In Touch out in the Field

Coalescence and Interactive Innovation of Technology for Mobile Work

Jan Henrik Kietzmann

Department of Information Systems

The London School of Economics and Political Science

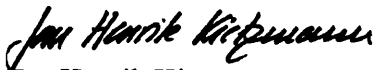
University of London, UK

Dissertation submitted to the University of London in fulfilment of the requirements for the award of the Degree of Doctor of Philosophy in Information Systems

ProQuest LLC
789 East Eisenhower Parkway
P.O. Box 1346
Ann Arbor, MI 48106-1346

Declaration of Authorship

The following dissertation is based on empirical and theoretical work conducted by Jan Henrik Kietzmann. Any non-original work is referenced throughout the document and a complete list of referenced materials is included at the end of this dissertation.



Jan Henrik Kietzmann

Abstract

Today, more than 90% of Britons own a mobile phone handset. Yet, the popularity of mobile telephony is a fairly recent phenomenon, with the first mobile phone call in the UK made only 21 years ago. Mobile technology has come a long way since the first mobile call that was made from St Katherine's dock to Vodafone's head office in Newbury. Many interesting mobile computing technologies have surfaced, including pagers, laptop computers, tablet PCs and Blackberries, constantly offering altogether new communicative acts to mobile workers. Innovation of mobile information systems, too, has changed quite dramatically over this time period. What was once an industry marked by low competition and high profit margins for devices developed purely by Research and Development departments now increasingly involves, even requires, the interaction with users for the innovation of new mobile devices in highly competitive environments.

Despite the increasing popularity of mobile technologies, the concept of mobility and the innovation of mobile information systems remain largely unexplored. This study takes up the challenge to examine how innovation of mobile technology unfolds today. With this focus, this research explores the relationships between innovators of technology for mobile work and its users. It departs from the prevalent product-oriented view of innovation and treats technology in the making as a conscious human activity, made possible through the trinity of innovator companies, their organisational clients as innovation partners and their particular mobile workers as end users of the technology. This study examines the complex interaction and coalescence of these parties as shaped by their respective organisational activities, their unique motives for cooperation with one another, their use of technology and their relationship to the geographical mobility and distribution of work.

From the outset, this study was committed to providing a rigorous examination grounded in actual work. As an Action Researcher, I was very fortunate to be invited to follow the innovation and development of a fundamentally new mobile information system, based on the convergence of mobile telephony and Radio Frequency Identification (RFID) technology. The empirical work and theoretical analysis emphasised the epistemological differences among innovation participants and unearthed many complications that shape how interactive innovation of technology for mobile work unfolds.

Moreover, the analysis of the empirical work led to the conceptual difference between mobility and pervasiveness of work as it pertains to innovation. It revealed *Individual Pervasiveness*, or the extent to which an individual's technology is aware of its immediate context and communicates details of its bearer and his behaviour. It also uncovered a *Pervasive Order*, imposed from superior to mobile worker and made possible in this case through mobile RFID. Together, these two concepts fundamentally change the information flow within mobile work activities. The trajectory from mobility to pervasiveness dramatically reshapes the activities of mobile workers and their superiors and, thus, the activity of interactive innovation of technology for mobile work.

Acknowledgements

First and foremost, my gratitude goes to my PhD Supervisor Dr. Carsten Sørensen, Senior Lecturer at the Department of Information Systems at the London School of Economics. Carsten supported my research interest from Day 1, inspired my work with his technology expertise and passion for Information Systems research and relentlessly encouraged and supported both relevance and rigour in my research. Thank you, Carsten, for always keeping an open door and an open mind and for being a great friend all along.

Within LSE, there are many individuals to whom I am very grateful. I thank Dr. Edgar Whitley and Dr. Jannis Kallinikos, my tutors in my first year at the Department. I am very grateful for my sessions with our late Professor Claudio Ciborra and thank Professor Ian Angell for the countless hours we spent mulling over technology, theory and world politics. I would like to take this opportunity to thank Professor Allen Lee for the insightful meetings we had over the past four years.

Of course, there are my fellow PhD students and friends who helped me along the way. Special thanks go to Dr. Gamel Wiredu for his advice as a friend and mobility expert. Dionesis Demetis, Daniele Pica, Silvia Elaluf-Calderwood, Cheryl Edwards, Flo Schultz, Sascha Pfrommer, Kenneth McElheran, Patrick and Josephine Mahaux, Dr. Alex Wieland, Ale Chehtman and Vero Puleio – thank you for everything.

Last, but not least, my most sincere thanks go to Sarah Emery, the heart and soul of the Department of Information Systems at LSE.

Outside of the walls of the London School of Economics, I thank Jyri Engeström for sharing his work with me and for providing me with invaluable industry connections that ultimately led to my empirical study. To maintain the anonymity of this study, I hereby thank everyone who was involved in my empirical work.

For theory development, I particularly thank Professor Yrjö Engeström from the University of Helsinki for our discussions of Activity Theory and Dr. Mike Chiasson from Lancaster University's Management School for our talks about my application of Action Research.

I especially thank Dr. Blaize Horner-Reich and Dr. Andrew Gemino for giving me an academic home away from home and for inviting me to use the facilities at Simon Fraser University during my time in Vancouver, BC, Canada.

To my family, especially my parents Ingolf and Christine, Christa Glaubitz and my brothers Sven and Tim, thank you for the air cover, for encouraging me to pursue my studies and for your continuous support, regardless of how silly some of my decisions may have been.

Finally, to my partner Kerstin Heilgenberg, thank you for your love and patience throughout this long journey!

Disclaimers

Anonymity

The subsequent dissertation is based, methodologically speaking, on a blended Action Research approach, details of which are discussed within the document. The empirical work conducted at its core took place at a number of organisations and locations; however the specific details of the identity of these empirical settings are not essential for the integrity of this research. Individuals, organisations and locations are anonymised to comply with contractually binding non-disclosure agreements.

Format

Supported by previous interpretivistic postgraduate research in the Department of Information Systems at the London School of Economics, the first-person voice is applied throughout this dissertation to reflect the direct experience and involvement of the researcher within the practical settings of the study. It offers an opportunity to present the unique account of the researcher's experience and his interpretation of the empirics. Especially in Action Research, the researcher's first-person expression plays a central role in his shared experience of both Action and Research.

Gender

The context of my empirical work includes both men and women, but for the purpose of readability, all individuals are referred to in the masculine gender throughout this document. Unless otherwise noted, whenever the masculine gender is used, both men and women are included.

Table of Contents

Table of Vignettes

Table of Figures

Glossary

Active	In RFID terms this means a tag or device with a battery as a partial or complete source of power to enable a greater read/write range or more memory on the tag.
ADC	Automatic Data Capture
Antenna	Aerial on tag or interrogator (reader)
Chip RFID	An RFID device based upon a semiconductor device. A chipless RFID device that does not use a semi-conductor integrated circuit. Chipless devices include acousto-magnetic devices, thin-film magnetic material devices.
Closed Systems*	A system in which relevant data regarding the attributes of the object is stored in a common database, accessible via data link by referencing the individual ID code. It usually refers to a system under the control of a single owner or authority.
Contactless Chip Card	Card which does not need to make physical contact with the read- writer in order to work because it passes electrical or magnetic signals through the air. Some operate only a few millimetres away from the reader; others work at many metres. The remote linking is either by capacitative or inductive coupling. More expensive but more reliable and sometimes more tamper-proof than contacted cards. The remote link is by either capacitative or inductive coupling. A Contacted Chip Card, on the other hand, communicates and receives power via metal contacts located on its surface.
EMI	Electromagnetic interference. Every electric current that flows produces a magnetic field. If the current increases or decreases, the magnetic field also grows or shrinks. If this moving magnetic field passes through a wire, a voltage signal will be induced in the wire, which may interfere with the correct operation of the circuit. Strong magnetic fields occur where cables carry heavy current so special attention must be given to the design of the computer power supply. If electric currents are changing very rapidly, then radio waves can be generated which may cause interference with other equipment.
EPC	The Electronic Product Code. A numbering system modelled on barcode numbering but with far more identities as required by The Internet of Things.
Exciter*	The electronics that drive an antenna are called the exciter or transmitter. Together with the antenna they are called a

	scanner.
Field Programming*	Programming information into the tags may occur after the tag has been shipped from the manufacturer to an OEM customer or end user or in some cases to the manufacturer's distribution locations. Field programming usually occurs before the tag is installed on the object to be identified. This approach enables the introduction of data relevant to the specifics of the application into the tag at any time; however, the tag would typically have to be removed from its object. In some cases, change or duplication of all data in the tag is possible. In other cases, some portion is reserved for factory programming. This might include a unique tag serial number, for example.
Geofencing	Using RFID to locate by association, e.g. sensors at entry and exit to a warehouse can give the information "Subject/object is in the warehouse".
Inductive Coupling	This technique is used in most RFID tags and cards in order to deliver power to the device and to allow it to communicate with the outside world. When the current is passed through one coil, say the read-write unit, magnetic field is created and, if the second coil, say in the contactless card, is bought close enough to it, this magnetic field leads to current being delivered to that coil as well. Once this occurs, the card has sufficient power to function and data can be exchanged between the card and the interrogator.
Internet of Things	The Product Internet pursued by AIDC where the EPC will be used to individually identify vast numbers of items using RFID over the internet. AKA Product Internet, T2T (Thing to Thing).
Middleware*	In a distributed computing system, middleware is defined as the software layer that lies between the operating system and the applications on each side of the system. In computing, middleware consists of software agents acting as an intermediary between different application components. It is used most often to support complex, distributed applications. The software agents involved may be one or many.
MIDlet*	MIDlets are Java programmes for embedded devices, more specifically the Java ME virtual machine. Generally, these are games and applications that run on a mobile phone. MIDlets run on any device that implements Java ME Mobile Information Device Profile. Like all Java programmes, MIDlets are "compile once, run anywhere". For improved readability of this dissertation, the spelling of MIDlets is changed midlets, the less common spelling.

MMS**	Multimedia Messaging System (MMS) is the logical evolution of the Short Message Service SMS, a text-only messaging system for mobile networks. MMS-enabled mobile phones enable subscribers to compose and send messages with one or more multimedia parts. Mobile phones with built-in or attached cameras, or with built-in MP3 players are very likely to also have an MMS messaging client, a software programme that interacts with the mobile subscriber to compose, address, send, receive and view MMS messages.
NFC**	Near Field Communication Technology holds the promise of bringing true mobility to consumer electronics in an intuitive and psychologically comfortable way since the devices can handshake only when brought literally into touching distance. Near Field Communication Technology or NFC jointly developed by Sony and Philips was approved as an ISO/IEC standard on December 8, 2003. It was approved as an ECMA standard earlier on. On March 18, 2004 Nokia, Sony and Philips form NFC-forum to advance NFC development. Although NFC was used within the setting of one trial, for simplicity and readability of this document the conceptual difference to RFID was viewed as negligible. For this study, the chosen terminology is RFID.
Passive*	In electronics this means either unable to generate its own signal, therefore has no power supply or an electronic component that cannot amplify signals and/or obeys Ohms Law (e.g. resistors or capacitors). Passive tags generally derive their power from the carrier signal radiated from the scanner/reader.
Reader*	The device containing the digital electronics which extract and separate the information from the format definition and error management bits. The digital electronics perform the actual reading function. These read electronics may also interface to an integral display and/or provide a parallel or serial communications interface to a host computer or industrial controller.
RFID*	Radio frequency identification. Use of small devices that can be electronically identified (and sometimes their data changed) at a distance without line of sight. Although radio is typically defined as 300 Hz to 300 MHz, nowadays the term even encompasses tags interrogated at 100 Hz and others at microwave frequencies (GHz).
Scanner*	The antenna's, transmitter (or exciter) and receiver electronics integrated in a single package called the scanner. They may be combined with additional digital electronics including a

	microprocessor in a package called a reader.
Smart Active Labels	Low cost laminar active RFID tags.
Smart Items	SAP defines these as physical objects that know something about themselves, can communicate that knowledge and have value for business.
Smart Labels	An RFID tag in the form of a flat, thin label or laminate. These are generally a low-cost form of the more conventional RFID tags.
SMS**	Short Message Service, which permits the sending of short messages (also known as text messages, messages, or more colloquially SMSes, texts or even txts) between mobile phones, other handheld devices and even landline telephones.
Tag*	The transmitter/receiver pair or transceiver plus the information storage mechanism attached to the object is referred to as the tag, transponder, electronic label, code plate and various other terms. Although transponder is technically the most accurate, the most common term and the one preferred by the Automatic Identification Manufacturers is tag.
TAV	Total asset visibility. The quest for automated electronic monitoring of large numbers of living or inanimate objects thus knowing their identification, location and what they are experiencing.

Definitions adapted with permission from IdtechEx (Harrop, Eberhardt et al. 2004), except otherwise indicated as follows:

* Adapted from Association for Automatic Identification and Mobility (2004)

** Adapted from Wikipedia (2004)

Chapter 1: Research Issues

Only few years ago, the idea of having mobile devices connect people and machines was unthinkable; it was a futurology shared among science fiction followers and technology enthusiasts. In the mid 1980s, when many were experimenting with cordless telephones, the first mobile telephones were introduced to the elite few who could afford the capital investment and operating costs of the new technology. Memorably large in size and heavy in weight, these devices were perhaps portable, but not particularly user-friendly and certainly not ubiquitous. Mobile telephony was flaky in terms of connectivity, quality of voice transfer and the reliability of networks. Among devices that did not require constant connection to a power terminal the majority suffered from poor battery duration and needed to be recharged in regular, short intervals. When the Moriba Talkman (Figure 1) was introduced in 1985, it was the size of a briefcase, weighed approximately 4.7kg, cost about £2,000 and had a battery life of little more than 20 minutes (BBC 2005).

Figure 1: Moriba Talkman

Innovations of the past 21 years have drastically improved the usefulness and ease of use of mobile devices, which over the same time have moved from their novelty status as high price items to widely used, much more inexpensive commodities. Unsurprisingly, the recent popularity of mobile technologies among users of all demographics has brought *mobility* to the fore of academic work, too. Here, new developments are discussed as emerging mobile (Sørensen and Pica 2005), pervasive (Hansmann, Merck et al. 2003), nomadic (Lyytinen and Yoo 2002) and ubiquitous (Avital, Robey et al. 2004) constellations of work and interaction.

Along the mobile telephone's trajectory from an elite to a mass technology, the associated industries of mobile technology manufacturers and service providers experienced a similar change of popularity. While there were very few manufacturers and operators in the 1980s, the competitive environment today drastically infringes on an individual company's ability to set and enjoy high profit margins, to the effect that some manufacturers and service providers no longer find the industry lucrative enough or simply can no longer afford to stay in business (Oldfield 2003). More recently, the pace of growth of the mobile technology sector has slowed considerably and arrived at a stable, high plateau of mobile handset sales and network usage for mobile services, leaving the industry actively competing for the next killer application (ibid.). So far, many of such attempts have been technology and marketing driven, based on technological capabilities and on assumptions of what users find attractive and useful. Among recent developments, some have been quite successful (e.g., Blackberry), while others have remained less victorious. Multimedia Messaging Service (MMS) is one example, the Personal Digital Assistant (PDA) another (Sørensen and Gibson 2006). The recognition that not every mobile invention is accepted and widely used combined with the increasing competition for users' attention presents manufacturers and service providers with a very interesting challenge: the need to involve users early in the process of innovation in an industry that has so far been able to successfully develop mobile technologies before introducing them to their future audience. This recent emergence of interactive innovation activities of mobile technologies has not yet been explored empirically and developed theoretically (Fontana and Sørensen 2005). The empirical and theoretical works of this study have at their heart the investigation of how technology for mobile work is shaped through interactive innovation.

This first chapter introduces the overall organisation of the dissertation. Section 1.1 presents my interest in the topic and research motivation. Section 1.1.1 introduces the joint field of innovation and technology for mobile work, followed by the underlying problem statement (Section 1.1.2). Section 1.2 outlines the investigative approach, including the research questions (Section 1.2.1), empirical settings (Section 1.2.2) and objectives of the study (Section 1.2.3). Lastly, Section 1.3 presents the structure and organisation of the remainder of this dissertation.

1.1 Research Interest and Inspiration

Perhaps surprisingly, some recent mobile technologies that were introduced through a push approach to innovating, developing and marketing technology failed to find an appreciative audience. At the same time, the curious, unanticipated success of modes of interaction that evolve from users (e.g., SMS, blogging) does not go unnoticed by manufacturers and service providers. Rather, these phenomena unveil and emphasise the importance of users as sources for practice-based knowledge and give rise to an innovation approach that relies on the user as an important contributor to the success of a new technology. Moving beyond the view that innovations are presented through the work of a sovereign individual, a leader and visionary, or through particularly innovative organisational structures, the concept of interactive innovation recognises the value of the interaction between developers and future users of an artefact. Interestingly, few studies have evaluated the interaction of developers and users adequately or pressed for a more educated perspective of *how* this interaction unfolds. In many ways, it seems, the legacy of the individual innovator with a revolutionary idea and the concept of the innovation company prevail, often neglecting the important role that users play in shaping the trajectory of an idea, from its conception to realisation.

Interactive innovation spans not only developers and users, but also brings to a light another interesting aspect, namely the blurring of the traditional distinction of innovation and design. While in the past the notion of innovation referred to determining a purpose of a particular idea or technology, design connected developers with users to determine the details to meet this purpose. Now it seems that the distance between innovator and designer or developer is shrinking, as one is incorporating elements of the other's domain. Innovation is no longer conducted separately from design, and design has very many innovative components (Wiethoff, Meulenbroek et al. 2005). Consequently, the concept of interactive innovation is here seen as the pursuit of developing novel ideas into products or processes through the interaction of innovators, developers, designers and users.

1.1.1 Interactive Innovation of Technology and Mobility of Work

The involvement of the user introduces the notion that innovation today is to be seen in a different light. Traditionally, an innovation is focused on a specific artefact; conceptually fixed, closed, non-malleable. An *innovation* is a clean, somewhat readily available product or service. Clearly, such an approach presents a fairly uncomplicated view of technology; one that is neither realistic nor suitable for recent developments, let alone those within the mobile technology domain. In comparison, interactive innovation, or rather the terminology of *innovating* preferred here, assumes the nature of a value-added process rather than being product-driven. It refers to an exercise, an activity, rather than its outcome. Interactive innovating focuses on the conscious interaction and learning occurring among a host of innovators, developers and users to determine the future paths of a novel idea, from its inception through its development. This dynamic interaction of a multitude of users and developers is conceptually complex, messy, flexible and available for change. In this activity, the technological artefact adopts a dual role, technology under development and technology in use. Innovators and developers work on technology and users work with technology; the interaction between them is to yield an increased level of relevance, responsiveness and effectiveness of the technology to be.

However straightforward this suggestion might appear, when merging the two problem domains the realities of the mobilities at work make the interactive activity of innovating quite difficult to carry out and to study. Mobile technology, although increasingly popular as a field of study in Information Systems, so far looks mostly at the phenomenon of mobility itself and focuses on its *effect* on the user in technical, social and socio-technical terms. In an organisational setting particularly, mobile technology has somewhat deterministically been heralded as an enabler of mobile interaction among people and objects, as initiating new ways of organising and processing information through data gathered with the aid of mobile devices. However, in a time when the effects of mobile technology are at the fore of scholarly work in Organisation Studies and Information Systems, the emerging *causal* involvement of the user from an innovative perspective has not been examined, despite its important and compound dynamics. As a result, research on the effect of mobility on the user is well populated; his involvement in the making of mobile

technology so far remains unnoticed. A partial reason for this lack of investigation may be the practical difficulty of studying interaction with mobile workers. While cooperative activities in co-located or location-specific settings can perhaps rely on established and commonly understood forms of interaction, involving mobile users presents many unique and complicated communication and interaction challenges.

At this stage, the commonly accepted terminology of *mobile technology* requires further attention to circumvent any subsequent confusion. While it is true that in many cases technology has made possible new kinds of mobile work, in other settings it simply supports traditionally mobile work activities. While the former receives a lot of attention in Information Systems research, the latter is of interest in this particular study. I believe the term mobile technology is often bounded up with enabling new kinds of previously non-existent work, with freeing workers from the temporal and spatial constraints of co-location and creating new, mobile occupations. Discussions of mobile technology often centre on the underlying debate over "the death of distance" (Cairncross 1997) versus "distance matters" (Olson and Olson 2000). For the focus of this dissertation, distance and mobility have always mattered since the nature of the work in question was never co-located; mobility here is not a new attribute of work introduced through technology. I will therefore use the terminology of *technology for mobile work* to refer to the introduction of new technologies for work settings that have always been mobile. In this context, novel technology is associated with new ways of mediating traditionally mobile, organisational activities as more people and firms adopt new mobile communication alternatives.

1.1.2 Problem Statement

The underlying motivation of this research lies in the intricate phenomenon of interactive innovating of technology when it is for mobile work. Individually, discussions within both domains, innovation studies and technology for mobile work, receive attention within industry but remain largely under-researched in concert. In practical terms, vague and perhaps overconfident assumptions about mobile work impair not only the processes of interaction and innovating but also lead to the development of technology that is disjointed from actual mobile work. In other words, today's particularly rapid advancements of technology for mobile work focus more on

churning out new artefacts and taking into consideration the occasional dud than developing a rigorous analytical understanding of the underlying processes and activities involved in innovation. For the development of more appropriate technologies, too little is attention paid to interactive innovating and too little emphasis is placed on the specific dynamics of collaborating with mobile workers. Thus, unless researched empirically, analysed theoretically and applied to practical settings, future innovations are likely to remain entirely product-focused and developer-driven. They will continue to miss out on the fundamental understanding of various parties, their unique demands on technology and interests in coming together to consciously innovate, develop and design technology that is truly useful for mobile work.

1.2 Investigative Approach

The abovementioned peculiarities of the interactive activity of innovating technology for mobile work spurred the research presented here. Of course, these two elements must not be studied in isolation, as this would be counterintuitive to a study of interaction. Consequently, it is the hermeneutic relationship that is of interest here; interactive innovating shapes and is shaped by technology and mobile work. It is this process that is under investigation and that promises to introduce new empirical and theoretical contributions to our conceptualisation of the impact of technology and mobility in its social and organisational sense.

1.2.1 Research Questions

Interactive innovating in this research is not treated as product-driven but rather as constituting of a number of interrelated activities. In an effort to examine the interaction of various stakeholders, a process-oriented perspective is adopted. Fortunately, as a researcher I was able to accompany a unique portfolio of interactive projects, which allowed me to observe and examine the innovating activities as they unfolded from early concepts through information systems implementation. The important roles played by innovators, organisations employing mobile workers, their mobile workforce and technology innovated during these trials are central to my investigation. Their interaction and the simultaneous negotiation of the technology

under development form the primary focus of this research. In an effort to develop an empirically-based understanding of the activity of interactive innovating of technology for mobile work, my primary research question is:

How does the interaction with mobile work affect the innovating of technology?

This primary research question guides the organisation of this research and dissertation. It furthermore points to a number of secondary research questions, including:

What is the role of mobility in interactive innovating?

What are the roles of the different parties involved?

What is the role of technology in mobile activities and interactive innovating?

In light of the problem statement and in pursuit of these resulting research questions, I conducted an extensive empirical study that concentrated on two main constituents, namely the technological component as the motive of the activity of innovating and the social and organisational context within which the various innovating activities were carried out.

1.2.2 Empirical Study

The subtitle of this dissertation, *Coalescence and Interactive Innovation of Technology for Mobile Work*, was motivated by the complexity of the involvement of various parties in the activity of innovating technology for mobile work. Their often-contradictory activities and conflicts emerging through the introduction of new technologies make this study both very interesting and quite complicated.

Throughout this empirical work, I worked closely with three categorically different parties involved in the activity of innovating technology for mobile work. These included work with the primary innovator who wanted to develop new technology for mobile work. I also involved this innovator's corporate customers who desired to improve their understanding of how mobile work was conducted and their ability to manage it accordingly. Additionally, the empirical work of course included these corporate customers' mobile workers who ultimately used the artefact under development.

It was with great pleasure that I accepted an offer to research innovating activities at the primary innovator, Nalle, one of the leading handset manufacturers of mobile telephones. Nalle's aim was to be the first company to innovate and develop a new handset technology that converged two previously separate and unrelated technologies. Under the name of mobile RFID, this new technology enabled selected models of traditional mobile telephones with the ability to engage in Radio Frequency Identification (RFID). The telephones were equipped with RFID readers, which were able to read RFID tags within their proximity and communicate object-specific information through a local-interaction server to the corporate back-end. By tagging a number of objects and tools in the field, this technology facilitated a much increased and improved level of interaction between various mobile workers, the objects of their mobile work and their office-bounded superiors. These new processes of automatically identifying and communicating the status of mobile work was aimed at addressing many of the shortcomings of previous information systems for mobile work. Each of the individual, empirical settings that collectively formed the overall empirical study was motivated by different organisational problems.

In terms of these empirical settings, I was introduced to three of Nalle's corporate customers who already employed mobile workers as part of their everyday operations (i.e., Grizzly Waste Management, Morrison Patrolling and Allô). As outlined earlier, the respective professions were not new; they were not made possible through mobile technology but rather occupations that had been traditionally mobile.

Prior to the trials, Grizzly Waste Management suffered from a very low level of understanding of many mobile components of their work. Grizzly Waste Management did not know details of how their drivers of industrial waste container carrying

vehicles conducted their work activities, where drivers and waste containers were located at any point and whether the latter were full or empty. A result of this ambiguity was an inability to schedule the delivery and collection of containers properly, which was felt by Grizzly Waste's respective customers to be a nuisance and reason to consider switching to a different waste collection company. The second empirical trial at Grizzly Waste Management involved the company's mobile engineers at specific waste landfill sites. Among other tasks, mobile workers managed the landfill gas conversion to electricity, which was used to power the landfill sites or added at a premium to the national power grid. The upkeep of the conversion ratio and the actual conversion engines required regular monitoring, maintenance and data communication between mobile workers and their offices, activities that were strewn with problems. Grizzly's powerlessness of maintaining an adequate account of their container inventory and workforce and the company's inability to manage gas conversion at landfill sites resulted in extensive inefficiencies of resource utilization (human and technical), which were the primary reasons for the company's interest in introducing an auto-identification technology to mobile work activities.

Morrison Patrolling, one of the other empirical settings, is a security services company that employs a number of guards who patrol various commercial properties. Morrison Patrolling's guards navigated their terrain either by car or on foot; they checked that gates are locked, windows closed, alarms enabled etc. and recorded their status on paper. Morrison Patrolling's respective customers needed to be updated about the security of their premises at all times and Morrison Patrolling's office-managers spent the majority of their time liaising via telephone between mobile guards and corporate customers. The obvious solution to this resource intensive exercise was to link the two parties more directly, a promise made by the new, RFID-based technology.

The remaining empirical trial was hosted at Allô, a mobile telephony service provider with a wide customer base within the UK and internationally. The organisational problem at the heart of this study was not Allô's inability to manage its mobile inventory or employees, but rather the urgent need to identify new services for its customers and new revenue streams for mobile services. The empirical work involved the experimentation with mobile RFID among Allô's mobile workforce, aimed at

increasing the awareness of the technology among its employees and the identification of new mobile services for its customers.

Thus, the overall empirical study and examination of innovating involved three categorically different parties across a number of empirical settings. First, Nalle, as an instrument-producing participant followed the objective of developing a new tool. Second, Allô, Grizzly Waste and Morrison Patrolling, who wanted to design new work practices and services with the use of this tool in part to improve their abilities to interact with mobile activities and in part to discover new uses for the technology. Third, mobile workers were equipped with a new device that promised to improve the shortcomings of their work, too. This presented a very interesting challenge for three distinct parties who directly participated in the innovating activity. Indirectly, the resulting tug-of-war between these three parties proved a very political exercise in which the different groups presented and defended their respective interests in the technological innovation, in its final properties and affordances.

1.2.3 Objectives and Significance of Study

Radio-Frequency Identification currently receives a lot of attention, within industry and from scholars of a host of disciplines. Among many other foci, privacy experts focus on the potentially invasive nature of the technology, security specialists analyse the extent to which reader and tag interaction can be protected from illegitimate access and logistics authorities discuss the auto-identification technology's ability to revolutionise supply chain management (Garfinkel and Rosenberg 2006) (Albrecht and Macintyre 2005). At the same time, mobility and mobile technology, still disciplines in their early formative stages, are increasingly moving to the fore of Information Systems research. The enormous advantage of this research is its priority access to the first interactive innovating efforts to convergence mobile telephony and RFID. It makes possible the empirical research of an area that can otherwise only be speculated about.

Motivated by the recent industry and market changes in mobile technology manufacturing, the objective of this research is to illuminate the intricate relationship of innovating, mobile work and technology. By investigating the interaction of three distinct parties, this study focuses on how different perspectives and objectives lead to

the negotiation of attributes of technology and work. As emphasised in the overarching research question, I place a primary focus on how the interaction with mobile work affects the activity of innovating technology. It further investigates how the inherent roles placed on individuals, mobility and technology shape this activity.

Viewed through an activity-lens, rather than from a product-focused perspective, interactive innovating is approached as a mediated and object-oriented process. Correspondingly, the research is fundamentally rooted in cultural-historical Activity Theory. It places emphasis on the unfolding of sub-activities of the various parties within the greater activity of innovating mobile RFID, empirically, and technology for mobile work conceptually. This leads to a number of objectives of this study that, from the outset of this dissertation, promise a number of unique contributions.

Methodological Significance

The focus on interaction as a key element of this work requires the direct involvement of the researcher as a participant of the innovation efforts under examination. An outside view of these activities is seen as introducing an unfavourable distance between researcher and the phenomena under investigation. As an Action Researcher, I was actively involved with all three parties; I played a role in Nalle's planning and design of the innovation experiments, I worked with the corporate clients to define the rules that the new technology had to adhere to and I spent an enormous amount of time 'where the action is', working with mobile workers on patrolling vehicles, on waste disposal trucks etc.

The underlying philosophy of the adopted methodology of Action Research emphasises that my direct involvement with the three participating parties aims to expose findings that are truly grounded in practice. Relevance, in these terms, aims to enable the examination of real phenomena against the theoretical, rigorous body Information Systems knowledge. In terms of scope, this work intends to research both the technical and social at the same time; and it responds to frequent calls to make research more relevant to practice (Zmud 1998). In this light, the examination of the suitability of Action Research for a complex study, involving multiple, geographically distributed interaction partners, promises an interesting methodological contribution of this research.

Theoretical Significance

Similarly, this study provides an invaluable opportunity to assess the suitability of Activity Theory for the analysis of mobile work activities. Moreover, the degree to which the underlying concept of tool mediation in fact takes into account specific tool attributes promises to release new notions of technology for mobile work.

By paying close attention to the technology under development and its specific attributes, this research aims to outline some of the novel affordances of mobile RFID, set in various organisational milieus. Overall, juxtaposing this technology to previous mobile technologies promises a new look at emerging mobilities at work. It provides an impetus for novel accounts of mobility, both within the boundaries of this dissertation and for future examinations of technology and mobile work.

Practical Significance

In terms of practical contributions, the value of this research was expressed through its immediate connection to the innovation of real technology. The study's findings were applied to the innovating activities and shaped true mobile RFID devices. Beyond this study, the findings aim to present a practice-grounded and reflective view of the activity of innovating technology for mobile work. By highlighting important attributes of mobile RFID, mobility and interactive activities, this study has application possibilities for those who set off on interactive innovating, development or design activities or aim to introduce new technologies or work practices to complex mobile settings.

1.3 Outline of Dissertation

Chapter 2 presents a review of the existent literature of the two underlying themes of this research, the mobility of work and the interactive innovation of technology. It first delimits the concepts of mobility, mobile technology and technology for mobile work. This chapter portrays the unique relationships between human subjects and the tools they use, and it points to the extent to which these offer possibilities for shaping activities of mobile work. In the pursuit of the previously outlined research questions, it further presents a review of innovation literature and general innovation theory.

This discussion puts forward a debate of innovating as an interactive, socially mediated activity. It proposes that technology for mobile work is in a unique situation; it involves a number of stakeholders and provides exceptional interaction and mediation challenges for the innovation of new technologies. The review in Chapter 2 presents the current literature and research on innovation of technology for mobile work and sets the stage for the theoretical and practical work of this dissertation.

Chapter 3 describes the methodological approach of this research. It discusses various forms of Action Research and presents a blended approach as the most suitable Action Research method for this work. The empirical study of this research is briefly introduced to substantiate the choice of this blended methodological approach.

In Chapter 4, the theoretical framework of Activity Theory is introduced. The previous discussion of the complexity of my involvement in the empirical settings warrants this in-depth discussion of the theoretical underpinnings. Chapter 4 outlines how the empirical study is examined through this activity-lens to provide insights into innovating mobile information systems. This chapter introduces the theory from its early developments to its most recent interpretations and advancements. It concludes with a discussion of Engeström's Activity System Triangle and the notion of representations as analytical tools for the empirical study.

Chapter 5 describes the empirical study that was briefly introduced in Chapter 3 in more detail. It outlines the various parties involved in the interactive activity of innovating technology for mobile work, including Innovators, Innovation Partners and Trialists. It further describes the various trial settings that collectively educate the innovation efforts and this research.

In Chapter 6, the respective empirical interactive work activities are presented and examined through the abovementioned activity-lens. Emerging contradictions and conflicts are discussed and their impact on the activity of innovating is examined. This analysis sheds light on the complexities of innovating technologies for mobile work, based on underlying epistemological conflicts of participating parties, their interaction and the continual involvement with technology. Additionally, this chapter subsumes the suitability of Activity Theory for a study of mobility, work and

innovating given that the underlying framework makes no theoretical allowance for work that is not co-located.

Chapter 7 presents a move from the empirical setting to an analysis of innovating of technology for mobile Work from a wider IS perspective. It maintains its commitment to the analytical activity-lens and examines the extent to which work environments are shaped by their underlying technologies and technological affordances. With a focus on the conceptual differences of various work environments and the influences of technological tools on interaction and mediation, this theoretical chapter juxtaposes mobility and the emerging phenomenon of pervasiveness at work. It presents an empirically-grounded and theoretically-led discussion of the uniqueness of innovating pervasive technology for mobile work.

Chapter 8 concludes this dissertation with a summary of research and findings. It presents the study's essential contributions, both practical and theoretical, the limitations of this research and propositions for future investigations that promise to move forward our understanding of innovating, technology and mobile work.

Chapter 2: Mobility, Technology and Innovation

This chapter presents a review and assessment of the two main themes of my research: mobility and innovation. As illustrated throughout this chapter, both are particularly complex and immensely difficult to delimit. Accordingly, efforts are first made to describe these concepts individually. In the first part, a discussion of the concept of mobility and its relation to work and technology is illustrated through themes from communication discourse before the subject of innovation is tackled through a three-tiered classification in the second part. The last part of this chapter unites these two themes in a discussion of research and literature on innovation of technology for mobile work and sets out the research approach for the remainder of this dissertation.

Section 2.1 introduces the broad topic of mobility and mobile technology. It describes the prevalent predispositions with the social *or* technical aspects of mobility that demarcate much of today's research. The section concludes by subscribing to a socio-technical approach, promising not to neglect important aspects of both the social *and* the technical world throughout the dissertation. In accordance to this plan, Subsections 2.1.1 and 2.1.2 discuss various aspects of mobile means of communication and mobile communicative acts, treating both technological devices as social constructs and social interaction as shaped by technological abilities and constraints. Section 2.1.3 addresses the important matter of choice that in many ways determines how mobile technology and its use are socially shaped. Short vignettes introduce Radio-Frequency Identification as the major technological focus of my empirical work and as a new way of mobile interaction within human activities. Section 2.2 introduces innovation as the second main theme of this chapter and delimits the often-neglected differences between inventions, innovations and the diffusion of innovations. Section 2.3 discusses the main strands of innovation research and introduces the individualist, structuralist and interactive innovation perspectives in the respective subsections before Section 2.4 unites the two main themes presented, mobility and innovation research and proposes to study innovation, or innovating, of mobile information systems as a messy process, a conscious human activity rather than through the more popular and cleaner product-oriented lens.

2.1 Understanding Mobility and Mobile Technology

Over the past decades, mobile devices have made fast inroads into people's private and professional lives. Ericsson and TeliaSonera laid the foundations for mobile telephony when they developed and launched the first fully automatic mobile telephone system in Sweden in 1956 (Scandinavia AB 2006). The first mobile devices in the UK were used primarily in professional settings since Racal, provider of military defence electronics, was awarded the first UK cellular telephone licence in 1982. Since then, mobile telephones have increasingly become icons of private and professional life and are treated as vital parts of how people communicate. Since its first mobile phone call from Trafalgar Square to Newbury in 1985, Vodafone alone connected one million people in the UK in 1993, two million in 1996 and five million in 1999 (GSM-Association 2005). In 2004, one billion global users were connected via GSM networks alone, which constitute approximately 75% of the world's digital mobile phone users (ibid.). The success of the mobile phone, in terms of penetrating society, has undeniably been enormous. The discourse of mobility studies is still young and recent mobile applications coupled with infrastructure improvements continue to raise the bar of information exchange to new heights. They enable a shift to mobility as the main technological focus of Information Technology (IT) development, as a new network structure and as a facilitator of novel business activities. While private persons have already approached a modus of constant availability via mobile phones, workers are in the midst of shifting to higher levels of communication mobility and are adapting their work practices accordingly.

Numerous studies from various disciplines (e.g., Information Systems, Organisational Behaviour, Engineering) have addressed the topics of organisational and private use of technology. Most have looked at ICTs exclusively from a technical perspective (Mark, Haake et al. 1997) or through a social lens (Seely Brown and Duguid 1991; Castells 1996; Eason 1996; Hildreth, Kimble et al. 1998; Engeström, Engeström et al. 1999; Lesser and Storck 2001; Zager 2001); only some have pursued a combination of both (Nardi 1995).

Among those who have focused on mobile interactions, there are again those who follow an engineering approach with a particularly deterministic undertone on technological aspects of mobility. While they are most often predominantly concerned

with technologically connecting users and devices to one another (e.g., Pierre 2001; Izadi, Pedro et al. 2002; Kim, Cho et al. 2003), those who examine mobility from a social perspective (Castells 1996; Ling 1998; Urry 2000; Agre 2001; Fortunati 2001; Plant 2001) have as their main tenet the societal and human impacts of technology and in return pay little attention to its respective underlying affordances. From a business perspective, these studies often focus on the adoption, diffusion or domestication of technology (Pedersen and Ling 2003). As further classified by Hosbond (2005), mobile systems development work falls within the categories of requirement, technology, application and business specification and development. Most of these views are exclusive, polarised approaches that are too focused to allow a more holistic, inclusive understanding on how ICTs and mobile technology in particular shape and are shaped by their everyday use (Kakihara 2003).

Recent and current work puts forward valuable contributions to our understanding of mobility from a *socio-technical* perspective, giving credit to both the technological affordances and their social implications. The above-mentioned research area of domestication of technology takes such an approach, as do other integrative studies particularly from research fields of Computer Supported Cooperative Work, Mobile Informatics and Information Systems (Kristoffersen, Herstad et al. 1998; Kristoffersen and Ljungberg 2000; Wiberg and Grönlund 2000; Wiberg 2001; Lyytinen and Yoo 2002). The research network for Mobile Interaction & Pervasive Social Devices at the London School of Economics, led by Dr. Sørensen, has brought forward socio-technical contributions such as Contextualising Mobile Informatics and the Concept of Location (Pica, Sørensen et al. 2004) , Emerging Work Practices of ICT-enabled Mobile Professionals (Kakihara 2003), Mobile Computing in Work-Integrated Learning (Wiredu 2005) and Supporting Mobile Professionals in Global Banking (Al-Taitoon and Sørensen 2004). Despite such strong emphasis in the UK and work on human computer interaction (HCI) at predominantly Scandinavian institutes of higher learning (e.g., at Viktoria Institute's Interactive Institute and at Umeå University), research of organisational mobility as a socio-technical discourse is still at its early developmental stage (Hosbond and Nielsen 2005).

Based on the importance of the organisational and technological properties of mobile interaction and the roles that people and artefacts play in the process of innovating,

my research clearly adopts a dual, sociotechnical approach. Especially with complex technological affordances such as the ones present in this study, there is an unambiguous need to describe and understand technical developments to comprehend the social implications, and vice versa. For this purpose, I apply the terminology from communication discourse to describe mobility and mobile technology, complemented by vignettes on Radio Frequency Identification that illuminate the type of technology employed in my empirical study. Communication theory in general differentiates between a technical evolution of *means of communication* (e.g., from telephone to computer or mobile telephone) and of *communicative acts* (e.g., from writing or speaking to texting or email). Nonetheless, as emphasised in the socio-technical approach adopted, it is the combination of these two components that has to be recognised as a way of organising information (Corner and Hawthorn 1989) and collaborating work practices. Accordingly, these two components are introduced individually in this chapter and discussed in concert throughout the remainder of this dissertation. Although it may appear that the two concepts follow the technical and social separation, they in fact both incorporate the socio-technical perspective as demonstrated in the following sections.

2.1.1 Mobile Means of Communication

The term and concept of mobility is difficult to delineate; in many ways are any attempts to define mobility too restrictive or not focused enough to be meaningful in any way (Kristoffersen and Ljungberg 2000). However, many mobile technology users agree that they are in fact *more mobile* than in the past, both in terms of their movement and with respect to the devices that they use (Oldfield 2003). Especially in the past decade have intrinsic technological shortcomings of mobility in terms of devices and infrastructure been reduced drastically. However, resource weaknesses vis-à-vis fixed-location (static, non-mobile) computers remain; security concerns continue to be higher, connectivity is of lower quality and battery resources are less than optimal for most users (Satyanarayanan 1995).

Defining Mobility

Despite the limitations of mobile technology, mobile artefacts often display properties that overcome the shortcomings of fixed-location devices. Recent developments promise to extend the continuum ranging from fixed-location technology (e.g., mainframe terminals) to mobile technology (e.g., mobile telephony) by one more component. *Nomadicity*, made possible through increased networking capabilities and a decrease in size of connected artefacts (Lyytinen and Yoo 2002), further enables the transmission of personal, organisational and public information. It is this concept of free flowing and sharing of information with no concentration on physical location that differentiates nomadicity from simple wireless technology.

In this context, a common presumption of mobility requires further clarification. Mobility is commonly seen as the opposite of the fixed-location devices. Mobility in this case would indicate that a particular application can be carried out at different geographical localities, whether within urban spaces or at remote sites. In this sense, the term refers more closely to the concept of portability of devices rather than mobility. The shortcoming of this definition of mobility is its close connection to the notion of location. The essence of mobility, however, lies in its independence from the concept of location, at least with respect to connectivity and data transfer. Viewed more conceptually, true mobility refers to nomadic arrangements that assume a convergence of systems and a compatibility of services across devices and operating systems independent of location. Kleinrock, the much acclaimed originator of the expression refers to this nomadicity as the arrival of the cliché of *Anytime, Anywhere* computing (1996), a concept approached with increasing capabilities of technology and infrastructure. Recent studies discuss the notion of hypermobility, signifying the "dynamic transformation in location, operation, and interaction in the workplace" (Kakihara 2003, p238) facilitated through mobile technology. Thus, a study of mobility refers to the ability to connect artefacts through information infrastructures and to communicate and transfer data at any location.

Nonetheless, such an understanding of mobility does not suggest that location becomes inconsequential in mobile settings. Much of the work carried out by mobile workers is in fact location-dependent; it is in many ways about being at being somewhere, at sometime (Cousins and Robey 2005), at a particular place, at a

particular time (Wiberg and Ljungberg 2000). Equally important, current assumptions that under such levels of connectivity "users get enabled to exchange and retrieve information they need quickly, efficiently and effortlessly, regardless of their physical location" (Hansmann, Merck et al. 2003, p13) are restricted views of interaction. As illustrated throughout this dissertation, mobile interaction is no longer reserved to human users, but also includes a wide array of object participants that communicate with one another and with human participants. Throughout this dissertation I assume an understanding of mobility as theoretically independent of location for purposes of data exchange and communication but as practically exercised in many cases at particular times and places. In other words, while location does not matter from the perspective of connectivity, signal reception and the ability to use a mobile device, it does play an important role in the examination of where and how mobile work is carried out. Accordingly, mobility within organisational settings experiences continued expansion in terms of the amount, depth and nature of data transferred and the number of connected people and devices on the move; phenomena to which the empirical context of this study testifies.

Adoption of Mobile Means of Communication

Lyytinen provides a comprehensive framework for the successful adoption of mobile technology, in which widespread use hinges on properties of nomadic information environments (2002). Nomadicity is here seen as a result of increased physical mobility, convergence and diffusion (mass scale) (ibid.). Among those who decide in favour of mobile technology, the change often introduces informating and automating developments, to borrow from Zuboff (1988), not only to every-day work practices but also to how the overall work-environment is organised.

Notwithstanding widespread enthusiasm about mobility, there remains reason for scepticism about the uptake of mobile technology, especially from a corporate-user perspective. Many organisations refrain from permanently switching to mobile solutions even after positive trial results (Oldfield 2003). This unexpected outcome might indicate undesirable spin-off effects associated with mobile technology. One reason is that people in decision-making positions see their authority and hierarchy-based ability to control others challenged by the flexibility, independence and spatial

freedom that mobile workers enjoy (ibid.). Despite the often-celebrated emancipatory potential of mobile technology, one clearly cannot arrive at the generalisation that mobile workers at large escape the traditional hierarchical structure. ICT does not necessarily affect the distribution of authority and control (Robey 1981). On the contrary, one might argue that individuals in fact support their self-interest by selecting mobile technology that reinforces rather than reduces their ability to exercise authority and control. The ability to log communication and monitor mobile employees electronically, for instance, carries connotations of punitive technology, comparable to Bentham's panoptic prison and its effects on inmate behaviour (Zuboff 1988; McPhee and Poole 2000).

Convergence of Mobile Means of Communication

Today, many seemingly new devices hit the market, promising to bring altogether new technologies to the user. In many ways are such items not entirely new inventions, but rather products that incorporate numerous existing technologies in one device. For example, computing and telephony devices are becoming more indistinguishable as one is adopting features usually associated with the other. Traditionally distinctly different technologies are blending into hypermedia (Kallinikos 2001(a)). Ljungberg and Sørensen (2000) describe such convergence as a combination of communication via wire, broadcast through the air and data transmission made possible through computers. The results are products such as mobile phones or satellite networks that make use of a host of these technologies. In addition to an increased depth through the convergence of technological features within devices, artefacts will assume new roles to facilitate amplified networking capabilities. Each new generation of mobile communication technology (e.g., infrastructure and mobile phones) allows for higher rates of connectedness and increased throughput for a range of devices. Technologies such as smart antennas, mesh networks and ad-hoc computing promise to elevate current networking technology closer to true ubiquitous computing, especially once agreed-upon standards are in place. Derived from nanotechnology's concept of swarm computing, amorphous technologies require that collective networks can be built on individual devices' capacities to transmit signals without intercepting them. This ad-hoc technology allows each client to simultaneously function as a server and signals to

hop from device to device, rendering a fixed-location infrastructure of senders and repeaters increasingly unnecessary.

The example of amorphous technologies indicates that means of communication include more than just handheld devices. They include the abovementioned supporting technologies and infrastructure, operating systems, middleware[1], applications on the devices and supporting infrastructure, among others. More importantly, means of communication go beyond the description of these technological items and include their adoption and appropriation along the journey towards increased convergence and connectivity of artefacts and people. The innovation of a novel means of communication in the empirical context of this study focuses on the convergence of mobile telephony and Radio Frequency Identification.

Vignette A: RFID – The Internet of Things

> Radio Frequency Identification (RFID) is an auto-identification technology that has been available for several decades; nonetheless the technology and the acronym remain fairly unknown to the general public. RFID was first utilised by the Royal Air Force in World War II to differentiate between friendly and enemy aircraft. Friendly planes were equipped with bulky RFID active transponders (tags) that were energised by an attached power supply and interrogated by an RFID transceiver (reader). Applications today rely on similar communication between RFID tag and reader, although now the tags (a miniscule microchip attached to an antenna) are generally passive, powered by an electromagnetic field emitted by the reader. Radio signals inform nearby readers of a serial number stored on the tag that uniquely identifies any item that bears that tag. So-called Smart Tags are used to track or trace objects. Worldwide, they already help keep track of about 100 million pets and 20 million livestock (Booth-Thomas 2003). The Auto-ID Center, initially established as an academic research project headquartered at the

[1] Middleware is defined as the software layer, or intermediary, that lies between operating system and applications on mobile devices, local interaction servers and legacy systems. It supports the complexity of distributed applications and devices.

Massachusetts Institute of Technology, developed the architecture for creating a seamless global network of all physical objects (Auto-ID Labs 2005). The technology has since been transferred to EPCGlobal, which now oversees the development of standards for Electronic Product Codes (EPC). Such EPC tags for every imaginable item, and even people, are revolutionising logistics, supply chain and inventory management around the world.

The novel developments that form the technological basis of this research utilise the combination of a mobile phone, equipped with an RFID reader, a local interaction server and a large number of passive tags that work over a short distance (<3 centimetres). For example, this means that with the new technology a security guard could use a mobile phone to read an RFID tag embedded in a gate, select an option from a menu on the phone (e.g., *gate is locked, everything is ok* and send it via the mobile phone to the back-end of the Security company. We already find that these tags are widely used[2], but no synchronous integration with back-end systems was possible until now. More detail about mobile RFID is provided in the context of my empirical study, in Chapter 5.

2.1.2 Mobile Communicative Acts

In essence, mobile technologies, including mobile RFID, allow more persons and more smaller and smarter devices to be able to talk to each other. Strictly speaking, communicative acts refer to *how* people interact. While these acts have traditionally focused on writing regular mail and talking in person and via landline connections, more contemporary mobile communicative acts include sending email, text-messages (SMS) and multimedia messages (MMS). They even involve undesired interactions such as bluejacking (i.e., sending unsolicited messages over Bluetooth connections to other devices such as mobile phones and laptop computers) and mobile phone spam. Many of these options can also be accomplished via location-based devices (e.g.,

[2] For a specific example, one only needs to look for small, silver 'buttons' (i.e., tags) at the doors leading to Information Systems Department in Tower One at the London School of Economics.

sending a SMS from desktop computers or recent landline telephones); however, these communicative acts are popular particularly among users of mobile devices. Interestingly, not only has the number of SMS texts sent via mobile devices surpassed the number of mobile voice calls in many countries (Gough 2005), SMS spam is already epidemic, reportedly even outnumbering email spam in some countries (Kim 2004). Some further phenomena include communication via abbreviations, acronyms and rebuses[3], which were previously known only from personalised license plates or crossword puzzles. Similarly, emoticons (e.g., ☺) enjoy increasing popularity in emails, on bulletin boards and in text messages.

Not only are these recent developments of communicative acts interesting from an applied interaction perspective, but they also point towards more fundamental changes of mobility itself. These communicative acts, including RFID, call for a closer view of the interaction of people, data and objects as they experience various forms of mobility.

Mobility of People, Objects and Data

Today, mobility is associated with the conscious, rational choice of people to move, to meander and to change location, often in a fluid, unstable way and at times unpredictable to themselves and others (Kristoffersen and Ljungberg 2000; Kakihara and Sørensen 2001). As people interact while they are on the move, as they change locales, they are often able to communicate in an uninterrupted fashion, in many ways without the other person knowing where they are or that they are in fact not stationary. Furthermore, mobile interaction characterises many of today's occupations and in many professions can one only survive, let alone compete and succeed, by accepting mobile communication as a way of doing business. Users' work radiuses and forms of interaction on the move change as they make less use of relatively locality-bounded devices and applications. To apply Kristofferson and Ljungberg's taxonomy of mobility, while people still wander, their use of technology will increase

[3] A representation of words or syllables by pictures of objects or by symbols whose names resemble the intended words or syllables in sound; also: a riddle made up of such pictures or symbols (Merriam-Webster 2006), e.g., "RUOK?" for "Are you ok?" or "CUL8R!" for "See you later!".

particularly in times of visiting and travelling (2000). These modalities of mobility delimit mobile workers according to their mode of transportation (i.e., travelling occurs when people move in vehicles), the time spent at any one site (i.e., visiting occurs when a person temporarily stays at one place on a transitory basis before moving on) and location (i.e., wandering occurs when a person moves about a building or specific premises). Lilischkis presents another illustrations of space and time as relevant determinants of mobile workers, with on-site movers who move about at a specific work site, yo-yos who occasionally work away from a fixed location, pendulums who work at two different sites, nomads who work from many sites and carriers who work on the move (2003). As illustrated in the empirical setting of this study, workers can also interact in a combination of these modalities. The notion of *roaming* might be an appropriate term for the increasingly popular communicative acts of peripatetic workers who drive, then spend time at a specific place, perhaps wander about and then continue to drive to different sites. Considered extreme only a few years ago, it is more commonplace today that a mobile worker *hotdesks* by working from different desks every day, within the organisation or outside (Brown and O'Hara 2002). While such a taxonomy of mobility may seem basic at first sight, their relevance and suitability for discussions of human mobile interaction and communicative acts is quite useful and is applied in Chapters 5 and Chapter 6 to describe the mobile work conducted in the empirical study. However, many of the mobile communicative acts occur not between people, but also actively involve mobile and stationary objects.

