technological interposition and interaction priority.

4.Praxis

This section applies the categorisations established previously in the analysis of the cultivation of interaction ubiquity in mobile working practices. The four empirical studies discussed in this section were all conducted as part of doctoral research work within the mobility@lse unit (http://mobility.lse.ac.uk) at the London School of Economics and Political Science between 2002 and 2005 and form part of a larger body of qualitative empirical studies of enterprise mobility conducted between 2001 and 2008 (Sørensen et al., 2008). Table 1 presents key-characteristics for each of the four cases and point towards further sources of information about the studies. For the purpose of this paper forwarding the understanding interaction ubiquity in mobile working, the four cases have been re-analysed. The following four sub-sections each present one case, and each case represents a diversity of technology affordances. Technology affordances are classified from the perspective of the mobile worker described. The outcome of this analysis is an understanding of how the cultivation of interaction ubiquity is constituted by appropriation of a diversity of technological affordances. Figure 2 summarises the findings.

#	Workers	Year	Country	Method	Topic	References
A	Police officers	2002-2004	UK	250+ hours participant observation with 40+ officers and managers. 20+ interviews. 2 focus groups	The rhythms of interaction with mobile information technology by operational police officers	(Sørensen and Pica, 2005; Pica, 2006)
B	Off-premises foreign exchange traders	2003-2004	Middle-East	102 interviews and participant observation of traders	Discretion and control in mobile working for off-premises foreign exchange traders	(Al-Taitoon, 2005; Sørensen and Al-Taitoon, 2008)
C	Security guards & Industrial waste workers	2004-2005	UK	Action research with 350 hours of meetings, interviews & observation	Real-life experimentation with RFID (Radio Frequency ID) enabled mobile phone technology supporting new ways of working	(Kietzmann, 2007; Kietzmann, 2008)
D	London cab drivers	2004-2005	UK	39 interviews and 14 hours of video-taped observations	The choice of location as core business strategy and the role of mobile technologies in pooling resources and informing individuals	(Elaluf-Calderwood, 2008; Elaluf-Calderwood and Sørensen, 2008)

Table 1: Summary of key-aspects of the four case studies re-analysed for in this paper.

Study A: Interaction Ubiquity at High Speed

In the study of operational policing, the technology subjected to most intense cultivation of ubiquity and most highly rated by the police officers was the personal radio mounted on the officer's shoulder (Pica, 2006). The radio was generally the only remaining technology in use during critical incidents demanding the officer's full attention and thereby in this situation offering the optimal sense of interaction ubiquity. Officers would remain in constant contact with the control room during incidents both to report progress, to rapidly gather information, to coordinate efforts with other officers and to request further assistance in case it was needed. In terms of technical affordances, the two-way radio system offered un-prioritised constant two-way connection between the police officer and the control room. In order for this to work, however, the police engage in intense cultivation of how this connection is shaped into a means of supporting ongoing collaboration by applying strict discipline as to how the shared radio waves are used. Officers themselves would also apply highly selective audio filtering to the stream of radio messages broadcast and through this maintain peripheral awareness of ongoing and upcoming incidents similar to that documented from studies of traders and underground train control room operators (Schmidt, 1993; Heath and Luff, 2000).

In the police vehicle, the radio had traditionally been the main means for individual officers to obtain information about new incidents to attend. This had been supplemented with a new means of obtaining the same information, namely vehicle-based mobile data terminals (MDT) providing a range of data services to the officers. These terminals provided officers with a more effective means of gaining information about an incident immediately before attending it as detailed case information. It could also provide information about related incidents involving the same address or the same citizens could be sent to the particular terminal. This allowed much more comprehensive briefing as the information would be filtered and only sent to the particular vehicle engaging the incident and not on a set of shared frequencies with implicit demands of keeping interaction brief and to the point. For the officers attending an incident, this filter engaging in an encounter downloading data from the control room to a specific vehicle MDT had significant advantages in terms of being prepared. Streaming data to the car also suited the officers as the officer in the passenger seat would read out the information and continue to negotiate over the radio at the same time. This system was, indeed so effective that over time there was a gradual shift away from using the two-way radio system for pre-incident briefing and instead relying on the more effective dedicated streaming to the relevant car. As a side-effect of this shift from an ongoing relationship with interaction symmetry, where information was freely pulled by all officers listening to the main frequency, towards dedicated and filtered push of information, only to those obtaining the information would have an overview whereas everyone else would be more in the dark.