The movement of people mostly refers to the extension of geographical reach. Movement of objects, on the other hand, has traditionally referred to shipping and transporting goods from one location to another, to importing and exporting of merchandise and to carrying personal belongings to new locations while travelling (Kakihara 2003). In discussions of mobile interaction, objects often refer to activity-supporting objects (e.g., paper and pen); in mobile technology debates these most often refer to technological artefacts such as mobile phones, PDAs and Blackberry terminals. Such an understanding assumes that objects are inanimate goods, unable of initiating and maintaining any type of communication, and that human involvement is responsible for their movement and participation in any activity. As such, the involvement of objects in mobility discussions is of limited interest; *things* are seen as

only supporting human activities on-demand. However, novel developments especially through RFID and Near-Field Communication have given life to objects. Passive tags, for instance, are able to initiate communication once they are in the proximity of a reader, and vice versa. Objects, as a result, become more active participants in communicative acts; they adopt an increasingly important role in our discussions of mobility. The argument that such interaction is simply machine-to-machine interaction is of limited viability since it still involves human participation; however, in many cases it is the human involvement that is on-demand, requested by objects in motion. As outlined in the empirical example, mobile objects increasingly assume a heightened level of agency in mobile interactions.

The mobility of data, or information, is another aspect that deserves special attention. In addition to, or perhaps as a result of more people and more devices on the move, the amount and depth of personal, public and organisational data transmitted is immense. In addition to wired artefacts (e.g., landlines, desktop computers), or fixed-location wireless devices (e.g., satellites), mobile devices supply an increasing share of data transmissions. Consequently, the need to be at specific locations to transmit, broadcast and receive data is at a decline thanks to mobile phones, blackberry terminals, pagers and even short-range Bluetooth enabled devices. Moreover, wireless local-area networks, often open to the public or inviting customers at a minimal charge, and wireless broadband connections are increasingly popular, adding to the mobility of data.

Forms of Mobility

While mobile technology is generally credited with freeing workers from spatial (Dix 2000; Rosander 2000) and temporal constraints (Ferscha 2000), mobility must further be examined in various contextual situations (Kakihara and Sørensen 2001).

Of course, the notion of spatial mobility was of enormous significance when devices were first networked in a wireless fashion. As mentioned earlier, mobility at that time resembled more closely the concept of portability and connectivity at specific locales. With an approach to nomadic user behaviour, at least in urban environments with the adequate infrastructure, users today are less concerned with where they are. The concept of location flexibility moves to the background since data under mobility

travels to the person, as opposed to people travelling to data under portability. This is not to say, however, that people's attitudes towards space are not of immense importance anymore. On the contrary, our increased keenness to be spatially mobile shifts the importance of location, evident through the immense popularity of international transportation, travel and business activity. As conquering a larger terrain becomes less of a novelty, mobile connectedness becomes more of a necessity to the contemporary worker and traveller.

Temporal aspects of ICT further address the technology's ability to influence how people structure their work and private lives. Through a combination of asynchronous technologies (e.g., email and fast turn around time for documents), always-on availability, synchronous mobile voice communication and instant messaging options, people's days have adopted drastically new dynamics. In this process, multitasking, once the buzzword of operating systems, allows multiple applications to be executed simultaneously and experiences a shift from the technology to its user. Workers informated by ICT address a number of tasks not in sequence, but in parallel (Zuboff 1988). The limits of multitasking are defined increasingly by the user's capabilities as opposed to being set by his tools' constraints. While traditional desktop computing changed how time was allocated *at* work, mobile technology adds yet another dimension and changes work time and time *away* from work. So-called dead time, for example, is revived as workers on the go productively use time away from scheduled work activities. Mobility promises increased temporal efficiencies and effectiveness, as communications are no longer tied to pre-arranged appointments on landline telephones or restricted by time delays caused by messages left on stationary answering machines. Communicative acts such as sending short messages, although asynchronous in nature, can still be considered temporally mobile as people can send and receive messages at almost any time, from almost all urban and many rural locations.

Contextual situatedness, the most recent addition to our understanding of the influential dimensions of mobile ICT, describes how people communicate and interact with technology in different scenarios (Kakihara and Sørensen 2002). For example, mobile telecommunication devices manage to interrupt, without intention and in an opportunistic fashion, any task that the recipient is engaged in, requiring him or her to

shift among different contexts (Perry, O'Hara et al. 2001). Mobile phones ring in the middle of meetings and text messages interrupt telephone conversations. Plant's (2001) mobile phone user categorisation indicates that while some people give priority to mobile calls at any time, others are more selective as to when they answer a call. Especially for the former group of users does communication through mobile devices increase the need to shift among various identities, from employee to parent, from consultant to husband etc. as mobile workers receive calls from friends, family, superiors and subordinates, and vice versa. Constant shifts among different communication modi occur, leading to a host of changes among contexts of mobile users. Most communication devices function in a binary fashion; their users are either generally available or not accessible to everyone. Some try to circumvent this problem by screening incoming phone-calls and selecting whom to answer or to ignore, prioritising among different contexts. Nonetheless, even this process requires a shift in context for the user, a cognitive move away from his previous activity and towards the mobile device. These interaction modalities range from unobtrusive to obtrusive and from ephemeral to persistent (Ljungberg and Sørensen 2000). As a result, individuals' work schedules, their tasks' start and completion times are harder to predict (Perry, O'Hara et al. 2001). With email and particularly with mobile telephony, expectations of responsiveness to such interruptions have increased, and one feels obligated to reply to a text message by sending another message, responding to an email with another email and so on. Repetitive non-responses on a mobile telephone cause unease, even suspicion, on behalf of the caller (Plant 2001), whereas the same scenario on a landline would not nearly have the same effect. These examples clearly highlight how mobile ICTs change the contexts in which people communicate and interact on a personal and professional level. Simultaneously, the use of mobile ICTs is dramatically shaped by the situation in which this communication occurs, giving additional weight to the contextual element of mobility of people, objects and data vis-à-vis the more traditional considerations of spatial and temporal circumstances and conditions.

Mobile Technology or Technology for Mobile Work?

The preceding review of mobile means of communication and communicative acts supports the popularity of the terms mobility and mobile technology in the extant

literature. In a fairly deterministic fashion, this often indicates that certain work practices, even professions, were made possible entirely by such mobile technology; it suggests that work that had previously been co-located was mobilised, freed from constraints of space and time. As such, mobility is an emancipating concept that revolutionises work constellations and introduces altogether new forms of organising resources; it conceptually separates work before, or without, mobile technology from work with mobile information systems. These views are somewhat limited and often neglect that the concept of mobility had of course not been reserved to the developments of the last 20 years; many occupations have always been geographically mobile. Although these may not have conventionally used proprietary, high technology tools, such traditional mobile workers have always experienced many of the characteristics that are now attributed to mobility and mobile technology. Although these workers are now exposed to modern ICT, their experiences with mobile technology are naturally different from those who were *mobilised* through technology. Although both use mobile devices and are to varying degrees subject to the phenomena discussed in this chapter, for those who have traditionally worked in a mobile setting this technology replaces traditional tools (e.g., pen and paper) that were previously used as part of their mobile work activities. Although the properties of the technology under investigation in this study undoubtedly contribute to the mobilisation of previously non-mobile occupations, this dissertation and its empirical study focus on the introduction of mobile RFID to traditionally mobile settings. Rather than relating to *mobile technology*, this dissertation prefers the terminology of *technology for mobile work.* This difference, which may seem semantic at first sight, also clearly outlines that the topic under discussion relates primarily to work. Mobile technology, on the other hand, includes devices used at work, to play, to maintain private relationships and to socialise (Plant). Similarly, technology for mobile work suggests that various technologies and entire information systems are at the focus of the discussion, including local interaction servers and legacy systems, as opposed to mobile technology's preoccupation with the mobile device itself. As discussed throughout the empirical study and its analysis, it is more than the mobile RFID device itself, but rather its connectedness and integration with legacy systems that shape the interactions and innovative activities, best described through the more encompassing terminology of technology for mobile work.

2.1.3 The Matter of Choice

Lastly, the matter of choice of communication media must be addressed. While we have a wide selection of communication devices at our disposal, we make conscious decisions to use one over the other, in terms of communicative acts and means of communication. By and large, the various decision-making criteria can be grouped by (a) task and medium, (b) task or (c) medium and social environment (Straub and Karahanna 1998).

Within the category of task and medium, Daft and Lengel's *Information Richness Theory* (IRT) proposes that individuals make effective use of a communication medium if its properties match the requirements of the task (1984; 1987). Information richness, in this context refers to various degrees of personal interaction, where face-to-face interaction ranks high and numeric written reports rank low (Straub and Karahanna 1998). Technology for mobile work ranks at various levels between these two ends, depending on the device in question and situation at hand. A chosen medium is considered effective when it corresponds to the information requirements of the respective task (Daft, Lengel et al. 1987) seen in Straub and Karahanna (1998). The value of information richness or leanness as a sole determinant of choice has been refuted by a number of recent studies that favour social definition theories (e.g., structuration, social construction of technology) that lay emphasis on emergent properties of social context and social determinants of behaviour (Ngwenyama and Lee 1997).

Under Short's *Social Presence Theory* (1976), individuals assess the degree to which social presence is required for the communication task. High levels of social presence are met by face-to-face interactions, lower levels by choices of an electronic medium. With reference to mobility tasks, high social presence occasions are naturally rare compared to co-located environments. Advancements of synchronous video-conferencing capabilities via mobile devices will further introduce electronic alternatives with attributes of social presence, but for now, mobile workers prioritise and reserve tasks of high social presence or information richness for later face-to-face interactions if possible.

Proponents of task-driven choices of a communication medium differentiate between the levels of communication synchronicity (Straub and Karahanna 1998). Individual tasks that require immediate feedback from the communication partner, for instance, are best addressed by a synchronous medium. For technology for mobile work, many devices offer a variety of synchronous and asynchronous options. As expected, communication medium attributes such as accessibility and diffusion of the technology in question largely determine its task-driven applicability. Similarly, social and environmental factors such as temporal (un)availability of the communication partner and geographic dispersion shape communication possibilities and hence media choices (ibid.).

The category of medium and social environment includes physical properties of the medium, accessibility of the medium, critical mass in the user's social environment as well as availability of the recipient and geographic dispersion (El.Sawy 1985; Straub and Karahanna 1998; Rice and Gattiker 2000). This category is not very narrowly defined but addresses some issues not raised in the first two groupings (i.e., category of task and medium and category of task-driven choices). Due to the particular nature of the respective technology and environment in question, this category does not provide generalised theories of choice but rather introduces topics to consider. Such reflections may contain physical environmental factors (e.g., is there enough space or light to use a device?) and social environmental factors, as introduced by Kristoffersen et al. (2000). Examples may include the lack of a rational choice among some mobile workers who give in to social pressure, see themselves forced to conform to peers' adoption of mobile devices (e.g., to compete with other consultants, one needs to be available at all times), or who have been ordered to use specific devices by their superiors (Mathiassen and Sørensen Forthcoming).

RFID-based means of communication and communicative acts promise to spur new debates about the participation and agency of artefacts in the interaction of people and devices. Similarly, mobile work with RFID-enabled devices introduces new communicative elements that determine the users' rational choice and disposition regarding the technology. As illustrated in more detail in Chapter 5, attaching tags to objects and indirectly associating them with individuals introduces altogether new mobile communication dynamics. Users adopt new roles, and the communication

among objects might occur not necessarily with the awareness or explicit consent of their bearer. RFID will introduce another layer of complexity to the discussion of mobile means of communication and communicative acts – one that may deviate towards unconscious, imperceptible mobile communication. This topic is of enormous interest and, I predict, will fuel future contributions to mobility studies. The questions at the core of my research aim to understand how mobile means of communication and communicative acts shape and are shaped by the interaction of various participants. The previous sections on communicative acts, means of communication and the matter of choice are tremendously important for the understanding of these activities and their impact on the innovation, development and design of a new technology for mobile work. With this research focus in mind, the second part of this chapter first presents a review of innovation literature in general and concludes with an assessment of research and literature on innovation of mobile systems.

2.2 The Invention, Innovation, Diffusion Confusion

Innovation, much like mobility, is a rather nebulous term and concept. Etymologically, the noun is first attested in 1865 and resembles progress, characterised by advancement and striving for change (Etymology Dictionary, 2005). In its translation from the Latin *innovare (novus=new)*, it also indicates change, "to make new or alter" (Oxford Dictionary, 1995) and "the introduction of something new" (Merriam-Webster 2005). Emphasis should be placed on the prevalent use of the terminology *thing*; in most cases innovation is equated with change, often technological, that spurs novel *products*. But not all such transformations have to be embodied in physical assets; innovation can also refer to disembodied changes to knowledge and skill sets, leading to new ideas, methods and practices (Rogers and Shoemaker 1971) or involving key changes in production, or processes and the work organisation as displayed in Whipp et al's Triangle of Innovation Dimensions (see Figure 2) (1986, p17).

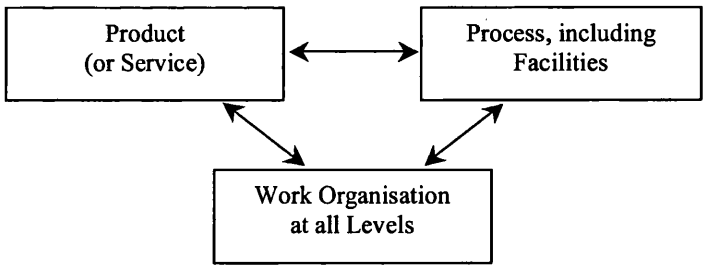


Figure 2: Whipp et al.'s Triangle of Innovation Dimensions (1986, p17)

The extant literature on the topic displays many other uses of the term innovation; an "extensive and potentially bewildering array of definitions and approaches" (Swan and Newell 2000, p27). Although these often alert the reader to underlying disparities, they all "stress the need to complete the development and exploitation of new knowledge, not just its invention" (Tidd, Bessant et al. 1997, p23). While Schumpeter describes innovation as the "combination of new things and new markets" and the "gale of creative destruction" (1950, p83), others praise innovation as a unique source of competitive advantage (Porter and Millar 1985; Davis and Devinney 1997), attribute it with the potential to change industry structures (Porter 2001) or credit it with the creation of new knowledge (Cohen and Levinthal 1990). In some cases, innovation is investigated as best-practices in social systems where the diffused innovation has demonstrated advantages over other, similar innovations (Rogers 1983). In a deterministic fashion, the best-practices approach assumes that the diffusion of a successful innovation from one setting to others will yield equally successful results. Others view innovation as emerging from research and development (R&D) practices and innovation communities (Von Hippel 1988), as user-centred (Shah and Tripsas 2004; Von Hippel 2005) or as improvised through bricolage and tinkering (Ciborra 2002). In most of these cases, innovation refers in some way to "the process through which new ideas, objects and practices are created, developed or reinvented" (Slappendel 1996, p107). This notion might involve periods of design and development, adoption, implementation and diffusion, leaving the reader slightly perplexed as to where innovation starts and when, or if, it ends. Most importantly, these differences among the uses of the term innovation are not simply varying definitions, but indications of different methodological and theoretical approaches to studying the topic.

Many papers refer to the complex subjects of inventing and innovation simply as stages of the lifecycle, from early product development and design to the eventual diffusion and adoption of technology. However, as outlined throughout this chapter, a linear, sequential lifecycle approach from inventions to diffusion presents an overly simplistic view of innovations. In addition to a need for a more encompassing view of innovation, the preceding paragraph on the subject points towards the ambiguity with which the term innovation is used. All of the noted researchers above address the same topic at first sight, but clearly their understandings of innovation are quite diverse, suggesting that a more in-depth view at inventions, innovations and their diffusion would be beneficial for the remainder of this dissertation.

2.2.1 Invention

Schumpeter treats inventions as a rough constellation of ideas and artefacts that may be commercially exploited at a later point (1950). The economic value of such inventions is not determined at this stage; in fact there may not be a market for the discovery or development at all. While many inventions are patented, most are never be developed into viable products or processes (Rouvinen 1999). In some cases, inventions might not be developed because there is simply no real perceived need for them at the time of invention; however, they might be revived at a later point. The development of the parachute before the invention of powered flight serves as an example here (Wikipedia 2005). With respect to identifying drivers that motivate people to invent, some support needs-based inventions (Von Hippel 2005), while others argue that excess resources spur inventions (Bourgeois 1981). In either case, inventions refer to theoretical proposals for further developing a particular product or process and introducing it into practice; which is exactly where inventions differ from innovations. Inventions have the *potential* to create the impulse "that sets and keeps the capitalist engine in motion [through] new consumer goods, the new methods of production and transportation, the new markets, the new forms of industrial organisation" (Schumpeter 1950, p83). As far as technological inventions are concerned, their transformation into innovations may require infrastructure support, without which a more widespread diffusion and therefore adoption would be impossible. Edison's light bulb serves as a suitable example of an invention that by itself would have little value, but with the development of the power-grid the

invention became an everyday innovation, an icon that would change the nature of private and organisational lives.

2.2.2 Innovation

Innovation refers in most cases to the commercial presentation of an invention. In this context, it refers to the introduction of a product or process to the real-world environments, to existing and to new markets. More than fifty years ago, Schumpeter already used the terminology of *creative destruction* and *industrial mutation* that "incessantly revolutionise the economic structure from within, incessantly destroying the old one incessantly creating a new one" (1950, p83). Innovative activity, then, is seen as a combination of research and development and activities related to commercialising inventions (Rouvinen 1999), to entering the economic pool of products and processes as complements or substitutes. The majority of all innovative research and development occurs at the edge; developments are evolutionary improvements of current products and processes, also known as sustaining, incremental innovations (Graham 2002). Consequently, these marginal changes might go somewhat unnoticed, since many do not require a new understanding or approach to daily operations (Christensen 1997). They are often expected advancements of a product or process that follow a predictable pattern. Graham illustrates such incremental innovations through the example of advancements of personal computers in the 1990s (2002).

Zuboff analyses how the innovation of office technology led to changes in the workplace. A main contribution of her work includes the conceptualisation of automating and the coining of the *informating* potential of innovations, particularly ICTs (Zuboff 1988). Automating refers to the simple substitution of human labour through technology with increased reliability, greater control and ultimately, less need for human skills. Informating, on the other hand, refers to a secondary process that is triggered through automation. Technologies "simultaneously translate the very processes, events and figures that they're automating into data or more sophisticated levels of information" (Zuboff 1995). Consequently, the increased levels of information are made transparent through technology, illuminating ever more detail about the underlying processes and thereby becoming a new resource for wealth

creation. Accordingly, innovations come in various different forms and shapes, from subtle innovations that go unnoticed by the majority of people to punctuated innovations that change society (e.g., the power-grid and electric light). Christensen outlines that sustaining innovations aim at improving existing products or processes along the performance measures traditionally used (1997). Disruptive innovations, on the other hand, involve altogether new ways of organising work or require rethinking of current designs of products and services (1997). The extent to which an innovation is sustaining or disruptive today depends largely on its trajectory vis-à-vis market needs, where "suppliers often overshoot their market: they give customers more than they need or ultimately are willing to pay for" (Christensen 1997, pXVI). This market-oriented view of innovations departs from a development perspective and approaches a supply and demand focus of new developments. In fact, many of the following scholars tout they study innovation, but in fact move beyond the innovative component described here and deal with the diffusion aspect of innovation.

2.2.3 Diffusion

Studies that focus on the diffusion of innovations examine how inventions, or rather innovations, are accepted by the external environment, how they are "accepted into the operations and practices of an organisation or business" (Huneycutt 1996, p27). It is difficult to draw a clear line between innovation studies and diffusion studies since both focus to some degree on the introduction and commercialisation of new products and processes. The main aim for initiating diffusion studies was to aid various mostly commercial, organisational functions (e.g., research and development, marketing, human resources, sales) in their planning and preparing for future product demand. The focus was on deriving knowledge for developing competitive advantages (Porter and Millar 1985; Ciborra 2002). The collective focus on innovation studies and the resulting conceptualisations led to a departure from their commercial, firm and product-specific nature and to cognitive discussions and diffusion frameworks and theories (Huneycutt 1996).

Rogers' seminal work on conceptualising diffusion identifies the phenomenon as "the process by which an innovation is communicated through certain channels over time among members of a social system" (1996, p5). The essential diffusion model "posits

that the rate of diffusion of an innovation at any time is a function of the gap or difference between the total number of possible adopters existing at that time and the number of previous adopters at the time" (Mahajan and Peterson 1985). The rate of adoption of many innovations follows an s-shaped diffusion curve (see Figure 3), indicating a period of slow growth, followed by a period of rapid growth (Rogers 1983, p11).

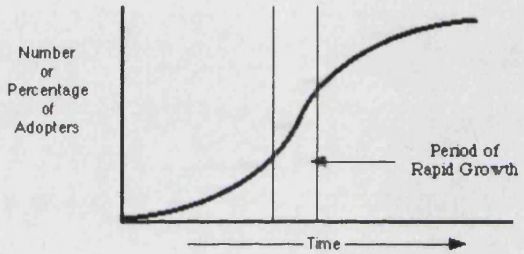


Figure 3: Rate of Adoption of Innovations (Rogers 1983, p11)

Rogers diffusion model is further characterised by a classification of adopters of innovations, ranging from early adopters to laggards (see Figure 4)(Rogers 1983, p247). These stages focus on the incremental adoption of an innovation, rather than a gradual adaptation of products and processes, or stages of invention itself.

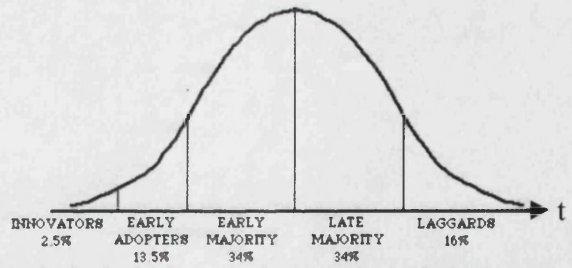


Figure 4: Categories of Adopters of Innovations (Rogers 1983, p247)

The Technology Acceptance Model focuses on technology adoption as measured by the innovation success factors of perceived *usefulness* and *ease of use* (Davis, Bagozzi et al. 1989), other models examine mostly human-computer interface and self-efficacy (Lee 2004). In his renowned book *Crossing the Chasm* Moore describes that the technology adoption life cycle is not as continuous as presented through Rogers' model (Moore 1991). On the contrary, Moore argues that technology innovations create a gap, or chasm, between early adopters and the early majority, between the

early market and the mainstream market (see Figure 5). Those to the left of the chasm are those who will explore new technologies before the technologies might have matured into bug-free products; they are Rogers' innovators and early adopters. Those to the right of the chasm require technology that can be used without any fear that it might fail them beyond repair.

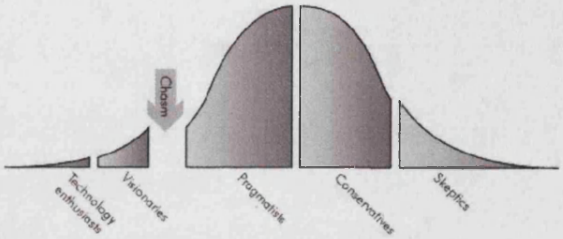


Figure 5: The Chasm according to Moore (1991)

Other models based on research that examines how society, in general or in specific cases, adopts innovations include similar diffusion stages (Cooper and Zmud 1990). Peltz (1983) and Norman (1999), on the other hand, discuss the pros and cons of treating innovations and their diffusion in exclusive stages. Diffusion studies have in common, contrary to innovation studies, that they neither address the process of innovation nor any activities underlying the development of new products or processes. Not surprisingly, many mobility studies centre on network externalities and the diffusion of mobile technology. Here, Metcalfe's network effect indicates the usefulness of communication technology, outlining that the utility and value of a network is proportional to the square of the number of users of the devices or services that form it (1995). This relationship between users and network value has been regarded as overly optimistic, especially in light of the sudden failure of the network-centric DotCom era (2005). However, the validity of its basic message is still accepted; the positive correlation between the number of users and the associated network value re-emphasises the difficulty of delimiting innovation from diffusion. If too few people adopt a mobile device in its current state, it often goes through another innovative iteration before a new attempt at a more successful diffusion.

2.3 Innovation Studies: From Linearity to Messiness

As demonstrated, there are a number of different definitions and uses of invention, innovation and diffusion of innovation. The following two chronological accounts by Rothwell and Slappendel, respectively, present how innovation is represented in the literature and how the topic has conceptually evolved into different research foci.

Rothwell's notable use of five generations (1992) grouped innovation in a chronological account on innovation processes, marketing and market economies. By and large, his first two generations are described as linear progressions from research and development through production to sales. The first generation (1950s- mid 1960s) follows a *technological push*; the second a *market pull* orientation to innovation and production (mid 1960s to early 1970s) (ibid.). The third generation is coined a coupling model of innovation and depicts the first interaction between technological capabilities and market needs, ranging from the early 1970s to the mid 1980s (ibid.). This generation still subscribes to a simple sequential model between idea generation and market place, but incorporates complex sets of communication paths and feedback loops among market participants. The next generation occurred between the early 1980s and early 1990s and was marked by heavy networking activity among small and large companies and shortened product life cycles (ibid.). Simultaneously, the influence of Japanese product development approaches had a strong impact on how developers viewed and integrated suppliers and other key players, leading to a functional and chronological overlap of various stages of the innovation process (ibid.). According to Rothwell, such efforts are intensely being pursued since the early 1990s, as we approach the fifth generation innovation process, with a focus on technological accumulation, strategic networking, speedy market access, product and manufacturing integration and greater organisational, manufacturing and product flexibility and adaptability (1992, p13). Rothwell's chronological depiction is an excellent foundation for studying innovation; however, it concentrates on market economies at the expense of explicitly addressing the underlying research focus of the respective periods (Swan and Newell 2000).

Three perspectives on innovation by Pierce and Delbecq (1977) and further conceptualised by Slappendel (1996) specifically concentrate on how innovation

research agendas developed over time, namely through their use of individualist, structuralist and interactive perspectives.

2.3.1 Individualist Perspective

The early innovation studies described above mostly examined the development, diffusion and acceptance of new products and methods and focused primarily on an individual innovator's characteristics as a unit of analysis. To some extent, the individualist perspective prevails today, as many continue to associate individual traits as a main cause of strategic change and innovation (Amabile 1988). Personality traits, permanent or temporary, are regarded as indicators of innovative potential. The ability to write, draw or compose music are indicative of creative talent (Sternberg 1988) and age, sex, education level, moral values, goals and cognitive style are analysed as to their ability to predispose individuals to innovative behaviour (Baldridge and Burnham 1975). Innovations are mostly perceived as led entirely by sovereign individuals who often receive charismatic names such as champions (Jenssen and Jørgensen 2004) and leaders (Topalian 2000). Recent examples from industry include e-commerce pioneers (e.g., Jeff Bezos from Amazon.com), Internet moguls (e.g., Barry Diller from IAC), serial entrepreneurs (e.g., Sir Stelios Haji-Ioannou from easyGroup), visionaries and futurists (e.g., Dean Kamen from DEKA). These approaches neglect in many ways the resource support these innovators benefit from; their organisations are blackboxed, organisational rules and constraints that shape the innovation and the innovator disregarded. Similarly, such studies ignore the impact, both positive and negative, that wider networks and external environment have on socially mediated developments.

Although still popular today, a shift away from the individualist perspective to the study of group work occurred in the 1950s (Slappendel 1996). Although the focus was now placed on the roles of individuals and the group, research was still driven by humanistic factors rather than the structure of their cooperation. However, it proved increasingly difficult to separate individuals and groups from structure (organisation), especially among scholars who looked at inhibitors and restrictions to innovative activity. The departure from an individual perspective was characterised and motivated by an increased focus on how organisations, rather than distinct people,

manage innovation. Firms became the topic of innovation studies, either as innovators or as target populations of innovative activity.

2.3.2 Structuralist Perspective

By the late 1970s, a problem with this shift towards organisational studies became apparent: firms were analysed with the same methods and described with the same attributes as individuals had been, despite their conceptual differences (Huneycutt 1996). By calling for a change in research, Baldridge and Burnham voiced their concern with studies of organisational innovation that treated firms simply as collections of individuals and disregarded any organisational traits (1975). Soon after, the focus shifted towards viewing organisational structures and firm-specific, contextual characteristics as formative factors of their predisposition to innovations and innovativeness. The discipline of innovation studies adopted a rather deterministic nature with the organisation as the main unit of analysis. Organisational units of analysis included a firm's characteristics (e.g., size, resources, complexity, structure, strategy), environmental factors and to some extent top leaders' personality traits to predict or explain the organisation's innovativeness (Radner, 1978, p2). Zaltman et al. parted with this prescriptive, deterministic *best-practices* view that indicated that a particular bureaucratic organisational structure, or special organisational traits, suited one organisations in any situations, but will also lead to positive change when applied to different organisations (1973). Rather, they discussed some of the organisational characteristics as they relate to innovation, including an organisation's degree of complexity, centralisation, and interpersonal relations. They outlined that an organisation must remain flexible and shift its structure as it moves through various stages of innovation (Zaltman, Duncan et al. 1973).

The main advantage of the structuralist perspective in general is that it no longer looks at the organisation only, but also pays attention to its interrelation with other firms and the organisational environment. However, this approach still fails to take into consideration the substantial complexity associated with describing an organisation. "It treats organisational features as objective realities whose factual character is unchallenged" (Slappendel 1996, p114). The reification of organisational structure traits freezes them into concepts, makes assumption that they are appropriate

structures and do not change and also neglects how they were formed in the first place. The structuralist perspective treats an organisation as a combination of structure and individuals; it neglects that people are difficult to study individually, let alone in group settings.

Neither the individual nor the structural approaches to studying innovation include how social participation shapes the innovative process; and neither can "adequately analyse the complexity of innovations and innovation processes because only part of the picture is illuminated" (Slappendel 1996, p122). More recently, a more holistic albeit less tidy perspective of innovation has emerged. It is the interactive perspective that takes into consideration the historical and contextual involvement of users, developers, the firm and other participants in the innovative process (Ciborra 1997).

2.3.3 Interactive Perspective

Despite our propensity to view processes as sequences of clear-cut individual sub-processes and our fondness of linear, chronological developments, the interactive perspective reminds us that reality is messy, non-linear and not necessarily sequential (Rothwell 1992). Just as much as invention, innovation and diffusion are not exclusive stages, but rather episodes that might occur in parallel, intersect and take place through various successions, innovation neither occurs through sovereign individuals nor through autonomous organisations. While in the past the research community focused on clearly selected elements or participants of the development cycle and viewed innovation as either being caused by individuals' actions or by objective structures, the interactive perspective argues that such a clear separation is quite difficult and in many ways neither appropriate nor representative of developments in industry. It emphasises the increasingly complex relationships between the organisation and innovation, which are viewed as interactively influenced by structure and membership, and the interaction of both. "In particular, attention needs to be given to how action and structure interrelate. It is this particular requirement, which sets the interactive process perspective apart from perspectives of the individualist and structuralist kind" (Slappendel 1996, p119).

The roles of networks

Interactive, or *open* forms of innovation (Chesbrough 2003) emphasise innovation as a process that involves not only individual actions and objective structures, but also social participation and communication among formal and informal social groups (Rothwell 1992; Alter and Hage 1993; Powell, Koput et al. 1996; Tidd, Bessant et al. 1997; Chesbrough 2003; Owen-Smith and Powell 2004; Fontana and Sørensen 2005). Informal, often invisible, networks formed by individuals from different organisations are recognised as strong sources of knowledge exchange. Such networks, whether based on weak or strong ties (Granovetter 1983), are seen as important contributing factors to establishing more formal innovative networks (Robertson, Swan et al. 1996; Conway, Jones et al. 2001). Some degrees of heterophily are viewed as necessary for knowledge exchange among individuals and networks; conversely, if participants are identical with respect to their understanding of an innovation, no diffusion will occur as they have no information to offer one another (Rogers 1983). Especially if the proximity of individuals and networks (i.e., low and high, weak and strong) is viewed in combination with their likeness (whether homophile or heterophile), weak ties that involve dissimilar participants are crucial to the interactive innovation process. They "seem to play a crucial role in the flow of information about an innovation" (Rogers 1983, p297) as they introduce participants to new ideas, notions that do not originate and may not be shared by their immediate peers, their strong ties.

Although recently the interactive innovation perspective has been criticised for not paying enough attention to the actual social or organisational processes underlying such innovation (Scarbrough and Swan 2005), in many cases the particular networks in question are already defined in more detail and speak to these points. For instance, theoretical accounts of network participation and boundary maintenance are at the root of discussions of Communities of Practice (Lave and Wenger 1991; Wenger 1998), Intensional Networks (Nardi, Whittaker et al. 2001), Knotworks (Engeström, Engeström et al. 1999), Communities of Interest (Fischer 2001) and Coalitions (Zager 2001). However, interaction and knowledge exchange with a direct focus on innovation processes has rarely been at the heart of such studies. The same argument holds for many other, perhaps more formal, constellations. Work with consortia, alliances, joint ventures etc. has focused more on the phenomenon of knowledge

integration than knowledge generation and the activities that allow this to occur (Scarbrough and Swan 2005).

Within the domain of technology, and more particularly in Information Systems, interactive innovation research that focuses both on networks and processes includes Swanson's prominent concept of *organising vision* (1997). Although complex at first sight (see Figure 6), this approach pronounces the totality of organisational perspectives and network involvement. It views the organising vision as a "focal community idea for the application of information technology" (Swanson and Ramiller 1997, p460). Here, IS innovations are portrayed as contributors to change in organisational roles, responsibilities and work flows, in other words as drivers of new organisational designs and intrinsically as new organisational forms (ibid.). The basic functions of such a vision, or idea, involve three aspects of the innovation process. First, through *interpretation* members of the respective community develop a common understanding of the innovation, its purpose and probable effects. Second, through *legitimation* the community links the innovation to the wider organisational context and emphasises its value to the organisation to general management. Lastly, through *mobilisation*, the innovation receives public exposure. Through conferences, exhibitions and fairs it will be visible to a wider audience whose support is needed for the material realisation of the innovation. The organising vision unites innovators, entrepreneurs and vendors, among others, and invites them to form social networks needed to develop the innovation further and to putting it into practice (ibid.). These three basic functions of the organising vision are produced, supported and shaped by various institutional forces and feedback loops between numerous members of the discourse community, as displayed in Figure 6.

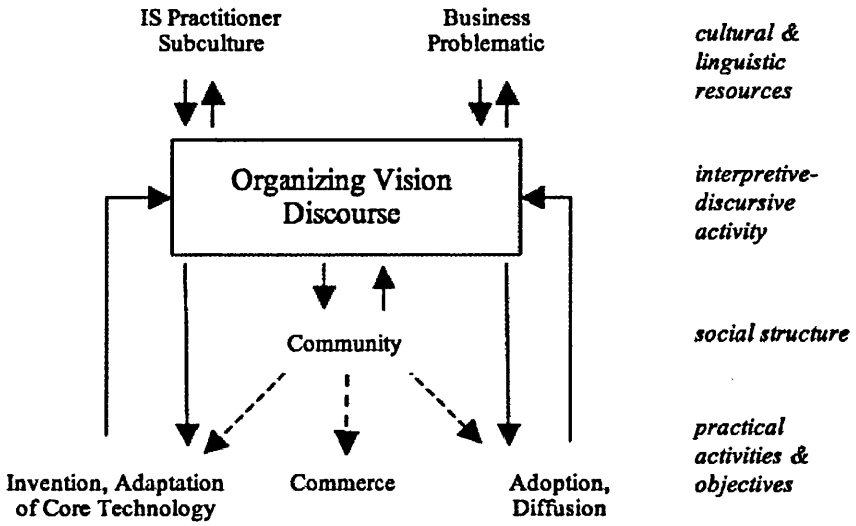


Figure 6: Organising Vision and Feedback Loops (Swanson and Ramiller 1997)

The organising vision recognises that different discourse communities exist, but does not propose how they interact or how different communities make sense of development in different, perhaps contrasting ways. It focuses on how innovations, particularly technologies, are "applied and diffused among organisations" (Swanson and Ramiller 1997, p458), not on how the actual activity of innovating unfolds. The vision approach is a valuable complement, rather than replacement of our understanding of organisations as active "interpretation systems" (Daft and Weick 1984).

User versus developer

The weight that suppliers and users of innovations, particularly of technological innovations, are given within the extant research appears to vary considerably. While some focus predominantly on the supplier (e.g., Rogers), others present a bottom-up or pull image of innovation, one in which users select and appropriate innovations (Christensen 1997) or develop it through *innofusion*, in which innovations remain malleable until they are implemented and used and open to improvements through users' innovation feedback loops (Fleck 1988). Users are seen as increasingly modifying products for themselves, especially as computing and communication technologies improve, giving weight to developers participating in user-centred

innovation processes (2005), as these are freely revealing their developments. Especially the role of lead users is given weight in this discussion (ibid.). Still others emphasise the network importance and highlight how innovative processes and *innovation pools* unite suppliers and users, thereby shaping the innovation (Robertson, Swan et al. 1996). In Robertson's approach, four episodes describe the decision-making process underlying innovation and diffusion in the interactive perspective, namely agenda formation, selection and implementation and usage (1996). During the first two episodes, users develop their own understanding of the innovation in light of their respective requirements, in the latter two their selections are introduced into the organisational environment and used within their contexts. This interactive, "muddled" (Robertson, Swan et al. 1996, p340) episodic approach to this process highlights the opportunities for appropriation and continued redesign and reinvention.

Participatory Design in Interactive Innovation

The involvement of two fronts in the innovation process, the users on one and the developers and designers on the other, points to another very important component of, and question about, interactive innovation. Although interactive innovation involves users and developers, can it be decoupled from the actual process or product in the making? In other words, can we innovate without developing? The innovation literature discusses the two in concert, but less attention is paid to the actual configurational design aspect of the interaction of users and developers. Publications are divided between those who emphasise interactive innovation and those who focus on participative design, with the underlying assumption that design is mostly concerned with *determining details to meet a purpose*, while innovation is *determining the purpose.* Nonetheless, many Information Systems publications on innovation address issues of design and vice versa, explicitly or implicitly. Especially with radical technological advancements is it hard to imagine one without the other. Users and developers, as outlined above, cooperate to determine the future of a particular technology, both in terms of its purpose and how this will be achieved. Consequently, elements of Participatory Design inform the innovation component of the exercise (as users provide feedback, new practice-grounded purposes are discovered) as much as aspects of innovation lead to new design features.

Participatory Design, while being referred to as an "alternative form of technological design" (Jones 1995, p72) or a "Scandinavian Approach" (Floyd, Mehl et al. 1989; Ehn 1993) only a few years ago, has gained widespread recognition thanks in large part to the work presented under the names of Computer Supported Cooperative Work (CSCW), cooperative design, collaborative design, prototyping etc. (Ehn and Kyung 1987; Bødker and Grønbæk 1991). Participatory Design underscores the involvement of the users in the planning and designing of information systems under the assumption that developers and users are teams of different experts (Bjerknes and Bratteteig 1987), both of which are essential for the design process. Similar in its approach to interactive innovation, Participatory Design emphasises that design "should be done with users, neither for them nor by them" (Ehn and Kyung 1987, p54). Consequently, Participatory Design has at its roots an element of learning between the two parties. In methodological terms, this suggests an active involvement of the designers with practitioners that will lead to mutual learning between developers and users, also often referred to as participatory Action Research. By involving the user in the design stage, this approach presents an emancipatory element that is guided by conflicts and concerns as perceived by the users.

While supporting a democratic view of systems design, mutual learning cannot always be ensured, especially in cases where the technological potential and constraints are hard to communicate and perhaps difficult to understand for the practitioners. This illuminates another intricacy of systems development, one that is of tremendous importance in my research of mobile information systems: the dilemma of multi-level users. If a particular information system involves a multitude of direct and indirect users of the devices and the data they yield (e.g., senior managers, middle managers and blue-collar mobile workers), whose participation will be sought? Clearly there are multiple levels of involvement and numerous contradicting political and emancipatory issues at hand. It would be overly ambitious, if not impossible, to try to involve all users and represent all issues. The conflict arises that multiple learning, the shared understanding of technology and work practices among users and developers, would be selective and exclusive. It might involve only managers and forego the involvement of direct, mobile users of the artefact. Alternatively, innovation might focus more on the user's experience and neglect managerial issues. The importance of this dilemma is elaborated upon in Chapter 5.

The study of innovation and our understanding of innovation processes and participants have dramatically changed focus over the past fifty years. The linear, clear models based on individual and structuralist perspectives have been reviewed and criticised for being too constraining, for viewing individuals in isolation or organisations as only structures. The interactive perspective is much less tidy and does not follow a simple linear sequential process. It does, on the other hand, take into consideration the interrelatedness of structure and action. It incorporates the environmental impact of networks and the importance that users and developers play in the process of innovation and design.

This study places emphasis on the innovative element, on determining a purpose; however, it does not neglect the underlying focus on design. The involvement of distinctly different parties will shed light on the degree to which various participants pay attention to the innovation and design elements of mobile RFID.

2.4 Summary of Research and Literature

The first part of this chapter illustrates the complexity that surrounds the topic of mobility and mobile technology. Some of the social and technical aspects of means of communication and factors that mould mobile communicative acts are highlighted in an effort to bridge the gap between schools that discuss mobility as either a technical or social phenomenon. The various sections in the first part of the chapter lay the foundation for a discussion of mobility in the making and provide the vocabulary necessary to discuss the empirical study that forms the basis of this dissertation. Through a short vignette, RFID was introduced as a novel development of means of mobile communication and communicative acts. It is clear that mobile RFID is too young as a truly mobile and synchronous technology and that any prognosis on its impact on mobile communication can only be based on speculation, not a rigorous analysis of established communication patterns. While I find this topic incredibly interesting and look forward to how it takes shape over time, the focus of this work is not placed on how communicative patterns become manifested, but how the activity of innovating technology for mobile work occurs; how systems are first developed and shaped both through design of technology and the involvement of various participants.

The second part of this chapter presents a review of a number of different approaches for studying innovation. While some follow a chronological account based on market economics, others focus on identifying aspects of innovation as they pertain to selected organisational themes, including strategy formation and marketing. Many of the studies reviewed pursue a best-practices approach with a prescriptive *if-then* undertone. The preferred typology of innovation for my research views the subject in its own rights, by examining the perspectives of innovation as individualist, structuralist and interactive. The interactive perspective adopted treats the process of innovation "not in a normative or naturalistic way, but as a socially constructed constellation of activities and practices" (Scarbrough and Swan 2005, p2). The individualist or structuralist approaches are not compelling in light of these requirements. However, it appears that in some interactive, network-centric discussions the structuralist school's legacy seems to prevail, where the focus is more the structure and form of the networks than the activities that occur within them. Similarly, activities are often examined post-innovation and research is based on historical accounts of the participants. Practice is seen purely as an outcome, the *opus operatum,* rather than in concert with the *opus operandi,* the mode of practices, to borrow from Bourdieu's discussion of a theory of practice (1977). The Activity-Lens proposed next and presented in more detail in Chapter 3 aims to address these points.

Innovating Information Systems for Mobile Work

The fields of mobility and innovation are immensely complex and, as shown, the amount of literature in the recent past indicates the exhaustive interest in studying both topics in separation. Nonetheless, few efforts have been made to examine them jointly, with a focus on innovating of technology for mobile work, or mobile information systems. Although over the past decade the increasing spectrum of mobility has brought forward novel means of communication and communicative acts, the research literature is sparsely populated with empirical or theoretical evidence. The subject of mobility is still a fairly new addition to the study of Information Systems and research to date is preoccupied with efforts of delimiting the phenomenon of mobility per se. No comprehensive account of mobility and innovation could be located within the literature, giving weight to the importance and potential contribution of this study. Among researchers, the consensus is growing that

current perspectives, views and theories do not suffice for our understanding of innovation alone (Christensen 1997; Pettigrew and Fenton 2000; Graham 2002), let alone with respect to the phenomenon of mobility. Mobility scholars emphasise that traditional views of innovation are not satisfactory for the study of mobile information systems (Fontana and Sørensen 2005) and calls for a process-oriented look at innovation to understand the social construction of technology are becoming increasingly prevalent and clear (Fontana and Sørensen 2005; Scarbrough and Swan 2005). Various definitions, views and studies of innovation have been outlined in the preceding sections, showing a number of contrasting approaches and indicating the need to clarify the specific perspective adopted for this particular research.

The previous discussion of current innovation literature outlines the importance of the interaction of structure and participation in innovation studies. It appears that most studies still favour a product view of innovation over a process perspective; they view innovation as an output, not an exercise, as a noun not a verb, as completed, not as ongoing. Among those who adopt an interactive perspective many favour studies of users, developers *or* networks. The danger is that the former two may miss out on the interactions that occur between users and developers, while the network-centric approach might ignore important individual perspectives of users and developers that occur outside of the network participation. Similarly, recent requests to take the technological artefact more seriously in our studies of Information Systems may go unnoticed in a purely people-centric study.

Although this may sound awkward, this study proposes to overcome the developer/user versus network nexus by looking at neither. In response to many calls for new looks at innovation, it focuses on the activities that occur in the process of innovation. While this study treats interactive innovation as a premise of its underlying research, the prevalent product orientation is primarily seen as a point of departure for a new look at interaction and innovation. Through an activity-lens, this study promises to shed light on various participants of the innovative process and the activities that occur between them. This study views innovation as a conscious human activity, as *innovating*, a terminology applied for the remainder of this dissertation. This interaction and activity lens also promises to contrast the prevailing rational choice approach by illuminating how the development of mobile information systems,

in particular, is a messy process that is shaped in the context of irrational, political processes and contradictions between innovators, organisations, users and technology.

Chapter 3: Research Methodology

The following chapter discusses the body of methods, rules and postulates employed throughout the empirical research study that I conducted from April 2004 until February 2005 and that forms the basis of this dissertation. A wide selection of methodology paradigms was available, many of which are commonly applied in the discipline of Information Systems. For the study under discussion here, deeply grounded in actual work practices, the choice of a methodological framework was led primarily by my ontological and epistemological conviction. Together, they determined the light in which the research was conducted, empirical materials were analysed and findings were viewed.

The first section of this chapter presents my fundamental philosophical assumptions. Section 3.2 draws together the research design and my involvement with research subjects. Chapter 3 aims to be descriptive, to present the characteristics of the methodology. However, since this particular section is formed around the considerable complexities of my empirical work it requires a thorough analysis of my involvement. Although perhaps unconventional, this section is seen as the most suitable part of this dissertation for the description, analysis and findings pertaining to my research design. The following Section 3.3 is a more generic section that outlines research methods, with further descriptions of units of analysis, types of evidence, sources of empirical materials and interpretive techniques provided in the respective subsections. This chapter draws to a close in Section 3.4 with a summary of philosophical and methodological considerations.

3.1 My Position as a Researcher

A researcher's convictions do not only describe how he views reality and knowledge, they also shape the ideological foundation that guides every step of his research. Especially in empirically-led projects, a researcher's understanding of his role in the investigation governs how his empirical work is conducted and evaluated. Thus, the philosophical stance maintains a crucial function throughout the process of research and knowledge creation. However, this involves more than an individual's justification of philosophical and methodological views. Rather, "knowledge is a

matter of societal (or group) acceptance" (Hirschheim 1985, p13). If research-based knowledge contributions are to be accepted, the underlying research must follow epistemological conventions approved by its research community (ibid.). Of course, there are different claims as to what constitutes reality and knowledge and how such knowledge can be acquired and developed accurately.

3.1.1 Philosophical Foundations

Although many different ontological and epistemological stances exist (Hirschheim 1985; Myers 1997), the discipline of Information Systems is dominated by two seemingly disparate philosophical foundations, namely positivism and interpretivism.

Positivism

According to Hirschheim (1985), positivism refers to a unity of scientific methods across all domains of study, in search for regularities and causal relationships among the elements studied. Positivist knowledge acquisition is viewed as objective, free from values and perceptions of the researcher who remains external to the phenomenon at all times, and whose involvement is not seen as having an impact on the phenomenon under investigation. Positivism is rooted in natural sciences and its claims to knowledge creation are based on value-free empiricism, deductive logic and mathematics (ibid.). Consequently, positivism places a strong emphasis on reductionism, where the overall phenomenon can be examined and described through analyses of its individual constituent elements. Although positivism can employ qualitative empirical materials, quantitative data is the dominant form in Information Systems. True to the objectivist position, positivism places emphasis on the repeatability of research. Although contended by some (Lee and Baskerville 2003; Weber 2004), the IS community appears to accept that positivism's specific aim is to produce generalisable findings (Lee and Baskerville 2003). In their extensive review of Information Systems literature, Orlikowski and Baroudi emphasise that "positivist studies are premised on the existence of a priori fixed relationships within phenomena which are typically investigated with structured instrumentation. Such studies serve primarily to test theory, in an attempt to increase predictive understanding of phenomena" (1991, p5). This importance of objective, value-free knowledge

acquisition and creation indicates that the ontological foundation of positivism must also subscribe to an objectivist perspective. In other words, one reality exists and it is the researcher's quest to discover and describe that reality. It is a reality that exists outside the researcher's mind and that can and should be studied independently of his involvement.

Despite the popularity, or even dominance of positivism in Information Systems (Orlikowski and Baroudi 1991; Walsham 1995; Khazanchi and Munkvold 2000), a number of scholars question the value of applying methods attuned to natural sciences to social settings (Klein and Lyytinen 1985; Galliers and Land 1987; Lee 1999). At the same time, the danger of juxtaposing positivism and interpretivism is that they might appear to be opposing and conflicting paradigms, as frequently presented in the literature. Instead, they have recently been portrayed as different approaches towards the common goal of advancing the state of knowledge, in this case in the discipline of Information Systems, through metatheoretical similarities and differences (Khazanchi and Munkvold 2000; Weber 2004). What they have in common is the underlying pursuit of IS relevant knowledge. Despite claims that neither positivist nor interpretivist findings may be generalised to settings in which they have not been empirically tested and confirmed (Lee and Baskerville 2003), positivism is widely viewed as the discovery of universal laws. Interpretivism, on the other hand, involves tendencies based on particular cases and unique traits rather than broad generalisations (Walsham 1995). Rather than relying on hypothesis testing, interpretivism is seen as relying on the interpretation of empirical materials and on induction; "generalisation [...] from the setting to a population is not sought; rather, the intent is to understand the deeper structure of the phenomenon, which is believed can then be used to inform other settings" (Orlikowski and Baroudi 1991, p5). Regardless of the notion of generalisability, the main differences between the two are their respective ontological and epistemological perspectives that support their pursuit of IS knowledge.

Interpretivism

Contrary to positivism, interpretivism assumes that there is no independent, objective truth; reality and knowledge are social constructs, where "reality is a subjective

construction of the mind" (Hirschheim 1985, p15). Unlike positivism, where a separation of subject and object is elemental to research, interpretivism argues that such a separation denies the unity of being-in-the-world (Walsham 1995, p378). Interpretivism relates to this unity and to how people develop and share meanings as they interact with the world around them (Orlikowski and Baroudi 1991). Interpretivism seeks to understand phenomena in their natural settings and from the perspective of the participant (ibid.). Rather than avoiding contact and cooperation with subjects and thereby tainting the phenomenon as is the argument of positivism, an interpretive researcher values in-depth research and the direct contact with the phenomena. While a positivist would remain passive, an active interpretive researcher aims to observe and gain as much rich insight as possible. Consequently, the acquisition of knowledge rests on interpreting the meanings constructed through the ongoing interactions of individuals with their social world. In contrast to positivistic research, where the investigator aims to discover the truth, an interpretivistic researcher's role is the interpretation of phenomena. Similarly, while positivistic research sets out to answer specific, predetermined questions, interpretivists permit participants to use their own words, points of reference and experiences (Orlikowski and Baroudi 1991); "the primary endeavour is to describe, interpret analyse and understand the social world from the participants' perspective" (ibid., p15). This means that observed, subjective realities are created through the interplay of the elements under investigation. Because of the direct involvement of the investigator, such a setting does not exclude the researcher himself. Quite the opposite is true; the interpretation of phenomena rests on the prior experience, value system and perception of the observer. Of course, meaning constructed from such holistic and socially dependent settings is neither reducible to its individual elements nor aimed at producing law-like generalisations.

3.1.2 A Socio-Technical Approach

Particularly important for a study of Information Systems is the treatment of technology as an important element within the social context under investigation. As outlined in Chapter 2, similar studies have either approached the problem domain from a technological or a social perspective, which contributed to an apparent dialectic of primarily technical and social schools of thought in Information Systems.

While traditionally the former is associated with the design, development and maintenance of systems, the latter investigates the use of technology and its impact on individuals, organisations or society. Within the walls of academia, the technical approach has been represented by detailed studies in engineering and computer science. Social studies often black box technology through the "decoupling of the operations of the technical system from the wider organisational and social relations within which such a system is embedded" (Kallinikos 2005, p191) and examine the use of information systems from the perspectives of organisational behaviour, social philosophy and psychology, to name a few. Requests for more encompassing views, especially among Information Systems scholars, are becoming increasingly prevalent, calling for a renewed look at the relation of the non-technical and the technical (Dahlbom and Mathiassen 1997; Orlikowski 2000; Avgerou 2001; Orlikowski and Iacono 2001).

In this research, the technical and the social are viewed as complementing one another; the technical elements adding value to the social and vice versa. Technical artefacts, their inherent rules, relationships and affordances are viewed as social constructions (Bijker, Hughes et al. 1987); part of the social reality under investigation. This research focuses in many ways on exactly this hermeneutic interplay of the technical and social dimensions of innovating. From a mobile perspective, particularly, it adopts the socio-technical perspective to understand the interactive reality that exists between Nalle's project managers, their corporate customers, mobile workers and artefacts (Mumford 2001), highly contextual and dependent on a novel understanding of time and space. Although the socio-technical importance has been recognised by leading scholars in the mobility field, much of today's mobility research remains either technical or socially directed. One of the contributions of my research, in methodological terms, is to help narrow the gap between the disparate realms of technical versus social school and to add value to the domain of socio-technical studies by emphasising the need for a more encapsulating view from a research project grounded in practice.

3.1.3 Adoption of Interpretivism

Both the topic of the study and its methodology rely heavily on how organisations and individuals make sense of technology in the making. Rather than studying the artefact in isolation, this research emphasises a process that entails individual and social participation. At the same time, rather than looking at social aspects only, it adopts a socio-technical view of the process of innovation. Most importantly, my research is guided by the ontological and epistemological perspective of interpretivism. As a researcher, I interpret the reality as it emerges around me, socially constructed in part through my involvement with it.

3.2 Action Research Design

The interpretive perspective adopted for this research and the determination for practice-driven relevance required a research approach that aimed to describe current practical problems while expanding scientific knowledge (Baskerville and Myers 2004). One popular approach is to tackle the research project as an outsider, to collect empirical materials through non-involvement with the topic under investigation and through interviews and observation of work practices. For observable work practices, particularly at their early, formative stages, this case-study approach is often an appropriate method (Benbasat, Goldstein et al. 1987). Clearly, the activity of innovating of mobile technology is at such a stage. Nonetheless, the aspect of interactivity between participants was seen as integral to the overall process of innovating and formed the focus of this research. A researcher not involved in this process would be excluded from the rich materials that form the context of innovating. Consequently, approaching this research study as a participant observer might overcome some of these limitations.

However, it was felt that the interactive element of the proposed research required the direct involvement of the researcher as a member of the social forum that actively engages with the innovative process. A case study researcher, even a participant observer, remains an outsider who engages only with the research subjects and observes technology, one who "seeks to study organisational phenomena but not to change them" (Baskerville and Myers 2004, p329). For my study of the innovating of

technology for mobile work, this distance between practitioners and the researcher would have created a void between rigor and relevance, thereby compromising the underlying element of pragmatism. Throughout the empirical phase of this study I was an insider and played an active role in the activity of innovating.

Action Research was selected as the most suitable strategy since the research was strongly oriented towards collaboration and change involving both researchers and practitioners. The element of interactivity was addressed through an interventionist research process in which participants learnt "within the context of the subjects' social system" (Baskerville and Myers 2004, p329). Action Research was mutually beneficial; practitioners gained an insight into the dynamic aspects of their work through the eyes of a researcher and the researcher's findings were enriched through actual active participation in the complexities of work: "Research informs practice and practice informs research synergistically" (Avison, Lau et al. 1999, p94).

3.2.1 Research versus Consultancy

In Action Research, the individual's involvement in organisational life and the practical significance of his work present the threat that the researcher might adopt the work of a consultant (Baskerville and Wood-Harper 1996). Activity Theory presents the additional dilemma that a researcher might be torn between "practice-driven and research-driven goals, and between general and specific knowledge interests" (Mathiassen 2002, p60). Often, this differentiation is determined by any financial compensation that may be granted to the researcher. In this realm, an Action Researcher's motivation would be to gain insights into the world of praxis, often without financial consideration. On the other hand, a consultant would work for financial gains and would not primarily be motivated by possible contributions to theory. In the case of this research, I was awarded financial compensation to offset the cost of conducing research, travel and communication expenses. Of course, according to the previous argument, research that is funded, partly or in full, may blur the distinction between Action Research and consultancy. However, at the same time, it implies a sense of contractual commitment, both on the side of the researcher receiving compensation and by the organisation granting it. A debate over the height of the compensation might shed more light on the acknowledgement of a researcher

as an academic or consultant. The financial magnetism of industry compensation vis-à-vis the less attractive 'expenses-paid' research agreements commonplace in academia might influence the research independence negatively. However, since the amount in question and the financial situation of each researcher, academic or consultant, may vary considerably among subjects we need to turn to other determinants for a distinction of proper Action Research versus consultancy. Mårtensson and Lee address this peculiarity by outlining procedural rather than monetary differences. In their traditional view of consultancy, a consultant would play the role of a problem solver, who in many ways might not rely on the expertise of managers involved to derive his recommendations (Mårtensson and Lee 2004). In my research, practitioners and I interacted very closely for the entire duration of the research. Additionally, in consultancy any solution would follow from the consultant's real world expertise and be projected onto the situation at hand (ibid.). In my research, my expertise was rooted in the academic world; in fact, I was in many ways a novice of the particular settings of these projects. Lastly, consultancy would traditionally treat feedback differently from academic research. Consultants who are typically employed on a project basis do not necessarily need to learn from unfavourable experiences; they can continue to apply the same skill set to other cases (ibid.). Negative feedback, however, in many ways triggers the academic attempts to learn, to develop new insight and to create new knowledge. As displayed above, according to Mårtensson and Lee's taxonomy, my research is clearly Action Research, not consultancy. To add weight to this argument, the research is compared to Baskerville's five distinguishing parameters between Action Research and consultancy (1999). Here, Action Research is again motivated by scientific prospects, not monetary benefits. Consultants are viewed as making a commitment to a particular client alone, whereas Action Research aims to make a contribution to the research community at large. In terms of the research approach adopted, collaboration forms the essence of Action Research, whereas client companies often prefer a consultant's unbiased perspective on the organisational problems (ibid.). In Action Research, foundations for any recommendations are based on theoretical frameworks rather than suggested solutions that proved successful in similar situations. Lastly, for an Action Researcher, organisational understanding is derived from iterative experimental changes in the organisation. Consultants typically develop insight through their independent critical analysis of the problem situation (ibid.). According

to Mårtensson and Lee as well as Baskerville's parameters, my research clearly falls under Action Research.

3.2.2 My Role and Involvement as an Action Researcher

Despite the unambiguous Action Research approach of my work, the above discussion raises an important question. I briefly outlined that I worked with Nalle but have not provided much detail of this involvement yet. What exactly was my relationship to the organisations and to the individuals I worked with? In Action Research, design and data collection are often more informal, so that the distinction between its constituent elements, action and research, might become quite fuzzy (Patton 1990). Exactly this blur requires a discussion of my position as a researcher and my role within the various organisations.

Although the exact projects, organisations and individuals involved will only be described in detail in Chapter 5, a brief introduction is essential for understanding the Action Research approach proposed in this chapter. The company that instigated all of the empirical projects was Nalle Corporation[4], who innovated the mobile RFID technology used in all trials and functioned as the host of my research. It was in Nalle's interest, to understand the actualities of mobile work for innovating mobile RFID technology that is reflective of and responsive to real work practices and requirements. For this reason, Nalle is referred to as the *Innovator* throughout the remainder of this dissertation.

Trials were staged in cooperation with a number of companies. In some cases, these trials were hosted as technology trials, in others as user trials. Their corporate involvement included Morrison Patrolling and Site Management Inc., Grizzly Waste Management Ltd. and Allô[5]. Each of these companies was interested in the technology for different reasons (e.g., data capture, synchronous data transmission, mobile service discovery); what they had in common was a genuine curiosity about the potential of mobile RFID (for more details about the companies' involvement in

---

[4] For simplicity and readability of this text, Nalle Corporation will from hereon be referred to as Nalle.
[5] For simplicity and readability of this text, the Innovation Partners are referred to as Morrison Patrolling, Grizzly Waste and Allô.

this research, please refer to Chapter 5). The individuals involved at this level included project managers, engineers and managers from the respective R&D and IT departments. They helped define the use-cases (i.e., scenarios that describe how systems and users should interact to accomplish of the overall Innovation Partner's objective), identify the business rules and set the parameters for the mobile phone's midlet (also known as MIDlet). These midlets are Java programmes that reside on the mobile devices; they are applications that present mobile workers with various menu-driven options for RFID events in response to corporate requirements and use-cases determined through interactive innovating. Most of the Action Research occurred within the everyday work at these companies. From this point forward they are referred to as *Innovation Partners*.

Lastly, and perhaps most importantly, there were the people who actually used the devices throughout the trials, mobile workers who were equipped with the technology, trained to use it and asked to provide feedback on its performance and report problems or ideas for further development. In essence, it was their input and feedback that gave direction and focus to much of the innovation process. For the rest of this document, these individuals are referred to as *Trialists*.

Innovator: Nalle Product Development and IT Managers	NALLE		
Innovation Partners: Mainly IT Managers and R&D Managers	MORRISON -PATROLLING-	Grizzly Waste mgmt	Allô
Trialists: End Users of the Technology	- Patrol Guards - Static Site Guards - Dispatchers	- Truck Drivers - Traffic Managers - Depot Managers	- Marketing - Research and Development - Admin. Staff - ...

Figure 7: Three Levels of Research Participants

Figure 7 provides a graphical illustration of the various parties involved in the Action Research, Nalle, Innovation Partners and Trialists. Figure 8 demonstrates the general Action Research cycle outlined by Baskerville (1999) and based on the former model of Susman et al. (1978). Figure 9 displays how my particular Action Research followed these stages across the three parties involved.

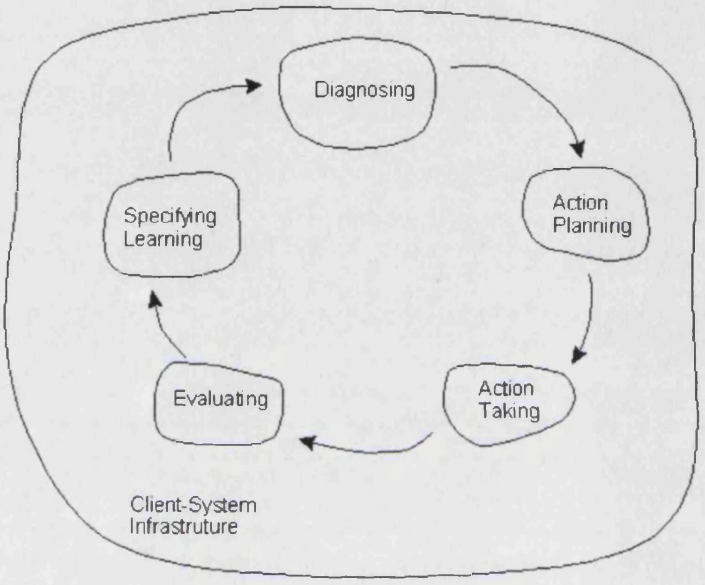


Figure 8: Action Research Characteristics outlined by Baskerville (1999)

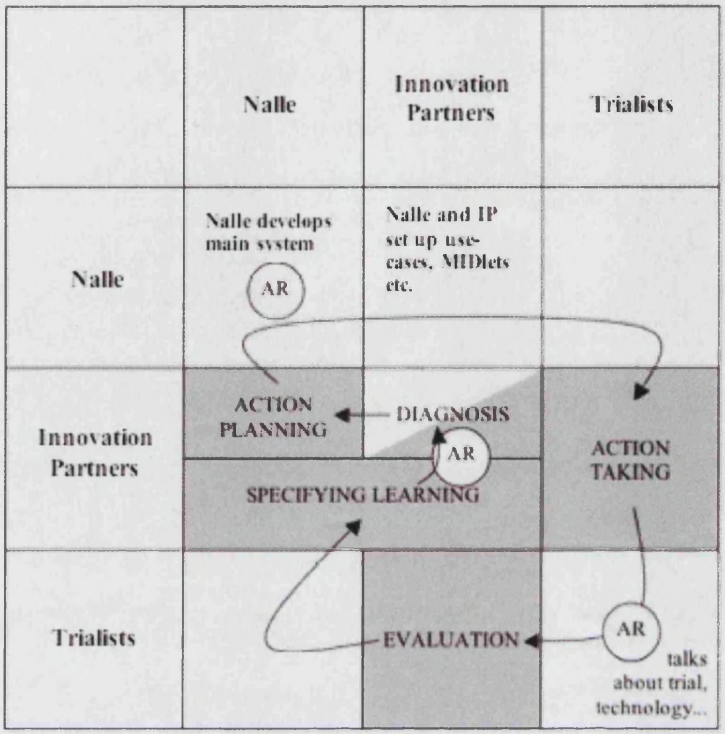


Figure 9: Action Research Characteristics in Context

Baskerville's individual phases include diagnosis, action planning, action taking, evaluating and specifying learning. In a cyclical fashion with a learning focus, once the last phase is competed, it provides the input for another iteration of the cycle. In Figure 9, Baskerville's Action Research cycle is imposed onto the context in which my research took place. The areas shaded in grey indicate my involvement of the formal, more structured phases of Action Research. The circular 'AR' symbol indicates my involvement in the phases in-between the formal phases. The importance of these symbols is described later in this section.

In the initial *Diagnosis* phase, the Innovation Partners identified the primary reasons (or problems) for the organisation's desire to change. Through self-interpretation of their complex organisational settings, they developed theoretical assumptions about the objectives of such change. For example, Grizzly Waste recognised that they were unable to track the whereabouts of their waste containers, despite their enormous sizes. Some were at customers' sites (e.g., large scale oil refineries), others at waste depots and yet others remained completely unaccounted for. This posed an enormous

burden, both financially and logistically, on the company and its employees. Mobile RFID was identified as a possible solution.

During the *Action Planning* stage, the Action Researcher and practitioners (both Innovation Partner and Nalle) collaborated in specifying organisational actions that addressed the motivators of change determined in the Diagnosis. The stages involved in action planning were guided by theoretical frameworks and by the steps that aimed at leading to the desired change. For example, Nalle and Grizzly Waste outlined the various steps required to build the technology (hardware, software, middleware), the applications on the devices and legacy systems and to train the staff to use them. Nalle then developed and prepared the technology for the Action Taking stage.

Action Taking refers to the implementation of the action delimited in the previous step. It resembles an active involvement with the Innovation Partner's organisation and the implementation of certain changes. This is where Action Research gains its label as an interventionist methodology. In the trials that formed the basis of this research, this step involved the Innovation Partner and the Action Researcher introducing the Trialists to the trial in general and to the technology in particular. For Grizzly Waste, this involved some of their IT managers and me. We equipped the waste removal trucks with RFID tags, hosted training sessions at the waste depots, distributed manuals to drivers and responded to their queries.

Evaluating refers to the assessment of the trial outcomes and the review of the action's result. This meant comparing the hypothetical effects of the intervention assumed in the Action Planning stage to the actual outcome of the trials. Care had to be taken to ensure that the effects examined were not caused by alternative changes that might have occurred within the scope of the trial. At Grizzly Waste, for instance, a number of organisational, or rather political issues seemed to determine which employees accepted and used the technology and who rejected it. Thus, all relevant feedback provided by those who were involved with the technology (e.g., container drivers, depot managers) was evaluated against the original assumptions from the Action Planning stage. The outcome of this Evaluation phase formed the practice-driven input sought for the continued process of innovating.

Once an Action Research cycle nears the end of one iteration, a final formal phase addresses the lessons-learnt by the practitioner and the Action Researcher. This *Specifying Learning* phase brought the individual experiences together and formed the contextual dimensions that informed the Diagnosis phase of a new iteration of Action Research. For this particular research, the involvement of three levels of participants made the learning specification more complex and more complicated. Due to the number of participants and the mobile nature of their work, it was not possible, as it may have been in co-located cases, to invite all practitioners (Nalle, Innovation Partners, Trialists and researcher) to share their experiences. As an Action Researcher who was heavily involved with the Trialists, I gave a voice to the Trialists' experiences in the field and helped specify their learning outcome of the trial. At Grizzly Waste, for example, I provided the input for this stage from my lengthy involvement with container drivers and depot managers.

3.2.3 A Contingent Framework

The Action Research cycle presented in Figure 8 outlines how the process of research furthers the practical aspects of the project. It presents a structured approach to implementing change to an organisational setting, in response to the practical problems outlined in the Diagnosis stage. The various iterations include interventions based on knowledge gained from previous Action Taking and Evaluation stages. The objective of the Action Research cycle is to allow the practitioner to put relevant recent feedback elements into action. However, Action Research is both action and research, and this process-oriented view offers the researcher the opportunity of a structured approach to knowledge acquisition, too. It not only problematises and informs organisational settings but also research settings. While our contributions to praxis are direct changes, or interventions, to organisational shortcomings, our contributions to theory respond to opportunities to advance our conceptual understanding of the real world. Viewed from a research perspective, I followed the practical stages of the cycle and in parallel developed and revised my theoretical understanding of innovating as an activity according to the stages of the Action Research cycle.

The intricate relationship that I maintained with some, but not all, research participants raised a very important issue. My proclaimed research method was Action Research, but what kind of Action Research? Action Research is not a single monolithic research method, but rather a general class of approaches taken from a variety or perhaps contrasting forms (Baskerville 1999). In general, all of these are participant forms[6] that rely on researchers' interventions and the study of change within multivariate social settings. As mentioned above, the circular 'AR' symbols in Figure 9 indicated my involvement between the formal phases. A closer look at the considerable variety of Action Research forms available to IS researchers (Baskerville and Wood-Harper 1998; Baskerville and Myers 2004) and my respective involvement revealed that no one Action Research approach, or form, appeared to suit my work exclusively. In other words, both Action Research dimensions, namely action and research, depended on the actual participant and context of my research.

In the first instance, my work could theoretically be described as Participatory Action Research with Nalle. My close cooperation with project managers, marketing managers and individuals from product research and development resembled research *with* people rather than *on* people (Heron and Reason 2001). They, too, were directly engaged with the focus of my research, satisfying the parameter of Participatory Action Research (Baskerville 1999; Street and Meister 2004). We treated each other as equals, using similar vocabulary with a mutual understanding what the other does, what the roles are and what the purpose of the work was. Applying this Activity Theory model to Innovation Partners already caused some doubt that the participatory approach would suffice as an encompassing form of Action Research. While my rapport with some managers at Innovation Partner firms was similar perhaps to my work with Nalle, they were too involved with their organisational settings and requirements to be able to, or care to, contribute directly to my understanding the activity of innovating. This research could more closely be associated with Canonical Action Research (Davison, Martinsons et al. 2004; Lindgren, Henfridsson et al. 2004). Lastly, my work with Trialists was inherently different. Some individuals had very relevant industry experience (e.g., Trialists from Allô's Research and

---

[6] The terms *participatory* and *participant* refer to the research method (e.g., Participatory Action Research) and the data collection technique (e.g., Participant Observation), respectively.

Development Team); others were predominantly concerned with working to pay their bills. These mobile workers (e.g., container drivers who collected and emptied large containers of industrial waste) had little experience or interest in technology in general or the activity of innovating in particular. Nonetheless, all Trialists' perspectives were important for the study and understanding the activity of innovating. In that regard, my work could perhaps best be described with Mårtensson and Lee's Dialogical Research, which considers the researcher's attitude as *scientific* and practitioners as having a *natural attitude to everyday life* (2004). If all participants (Nalle, Grizzly Waste, Allô, Morrison Patrolling and their respective Trialists) were brought together into one group, or had already established collective cross-institutional links, one might be able to describe my work as Community Action Research (Senge and Scharmer 2001). However, the only common links that all participants shared were the researcher and their direct or indirect ties to Nalle.

In summary, within one study, my work with Nalle was different from my involvements with Innovation Partners, and my research with Trialists varied considerably across the different trials. The different people involved looked at these trials from a number of different perspectives and contributed to my research in varying ways. As a result, my research method, though clearly embracing Action Research, was dissimilar in its actualisation across the respective environments. Action Research, in its existing forms did not appear to tailor to mobile settings that involve a number of different categories of participants; no one approach suited the overall research project. Rather than switching between various Action Research genres, my intention was to identify an Action Research approach with enough flexibility to allow me to switch among my roles within it. Consequently, in order to reflect the complexities associated with dissimilar objectives and mindsets present in this multileveled Action Research project (including Nalle, Innovation Partners and Trialists), I adopted aspects from Multiview from systems development, as described below. The resulting contingent framework approach offered the most appropriate description of my action and research involvement.

Multiview

Avison and Wood-Harper (1990) present Multiview as an interventionist approach to understanding both the technical and social worlds they were examining (Wood-Harper and Wood 2005). Multiview is described as a mixed, or blended, methodology, "developed in the tradition of Action Research" (Avison and Wood-Harper 1990, p16), and combines proposed and various already existing methodologies (ibid.). It is most suitable for this Action Research investigation since it permits the researcher to describe in detail the different capabilities and characteristics of the research at different stages of the study (Mingers 2001). Contingent approaches and flexibility are supported within the Multiview framework, rather than demanding an exclusive choice among various existing Action Research alternatives, "where the steps are prescribed in great detail and are expected to be followed rigorously in all situations" (Avison and Wood-Harper 1990, p13). It permits the use of different methodological approaches, based on user types, variability in skills and activities involved and how these contribute to the project. This flexibility addresses the difference between the ideal situations assumed by other Action Research methodologies (e.g., participant or canonical Action Research) and the somewhat messier reality of my multileveled research project, as outlined above. Multiview was developed as an Information Systems Development methodology; however, this does not limit the concept's suitability as a research methodology (Baskerville and Wood-Harper 1998). In this methodology section I will apply Multiview's role-focus to describe the various roles and characters I adopted throughout this project.

Drawing the attention again to Figure 9 (reproduced on right), part of my work involved multiple participants and occurred at the formal stages of Action Research (shaded grey). The work that occurred in-between these stages was highlighted by circular 'AR' symbols. It did not involve multiple parties and occurred solely with Nalle representatives, with members of Innovation Partners *or* with Trialists. Interestingly, much of

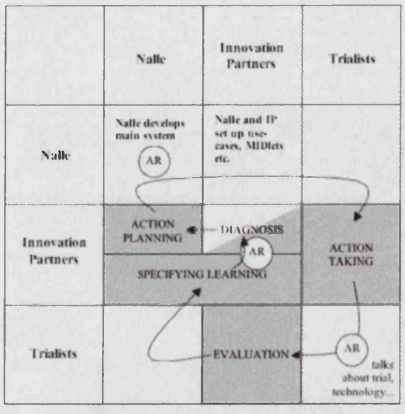


Figure 9 reproduced: AR Characteristics in Context

the value creation of these projects relied on the work conducted during these in-between stages. It was these interactions that provided rich empirical materials for understanding the balance of the technical components and their social context, which in turn provided the input for the formal stages (i.e., Diagnosis, Action Planning, Action Taking, Evaluation and Specifying Learning) and consequently the following iterations of development. None of the previously suggested forms of Action Research (e.g., canonical, participatory or dialogical) were suitable approaches to describing this informal element and the totality of the various genres of Action Research involved.

Multiview suggests the use of root-definitions for describing a system and, for this methodological purpose, the various roles of the researcher. The individual characteristics that define root-definitions include Customer (interaction with whom), Actor (who is carrying out the work), Transformation (what is being done), Weltanschauung (i.e., world view, or assumptions), the Owner (who is answerable) and Environmental constraints (Avison and Wood-Harper 1990). These dimensions are most suitable for describing the three roles I assumed in my research:

The Nalle Colleague from LSE	
Customer	Nalle Product Developers
Actor	Jan Kietzmann (as a similar-minded colleague)
Transformation	To enable Nalle to learn about the use of mobile RFID technology during the trials and to improve their organisational understanding of the management of mobile work.
Weltanschauung	Aimed to actively understand mobile work and advance the development of mobile RFID technology. We spoke the same language and shared our opinions.
Owner	Nalle and Jan Kietzmann
Environment	Nalle: Meeting Rooms and distant communication (email, fax, telephone conferences etc.)

As a researcher from the London School of Economics, I was treated very much as an equal among the Nalle employees with which I interacted. We shared similar objectives for the project, i.e., studying the innovation process and developing the technology in accordance to our practical findings. Our individual opinions and findings were beneficial to the respective other party and we engaged in open discussions. I can best describe my role as a Nalle colleague from LSE.

The Researcher from Nalle	
Customer	Innovation Partners' R&D and IT Managers
Actor	Jan Kietzmann (on behalf of Nalle)
Transformation	To cooperate to understand how mobile RFID could be used by these Innovation Partner companies
Weltanschauung	Aimed to actively understand and advance the development of mobile RFID technology in each company.
Owner	Jan Kietzmann
Environment	Innovation Partner's offices, telephone and electronic communication

I was introduced to the Innovation Partners as a researcher from Nalle who would work hand in hand with the Innovation Partners to elicit some of the softer, organisational settings and collect Trialists' feedback throughout the trials. I was then granted access to the Innovation Partners' sites and met regularly with Innovation Partner managers (mainly R&D and IT managers). They regarded me as a researcher from Nalle. The foremost interest of the Innovation Partners was to develop the technology for their purpose. The exchange of knowledge was project-based and hardly ever reached a more general, innovation-focussed state. While I was interested in their practical world, they had no interest in furthering the study of innovation per se.

The Buddy from Nalle	
Customer	Trialists (Patrolmen, Container Drivers, Traffic Managers etc.)
Actor	Jan Kietzmann
Transformation	I helped introduce the technology, troubleshoot it and collect feedback for changes to the technology and for future iterations of the Action Research cycle.
Weltanschauung	As a Buddy, I was not associated with the Innovation Partner. I guaranteed confidence and listened to Trialists' experiences and any problems (organisational, technical and personal). As a researcher, I collected these materials and analysed them for input into the innovation cycle.
Owner	Jan Kietzmann
Environment	Various, from mobile environments (e.g., waste container trucks, security vehicles) to fixed locations (e.g. offices, canteens) and telephone communication.

This role was the most resource-requiring involvement with the trials. Trialists were from various walks of life and their work involved varying degrees of cognitive and physical ability and activity. I was generally introduced to the Trialists during the training phase, in which they were shown how to operate the technology. At Morrison Patrolling and Grizzly Waste I was introduced with: "This is Jan, he will be with us for a few weeks. At some point, he will your buddy for a few hours or even a whole day and look at how you use the new RFID technology as part of your work" (Miller 2004). As an outsider to the Trialists' employer, the Innovation Partner, I was seen as objective and was trusted not to relay confidential information to the Trialists' superiors. I followed Trialists for entire work-shifts (up to twelve hours) who otherwise worked alone in their mobile settings. Many Trialists bonded with me during these encounters and shared a number of organisational and personal details with me that they did not communicate to a co-worker or superior. Although some were irrelevant to the research, many others in fact revealed very important aspects

about their work practices to me. This in turn informed the next iteration of the Action Research cycle. In some occasions, I was asked to deliver a message without disclosing the originator. In many ways, I was seen as a Buddy, not a researcher and not a superior. For the purpose of this research, this meant that in order to relate to the Trialists, I had to attempt to speak their language, accept them as the experts and welcome their sharing of organisational and personal details (Mårtensson and Lee 2004).

These three different roles and the flexibility of moving from one to another with ease, most adequately describe my involvement in this research. The contingent method adopted from Multiview provides the most suitable way of describing the complexity of this project; the exclusive use of other Action Research alternatives was too restrictive in this context and would have been a dishonest representation of my work.

3.3 Methods

Contrary to the complex Action Research design of this study, the research methods were straightforward and conventional in their choice and execution.

3.3.1 Unit of Analysis

My research concentrated on interactive innovation, not in terms of the traditional deliverable of a final product or its constituent physical elements, but rather as the activity of innovating. Consequently, the interactive activities of subjects involved in this process, from Nalle, Innovation Partners and Trialists formed the units of analysis. In combination with this activity focus, the particular interest was how interactive innovation of technology for mobile work could involve mobile workers. In other words, treating the process, or activity, as the unit of analysis allowed me to examine to what extent interaction and mobility aspects shaped the activity. Additionally, this activity-focus provided relevance for study of innovation, or innovating, from a practical perspective and from the perspective of Activity Theory as its underlying framework (as discussed in Chapter 4).

3.3.2 Empirical Evidence

Action Research assumes that the complexities of the interaction of people, organisations and context can be studied best by intervening in regular work practices, introducing change and observing and learning from its effects, as previously outlined in the Action Research cycle. Action Research is a holistic approach that emphasises the importance of contextual situatedness. In a post-positivist fashion, Action Research moves away from a single method of knowledge acquisition; it is idiographic, not nomothetic. Empirical materials therefore include the intervention, the direct involvement of the researcher and his interpretations that shape the observation (Baskerville 1999). Examining phenomena involving people, organisations and contexts in terms of quantitative variables that together present an informed view of the whole is not sensible (ibid.). Consequently, the type of evidence accepted as the basis for this Action Research was qualitative in nature.

Qualitative Materials and Quantitative Data

For this study, I was able to accompany a number of individuals throughout their workdays, sometimes for short periods (up to one hour), at other times for entire shifts (up to twelve hours). I was also able, as explained in the following subsection in more detail, to observe people at work and to collect impressions of their attitude towards the technology (e.g., frustration and expressions of excitement), their ability to navigate the RFID devices (e.g., carefully studying the device options before making a selection from the RFID menu) and eagerness to demonstrate the technology to colleagues. Clearly, these phenomena would have been difficult to measure in quantitative terms. Similarly, since many of these materials were based on observation, or in some other cases on topics that emerged in interviews, such areas might have been difficult, if not impossible, to predict as elements for a quantitative study.

Nonetheless, in addition to qualitative materials, quantitative data was captured, analysed and reported throughout the research by logging the RFID local interaction server traffic. Most tag events were routed through a server and a back-end system that stored the tag events and in some cases returned information back to the mobile device. Despite its importance for the technical support team, which used this data to

validate that the technology worked properly and that the RFID readers responded to the tags (and vice versa), such data provided no intrinsic value to the Action Research. In addition to the post-positivistic elements outlined earlier, the quantitative data collected through the RFID servers was by no means complete, nor was it intended and designed to serve as a basis for this research. While some tag events were captured, many other tag interactions were not. Similarly, quantitative data did not include any phone conversations, text messages or any rich interaction between individuals, technology and their surrounding. As a result, while important for the action component of the projects, quantitative data were disregarded for the research component.

Collecting Empirical Materials

A distinguishing feature of this research was the significant amount of time spent in the field. As a result, fieldwork notes and the experience of what phenomenology would call the *Dasein*, the being there, became important additions to more formal materials gathered. Based on the three Innovation Partners, the various trial settings in which this research study was conducted and the interactive nature of the phenomenon under investigation, various sources and techniques for collecting empirical materials were employed, including observations, interviews, meetings, electronic mail and other documents.

Observations formed a major source of qualitative material within this study. True to the study of mobility, an effort was made to follow the individual subjects and the technology throughout their workday. This included observations within the constraints of wandering through particular buildings (e.g., office rooms, cafeterias, restaurants), travelling in vehicles (e.g., patrol vehicle, container trucks) or visiting exterior grounds (e.g., patrolling premises, checking landfill sites). Research participants used the technology throughout these times and observations played a critical role for the researcher. They allowed an insight into the use of technology as it happened, rather than relying on the recollection of the participant at later points in time. I was also able to collect impressions during down-times (e.g., no signal reception), when subjects quite often engaged, or tinkered, with their devices. While most of my observations were unstructured and informal, subjects were also invited to

one-to-one interview sessions in which they often demonstrated how they used the device.

Interviews followed a similar arrangement. When I followed and observed the subjects, constant interaction provided me with rich materials. While following a patrolman throughout his twelve-hour shift, for example, most of the interview content emerged. Although an interview agenda was developed, it was only used as a skeleton of interview topics, which could be raised if these did not emerge naturally. Interviews were important as means to talk about the use of technology, its attributes and effects, both physically and psychologically, on the mobile work. Interactive interviews allowed the in-depth discussion necessary to complemented and clarify some of the observations made. Not all interview sessions covered entire work shifts; however, none of the open-ended interviews were constrained by time. Sometimes an interview that was expected to last ten minutes lasted more than one hour.

In addition to scheduled interviews, observations were made throughout meetings with participants from perhaps more than one level (e.g., Nalle internal meetings, Nalle and Innovation Partner, Innovation Partner and Trialists). These included scheduled project kick-off meetings or meetings with senior managers to report the outcome of a project development. These exchanges also occurred as short, unscheduled and informal group meetings that simply took place because certain people happened to be in the same vicinity. It is difficult to describe the range of these meetings as they included in many ways those get-togethers that are part of everyday business. Similarly, meetings with Trialists often occurred naturally. When working at a subject's site, I often met individuals by chance, in elevators, in staircases and even on the train. In one instance, I made myself readily available for unscheduled feedback drop-in sessions by announcing that I would work in an open-access area for one week. Although unsure about the effect this would have at first, this approach turned out to be of enormous success. People were not bound by time-windows, nor did they have to schedule visits; many simply dropped in when they noticed that I was available. A total of 30 Trialists came throughout five days and spent between ten minutes and one hour with me, providing feedback on the technology, ideas for its improvement and further development and concerns surrounding its wider adoption in a public or company-wide spectrum.

Other interpersonal communication was exchanged in the form of electronic mail. Approximately 200 emails were sent and received throughout the study. This form of communication involved managers from Nalle, Innovation Partners and some Trialists. It allowed the exchange of information pertinent to the technology, mobile work etc. that was not otherwise covered. In some cases, participants sent emails to provide additional feedback on instances that occurred either after a personal talk or which the participants failed to mention at the in-person meetings. Away from any of the empirical sites, primary research took the form of archival, unpublished company reviews of the development of previous technologies, unpublished working papers and other company reports. Secondary research included newspaper articles, books and journal papers, including RFID, mobility and innovation literature. These forms of literature reviews informed the theoretical, technical and organisational aspects of the empirical work and the interaction throughout the Action Research stages.

Empirical Materials Summary

The individual methods and respective materials collected differed depending on the subjects of the research, the context and in many cases the location of the respective investigation. According to the multileveled Activity Theory approach, these were classified into three distinct groups, namely Nalle, Innovation Partners and Trialists and three roles of the researcher (i.e., Nalle Colleague from LSE, Researcher from Nalle, Buddy from Nalle). Work directly with Nalle included materials in the forms of face-to-face meetings, email messages, facsimiles, company documents and teleconferences. With respect to Innovation Partners, research materials included meetings, emails, observations, interviews and teleconferences. Lastly, with Trialists, materials were collected mainly through observation, interviews and meetings, scheduled or unscheduled.

With respect to the amount of time spent on collecting materials and the number of encounters with Nalle, Innovation Partners and Trialists, I can only provide rough estimates. The Action Research started in January of 2004 and was completed in February of 2005; however, not all of this time included research with all three levels of research subjects. A total of approximately 350 hours was spent in meetings, interviews and observation time with Nalle, Innovation Partners and Trialists (Figure

10). Interviews and meetings were recorded electronically when possible; nonetheless, in most cases I took field notes on paper and transcribed them as soon as possible. In many cases, a recording device was seen as too disruptive; at other times subjects requested I take no audio recordings. Approximately 500 photographs and a few short video-clips were recorded of the subjects using the technology.

Subject	Duration	Location	Content	Effort (hrs)
Nalle R&D personnel, project managers, technological support	05.01.04 – 01.10.04	Various	In meetings and interviews discussed the development of the mobile RFID technology, role of trials for Nalle, details for gathering of empirical materials etc.	50
Morrison Patrolling National and regional managers, security guards, clients	12.03.04 – 15.07.04	Morrison headquarter, regional offices, patrolling vehicles, client sites etc.	In meetings and interviews with management, discussed what the technology should do, how and with whose help it would be implemented, how success would be measured, potential trial difficulties, access to organisational data and the role of the researcher. Field interviews and observations with five security guards addressed how the technology performed, how it changed mobile work, how it could be improved etc.	30 40
Grizzly Landfill Meter Reading Directors, managers and gas engineers	14.10.04 – 07.12.04	Grizzly headquarter, landfill sites, corporate vehicles	In meetings and interviews with management, discussed how the technology should address organisational information system deficiencies, how it would fit with bigger organisational information systems, how mobile RFID would be implemented, potential trial difficulties, access to organisational data, to research sites etc. Field interviews and observations addressed how the technology performed, how it changed mobile work, how it could be improved etc.	30 40
Grizzly Container Services Directors, managers, field supervisors, traffic managers, drivers, depot supervisors	14.10.04 – 07.12.04	Grizzly headquarter, regional offices, waste depots, waste removal vehicles, restaurants	In meetings and interviews with management, discussed how the technology should address organisational information system deficiencies, how it would fit with bigger organisational information systems, how mobile RFID would be implemented, potential trial difficulties, access to organisational data, to research sites etc. Field interviews and observations addressed how the technology performed, how it changed mobile work, how it could be improved etc.	35 45
Allô Directors, R&D mangers, technical developers, content developers, marketing, HR, administration, office support etc.	19.10.04 – 05.02.05	Allô headquarters and surrounding public spaces and organisational offices.	In meetings and interviews with management, discussed how the technology could potentially be used for future applications. Discussed some of the fundamental properties of mobile RFID and developed trial applications to trigger more thoughts and feedback from Allô employees. Discussed role of the trial and the technology for Allô, how mobile RFID would be implemented throughout the mobile environs, potential trial difficulties, access to organisational data, to research sites etc. Extensive field interviews with 75 interviewees and field observations addressed how the technology performed, how it changed mobile work, how it could be improved, suggestions for future services etc.	30 50
				350

Figure 10: Empirical Materials Collected

3.3.3 Interpretation Technique

The analysis and interpretation of qualitative materials is "is a messy, ambiguous, time-consuming, creative and fascinating process. It does not proceed in a linear fashion; it is not neat" (Marshall and Rossman 1995, p111). In order to make sense of the materials collected through various means and from a number of categorically different sources, an evaluation criteria attuned to the underlying philosophical stance of interpretivism was required. The close cooperation between the researcher and the empirical subjects and the iterative nature of the development of both theory and praxis strongly indicated that researcher and subjects share a common understanding of the situation at hand. In other words, the distinct realities of the researcher and the subjects came together through the meaning of the shared action. This acknowledgement in turn meant that the researcher's and subjects' realities, their Weltanschauungen, became part of the materials that formed the basis for the research (Checkland 1981). This is especially true for Action Research as an interventionist method: "When the researcher intervenes, the researcher becomes part of the study, i.e. one of the study subjects" (Baskerville 1999, p4). In a hermeneutic fashion, action and research influenced and were influenced by the context of the study.

In order to make sense of these activities and meanings, involving individuals (i.e., Project Managers, R&D and IT managers, Trialists and the researcher), organisations (i.e., Nalle and Innovation Partners) and Technology (e.g., mobile RFID devices, tags), empirical materials were recorded and stored whenever possible. Social semiotics was adopted as a mode of analysis of the signs and symbols that populated these documents, transcripts, sketches, audio and video footage.

The conceptualisation of semiotics, also known as semiology in its original form, can be traced back to the works of Saussure and Peirce at the turn of the 19th century. Semiotics examines the nature of signs and symbols, as these may include visual signs, words, sounds, objects and body language (Chandler 1994). While structural semiotics, based on Saussure's work, focuses on the deep structural meanings of signs and symbols, social semiotics employed in this research concentrates on delimiting their social meaning in specific situations (ibid.). The objective of semiotics is to examine how such signs are constructed and to study the process by which they become manifested as social representations. In other words, semiotics examines how

meanings are created through the analysis of signs. By extension, this indicates the ontological importance associated with signs. Their connection to the creation of subjective meanings indicates that there can be no unmediated objective reality. In the contrary, "language ceases to be a mere system of sounds and symbols - it becomes the expression of being" (Hirschheim 1985, p24), which forms the basis for the social construction and maintenance of reality (Chandler 1994).

Consequently, in social semiotics, signs cannot be studied independently. Rather, they must be analysed within the context in which they were created, or used. The term *text* is employed in semiotics to refer to a collection of signs; however, such a text does not necessarily refer to our common assumption of a collection of written words. Instead, semiotics includes texts that can exist in a number of possible mediums, verbal, non-verbal, or both (ibid.). Text in the context of this study refers to messages that have been formed and exchanged between Trialists, researcher, Nalle and Innovation Partners. These messages were at times transmitted electronically, via telephone or in person. Signs included mostly words, spoken and written, images such as photographs, video-recordings and diectic behaviour or gestures. Their construction and subsequent interpretation occurred within the contexts of the particular situations at hand (e.g., communication with a driver in a waste truck, with a Nalle representative via a mobile phone, in an Innovation Partner's meeting room).

Clearly, these signs and texts were dependent on how individuals shared the meaning associated with them, supporting the interpretive underpinning of this research; there is no one objective interpretation of signs and texts formed and used throughout the research. This was particularly clear during various stages of the Action Research cycle, when the researcher and members from Nalle and an Innovation Partner came together. The texts, or collections of signs, were at times read quite differently by the respective parties, emphasising again the value of sign systems in the creation of subjective realities. "Although things may exist independently of signs we know them only through the mediation of signs. We see only see what our sign systems allow us to see" (Chandler 1994). Signs or texts can be many things to many people. As social constructs they build frames of reference, which are often shared by individual cultures and vary in the course of time (ibid.). In this research, socio-cultural groups were based on shared beliefs, attitudes, values and goals, separated most clearly by

the nature of their everyday work practices. The clearest cultural borders existed perhaps between Nalle, Grizzly Waste and its employees, Trialists who make a living driving trucks and emptying industrial waste containers. Consequently, the signs and texts that provided meaning in the lives of these different individuals and defined their realities varied accordingly. As such, signs and texts do not convey their meaning to the researcher, but rather demand an active process of interpretation. Social semiotics provided a very helpful and effective analytical tool for interpreting the empirical materials collected in this Action Research study.

3.3.4 Methodological Limitations

The bold claim that in Action Research the emphasis is "more about what researchers do, than what they say they do" (Avison, Lau et al. 1999, p96) places it in a difficult position within the Information Systems community. However my adoption of aspects of Multiview and CATWOE are seen as the only approaches that could truly describe what I did, my involvement with the empirical setting. Action Research clearly opposes the fundamentals of positivism; based on its close proximity and active involvement in the empirical setting it might remind outsiders of consulting work. In this chapter, I have aimed to present a solid case for my choice of interpretivism as a suitable orientation for the study of a complex mobile setting with many unpredictable social and technical processes and outcomes. Similarly, I have discussed my Action Research focus vis-à-vis a consulting concentration. Although compelling for my particular settings, these two elements (i.e., Interpretivism and Action Research) differ from mainstream approaches in IS and can be viewed as methodological limitations. In the context of my research I hope I was able to convince the reader otherwise.

One aspect that is difficult to refute is the effect that my involvement may have had on the actual behaviour, responses and therefore outcome of the study. Action Research's special attention to the everyday work of the Trialists, for example, and the intervention into their organisational context might have had an impact on the study itself and the findings derived from it (i.e., Hawthorne Effect). Nonetheless, one focus of the intervention was to impose change to these settings. The subsequent unfolding of the research process presents the responses and experiences of real

Trialists, Innovation Partners and Nalle in the face of these changes, emphasising again the closeness of rigour and relevance in Action Research.

Lastly, the findings of this study were interpreted to varying degrees by the researchers, Nalle and Innovation Partners as they pertain to the practical impacts of RFID development and the notion of innovating mobile information systems. The practical decisions made and the findings presented in this dissertation are consequently limited by the respective biases of these participants and their resulting chains of actions.

3.4 Summary of Methodology

This chapter presents a description of the methodological considerations of my research. The ontological position and choice of interpretivism are outlined, both in terms of my personal conviction and the suitability for this particular study. As an epistemological position, it further provides a basis for selecting a methodological framework that guides the actual research, my involvement with it, the collection of materials and the analysis of empirical findings. The interventionist approach of Action Research allows me to investigate the process of innovating technology for mobile work. A brief discussion of elements of Action Research vis-à-vis consulting resolved any scepticism that this research might not have been an academic exercise. My procedural involvement as a researcher is further described in terms of the Action Research cycle. Moreover, the complexity of three different researcher roles is outlined through the use of Multiview's role focus and root-definition model. At this stage, my involvement as a Nalle Colleague, a Researcher from Nalle and a Buddy is introduced. Individual research methods and units of analysis indicate the process-focus of my research. Types of evidence, empirical materials and interpretation techniques are described to provide the reader with an adequate, holistic picture of how this research was conducted and subsequently, how meaning was formulated through the use of social semiotics.

Chapter 4: Innovating as an Activity

The literature review of the topics of mobility and innovation in Chapter 2 arrived at the conclusion that mobility and technology for mobile work are still underpopulated phenomena in Information Systems. Especially the underlying dynamics of the innovation of mobile information systems have not been addressed satisfactorily, and calls for practice-driven, process-oriented research have been voiced by innovation scholars and mobility experts alike. As indicated in the previous chapters, this study adopts an activity-lens as a research perspective. I will specifically employ Engeström's interpretation and extension of *Activity Theory*, through his Activity Theory Triangles, as a recognised conceptual framework for describing the structure, development and context of computer-supported activities (Kaptelinin and Nardi 1997). Activity Theory is not to be seen as a fully developed theory as of yet, but it provides a framework "of assumptions rather than providing a complete explanation in its own right" (Rogers and Scaife 1997, p10) from which numerous ideas, theories and methods for the "conceptualisation of human practices (activity) in relation to computers emerge" (Mwanza 2002, p.50). This activity-lens allows my research to focus on innovating of mobile technology as an activity, as a process rather than a product, as dynamic and flexible as opposed to rigid, open rather than closed to interpretation. Its focus on tool-mediation is particularly important for the role of technology for the interaction with mobile work. Furthermore, the attention paid to object-orientedness and consciousness emphasises the different interests and motivations of the various participants. The inherent contradictions within and between activities reveal a practice-oriented view of conscious human behaviour rather than a mechanistic production-oriented perspective. Given this suitability of the theory, the use of Activity Theory promises to illuminate intricate details of the interactivity involved in the innovating of mobile information systems. Furthermore, a test of Activity Theory in a highly dynamic and mobile environment will shed light on the theory's usefulness, and perhaps shortcomings, for studies of interaction, mobility and technology.

In Section 4.1 I describe the development of Activity Theory from its early days in Soviet Psychology. This understanding is essential for the more recent interpretations

and developments among activity scholars. Sections 4.1.1 describes the tripartite hierarchy of activities. Section 4.2 and its subsections shed further light on the fundamental principles of Activity Theory before Section 4.3 presents how an Activity Theory approach supports this study through various levels of interaction (Subsection 4.3.2), contradictions (Subsection 4.3.1) and representations (Subsection 4.3.3). Section 4.4 concludes this chapter with a summary and a recap of the theoretical part of the dissertation before the following chapter (Chapter 5) turns the reader's attention to the empirical settings.

4.1 Introduction to Activity Theory

The early developments of Activity Theory (or Cultural-Historical Theory of Activity) are mostly attributed to Sergey L. Rubinstein (1889 – 1960), Lev S. Vygotsky (1896 – 1934), Alexei Nikolaevich Leontiev (1903 – 1979) and Alexander Romanovich Luria (1902-1977). Their work at the Moscow Institute of Psychology introduced a new conceptual approach to understanding the human mind, one that would transcend the prevailing focus on psychoanalysis and behaviourism. According to Activity Theory, the human mind could only be understood as it develops and exists purely in the context of meaningful, goal-oriented and socially determined interaction between human beings and their material environment (Bannon 1997). Consequently, the main focus of Activity Theory is to understand the unity of consciousness and activity.

Vygotsky, founder of cultural-historical psychology, focused his work on examining human behaviour and cognitive development, in particular the relationship of language and thinking. Among Vygotsky's main contributions to the study of activities was the notion that consciousness is constructed through human interaction with the world, as action mediated through tools and signs. Previous studies had put forward a direct relationship between stimulus and response; however Vygotsky viewed this as too simplistic and argued that human behaviour could not be reduced to simple reflexology. He proposed that human behaviour was directed by a mediator between stimulus and response, known since as tool mediation in Activity Theory. For Vygostky, this involved tools, signs and symbols; "the use of signs leads humans to a specific structure of behaviour that breaks away from biological development and

creates new forms of a culturally-based psychological process" (Vygotsky 1978, p40). Accordingly, signs are internally-oriented (e.g., thoughts) whereas tools are viewed as externally-oriented (e.g., language), with the aim of applying change to the natural world (Vygotsky 1978).

Vygotsky was further Alexei Nikolaevich Leontiev's teacher and colleague, and while the former placed emphasis on the role of semiotics within Psychology, the latter emphasised the importance of activity as the principle mode of interaction with reality (Rogers and Scaife 1997). Leontiev's conceptualisation of the theory of activity points to a tripartite, hierarchical view of human behaviour, consisting of activities, actions and operations, one of the key principles of subsequent developments of Activity Theory.

The initial approaches developed by Vygotsky and Leontiev defined the key principles of Activity Theory and are illuminated in the following sections, before turning to more recent contributions by scholars who have worked on the continuing conceptualisation and understanding of consciousness and activity.

4.1.1 Leontiev's Tripartite Hierarchy of Activities

> Up to this point we were talking about activity in the general collective meaning of that concept. Actually, however, we always must deal with specific activities, each of which answers a definite need of the subject, is directed towards an object of this need, is extinguished as a result of its satisfaction, and is produced again, perhaps in other, altogether changed conditions (Leontiev 1978, p62).

Vygotsky's model received criticism for ignoring activities that are socially mediated and collective in nature. Leontiev subsequently developed the hierarchy model to distinguish between individual action and a complete system of social, or collective activity. In his representation of activities, he separates the individual's activity from this collective context and describes activities in a very structured manner (Mwanza 2002). Accordingly, a single activity is examined and described at three hierarchical levels, consisting of the actual activity, actions, or chains of actions, which in turn are made up of operations (see left side of Figure 11). As emphasised in the quote above, these activities are motivated by specific needs. Correspondingly, a hierarchy of

goals, on the right side of Figure 11, illustrates drivers of the respective activity, action or operation.

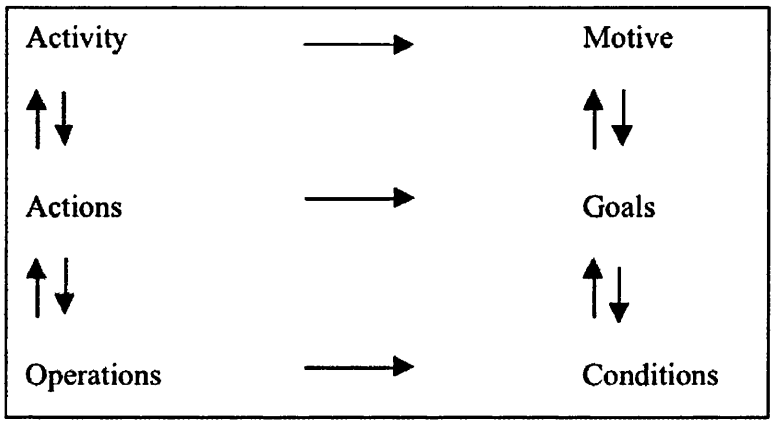


Figure 11: Hierarchical Model of Activity (Leontiev 1978)

The uppermost order in this hierarchy is formed by *activities* and *motives*. Collectively, subjects have certain needs, and activities are seen as responses to this presence of needs. However, needs by themselves cannot direct the course of activities directly, they merely instigate them. When subjects are presented with objects, real or ideal, which they feel might satisfy their needs, they become motivated to pursue the respective activity. Consequently, a motive directed at an object is the necessary precondition of the entire activity. It is important to note that activities are not self-contained. Various related activities are pursued at the same time, differentiated by the motives of each individual activity. Activities, whether primarily internal or external, are realised though actions, individual or collective, or chains of actions linked by the same objective.