The data terminal also embedded a updated list of current incidents registered, which much like the queue of customer requests in a taxi system presented for the dispatch office a semi-automated way of coordinating the allocation of incidents to police vehicles simply by allowing officers to pick incidents themselves on the touch screen in the vehicle. From the point of view of the individual officer in a vehicle, the active queue of incidents represented mediation of ongoing available- and completed jobs. The officers evoked connectors when sending messages similar to SMS messages between the mobile data terminals installed in their patrol cars as well as using mobile phones to contact witnesses and colleagues to gather critical information or for instant micro coordination (Ling, 2004).

Study B: Trading Foreign Exchange Out and About

At a large Middle Eastern Bank mobile foreign exchange traders would spend their days in the trading pit and then continue to trade foreign currencies after normal working hours (Al-Taitoon, 2005). This arrangement was made in order for the bank to continuously engage with the market 24 hours each day of the week. In the past, the bank had experimented with 3-shift pit-based trading both in headquarters; with distributing trading across time zones in branches, and with selected traders trading out of hours from a stationary PC at home. These three previous attempts to extend trading hours beyond normal working hours all proved unsuccessful primary because they did not yield satisfying results when traders engaged in individual process of cultivating interaction ubiquity (Sørensen and Al-Taitoon, 2008). This was crucially required for traders to get on with their private life while continuing to engage in trading.

The fourth, and successful, solution supported traders in out-of-hours working through a combination of Reuter's SmartWatch, a small trading information device showing rate changes, a mobile phone for coordinating trading limits with colleagues, and for calling into an answer machine at the office to leave auditable details of the trades made out of hours. A highly select and trusted subset of traders engaged voluntarily in this working around the clock. This imposed very high demands on the technology being able to support the individual's need to cultivate an acceptable level of interaction ubiquity.

As the traders throughout their working day were subjected to various coordination mechanisms and control systems, they were allowed significant discretion when engaging in mobile trading and they engaged in extensive cultivation of ubiquity with their Reuters SmartWatch, setting up limits triggering alarms and views through filtering. The SmartWatch represented a coordinator supporting the traders continuously being kept up-to-date about market fluctuations in a focused and filtered manner ensuring minimum disruption.

Traders generally kept the interaction with colleagues through connections such as the mobile phone to an absolute minimum and generally were left to trade on their own. In rare cases a trader would call a colleague to coordinate trading limits. An organisational coordination mechanism imposed some minimal interaction asymmetry from the trader to the organisation as each was required to record details for each trade on an automatic answering machine for subsequent processing the following day. Their individual cultivation of filters for tracking rate changes and for providing a constant stream of information on the SmartWatch was entirely unregulated and allowed the individual trader to accommodate his own rhythm of work.

Study C: Loosely or Tightly Coupled Relationships

An organisational system with RFID-enabled mobile phones used for recording RFID tags and automatically sending SMS messages with the readings to a central server comprised coordination used by the work force in two different organisations (Kietzmann, 2007). In a security firm the guards would swipe the phone over passive RFID tags embedded in the walls along their route. After each swipe the phone would automatically send an SMS message to a central server updating it with the security guard's position and the status of the situation selected by the guard on a menu in the phone. For the individual guard, this was an example of explicitly imposed coordination of the work and represented a coordinator and not a case of the individual choosing how their interaction ought to be carried out. The security guards generally found it easy to cultivate their interaction ubiquity with the new system as the main difference from the existing system, where a torch-like tag reader was used, only was the immediate update of position instead of infrequent batch-updates. As the work already before was highly regulated with little scope for individual discretion, the guards did not find it difficult to cultivate ubiquity with the new system. The security guard would also occasionally use the mobile phone for calls.