Actions are specific, *goal*-oriented components of activities, where the "goal of an action is a conscious mental representation of the outcome to achieve" (Decortis, Noirfalise et al. 1997, p7). As objects of all actions, goals may be complex and may require various actions to be realised. Similarly, individual actions only make sense in the social context of shared activities in which they are carried out. Goals are set and pursued individually, as part of activities that are collective in nature. Consequently, while individuals pursue their own actions and goals, these could potentially neither contribute directly nor necessarily positively to the overall activity and its motivation. Individual actors engage in different actions in pursuit of various goals and indirectly

support different activities and motives. While the motives pursued by one collective are the objective for the group, the goals that individual members follow are shaped by additional, often contradictory activities in which they participate with different group members. Hence, individuals may exercise one action and goal that is to satisfy different activities and motives, thereby making actions and goals a truly subjective matter (Wiredu 2005).

Operations, at the bottom of this hierarchy, execute the goal-oriented actions. They are often subliminal, automatic, routine practices and respond to *conditions*, rather than conscious goals or motives. The assumption is made that with increasing practice, the mental requirement for a specific tasks diminishes, enabling actions to become operations. This, of course, assumes that the conditions underlying the operation do not change, including the goal of the superior action and the motive of the entire activity.

Bannon summarises "activities, which are driven by motives, are performed through certain actions which are directed at goals and which, in turn, are implemented through certain operations" (1997, p3). While this indicates a rigid structure, Leontiev also emphasises the flexibility of human activity by acknowledging that specific conditions of operations may have an impact on certain actions and reshape the structure of an activity (Collins, Shukla et al. 2001). The fluidity and interrelatedness of the three components of both sides of the hierarchy (i.e., activity and goal hierarchy) are indicated through the vertical arrows in Figure 11. Constituents of an activity are not fixed but can move up or down this hierarchy to reflect emerging changes in underlying conditions. For the hierarchy of activities, this means that with increasing practice and skill development, conscious actions can become unconscious operations, indirectly freeing up capacity for the pursuit of new goals. This has been illustrated through the example of learning to drive a car. At the beginning, shifting through the gears is a conscious action, but over time and through practice it becomes a unconscious operation (Leontiev 1974; Nardi 1995). Similarly, a change in underlying conditions can require conscious, goal-oriented behaviour and call operations back into conscious actions. For the previous example, if the brakes of the car fail, shifting through the gears becomes a conscious action, with the goal of slowing down the vehicle. Likewise, the differentiation between activity and action is

quite flexible; changes in motives can lead to an ill-alignment of needs and motives, possibly turning an activity into an action; however "the motive for carrying out that activity does not change" (Mwanza 2002, p61). In a reversed fashion, an activity's motive may shift to the fore of an action's goal, thereby promoting the action to an activity with a new motive. Rogers and associates add that this flexibility is possible because the Action Theory model is functional, rather than structural; hence, behaviour is ascribed to the components of the hierarchy based on their role in the activity (1997).

The tripartite hierarchy of activities is of particular interest for a study of the interactive innovation of technology for mobile work. From a technological perspective, the usefulness of the tool under development is reflected through its impact on the overall work activity. If the innovation meets the requirements of the worker, in other words supports the pursuit of his goals adequately, its affordances become a part of the overall work conditions and the tool is accepted and employed in mobile operations. If, however, it fails to support the pursuit of the worker's goals, it constantly requires his attention and fails as a tool and innovation. Similarly, the innovation's ability to mediate and assist the collective work, as a tool for work and as a tool for interaction, determines to what extent the innovation supports mobile activities and interactive innovation.

4.2 Key Principles

The hierarchical view of activities and three-tiered perspective of associated motives, goals and conditions form some of the underlying philosophical tenets necessary to understand the remaining elements of Activity Theory. A closer look at how these activities are carried out emphasises the need for further guidelines for a theoretical approach to studying and understanding activities and cognition. The holistic *Principle of Unity and Inseparability of Consciousness and Activity* is recognised as a basis for the development of cultural-historical Activity Theory (Bannon 1997). It emphasises that the existence, development and interpretation of the human mind must occur within the context of meaningful, goal-oriented and socially determined interaction between human beings and their material environment. Derived from these tenets are the main principles of Activity Theory, namely object-orientedness, tool

mediation, internalisation and externalisation, historical development, consciousness and context.

4.2.1 Object-orientedness

> A basic or, as is sometimes said, a constituting characteristic of activity is its objectivity. Properly, the concept of its object (Gegenstand) is already implicitly contained in the very concept of activity. The expression 'objectless activity' is devoid of any meaning. Activity may seem objectless, but scientific investigation of activity necessarily requires discovering its object (Leontiev 1978, p52).

In the development of Activity Theory, the notion of *objects* is of immense importance. In essence, the Activity Theory trajectory of human practices follows the logic that activities are driven and predetermined by motives, which in turn are determined by the subjects' quest to satisfy their underlying needs.

> It is understood that the motive may be either material or ideal, either present in perception or exclusively in the imagination or in thought. The main thing is that behind activity there should always be a need, that it should always answer one need or another (Leontiev 1978, p62).

As pointed out earlier, needs are unable to drive or direct an activity. However, object-orientedness can be synthesised as a chain of events starting with a subject who is presented with an object that may provide a satisfactory solution to his needs, which in turn motivates the overall activity (Figure 12). Hence, "the main thing that distinguishes one activity from another [...] is the difference of their objects. It is exactly the object of an activity that gives it a determined direction" (Leontiev 1978, p63).

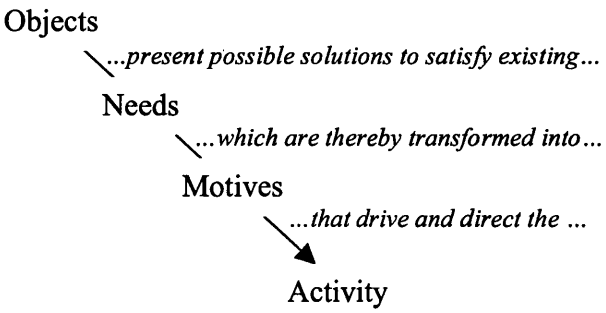


Figure 12: Chain of Events leading to Activities

The question remains as to what these objects are. From an activity perspective the world of objects transcends the physical attributes that shape such an objective reality and includes socially shaped and culturally defined attributes of objects. Accordingly, an object can be material, less tangible or totally intangible in nature "as long as it can be shared for manipulation and transformation by the participants of the activity" (Kuutti 1996, p23). The focus on motives as drivers for activities implies that we are constantly, and perhaps at times unconsciously, motivated to pursue determined, purposeful activity (Mwanza 2002), which in turn is reflected through the object-orientedness and objectivity of that activity (ibid.). Consequently, through the logic of objects-needs-motives-activities, objects are at the roots of human practices and at the heart of activities that aim to transform said objects into desired outcomes. Simply put, the principle of object-orientedness reminds us that we need to examine these objects if we are to understand human practices (Mwanza 2002).

4.2.2 The Role of Mediation and Mediating Artefacts

The importance of objects and their position in human activity indicate the distinctiveness of Activity Theory and the role ascribed to tools. Tools are seen as mediating between the person and the world. It is a hermeneutic relationship; people and tools shape the attributes of and participation within activities of the other. Vygotsky expressed his view of the influence of social and cultural factors on the human mind and human activity by denying the simple reflexology approach between stimulus (S) and response (R) prevalent at the time (see Figure 13). "The use of signs leads humans to a specific structure of behaviour that breaks away from biological

development and creates new forms of culturally-based psychological process" (Vygotsky 1978, p39).

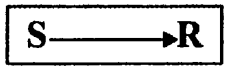


Figure 13: Unmediated Behaviour (Vygotsky 1978, p39)

According to Vygotsky it is the mediating role of tools (expressed through *X* in Figure 14 below) as an intermediate link between stimulus and response that introduces change to human activities and cognitive functions. Here, a direct reaction to an impulse is inhibited and the completion of the operation is facilitated through indirect means, mediated through tools. This in turn suggests higher mental capacity involved in behaviour, since it permits humans through the "aid of extrinsic stimuli, to control their behaviour from the outside" (Vygotsky 1978, p39).

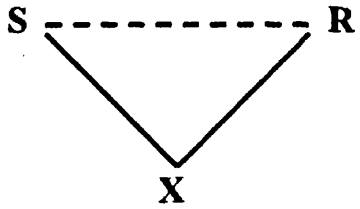


Figure 14: The Structure of a Mediated Act (Vygotsky 1978, p40)

Clearly, such mediators have physical and social attributes; artefacts in Activity Theory are viewed as more than physical *things*, they also include socially shaped, purely abstract and cognitive artefacts such as words, signs, symbols and rules. The former are viewed as tools in physical environments, exercised externally to triumph over nature (e.g., a hammer), the latter are to be exercised internally by and on human beings, including one's self (e.g., a mental calendar). Neither of the two occurs in separation; the manipulation of nature and behaviour are directly linked, as "man's alteration of nature alters man's nature" (Vygotsky 1978, p55). In essence then, Activity Theory views our participation in the world not as sovereign and isolated, but as mediated through artefacts, physical or psychological. For any activity, this means that artefacts in turn mediate among elements involved in it, be they human or not. It is this mediation that both enables transformation processes and human activity and at

the same time limits it "to be from the perspective of that particular tool or instrument; other potential features of an object remain invisible to the subject" (Kuutti 1996, p25).

Further, external tools are inherently historical developments, socially shaped through previous activities not only in cognitive terms but also with respect to actual physical attributes. For example, the design of a computer keyboard is in part shaped through the design of early mechanical typewriters and in part through our cognitive map of how a keyboard should be used (shaped in turn by the historical development of the keyboard). Hence, "the use of tools is a means for the accumulation and transmission of social knowledge. It influences the nature, not only of the external behaviour, but also of the mental functioning of individuals" (Bannon 1997, p2).

For the activity of interactive innovating, object-orientedness plays a crucial role. Both within the central activities and the interaction of Innovator, Innovation Partners and Trialists, the objects that motivate the respective actions and operations serve as important analytical tools. The technology under development, in this case, plays both the role of an object and a tool. Moreover, given the interaction focused on innovating, the separation of an object and a tool is often very difficult, as outlined above, and is determined by the attention paid to the technology as a motivating or mediating factor.

4.2.3 Duality of Activity: Internalisation and Externalisation

Activity Theory places an emphasis on the duality of activities, in which cognition does not develop purely internally, as mental activities or only through external activities. We live in an "objective reality that determines and shapes the nature of subjective phenomena" (Bannon 1997, p2), pointing towards individual, subjective interpretations of general, neutral objects. A subject, through the social interaction with his environment, internalises cultural knowledge about each activity as it develops over time (Mwanza 2002). The environment here is to be seen as consisting of objects and human participants with whom a subject interacts when carrying out the activity.

The concept of internalisation and externalisation describes mental perceptions about the transformation of internal activities to external ones, and vice versa. With the above-described object-orientedness in mind, this means that when individuals draw their attention to external objects in pursuit of their needs, this external activity becomes internalised. Internalisation refers to the transformation of an external psychological and physical activity into an internal, purely psychological activity. It "provides a possibility for human beings to stipulate potential interactions with reality without performing actual manipulations on real objects" (Bannon 1997, p2). Mental calculation serves as an example of a purely mental exercise (ibid.), but internalisation can also refer to mental modelling of an exercise before performing it, perhaps mentally building a house. Both modes of internalisation are subjective, mental pictures of the objective world.

Externalisation, on the other hand, refers to the transformation of psychological, internal activities into external activities. Externalisation is often necessary when an internalised action needs to be repaired, is too difficult for internal transformation or when a collaboration between several agents requires their activities to be performed externally in order to be coordinated (Kaptelinin and Nardi 1997). Clearly, the two activities of internalisation and externalisation do not exist in separation, and neither can they be isolated; they transform into each other and coexist in every human activity (Kaptelinin and Nardi 1997); the activity is not external but also in the subject's mind in an objectified form (Cole 1996).

For the activity of interactive innovation, the concept of internalisation and externalisation is of tremendous importance. The activity is focused on the exchange of workers' expertise, the Innovation Partner's requirements and the Innovator's motivation to learn more about the other two parties and their activities. As a result, the impact that a new technology, or externalisation, has on the physical environment indirectly shapes the technology under development. Similarly, the changed externalised actions of mobile workers, transformed through the new technology and work conditions, are important factors influencing the interaction with the other parties.

4.2.4 Context, History and Continuity

Cultural-historical Activity Theory, as the name suggests, places emphasis on the development of human activity over time, shaped and transformed in part through social and cultural changes. It refers to the impact of yesterday's social and cultural changes on today's activities. Many of these changes are unpredictable and non-linear; and the evolution of activities is marked by developments that appear knotty and convoluted. The development from bureaucracy to new-forms of organising is a good example of the importance of the historical perspective, as is the move from fixed-location to mobile information systems. Neither of these developments followed a straightforward pattern nor can either be understood irrespective of its progression over time. Each activity has a history, and the focus on the evolution of activities allows detailed insights into the choices of various mediators, physical or psychological.

Likewise, a study of mediating artefacts requires a view of the activity that incorporates not only the development of the past but also their particular present-day context. Seen as socially and culturally shaped and performed among members of a community, or network, the particular context that in turn shapes these groups also has an undeniable and immediate impact on the activity. In other words, the context and the activity are not separable, "the context is the activity itself" (Decortis, Noirfalise et al. 1997, p6), constantly renegotiated among the participants, and in fact, through the activity itself. Therefore, context is not an external entity, according to Activity Theory it is not *where* the activity occurs, but rather *what* takes place in the activity itself. In order to understand some of the individuals' choices for particular tools, practices, or externalisations and their respective relationships to one another through existing social rules and conditions, attention must be paid to this situated context.

Although often listed as a separate principle of Activity Theory, the notion of continuity is directly linked to the discussions of history and context. Accordingly, it is the continuous development of an activity that provides value to the study of an activity. Practices are viewed as rooted in the past, but continuously reformed and redeveloped in response to changes of underlying conditions. These developmental transformations provide value and emphasise participation on the side of the

researcher in formative contexts and experiments, rather than more traditional laboratory experiments (Bannon 1997).They further accentuate the suitability of Action Research for a study informed by Activity Theory.

For the setting of this study, context, history and continuity shape the background into which the technology under development is introduced. As a result, the research had to remain sensitive to these aspects of the activity under investigation and involve the historical background and setting of the specific organisations, workers and technologies within the analysis of empirical materials.

4.2.5 Conscious Development

The involvement of consciousness in Activity Theory was assumed throughout all previously discussed principles. It was already conceptually recognised and presented in early development by Vygotsky on the matter of stimulus response theory. Humans, as opposed to animals or inanimate objects, are capable of conscious behaviour through a unity of mind and activity, conscious of their own decisions, able to choose one artefact over another and capable to control their behaviour in pursuit of goals and desired outcomes. Similarly, the principle of consciousness implies that humans are able to choose not to follow certain paths to circumvent undesired outcomes. By extension, this implies that we are able to consciously and continuously create a mental image (internalisation) of a particular, external action and activity as it evolves. It further means that we can consciously try to forecast and predict possible outcomes of certain actions, in our quest to satisfy our goals. For this to be true, the assumption must hold that the source of knowledge, or thinking, stems from internal, conscious activities about external activities, as indicated above, not vice versa. It is this relationship of consciousness and activity that allows us to understand the human mind through the study of activities.

4.3 An Activity System Approach

After discussing the Soviet developments of Activity Theory, I will now turn to, as Kuutti says, the 'other' use of the term, "referring to the international, multi-voiced community applying the original ideas and developing them further" (1996, p19).

Such developments have occurred mainly since the mid 1980s, when scholars from Scandinavia and the Nordic Countries turned their attention to the study of activities. The main contribution here has been presented through Engeström's Activity Triangle System (Figure 15), in which he addresses the criticism of Vygotsky and Leontiev's work.

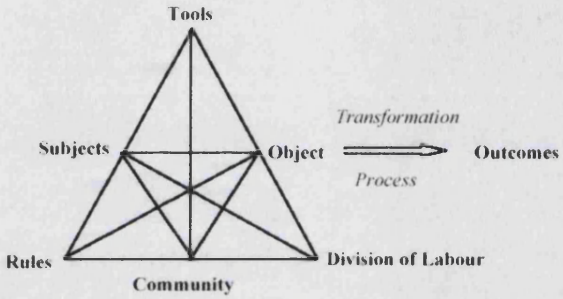


Figure 15: Engeström's Activity Triangle System (1987)

Through individual Activity Triangles, Engeström focuses on Vygotsky's mediated activities. Engeström further outlines that the mediating component of Leontiev's model of subject-activity-object does not receive enough attention and calls for a closer look at "the components of the mediating 'third' factor, activity" (1988, 473). He emphasises that previous attempts are two-dimensional models of the interaction of the individual and object, "depicting individual actions which are the visible tip of the iceberg of collective activity" (1990, p172). Engeström criticises the attention paid solely to individual behaviour: "if we take a closer and prolonged look at any institution, we get a picture of a continuously constructed collective activity system which is not reducible to series or sums of individual discrete actions" (1990, p78). With his Activity System Triangle approach, Engeström suggests a move from an instrumentalist approach to an interactionist perspective, in which an entire activity system becomes the unit of analysis, insisting on the importance of the holistic interplay of the inherent elements. In recognition of the impact of the supra-individual influences on activities, even when a subject is apparently working alone, the *community* component gives weight to the social and cultural context of the work environment and particularly the activity under investigation.

In essence, each Activity System entails two main subsystems, including Subjects, Community and Objects of an activity in one and the mediators of an activity, namely Tools, Rules and the Division of Labour in the other. In an Activity Theory approach

to understanding human behaviour, "all human experience is shaped by the tools and sign systems we use" (Nardi 1995, p5). The different mediators are displayed on the outer nodes of the activity triangle, which is not to suggest that they do not play a central part in the activity. On the contrary, mediation forms the heart of any activity and therefore any activity system.

The *tools* node represents physical tools that are applied to particular objects in a pursuit of goals and indirectly of objectives and psychological tools used to manipulate behaviour. Engeström adopts Wartofsky's (1979) differentiation between primary artefacts such as hammers and scissors and secondary artefacts as internal or external representations of primary artefacts (e.g., mental or physical pictures). Engeström notes the particular role that secondary artefacts assume, "Whenever we contemplate on the nature and use of a tool, we activate and manipulate secondary artefacts, internal and external representations concerning that tool. Being seen through these representations, the tool itself in some sense becomes the secondary artefact" (1990, p173) . The immense importance of this perspective is discussed in more detail in Section 4.3.3. Tertiary artefacts include visions and world views. Despite this three-fold separation, it is the combination of physical and psychological tools, primary, secondary and tertiary artefacts that shape the outcome of the activity. Engeström's representation of tools reflects previous illustrations of mediated activity by Vygotsky, illustrated through the comparison of Figure 16 and

Figure 17.

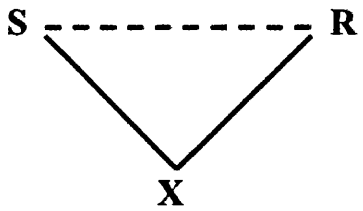


Figure 16: The Structure of a Mediated Act (Figure 14 reproduced)

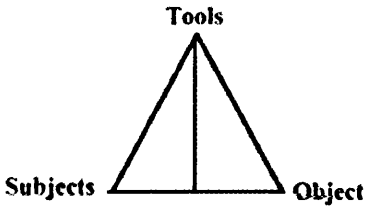


Figure 17: Engeström's Tool Mediation (1987)

By the same token, social conventions of *rules* and norms, whether implicit or explicit determine further factors that influence how individuals perform activities. They mediate the relations between subject and community. Lastly, *division of labour* describes the social strata of varying job contents and levels of responsibility implied by the community node.

In an Activity System Triangle, the direction of an activity is illustrated through the above-mentioned orientation towards an object, "a raw material or problem space" (Decortis, Noirfalise et al. 1997, p2) which is perceived to provide a solution to a given need once transformed into an outcome. All the components illustrated in the Activity System coexist in an interactive fashion. They are interconnected and shape one another through various types of interaction.

4.3.1 Contradictions

An Activity System consists of many elements, including those that shape the outcome of an activity through conscious participation and those that set the parameters within which such practices occur. A closer look at the Triangle (reproduced in Figure 18) reveals a number of interconnections, literally linking all the nodes of the system and united through the object and outcome orientation of the entire system. Based on these interconnections is the notion of contradictions in the system, both between these nodes and within them, as they play an integral part in the activity, how the objective is pursued and how activities are examined.

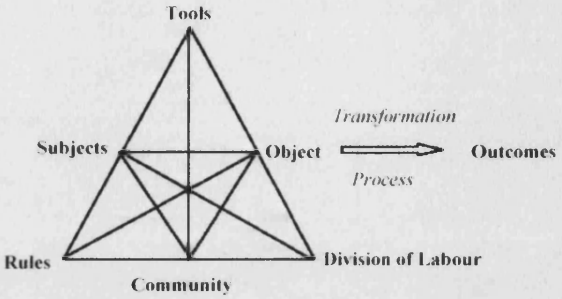


Figure 18: Engeström's Activity Triangle System (Figure 15 reproduced)

Although the terminology of contradictions has a rather negative connotation, these contradictions are only obstructive to the pursuit of the objective of the activity itself. They are disruptions from regular work practices. From the perspective of research; however, they are invaluable. They are expressions of the tensions that exist within the system as the collective engages in goal-oriented activities. An activity system is "a perpetual change machine, transforming itself through a series of expansive cycles. With disequilibrium as the norm, the movement through their [these] expansive cycles is energised by inner contradictions which create disturbances and ruptures in the flow of normal activity" (Blanton 1995, p4). Interestingly, the very introduction of new tools, or primary, secondary or tertiary artefacts can throw an existing system into disarrangement. As these inner contradictions, or disruptions occur in the state of internalisation, members of the system (the collective subject) seek to reduce the tension through the use of new tools; they are "the driving force of change and development in activity systems" (Engeström 2001, p2). It is through the externalisation of these ideas into actual tools that the activity system is modified or a new system is created altogether. From the participants' *practice* point of view, these contradictions are obstacles that hinder the process of the activity and the pursuit of the objective, but it is not only this link between inner contradictions and externalisation that shapes the expansive cycles. Engeström extended the notion of contradictions to four levels (see Figure 19).

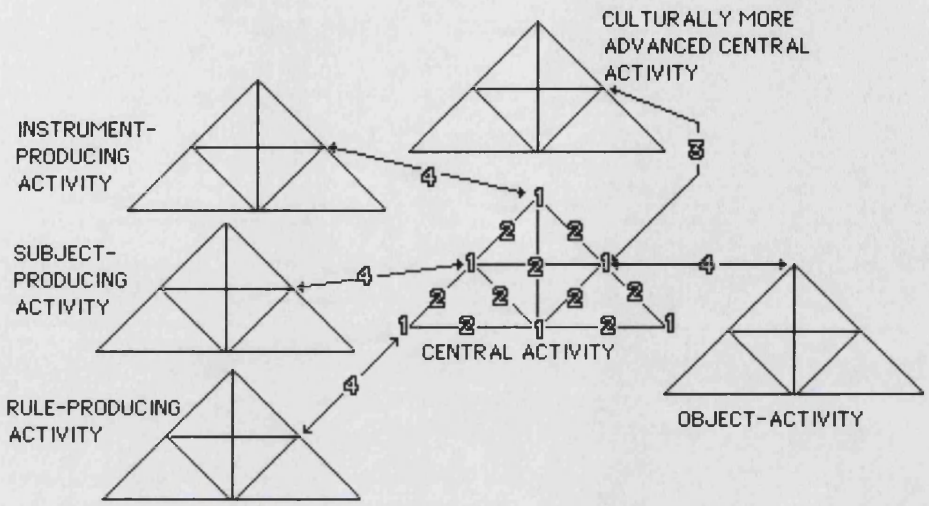


Figure 19: Four Levels of Contradictions (Engeström 1987, p79)

Primary contradictions (1) occur within each node of the activity system and represent a disequilibrium between exchange value and use value of the respective element. Secondary contradictions (2) occur between them. Engeström uses the disparity between the progress of stiff hierarchical division of labour and the development of advanced instruments as an example (1987). Tertiary contradictions (3) occur when a culturally more advanced central activity is introduced into an existing central activity. Engeström outlines here that primary school pupils' motive at school is play, but parents and teachers try to enforce studying, the culturally more advanced object (ibid.). Quaternary contradictions occur between the central activity and its neighbouring activities, as these may include objects and outcomes of the central activity (object-activity), as they produce the tools for the central activity (instrument-producing), involve educating and training the subjects of the central activity (subject-producing) or present an administrative or legislative layer for the central activity (rule-producing).

From an activity *research* perspective, these contradictions "reflect a source of development or represent the presence of unfamiliar elements whose study is necessary so as to establish the kind of new developments that are taking place within an activity system" (Mwanza 2002, p.65). In other words, contradictions are

opportunities for learning more about an activity and activity system. They are an informative part of the structured model to understanding, and framing, an activity.

4.3.2 Levels of Interaction

Activity Theory and particularly the notion of interactive innovation hinge on tasks that are not carried out by a sovereign individual, but by groups of participants who contribute to the overall development and work towards a common objective. Such interactive activities surpass the production-oriented view of innovation (Barthelmess and Anderson 2002); they are characterised by three process-oriented forms of coordination, cooperation and communication (Raeithel 1983; Fichtner 1984) and further expanded by Engeström (1991).

In *coordinated work*, actors follow their scripted roles and the underlying coordination aims at aligning their actions to accomplish a common object (Barthelmess and Anderson 2002). The script outlines the content and sequence of work through regulation but also includes inferred rules about work; the script "coordinates the participants' actions as if from behind their backs, without being questioned or discussed" (Engeström, Brown et al. 1991, p90). *Cooperative work*, on the other hand, moves away from individual concerns and independent actions (ibid.). Here, participants no longer focus on their own script but concentrate on a shared problem space in an effort to "find mutually acceptable ways to conceptualise and solve it" (Engeström, Brown et al. 1991, p90). *Reflective communication* refers to "interactions in which the actors focus on reconceptualising their own organisation and interaction in relation to their shared objects" (Engeström, Brown et al. 1991, p90). This reconceptualisation encapsulates all elements of the actors' overall work environment, including the shared objects, scripts and interaction with other actors. It is considered reflective as it represents a de- and re-construction of work itself, in a joint effort to present new or improved ways of conducting work, perhaps leading to a redefinition of work or the organisation itself.

Naturally, these levels of interaction are not rigid; there is a dynamic interplay among coordinated work, cooperative work and reflective communication; they are all elements of a collaborative activity (Barthelmess and Anderson 2002). Similar to the

notion of activities, actions and operations, coordinated work can become cooperative and reflective communicative, and the other way around. In this aspect, Activity Theory maintains a flexibility of transformation among interactive levels, recognising again the cognitive, object-oriented nature of human activity. In many instances, these transitions become manifested through incongruencies among actors within an activity. Here, so-called *disturbances* are unintended digressions from the script; they are "deviations in the observable flow of information" (Engeström, Brown et al. 1991, p91) that can lead to disintegration (e.g., confusion of the participants), or contractions (e.g., by limiting the participants' ability to cooperate and communicate). *Expansions*, on the other had can occur when individual participants collectively reframe the object and move to cooperation or reflective communication, without necessarily being caused by a disturbance. Lastly, *ruptures* are "blocks, breaks or gaps in the intersubjective understanding and flow of information between two or more participants of an activity" (Engeström, Brown et al. 1991, p91); however they do not necessarily disturb the flow of a work process. Especially with respect to the use of technology for mobile work, mediated interactions are of tremendous interest as they further introduce potential contradictions as sources of disturbances, ruptures and expansions to the flow of an activity.

4.3.3 Representations as Dialogue

Activities involve interactions among various participants, including human and non-human actors. An activity consists of *subject-subject* interactions and *subject-object* interactions, the instrumental aspects of an activity. The focus of this research, interactive innovation of technology for mobile work, emphasises in both of its key terms the importance of communication between subjects. As discussed in the first part of Chapter 2, mobile work practices are inevitably communicative practices, revolving around mobile means of communication and communicative acts. As further outlined in the second part of Chapter 2, the notion of innovation occurring not in isolation or in a linear fashion points us towards the importance of subject-subject communication between individual participants in the interactive innovation process. For these reasons we need to take seriously the attention paid to communication and the role assigned to it in Activity Theory.

As previously outlined, the focus of any research informed by Activity Theory is the activity system itself. In technologically-oriented projects, we are used to seeing a focus on the use of computers or human-computer interface studies, for example. These interactions occur between subjects and objects. They represent the relationship between a technological device and its user. It is rather novel that we look beyond the user and the artefact and take a view of the activity they are pursuing, mediating and supporting. In the activity system and in the approach of interactive innovation, we make the assumption that any activity involves, directly or indirectly, knowingly or unconsciously, a number of people, objects and socio-cultural factors. In this study's empirical setting this is clearly the case, as illustrated in the following chapter.

So far, the discussion of activity systems has called attention to the interconnectedness and object-orientedness of subjects, community and tools, but the question of how these parties are connected, *how* they interchange their knowledge and work experiences has been left unaddressed. As individuals work towards goals to achieve common objectives, the need to communicate, to coordinate and cooperate is obvious (i.e., subject-subject interaction). Particularly in environments that are not co-located is such communication difficult, as workers have to overcome the lack of face-to-face interaction when they work on common objects. As a matter of communication for coordinating their actions, the various aspects of mobility have been discussed in Chapter 2. However, when it comes to an activity view, the manipulation of common objects is of utmost interest and transferring them between categorically different participants of the activity and neighbouring activities presents interesting challenges to the mobile environment. Mobile working and cooperating from a distance require that the notion of these common objects is recreated for various subjects involved in the activity. This type of interaction joins the subject-subject and subject-object interaction into a mediated subject-object-subject relationship, which was discussed from the subject-perspective in Section 4.3.2 above.

In computer supported cooperative work, the role that is assumed by the object in this subject-object-subject interaction is often referred to as *representation*. The common perception is that such representations are mappings, perhaps abstractions, of present and future work practices and of technological installations. Likewise, they are seen

as closed, fixed images of these objects that are externalised from the activities and passed on from one subject to another. As Bødker points out, there are a number of practical problems with such representations, especially when they cross the boundaries of different categories of subjects (1998).

The role that representations play in this interactive innovation activity is quite important, yet hard to conceptualise in detail. Examples of representations include prototypes, with which developers provide an image of how technology is supposed to work to future users. Through sketches, descriptions and so on, users try to relate their work practices to developers. "Representations reflect the expectations and experience of their creators" (Bødker 1998, p111). When different groups of people are involved, it becomes obvious that representations are poor *boundary objects*. As they travel from one user group to the next, they need to remain flexible enough to adapt to local needs and so that all parties can derive their own opinions but rigid enough so that they maintain their own identity across sites (Star and Griesemer 1989). Especially in very dynamic activities, such as the ones involved in interactive innovations, is fixing or closing a representations before they cross the boundary to another context, activity or group particularly difficult. On one side, they set a direction for the development of the new technology, the new systems, at least temporarily. They are *affordances* in interactive innovation, developments' properties that are to be perceived as possibilities for action by their users (Norman 1988). On the other hand they resist the very process of interactive innovation through being fixed (Norman 1991). Different kinds of representations are able to offer different degrees of resistance. Introducing prototypes for instance, drives and enables the understanding and further development of new technology; simultaneously, it can cause enormous resistance among the users who may not understand the reasons for and limitations of prototypes. Similarly, the closure of the representation, here the prototype, before it crosses the boundary between developers and users causes further resistance to how and to what degree it can be reshaped and reinterpreted (Bødker 1998).

The inherent problem of (and opportunity for) a study of innovation of technology for mobile work lies in this boundary crossing of objects and representations. Here, an important aspect is not only how different user groups interpret these artefacts, but

also what role these play in their daily lives. Trialists in my empirical settings, for instance, saw the mobile devices as *tools* that they applied at work in pursuit of an activity. To them, the mobile technology provided a possible solution to the needs they had at work. Consequently, representations were also aimed at providing images of these tools within their wider work practices. Developers, however, worked *on* rather than *with* these artefacts. To them, the same artefact was the object of their work, the motive of their activity.

Similar in nature to the discussion of disturbances that cause a transition of the level of interaction of subjects (e.g., from coordinated to cooperative), the tool-object dichotomy presents interesting insights into mediated human activity. The transition from a tool to an object of a mobile worker's work, for instance, represents the failure of the device to continuously support, and mediate, the activity. Although the changing status of the artefact from tools to objects and vice versa within the same user group can be viewed as skill development and learning from a subject's perspective (Wiredu 2005), from a tool-perspective it can also indicate the breakdown of a device as conditions of operations change.

The involvement of Nalle, Innovation Partners and Trialists as distinct groups in my empirical settings increases the study's complexity from the interactive perspective. For this reason, both interaction levels and existence of representations as tools and objects receive particular attention in Chapters 6 and 7.

4.4 Summary of Activity Theory and Dissertation Recap

As outlined in Chapter 2, Information Systems are often treated from either an exclusively technical or social perspective. Applications of theoretical models from social psychology have been criticised for neglecting some of the important technological features that shape IS phenomena under investigation. Mainly technical analyses have had the tendency to neglect the social, historical and contextual aspects of a systems-view. Activity Theory has been applied within Information Systems in an effort to overcome this focal dichotomy and to present a holistic view that encapsulates human and non-human participation in Information Systems activities.

With an expressed focus on the activity of innovating in this study, the framework of Activity Theory and its fundamental tenets present valuable analytical tools.

Through its key principles, Activity Theory is a form of *doing* directed to and driven by an object (Kuutti 1996). It views activities as mediated by tools and motivated by the transformation of an object, whether physical or less tangible, into an outcome. Objective-oriented activity is seen as a collective process, which traditionally has been defined and pursued through goal-oriented actions and operations. However, Engeström emphasises that a systems approach yields more accurate information about activities, as these cannot be defined through the sum of the underlying actions and operations alone. In his Activity Triangle, he suggests rules and division of labour as mediators in addition to tools, and the element of community to define the social milieu within which activities are carried out. Viewing such a collective system historically and applying it as the unit of analysis allows researchers to examine how members continuously interact in various ways to renegotiate and reconstruct their own activity systems. A view at these processes helps identify internal contradictions as the driving force behind disturbances, innovations and the resulting changes in activity systems.

From a mobility perspective, the notion of interaction is particularly interesting and important. The various communicative elements have been discussed in Chapter 2, but from an activity perspective the artefacts play an interesting role as they cross the boundaries between mobile workers and their fixed location colleagues. Representations add an invaluable component to a discussion of innovation of technology for mobile work as they cross the boundaries between innovators, innovation partners and users, too. Not only do these groups have different frames of references and experience with representations, but for some they are tools used in activities and for others objects of activities. In this research, these representations travel from mobile workers, or Trialists, to Innovation Partners to Nalle and back. It is through such a complex web of activity elements and mediators that the empirical research is analysed and presented as a new process- and activity-oriented view of interactive innovating of technology for mobile work.

The end of this chapter marks approximately the halfway point in this dissertation and the transition from the theoretical, conceptual components to empirical elements. This

point presents an opportune moment to recapitulate my work so far and to outline the remainder of this dissertation.

In Chapter 1, I introduced the topic of my research, in broad terms, and indicated opportunities for advancement based on current research and literature. An outline of the dissertation presented my approach to developing our understanding of innovation as an interactive activity that pertains to mobile work.

Chapter 2 provided an in-depth review of mobility literature, both in terms of mobile means of communication and communicative acts. Subsequently, the subject of innovation was presented through a thorough review of various views and conceptual approaches to the phenomenon.

In Chapter 3, the methodological approach of Action Research was presented, leading to the development of a blended methodology that includes the principles of Action Research and role focus and root definitions from Multiview.

Chapter 4 presented an activity-lens to the empirical study for much-demanded insights into innovation of mobile information systems. It concluded with a discussion of Engeström's Activity Triangle and the notions of representations as analytical tools for the empirical study.

The remainder of this dissertation proceeds as follows:

In Chapter 5, I operationalise Activity Theory and describe the empirical settings in great detail. The respective parties involved, their activity systems and subsystems are presented and examined from an interaction perspective, including the technologies currently in use and introduced throughout the trials at the heart of this study.

Chapter 6 concentrates on interactive innovation of technology for mobile work as an activity. By highlighting the contradictions within and between the Activity Systems, implications for mobile interactive innovation are presented. Contradictions and conflicts that emerged in the empirical work are discussed and their impact on the activity of innovating is examined.

Chapter 7 presents a move from the empirical setting to an analysis of *Innovation of Technology for Mobile Work* from a wider IS perspective. In an effort to examine the

extent to which work environments are shaped by their underlying technologies and technological affordances, this final chapter juxtaposes mobility and pervasiveness at work.

Chapter 8 concludes this dissertation with a summary of research and findings.

Chapter 5: Empirical Study of Mobile RFID Innovation

Studying aspects of interactive innovation of technology for mobile work is novel partially because the subject matter is quite new, and partially because of the aforementioned gap between technology and social studies. The popular press provides us with a lot of speculation as to how mobile work is conducted, only little of which is supported by analytical work. Research literature, on the other hand, focuses its attention increasingly on mobile communication; however, more empirically-supported and theoretically-informative work is needed for a more educated understanding of mobility and technology in the making. Especially an approach that is grounded in practice through an Action Research and Activity Theory perspective promises to shed new light on innovation and mobility. RFID and mobile technology are at a very interesting junction from this perspective; both have existed in separation for quite some time and only in this project do they converge into mobile RFID systems for the first time. Before its realisation the new technology had already been heralded by the press as a "killer combination not killer application" (Roberge 2004, p1) with an enormous impact of contactless interaction on work and society. This dissertation, as outlined throughout the previous chapters, is focused on providing more empirically-sound and theoretically-educated views of the activities that helped shape the innovation of these mobile RFID systems.

My involvement in the research phase is described in detail in Chapter 3. Complementing the researcher-focused chapter on methodology, this chapter provides details of the action component of the Action Research duality. Fortunately, I was able to join Nalle's introduction of the first global prototypes of mobile RFID devices to real-world settings at a very early stage, which offered the opportunity to examine the process of interactive innovation between the various participants of these trials. The technology in question was open to new configurations and reconstruction in response to the Trialists' feedback. My close work with mobile Trialists involved interpreting their work and feedback and communicating it to Nalle and the Innovation Partners. This chapter provides more detail of the empirical technology, the organisational trial settings and of my involvement.

In Section 5.1, I present the background of RFID developments at Nalle before I provide a schematic and description of mobile RFID transactions in Section 5.2. Section 5.3 introduces the Use Trials in terms of participants, the process and the notion of interactivity. It also includes short vignettes on work before and after mobile RFID. Section 5.4 illustrates the four different settings of the empirical work and Section 5.5 concludes this chapter with a summary of the key findings of the empirical project and sets the direction for discussion in the following two chapters.

5.1 Background of RFID developments at Nalle

As outlined in Vignette A in Chapter 2, RFID is not a recent development. However, only recently has the technological evolution of RFID enabled more advanced RFID interactions. Substantial gains in the efficiency of power conversion in circuits now provide power for cryptographic operations. The least expensive and powerful tags, for example basic Electronic Product Code (EPC) tags, provide no layers of security, but more advanced tags require additional power for cryptography, e.g. for static key operations (PINs and passwords), symmetric key encryption and cryptographic co-processors. These extra levels of security make sensitive transactions possible and enable novel opportunities not only for transactions of fixed-location devices, but even more so for mobile RFID applications. Additionally, tag prices have fallen in recent years and are currently at levels that make large-scale mobile field force application implementations feasible.

Nalle's interest in RFID technology has been influenced by the highly dynamic and competitive industry of mobile technology and by the novelty of the opportunities offered by RFID-enabled mobile interaction. In an effort to reap first-mover advantages, Nalle spent immense time and energy on enabling the technological aspects of the mobile RFID system, and only after it was conceivable that the complicated integration of the components would succeed did the true innovation of the business-applications begin. As highlighted in Chapter 2, this emphasises the difference between empirical work focused on design issues or innovative activity, where the design of information systems is mostly concerned with determining details to meet a purpose; innovation is determining a purpose, two elements that are difficult to separate. While it would appear natural that design follows innovation from this

perspective, the developments here in some instances seemed backwards, with innovation at times chasing design. It is from this perspective that this study was conducted; RFID coupled with mobile telephony had been proven in its embryonic stage and Nalle's aim was to actively identify what to do with a working and very promising mobile RFID technology. In that respect, it focused primarily on the innovative aspect (i.e., finding a purpose for the technology) by adhering to design requirements (i.e., what socio-technical requirements will meet this purpose) that were both determined through the interaction with Trialists and Innovation Partners.

Vignette B: Work before mobile RFID technology

> Simon, a security guard for Morrison Patrolling started his shift at 6pm, five evenings per week. He arrived at the main office, where he collected a worksheet that contained the various stops for his shift, a vehicle and a mobile phone. Throughout his twelve-hour shift, Simon did not return to the office. He patrolled the assigned premises and ensured that they were secure. In the event that they were not, he called his superior to inform him that he would be late for his remaining stops. In the event of an emergency at a different site, a dispatcher called Simon on his mobile phone to direct him away from his scheduled visits and towards the more urgent matter. Of course, it was very difficult for the superior or dispatcher to know where Simon and his colleagues were throughout their shifts. Equally importantly, it was very difficult for Morrison Patrolling's customers to know if their premises were secure, if the guard ever came to check and if so, at what time and at what intervals. As a result, Simon's superior who spent 90% of his time on the phone responding to questions from customers and inquiring about the whereabouts of the individual guards and the status of their work status. Likewise, Simon spent an enormous amount of time on the phone, reporting on his progress and his location. In many cases, this involved justifying that he could not respond to an emergency because he was simply too far away. Simon used an asynchronous reader, called The Torch, every time he arrived at the assigned location to record the event's details. About once per week, the

data stored on this device was synchronised via a cradle to the office computer and then sent to the headquarters where it was analysed and returned within a week to Simon's office. Only at this point was his superior truly able to report to his customers the details of Simon's work. He was still only able to give an account of the time of Simon's visit; the condition of the premises at that time could be illuminated only through comparing the reading of The Torch with the manual log that Simon and his colleagues had to keep. Understandably, Morrison Patrolling's customers demanded faster answers to their inquiries; in fact, everybody was quite frustrated with time delays and the constant need for telephone calls between customers, managers and mobile workers.

5.2 Empirical Technology Setting

This section introduces how the actual technology used in the trial responded to the organisational requirements to connect to workers like Simon and to overcome problems associated with the mobility of their work. As previously outlined, the two main components that facilitated the mobile components of the RFID system included readers and passive tags.

Here, the reader component was incorporated into the battery cover of two mobile phones. Essentially, adding this reader increased the thickness of the phone by less than 1 centimetre and resembled a negligible increase in weight. The location and placement of the reader was chosen in response to the need to have the reader powered with the battery of the phone and the desired ability to use the reader and the display of the device at the same time. Tags used in these trials were all contactless, chip-equipped passive RFID tags, able to communicate with the reader over a distance of approximately 3 centimetres. These tags came in various forms or shapes, but all of them included a microchip attached to an antenna (see Figure 20). In these empirical trials, some tags were donut-like in shape (approximately 2 centimetre in diameter) and could be attached to other objects with a rivet through the hole in the middle (see Figure 21). Others were Smart Labels that could be laminated or glued on the back of regular ID-Cards or behind posters (see Figure 22). Mobile workers in the trials had such tags attached to their ID-Cards. When they started their work shift they

read the tag with the reader in the phone, which identified them to the corporate back-end system and signed them into work. Throughout their workday, these mobile workers read a large number of tags attached to various objects of their work. At the end of their shift, they read the tag again to sign out from work.

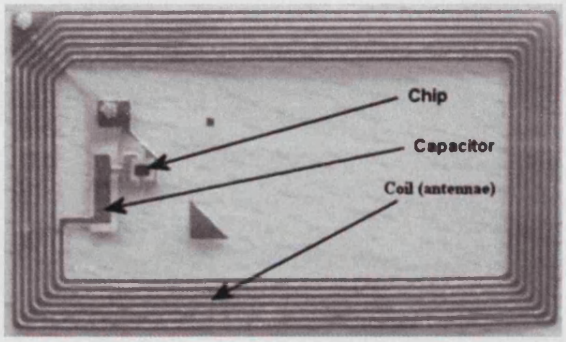


Figure 20: Passive RFID Tag Technology

Figure 21: Passive Donut Tag

Figure 22: Reading a Tag glued onto the back of a Poster

RFID Event Navigation on the Reader

Once the device read a personal RFID tag attached to an ID card (see Figure 23, (a)), an application started on the phone. Based on the information on the personal ID tag, the phone identified this person (b) and started a secure connection to the back-end

system (c). Once this operator now brought his RFID enabled mobile phone within a three centimetre distance from a passive RFID tag attached to an object of work (e.g., a gate) (d), the mobile phone's RFID reader's electromagnetic waves woke up the passive tag and the two exchanged data (e). In most cases, such data was simply the serial number of the tag, thereby indirectly identifying its bearer (e.g., the gate). The midlet programme queried the mobile worker for further input and he chose among a number of options on the phone, for example *All ok* (f) and hit *Send* (g) to transmit the information to the back-end of the system (h).

Figure 23: Mobile RFID Events Unfolding

RFID Communication Architecture

The scenario above outlines the conceptual steps involved in navigating through an RFID interaction on the mobile device. The sequence of steps and the respective input required from the mobile worker were defined for each trial to reflect the respective work practices of the mobile work in question. Naturally, midlets for patrolmen and container drivers were quite different.

Figure 24 illustrates a view of the tags and mobile RFID phone and how they are connected to the bigger picture of the new system in these trials. Once any RFID-related segments of the sequence above were completed, the phone initiated a broadcast of a SMS to the so-called Li-Server (short for Local Interactions Server). According to previously determined business rules, the respective selection then triggered an instant reply to the mobile phone via GPRS (e.g., 'please check gate B next'), logged the information for later use (e.g., payroll) and linked the information to further servers or provided the updated information to other parties via a secure-connection website (e.g., to provide Morrison's customers with access to their premises' status).

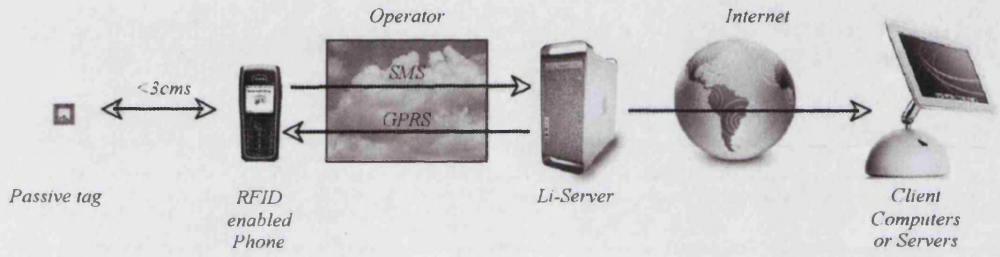


Figure 24: Mobile RFID Schematic

The technology in essence allowed mobile workers to transmit data instantly, with various options to reduce time-delays, paperwork etc. The aim was to introduce higher efficiencies of mobile work, both from a worker's perspective and the support provided from his office. Equally importantly, it was to result in advanced access to critical data among the third parties who could now access critical field data. After presenting an example of use of mobile RFID in Vignette C, various attributes of the technology are next illustrated against the backdrop of the empirical study of this dissertation.

Vignette C: Work with mobile RFID technology

When the new system was introduced, Simon was somewhat hesitant. He had a wrong impression of the technology and thought: "Now you

[superiors] are able to watch every step I take" (Francis 2004). After learning more about how RFID works (versus GPS technology, in particular), scepticism and privacy concerns wore off within the first week. In addition, it appeared that for Simon the convenience gained from the system outweighed any remaining questions about its intrusive potential. For the remainder of the trial, Simon grew increasingly skilled and fond of the new system. It had virtually eliminated his manual log and work-sheet and drastically reduced the time he had to spend on the phone to report on his whereabouts. Mobile RFID was also a way for Simon to prove that he was serious about his work, "Before I always had to justify and explain everything because I work on my own, now they [superiors] can see that I am doing good work and I have to spend less time on tedious tasks" (Walsh 2004). His managers, too, were quite pleased with the benefits of the system. They had to spend much less time manually locating and coordinating the security guards and the inquiries from the customers were handled via the extranet. Reports could be drawn up within minutes. Guards and managers were quite willing to participate in the trials and supported the interactive innovation process as much as they could so that the technology would be adopted more permanently.

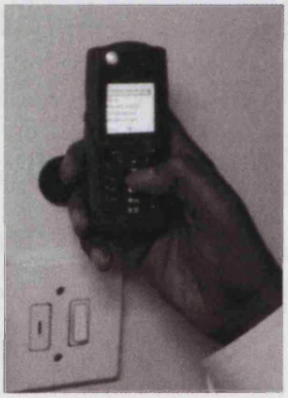


Figure 25: A Guard Reading a Tag

However, in spite of the success in Simon's case, it was too early for jubilation; not all Trialists and managers shared the same experience, as illustrated next.

5.3 Use Trials

Chapter 3 briefly indicated the complexity of this study to highlight some of the methodological intricacies. This section builds on this brief introduction. Nalle

pursued its objective of identifying business opportunities for its new technology by staging a number of trials that formed the basis of the interactive innovation activity.

5.3.1 Participants

The various categories of participants in the trials were briefly introduced in Chapter 3. Figure 26 below is a reproduction of Figure 7 on page 76 (Chapter 3).

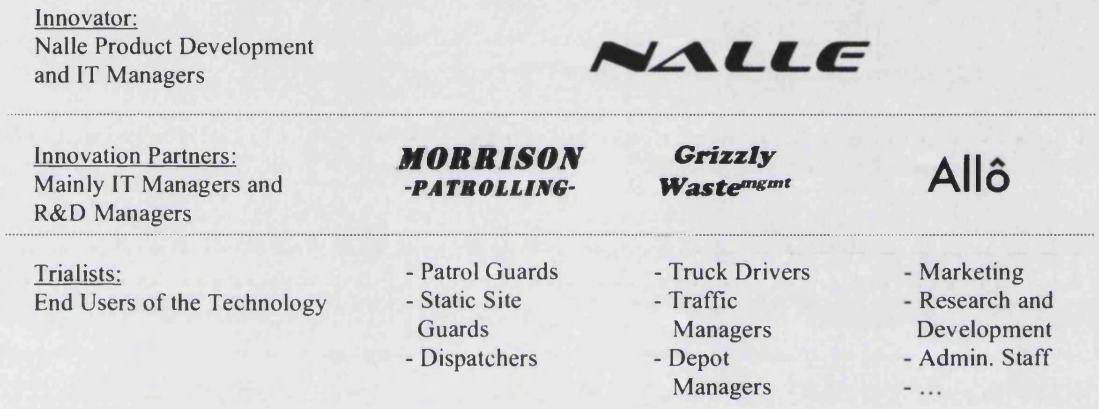


Figure 26: Three Levels of Research Participants (Figure 7 reproduced)

Nalle was the developer and primary host of the innovation trials. A large number of people were involved from abroad; those who were present in the UK were mainly Product Development and IT Managers.

Innovation Partners included companies for whom it made business sense to consider mobile RFID systems for their mobile workers. The representatives from the Innovation Partners were mostly IT Managers and R&D Managers.

Trialists were the workers who used the mobile RFID systems. In most cases they were mobile workers; nonetheless, office-bound work was also influenced by the new system. Workers here included dispatchers who were in charge of keeping track of mobile workers, their managers and, to some extent, the customers of the innovation

partners (e.g., companies retaining the security services outlined in the vignette above).

Lastly, as the researcher I was involved at all stages and worked with all other participants as outlined in detail in Chapter 3. True to Action Research, my involvement was close to practice and I adopted various roles. Especially in the early stages of the trials I assisted with the use of the technology and acted as a trainer and troubleshooter. Later, I followed the mobile workers throughout their shifts, observed how they used the technology and discussed its weaknesses and advantages with them. In many ways, I was the voice of the mobile workers. Most of the feedback they provided about the technology went through me to Nalle or the Innovation Partner, or both. At other times, I worked closely with Nalle or the Innovation Partners to discuss and incorporate any changes to the technology and the midlet. In this sense, the innovation activity was truly interactive and encompassed all three levels of participants.

5.3.2 The Course of the Empirical Study

In the initial stages of selecting appropriate Innovation Partners for the new mobile RFID systems, Nalle searched for business requirements and opportunities that matched the key characteristics of its new technology. In essence, these included the need for auto-identification through the tag-reader interaction, synchronous data transfer through the mobile phone, two way communication between front-end (phone) and back-end (Li-Server) and logging capacity. Based on these features, contact was made to a number of companies, including the abovementioned security services company. Among those who decided that they would indeed benefit from the technology the initial contacts were in all cases IT or R&D Managers in senior positions.

Identifying Business Requirements and Work Practices

After the first stage of identifying and selecting Innovation Partners, the context and application of the RFID technology were defined so that the respective hardware and software requirements could be developed. Here, Innovation Partners' IT Managers

took it upon themselves to determine the main use-cases that they would provide to the end users. Considerable effort went into establishing these use-cases, but it was clear from the beginning that the end users would have suggestions for their improvement. From the beginning, emphasis was placed on interaction with all levels of workers involved.

Developing Technology

Once these details defined, IT Managers and Nalle designed the technological aspects in response to the business needs. Nalle worked on the midlets (Java-based programmes that ran on the phone and coordinated the mediation between tags, phone and Li-server) and provided the hardware pre-programmed at the outset of the trials. The respective Innovation Partner's IT Managers determined the types and number of tags required and worked on the integration of the new system with their existing setups.

Hosting User Trials

The actual trials consisted of a number of steps. First, the Innovation Partner's managers and IT personnel were introduced in more detail to the technology. These were in most cases the individuals who had helped with defining the business rules in the previous step.

Once these managers had received proper training, the mobile workers under their supervision were introduced to the trial technology. They were told how the front-end data, based on their input, would be integrated with the corporate back-end system. They were at this stage presented with Nalle's and the Innovation Partner's objectives of the technology development. This was also the first time at which they were introduced to the business rules that had been established about their everyday work practices and built into the technology.

The implementation of most of the technology was in place at this point, including tag integration with local interaction server and the corporate back-end. However, IT Managers understood that the physical installation of the tags had to be done by the mobile workers in order to reflect their work practices most closely. In most of these

work settings, the mobile workers were in fact the only people in the Innovation Partner companies who ever set foot onto their customers' terrain. The tag installation was problem-free and completed in a matter of days.

Over the course of the following weeks any prior speculation about how mobile work was conducted had to stand the test of actual practice. In most of these 'conceptual technology meet real-world' scenarios the input of the mobile workers was of the highest importance to the innovation cycles of the systems, including the design and development of hardware, software and midlets and the redefinition of use-cases.

De-briefing and Learning

In regular intervals, feedback from the mobile workers was related to both Nalle and the respective IT Managers. Solutions to problems were developed and implemented so that they could be tested by the mobile workers. As discussed in Chapter 3, this process clearly resembled the Action Research Cycles. The de-briefing and learning stage resembles the last stage of the Action Research Cycle, providing the learning input for the necessary improvements and the next iterations and releases of the systems.

At the end of the trials, formal reports were drafted and high-level board meetings with Nalle and the respective Innovation Partners were held to determine the suitability of the respective RFID systems, to weigh their benefits and potential shortcomings and to discuss more long-term adoption possibilities of mobile RFID systems.

5.4 The Empirical Corpus and Individual Settings

The study based on four trials with three unique Innovation Partners presented one coherent body of empirical evidence. Collectively, these interactive trials formed one project, one study whose findings educated the innovation of mobile RFID. These cases are presented next.

5.4.1 Morrison Patrolling

This particular trial focused on Nalle's developments of mobile RFID at Morrison Patrolling in Manchester. Since Morrison Patrolling was founded about 40 years ago, the company has focused on communications, distribution and business services in the UK and worldwide. Within the past two decades, Morrison Patrolling expanded its security expertise across the globe, acquiring businesses in USA and Europe whilst also expanding in countries where Morrison Patrolling already had a presence.

The main organisational focus of Morrison Patrolling concentrated on cash management, justice services and manned and electronic security services. Although mobile RFID technology had merits for all of these functional areas, this particular trial was hosted only in Morrison Patrolling's security patrolling sector. For the study, mobile RFID was made available to various sites throughout Greater Manchester. Among the numerous functional departments that were managed from the various locations, *manned guarding* and *monitoring and response* used the mobile RFID technology for their work-practices.

Manned Guarding: Guards were located in various buildings to ensure the access to and security of the premises. These included static guards at the entrances and exits and mobile guards who patrolled the sites.

Monitoring and Response: Mobile patrol guards monitored a range of customer-sites on a 24-hour basis and provided so-called keyholding services. These guards covered hundreds of kilometres during each shift. During welfare-visits, mobile guards accompanied customers who required access to often remote properties, particularly at night. This study focused on mobile guards dispatched from Morrison Patrolling's offices in Manchester.

User Roles

Within the different sites, two different categories of users were involved with the technology and carried out the following tasks.

Managers: Initially, regional managers were trained at Morrison Patrolling's main office in Manchester. They learnt how to use mobile RFID devices and how to work

with the integrated database at the back-end of the system. Managers then selected and trained a small number of guards within their own regional offices and agreed on sites and locations for installing passive RFID tags. Furthermore, managers and the researcher drafted and entered messages into the system that were relayed back to the guards upon reading particular tags (e.g., upon reading the tag of Gate A, the system sent a message reminding the guard to read a newly added, nearby tag attached to Gate B). Throughout the trial, managers were encouraged to use the database for as many tasks as possible to enable valid user feedback.

Guards: Patrolmen were equipped with mobile RFID enabled devices. Passive RFID tags were distributed to the guards who then placed them on the chosen checkpoints throughout the premises. On their scheduled routes, these static and mobile guards then read the tags with their devices, entered comments and chose among the available options on the menu of the phone (e.g., *All ok*). Guards returned the devices once they completed their shifts and their colleagues would then use them on the following shifts.

Existing Technology

Prior to the trial, guards and managers relied on a range of asynchronous devices that used a similar tag-reading technology (e.g., Morse Watchman and TKS Torch, see Figure 27). Although they appeared to be similar in function to mobile RFID device, their ability to manipulate and transfer data was quite limited. No options existed to add comments or notes to the readings. Data could simply be read and stored on the tag readers until downloaded via a cradle to the respective computers in the regional offices. In some locations, this was done daily; however, the majority of managers downloaded data once per week and then transferred it to London for central processing. The analyses of the tag readings were then returned to the regional managers within five to seven days.

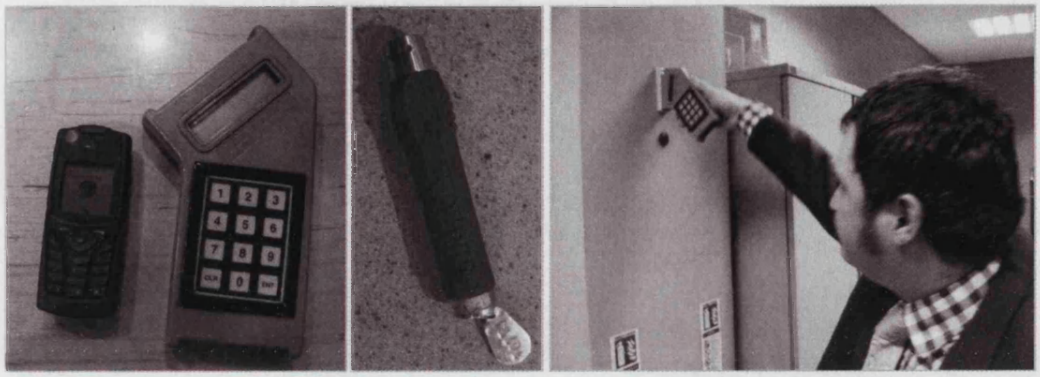


Figure 27: Mobile RFID device, Morse Watchman and TKS Torch

Implementation Environment

A total of twelve readers were provided to five managers and 23 users. Approximately 900 RFID tags were installed by mobile workers and used during the four-week trial period.

> At the beginning, finding the tags was a bit of a problem. Different guards installed tags at different premises. Although we had agreed before where the tags would be, it often took a little time to find them (Peters 2004).

Each of the five sites was issued with two readers with the remaining two readers allocated for testing and demonstration purposes. At each site, one reader was for regular use and the other was a spare in case of any faults with the primary reader. Nalle's mobile RFID system was tested in-house and introduced to Morrison Patrolling not in parallel to current systems or in a modular fashion but through an instant, complete change-over for the duration of the trial.

Figure 28: Mobile RFID in use at Morrison Patrolling Services

Outcome of the Trial at Morrison Patrolling

As the vignette above indicates, the trial of the mobile RFID reader was viewed as very successful by all individuals involved and interviewed. Managers saw the product as a means of communication, with synchronous and asynchronous features that increased the transparency of their guards' work and enabled more efficient and more effective data collection, data analysis and particularly report generation. Among the main points was the timely and detailed knowledge about the guards' work and the capability to provide a higher level of customer satisfaction. For the guards, the benefits of the technology were quite straightforward: the mobile phone with the RFID reader became tools that performed much of the least meaningful components of patrolling, namely report keeping and activity logging. In this respect, the RFID device became an important means of communication and interaction, allowing the parties to exchange pertinent information in a time sensitive manner.

> I no longer have to answer the phone to respond to the constant questions from the dispatcher. He knows where I am and I can concentrate on my job. The other thing that is really helpful is that he can look at the electronic log and find out what happened in the past days. I no longer have to come in to help him read my writing. Now, when we talk it's about topics that actually make sense (Peters 2004).

In addition to its current features, managers and guards saw the technology as the way forward in security services and were able to envision how this product could provide further benefits to their work in the future.

One of the main attributes of the technology, including front-end readers and the back-end database, was the ability to automate those elements of work that were most time consuming and least enjoyable. At the same time the system was able to raise, or informate, the level of other work practices by providing additional value to the users, creating new demands for intellective skills and generating deeper levels of data.

5.4.2 Grizzly Waste Services – Landfill Meter Reading

This particular trial focused on Nalle's developments of mobile RFID at Grizzly Waste Services in Manchester. Upon its foundation in 1962, Grizzly Waste was largely dedicated to the collection of residential and special waste. In particular, this involved clinical waste, landfill gas management and environmental services. In the more recent past, Grizzly Waste Services geographically expanded throughout the UK

and serviced a wider scope of waste services. Today, Grizzly Waste handles waste from industry, commerce, retail customers and the health and public sectors. The company's operating divisions cover the spectrum from collection to sorting, recycling, treatment and ultimately disposal of non-hazardous and hazardous waste streams.

Among the many waste services offered by Grizzly Waste, the RFID trials focused on applications of waste management at actual landfill sites and waste in transit (on container trucks, at waste transfer stations etc.). This section introduces the former aspect of the trial, the meter-reading responsibilities carried out by gas technicians at various landfill sites; Section 5.4.3 describes the trial involving container services.

Landfill waste management requires a number of highly skilled tasks. These services, among many others, include the management of leachate, an ammonia-rich by-product of landfill waste and the gas conversion at landfill sites. Leachate levels must adhere to environmental regulations and municipal standards since it can potentially introduce harmful toxins to the sewage system and is accompanied by a smell that is not easily forgotten. The work of Grizzly Waste gas technicians to a large extent involved measuring and monitoring the amount of gas extracted and converted into electricity. The electricity produced was either used on site or added to the national power grid. The landfill sites' own electricity needs were filled either through electricity produced on-site, as far as available, or from the national grid. Naturally, electricity produced in-house was cheaper to Grizzly Waste than that bought from the national grid. Similarly, extra electricity produced at the landfills was sold at a premium to the national grid. As a result, it was in Grizzly Waste's interest to maintain the highest conversion ratio of gas to electricity possible without stressing the gas conversion engines too much.

> We take our job very seriously. Odour control is a big part of what we do, as is of course maintaining good levels of gas conversion. The various amounts of gas extracted and converted as well as numerous indicators of engine performance are displayed on meters located close to these engines on the landfill sites (Smith 2004).

User Rules and Existing Technology

The gas technicians involved in the RFID trial travelled between different landfills to manage landfill gas on the sites, to identify gas wells and to service the sites'

equipment (check belts, oil levels, motors etc.). Six gas technicians in the Manchester area, for instance, monitored the meters that indicated rates of gas conversion at ten different sites. These sites were up to 150 kilometres apart and had up to ten different gas meters each. As a result, a gas technician needed to cover a large geographical space in a workday. In addition, the data from the meters needed to be transferred to Grizzly Waste for quality assurance. Before the trial, the meters' data was recorded on paper and sent via fax to Grizzly Waste at the earliest possible time. Alternatively, data was transferred from paper to a laptop and emailed to the respective offices. However, once an engine needed to be repaired, for instance, this became the gas technician's highest priority – the meter data had to wait for sometimes up to six hours before it was sent to the office. The time that passed between meter-reading and data transmission clearly influenced the accuracy of data provided. As engines under-performed, less electricity was generated and could be exported to the national grid. Similarly, the continuing underperformance of engines, if not tracked accurately, led to a loss of revenue, poor allocation of resources and the deterioration of the actual engines.

> Sometimes we enter data into Excel sheets and email them from our laptops. But sometimes connecting through dial-up from our trucks can take 30 minutes, which is why we usually send a fax when we get to an office. But that, of course, is only possible if all goes well. Once there is a problem with an engine, the fax has to wait, sometimes for more than six hours (Smith 2004).

Implementation Environment

The RFID solution proposed to address many of these problems. Once a gas technician read a gauge on a meter, he identified the exact meter by reading the RFID tag with the mobile RFID device, entered the reading through the telephone's keypad and immediately sent it through the local-interaction server to the office.

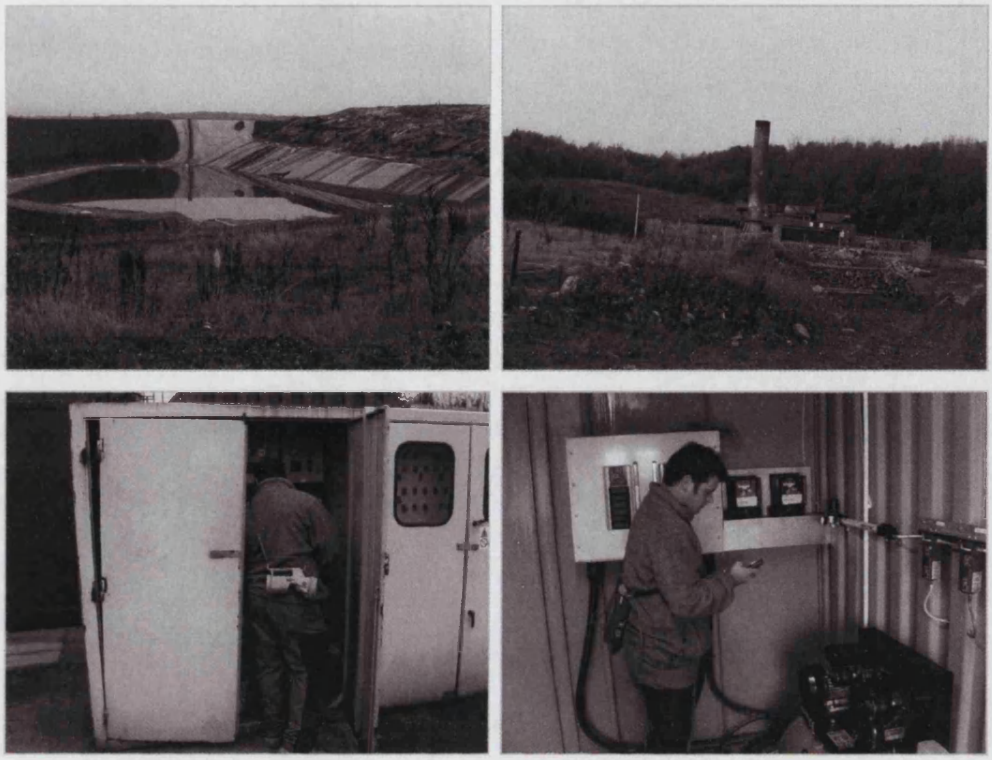


Figure 29: Conversion Reading via mobile RFID at Grizzly Waste

Submitting paper copies via fax was no longer needed; the time problem outlined above was solved through synchronous data transfer between the phone and the database in the office. A total of six readers and approximately 150 RFID tags were provided to six gas technicians at twelve sites. A total of 123 tags were in fact installed at 49 meters and used during the seven-week trial period. For the duration of the trial, Nalle's mobile RFID system was introduced to Grizzly Waste not in parallel to current systems but through an instant changeover. However, some of the gas technicians used their paper-based system for backup, not because they did not trust the system, but because they felt that it would provide coherence for any possible audits by environmental regulatory agencies.

> The tags were very good when they worked, and it was surprising how quickly we got used to the new system. The trouble was when a tag had fallen off, or when the reader malfunctioned. This hardly happened, but when it did we needed to figure out what was wrong, replace the tag or reboot the phone, which was a bit of a nuisance (Mahaux 2004).

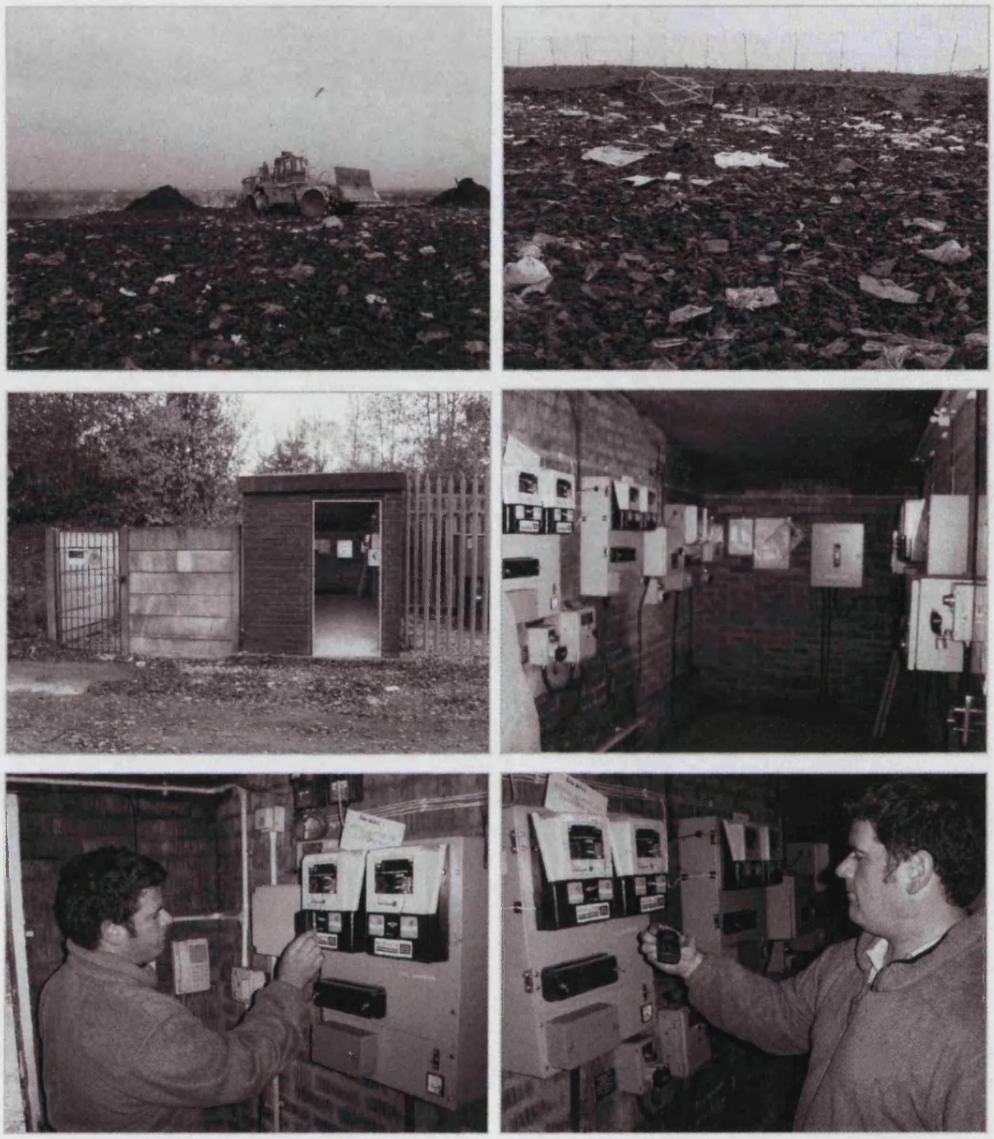


Figure 30: Reading Gas Meters on Grizzly Waste Landfills via mobile RFID

Outcome of the Trial at Grizzly Waste Services Meter Reading

Throughout the trial, it became clear that gas technicians found the adoption of the RFID technology fairly undemanding and straightforward. The implementation of the tags occurred without difficulty. The reading of the meters and the entering and sending of the data posed no challenges. The threat was that although individuals were technologically sophisticated and found the system easy to use, they might view RFID as an intrusion into their work, into their lives and their freedom to exercise their daily routines and activities. Among the individuals interviewed, this was not the case. On the contrary, the feedback provided by gas technicians highlighted their high

level of acceptance of the technology and their interest in developing it for further uses for their teams in particular and for the company in general.

5.4.3 Grizzly Waste Services – Container Services

Among the many waste services offered by Grizzly Waste, this particular RFID trial focused on waste in transit (from client sites, onto container trucks and to waste transfer stations etc.), as opposed to waste management at actual landfill sites. In particular, the work investigated involved truck drivers dispatched from the depot in Manchester.

Landfill waste management relies on a number of highly specialised gas extraction and leachate reduction processes. One might assume that the task of moving waste to the landfill is quite simple and straightforward in comparison. However, the planning and control of the flow of waste from customer sites to the final destination (i.e., landfill sites) is a highly complex task that involves a number of technical and human elements.

Participants of this RFID study were drivers of bulk carrier vehicles who serviced waste requirements for a number of commercial and industrial sites. Grizzly Waste customers in this context were either regular customers who always kept a Grizzly Waste container on their site and relied on scheduled waste collection (e.g., large scale bakeries), or they were temporary customers who called upon Grizzly Waste for waste removal for a specific time span (e.g., construction projects). By and large, the responsibilities of the truck drivers involved the maintenance of their vehicles, the collection of full containers from customers' sites and the delivery of empty containers to customers. Full containers were emptied, or *tipped*, at so-called transfer stations or taken directly to landfill sites, depending on the distance and time available. At these transfer stations, loading shovels separated the waste into different categories before loading it onto other trucks that moved the waste to the respective landfills or recycling stations.

Existing Technology

Before the trial, Grizzly Waste used no advanced technology to trace where the individual containers were located. Not only were containers capital-intensive investments (£5,000 each), but many of them lay dormant at transfer stations, customer sites etc. With the budgetary constraints for only few new container purchases and the number of customers growing quickly, the availability of containers to truck drivers decreased considerably. In other words, the need to trace their equipment to provide enough containers to the truck drivers and to minimise the interruption of their work was becoming more and more apparent. Similarly, tracing the whereabouts of containers and using them efficiently promised to result in higher a return on the investment and in fewer orders for replacement containers.

As for the administrative record keeping, truck drivers documented most of the data on paper, which was then submitted to the office and entered into the company's database. The data recorded here included the driver's waste collection point (customer name) and waste disposal site (e.g., transfer station name), weight of the cargo etc. The locations of the individual containers were not traced in this system; they were neither numbered nor otherwise identifiable or attributable to a particular driver, customer or site. Containers carried the Grizzly Waste logo as their only identifying feature.

As far as the availability of drivers for other collections throughout the day was concerned, a mobile phone driven system was in use. Here, individuals entered a key-code that determined if they just collected, tipped or delivered a container. The key code was entered into a mobile phone that was permanently mounted to the dashboards in the cabins of the trucks. Although this system provided up to the minute information as to what drivers were doing, it missed out on identifying which customers, containers or tipping stations the drivers were working at. As a result, the dispatcher still needed to rely on voice-driven calls to identify the drivers' whereabouts to determine which driver was closest to a site that needed to be serviced. No log of either the dash-mounted system or the voice calls was maintained.

Implementation Environment

The underlying motivation for this RFID trial was Grizzly Waste's desire to successfully trace where the company's containers were, whether they were full or empty, on their way to or from a customer's site or transfer station. In terms of data management and driver dispatching, the mobile RFID technology promised to provide real-time information on the last whereabouts and respective activities of the drivers.

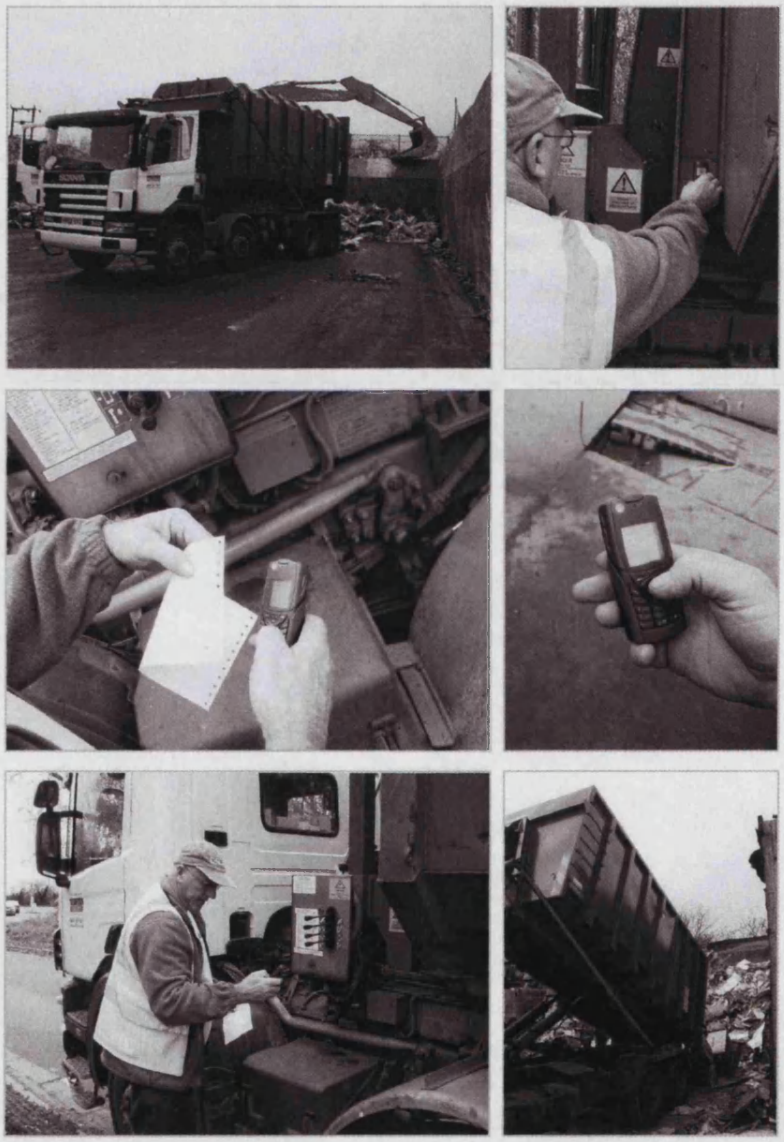


Figure 31: Mobile RFID Container Services at Grizzly Waste

All of these location-based services were at the heart of the six-week RFID trial. RFID tags were attached to a total of 135 containers serviced by truck drivers

dispatched from the Manchester depot. Five drivers obtained operator tags that they used for signing in and out of their shift. They simply read their tag with the RFID reader, which activated their session on the phone and initiated the data transfer to the depot. Dispatchers and managers then knew which drivers were working. Every time they collected, tipped or delivered a container, drivers read the container's tag and chose the respective option from the phone application.

Depending on the option selected, the device queried the truck driver for the name of the transfer station (tipping) or the conveyance number of the customer site at which the container was collected or left. The Grizzly Waste office was able to collate all the data and derive the whereabouts of each container and driver and whether they were on their way from or to a customer or tipping station. Based on this data, the dispatcher knew which drivers were available to respond to additional service-requests and what their approximate distance to this customer's site was.

Outcome of the Trials at Grizzly Waste Services Container Services

Throughout the trial, it became apparent that the growing pains that were experienced would be of a temporary nature. The 'old boys' that formed the cadre of truck drivers resisted the change to a new system. In their eyes, there was nothing wrong with the current system; and although they saw a strong benefit in tracking containers they felt that this should not result in any extra work on their part. In many ways, this resistance appeared to be a generational problem, both in terms of the driver's age and seniority within the company. Younger drivers had less of a problem with mobile RFID, conceptually or in terms of its usability. As observed in the trial, more senior members found the adaptation of the technology demanding. Nonetheless, within a week they had grown used to the technology. The difficulty was not *using it*, but *remembering to use it.*

> The trouble is that in the past, I have always left the cab with a pencil and my clipboard. Now, I have to remember to take the phone. Even worse, I also have to remember to take my reading glasses, otherwise I can't read the small display. I guess over time, I will get used to it (Francis 2004).
>
> Some of the features are spot on, but some others could be improved. Some changes are very small and I know what the phone should do to work better for me, but of course I cannot make any changes to it. It is good that you [Jan] are here, since I would not know how to talk to the engineers at Nalle about our work, the technology and the changes. It's like they have to imagine what we do here and we have to try to tell them everything about our work to help. The other problem is that we almost

> speak two different languages. Sometimes what they say makes no sense to us. It's good, too, that we have our managers to talk to, although they're never where we are (Springer 2004).

Moreover, in some cases it appeared that it was not the technology that was doubted, but the drivers questioned the corporate agenda hidden behind the RFID implementation (i.e., more work and additional control) as discussed in more detail in the following chapter.

5.4.4 Service Discovery at Allô

The last trial focused on Nalle's developments of mobile RFID at Allô's Headquarter, approximately 20 kilometres south of Manchester. Allô is a mobile telephony service provider with a wide customer base within the UK and internationally. As outlined in the introduction of this dissertation, the mobile telephony industry is experiencing decreasing returns on the voice telephony services. Consequently, it is in the interest of all service providers to actively investigate opportunities for future developments of mobile telephony applications.

This particular trial was hosted by Allô's Research and Development Team, which was set up to serve Allô as a centre of excellence in research and development in mobile communication and applications. The Research and Development Team focuses on applied research that was positioned between the basic research undertaken by universities and commercial product development. The team provided a systematic programme of work in pursuit of innovation to guide and underpin the company's business and technical strategy. This trial set out to gain an understanding of mobile workers' opinions of mobile RFID, of the trial services provides and of their experience of using a new technology in a social environment.

The Trialists from this perspective were participants who worked within the extensive geographical setting of the head office. Similar to the previous trails, these Trialists had always been mobile workers; contrary to the other trials, the were white collar workers whose mobility concentrated on wandering and roaming within the terrain of their office environment, not travelling across widely dispersed locations. The experiences of these mobile workers were shaped as much by technology (e.g., does the system work?) as by the social environment (e.g., what will others think of me

when I use the technology in the office?) and the services offered (e.g., why would I want to use this system?). The trial's aim was to help Allô understand the possibilities and limitations of mobile RFID to develop new services for their respective customers. As a service provider, the focus was on mobile RFID service discovery.

In this regard, the trial complemented the other trials, which focused more on the RFID-supported orchestration of mobile work than on the discovery of new RFID services for mobile workers. Allô's objective of service discovery was more closely related to Nalle's innovation interest in developing the technology than the other Innovation Partners. Different from the other trials, Allô was interested in innovating new services not necessarily for its employees but more importantly for its own customers. As part of the overall project involving a range of trials, the Allô trial was aimed at providing Nalle with an understanding of innovation opportunities for new, next generation mobile RFID services, thereby fuelling the next cycle of innovating activities at Nalle.

Implementation Environment

Prior to the trial, a total of 710 tags were placed throughout 40 main locations in four departments in Allô's Headquarter (HQ), spread over four buildings and an area of approximately one square kilometre. Similar to the other two trials, the work environment of mobile workers was equipped with a number of tags. Nonetheless, the aim was not to directly steer current mobile work practices through the use of RFID but to discover how people used devices and how, as a result, new services could be developed. Initially, a number of use-cases were developed that would allow the individual Trialists to experiment with the technology.

To entice mobile workers to use these RFID services the trial was hosted on a reward basis; Trialists were not paid for their participation directly, but the use of the mobile RFID system could lead to various rewards and prizes. For instance, tags were embedded in posters that were placed in the business centres, kitchens and in tabletop signs distributed in various meeting areas. The particular services triggered by reading a tag with the mobile RFID device included local traffic news delivered to the users phone (once the respective tag was read, see Figure 33), maps and directions (Figure 34), free daily wallpaper and ringtones. Additionally, Trialists could read special tags

that entered them into a music or sports competition for the entire duration of the trial. Another main incentive for trial participants to use the phones and tags was a competitive treasure hunt that started on the first day of the trial and was hosted for five days. Participants who managed to read all the tags embedded in posters with a treasure hunt icon entered a draw for miniature collectible automobile models and those who entered the sports competition were entered into a draw for premier league tickets. The prize for the winner of the music competition was a free audio CD.

Figure 32: Tagged Tabletop RFID Sign

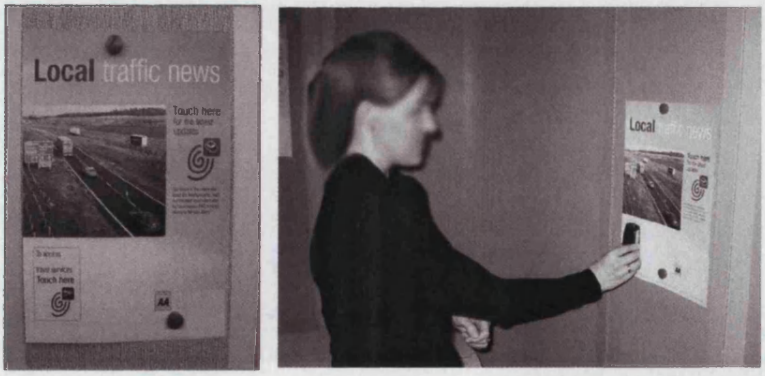


Figure 33: Local Traffic News RFID Poster

Figure 34: Maps and Directions via mobile RFID

For two days prior to activating the treasure hunt, Trialists collected their trial packages. These included the phone (including pre-charged battery, charger and built-in RFID reader), an introductory letter to the participant and a selection of tags. Among these tags, a *trial helpline* tag would connect the participant's phone directly to the R&D department for technical support and an *information WAP* tag triggered a connection to an informative Wireless Application Protocol (WAP) website on the phone. Additionally, two *keep in touch* postcards were included. Participants were encouraged to use the phone to write text messages, web addresses or mobile numbers to the tags embedded in these postcards, which they could then pass on to other trial participants or leave in their physical mailboxes. Moreover, a *directory assistance* tag was included, which participants could read with their phones for a direct call to directory assistance. Lastly, the welcome package also contained *free daily wallpapers* and a *free daily ringtone* postcard, which delivered these features to the phone once the respective tags were read.

End User Feedback

The objective of feedback collection from Trialists for this experiment was to evaluate RFID technology at its current state and to identify how and in what format RFID could be embedded in Allô's mobile telephony strategy to deliver new services to end users. A total of 80 employees participated, including two trial leaders, the principal researcher and 17 so-called wizards, who were volunteers who agreed to help others with any trial questions or concerns they had. Participants were of various age groups and from different functional departments at Allô HQ. From an R&D

perspective, this trial was also aimed at increasing the awareness of Allô employees of mobile RFID technology, especially in the R&D department. The information provided by trial participants fell into the categories of (1) actual device adoption and use, (2) experience with mobile RFID technology, (3) possible uses of it in real-life situations and (4) privacy or security concerns.

Outcome of the Trial at Allô

Participants who experimented with mobile RFID at Allô found the use of the device and the RFID interaction process straightforward and intuitive. Although the location of the reader was obvious to almost all participants, most said that they had to experiment with the reader at first, as it was not clear if one had to hover, slide, wave or press the reader onto the tag. After a short period of growing accustomed to the RFID interaction process, individuals had worked out the best possible way of reading a tag. Surprisingly, different users reported different techniques, ranging from holding the phone at a distance of 3 centimetres, touching the tag with the top of the phone or sliding it across the tag. Although participants differed on their best practices of RFID events, they formed a very similar conceptual opinion of the technology. Mobile RFID and its potential uses were viewed as most interesting. Trialists agreed that beyond some of the teething problems encountered in the trial, they could envision how mobile RFID would change many current services and introduce altogether new ideas into the mobile technology domain.

As outlined above, RFID applications and services available during this trial included mainly options that provided entertainment and rewards to the participants. As such, they were viewed as valuable mostly because they introduced the technology in a playful manner, including mobile content downloads (e.g., free wallpapers, games and ringtones), leisure competitions (e.g., sports and music competition for premier league tickets and audio CDs), travel information and the treasure hunt. These services not only introduced participants to the various RFID applications, but more importantly triggered further thoughts about additions to mobile services. When asked about their suggestions and thoughts, participants' opinions generally fell in the categories of access control, mobile payments (M-payments), information storage, retrieval and transfer of data, access to 3G services and privacy and security concerns.

5.5 Summary and Key Findings of Mobile RFID

The findings yielded from the various trials of this project were complex and contextually dependent on the individual trials. Action Research as a methodological approach focused on interactive innovation of technology for mobile work, whose findings are addressed over the following two chapters. This section summarises Chapter 5 and presents key findings that concern the practitioners, Nalle, Innovation Partners and Trialists.

From an innovation and product development perspective, Nalle was presented with important feedback about mobile work and RFID. Some of the more influential insights came from the trial at Grizzly Waste Container Services, which indicated more than others that mobile workers live and work within a particularly interesting, complex and often-invisible entanglement of organisational rules and power structures. True to the role of contradictions of Activity Theory, these conflicts placed an emphasis on this social dimensions of mediating technology and uncovered organisational predicaments of automatic data capture (ADC) that would have otherwise gone unnoticed and which became important considerations to the innovation and development of the new mobile RFID system. With respect to the technology itself, these trials unveiled a number of interesting hardware and software features. From this perspective, the trials informed Nalle about some improvement requirements for the next innovation cycle, including the tag's ability to withstand electromagnetic interference (EMI) better and the need for enhanced resistance of tags to harsh working environments. Likewise, some of the features of the phone were uncovered as inappropriate for the mobile environment, including the backlight of the device, the size of the keys etc. Although first thought of as too delicate for some of the mobile trials, the mobile RFID readers performed quite well overall and no major technical concerns emerged.

For all Innovation Partners, particularly Grizzly Waste's Container Services, the importance of the organisational context outlined that any contradictions and conflicts that emerged during the trial needed to be addressed before a more permanent adoption of the technology could be considered. Grizzly Waste's Meter Reading and Morrison's Patrolling Services, on the other hand, outlined important characteristics of geofencing (i.e., the use of RFID to locate by association, e.g. passing a sensors at

the entry to a warehouse but not the sensor at the exit indicates that a person is in the warehouse) and a synchronous communication link to other mobile workers and office-bound superiors. The trial at Allô emphasised how the next innovation cycle and generation of mobile RFID needed to include not only the lessons-learnt from the use of mobile RFID in actual work practices, but also new and emerging opportunities presented for additional applications of the technology. For Innovation Partners, the trials carried a sense of awkwardness and excitement. While of course the IT Managers were eager to introduce a new technology, their understanding of how mobile work was conducted was put to a test. Similarly, it was through the proxies of technology and an outside researcher that any misperceptions of mobile work surfaced. It seemed that the potential downside for the IT Managers in the event of a project failure was large, but so was the upside in the event that the new system succeeded. In any event, the trials were viewed as very educational from the perspective of the Innovation Partners. They illuminated practices of mobile work that had previously been unknown and shed light on some organisational phenomena that to some extent impeded organisational change. Furthermore, the introduction of new technologies through the interactive focus of the trials uncovered important attributes of cooperation and coordination of mobile work.

With respect to innovation and product development from the mobile workers' perspective, this research revealed that mobile developments must pay particular attention to issues that concern the adoption of technology, including appropriation, HCI and connectedness. The different trial outcomes provided different impetuses for further development and innovating of technology. More importantly, direct and indirect implications for work practices had to be incorporated into the innovation cycles. With respect to RFID technology, these trials indicated a strong sense of privacy concerns, total asset visibility (TAV), the added transparency of mobile work through visible RFID interactions, the virtual elimination of the perennial clipboard and other paper-based recordkeeping and, most importantly, changes to existing structures of cooperation and collaboration with peers, colleagues and superiors, mobile or not. Many of these aspects play an important role in how activities are carried out and, indirectly, how mobile workers support the process of interactive innovation. Accordingly, these aspects are discussed in more detail in the following chapters.

Chapter 6: Mobility, Interaction and Innovating

This chapter presents the logical continuation from the descriptive section of the empirical setting in Chapter 5 to the analysis of the findings. In light of the existing work and research on mobility, technology and innovation (Chapter 2), it reflects the research aim laid out in Chapter 1, i.e., the provision of an activity-oriented analysis for interactive innovating of technology for mobile work. This analysis further provides an empirically-based insight into the interplay of the phenomena of mobility and technology. Through the examination of the interaction of neighbouring activities and the notion of tool mediation in particular, aspects of Activity Theory are used to illuminate the intricate mutual effects of innovation, mobility and technology on each other.

This chapter first introduces the interaction of the various parties involved in the activity of innovating through an Innovation Framework, including a number of unique epistemologies (Section 6.1 and its subsections). In Section 6.2, these relationships are analysed through the previously introduced activity-lens, leading to a number of interactive, technological and mobility-related contradictions within and between neighbouring activities (Section 6.3). Section 6.4 extends the perspective of technology for mobile work by questioning to what extent the technology in question is related to the mobility experienced by its users.

6.1 Interactive Innovating

Interactive innovation is commonly seen as a cooperative, mutual learning effort involving **two** parties, for instance designers and users (Bødker and Grønbæk 1991). However, especially mobile artefacts are no longer only shaped by developers with the input of users, but are more complex and involve more parties. My empirical setting is indicative of the importance of innovating mobile technologies in mobile work settings that involved **three** parties, including product innovators (Nalle), organisational customers (here the Innovation Partners) and final users of the artefacts (here the mobile workers, or Trialists).

Interestingly, in my empirical work this trinity raised novel dynamics from an interactive innovation perspective, one in which Nalle's customers (i.e., the Innovation Partners) were not the users of its technology and in which the users of the technology (i.e., Trialists) were not the customers paying for its development. The potential danger in this development lay in the convoluted differences between the interests of customer and user (or employer and employee, Innovation Partner and Trialist), expressed through contradictory motives regarding interactive innovation, affordances of the empirical technology and the future of mobile work.

Nalle's proximity to and the direct contact with the Innovation Partner raised the danger of being responsive to customer-needs and neglecting the requirements of the actual users. As a consequence, Nalle placed a strong emphasis on interacting with all participants of the activity of innovating. Nalle could neither focus exclusively on customers' needs nor on users, since all three parties had developed and maintained different types of knowledge that were required for the successful product innovation and development. This of course increased the importance and complexity of effective interaction within this trinity. The research questions set out earlier (see below) focused on the activity-led analysis thereof, aimed at the constituent parts of interactive innovating of technology for mobile work.

Research Questions laid out in Chapter 1:

How does the interaction with mobile work affect the innovating of technology?

What is the role of mobility in interactive innovating?

What are the roles of the different parties involved?

What is the role of technology in mobile activities and interactive innovating?

6.1.1 Interaction Framework

As emphasised in these research questions and further outlined in Chapter 2, the notion of interaction is particularly important for the creation and communication of

innovative knowledge. In the trinity of innovators (e.g., Nalle), Innovation Partners (e.g., Grizzly Waste, Morrison Patrolling) and Trialists (e.g., Security Guards, Waste Truck Drivers), this emphasis raises the question of who should interact in an interactive innovation activity (i.e., their ideal, normative relationships) vis-à-vis how these parties actually interacted (i.e., the empirical evidence). Clearly, various interaction opportunities exist between the three participants (Figure 35).

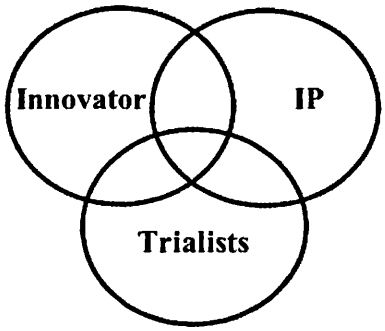


Figure 35: Basic Interaction

A key argument that provides value to this otherwise very basic interaction framework is the notion that the three parties possess different kinds of unique knowledge. It is a fundamental premise of the activity of interactive innovating that different sets of knowledge must exist and be communicated and combined in order for interactive innovation to truly occur. In recognition of the customer/user dilemma outlined above, the acknowledgment of different, exclusive sets of knowledge becomes an important factor in the development of technology for mobile work. Rather than relying on a straightforward separation of two parties, innovator and user, and their naturally different sets of knowledge, the framework required here must more narrowly differentiate the interests and unique knowledge sets of the three fundamentally different participants.

6.1.2 Unique Sets of Knowledge

Nalle's expertise as the Innovator lies in the development of mobile technology. The company is well known for its expertise of innovating, developing and manufacturing mobile telephony handsets and other mobile devices. Most of Nalle's products are

developed in order to fulfil mobility needs, either personal or professional. In this setting, it was Nalle's know-how of incorporating an RFID reader into the shell of traditional handsets, powering it from the mobile phone's battery and driving the transfer of RFID data from the reader through the phone and local interaction server to the corporate back-end system. Nalle's interest, as elaborated upon in more detail in Section 6.2.1, was twofold. First, Nalle was of course very interested in employing its technology within corporate environments (of the Innovation Partners) to find a practical application for its technology. Secondly, to Nalle the activities of the different trials of this project were also aimed at providing more grounded knowledge that would provide valuable lessons-learnt for the next iteration of the innovation cycle of mobile RFID. In part, then, Nalle wanted to provide a solution to the Innovation Partner's organisational demands and to experiment with the technology in real-life settings to inform future innovating activities aimed at solving other organisational problems. From an innovator's perspective, Nalle took a solution-based approach by offering a technology to address organisational inefficiencies. **Nalle's knowledge, accordingly, was solution-based.**

Innovation Partners, (e.g., Morrison Patrolling), possessed a different set of knowledge. Within the context of their organisational settings they were of course very knowledgeable of their existing information systems and how these were tied into their daily operations. These practices involved technological information systems and manual procedures, mobile workers and office-based employees. In other words, Innovation Partners understood how mobile telephony, for instance, and asynchronous, often paper-based logging procedures existed side-by-side and provided the knowledge base for their daily operations. Based on their technical and managerial perspectives, the Innovation Partners were also conscious of some of the organisational inefficiencies that a new technology needed to address. The previous asynchronous flow of data collected from mobile workers, the gaps left from incomplete data capture in the field and the need for synchronous, more complete and detailed field-data formed the motivation of Innovation Partners to participate in the trials. In other words, Innovation Partners were knowledgeable of their current technologies, solution approaches and respective shortcomings. However, they were not in a position to develop the desired technology in-house. Their core skills were not the development of handsets or RFID technologies, but skills rooted in their

respective organisational objectives and contexts. In order to take advantage of the promises of incorporating mobile RFID technologies into these organisational processes, the **Innovation Partners offered their context-based knowledge to the interactive activity of innovating.**

Trialists (e.g., Grizzly Waste's truck drivers) were focused chiefly on the actual work to be completed; they were concerned with finishing the tasks assigned to them in the time demanded. Their motivation was neither to develop new technologies nor to advance organisational information systems. As part of their work practices, mobile workers relied on the use of various technologies at work, including paper-based record keeping and mobile telephony. More importantly, the immediacy to everyday tasks and problems placed them into the remarkable position that they were the only people who really knew what happened out in the field. Although their employers (i.e., Innovation Partners) had access to the logs and other asynchronous records of their work, these were merely accounts of a subsection of mobile work. Only Trialists knew the shortcuts they took to get the work done, such as temporarily storing containers half-way between customers (known as running-containers) to save time on return trips or stories to tell the security patrolmen dispatcher to avoid being called to far-away emergencies. Although these examples may shed a negative light on mobile workers at first sight they indicate that they understood their current work environment in all of its finesse to fulfil their work. On a more positive side perhaps, Trialists also knew how to overcome some of the shortcomings of existing information systems. Work practices involved tweaking some tools so that they would work as needed (e.g., finding good signal reception to use a mobile telephone, restarting the laptop when it froze, leaving work-related notes in the field for mobile colleagues). Whether positive or negative, over time they developed work-arounds, to make due and to be able to complete the work that was required of them. Trialists were the only ones who knew the details of their work, the underlying processes and skills needed in the field. Consequently, **Mobile workers possessed needs-based knowledge.**

Accordingly, three different sets of knowledge shaped the activity of innovating technology for mobile work. In an interactive fashion, they theoretically informed one another, leading to technology that is both customer and user responsive. In this

realm, the interaction of the different parties and the nature of their knowledge exchange needed to be examined in more detail. Were these sets of knowledge communicated effectively or were they too sticky, too hard to transfer from one party to another (Von Hippel 2005)? In previous views of interactive innovation that involved only two parties, the knowledge asymmetry between developer and user could more easily be described in terms of stickiness. A gradient of information described the difficulty of balancing the solution-based knowledge possessed by one party with the needs-based knowledge of the other, for instance. However, with three parties, the use of the Interaction Framework and the Innovating Spaces proposed below is a more practicable approach of looking at knowledge exchange and interactive innovation.

6.1.3 Interaction of Unique Sets of Knowledge

The preceding illustration of the unique epistemologies (i.e., solution-based, context-based and needs-based) focuses on the three different parties; however, it does not look at their interaction. The Basic Interaction (Figure 35) addresses the individual circles but neglects the more complex intersections, or interactions, that occur between them. It is at these junctions that knowledge is exchanged; the negotiation of respective participants and knowledge types determined the combined knowledge created. I refer to the intersection of two epistemologies, the interaction of two participants within this framework, as Innovating Spaces (see Figure 36, A, B and C). Within these Innovating Spaces, participants balance the information asymmetries that exist between them. Once combined, the knowledge-exchanges from individual Innovating Spaces form an overall Coalescence Space (D), in which all of the different perspectives inform the innovation of a new technology. In what I refer to as the Interaction Framework from this point forward, the following asymmetries existed and motivated the interaction of the participants.

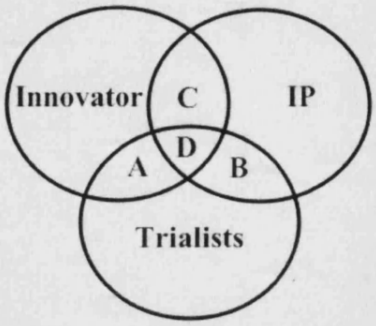
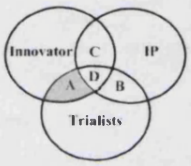


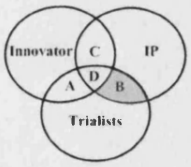
Figure 36: Interaction Framework

Interaction in Innovating Space A: Technology Development



The interaction in this particular space involved Nalle and the Trialists. From Nalle's perspective, the input from Trialists provided the needs-based knowledge of work requirements, and practical feedback on the usability of the technology, on some of its shortcomings and relevant suggestions for its improvement. In essence, the Trialists' input became an important part of the toolset used by Nalle to develop the technology. The interaction in this Innovating Space involved Nalle's talk about solution-based features of the technology and Trialists' needs-based input into Nalle's instrument-producing activity – **this was talk about work practices and technology development.**

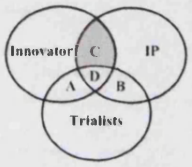
Interaction in Innovating Space B: The Future of Work



On paper, it may not come as a big surprise that Innovation Partners and Trialists interacted, they were all members of the same respective companies and were based in most cases in the same location. The fact that mobile workers spent very little time at these locations might account in part for the scarcity of natural interactions between Innovation Partners and mobile workers. Another element, of course, is the functional focus and hierarchical separation of Innovation Partners and mobile workers. In reality, these individuals had rarely, if ever, talked to one another. As part of the innovation and development of mobile RFID in their companies, Innovation Partners needed to identify and develop use-cases for the new technology. In most cases,

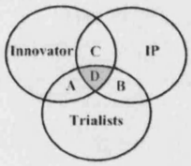
Innovation Partners realised that their somewhat removed and abstract understanding of mobile work needed to be informed and validated throughout the trial. Similarly, in order to manage and advance mobile work, Innovation Partners had to ground their contextual knowledge in mobile activities. As a result, Innovation Partners needed to talk to Trialists to balance the needs-based understanding of mobile work practices with the context-based knowledge of organisational requirements. This provided input to the development of a more advanced central activity for mobile work – **this was talk about work practices and the future of work.**

Interaction in Innovating Space C: Systems Development



In an effort to remain responsive to actual work practices, rather than innovating and developing technology in isolation (or only based on the interaction with mobile workers), Nalle needed to place a strong emphasis on the organisational contexts of its Innovation Partners. Similarly, for Innovation Partners it was important to learn about the actual properties and capabilities of the technology to be developed so that use-cases could be designed and work practices amended. From a technological perspective, it was elemental for both Nalle and Innovation Partners to closely interact so that new mobile RFID systems and corporate legacy systems could be prepared and integrated. From this perspective, Nalle developed the technology to work accordingly and in line with Innovation Partner's legacy systems; Innovation Partners prepared their systems for the introduction of mobile RFID – **this was talk about technology requirements and systems development.**

Interaction in Coalescence Space D: Innovating Technology for Mobile Work



When the three Innovating Spaces intersected, they in fact brought more than three different, isolated sets of knowledge together. Solution-based, context-based and needs-based knowledge coalesced as a united result from individual negotiations within the respective Innovating Spaces. In other words, the Coalescence Space does not suggest that all three parties come together physically, but rather that the outcomes of the Innovating Spaces and the resulting knowledge bases are combined. Through

continuing interaction with the Trialists, the relevance of this coalescence is constantly validated. In this case, Nalle's solution-based knowledge was in part based on Trialists' work practices (needs-based information) and Innovation Partner's system requirements (context-based information) through the interaction in Innovating Spaces A and C. An Innovation Partner's context-based knowledge was in part shaped by what solutions were possible and feasible (C) and by what the Innovation Partners learnt from Trialists (B). Innovation Partners developed a more advanced activity (work practices) accordingly. Through communicating their needs-based information, Trialists had an input in the development of technology and the more advanced activity, leading to a harmonious interaction and socially constructed technology and mobile work practices – in theory.