A similar system was also implemented in another organisation to help track industrial waste barrels with RFID tags. In this domain, however, the workers found this particular interactive type of mediated coordination problematic as they were used to having considerable discretion in the organisation of work and now would have to engage in discussions with central management who felt they had a good overview remotely through the updated information fed by the RFID-based coordination (Kietzmann and Sørensen, Forthcoming). The embedded coordinator mechanism automated aspects of the work previously conducted by the user and also provided the possibility of real-time interactivity as opposed to data being recorded in the centralised system with some delay.

Study D: Finding Fares in London

There are around 21,000 of the famous London Black Cabs and most of them are owned by the licensed cabbie driving it. Each Black Cab driver has since 1865 been required to pass a difficult set of exams, "The Knowledge", covering 25.000 streets in a six miles radios from the centre of London. The drivers rely extensively on mobile phones for flexible connections exchanging information on available customers, roadwork and for engaging in general social conversation with fellow taxicab drivers, friends and family when on a job or when waiting for one to emerge (Elaluf-Calderwood, 2008). Most London taxicab drivers traditionally work entirely on their own with no overall support for coordination of their efforts. They have appropriated the mobile phones as a means of obtaining work, and for staying in constant touch through mobile phone connections. However, competitive pressures from minicabs, who can hire less qualified drivers has meant that London taxicab drivers increasingly seek membership of computer-cab organisations, which dispatch jobs to taxis through a computer-system based on drivers continuously updating their position to the central dispatch office. This system acts for the cab driver as a coordinator of jobs. The embedded rules for allocating jobs is a subject for much discussion among drivers as these rules greatly influence the overall performance and perceived fairness of the dispatch system (Elaluf-Calderwood, 2008). The study also revealed the further innovation of a coordinator where the driver's mobile phone location automatically is updated in a central system. The matching of customers and drivers is then almost automatically resolved when the customer calls the company from their mobile phone and here reveals their location to the system, which in turn automatically seeks out the nearest available black cab. The driver of this cab will be called on their mobile phone and can then accept or reject the fare. This coordination is an example where the customer and the cab driver are matched automatically through coordination as opposed to the traditional system where the customer would either call one cab directly or a human operator who would locate a cab.

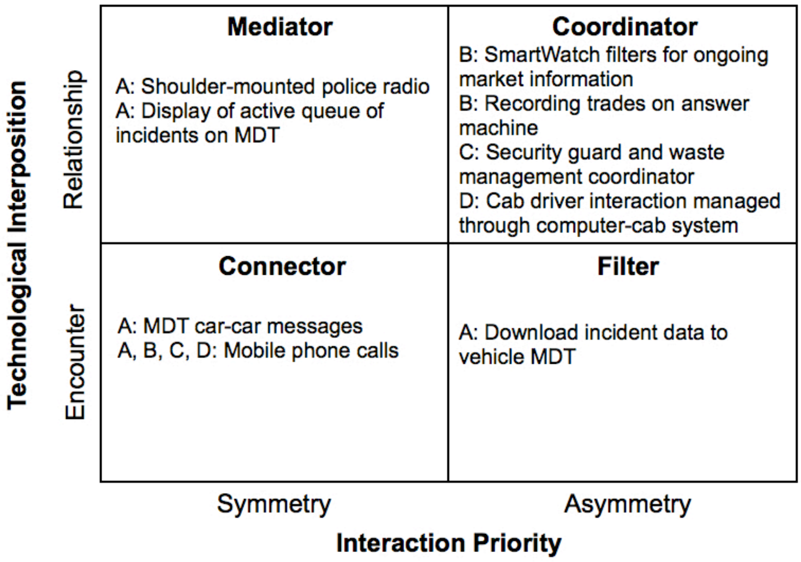

Figure 2: The diversity of affordances in the four case studies: **A**: Police, **B**: Mobile traders, **C**: Security guards and industrial waste management, and **D**: London cab drivers.