6.2 *Interactive Innovating through an Activity – Lens*

The Interaction Framework presents an ideal situation in which all three participant categories are not only aware of their unique sets of knowledge, but are also willing to interact with the respective others and agree to share their expertise freely. In addition to this collaboration readiness (Olson and Olson 2000), the exchange of sets of knowledge had to be practically possible, too, and was made difficult through the mobile nature of the workers' everyday activities. As a result, the reality of interaction between Innovator, Innovation Partners and Trialists was less straightforward than the Interaction Framework would suggest. An activity view of their interaction provides a valuable lens for analysing how the interaction occurred and for shedding light on interactive innovating of technology for mobile work.

The analysis of the empirical study through an activity-lens requires that we look at the overall exercise not only as one encompassing activity, but more importantly as a number of activities that together form a whole. Accordingly, there were a variety of foci and objectives that determined these individual activities and their interrelatedness, much like there were a number of epistemologies and Innovating Spaces. Chapter 4 already introduced the notion of a central activity and neighbouring activities (e.g., instrument-producing, developing a more advanced central activity), an approach that is applied in this section to the activities of Nalle, Innovation Partners and Trialists.

6.2.1 Individual Activities

In Chapter 4, Activity Theory was described in detail. In his conceptual development of Activity Systems, Engeström extends Vygotsky's elements of mediation and Leontiev's model of subject-activity-object. Engeström further calls for more attention to "the components of the mediating 'third' factor, activity" (1988, p473) to recognise the collective component that shapes any activity. With his Activity System Triangle approach (see Figure 37 for a reproduction), Engeström suggests a move from an instrumentalist approach to an interactionist perspective, most suitable for the focus of this study. In addition to the impact of the supra-individual influences on activities he further outlines various levels of neighbouring activities to place weight on the social and cultural context of the work environment and particularly the activity under investigation.

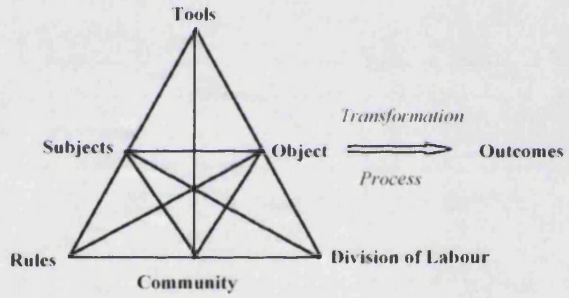


Figure 37: Engeström's Activity Triangle System (Figure 13 reproduced)

In this section, Engeström's Activity Triangle System is applied to the empirical setting to shed additional light on how the activities of the three categories of participants unfolded and to draw attention to their interrelatedness and to the interaction of the epistemologies outlined in the Interaction Framework.

Innovator

The first element that is important from Nalle's perspective is the motive behind the company's involvement, or rather instigation, of these trials. As an object-oriented activity, the aim of Nalle was to innovate and develop a new technology consisting of a number of devices (e.g., mobile RFID reader, tags) that would be used for mobile work. Consequently, in the connection of neighbouring activities and with a focus on interactive innovation, Nalle pursued an instrument-producing activity. Although

other mobile technologies had been developed in isolation before being presented to their users, Nalle had become quite conscious of the uniqueness and ambiguity of mobile work. Thus, Nalle's motive was to derive practice-based knowledge of mobile work and to translate, or transform, that object (i.e., the psychological object of knowledge of mobile work) into the outcome of the development of mobile RFID. As part of this relation to actual work, from an activity perspective, the input that mobile workers had on the process or activity of innovating was crucial to its execution. As outlined in the Interaction Framework, Nalle and Trialists interaction focused on work practices and technology development. Accordingly, Trialists and their needs-based knowledge became important tools, used in the transformation of Nalle's instrument-producing activity alongside other more traditional tools of systems development. Similarly, the Innovation Partner's context-based information, through interaction in Innovating Space C, formed another valuable mediator and tool of the activity. To Nalle, the aim of the trials was of course to develop a technology that would succeed in the settings of the trial when brought together in the Coalescence Space. Beyond the trials, however, this practice-based learning was aimed at educating the further development of the technology across additional settings and populating the work in many other organisational settings. Hence, to Nalle these trials were viewed as gathering a practice-based, grounded understanding of mobile work with the goal of generating new knowledge about the interplay of mobile RFID and work.

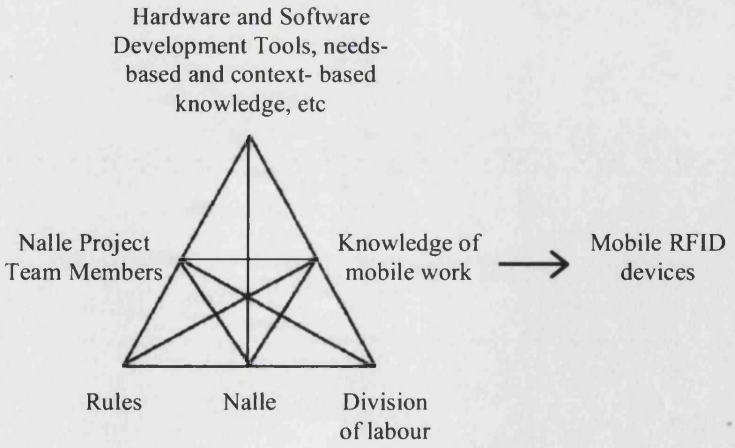


Figure 38: Instrument-Producing Activity

Innovation Partners

Innovation Partners were clearly much less concerned with how the learning from these trials benefited Nalle's development team for further, unrelated developments or for work with other Innovation Partners or future customers. The Innovation Partners primary interest was without a doubt concentrated on their specific corporate settings. Innovation Partners focused on the improvement of their operations, their ability to capture and manage field data and to understand, conceptually and practically, what their mobile workers did after they left the office, the garbage depot, etc. The aim of the Innovation Partners was to increase the organisational understanding over their mobile work practices and to illuminate aspects of their corporate work that had previously been out of their sight, both physically and conceptually. The motive behind their activity was to increase the transparency of mobile work practices, to increase mobile work-related knowledge creation and dissemination through increased transparency of mobile practices. The outcome of this motive was the transformation of this knowledge into the development of RFID supported mobile work practices and fieldwork. Contrary to Nalle, Innovation Partners were not concerned primarily with developing a new artefact but with developing a more advanced activity of mobile work within their organisations. In Activity Theory terms, this activity was aimed at improving, from a corporate perspective, the central activity of the mobile workers. Hence, Innovation Partners activities were best described as developing a more advanced central activity, namely RFID supported mobile work. Among others, tools required for the development of such new mobile activities were the solution-based knowledge of Nalle (i.e., the technological opportunities presented to Innovation Partners to develop more advanced mobile work practices) coupled with the needs-based information of mobile workers, both gained through interaction in the respective Innovating Spaces.

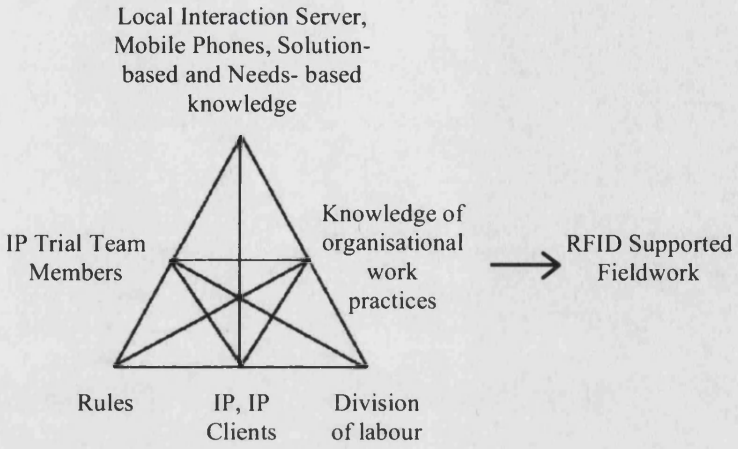


Figure 39: Developing a More Advanced Central Activity

Mobile Worker

The instrument-producing activity and the development of a more advanced central activity aimed to remain responsive to the actual mobile work, pursued in the interaction of Innovating Spaces A and B. The mobile work itself involved the everyday practices of garbage truck drivers, security guards, gas engineers and Allô employees and was central to the overall activity of interactive innovating. In contrast to other innovative activities, these particular empirical developments were neither demanded explicitly by mobile workers nor based on user-centred developments (compare Von Hippel, 2005 etc). Nonetheless, mobile workers had previously experienced shortcomings with their tools and had requested new and improved tools for their work. Implicitly, then, they supported the improvement of their overall work through the development of a more advanced central activity for mobile work, as became evident when examining some of the work-arounds mobile workers developed for the use of their equipment. In many cases, these needs-based solutions were accepted as recognised methods, both by mobile workers and their superiors (e.g., the use of running containers). In other cases, these work-arounds were not known to superiors although they were everyday practice of mobile work (e.g., not responding to mobile calls and pretending the phone received no signal). The notion of the empirical trials was very interesting to mobile workers as it presented not only the recognition among managers that mobile work was complex and required many

work-arounds but also the promise that mobile work situations would be improved with the mobile workers' input. Before the trial, the mobile workers' motivation was pursued by transforming the objects of mobile work skills into the outcome of reliable mobile work practices and fieldwork. Without a doubt, the objective for the Trialists was primarily to 'get their job done'; security guards were concerned with ensuring the security of their assigned premises and garbage truck drivers were concerned with the delivery of empty containers and the collection full containers, on time and with as little friction as possible. These deliverables were the main content of their work and the measures against which their performance was evaluated by their superiors. The outcome of reliable work in the field was manifested through the transformation of these objects.

From an innovating perspective, the mobile work activities served as the basis for the interactive innovation. The mobile workers' needs-based knowledge was at the core of the innovation, Nalle based its instrument-producing activity on it and the Innovation Partners relied on it for the development of more advanced mobile work practices. In other words, the mobile worker's activities formed the central activity among all the neighbouring activities (see Figure 40).

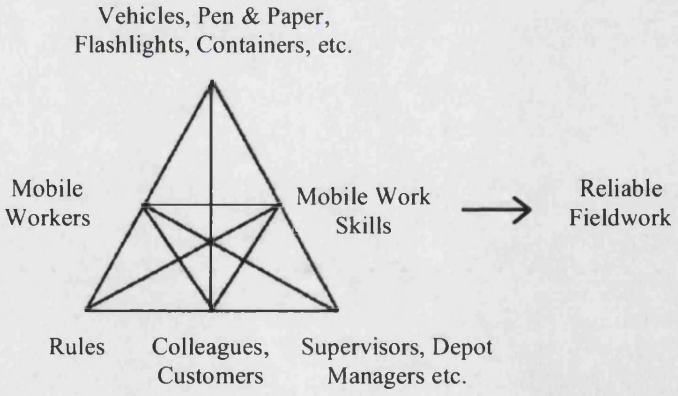


Figure 40: Central Activity of Mobile Work before Trial

Within the empirical settings, there were different needs and goals that motivated the different mobile occupations (e.g. security services, waste removal), different tools and different organisational rules. However, the objective of the mobile workers was neither primarily to help Nalle innovate and develop better products, now or in the future, nor explicitly to help the Innovation Partners (i.e., the mobile workers'

employers) introduce new systems to their mobile work. At the centre of the mobile workers' attention and interest was their own work and the transformation thereof. Accordingly, the shaping of the central activity through the activities of Nalle and Innovation Partners informed the participation of the mobile workers in the overall activity of interactive innovating.

6.2.2 The Interaction of Individual Activities

In Activity Theory parlance, the mobile workers' focus on their everyday completion of assigned tasks formed the central activity. Nalle's involvement focused on creating new knowledge of mobile work practices and the use of mobile RFID, their involvement in this exercise was that of an instrument producer, which in itself involved many complex activities (development of hardware, development of middleware, designing midlets in response to Innovation Partner requirements, use-cases etc.). The Innovation Partners, on the other hand, were less concerned about the actual activity of producing new tools, their motive was to improve current work practices through mobile RFID; they were concerned with introducing mobile work of a higher order, a more advanced central activity.

At this stage, the Interaction Framework (Figure 36) introduced the various types of knowledge possessed by the respective participants of the activity of innovating. At the same time, this framework outlined how these parties would meet in Innovating Spaces to share these sets of knowledge to inform the overall activity of innovating. Additionally, the individual activities outlined above describe the motivation and objectives for each neighbouring activity and the tools used in their pursuit.
Figure 41 presents a combined view of the Interaction Framework and the individual neighbouring activities. It includes the Innovating Spaces of the Interaction Framework, which combined with the individual objectives outline areas of particular interest to the analysis of the overall activity of innovating. The interaction of different individual activities (including different epistemologies, tools, objectives etc.) presents the focus for the examination of contradictions; the tensions that exist within the system as the collective engages in goal-oriented activities and that led the activities through a series of expansive cycles.

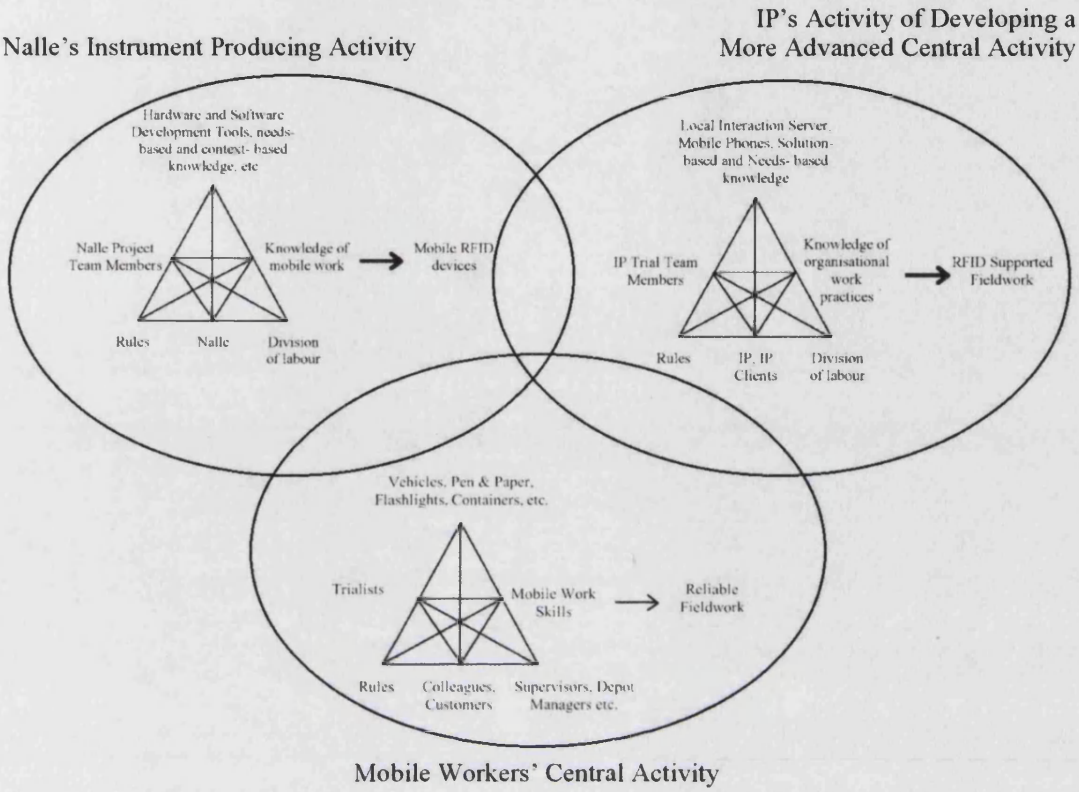


Figure 41: Interaction of Individual Activities

Including the individual activities in the Interaction Framework provokes a discussion of both internal and external contradictions as they emerge in the overall activity of innovating. Internal contradictions emerged within each individual activity as members externalised their perspectives through their work *with* or *on* the new mobile RFID system. From these individual participants' practice point of view, such contradictions were obstacles that hindered the process of the activity and the pursuit of the motive. Furthermore, from an interaction perspective, contradictions included disruptions that occurred when different members of the system (the collective subject) sought to negotiate within the Innovating Spaces during the trial activity.

Mediation and the Negotiated Outcome of a Trial Activity

The figure above outlines the relationship of the three different levels of participants in the overall activity of innovating. Each category of participants pursued the transformation of its respective object into the desired outcome. Together, these activities form the mediated, interactive activity systems displayed in

Figure 41. The interaction of all three individual systems presents the combination and inclusion of all respective sets of knowledge (solution, context and needs-based), resulting in a new, more advanced central activity for the trials, supported by the use of the new mobile RFID system and centred on the mobile workers, the Trialists, as depicted below. This *Trial Activity* system describes the tools (e.g. mobile RFID system) and rules as they are embedded through the midlet and implemented through psychological tools and procedures for the trial. It encompasses the community of those who are directly affected through this activity system, including Trialists, their colleagues, managers and the Innovation Partners' customers. The motive of this activity was to use the mobile RFID systems alongside other central activity tasks and tools to provide mobile RFID supported fieldwork.

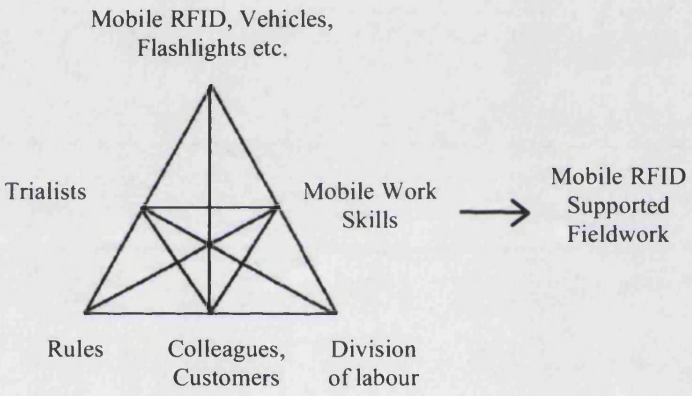


Figure 42: Trial Activity with More Advanced Objective and the new Tool

This trial activity was to test properties of the more advanced activity using mobile RFID technology. In many ways, it was similar to the more advanced central activity; however, Trialists in the trial activity needed to focus on the central objective of their work (e.g., emptying containers) while at the same time testing the device and new work rules it presented (logging problems with RFID events etc.). They also needed to interact with the Innovator and Innovation Partner, to provide feedback to the instrument-producing activity and the development of a more advanced central activity. If the technology had been adopted more permanently and the more advanced central activity imposed onto mobile work, this would no longer be required. The development of the tool and all of its properties would be completed and the mobile workers could once again focus on the true content of their work. The

difference between the trial activity and the more advanced central activity, then, was the mobile workers' attention paid to tool and procedure development.

Viewing these activities involved in the trial as negotiated outcomes based on interaction is correct, but it is also deceiving. Similar to the Interaction of Individual Activities (Figure 41), it presents a rather rigid view of an activity. However, the activity systems involve highly complex and dynamic, interactive elements of collective activity between Innovator, Innovation Partner and Trialists. As such, these activity systems are in constant flux and go through continuous expansive cycles. With change as a fundamental nature of the interactive activity systems, conflicts and contradictions drive the interaction and thus the innovating of technology for mobile work.

6.3 Contradictions of Activities

A birds-eye view of the whole array of activities displayed above suggests a harmonious relationship between central activity and neighbouring activities, where the individual activities interact through the Innovating Spaces. Together, it would appear, the subjects from each activity form a collective of individuals who work towards a common goal in the trial activities. Nonetheless, a closer examination illuminates a number of conflicts. In accordance with this research's focus, the next three subsections of this analysis concentrates on the respective themes of interaction, technology and mobility.

6.3.1 Contradictions of Interactive Innovation

Shared Objective, Contradictory Motivation

The interaction of individual activities outlines how three disparate systems interact and shape a collectively negotiated, new activity. From the outset of the trials, all three participant groups shared the same objective and worked towards the same object-activity and outcome, resulting in the negotiated trial activity triangle (Figure 42). However, this is not to suggest that by definition they had to share the same

motivation. Looking at an activity in terms of the triangles (Figure 43(left)) presents only a partial picture of mobile work.

One major premise is that activities are motivated by the transformation of objects into outcomes, that actions are goal-oriented and that operations occur as long as certain conditions are warranted (Figure 43 (right)). By looking only at the elements that define the activity triangle, the innovation process again assumes an outcome-oriented perspective. It is a view of activities, actions and operations; a snapshot of mobile work practices. As such it is a very static approach to understanding how certain processes unfold. The main contribution of Activity Theory, however, lies not only in how work practices are conducted on the surface, but more importantly in what motivates mobile workers to transform their objects into certain outcomes. The former, static picture of the activity triangle represents a good understanding of the different elements that play a role in an activity, actions and operations. A closer look at how these elements transformed objects and interacted with each other unveils more details of the motives, goals and conditions of various neighbouring activities and subject categories.

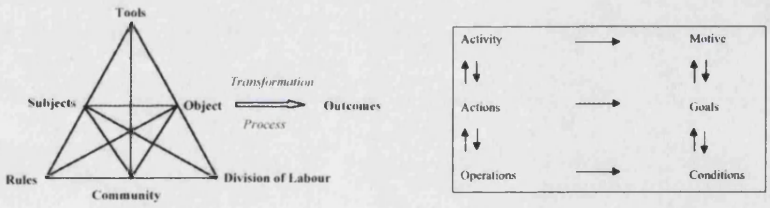


Figure 43: Activity Triangle (left) and underlying Activity Tripartite (right)

In the trial activities, the participants' respective motivations were not necessarily in agreement. While Nalle was motivated by a need to innovate and develop mobile RFID as a grounded and practice-driven technology, Innovation Partners were motivated by the need to respond to the perplexing lack of knowledge and control of mobile work practices. Mobile workers, on the other hand, were motivated to participate by a wider array of needs, including their own desire to advance their work practices, the felt animosity towards outdated, paper-based systems, the persistent need to justify their work to superiors etc.

The differing motivations of the three participants separated their respective reasons for the interaction with each other during the trials. This focus on their respective motivations suggests that their underlying viewpoints and consequences associated with success and failure of the trial also differed, indicating an important contradiction for the examination of interactive innovation. Of course, all participants had a positive predisposition to achieving their goals, to satisfy their motivations for the trial activity. If all the objectives were met and needs were fulfilled, this transformation would have succeeded and there would have been no reason for friction, no reason for conflict. However, the participants had quite different predispositions to the notion of failure of the shared activity, as this would ultimately endanger the pursuit of their individual activities and objectives.

In this context, Nalle was fully aware that failure in the trial activities was a possibility, despite all efforts of negotiating the individual elements. However, even in such an undesired occasion, the trials would still have been considered a valuable source of learning for further development. Similarly, it was conceivable that some unforeseen circumstances or developments would have slowed down the development of the technology or made it infeasible to pursue the activity for the context of the Innovation Partners. For example, an electromagnetic interference (EMI) problem occurred when the RFID tags could not be mounted onto the steel containers, since this material interfered with the electromagnetic field of the RFID communication. The tags had to be re-engineered to withstand the shielding of the containers. Although this presented a problem in the context of the Innovation Partner, it enabled Nalle to learn from the practice-based context of mobile work and to develop its technology accordingly. It was a major goal of Nalle to overcome such problems to make the more advanced central activity possible, but the notion of failure here had few crucial consequences for Nalle. Even though a trial possibly could have been unsuccessful in traditional terms, experimenting with the new RFID system would have enabled Nalle to learn, helping the development of future RFID systems. For Nalle's innovating and instrument-producing activity, failure was not necessarily unfavourable if accompanied by constructive learning opportunities. Allô was in a similar position. Its focus on service discovery placed it at par with Nalle's interest in lessons-learnt. While Nalle was of course interested in the development of the technology, Allô aimed at learning about new service opportunities based on the

technology. Its involvement in the trials was not part of their employees' central activities, but rather an invitation for employees to experiment with the new device and some trial applications developed for it. Failure of such trials, although of course undesirable, was part of the reality of the service discovery team.

For Grizzly Waste and Morrison Patrolling, on the other hand, their respective trial activity was a considerable investment, very clearly aimed at solving real, context-specific needs of their understanding of mobile work. Especially given the financial commitment and time investment, each trial had to succeed not to be seen as an ill investment and waste of organisational resources. Success was not measured in terms of learning and failure was most definitely seen as an entirely negative outcome of the activity.

Trialists measured the success of the trial against how it contributed to or infringed on their work practices. Regardless of the outcome, failure or success, Trialists neither had a financial investment in the exercise nor a particular stake in informing the next cycle of innovative activity at Nalle. As a result, failure of the trials had no negative consequences. In the worst-case scenario, mobile workers would return to their central activity after the trial. However, the success of the new tool and the implementation of the more advanced activity promised to have a tremendous impact on their everyday life as it dramatically altered their central activity through the permanent acceptance of the more advanced central activity. To this end, Trialists had an enormous stake in the outcome of the trials. As the following sections show, workers assumed different roles within the trial activity, which represented an improvement to some Trialists and a worsening vis-à-vis the central activity to others.

The Mobile Worker: Subject, Tool or Object?

In the various neighbouring activities, the mobile worker assumed a number of different and quite contradictory roles (Figure 44). In his central activity, the mobile worker was at the core of his work practices. He was the subject who, with the use of tools etc., transformed the object of his labour into the desired outcome. In this sense, the mobile worker was at the core of his activities. While it was acknowledged that mobile workers remained central to the notion of interactive innovating, they assumed a number of different roles in the neighbouring activities.

Based on their needs-based knowledge, the input that these mobile workers provided was seen as imperative for the development of the tool itself. As outlined in the Interaction Framework, this needs-based knowledge was needed to overcome the knowledge asymmetry between the Instrument Producer (Nalle) and the Trialist. In essence, the mobile worker along with his grounded understanding of his work practices became part of the tools used by those developing the new technology.

At the same time, Innovation Partners relied on the mobile worker to develop the more advanced activity. The needs-based information was needed to determine the use-cases that directed the new technology in practice. More important than the mobile workers' tool-role for Innovation Partners, though, was the role they assumed in the in the Innovation Partners' efforts of developing a more advanced activity. Here, mobile workers were seen as constituent elements of the object the Innovation Partners were working on. In other words, Innovation Partners concentrated on transforming their objects, the mobile worker and his central activity, into a more advanced activity. This placed the mobile worker into interesting and highly contradictory positions in the activity of interactive innovating.

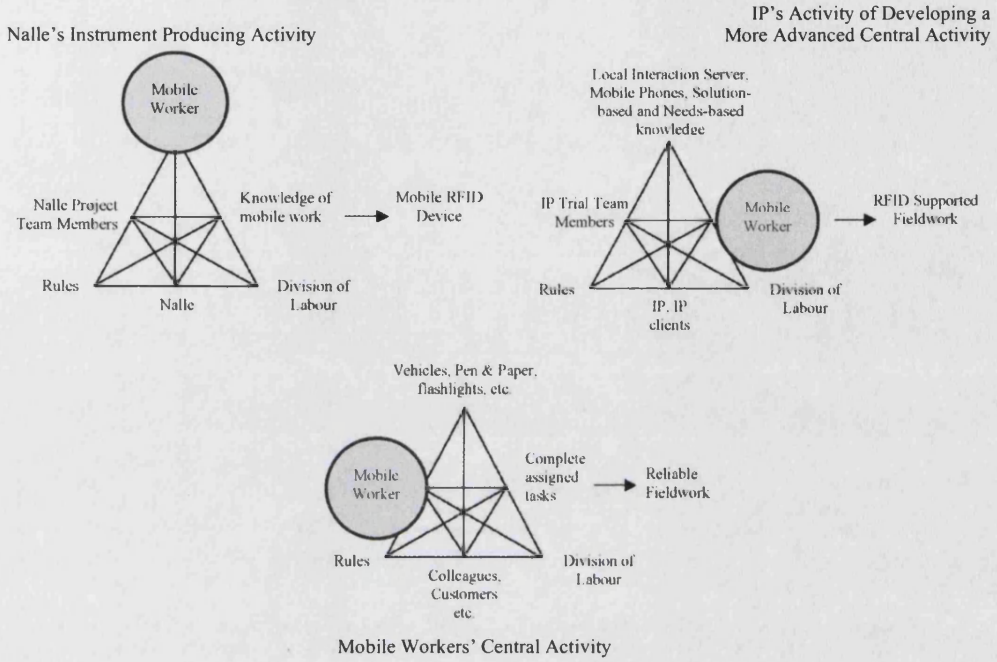


Figure 44: Contradictory Roles of Mobile Workers

The diversity of roles the mobile workers during the trial activity became apparent through the contradictions that emerged in front of them in the field. Here, mobile workers were constantly torn between different responsibilities. Each situation presented a number of inherent conflicts and interests that could not be served simultaneously. For example, an invaded property required the immediate attention of a security guard (central activity), but it also presented an opportunity to compare the usefulness of the mobile tool (for the instrument producer) and the suitability of the midlet for the advancement of the central activity (for the Innovation Partner). In this case, the three possible roles presented an immediate conflict to the mobile worker, where a focus on instrument development meant neglecting the central activity and the activity of designing a more advanced central activity, etc. In all cases, mobile workers had to maintain accountable to their central activity and their immediate supervisors. For example, neglecting an invaded property to take notes for the instrument producer or placing an underperforming gas conversion engine second to improving the process with which it is addressed through mobile RFID use-cases would have had serious repercussions for the organisation and the mobile worker.

Consequently, the activity of innovating suffered from severe interaction limitations based on the diversity of roles assigned to mobile workers.

Contradictory Interaction and Membership

The notions of Innovating Spaces and the interaction of individual activities beg the question if the interaction between the three different parties in the trial unfolded as described in these frameworks. The mobile worker was already placed in a difficult position through the various roles he faced, impeding the interaction of Innovators and Innovation Partners with workers in the field. Who truly interacted and how were the different sets of knowledge actually exchanged to negotiate the trial activity? How were the interacting groups defined?

One of the earlier contradictions emerged with respect to the three different categories of participants (e.g., Nalle, Innovation Partners and Trialists). Subjects shared a number of common tasks, tools, rules etc. and were joined through the common objective of the trial activity. Within the settings of these trials, the individual subject groups were without a doubt exclusively defined. Nalle employees shared a common lore with their colleagues, Innovation Partner representatives from the respective organisations shared tasks specific to their groups of colleagues and each Innovation Partner's mobile workers had established common work practices. As a result, no multimembership existed in any of these groups. Although in some cases different groups appeared quite similar (e.g., Nalle's R&D and Innovation Partners' R&D representatives), their belonging to the specific group was always clearly defined. As a result, as the primary researcher I became the only person who was neutral, in the sense that I did not belong to one specific group only and could assume the roles outlined in the methodology chapter. Applying the concept of role definitions clearly described how my interaction between the different parties was carried out. However, in addition to my action role as a communicator between the different parties, the main interactions for the activity of innovating occurred between them.

The interaction in the Innovating Space A, between Nalle and mobile workers, proved very difficult from the early stages of the project. However, this is not to say that Nalle had no interest in the Trialists' needs-based information. On the contrary, many of the technological specifications had to be determined through the overall

experience of the Trialists with the devices, not only for the context of the Innovation Partners and Trialists but more globally for the continued innovation and development of mobile RFID. Major contradictions in this context emerged from the inherent difficulty of meeting and talking to mobile workers. How the different parties made sense of distance and mobility during the trials is addressed in Section 6.3.3 and discussed in more detail in Chapter 7. For the duration of the trial, Nalle had little direct interaction with mobile workers. Nalle primarily met with Innovation Partners and relied mainly on Innovation Partners to elicit the needed information from mobile workers before and during the trial activities.

Interaction in the Innovating Space B involved talk about the future of work and the development of the more advanced central activity. It occurred between members of the IT department of the Innovation Partner and mobile workers. One of the main problems in the ensuing discussions was the abovementioned contradiction of motivations. Furthermore, the inherent mobility of the workers made the interaction and negotiation more difficult. As a result of the complicatedness of this talk, Innovation Partners often complemented these interactions by relying on Innovation Partner's traffic managers', dispatchers' and office managers' understanding of the needs-based knowledge of mobile workers. To a large extent, the talk about mobile work and the more advanced central activity was based on these interactions. Of course, retrieving needs-based knowledge without directly consulting the mobile worker did not help overcome the difficulty of understanding mobile work. The added problem was that Innovation Partners acted as proxies for collecting needs-based knowledge for Nalle, as outlined above, compounding the conflicts of interaction with mobile workers.

From a developer's perspective, most of the interaction clearly occurred in Innovating Space C. Nalle and Innovation Partners met on a regular basis and discussed how the device was going to be developed (instrument-producing activity) and used for an improvement of mobile work practices (in a more advanced central activity).

Before the trial, all participants expressed collaboration readiness (Olson and Olson 2000); however, contradictions within the trial setting introduced a number of interaction difficulties, as outlined above. Nonetheless, despite these problems, the actual development of the more advanced central activity with the mobile RFID

device was based on this trial and the inherent social communication and exchange of technical, work based and organisational knowledge (Scarbrough 1995). Specifically, the direct input of the mobile workers was for practical and communicative reasons difficult to obtain and was complemented with others' knowledge. The Coalescence Space D was therefore populated with pertinent information, but this information itself was tainted to some extent by how it was derived. Rather than relying on the Interactive Spaces, the needs-based knowledge was obtained through other sources (see Figure 45). This *interaction through proxies* presented an important contradiction of relevance for the instrument-producing activity and the Innovation Partner's development of a more advanced central activity. By removing the mobile worker from the direct interaction at this stage, the activity of innovating was less practice-oriented than it had initially set out.

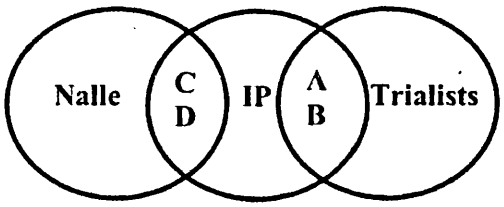


Figure 45: Empirical Interaction

To overcome some of the problems of interacting with these Trialists, Nalle and Innovation Partners relied on communication and interaction with the Trialists through the mobile technology under development; a tremendously difficult and potentially contradictory task.

6.3.2 Contradictions of Technology for Mobile Work

Section 6.1.3 described various talks needed for the activity of interactive innovating, including talks about mobile work practices, technology development, systems development and the future of mobile work. A separation was drawn between different epistemologies: Nalle's knowledge was solution-based, mobile workers' know-how was needs-based and Innovation Partners relied on their contextual facts. It was further established that Nalle and Innovation Partners maintained a good rapport, that the exchange of solution-based and context-based knowledge was warranted. It was evident that the initiating interaction with mobile workers was more complex and

that in many cases the collection of needs-based information for the Innovator was left to the innovation partner, researcher and other proxies. Similarly, the ability for mobile workers to initiate interaction with Nalle and the Innovation Partner was often difficult. This was based in part on the mobility of the worker, the distance to the other parties and the added difficulty of finding time to interact during otherwise very busy workdays of mobile workers. Accordingly, the technology itself became a major representation of mobile work actions and operations in the trial activity and facilitated in the interaction between participants.

Conflicting Roles of Technology

A very interesting discussion focuses on technology in its own right. In the context of interactive innovation, of course, this questions the role that the artefact played in the activity. In its very nature, technology is considered a mediator, a tool of the mobile worker that he employs to transform the object of his labour into the desired outcome. However, here technology became the focus of innovation at the same time as it was used as a tool in its pursuit. Technology adopted more than one role, presenting a contradiction within the activity of innovating. In this juncture, technology was seen as a tool, an object and an outcome of the various neighbouring activities (Figure 46).

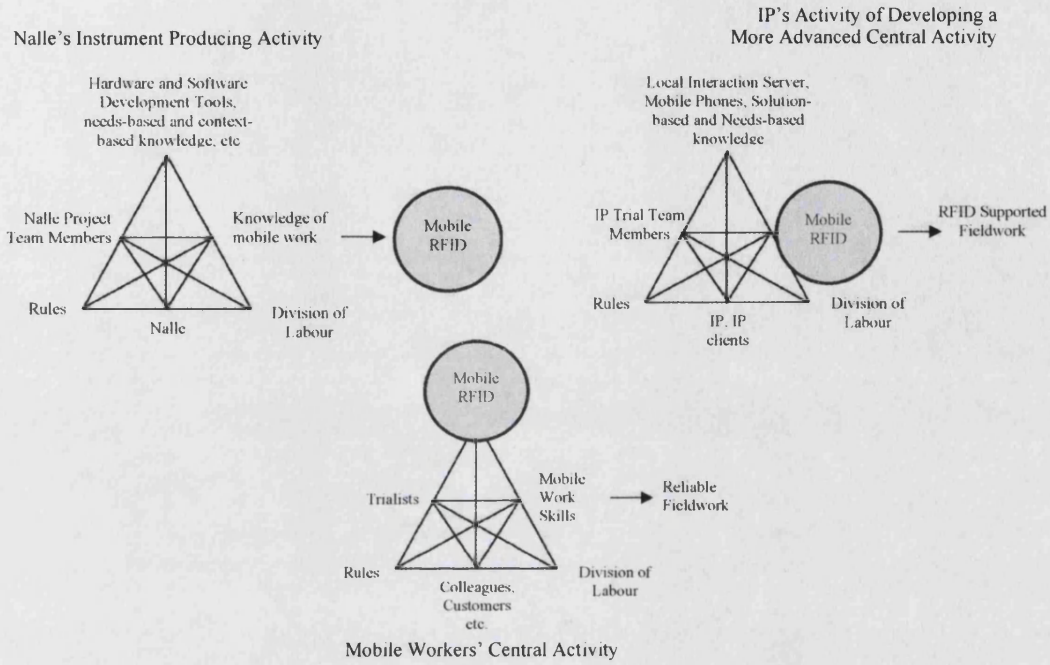


Figure 46: Contradictory Roles of Technology

The motivation of Nalle was to develop mobile RFID devices in general and middleware, midlets for the trial specifically. The object that Nalle was manipulating and transforming into this outcome was the knowledge about mobile work that was being created with the tools of needs and context-based knowledge, the technical skills of developing the hardware and the experience of innovating mobile technologies. Contrary to mobile workers, Nalle did not work *with* mobile RFID. Rather, Nalle's activity involved working *on* the technology. Using a selection of other tools, engineers and programmers at Nalle saw the artefact not as a tool but as the immediate focus, the content and outcome of their work.

For Innovation Partners, the development of the interface and the rules underlying the midlet definition underwent many iterations until they were deemed useful under the conditions assumed for mobile work. Technology here was an object that was controlled to contribute to the overall objective of developing a more advanced central activity for mobile workers (i.e., RFID supported fieldwork).

Ideally, from a mobile worker's perspective, the mobile RFID technology would have been introduced as an instrument *through* which he could work, to borrow from

Bødker (1991). It should mediate the actions and operations during the trial activity and the resulting more advanced central activity, thereby satisfying the requirements of Nalle, Innovation Partner and his central activity.

Viewed from these three perspectives, technology received a dramatically different focus and level of attention by the various participants. While at first sight mobile RFID appeared to be quite fixed in its ability to perform technical functions and support mobile workers in their central activities, the differences of its various roles determined the degree to which individual parties were able to relate to one another (and their representations, as discussed later in this section). In other words, while a mobile worker saw and treated mobile RFID as a tool, he was less able to relate to RFID as an outcome (for Nalle's engineer). By the same token, mobile workers who treated the device as a tool in their central activity were unable to relate to the higher level involvement of the technology as an object of the Innovation Partner. Similarly, for Nalle's engineers and programmers it was difficult to view the technology as a tool through the eyes of a mobile worker or as an object that was to play a bigger role in the more advanced central activity. Nalle's engineers' expertise supported an outcome perspective, not a tool or object perspective. In line with the epistemologies, this outcome perspective advocates the solution focus of the Innovator, tools support the mobile workers' needs in the field and objects relate to the context of Innovation Partners. Consequently, the activity of interactive innovating suffered from the different roles that the actual technology under development assumed for the different participants.

Hardware in Practice

In addition to these contradictions of technology, conceptually, and the respective roles it played within each activity, a major contradiction emerged within the trial activity. Mobile workers, presented with the more advanced central activity and the mobile RFID system at the heart thereof, needed to embrace the technology as a new tool for their work practices. As such it mediated the interaction of mobile workers with their environment, it was a tool of their activity and not the target of their actions or objects of their labour. In other words, they needed to work with or through mobile RFID rather than on it. In Activity Theory parlance, a device is embedded into work

effectively, as a tool, if the overall conditions of use allow it to be adopted and employed unconsciously in operations. Contradictions arose when mobile RFID required the cognitive attention of the mobile workers.

Many of the early difficulties with using mobile RFID could be attributed to mobile workers' inexperience with the device. As they gained practice they moved from applying specific, conscious mental actions to automatically executing operations. Thus, the technological devices were at first objects that required their users' attention, but with time became tools that were employed for routine practices. It is with this learning curve in mind that technology for mobile work is innovated and developed; once a technology becomes a tool it should not degrade to an object unless the accompanying conditions, goals and motives change. From this perspective, the empirical evidence varied. Some mobile workers required very little conscious, directed action before mobile RFID was operationalised and moved into the unconscious. In a matter of approximately 20 minutes they had adopted it and used it alongside their traditional tools. Others found the device more demanding and needed days of treating it as an object rather than a tool. Nonetheless, all Trialists managed to adopt the device as such into their cognitive tool sets, but as outlined above the underlying conditions of the trial activity determined if it stayed there permanently or subsequently degraded to an object.

A discussion of the mobile RFID device in terms of its physical makeup led to varying results. Mobile workers agreed that the actual convergence of mobile phone and the RFID reader combined with the use of tags and phone menus were suitable for their needs. Throughout the trial the resulting tools were tested extensively under the conditions of mobile work. The phone was an outdoor phone for the use in rugged and potentially wet environments. It was designed to withhold a drop from two meters height, a feature that was tested by many mobile workers, accidentally or intentionally. After a few improvements to the original prototypes, the RFID tags, too, were sturdy enough to withhold the harsh conditions of outdoor use. Only in the setting of the waste disposal trucks could some tags not withstand the power of high-pressure washers used to clean the containers. In terms of the usability of the device, in physical terms, all mobile workers agreed that the phone was small, like most other phones, and that navigating the keypad for long text messages required practice.

Towards the end of the trial, all mobile workers were fluent in the art of composing SMS and navigating the menus. In terms of its operation, few mobile workers experienced massive shutdowns of the device. In a couple of cases, the actual devices were faulty and replaced immediately with the backup RFID devices that were available at each trial site.

Nalle and Innovation Partners had expected that battery duration would be a major concern among mobile workers. It had been one of the main complaints about mobile devices in general and the additional power requirements drawn from the battery for the RFID reader shortened its life expectancy dramatically. A low battery would most certainly cause the device to degrade in value as a tool since workers would have to be aware of their power consumption and adjust work with the device accordingly. An empty battery would render the device completely useless. To alleviate this problem from the start, each mobile worker was equipped with a car-charger and advised to keep the phone plugged in at times of travel. Additionally, the in-car system included a hands-free kit, which many of the mobile workers had already used with their regular mobile phones. Surprisingly to Nalle and Innovation Partners, not a single mobile worker across all trials complained about the battery duration. Similarly, there was no dissatisfaction with the internal memory of the device, since most of the processing was not done on the mobile phone. Mobile RFID devices simply read the tags and passed on the respective messages to the local interaction server. Aside from the RFID functionality, the device's use was limited to regular voice communication and auxiliary features. Here, too, Nalle and Innovation Partners were positively surprised. Many mobile workers said that the camera and the built-in torch were very useful for their work. They could illuminate dark areas without having to get a traditional torch from the truck. Security guards also took pictures of premises and gas technicians photographed broken equipment for later use rather than recording details on paper. These features, although considered marginal in the process of development, found actual use in mobile work. They satisfied both the Trialists' needs (e.g., easy to take pictures, more accurate) and the objectives of the more advanced central activities (e.g., logging the conditions of premises and photographing broken down equipment). These features positively supported the device-use as a tool. The needs-based feedback initiated to the development of new practices and use-cases for using the camera and educated important elements of

instrument production, truly an interactive outcome of innovating. Although the hardware used, tested and developed was of enormous importance during the trial, it had no direct implications for the interactive activity of innovating technology for mobile work. As such, the hardware was mainly tested for its usability and usefulness; however, the configuration of the mobile RFID system was much more insightful from this perspective.

Configuration in Practice

Contrary to the overall very positive experiences with the actual physical technology, the design of the midlets was more controversial. These programmes provided the connection between the mobile work environment, the worker and mobile device and determined the information available through the local interaction server to management. Upon reading an RFID tag, a mobile worker selected a response from the menu on the phone (e.g., *Premises are ok* or *Tipped container at depot*). By virtue of the communicative potential of the midlet's association with the mobile phone, the definition of the various options in the menu was particularly important. Designing the rules of the midlet properly reflected the practices of the mobile worker, erring in their design meant that the device would not be accepted as a tool but rather remain an object of work from the start. Interestingly, the design of the midlet in response to mobile practices revealed a distinct role of the technology in mobile work. Through the development and inflexibility of the installed midlet, it demanded the mobile worker to follow a protocol that was to varying degrees an accurate reflection of his work.

> We often save all the paperwork until there is time to fill in all the logs at the same time. Sometimes we complete the paperwork while we're waiting at a tipping station, sometimes at railroad crossings, sometimes over coffee. Now, we have to type the information into the phone immediately, but sometimes there is no time to do it. I just keep the menu open after I read the tag and fill in all the details on the menu while I am driving, I guess that is dangerous though, because it does need my attention (Winters 2004).

Even when the midlet was a truthful representation of mobile work, it had the potential to ask mobile workers to reveal information that was previously unknown to management. Not surprisingly, this also caused the device to move from a tool to an object.

> Through the RFID, they [managers] can tell when I dropped off a container and when I picked up the next. We always pinch 20 minutes here and there; we drive twelve hours per day and need breaks. In the meanwhile, the truck is empty – they don't like that. It's always been like that and they have always turned a blind eye if we did not overdo it. But now they have proof and they have to act on it. They asked us to send an SMS when we go on break so that they know that we're not lost or in an accident. We never did this before and we need to figure out a way around this (Schaitel 2004).

This example portrays how the midlet did not correspond to the conditions of the central activity. It depicts a conflict between the needs of mobile workers and representations of the Innovation Partner. The waste truck drivers, in pursuit of the actions of the central activity, saw the technology of the more advanced activity partially as an intrusion. In essence, the new technology was then not only used as an object that required their attentiveness but it also interfered with other operations (e.g., it changed the driving conditions). Some aspects of the device addressed the needs and motivation of their central activity and proved useful in their transformation into the outcome of reliable fieldwork. Other aspects were perceived as not responding to their requirements; there was no need or motivation to log the break time; the device was not a tool that satisfied a need or motive.

While it was possible for the mobile worker to simply abandon the new technology for some tasks (e.g., logging their breaks), it did not provide an option to accept or reject it for other tasks. However, workers could not decide which RFID tasks to log and which not to log since a complete chain of actions was required for any single action to make sense (e.g., if a worker failed to log that he dropped off a container before loading the next container, the data on the back-end would indicate that he now had two containers on the truck, an impossible scenario in the system and in practice). In some cases, the perceived net drawback of the device as an object outweighed the perceived benefit as a tool and mobile workers rejected the device outright. In these instances, the configuration of the technology did not succeed at addressing the mobile workers' needs correctly.

Clearly, this tool-object transition and the respective acceptance and rejection of the device led to another conflict in the interactive activity: How could the innovation partners and Nalle know why a device was used or not used? When the local interaction server indicated that a particular mobile worker did not employ the device, was it because it malfunctioned or because he decided not to use it? Without direct

interaction, Innovators and Innovators did not know if the technology was adopted as a tool or used as an object of the mobile workers' labour. It was not clear if the device failed to address the needs of the mobile worker in the first place or if the underlying conditions of the operations had changed. In this context, the role that technology played in representing different parties, actions and operations in the interactive activity became very important.

Representation and Contradictory Mediation

The mobile workers used the technology within the context of the more advanced central activity throughout the trials. Their subjective interpretations of their needs within the field to the actual technological affordances of mobile RFID fuelled the expansive cycles of the activity of innovating. The duality of activity (see 4.2.3) emphasises that such cognitive feedback results from either externalised results of individual actions, to serve as a means for collaboration and coordination between the different parties (Kaptelinin and Nardi 1997), or internal, purely psychological activities of individual subjects. Given the different nature of their work and the unique epistemological perspectives, knowledge exchange between the different category participants involved in the trial needed to be externalised before the resulting representations could be communicated in the Interactive Spaces.

The interaction of Nalle, Innovation Partners and Trialists relied on the manipulation of common objects as externalisations, as mediators of their subject-object-subject relationship. A main challenge was that the subjects interpreted and recreated these objects differently within the specific contexts of their work, leading to three main contradictions of representations.

First, in their communicative roles, all participants were to varying degrees used to express, or externalise, their cognitive understanding, mappings and abstractions of the tools, rules, etc. of their respective activities. The communicative role of the representation addresses the ability to form and express internal concepts through externalisations. While some individuals were familiar with such procedures, others were quite new to externalising what they do. Some participants were engineers and others drove waste disposal trucks for a living. While the former were used to group work and abstract notations, the latter were mobile workers who truly worked by

themselves and were seldom required to describe their work. Accordingly, their experience with and ability to compose and comprehend representations of work activities, actions and operations were quite different. In my study, the sheer number of different subject categories (developers, project managers, waste depot managers, gas engineers, truck drivers and security guards, to name a few) made the notion of representations quite interesting. Internal contradictions, for example, included the requirement of mobile workers to provide feedback about their needs-based knowledge before the trial and their experience with the new tool during the trial activity. To request a summary of the actions and operations of a garbage truck driver turned out to be quite difficult; their externalisations (e.g., drawings on maps, verbal summaries, demonstrations of their tasks) often turned out to be incomplete and even plain wrong. Reason for this incompleteness was the unconscious, routine fashion with which they carry out their central activity; calling these operations back into the conscious out of the context of changing conditions was felt to be difficult. Consequently, the activity of interactive innovation was partially based on representations that were difficult to derive and needed to be verified and validated throughout the trial activity, leading in some cases to a need to re-design use-cases and technological devices.

Second, external contradictions emerged when these internal representations and externalisations were exchanged. These representations assumed a critical role in the activity of interactive innovating. In their boundary-crossing role, they became means of communication and interaction between Nalle, Innovation Partner and Trialists. These subjects' incongruent work contexts led to a contradiction of representations as mediators. The trial activity system's interaction complexity demanded that many decisions made by developers, for instance, needed to be transmitted to Innovation Partners and mobile workers. On the other hand, the experience of the mobile workers had to be related back to the Innovation Partners and Nalle's developers, so that future releases of hardware, software, middleware and midlets could incorporate important fixes, minor corrections and relevant suggestions. Nalle and Innovation Partners were quite able to relate to one another's notations and models. These involved technical mappings of the design elements of mobile RFID, project management charts, charters, flow charts etc. At the early stages of the trials, mobile workers' representations were needed to shape the use-cases for the development of the

technology; they were "intended to hold on to something not yet existing, something under construction, whether this is specific parts of a technical solution or a description of future work procedures" (Bødker 1998, p109). Not only were these representations difficult to construct for mobile workers in the first place, but their interpretation was highly dependent on sender and recipient, their respective activity systems and historically developed frames of reference. Similarly, in the pursuit of technology development (Interactive Space A), Nalle and Trialists had to exchange their solution- and needs-based sets of knowledge. This involved representations of technical details (e.g. through technical diagrams and use-cases) as much as central activity details (e.g., accounts of mobile work practices such as operations involved in tipping a container). Interpreting these descriptions out of their context by subjects of neighbouring activities led to misunderstandings in the interactive activity and correspondingly to ill alignments of technological developments.