5.Choices

Several researchers have explored the complex and contradictory relationship between individuals and technology, such as (Mick and Fournier, 1998; Arnold, 2003). Characteristic for this type of study is a strong emphasis on the social context in which the technology is used with little or no attention directed towards the role of different technology affordances. The technology is generally considered a black box. Jarvenpaa and Lang (2005) explore the paradoxes of mobile phone use and suggest a range of design features supporting the users in coping with these paradoxes. In particular, they suggest increased support for: Presence management, collaboration, context awareness, location awareness, and role management. These are all aspects related directly to affordances beyond the connector, and in particular emphasising the need for technology affordances assuming interaction as ongoing relationships as opposed to encounters.

In the analysis of the four field study cases it was shown how ubiquitous interaction at work was organised through a diversity of technology affordances where some allowed extensive flexibility for emerging symmetry of encounters, such as the mobile phone used in all four cases and as in the security guard case carefully stipulate the individual's interaction with systems. This diversity of affordances marks a departure from studies emphasising a single technology, most often the mobile phone, primarily used as means of establishing connections, such as the study of mobile email pushing individual workers to constantly rendering themselves available (Mazmanian et al., 2005).

It is of course important to understand both the diversity of affordances and the contradicting performances when the technology is situated in social and organisational contexts. Human interaction is always conducted within a complex context of assumptions about others and about the interaction. This has been described best by Goffman (1963) in his study of the ongoing social processes of seeking to shape others' opinions of oneself, whilst these seek to gain the truth behind the masquerade. Goffman argues that in this ongoing process, we will always be a bit better at revealing the true intentions of others than they are at developing further strategies for obscuring these. Ling (2008) offers an extensive analysis of how the ideas of co-located interaction as studied by Durkheim, Goffman, and Collins can be understood in the context of new forms of technology-mediated interaction.

An interesting duality can be identified in the tension between the overwhelming success of connections assuming encounter symmetry, and the assumptions governing social interaction of relationship asymmetry. Emails, SMS, and mobile phone conversations are popular means of engaging flexible encounters in social situations of ongoing interaction relationships characterised by asymmetry. Whilst relying on *connection* and *mediation* embed assumptions of symmetry in the interaction, *filtering* and *coordination* directly stipulate assumptions of interaction asymmetry and through this supporting the user in prioritising the interaction. These dimensions offer a span of possibilities for designing interaction support. Applying connectors and thus leaving most to the discretion of the individual makes a compelling case for easily cultivated ubiquity.

However, issues of interaction overload and -addiction reveal possible consequences, as also illustrated by (Mazmanian et al., 2005) and (Jarvenpaa and Lang, 2005), of avoiding support for the cultivation of interaction ubiquity. As interaction and requests for interaction intensify this becomes increasingly problematic and there will be a need to establish principles, rules and mechanisms affording the technology managing aspects of the ongoing relationship as well as stipulating some interaction asymmetry. Immediately, the problem with interaction symmetry seems worse when engaging in obtrusive interaction, such as phone calls, as opposed to asynchronous text messages or emails, which seem more inconspicuous as they need not disturb directly. However, any initiation of interaction can be viewed as a request for someone else's' time and whilst missed calls only leave behind information that they are missed, emails and SMS messages leave themselves behind entirely as long-lasting requests for attention. One of the useful features of buddy-lists in instant messaging clients, or the invite system in social networking sites, is the ability to include and exclude — applying *filters* and *coordinators* stipulating asymmetry in instant encounters or ongoing relationships.

The underlying assumption of interaction asymmetry also relates directly to the ongoing and relational nature of interaction at work mediating, negotiating and resolving mutual interdependencies (Schmidt and Simone, 1996; Karsten, 2003). Much of the literature on meetings assume these to be relatively long-lasting atomic encounters, few in numbers, several in participants, and based on a pre-determined agenda. Empirical studies of interaction at the workplace have, however, found that the most frequent meetings are unplanned and involve two people discussing ongoing issues for around 90 seconds (Whittaker et al., 1994; Wiberg, 2001; Wiberg and Whittaker, 2005). Assuming this to be the case, it is not a surprise that technologies such as mobile voice calls, SMS messages and mobile email has turned out successful as they directly support such micro-coordination activities (Ling, 2004). However, this leads to users' spending considerable time managing multiple contacts as well as many ongoing conversations (Whittaker et al., 2001). Whittaker et al (2001) illustrate how a desktop-based coordinator can support both remembering the content of conversation, tracking status of conversations and outstanding actions, as well as maintain contact information. Wiberg (2001) identifies how ongoing interaction consisting of multiple concurrent conversations can be supported and here identifies the ability of the technology to mediate the relationship through *mediators* and *coordinators*.

The successful cultivation of ubiquity relies critically on the specific context. Whereas some work contexts, for example as in the case of security guards, require the explicit mediation of ongoing relationships through *mediator* or *coordinator* mechanisms ensuring sufficient technological support, other contexts, such as for example the Black Cab drivers, mainly require relatively simple *connector* mechanisms to ensure the appropriate levels of individual discretion for the user. Extensive changes in the ways the ubiquitous services relate to the individual, for example in terms of shifting from symmetry to asymmetry, can make it problematic for users to cultivate interaction ubiquity and the mechanism may be seen as foreign and inappropriate. For the security guards, the added interactivity and transparency of their movements did not impose a critical barrier for ubiquity as they already were used to being closely managed, whereas the industrial waste management workers found the added visibility problematic as it led to more intervention from management and less discretion for the workers. For the mobile traders, there was an absolute premium on individual discretion even if they worked in the highly regulated banking business. They would, however, on their own cultivate ubiquity through asymmetry embedded in profiles and alarms on their Reuters SmartWatch. This cultivation was, however, entirely determined and controlled by the individual trader (Al-Taitoon, 2005; Sørensen and Al-Taitoon, 2008).

Working life represents a myriad of emerging relationships continuously connecting and disconnecting social activities through technological capabilities and face-to-face engagements. Some of these connections are relatively easily established and broken, for example in close-knit networks of mobile phone connections. Others take hard work and significant organisational commitment to establish and to get accepted, such as establishing more significant direct support for collaboration through *mediators* and *coordinators* where the technology directly supports work processes. In general, symmetry, such as that offered by email systems and telephones, have easily found a place in organisations as flexible means for instant negotiation and micro-coordination. These connections offer flexible complements to interaction conducted by a variety of technology affordances embedding assumptions of interactional asymmetry, such as coordination mechanisms, schedules, organisational procedures and forms (Yates, 1989; Carstensen and Sørensen, 1996; Schmidt and Simone, 1996).

6.Conclusion

The paper argues that the study if ubiquitous computing must take into consideration the primary ubiquitous technology of the past 20 years, the mobile phone. It is also forwarded, that the abundance of studies emphasising the social context for mobile phone interaction must be balanced with insights into the diversity of affordances supporting individuals in cultivating interaction ubiquity beyond connections assuming interaction symmetry between the parties. It has been the aim to unpack some of the central issues related to technology affordances when individual users cultivate interaction ubiquity. The paper studied this in the context of work. The paper characterises the diversity of technology affordances supporting the cultivation of interaction ubiquity as four types: 1) *Connectors* providing support for symmetric encounters with no assumptions about the process or the relative importance of elements; 2) *Filters* embedding assumptions of interaction asymmetry supported through encounters with no memory of the process; 3) *Mediators* providing support for ongoing symmetric interaction; and 4) *Coordinators* embedding assumptions of asymmetry in the unfolding of events as well as mediating support for the process. Four case studies of mobile working were analysed using this distinction.

With rapid innovation in the diversity of technologies and services available for the support of inter-personal and organisational interaction, there is a great need to reflect further on what the consequences of these technological choices may be once the technology engages in a process of social appropriation. The emerging debate of information growth, overload, and other unforeseen consequences of the broader digitisation project can greatly inform such discussions. However, this paper argues that there is a need for an additional vocabulary when discussing the intimate relationships forged between individuals and technologies. This vocabulary must support us in understanding the consequences of socio-technical choices as well as guide our decisions of how to design further support. The argumentation provided in this paper marks one small step in this direction.

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