During the trials, representations exchanged with mobile workers were in most cases reduced to the technological artefact itself. The mobile RIFD device was the shared object that encompassed and embodied a large number of externalisations by both Innovation Partners and Nalle. As such, the mobile RFID device became the mediator between different neighbouring activities, between different subjects and different motivations and objectives. It represented, through its physical properties, the menu-driven options, use-cases and the negotiated attributes of the trial activity. True to the interactive focus of the activity, mobile workers needed to provide feedback, too. However, they were unable to manipulate the mobile device itself, to externalise their cognitive mapping of the tool within the more advanced central activity. They could neither shape the very representation in order to align it more properly with their work practices, let alone communicate this need for a change effectively, nor could they change the rules of the trial activity. This, in fact, presented a major contradiction to the interactive activity. Abstractions, feedback and externalisations of mobile workers could not be communicated directly, largely restricting the interaction directed at the Innovator and Innovation Partner.

Third, in its instrumental role, the data gathered through mobile RFID devices connected mobile workers and Nalle and Innovation Partner, giving the technology as representation another role in the interactive innovation. In essence, the previous two

roles of technology focused on the communicative interaction of subjects through the tool. The motivation was to control the exchange of different epistemologies. In comparison, the instrumental focus here lay on the actual use of the technology in work practices. Through the synchronicity of the mobile RFID events through the local interaction server, mobile work with the device became visible to both Nalle and Innovation Partners. Perhaps unsurprisingly, the interpretation of local interaction server data was at times contradictory to the reality of mobile work, introducing another layer of complexity to the activity of interactive innovating. As outlined above, some instances were intentionally not logged (e.g., break times), but others were not captured with mobile RFID for different reasons.

> The tags work great, we attach them to all the windows and gates we check on our route. The only problems we find are at schools and outside of some office buildings. I think the pupils during the school break times find the new tags and rip them off. Office workers come out for a cigarette and do the same. Most often we have replacement tags with us, but sometimes we do not and cannot log that we checked a particular site (Schultz 2004).

This example and other similar occurrences outline the complexity of interpreting the local interaction server data and relying on the instrumental mediating role of mobile technology. In addition, as outlined in the methodological Chapter 3, some of the data from the field did not pass through the local interaction server in the first place (e.g., SMS and voice calls), making the instrumental use of mobile devices even harder to interpret and use in the activity of interactive innovating.

The previous arguments examine the first two themes of this research, namely contradictions of interaction and of the technology itself. Hence, the remaining topic and the last theme that requires an in-depth examination is the mobility of work. It addresses how the conditions underlying mobile work (e.g., wandering, travelling, roaming of the mobile worker) presented unique contradictions for the innovative activity.

6.3.3 Contradictions of Mobility of Work

The concern over the importance of geographical distance, distribution and mobility has been heavily debated over the past decade and continues to fuel very interesting discussions. The proverbial *Death of Distance* was proclaimed by Frances Cairncross (1997) in an effort to describe how telecommunications would revolutionise

interpersonal interaction and consequently, everyone's lives. Her contentions are in line with Kleinrock's *Anytime, Anywhere* argument (1996) of pervasive computing; however, these notions have been contested by those who claim that space, location and distance remain important factors of human interaction (Olson and Olson 2000; Wiberg 2001). For my empirical work, the reader may wonder if the fact that Trialists were mobile workers had any impact on the activities under scrutiny. To what extent did the inherent mobility really matter for interactive innovation? The impact on interactive innovation is best illustrated by juxtaposing the mobility inherent in the mobile workers' central activity vis-à-vis the mobility of the advanced central activity, mediated in the trial activity through the RFID device. This comparison unveiled two main conflicts. First, contradictions surfaced with respect to co-presence, mobility and interaction. Second, changes introduced in the trial activity raised contradictions of the identity, sovereignty and control of the mobile worker.

Contradictions of Co-Presence, Mobility and Interaction

From an interactive innovation perspective, the level of mobility of the Trialists was of course most interesting. In Chapter 5, I suggested that Trialists covered large geographical terrains, some wandered or visited and yet others travelled (Kristoffersen and Ljundberg 1998). In that respect, they covered different distances from their main places of employment, including Grizzly Waste's depots, Morrison Patrolling's offices and Allô headquarters. The importance of these physical, geographical places of employment also varied considerably. For example, to Security Guards, the time they spent at the office was minimal, a matter of a few minutes when they signed into work, collected a vehicle and when they returned, signed out and left. The physical distance to their place of employment played a limited role in the central activity. If any problems occurred, guards used their phones to discuss any further action; they did not need to return for face-to-face interactions.

> Sometimes when I find a gate unlocked I need to spend more time making sure that the premises are safe. Of course, that's not a problem for my manager. Sometimes I get caught in a traffic jam and I know I'll be late for a checkpoint. I use my phone to inform my manager. We never really need to see one another in person (Cousteau 2004).

To others, geographical distance and occasional co-location mattered more. For instance, gas engineers needed to discuss broken pipes with their colleagues and their

superiors to develop a plan as to how they should be repaired. In most cases, this involved the physical presence of others to see the actual pipe etc., since describing the damage over a distance was viewed as problematic.

> From the smell in the air I am pretty sure that there is a gas leak. It's hard to describe that to others, isn't it? One day you can really smell gas, the next day you cannot, it has to do with a lot of conditions, wind, temperature etc. Logging what kind of smell I smelled for colleagues or managers who are in charge of repairing it is impossible – they have to come over and smell it themselves (Mahaux 2004).

Accordingly, the central activity determined the extent to which mobility and distribution led to a need for technologically mediated interaction with others (e.g., Security guard and manager) or required their physical co-presence (Gas technicians and Engineers). In the trial activity, this was the case, too, but the various requirements for co-presence (technologically mediated or physical) led to contradictions between immediate needs of the central activity and the trial activity since interaction now involved communicating about innovation in addition to communication about elements of the central activity. These roles of co-presence, mobility and interaction mirror Wiberg's criticism (2001), of *Anytime, Anywhere* computing and interaction (Kleinrock 1996). Time and space remain pivotal for interaction between mobile workers and with remote interaction participants; requiring in some cases that interaction occurs at particular times or places (or both) as outlined in the empirical examples above.

Moreover, Trialists had to go through a number of learning stages to comprehend the role of the new technology and to master its use. They needed to be able to navigate it properly as a tool. As expected, this was more problematic in the beginning than at later stages of the trial. But in addition to this natural learning curve, the level of mobility determined the speed and efficiency of this process through workers' interaction with Innovation Partners and Nalle for support queries. Interestingly, this presented contradictions of physical co-presence and technologically mediated interaction during the trial activity. For physical co-presence our current notion of distance, measured in absolute terms (meters, kilometres etc.), did not suffice to explain the interaction contradictions. Whether Trialists requested help depended on a *perceived* critical distance and distribution between mobile workers, Innovation Partner colleagues and Nalle team members.

> If there's no one I can talk to about using the device, I will not. Sometimes the reader does not work and I need help, but in other cases the menu is just not set up properly

> [I can help]. If someone was here I would tell them, but later I don't remember... or I just want to go home after my round (Walsh 2004).
>
> Sometimes, it acts up. I just don't know what to do; I just restart the phone and hope it goes away. When I am back at the office I try to describe what happened, but I cannot show them and it's hard to put what happened into words because I am no techie (Springer 2004).

As became evident in my fieldwork, it seemed that a certain distance was acceptable to return to the office to report any shortcomings or recommendations of the device. In one event a truck driver encountered an error on the mobile RFID device and since it was not too much of a detour he decided to return to the depot. However, by the time he had arrived at a suitable area for turning his truck around he decided that it was now too late to return. The interval between the two decisions was negligible in terms of the time and distance that lapsed between them (i.e., a matter of 100 meters and 20 seconds at most), but the worker was convinced that it was now too inconvenient and too late to return. This phenomenon is interesting from a product implementation and support perspective and it is of tremendous importance for interactive innovation. In the Interaction Framework, the Innovating Spaces A and B focused on talk about work practices, mobile technology development and the creation of a more advanced activity. From the perspective of Nalle and Innovation Partners it was difficult to get in touch with mobile workers, to get a practice-based understanding on the needs-based requirements in the central activity before the trials and the more advanced activity during the trials. Interestingly, this importance of mobility, distance and distribution appeared to be valid from both sides, as mobile workers found it difficult, too, to interact with other project participants. The immediate needs of the central activity (e.g., to meet the delivery deadline of a container) and the need for interaction for the development of a more advanced central activity and instrument (e.g., return to the office to illustrate the shortcoming of the device) stood in sharp contrast, based to a large extent on the workers' needs to wander, travel, etc. as part of the central activity.

The RFID device, although a mobile, synchronous communication tool did not always prove to be helpful as a technological mediator for bridging these real and perceived geographical distances and activity contradictions. On the contrary, at times subjects found that reporting a technological or procedural problem over the mobile phone was particularly difficult.

> Sometimes, something goes wrong and I call the helpline. Daniel [from the support team] asks me what happened, but in order to redo and describe the error I need to read a tag with the device – but I can't do that while I am on the phone. It's like I need a second phone (Francis 2004).

This is an interesting reoccurrence of the contradiction between tools and objects outlined earlier. The worker experienced a problem with the RFID device, it moved from being a tool to being an object of his labour. When he then tried to report this problem with a mobile phone, a common tool of his work, he discovered that this, too, degraded from a tool to an object, leaving him essentially with two objects and no tools – a very interesting internal contradiction of tools based on the inherent mobility of workers.

Contradictions of Identity, Sovereignty and Control of the Mobile Worker

During the trial activity, mobile workers were exposed to the neighbouring activities of Nalle and the Innovation partner at all times, either through the new, mobile RFID tool or through changed working conditions (e.g., they no longer needed to come into the office to sign in to work). Contradictions based on the mobility of work became manifested in the trial activity and directly affected the identity of the subjects, the mobile workers.

For some mobile workers (e.g., Grizzly Waste truck drivers), mobile RFID was at times seen as a tool quite different from their other tools. The properties of RFID were compared to such things as *spyware, the eye in the sky* and a *big brother's tool.* Through these perceived characteristics, the new tool changed how Trialists viewed their own identity.

> We're treated like second-class citizens, I see no one else being monitored all the time (Francis 2004).
>
> My daughter, when they took her away from us, was tagged, too, so she couldn't run away anymore. I guess it's "like father like daughter" (Springer 2004).

But not all responses were negative. In the trial activity at Morrison Patrolling, mobile guards were excited about what the artefact stood for.

> This is great, I no longer have to do any paperwork. This is the future of our job. When I talked to my friends who work in security services, too, they all wanted to see it [the device] and play with it. It feels quite good to be cutting edge (Landau 2004).

This important contradiction does not only indicate that the identity of the subject is a reflection of his relationship to the technology, among others, but also how this association can introduce a conflict between the motive of the central activity and the tool. Within the central activity, mobile workers focused on completing their assigned tasks and maintained the same motivation in the trial activity. However, the new tool changed the conditions and thereby the overall dynamics of their actions and operations. The abovementioned quotes illustrate two of many outcomes of the introduction of the trial activity. To some, the new conditions were beneficial (e.g., Security Guards) and buttressed the motivation of the previous central activity. Hence, central activity and trial activity supported the established identity of the mobile worker. To others, the new conditions of the trial activity presented enormous contradictions (e.g., Waste Truck Drivers); the conditions during the trial presented a major discrepancy between their identity as subjects of the central and more advanced central activity, epitomised by the mobile RFID tool and the mobility of their work.

Of course, these impacts on the perceived identity of mobile workers were of major importance for innovative efforts, as the relationship between subjects, tools and rules of the trial activity shaped the development of the technology and the more advanced activity. Additionally, perceived identity changes within activities were hard, if not impossible, to reverse. This again relates to both changes of identity; the positively changed image of a security guard who saw himself as a more advanced professional with the new device was difficult to revert to the previous central activity and identity. By the same token, the waste truck driver's as a second-class citizen was hard to undo even with a return from the more advanced to the central activity.

Furthermore the relationship to their new tools as mediators further affected the degree to which mobile workers were able to conduct their work as independent individuals. Although all mobile workers had been members of bigger communities of peers and managers in the central activity, they were quite autonomous in how they conducted work. Once they left their respective waste depots or offices they were independent in the sense that they controlled much of how they went about their work day, the sequence in which they visited different sites (e.g., Security guards made choices according to traffic conditions, waste truck drivers selected their next stop based on traffic, distance to cover and time of day), when and where they took breaks

etc. Through the introduction of the new technology and the rules that governed the trial activity, either directly or through the midlet of the tool, the worker's personal independence and ability to make autonomous decisions in the field were challenged. From this perspective, the contradiction was not only about the sovereignty of the mobile worker, manifested through changed conditions within the pursuit of the central activity's objective, but also about the changed exercise of control and conflicting relationships to neighbouring activities.

The previous contradictions of interaction, identity and sovereignty point to the rules that governed mobile work practices and to how these were exercised through implicit or explicit control mechanisms. Despite the sovereignty with which mobile workers went about their daily work in the central activity, they were already faced with a multitude of contradictory controls. Partially, these were shaped by the formal rules set by superiors and by conventions that developed into common work practices over time. For instance mobile workers faced a control contradiction in the central activity when the local conditions suggested a particular action that conflicted with formal rules. When drivers felt tired, they would "[...] pinch 20 minutes here and there" (Schaitel 2004) to ensure their personal safety on the road. Clearly, this was against the formal rules that prescribed certain intervals and durations for break time. In such cases, drivers were faced with a conflict between the local condition and the formal rule; they were held accountable for any extraordinary breaks they took. In this example, drivers were often able to make up for lost time by rushing some of the other operations of their work, in which case their superiors did not mind the extra break time and the violation of a formal rule. In the trial activity, the use of the new tool most certainly presented an important contradiction as it changed the mechanisms of control. The reading of tags triggered a synchronous transfer of event data through the local interaction server to the mobile workers' superiors. With this immediate access to field data, managers felt that they had to act upon the additional knowledge they had gained. An extraordinary lapse of time after the collection of a container, for instance, led them to call the mobile worker to inquire about the reasons for the delay. From the worker's perspective, this was a clear contradiction to previously established work conditions and control practices. During the trial activity, mobile workers were now faced with local conditions, formal control mechanisms and remote control through the mediated and immediate availability of field data to their

superiors. The consequence that the changed conditions introduced through the new technological tool had on the mobility of the worker and thus on the activity of innovating technology for mobile work is the focus of the following chapter.

6.4 Beyond 'Mobile' Technology for Mobile Work

This chapter takes a view of interaction, technology and mobility as they pertain to activities of innovation and mobile work. Through the use of Activity Theory as an analytical lens, this chapter outlines many contradictions inherent in the process of innovating and developing mobile technology. It sheds light on the intricate relationship and interaction of innovators, innovation partners and the respective mobile workers and examined three different epistemologies: Nalle's knowledge was solution-based, mobile workers' know-how was needs-based and Innovation Partners rely on the knowledge of their organisational context.

By focusing on mobile RFID as a specific empirical technology, this discussion emphasises unique ways of interacting with mobile workers, for Innovators and Innovation Partners. Contrary to mobile telephony, the most recognised technology for mobile work that primarily focuses on the interaction between subjects, mobile RFID introduces interesting and sometimes contradictory opportunities of linking subjects on the move, subjects with objects and even objects with objects. This added complexity of communicative acts and means of communication enables an increasingly tight web of interactions, further complicating activities of interactive innovation.

In many ways the emerging contradictions describe problems associated with innovating, developing and designing technology for mobile work, based on the physical and conceptual distances between the parties involved. Not only do these distances lead to complicated interaction and communication, but are indicative of preconceptions about work in the field that turned out to be dissimilar to the reality of mobile activities. Emerging contradictions further led to a conceptual separation of designing technology with inherent control mechanisms for different audiences; while those who already exhibit a high degree of control are in favour of creating and leaving a more efficient electronic trail of their work, more sovereign workers object

to the connectedness offered by the new technology. While the former support the innovation process and offer insights into their mobile work through frequent interaction with Nalle and the Innovation Partner, the latter at times "sabotaged" (Goodman 2004) the development through non-use of the technology or non-compliance with new work procedures. Elements of identity, sovereignty and control of the mobile worker were challenged in the trial activity, indicating that the technology as a mediator and tool ties the subject much more closely to his work than previous mobile solutions. Mobile RFID, as a tool that accompanies the worker, becomes aware of its immediate work context through RFID events and connects the individual worker's actions and operations through the local interaction server to the corporate back-end. Such *pervasive activities* are the focus of the next and final chapter of this dissertation.

Chapter 7: Interactive Innovating from Mobility to Pervasiveness

The focus of this chapter is to move from the particular to the general; however it is not to induct and provide a generalisation of the previous chapters' findings, but rather to view them within the bigger picture of Information Systems. Particularly for innovating and developing mobile RFID technology, an enormous number of theoretically abstract topics was suitable for a wider IS discussion (e.g., the improvisation and coordination of mobile activities, privacy and security of mobile work, standardisation and managing IS change). At first, a theoretical contribution to an Activity Theory-educated analysis of mobile and co-located interaction seemed the most sensible discussion, especially as we become increasingly mobile (Pooley, Turnbull et al. 2005) and introduce and rely on technology as part of everyday mobile activities. These arguments and contradictions would have offered an opportunity to revisit our understanding of mobile versus co-located activities, conceptually, and to inform our Activity Theory-based understanding of activities involving mobile work.

However, the unique affordances of the empirical technology point to a more fundamental discussion of the intricacies of the distribution of mobile workers and remote participants (e.g., Innovators and Innovation Partners) and the contradictions that emerge in their interaction with and through technology. The following discussion presents a fresh look at technology for mobile work; it offers a conceptual review of our understanding of mobility itself and further clarifies the findings of the preceding chapter on mobility, interaction and innovation.

In this sense, this chapter merges technological affordances, demonstrated through mobile RFID, and their interactive social implications. It investigates to what extent technology gives rise to new forms of mobility and how these differ from our current understanding of mobile environments. This discussion departs from a debate of mobility and mobile technology, in general, and analytically separates the central activity of mobile work from the emerging, more advanced activity exemplified through mobile RFID. In light of current industry trends, this discussion is placed in a timely manner against the backdrop of mobile work versus pervasive computing,

respectively, with the aim of illuminating the difference of interactive innovating of pervasive technology for mobile work.

Section 7.1 introduces pervasive activities by first deconstructing mobility (Subsection 7.1.1) and pervasive interaction (Subsection 7.1.2) with the goal of juxtaposing their inherent conceptual differences. Subsection 7.1.3 discusses the embeddedness of computing in mobile work. The following Section 7.2 introduces the context of fieldwork and Individual Pervasiveness before turning to activity contradictions that emerge in pervasive activities, including conflicts of mediation, transparency. Section 7.3 discussed the notion of control and the emergence of Pervasive Order. Section 7.4 concludes this discussion through aligning pervasive environments and interaction innovating of technology for mobile work before this chapter is summarised in Section 7.5.

7.1 Pervasive Activities

This study's socio-technical focus requires a reassessment of the extent to which technology as such participates in the shaping of the findings. Consequently, as the first IS-based study of the development of mobile RFID technology for mobile work, the technological, systemic properties and affordances of this auto-identification technology require further attention. Indeed, this focus on technology challenges if the previously observed phenomena, the experienced contradictions etc., are general problems of developing technology for mobile work or if they are shaped more directly by the particular technology under development. Among the observed activities of innovating technology for mobile work what, if anything, is shaped by the specific technology under investigation and the mobility it enables?

7.1.1 Deconstructing Mobility

In general, in the Interaction Framework (see Section 6.1.1) the motive of the Innovator is to understand mobile work and to develop mobile RFID devices accordingly. Innovation partners are interested in understanding mobile workers' activities and developing more advanced central activities. The mobility of workers and objects across numerous locales emphasises the geographical flexibility of data

and of individuals who carry and use tools for mobile work in their central activities. Although mobile work of course precedes the advent of modern-day mobile devices, those who now employ information and communication technologies as tools of their mobile activities participate in distant communication with little regard to time and location. In these *mobile activities*, the geographically mobile and dynamic workplace, as such, remains an undefined space that is traversed freely by mobile workers. In many cases, their communication partners are also mobile workers. In others cases, while the mobile workers roam (i.e., travel, visit and wander) (Kristoffersen and Ljundberg 1998) within their work environment they at times interact with their remote, location-bounded colleagues and superiors.

This suggests that, in mobile interaction scenarios, communication partners are rarely co-located. Consequently, any communication that occurs relies on the subjects involved and on how they present their work and location in their pursuit of individual actions to others. It is through this interaction that communication partners negotiate the shared activity of object-oriented mobile work, report and query the progress of mobile work and exercise and follow remote managerial supervision. In such discussions of mobile technology, the focus is directly placed on the human subject, and his externalisation of work. In interactions with mobile workers, the overall focus is to locate the individual user at the centre of mobile activities; the actual capture and transmission of data through mobile devices remains marginalised. From this perspective, the activities carried out in mobile work before the introduction of mobile RFID are undoubtedly people-centric (Figure 47) (see also Kalakota and Robinson 2002; Sørensen 2005). All interaction occurred either directly between individuals or through their external representations. In this comparison of mobile and pervasive work environments, *mobile activities refer to people-centric interactions at mobile work and communicative acts in mobile environments.*[7]

[7] In the empirical study described earlier, these represent the central activities of mobile workers before any of the trials were introduced.

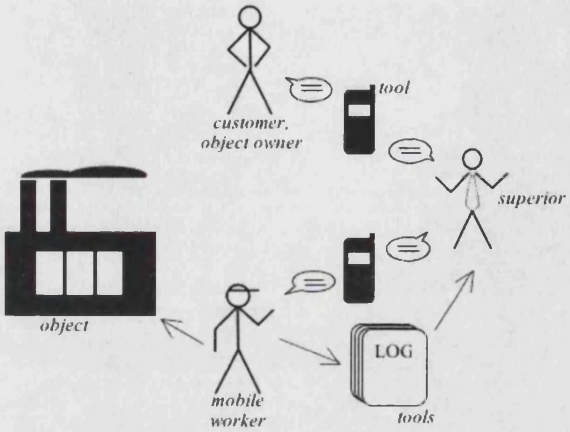


Figure 47: People-Centric Mobile Activity

Of course, abstract discussions of the unique characteristics of mobility and its conceptual delimitations are hardly the concern of industry participants. On the contrary, the question of who or what constitutes the centre of mobile work activities, and to what extent work is people-centric, plays an unimportant role. Instead, the motives of the various parties (e.g., Innovators' solution-based, instrument-producing motive and Innovation Partners' context-based motive of developing a more advanced central activity) aim directly at finding solutions to what are considered real problems rather than academic topics. Their focus is the innovation and development of a new generation of mobile technology and mobile work. As a result, among Innovators and Innovation Partners in the empirical setting, the terminology of *pervasive* technology was never debated explicitly; however, pervasive attributes were clearly at the core of their innovating activities. Under the guise of commonplace mobile technology, with added functionality, industry today shapes the pervasive future of mobile work.

While it is the aim of this chapter to demarcate mobility and pervasiveness, the focus remains the use of technology for *mobile work*. In fact, the terminology of mobile work remains very suitable. The physical terrain of mobile workers is barely altered through mobile RFID; in fact the geographical area navigated remains exactly the same. Similarly, mobile workers' responsibilities may not change since the central activity's motive is not necessarily affected. However, the development of a tiny device and supporting technology (e.g., RFID tag and reader), presents enormous repercussions for the conditions of traditional mobility, practically and conceptually.

7.1.2 Introducing Pervasiveness

In the move towards pervasiveness, small and unassuming technological devices are added to the previously people-centric activities. According to the National Institute for Standards and Technology, pervasive computing is defined as "numerous, casually accessible, often invisible computing devices, frequently mobile or embedded in the environment and connected to an increasingly ubiquitous network structure" (National Institute of Standards and Technology 2001). At first sight, they are simple tools aimed at improving the interaction between mobile workers, their work activities and other remote parties. In terms of the technology employed, the change is very small, and may go unnoticed to those who are not vastly familiar with the physical environments of mobile work. Nonetheless, it is not the physical settings and differences of old and new tools that matter but rather the information flow they facilitate (Meyrowitz 1994; Taylor 2005). The new social landscape, shaped by RFID tags, readers and events, automatically identifies the bearer of a tag or reader, whether human or object.

The resulting flow of information occurs, unmistakably, according to previously established interaction protocols, triggered in turn by the increasingly involuntary interaction of reader and tag. In fact, with more RFID tags, or other sensors, and readers distributed throughout the mobile work world, we create an architecture of devices that become increasingly aware of their environment and facilitate and transmit detailed information about technology-based interactions (Figure 48). As a result, the focus of the interaction shifts from the worker to the technological participant. In this sense, the new environment for mobile work is marked by increased attention to the tool at the core of mobile activities, at the expense of the human subject. In this comparison of mobile and pervasive work environments, *pervasive activities refer to tool-centric interactions at mobile work and communicative acts in pervasive environments.*[8]

[8] In the empirical study described earlier, these represent the more advanced central activities of mobile workers introduced through the trials.

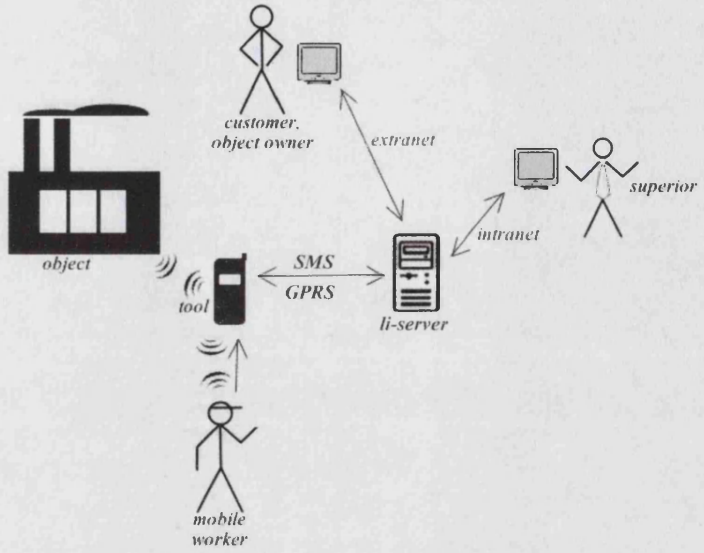


Figure 48: Tool-Centric Pervasive Activity

This move towards pervasiveness exceeds previous attempts of linking technology to the person (e.g., Steve Mann's project of the wearable computer (2002), Kevin Warwick's Cyborg Project (2005)). By embedding computing into the everyday environment of mobile work and modelling the social in the technical (Sørensen and Gibson 2006), pervasive systems increase the information flow that links humans, their tools and the objects of their work. The more computing devices become embedded and linked to each other, the more they shape the interaction of mobile work and support the move from people-centric, mobile activities to tool-centric pervasive activities.

7.1.3 Embeddedness of Computing in Mobile Work

As mentioned above, handheld information and communication technologies that facilitate interaction independent of spatial and temporal constraints are categorically referred to as mobile devices among industry representatives. Whether they are in fact mobile or pervasive is not only determined by the actual technology in question but also by the information flow that is shaped by its embeddedness into actions and everyday operations. Increased levels of embeddedness of computing devices challenge previously established practices of the mobile worker (Sørensen and Gibson 2006) and his interaction with the technological artefact.

In his book *The Invisible Computer*, Norman (1999) calls for the development of the next generation of the personal computer (PC) as an *information appliance*. Its claim is that today's technology is in fact focused on the artefact, and that tomorrow's technology ought to rediscover the user at the centre of the activity. At the same time, Norman (1999), Weiser (1991), McCullough (2004) and others call for the disappearance of the computer with the assumption that once the "technology of the computer disappears behind the scenes into task specific devices" (Norman 1991, pviii) it will "serve human needs invisibly, unobtrusively" (Norman 1991, pix). Accordingly, "the most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it" (Weiser 1991, p1).

While for instance Norman's arguments mostly concentrate on the PC, the next generation of pervasive technology used for mobile work displays an altogether different picture. Embedding RFID tags and equipping mobile workers with readers enables imperceptible interaction between subject, object and tool and without a doubt qualifies as the disappearance of the computer, but does invisible computing lead to unobtrusive interaction with mobile work? In order for the computer to disappear, it needs to be more tightly connected to its environment, embedded within the context of its use. The extent to which technology for mobile work, under mobility and pervasiveness, is embedded within mobile work is discussed in the remainder of this section. The impact of a changed level of embeddedness on mobile work activities and interaction is discussed in the subsequent section.

Embeddedness and Mobile Computing

Mobile activities before the introduction of mobile RFID refer to the ability to carry information and communication devices and to use them, by and large, irrespective of location. By extension, this location independence also suggests that mobile devices are not directly affected by the respective properties of their operating environment; they offer the same computing services regardless of location (Lyytinen and Yoo 2002). Tools of mobile activities are binary and either provide a particular service or do not. In this regard, they are not aware of the context within which they operate and do not transmit location-specific information that is of relevance to their interaction

partners (e.g., a mobile phone does not show which cell it is sending from). Similarly, mobile computing services do not offer different applications and functions in response to changes in location, unless so configured and demanded by the conscious involvement and participation of the user. Central computing activities of mobile work are therefore highly mobile, but low in terms of embeddedness within their environment (see Figure 49 below).

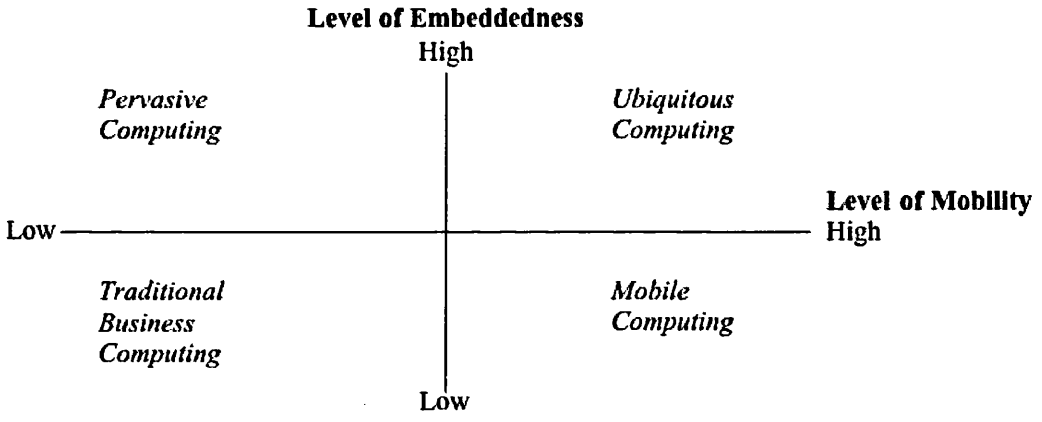


Figure 49: Embeddedness and Mobility of Computing (Lyytinen et al. 2002a)

The tools of the mobile activity, consequently, remain separated from the actual context of work. In Weiser's words, they weave themselves into the everyday fabric (1991), but rather than becoming part of the environment, over time they become accepted as external tools used in the environment. They assume an integral part of work when individuals become habituated to their use. According to Leontiev's Hierarchy of an Activity (1978), it is through the continued use of tools that conscious actions become operations. According to their cultural-historical trajectory, as tools become accepted into activities they influence the activity within which they are applied, as well as its neighbouring activities.

Embeddedness and Interaction in Mobile Activities

The relationships within and between activities can be expressed in terms of their level of coupling and cohesion, to borrow a popular concept and notation from engineering and computing sciences.

Coupling, in this case, refers to the measure of interdependence of one activity with another. When there is no direct coupling, two activities exist that do not rely on constant interaction and information flow. Tight coupling, the opposite extreme, describes that what happens in one activity directly affects the other (Perrow 1999). For this discussion of mobile interaction, tight coupling suggests that two systems, or mobile and remote activities, are in constant interaction and information exchange. As argued by Olson and Olson (2000), this means that loosely coupled work has fewer direct dependencies and is more routine, as opposed to tightly coupled work with short but frequent feedback loops. This notion of coupling applies to mobile activities very well; they are not directly coupled and actions and operations of mobile workers are carried out largely independently from other mobile or remote parties. However, this is not to say that their work is of no consequence to that of others. Indeed, mobile and remote individuals are still mutual dependent in their work (Schmidt 1993), as the cooperative nature of their activities requires the interaction and communication of various work details at different points in time (Thompson 1967). Based on the largely autonomous activities of mobile work, efforts to systematically create and enforce this interaction through coupling are reduced to ad-hoc mobile phone conversations.

The concept of cohesion, on the other hand, describes intra-activity interaction and expresses the strength of the association of participants and mediators within the activity. Here, too, the mobile worker remains at the centre of the activity; his ability to interpret and follow instructions in the field, his autonomy of applying tools and following their inscribed rules etc. emphasise that the association within mobile activities is low. For example, it is left to the mobile worker to adhere to the mandatory regular breaks from driving or to record events properly on paper logs. In the activity triangle notation, cohesion would best be described as the interactions between subject and the remaining nodes of the triangle.

This combination of no direct coupling, ad-hoc interactions and low cohesion points to the mobile worker's unique position. The interaction depends on his discretion and willingness to accurately conduct mobile work and disclose the requested information (e.g., location, time and the status of the object or activity). Details of mobile work are communicated directly through a mobile phone and through field notes,

asynchronous logs and progress reports. The worker's discretion and the accuracy of his representations determine the overall interaction and its context. In terms of the duality of their activities (please see 4.3.2), these means of communication are the mobile workers' externalisations of their otherwise purely cognitive accounts of their work. Their chosen language, the frames of reference and the resulting reports, logs or progress forms, for instance, form the most important representations of mobile work, the common objects shared by mobile workers, mobile colleagues and their remote supervisors (or Innovators and Innovation Partners, in the context of innovation). These representations mediate between subjects, enable the subject-object-subject interaction and facilitate the coordination of mobile work. However, such subjective, imprecise evidence of details of mobile work requires extensive synchronisation with other logs and legacy systems to replicate the chain of events of mobile actions and operations.

Due to this inherent ambiguity of details of mobile activities, the drawback of asynchronous representations and the challenge of interpreting others' externalisations, participants increasingly need to rely on synchronous verbal confirmations via the mobile phone for the coordination and control of mobile work activities. However, just as much as the asynchronous representations of mobile work, the mediating tool (e.g., a mobile phone) guarantees no meaningful, objective account of fieldwork for this subject-object-subject interaction; it is merely a conduit that enables the interaction. The mobile worker maintains his autonomy over the content of the interaction, his cooperation and participation in such communication (e.g., in some cases, disclosed information about location may be deliberately incorrect, in others the phone could consciously not be answered). This is not to suggest that mobile subjects necessarily violate the rules of central activities or decisively provide wrong external representations, but rather to emphasise that they remain sovereign in their pursuit of the central activity and their externalisation thereof. Tools are neither cohesively embedded within the mobile work environment nor directly coupled to work activities. Attempts to exchange parameters of mobile work most definitely depend on the subject's willingness to share details of their mobile work. Thus, the human remains at the core of the mobile activity, in charge of supporting the association of intra-activity participants and mediators and inter-activity interaction.

Embeddedness of Pervasive Computing

While such an understanding holds true for the majority of mobile activities today, the development of mobile RFID is an indicator of a changing level of coupling and embeddedness of computational devices for mobile work. Good practice of systems development, also relevant for activity systems, is to focus on a high level of intra-activity cohesion and a low level of inter-activity dependencies, facilitating resilient relationships with minimal assumptions between interacting activity systems. As computers disappear and blend into the natural human environment (Weiser 1991), they promise to become less distinguishable from human affairs and to support their practices. Mobile technology lacks this embeddedness; it is developed and diffused as a blank slate technology, one which has no built-in knowledge base or knowledge capability of its environment beyond the planning reasoning of its designers. Pervasive computing, on the other hand, negates this concept and spirit of tabula rasa (McCullough 2004) and relies on inscriptions into the social and physical environment (ibid.). Through this newly enabled ability to interact with the environment, e.g., through RFID or sensor technology, and to collect and receive data from a distance, technology is becoming increasingly embedded and context aware.

The embeddedness of pervasive technology meets current demands for an increased time and data-sensitive understanding of the contexts of mobile work as Innovation Partners and their customers insist on improving their insight into mobile work practices. By developing an infrastructure of embedded, physically nearly undetectable and location-independent tags and mobile RFID readers with inscribed rules, the pervasive work environment provides cohesive, context-specific information directly to the tag-reading device. Indirectly, this information is relayed to mobile workers and other participants of the central or neighbouring activities. Given this increasing participation of information and communication devices, interaction becomes much less focused on the mobile worker and places greater emphasis on the tools at the core of work activities.

In terms of location independence and mobility (please see Figure 49), these pervasive activities score low since they are limited to tag-events, which in turn are still restricted to reading ranges of only a few centimetres. However, current developments directly shape the future of mobile work environments. Reading ranges

are projected to approach 20 meters for more stationary readers (Garfinkel and Rosenberg 2006). As a rising number of increasingly mobile, invisible and powerful readers and tags populate the mobile work environment, a tight net of information flows accompanies pervasive activities. As more and more objects and tools of mobile work become embedded with tags and improved readers, we witness a continuously increasing mobility with pervasive devices, ultimately approaching ubiquitous computing environments (Lyytinen and Yoo 2002). Visions of the future home and retail organisations (Albrecht and Macintyre 2005), the next generation of cash (Angell and Kietzmann forthcoming), interactive fashion (Albrecht and Macintyre 2005) and wearable computing (Mann and Niedzviecki 2002) etc. contribute to the notion of ever-increasing mobility and location independence of computing occurrences. With respect to embeddedness, on the other hand, the pervasive technology already ranks high, since a number of elements of mobile work are equipped with nearly invisible tags that facilitate potentially imperceptible interaction between tag and mobile reader and subsequently between mobile reader, the location interaction server, legacy systems, intranets, extranets and other mobile devices.

In these more advanced, pervasive activities, it is not only the mediated subject-object-subject interaction that is improved through this increased embeddedness and availability for participants to interact (e.g., through consciously writing to tags and sending messages that are associated with tag-events). Contradictory to mobile activities, in pervasive environments objects assume an increasingly active role in the exchange of work information. They not only convey information and mediate the interaction between subjects, but rather adopt an active stance and add value through event-specific information, at times without the explicit permission or knowledge of the mobile worker. Through embedding pervasive devices among subjects (e.g., ID cards), tools (e.g., mobile phones) and objects (e.g., waste containers or trucks) much more sophisticated and cohesive information systems emerge, in which subjects, tools and objects are beginning to talk to one another and, by extension, know about each another. It is this pervasiveness, this interaction and embeddedness that determines mobile behaviour at work, rather than the free navigation of geographical spaces. A mobile worker no longer travels through his work world without traceable interaction (Sørensen, Fagrell et al. 2000), as "mobility becomes less of a description of an

autonomous user freely moving in the world and more of a contingent subject-position made possible by object-object communication" (Elichirigoity 2004, p10).

As an aside, a discussion of pervasive technology and smart tags that are *aware* of and *know* about their immediate context without a doubt recalls the notion of artificial intelligence and requires a short clarification. As outlined earlier, tags can be smart, and so can phones. Nonetheless, this does not imply that they are truly intelligent, or in any way capable of making truly independent decisions. It does, however, infer that smart devices such as tags, antennas or phones know something about themselves and their environment and can communicate that knowledge. Although I attribute smart technologies with such traits as intelligence and knowing, I do not subscribe to the posthumanist school of thought that describes how sovereign objects start talking with one another autonomously (e.g., Elichirigoity, 2004) or that place objects at par with human participants. I do, however, endorse thoughts that take objects seriously, especially when these are increasingly smart. Devices that are aware of their immediate context and connected to bigger systems alter our notion of tool mediation and consequently our activities and the reality in which these are carried out. To enable this context-awareness for pervasive environments, "no revolution in artificial intelligence is needed – just the proper embedding of computers into the everyday world" (Weiser 1991, p3).

7.2 The Mobile Worker and Individual Pervasiveness

Clearly, central mobile activities and more advanced pervasive activities present dramatically different requirements on their information infrastructure. While a contemporary mobile device cares little about its contextual environment (e.g., a mobile phone provides the same service in all areas that provide coverage), a pervasive device requires the interaction of a number of information components to determine the required context-specific information and to deliver the respective interaction services. A discussion that centres on a dual interaction of mediated subject-object-subject and direct object-object interaction at mobile work requires a close look at what exactly becomes the focus of the communication of objects. In other words, the specific dimensions of mobile work these embedded, auto-identifying, pervasive systems capture and transmit is elemental. On what basis do

they become smart and context-aware? In work that is conducted by individual mobile workers, certain contextual elements of their work are reflected through the capture and transmission of details of their work activities, actions and operations.

7.2.1 The Context of Mobile Activities

Before discussing these particular *contextual* elements of pervasive activities, a significant and potentially misleading Information Systems topic requires attention. The notion of context is a heavily discussed and often contradictory subject of Information Systems scholars. While different technologies (e.g., embedded tags, sensors, webcams) to varying degrees reveal environmental and use characteristics (e.g., the temperature of a room, users' facial expressions) (Höök, Benyon et al. 2003), their very ability to successfully capture, properly codify and realistically represent the context of use continues to fuel deeply theoretical and philosophical debates. Positions range from easy, unproblematic assumptions of context to highly phenomenological approaches where codification itself is not an acceptable, viable strategy and the *Dasein* become the only true way of understanding context. Within this spectrum, one can witness discussions of classification, coding and categories as the underlying method of gathering, generating and using (mobile) field data to represent context (Bowker and Star 1999; Kristoffersen and Ljungberg 2000; Pica and Sørensen 2004). Alternate approaches define context through the complicated use of context perspectives and scenarios (Steward 2005), through *ba*, the combination of blended layers of physical, virtual and mental spaces (Nonaka and Konno 1998) and extended by Vartiainen (2005), through the intrinsic unity of context, activity and intentionality (McCullough 2004), Activity Theory supporting perspectives (Nardi 1996) or situated action theory (Suchman 1987). Phenomenological discussions of locales (i.e., the discussion of space versus place*)(Dourish 2001)* and *Befindlichkeit*, i.e., situational circumstances of action and the emotional disposition of how one feels (Ciborra 2004), further discuss the contextual relationships between individuals, artefacts and social groups within their wider environment. At the heart of all of these discussions is the difficulty of context, conceptually, for research in Information Systems and other disciplines.

While a discussion of the viability of categories and context is of tremendous interest from ontological and epistemological perspectives (e.g., Suchman 1993), at its abstract level it remains a fairly academic exercise. However, some studies involving context are very closely based on the reality of work (e.g., Pica and Sørensen 2004). Perhaps partially based on their ability to marry theory and praxis, systems design experts, who were previously said to work on technology outside of its future application, now increasingly focus on context (McCullough 2004). By building technology around everyday life their values shift from "objects to experiences, from performance to appropriateness, from procedure to situation, and from behaviour to intent" (McCullough 2004, p50). Thus argued, industry moves from linear to more complex and interactive ways of viewing both technology and its future use in light of their complicated cognitive and physical attributes. Nonetheless, in the practical world, categorisation and the terminology of context are used much more freely and are generously applied among systems developers, programmers, engineers, with the understanding that technology's "appropriateness is almost always a matter of context" (McCullough 2004, p3). Especially for pervasive technologies, the role of codification and context are essential. Their very essence embraces the need of classification, codification and context (e.g., EPC concentrate on object class codes to identify unique goods, their manufacturers). The question among professionals is not whether it is possible at all to capture, codify and represent context, but rather how to do so most appropriately for objective of the technology under development, to "disregard irrelevant details while isolating and emphasizing those properties of artefacts and situations that are most significant" (Brooks 1991, p53).

7.2.2 Individual Pervasiveness

In this sense, the following subsections analyse general metrics of context for the use of pervasive technology for mobile work. For this purpose, I introduce *Individual Pervasiveness* as the extent to which an individual's technology is aware of its immediate environment and communicates very specific details of its bearer and his behaviour. Put differently, under Individual Pervasiveness, the mobile worker no longer maintains absolute autonomy over what aspects of his actions and operations are captured and passed on to others. Mobile RFID tag events, for instance,

automatically identify various attributes of their mobile work context and make their details more widely available.

While I agree that context includes many attributes (e.g., mood and disposition of worker), it is context as a more narrowly defined concept that motivates the Innovator and Innovation Partners' activities. To support this notion, I delineate *context* as the combination of four essential, interrelated variables of mobile work (Figure 50). Among these four, location and time remain pivotal to discussions of Individual Pervasiveness, and identity and status are important new variables of contextual information.

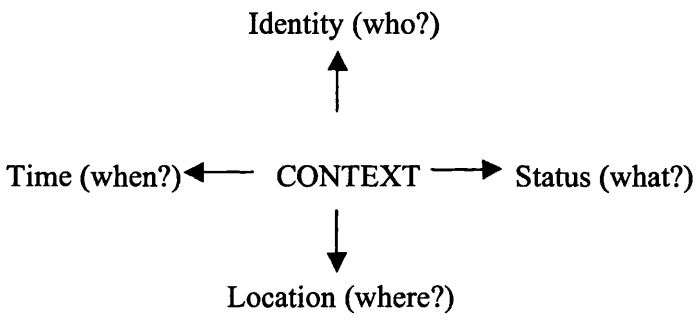


Figure 50: Individual Pervasiveness Framework

By providing answers to four simple questions, a pervasive information system is able to gain a contextual view of mobile work. It can therefore dynamically adjust its computing services accordingly and allow others to reconstruct fieldwork from remote sites. The direction of the information flow is quite important and presents a core argument for the further development of pervasive systems in this chapter. At this stage, the respective information streams from the captured context outward to other activities and elements of the associated information systems (local interaction server etc.), enabling complex referencing systems of four main variables of individual mobile workers' behaviour:

Identity connects the agents participating in a particular action or operation. In pervasive environments, the identity of the tool (i.e., the reader's unique identification

number), the identity of its bearer (i.e., a mobile worker initiates his work shift by reading the tag of his ID card with the tool) and the identity of the object of the mobile activity can automatically be captured and connected. The use of auto-identification technology such as RFID overcomes the unreliability of manual, people-centric identification (Mitchell 2003). In other words, in a pervasive environment, the device asks who was involved, and by reading the respective tags spins a web that encompasses the unique identity of the mobile worker, the tool used and the object worked on. In some cases, this is still done with the cognisant participation of the mobile worker who consciously needs to bring reader and object into close proximity. As the read-range of the mobile readers increases, stronger associations among these participants enable the increased connection of the three identities of subject, tool and object.

The *temporal* aspect of mobile actions and operations is no longer dependent on the time subjectively logged by the mobile worker. Rather, it is strongly connected to tag events based on two temporal occurrences, namely the reading of the tag determined by the mobile reader's internal clock setting and the time at which the event is logged by the local-interaction server. In a synchronous environment, no time should pass between these two time stamps; however, even urban areas still suffer from dead spots in which there is no mobile network connection and thus no opportunity to interact synchronously with the local interaction server. The tag-event data is in these cases sent as soon as the mobile reader regains access to a mobile network. Not only does this ensure that the event is logged and time-stamped for a proper account of the action or operation, but it also makes visible a time-span between tag-event and local interaction server entry, indicating, among other things, how long it took the mobile worker to return to connectivity.

In the central mobile activity, the *object's status* is asynchronously reported and loosely connected to the actual object and reality of mobile work. In the more advanced, pervasive activity, this status is increasingly reported without input of the mobile worker. Local sensors, for instance, can automatically attach a temperature reading to a tag event or report other functional data of the equipment (e.g., in one empirical trial, mobile workers reported that sometimes machines called them to report that they were overheating and required maintenance). Individual

pervasiveness today still relies on the mobile worker's choice for a number of status-related properties. In an effort to strengthen the associations within activities and to elicit data meaningful for other activities, most of the input is automated or offered through predetermined, standardised and menu-driven options. The increasing use of sensors that automatically report on their status will provide higher cohesion between objects, tools and subjects as participants of the overall pervasive activity.

Lastly, the fourth element of context-related Individual Pervasiveness relates to the notion of *location.* While a lot of mobile work is carried out at particular locations (Wiberg and Grönlund 2000), there are a number of mobile actions and operations that are not directly connected to any specific location. In these cases, mobile workers perform their actions and operations with tools on objects anywhere within their terrain, leaving the organisation with no clear understanding of the whereabouts of their employees and equipment (e.g., the use of running bins in one of the empirical trials). Although exact identification of the location of objects or tools is not always possible (e.g., based on read range limitations), Individual Pervasiveness connects the location of the mobile activity to the more narrowly definable location of the objects of his work. Geofencing, or the triangulation of pertinent temporal and spatial information derived from tag events, further helps identify the location of subject, objects and tools. The addition of Global Positioning Systems (GPS) is the next logical extension of these pervasive systems, identifying the exact location of the tag-events at all times.

By embedding information system components (e.g., tags) into mobile activities and imperceptibly gathering answers to the four basic questions of who, when, where and what, pervasive information systems gain invaluable information about the context in which they operate. Through such highly integrated and embedded context-aware systems, mobile computing settings can be reconstructed remotely, reconfigured dynamically and, as part of bigger information systems, lead to a more appropriate coupling of activities. Pervasive systems not only relate mobile workers, their tools and objects more strongly, but also created a firmer connection to the underlying regulation governing their mobile work (i.e., inscribed rules), to other subjects (i.e., community and hierarchy of labour) and their tools.

7.2.3 Contradictions of Individual Pervasiveness

Although the notion of pervasive technology and Individual Pervasiveness appears to be vastly complex at first sight, embedding auto-identification technology and accessing it via synchronous mobile readers has become quite uncomplicated on a technological level. Implementing the relatively small technological change of adding tags and readers to mobile work activities for all intents and purposes hides the computer with the aim of serving the mobile worker and remote colleagues effectively and unobtrusively. New information flows and consequently new dependencies of work activities are created that immensely increase the complexity of mobile work (Schmidt 1993; Norman 1999; Perrow 1999). Through the ensuing context-awareness new types of contradictions emerge that significantly set mobile and pervasive work activities apart.

In Activity Theory parlance, pervasive activities, actions and operations are shaped by goals and motives and in their pursuit are determined by conditions underlying mobile work. From a mobile worker's perspective, the move to a pervasive computing system changes the tool of their mobile activity, but this does not by definition change the goals and needs that motivated his mobile actions and activities in the first place. However, the rules that accompany the more advanced pervasive activity, along with the important information flows of Individual Pervasiveness present altogether different working conditions. Such new conditions challenge the established activities and call into the conscious those operations that had become routine mobile work practices. Consequently, the conditions of pervasiveness, including resulting tensions and contradictions, test the stability of mobile activities and potentially give rise to change and development within work practices of the mobile worker. The more noticeably these conditions change, the more they lead to a renegotiation of the goals of the mobile worker (please recall Figure 11), potentially changing the entire mediated activity.

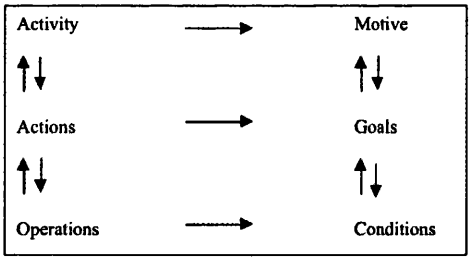


Figure 51: Hierarchical Model of Activity (Leontiev 1978) (Figure 11 reproduced)

On the surface, it may appear that in pervasive environments only four variables of mobile work are captured and communicated, which were in part already available in central mobile activities through ad-hoc interactions, hence resulting in no change to the activity. While it is true that pervasiveness as such does not change a mobile worker's object-oriented tasks, it does change how he pursues them. The modification of the underlying conditions of information flows matters to the extent to which these indeed alter mobile work practices. In a circular hermeneutical fashion, this questions how pervasive information about individual behaviour (i.e., Individual Pervasiveness) influences and changes individual behaviour. This relationship emphasises the importance of how the individual mobile worker perceives and interprets changes to his working conditions and reconstructs his reality of mobile work. The perception of the new technology and its capacity to capture and transmit information determines how a mobile worker sees himself, his identity as an agent involved in pervasive activities and how, accordingly, new internal and external contradictions emerge.

In mobile work that is not conducted among self-employed mobile professionals (e.g., Kakihara and Sørensen 2002), but among mobile workers who are part of collaborative activities, changes to individual workers by definition trigger changes to the overall neighbouring activities. Consequently, the elements of Individual Pervasiveness influence individual behaviour and have an impact on the coordination, cooperation and reflective communication of all participants directly and indirectly involved in pervasive activities (please refer to Section 4.3.2). Contradictions are marked by internal contradictions of *mediation* and external contradictions of *transparency* and *control* of the mobile vis-à-vis pervasive activity, as discussed in the following sections.

Mediation

The changing conditions of pervasive operations, actions and activities are manifested through altered levels of participation of subjects and tools in the pursuit of the mobile work objective. In mobile activities, focused on the individual at the core of work activities, the mobile worker is predominantly in charge of conducting, logging and reporting his work. Tools for mobile work are employed and controlled by the mobile worker and over time become operationalised in their use. Mobile devices become accepted as tools for operations and thereby move into the cognitive background of work; unchanged conditions of activities allow devices to become and remain habituated. Through practice, the mental requirement for the specific mobile tasks diminishes and tools become elements of subliminal, automatic, routine practices. Despite becoming hidden and invisible in the fabric of the mobile activity, mobile technologies remain unresponsive, in terms of their geographical location and application to work settings, to the respective contexts in which they are employed. To a mobile phone, for example, it does not matter where exactly it is used as long as it receives a signal; it nearly provides an anytime, anywhere service.

In pervasive environments, the balance of human versus tool participation changes in favour of the context-aware technology. Presupposing complex, tag-equipped environments and workers with mobile RFID tools, work that used to be autonomous and instigated by mobile workers is now increasingly shaped through objective tool-to-object interaction. Through such complex pervasive systems, various subjects including peers and superiors are able to recreate the reality of mobile work, regardless of their location. Mediating tools are at the heart of this change and the worker's awareness thereof recalls work that had previously been routinised and moves it to the mobile worker's cognitive fore. Paradoxically, in the shift from mobile to pervasive environments, embedded tools that are supposed to facilitate imperceptible interaction start to meddle with the underlying conditions and the subject's ability to conduct sovereign mobile work. Rather than blending in with the background, they become the clear focus of the worker's attention. Rather than unnoticeably supporting operations, they become almost palpable tools for actions within more advanced pervasive activities. The more pervasive tools mediate in the

activities of mobile workers, the less they are able to disappear into the cognitive background of mobile activities.

Moreover, pervasive computing environments not only change the notion of mediation through particular interactions at certain locations and at certain times, but more importantly lead to the ability to dynamically reconfigure activities and computing models as mobile workers navigate the terrain of their work. Accordingly, pervasive devices are able to react to contextual circumstances and can request the mobile worker to conduct certain tasks in response. Mobile workers, who had previously exercised autonomy over their mobile actions and operations and used fairly unobtrusive tools (e.g., pen and paper), are now disrupted in their regular flow of work by obtrusive interaction tools.

Vignette D: Pervasive Mediation in Action

> In the empirical study, gas engineers quite often received telephone calls from engines. Certain engines had heat sensors, which, given an abnormally high operating temperature, triggered a call to the mobile worker's mobile phone. Assuming a fairly human character, this call contained a pre-recorded voice message with the respective engine's location, its unit number, the time of the event and its current operating temperature as measured by am embedded sensor. It relayed the four variables its context back to the mobile worker (i.e., its location, identity, status and time). In other cases, mobile workers received text messages with similar context-related content. Not only do these interactions present an example of how computing environments can be dynamically recreated once just a little bit of information about their context is transmitted, they also present a reverse picture of tool-mediation of human activities. The notion of responding to an engine, an object of the central mobile activity, led to an inner contradiction among mobile workers, who saw a conflict between their previous identity of mobile, sovereign workers and their new role as mere respondents to computer-initiated orders.

This increasingly close tie between human subjects, their activities and embedded technology transcends the activities of the individual subject. In work settings that rely on interaction of the individual subject with others (both from the central activity and neighbouring activities), the altered mediation of Individual Pervasiveness enables previously unknown insights into mobile work practices.

Transparency

The extent to which an individual's work is *transparent* to others is a highly sensitive and political element of mobile work. Transparency in this case suggests a relationship of a mobile and a remote worker, and the visibility of the details of the former work practices to the latter.

In a mobile setting, through their externalisations and representations, mobile workers make their work practices visible to others. The transparency of mobile activities rests closely with the individual worker. It is through the mobile worker's chosen degree of transparency of otherwise poorly interconnected, not directly coupled mediums, that he invites others to view and understand his mobile activities. In this sense, the mobile worker enjoyed a latitude of choice regarding the interaction and content shared with remote parties. However, this is not a level of discretion that is explicitly granted by the mobile worker's superior. Rather, the mobile worker's autonomy and his discretion regarding the transparency of his work were based on the independent, mobile nature of the work activity (Pinelle and Gutwin 2003; Al-Taitoon 2005). For remote parties, the only synchronous access to mobile activities, actions and operations is via ad-hoc mobile phone calls or actual site visits. Asynchronous mediums include paper-based logs and reports, which are often filed and in many cases rarely reviewed (Goodman 2004). In other words, although a trail and record of mobile work often exists, it does not necessarily lead to a high degree of transparency of mobile work. The complexity of paper documents etc. and the time required to locate and collate the required information is often prohibitive. As one manager put it "It's all in there, all the information we need. But getting it out is impossible" (Peters 2004). Accordingly, remote parties are able to reconstruct a very limited reality of mobile work, at best.

Under Individual Pervasiveness, on the other hand, details of various context-related variables are automatically captured and made visible, not only to the mobile worker, but also to his superiors and colleagues. As the mobile worker and his tools travel together through the terrain of tagged objects of their labour, details of his respective actions and operations are automatically collected and forwarded. The remote reconstruction of mobile work activities in pervasive environments clearly exceeds the previous ability to understand mobile work; it enables a view of previously invisible actions and operations. Of course, this is the motive behind the introduction of the technology in the first place (recall the Innovation Partners' motives). However, while the pervasive environment makes mobile work activities more transparent, it also shines a light on elements of a subject's mobile activities that are considered personal and privileged.

A contradiction exists between the clear separation of public and private elements of work under mobility and the all-pervading transparency of pervasive environments. The daily hands-on actions and operations of a mobile worker are conducted predominantly in isolation from his colleagues and superiors. Only contexts and circumstances that require others' input or knowledge lead to externalisations, communication and cooperation between mobile workers and possibly their superiors. Once these communicative tasks are completed, cooperative mobile work becomes individual work again and is no longer visible to others. To this extent, mobile work is demarcated by both individual work and cooperative practices. The balance of these two elements, in Activity Theory parlance, develops over the course of its cultural-historical trajectory. More advanced pervasive activities, on the other hand, are highly transparent, leading to a number of internal and external conflicts and contradictions. The high cohesion and synchronicity of pervasive information unveils very specific information based on an individual's behaviour beyond what is considered public or cooperative (e.g., through geofencing, one can triangulate the location of a mobile worker, and through comparing the time stamp of a tag event and the reading of the local interaction server estimate how much time a mobile worker has taken to return to locations with connectivity). It no longer makes the distinction between individual and cooperative work and exposes a high amount of information about location, identity, status and time of all operations, actions and activities to others. The private,

isolated conventions of mobile work disappear, leading to an external contradiction of transparency of mobile versus pervasive activities.

Ephemeral and Persistent Aspects of Mobile Work

Of course, another contradiction points to the permanence of this transparency. In the central mobile activity, workers carry out a number of short-lived tasks (i.e., actions and operations) that are part of everyday mobile work. Many of these tasks are never disclosed, discussed or logged; they include shortcuts or routine actions that do not receive any further attention since they are part of commonly accepted work practices. Pervasive systems now create a traceable path of increasingly transparent actions, previously considered passing conventions. More importantly, Individual Pervasiveness retains this contextual information and turns previously ephemeral tasks into persistent actions and operations (Schmidt 1994). Formerly temporary and invisible tasks now leave immediately available and permanently stored trails as external representations. Directly connected to the mobile worker, such individual pervasive information crosses space and time and becomes visible to others, at any moment in time. In essence, Individual Pervasiveness permits the collection and retention of information about the mobile worker's actions and operations, extending profiling, traditionally aimed at customers of an organisation (Perrin 2006; Weinberg 2006), to individual mobile workers. More than retaining work-related information, including conclusions about the particular tasks in the field, these permanent traces allow others to draw extended inferences about personally identifiable, previously undisclosed activities (e.g., the location and time of breaks) at any point in time (Sørensen, Fagrell et al. 2000).

The changed level of transparency and permanence of mobile activities dramatically changes the conditions of mobile activities. Workers who had enjoyed the liberty of autonomously carrying out their work, who had control over the context-related information they would share and had no obligation to synchronously reveal details thereof are now faced with a much more invasive work environment. Through Individual Pervasiveness, mobile worker's actions and operations become immediately visible from a distance, and can at any point in time be recalled to reconstruct the context of the fieldwork. For most subjects, this entails changes to

their work conditions that defy many of the advantages of their work and undermine their sovereignty as mobile workers.

Unsurprisingly, a strong contradiction emerges between muggier, asynchronous and ephemeral mobile activities and the emerging Individual Pervasiveness of clean, transparent pervasive and persistent activities. As this new, powerful information flow from the field reaches remote parties, their use of these new work-related details to control mobile work presents another important change to the conditions in the field.

7.3 The Mobile Worker and Pervasive Order

Control over the release of information pertinent to mobile work had previously rested with mobile workers and is now placed in the domain of tools and objects. The implications are manifold and, among others, point to potential conflicts with mobile workers' right to privacy and surveillance concerns. The move to Individual Pervasiveness provides vast amounts of material for very interesting and contentious ethical and legal discussions, but this is beyond the scope of this dissertation. From an activity perspective, it is nonetheless of importance to evaluate how an increased level of transparency and changed mediation of pervasive information influences control mechanisms of mobile work.

7.3.1 Control

The potential for external contradictions between superiors and workers is naturally high in mobile activities. While the former might view the mobile worker either as the objective of their control activity, or perhaps even as a tool of the activity that needed to be controlled, the mobile worker of course sees himself as the subject conducting his work. The superior's need to check the status of mobile activities is often regarded as a strong sense of domination, rather than an attempt to couple individual activities more directly as an element of the superior's duties. Information gathering is regularly seen as monitoring and controlling mobile work. The contradictory nature of mobile activities and control from distant authorities are often at odds with the localised context of mobile workers, as displayed in the empirical study. Accordingly, the nature of the contradictions of mobile work determines "the kind and range of

possible actions performed by individuals in any location" (Wiredu 2005, p186), as evident in the empirical setting.

In practical terms, in mobile activities the control of work involves instigating ad-hoc, synchronous voice communication by superiors to receive the status of mobile activities and to dispatch orders accordingly. In terms of control, this impromptu interaction between mobile activity and activity of the supervisor is flawed. It is neither based on an objective account of work practices, nor can it be validated that the mobile worker receiving orders actually follows them as instructed. The mobile worker remains largely sovereign and in charge of his participation in remote control mechanisms.

In many cases, this means that a mobile worker can hypothetically give incorrect information about his location or status of his work, or simply refuse to answer a call. Even in the best case, where mobile workers fully comply to all reporting and communication requirements, ad-hoc mobile control mechanisms are both cumbersome and suffer, at least in part, from degradation over time since they are not often permanently recorded. Data entries of mobile activities that are noted on paper are frequently not standardised, are difficult to interpret and continue to rely on the frame of reference of the subjects recording and reviewing the notes. Elements of the activity are not associated strongly, and information exchange between superior and the mobile worker, while potentially rich in content, remains highly subjective and resource-intensive.

In pervasive systems, the transparency of activities increases dramatically and consequently amplifies the amount of knowledge about mobile work at the disposal of superiors. The degree to which pervasive technologies wield control over the mobile worker varies considerably from one mobile setting to the next, as was obvious in the empirical work. However, the inherent difference between using a tool for its functional affordances or as a means of transparency and control are blurring in pervasive activities, where one largely implies the other.

This changed relationship of transparency and control is primarily visible through pervasive tool mediation. Tools no longer facilitate interaction solely dependent on the subject's willingness to operate them, but they are able to interact in object-to-

object communication without the expressed consent of the mobile worker. This implies that the interaction of mobile workers and their superiors are dramatically altered, as superiors gain access to context-specific information based on the individual mobile worker's behaviour. In a mobile setting, this control is exercised from a distance through synchronous voice calls; in a pervasive setting this control is omnipresent. Every tag-interaction, for instance, increases the transparency and consequently enables a higher level of perceived and real control from superiors and information systems. Through dynamically reconfiguring computing environments and redirecting a mobile worker's actions, pervasive systems and superiors accompany a mobile worker along the navigation of his workspace. Rather than overseeing activities from a distance, superiors are quasi co-present and have immediate access to pervasive information of mobile work. As mobile activities become more transparent and controllable, the identity of the mobile worker shifts to one that is no longer autonomous. Accordingly, mobile workers face an array of control mechanisms quite different from their work in the central mobile activity.

Contradictions

In mobile activities, control mechanisms come in the form of immediate local demands expressed through the mobile setting (i.e., context) or rules from distant authorities. While in many cases these two control sources are in agreement, in others they present the mobile worker with a difficult contradiction between his needs and goals in the field and the objectives of his superior. The shortcoming of the mobile activity and consequently the source of these control contradictions is the ambiguity associated with mobile work, the lack of synchronous context-related information and the resulting inability to reconstruct changing mobile realities from a distance. The formal rules formed by the superior, embedded in rules of the mobile activity and in the tools used, are not flexible and do not respond to the specific context the mobile worker encounters in the field.

In pervasive systems; however, superiors are able to reconfigure their orders in response to context-related information they receive. The information flow between mobile work and remote supervision enables a quasi co-presence. Supervisors are able to relate more closely to mobile work contexts and, in theory, can alter their

control mechanisms in response, ultimately aimed at improving mobile work circumstances. As evident in the empirical work, new contradictions based on the association and interrelatedness of participants and activity systems emerge. In essence, the increased complexity of pervasive systems creates new contradictions in which the cloudiness of mobile work conventions clashes with the clarity and transparency of control in pervasive systems. At the core, this conflict forces participants into a vicious circle. First, control demands emerge from the local reality of mobile settings (e.g., a driver is tired and needs to take a break). Secondly, rules and control mechanisms are exercised from distant authorities (e.g., mobile workers must take regular breaks, but these are not strictly enforced by supervisors). So far, this describes the reality of many mobile activities. Now, demands are inscribed into pervasive systems (e.g., according to the information in the system, a mobile worker must take a break at a specific time, regardless of the situation at hand). These differing instructions place the mobile worker and his superior in a particularly difficult situation, as the obvious contradiction between control mechanisms requires an immediate resolution, which by definition has to violate one of the other demands. Placed in other words, the motives and objectives of the mobile worker and the controlling superior might be contradictory, but allow a certain interpretive flexibility with respect to mobile work activities. The added rigidity of pervasive systems, although aimed at flexibly reconfiguring mobile work, does not account for this subjective, human flexibility. The immediacy of context-sensitive information requires a choice that ultimately leads to a contradiction of control mechanisms.

7.3.2 A New Magnitude of Order

Mobile activities develop over time, based on commonly accepted configurations of mobile work practices. Elements of mobile activities comprised of workers, tools and objects suffer from weak intra-activity cohesion and ad-hoc interaction with superiors. In terms of mediation, transparency and control they leave a degree of interpretive freedom and flexibility to the mobile worker and his superiors. The mobile worker is autonomous in his decisions to reveal details of his activities and to some extent maintains control over the transparency of the context-specific information of his work. At the same time, the supervisor, with plenty of asynchronous logs and records of mobile work at his disposal, is only exposed to mobile work details to the extent

that he chooses to. The degree to which he exercises control over mobile work depends on his willingness to comb through asynchronous records, instigate synchronous voice interactions and interpret the reports of actions and operations in the field. As a result of this interaction, mobile work practices as cultural-historical activities are not bounded by strictly enforced methodological interaction requirements and are constantly renegotiated and dynamically changed. No order is explicitly developed or imposed. However, this is not to say that chaos reigns in mobile work or that no order exists, but rather that mobile activities are never ordered consciously and explicitly; mobile activities are information ecologies (Nardi and O'Day 1999; McCullough 2004) guided by *unorder* rather than disorder (Angell 2005; Angell and Kietzmann forthcoming). Mobile work is comprised of individual and organisational objectives, rules, transparency, control and tool mediation. But it also involves an understanding of the unorder in which mobile activities occur and how these are flexibly negotiated among individuals. After all, central mobile activities are to varying degrees externalised through representations (e.g., voice calls, paper-logs), highly centred on individuals at the heart of the activity.

Pervasive systems, however, are much less flexible and present an architecture of a more rigid and enforceable structure. Through the embeddedness of technology into mobile work environments, Individual Pervasiveness creates a flow of information (i.e., location, identity, status and time) from the context of work outward to peers and superiors of mobile workers. As a result, mobile workers who had been relatively autonomous with respect to how they carried out and logged mobile activities are now presented with pervasive systems, advanced information flows and the ability for others to dynamically recreate mobile computing environments from a distance. By collecting pervasive individual information, pervasive systems offer a highly context-sensitive ability to predict, to presume and to interpret mobile work activities and to provide structure and certainty for previously unstructured and ambiguous activities.

So far, Individual Pervasiveness describes the outward flow of information from work activities in the field to others, including superiors at remote sites. The very same information infrastructure allows superiors, for instance, to return context sensitive information to the mobile work activity. In other words, in an opportunistic fashion, pervasive systems are able to utilise the embeddedness of technology to reverse the

flow of information and to direct it back to the field. This enables and imposes a sense of order onto mobile work that had so far been unordered. By disseminating the same kinds of information previously collected from mobile work, this *Pervasive Order* is also able to direct at least a partial order and an invariant sequence to mobile activities.

Detailed information again centres on the elements of location, identity, status and time. By relaying such details to the mobile worker, pervasive systems impose new demands on mobile work (Figure 52). For instance, once a mobile worker approaches an RFID tag, or reader for that matter, a message is sent to the back-end system. This simple piece of information can already trigger a reply from the corporate back-end system and direct him to conduct specific actions in the field. Similarly, sensors embedded into objects in the field can generate messages that instruct a mobile worker to conduct a certain task (e.g., the abovementioned engines that frequently call mobile workers with very specific instructions). In both of these illustrations, mobile workers are furnished with information that includes the identity of the object to work on, its current status and location and the time of the instruction. This imposes an order on the behaviour of the individual mobile worker and dictates in what sequence his work activities must unfold.

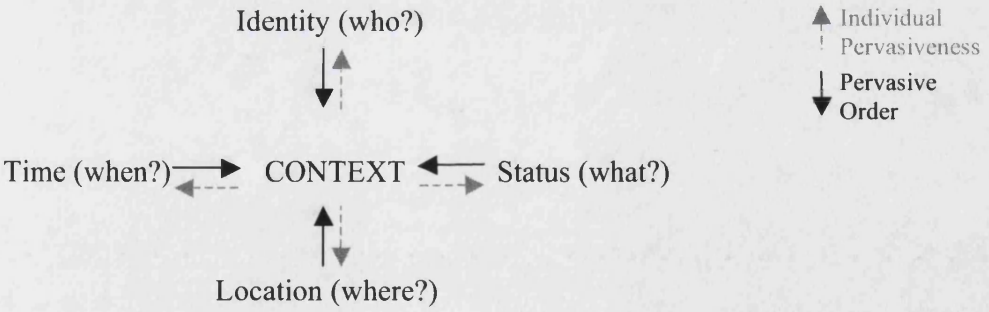


Figure 52: Pervasive Order and Context

Most importantly, this Pervasive Order becomes possible by more tightly involving technology at the heart of the interaction. Rather than relaying all the required information between human subjects (e.g., from supervisor to mobile worker), technology gets actively involved in creating and enforcing a plan of action(s) for

mobile work. A pervasive system places smart tools and objects at the core of the work activity, as they derive and impose pervasiveness, and order, from the information flow they enable in the first place. This transition from people-centric to tool-centric activities was previously discussed in terms of context-variables captured from the field (i.e. Individual Pervasiveness); Pervasive Order now adds the distribution of context-variables back to the mobile activity.

This Pervasive Order introduces a number of unique conflicts and contradictions to the unorder of the central, mobile activity. These problems arise despite the fact that pervasive systems support the central activity of mobile workers (Perry and Brodie 2005). However, it does so by providing new couplings within and between activities. In some cases, the ensuing Individual Pervasiveness and Pervasive Order introduce contradictory changes to the conditions of mobile work. In others cases, these exact changes help understand why mobile workers who experience order and sequence in their mobile actions (e.g., Security Guards who follow explicit protocols), do not suffer any contradictions when the pervasive structure is imposed on their work. On the contrary, the pervasive information flow improves the already existing structure and order. In these cases, it provides the information flow demanded by all participants, including the mobile worker, which effectively reduces the contradictions that had previously existed in mobile activities. The diversity of the characteristics of mobility and pervasiveness naturally extends to the interaction of Innovators, Innovation Partners and Trialists at the heart of this study. Thus, interactive innovating of technology for mobile work is directly shaped by the pervasiveness of the technology under development.

7.4 Interactive Innovating of Pervasive Technology for Mobile Work

Popular predictions and futurologies of the disappearance of the computer (Weiser 1991) promise a utopia of seamless, unproblematic interaction through the device. However, in the pursuit of improving our understanding of interactive innovating of technology for mobile work, the advancement of information systems towards Individual Pervasiveness and Pervasive Order introduces unique developments. The interaction of participants and hence the innovation of and experimentation with

pervasive technology experiences dramatic contradictions of mediation, transparency and control. The difficulty of introducing order to previously unordered mobile activities presents further hindrances to innovating of more advanced activities for mobile work.

However, as outlined at the beginning of this dissertation, the diffusion of mobile technologies is increasing at a rapid pace. Mobile devices exercise a significant influence on all participants, regardless of whether these technologies support traditional mobile work, enable occupations to become mobile or help create altogether new mobile professions. In this sense, the use of mobile technology as we know it continues to support ad-hoc interaction and the flexibility of unordered mobile work in which the sovereign human remains at the heart of any activity. This presents an interesting conundrum of interactive innovating of mobile technology or a *mobility conundrum* for short. As outlined above, by arming workers with complex mobile technologies, activities are carried out discretely and without releasing context-specific information to others. The development of technology aimed at lowering the spatial and temporal constraints of work, at increasing the flexibility of mobile work and at making the communication and interaction with mobile workers easier in fact makes the process of understanding work practices and innovating increasingly difficult. It appears that the interactive innovating of mobile technology hinders the development of mobile technology.

As exemplified by the empirical study, the invisibility and difficulty of managing mobile activities currently trigger interactive activities of innovating new, more advanced tools and more advanced central activities. At a time when new information flows make visible more and more details of non-mobile work environments, there are no strong arguments to categorically exclude mobile workers from synchronously details of their fieldwork to legacy systems etc. Instrument producers, employers as well as their clients support that mobile activities, actions and operations must be made more transparent.

The objective of such developments is the optimisation of internal organisational resources, including both human labour and tool use, and the transparency of mobile activities and demands for more immediate and detailed status updates on properties (i.e. objects) in the field. These market-born demands and calls for a new, more

advanced generation of information systems lead to the conceptualisation and development of context-aware, pervasive systems. In the pursuit of the interactive innovating of such pervasive technologies, the close cooperation between innovators, innovation partners and mobile users is of utmost importance (recall Figure 36 as reproduced below). Based on the close interrelatedness and interdependencies of all three activities and participants, the observed experiences are indications of the potential tensions between the instrument-producing activity (Innovators) and the central activity (Trialists).

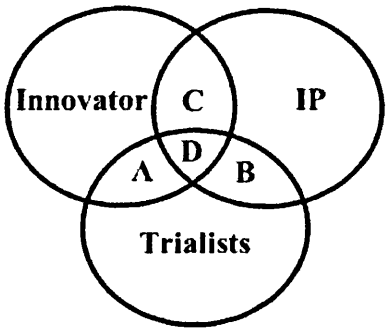


Figure 53: Interaction Framework (Figure 36 reproduced)

The development of future work practices, subject of the Innovation Partner/Trialist interaction (Innovating Space B), clearly concentrates on the interactive negotiation of future rules. In Innovating Space C these are relayed to the instrument producer (i.e., Innovator), who includes these considerations in the development of the hardware, middleware, software architecture as well as midlet programmes. The discussion of how these interactions and elements of mediation, transparency and control aim at technology development for either an unordered, mobile activity or an ordered, pervasive activity directly point to another important contradiction: the openness and closedness of mobile versus pervasive technologies.

Openness and Closedness of the Artefact

The interaction and negotiation of future mobile work practices (Innovating Space B above) is an ongoing process between mobile workers and their employers. Over time, new work practices emerge through constant feedback loops between mobile

workers and superiors. If contradictions arise, the underlying requirements and work rules are amended to ease the tension in the activity, as long as they support the overall objective and do not clearly lead to other contradictions. Technology, in these cases, is an off-the-shelve tool used in the interaction; it is merely a conduit that has no direct connection to the work context. Consequently, mobile activities stem from cultural-historical developments that involve a high degree of interpretive flexible regarding the use of context-indifferent technologies. Mobile activities are entirely people-oriented; they rest on the openness of their affiliation and the ability to negotiate and renegotiate the conditions within which work activities are conducted.

Embedding technologies in the landscape of mobile work, however, has different demands on the activity and its constituents. The innovation and development of context-aware technologies requires the exchange of specific solution-based, context-based and needs-based sets of knowledge in the interaction framework. When this exchange stops to enable the next iteration of the innovative cycles, these negotiations need to be fixed, locked and closed to further negotiation. This enables the actual production of technology and acceptance of it as a tool for the more advanced central activities. In the move from mobile to pervasive systems, the emphasis moves from people-centric to tool-centric activities. Tools are no longer conduits, they move to the very core of mediated activities. Although people can maintain a highly flexible and open affiliation to their work environment, the technology under development requires closure. In other words, the move from unconnected, people-centric systems to tool-centric systems requires a stronger and fixed association between the elements that shape work practices.

Standardisation and closure enable the innovator to complete any particular round of hardware development, any specific software or midlet builds. Pervasive systems must incorporate a set of mobile actions, operations and contingencies, as well as their underlying conditions and goals, to enable the technological context-awareness and resulting information flows. This context-awareness requires standardisation of work practices to overcome the ambiguity of previous mobile activities. Given the flexibility of mobile work, a pre-determined number of contextual possibilities forms the basis of this standardisation that in turn determines the contextual flexibility of the pervasive system. In its respective constitution, pervasive systems are able to replicate

changing contexts in mobile activities, but only within the given parameters. In its closed form, pervasive technology produces "a minimum platform of predictable relations, in an otherwise shifting and contingent world" (Kallinikos 2005, p189). This strong association of elements, or closedness, enables Individual Pervasiveness, the recreation of mobile work realities from a distance and the imposing of a Pervasive Order.

Thus, the activity of interactive innovating of technology for mobile work, which assumes a sense of balance between innovators and users, is faced with a fundamental instability. Mobile workers are used to unordered, autonomous work under rules and work contexts that are temporarily stable and subject to future negotiations with superiors and colleagues. The demands of innovation of pervasive technologies for mobile work, on the other hand, counter this notion of flexibility, openness and change of mobile work activities. This contradiction is no longer concerned with the transparency, control or tool mediation of pervasive activities, but rather focuses on the essence of closedness. The underlying contradiction results no longer from the Individual Pervasiveness and Pervasive Order, but rather the very notion of fixing mobile work practices (i.e., activities, actions and operations) through technological closure.

This openness versus closedness conflict has dramatic consequences and implications for the interactive innovation of technology for mobile work. Mobile workers' future tools become closely tied to their present work activities, or rather their externalisations and representations thereof. In interactive innovation, as outlined in Chapter 5, instrument producers cooperate with mobile users to determine the tool requirements, in other words to arrive at a standardised set of mobile work activities for which a standardised tool can be used. The mobile workers' respective external representations, which become the communication medium between innovator and user, are shaped by their underlying motives for participating in the interactive activity of innovating. Instrument producers, in their quest to normalise and standardise activities especially towards the end of the innovative exercise, request information from the mobile workers to be focused on common work practices. The closer the instrument-producing activity comes to its last innovating iteration, its final closedness, the more do innovators have to rely on standardised mobile activities,

actions and operations. At the same time, mobile workers experience that some of the newly standardised and embedded operations may lead to contradictions of tool mediation, transparency and control, as outlined above. As the contradictions of Individual Pervasiveness and Pervasive Order emerge, they warrant a continued negotiation with superiors from the perspective of the mobile worker. Discontinuing these negotiations and agreeing to freeze the established work practices through the closure of the technological development may not be in the interest of the mobile worker. In an effort to maximise the flexibility of their future work, mobile workers might oppose this move towards the closure of the technology. As evident in the empirical work, this can lead to the continuous provision of new representations and the externalisation of non-standardised actions rather than everyday routine operations by the mobile workers, especially towards the end of the development cycle[9].

The embeddedness and context-awareness of technology and the resulting information flows from and to the mobile work settings strongly shape the interaction of mobile and remote parties. Throughout the activity of innovating technology for mobile work, the interaction between innovators, innovation partners and mobile workers is formed by the transformation of information flows. The different motivations behind the individual activities play an increasingly significant role towards the end of the interactive innovating activity, when it is in the interest of the innovator and innovation partner to close the technological development cycle while mobile workers support its continued openness. The interactive innovating of technology for mobile work is thus strongly shaped by a trajectory from the context-independent, mobile technology and the interpretive flexibility of mobile activities towards the context-aware, pervasive technology and interpretive rigidity of pervasive activities, epitomised through the closure of the interactive innovating activity and hence the technology under development.

[9] This contradiction helps explain why at the beginning of the empirical interactive innovating project, innovator and mobile worker exhibited a sense of camaraderie and towards the end they displayed a sense of hostility towards one another, although the content of their interaction and communication had not changed at all.

7.5 Summary of Pervasiveness of Mobile Work

The technological developments and interactive activities at the heart of this empirical study encourage a fresh, new look at mobility. In Activity Theory terms, this mobility is no longer reserved to subjects who move and interact, but it increasingly involves objects and tools in the world of mobile social affairs. More importantly, mobile RFID, as the first example of this new mobility not only introduces a previously unknown degree of transparency of tools and objects, but also meddles with the formerly people-centric mobility itself. It introduces direct coupling of the activities of mobile workers and their peers, supervisors etc. to previously uncoupled activities; at the same time it increases the cohesion of intra-activity elements beyond previously possible levels of association. It is exactly this linking of subjects, tools, objects and object-oriented behaviour that affects the established concept of mobility. Under this emerging form of pervasiveness, the mobile worker is no longer an autonomous agent and the only source of information regarding mobile activities, but a subject in an increasingly tight net of previously only loosely connected, information-laden activities. Pervasive environments tighten the information about the constituents of a mediated activity (e.g., subject, tool, object), and create much stronger links between them. The resulting information flows through Individual Pervasiveness enable the reconstruction of mobile activities from a distance and make possible the initiation of a Pervasive Order onto mobile work. As a result, a pervasive activity is no longer a fragmented model, but a unified view of mobile work contexts in which the subsequent separation of elements becomes increasingly difficult. Imposing a pervasive technology onto a previously mobile work activity outlines some fundamental differences and contradictions between the two, including conflicts of tool mediation, transparency and control, summarised in the contradiction between a mobile unorder and a pervasive order of activities.

The overall implications for interactive innovation of pervasive technologies for mobile work, therefore, involve a number of contradictions between innovators (instrument producers), employers (Innovation Partners) and their mobile workers. The analysis of mobile work activities for the innovation and development of pervasive technologies centres on the various conflicts that emerge when three parties coalesce to innovate and design a context-aware tool and the future of mobile work.

To understand the impact of pervasive technology, it becomes necessary to gauge the extent to which mobile workers' activities are already transparent, controlled and exposed to some sense of order under mobility. Exploring these elements is essential for comprehending the conditions within which mobile actions and operations are carried out. Consequently, violations of these existing conditions through the pursuit of context-aware technologies and more advanced activities point to possible contradictions between mobility and pervasiveness. Similarly, the transformation of these conditions indicates the mobile workers' potential predisposition to technological closure, and thus to supporting the process of interactive innovation from central, mobile activities to more advanced, pervasive activities of mobile work.

Chapter 8: Conclusion

This final chapter of this dissertation summarises the preceding chapters and presents a condensed version of its findings and contributions to research and practice. The objective-orientation of this research activity, to remain truthful to activity parlance, was to advance the contemporary understanding of innovation of technology for mobile work. The researcher's emphasis on practice-grounded academic research was satisfied through the direct involvement with the innovating and development of a real technology. Fortunately, this research was able to follow mobile RFID from its inception through the complex interactions of various participants and activities that helped shape the mobile RFID technologies. The widely visible global introduction of mobile RFID today emphasises the timely importance and relevance of this research and highlights both the theoretical significance of studying mobile work and the practical promises of this Action Research for technology in the making.

Section 8.1 summarises the individual chapters and their respective roles for this dissertation. In the following section (8.2), contributions to theory and praxis during the study are discussed in separation from the dissertation's wider contributions to research and industry. Section 8.3 outlines the limitations of this research and points to future research inspirations (Section 8.4). Finally, Section 8.5 concludes this dissertation.

8.1 Dissertation Summary

In Chapter 1, I introduced the topic of my research, in broad terms, and indicated the opportunity to advance our understanding of innovation of technology for mobile work in light of the existing research and literature. It placed an emphasis on my interests in the topic and my inspiration to merge the domains of Innovation of Technology and Mobility of Work. At this stage, I introduced the overarching research question of *how the interaction with mobile work affects the innovating of technology* and succinctly presented the empirical study and objectives guiding this research. Subsequently, an outline of the entire dissertation presented the sequence of rigorous ambitions aimed at providing novel contributions to our understanding of innovation and interactive activities pertaining to mobile work.

Chapter 2 provided an in-depth review of mobility literature, both in terms of mobile means of communication and communicative acts. At that point, RFID was first introduced through short vignettes. Subsequently, the subject of innovation was presented through a thorough review of various views and conceptual approaches to the phenomenon. Here, the classification of individualist, structuralist and interactive innovation was used to introduce and highlight aspects of the interwoven, interactive complexities of innovation that dominated the empirical study. At the same time, this review outlined the current product-oriented view of innovation and the resulting lack of our understanding of how mobile systems are indeed innovated. An activity-lens was proposed to address this shortcoming and to examine interactive innovating from a process and activity-perspective.

In Chapter 3, the underpinning commitment to interpretivism and the methodological approach of Action Research were presented. It appeared that no one form of Action Research resembled my novel involvement with the empirical study. This introduced two interesting points. First, there seemed to be a gap in the conceptual suitability of existing forms of Action Research studies of mobile work and equally importantly for our understanding and study of interactive innovating. Second, this lack led to the development of a blended methodology, including the principles of Action Research and role focus and root definitions from Multiview. Although this approach was born out of the lack of a suitable Action Research form for my empirical study, the blended methodological approach put forward promises for other studies of mobility and mobile work. Lastly, Chapter 3 outlined the specific research methods, including types of empirical evidence, forms of collecting them and the interpretation technique employed.

Chapter 4 combined the foci of the two preceding chapters. As previously proposed, applying an activity-lens to the empirical study educated this research with the much-demanded insights into innovating mobile information systems. A discussion of the complexity of my involvement in the empirical settings demanded a more in-depth discussion of the theoretical underpinnings of the adopted Activity Theory approach. This chapter introduced the theory from its early developments to its most recent interpretations and advancements. It concluded with a discussion of Engeström's

Activity Triangle and the notions of contradictions and representations as analytical tools for the empirical study.

In Chapter 5, I operationalised Activity Theory and described the empirical settings in detail. The view of mobile work and innovating as tool-mediated activities placed an emphasis on traditional technologies versus the empirical technology at the heart of this study. Accordingly, mobile RFID and its affordances were introduced first. Then, the respective parties involved in the activity of innovating this technology and their respective activity systems were presented and examined from an interaction perspective. Important for the remainder of the dissertation, Chapter 5 introduced three levels of participants involved in the innovation activity, including the Innovator, Innovation Partners and Trialists. Within this single study of mobile work, different settings of mobile work collectively educated the innovating of mobile RFID. The real-world stories told in this chapter include Nalle as the Innovator and mobile work at Grizzly Waste, Morrison Patrolling and Allô. Especially the focus of their involvement and the resulting experiences at the Grizzly Waste and Morrison Patrolling were important from an interactive innovating perspective and became the primary focus of the subsequent analyses.

Chapter 6 concentrated on the collective activity of interactive innovating of technology for mobile work. Different epistemologies of participants were introduced through the Interaction Framework. By drawing from the inherent Innovating Spaces, this chapter focused on the various neighbouring activities of Innovator, Innovation Partner and Trialists. The chief arguments of their interactions were illuminated through the inherent contradictions of instrument-producing activities, activities aimed at developing a more advanced central activity and the underlying central activities of mobile workers. The resulting discussion highlighted the contradictions within and between these three Activity Systems, based on interaction, artefacts and mobility of work. It emphasised emerging conflicts in the empirical setting and their impact on the activity of innovating in general. It further illuminated the materialisation of a more fundamental difference of mobile work environments before and during the empirical work.

Chapter 7 was directed at the analytical difference of mobilities that emerged in the previous chapter, but moved from the empirical setting to an analysis of innovation of

technology for mobile work from a wider IS perspective. In an effort to examine the extent to which work environments, shaped by their underlying technologies and technological affordances, influence the activity of interactively innovating technology, this chapter juxtaposed mobility and pervasiveness at work. The deconstruction of the concept of mobility and of the impact of embeddedness of technology within mobile work environments led to the introduction of the concept of Individual Pervasiveness. Marked by an individual's technology's awareness of its immediate context, details of its bearer and his behaviour can be synchronously and autonomously communicated to remote parties. In a move from a mobile to a pervasive environment, this ability led to important contradictions of mediation and transparency, which became ultimately manifested through new opportunities for remote control and a Pervasive Order imposed onto previously unordered mobile work. With respect to the topic of *Interactive Innovating of Technology for Mobile Work* that guided this dissertation, this contradiction shaped the overall relationship between mobile and pervasive work. Mobile work proved as a people-centric activity and relied on flexibly arranged work constellations; a pervasive work environment on the other hand relied on tool-centric activities and required rigidity, standardization and the closure of the technological artefact at the heart of pervasive activities. The fundamental perspective of this chapter supports that, as we move from mobile work to a higher embeddedness of tools within pervasive work environments, the potential instability of this trajectory shapes the Innovator's ability to rely on the support and interaction with Innovation Partners and mobile workers for activities aimed at innovating technology for mobile work.

8.2 Research Contributions

This research is, in general terms, a contribution to our continued effort to innovate, design and develop information systems to support people at work. More specifically, its contributions focus on understanding the complex interaction necessary to determine the needs and goals of end users, corporate users and innovators of mobile information systems. At the core of these activities, as displayed in the last two chapters, is our continuous effort to understand the interplay of mobile work activities and technology.

Study-Specific Contributions

Throughout the empirical study, the exchange of the researcher's results from the field with the Innovator led to a number of insights that shaped the actual technology in the making. The regular reports delivered to Nalle were incorporated into the innovating activity and led directly to changes to the technology throughout the innovative cycles. The development of the Interaction Framework, although surprising to the Innovator at first, led to the Innovator and Innovation Partners' appreciation of different epistemologies that shape their interaction with workers in the field. Ultimately, this explicit acknowledgement permitted changes for tag-design and the refinement of the mobile RFID systems to align the technology more closely with demands of mobile work. The mobile RFID devices emerging in North America and Europe today are in part shaped by this particular study and its direct involvement with the primary innovator.

The research component, the blended methodology of Action Research and Multiview, was perceived as a very successful approach and has since been applied to a number of other studies. The physical outcome of the action component of this research, namely the actual artefact, promises to become the subject of many more studies that examine mobile RFID and privacy, security of mobile RFID, logistics and retail management, to name a few.

Other practical contributions of course involve the direct improvement of the Innovation Partners' understanding of their mobile work activities. Details of numerous collective activities, actions and operations in the field surfaced and exposed previously unknown work practices, some positive, some negative. Accordingly, the various Innovation Partners were able to re-evaluate their current interactive activities involving superiors, technology and mobile workers. The notion of mobility versus pervasiveness, for instance, and the inherent impact on the interaction between Innovation Partner and mobile workers in the field was an entirely new concept to all participants. The fundamental difference of these two work environments led to a reconsideration of mobile RFID as a new tool and way forward for managing mobile work. In practical terms, the contribution of this study *during* the Action Research was invaluable to practitioners and informed many of the subsequent changes to their work activities.

Beyond this Study: Contributions to Theory

The use of an Action Research method, in methodological terms, offered the opportunity to narrow the gap between its constituent elements, namely action and research and to respond to calls for studies that are truly grounded in practice. This study provided a close connection of the technology under investigation, either as a tool or an object of work activities, and to its surrounding environment, helping bridge the divide between either technically or socially-oriented investigations of mobile information systems (Orlikowski and Iacono 2001). More specifically, by developing a contingent framework based on these two established research methodologies (i.e., Action Research and Multiview), it presents a unique and rigorous approach that at the same time remains unconditionally true to the actual research that informed this study. In essence, my approach criticises the existing understanding of established forms of Action Research as suitable for all research settings. Especially in complex mobile work settings such as the one informing this study, we need to adopt our research methods to changing work environments in order to remain truthful to our many roles as action researchers. Beyond this study, this novel approach shows that blending Action Research with other methodological tools is possible, albeit much more difficult than simply subscribing to one of the cleaner, more traditional forms of Action Research. I hope that this method will inspire the advancement of Action Research as an interventionist methodology that remains devoted to both action and research in complex environments.

With a focus on the complex activity of innovating, this study complements the existent body of literature that is predominantly product-focused and diffusion-oriented. By examining three participants of innovating, it is the first study that concentrates on the multiple learning and shared understanding of technology and work practices of Innovator, Innovation Partner and end user (i.e., Trialist), when other studies are primarily concerned with developer, managerial *or* user-acceptance issues. The contradictions that emerged in this interplay have the potential to inform further research that aims to understand the innovating of technology as well as studies concentrating on the diffusion, adoption and appropriation of technology for mobile work.

Furthermore, this study examines the usefulness of Activity Theory's account for technologies, or tools and their affordances, as these increasingly meddle with human activities. Here, a clear difference was drawn between mobile, unordered activities and pervasive, ordered activities. The concepts of Individual Pervasiveness and Pervasive Order promise to inform future studies as we witness technology becoming increasingly embedded into work environments and more actively involved in otherwise human affairs. Simultaneously, for our studies of interactive innovating, this activity-lens put forward a number of unique insights for mobile environments of work. It points to fundamental differences of mobile workers who participate in interactive activities of innovating technology for mobile work when this requires the closure of innovation cycles and the fixing of the technological development. The alignment of openness and interpretive flexibility under mobility vis-à-vis the closedness and rigidity of pervasiveness contributes to our understanding of how technology indeed intervenes with human affairs. This conceptual demarcation promises to inform further studies of highly embedded technologies.

Beyond this Study: Practical Contributions

The usefulness of this study for practical purposes is manifold. Based on its closeness to industry (Innovators, Innovation Partners and mobile workers), this dissertation presents a practice-grounded and reflective view of the activity of innovating technology for mobile work.

The lessons-learnt throughout this study present value to innovators setting off on interactive innovating activities. Contradictions based on interaction and communication, the role of technology and representations etc. point towards areas that require particular attention. Among the organisations involved, the research methodology was seen as highly suitable for mobile environments and has since been implemented as a standard approach and template for a number of interactive innovating activities. For these reasons, the methodology applied and discussed has already proven its contribution to industry. By extension, its expressed value shows signs of the methodology's usefulness for other innovators, developers and designers who subscribe to an interactive philosophy. Similarly, the acknowledgement of epistemological differences among participants is important and the interactive spaces

outline the need for care and detail exercised throughout interaction with innovation partners and users of the technology. With a focus on technology for mobile work, this dissertation presents reflections on mobility and distribution and sheds light on how these elements shape the activity of interactive innovation and the resulting technology.

For innovation partners, the study puts forward interesting dimensions of object-orientation and tool-mediation that shape how changes to work practices are accepted in general. More specifically, to those considering the introduction of more advanced tools and activities to their mobile workforce, this dissertation outlines many considerations and potential contradictions that may prove crucial to the success of new work practices, especially when these approach pervasive environments.

8.3 Limitations

The lengthy empirical investigation and in-depth analytical work led to a number of theoretical and practical contributions. Despite these advancements of both theory and practice, the study is of course limited by the investigative methods chosen and applied. As such, I acknowledge the following limitations of my work.

True to its interpretivistic nature, this study did not aim to produce generalisable findings (Lee and Baskerville 2003). While this may be seen as a definite drawback, the aim of this study was to seek a deep understanding of the activities involved in the empirical setting through rich, qualitative work. Although the findings are not presented as law-like generalisations applicable for all settings, their value lies in their usefulness to inform other studies of information systems.

Similarly, the involvement of the researcher in the middle of the empirical setting and all activities concerned, involving the analysis of qualitative materials, limits the study's value as objective research. Especially in an interventionist approach such as Action Research, the researcher becomes part of the study – an enormous limitation, or flaw, in the eyes of positivism. At the same time, interpretivist arguments clearly support that this limitation provides the actual strength of the study, through simultaneously addressing current practical problems and expanding scientific knowledge. This section is not intended to unfurl the old and persistent arguments of

these two ontological perspectives, but acknowledges that the strengths of one can be viewed as limitations by the other, and vice versa. I acknowledge that the study is directly shaped, and in a sense limited, by its exposure to very specific empirical settings, activities and participants in the United Kingdom.

Furthermore, the study is limited by the time frame within which it was conducted. Longer-term changes to the respective neighbouring activity systems and their interaction were not studied. While a longer time frame would have likely yielded dissimilar results, such a long-time perspective was beyond the scope of this research. More directly, the study was clearly focused on the time-sensitive process, or activity, of innovating technology for mobile work. The heart of this study, from the outset, was a short-term focus on the activity of innovating, which was pursued through closely following the innovation of mobile RFID. Studies of longer-term aspects of this technology amid mobile work activities are left to scholars of diffusion, appropriation and adoption, among others.

8.4 Inspiration for Future Research

This study introduces vastly increasing levels of mobility of data and much higher levels of embeddedness of technology within mobile (work) environments. It is this dissertation's aim to inspire its audience to pay attention to how embedded technologies and their interaction change our everyday activities before our eyes. We can witness how technological embeddedness is just now progressing through its early stages and, partially through the distribution of RFID tags and mobile RFID readers, supports a sharp increase of synchronous interaction woven into the context of our work and personal environments. At the same time, the addition of increasingly smart technology (e.g., GPS, temperature sensors) fuels this current move towards pervasive activities.

This dissertation argues that this progression from mobility to pervasiveness is marked by a transition from people-centric to tool-centric activities. This trajectory gives weight to future studies that look at technology and work through an activity-lens, further investigating the shifting emphasis of the human subject versus the technical artefact. Means of communication and communicative acts fundamentally

change, of course affecting all interaction-led activities. This includes, among others, interactive innovation, but also affects such tool-mediated activities as the management and control of mobile work, mobile learning, the balance of professional and personal time of mobile workers, privacy and ethics discussions of information systems etc. It would be wonderful if this dissertation helped inform further studies that take seriously the role that technology plays within human affairs.

8.5 Conclusion

This dissertation is the outcome of four years of studying and aligning abstract theoretical concepts with the reality of innovating technology for mobile work. Much of this time was spent in the field, learning from interesting Innovators, Innovation Partners and mobile workers. Throughout this time, theory educated the actual work setting and vice versa, eventually leading to new theoretical insights and ultimately supporting the development of mobile RFID as a new tool for mobile work.

Most importantly, along its path this research unearthed a number of true surprises that repeatedly put my understanding of innovating, technology and mobile work to a test. This dynamic back-and-forth between practice and theory truly facilitated learning in action, leading to a substantial improvement of my understanding of the research topic and ultimately to this dissertation.

References

Agre, P. E. (2001). "Changing Places: Contexts of Awareness in Computing." Human-Computer Interaction **16**(2-4): 177-192.

Al-Taitoon, A. (2005). Making Sense of Mobile ICT-Enabled Trading in Fast Moving Financial Markets as Volatility-Control Ambivalence: Case Study on the Organisation of Off-Premises Foreign Exchange at a Middle-East Bank. London School of Economics, Information Systems. London, University of London. **PhD**.

Al-Taitoon, A. and C. Sørensen (2004). Supporting Mobile Professionals in Global Banking: The Role of Global ICT-Support Call-Centres. HICSS, Hawaii.

Albrecht, K. and L. Macintyre (2005). Spychips: How Major Corporations and Government Plan to Track Your Every Move with RFID, Nelson Current.

Alter, C. and J. Hage (1993). Organisations Working Together. Newbury Park, CA, Sage.

Amabile, T. (1988). "A Model of Creativity and Innovation in Organizations." Research in Organizational Behavior **10**: 213-167.

Angell, I. (2005). Unorder and Disorder, London School of Economics.

Angell, I. and J. Kietzmann (forthcoming). "RFID and the End of Cash?" Communications of the ACM.

Association for Automatic Identification and Mobility (2004). Glossary of Radio Frequency Identification (RFID) Terms. http://www.aimglobal.org/technologies/rfid/resources/papers/rfid_glossary_of_terms.htm.

Avgerou, C. (2001). "The significance of context in information systems and organizational change." Information Systems Journal **11**(1): 43-63.

Avison, D., F. Lau, et al. (1999). "Action Research." Communications of the ACM **42**(1).

Avison, D. E. and A. T. Wood-Harper (1990). Multiview : an exploration in information systems development. Oxford ; Boston, Blackwell Scientific Publications.

Avital, M., D. Robey, et al. (2004). "Surfing the next wave: Design and implementation challenges of ubiquitous computing environments - Social and Organizational Issues in Ubiquitous Computing." Communications of the ACM **13**: 697-176.

Baldridge, J. and R. Burnham (1975). "Organizational Innovation: Individual, Organizational end Environment Impacts." Administrative Science Quarterly **20**(2): 165-176.

Bannon, L. J. (1997). Activity Theory. CHI97, University of Limerick: 1-6.

Barthelmess, P. and K. M. Anderson (2002). "A View of Software Development Environments Based on Activity Theory." Computer Supported Cooperative Work **11**.

Baskerville, R. (1999). "Investigating Information Systems with Action Research." Communications of the AIS **2**(19).

Baskerville, R. and M. D. Myers (2004). "Making IS Research Relevant to Practice." MIS Quarterly **28**(3): 329-335.

Baskerville, R. and A. T. Wood-Harper (1996). "A Critical Perspective on Action Research as a Method for Information Systems Research." Journal of Information Technology **11**(3): 235-246.

Baskerville, R. and A. T. Wood-Harper (1998). "Diversity in Information Systems Action Research Methods." European Journal of Information Systems **7**: 90-107.

BBC (2005). Mobiles Rack Up 20 Years of Use. http://news.bbc.co.uk/1/hi/technology/4138449.stm.

Benbasat, I., D. Goldstein, et al. (1987). "The Case Research Strategy in Studies of Information Systems." MIS Quarterly **11**(3): 369-386.

Bijker, W. E., T. P. Hughes, et al. (1987). The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology. Cambridge, MA, MIT Press.

Bjerknes, G. and T. Bratteteig (1987). Perspectives on Description Tools and Techniques in System Development. System Design for Human Development and Productivity: Participation and Beyond. P. Docherty, K. Fuchs-Kittowski, P. Kolm and L. Mathiassen. Amsterdam, North-Holland.

Blanton, B. (1995). Yrjo Engeström Trajectory. LCHC. San Diego, University of California.

Booth-Thomas, C. (2003). The See-It-All-Chip. Time Online Edition.

Bourdieu, P. (1977). Outline of a Theory of Practice. Cambridge, Cambridge University Press.

Bourgeois, J. (1981). "On the Measurement of Organizational Slack." Academy of Management Review **6**(1): 29-39.

Bowker, G. and S. L. Star (1999). Sorting Things Out: Classification and Its Consequences. Cambridge, Massachusetts, MIT Press.

Bødker, S. (1991). Through the Interface: A Human Activity Approach to User Interface Design. Hillsdale, New Jersey, Lawrence Erlbaum Associates.

Bødker, S. (1998). "Understanding Representation in Design." Human-Computer Interaction **13**: 107-125.

Bødker, S. and K. Grønbæk (1991). "Cooperative prototyping: users and designers in mutual activity." International Journal of Man-Machine Studies **34**(3): 453-478.

Brooks, R. (1991). Comparative Task Analysis: An Alternative Direction for Human-Computer Interaction Science. Designing Interaction: Psychology at the Human Computer Interface. J. Carroll. Cambridge, Cambridge University Press: 50-59.

Brown, B. and K. O'Hara (2002). "Place as a practical concern of mobile workers." Environment and Planning A **11**(11).

Cairncross, F. (1997). The Death of Distance. Boston, Mass, Harvard Business School Press.

Castells, M. (1996). The Rise of the Network Society. Malden, Mass., Blackwell Publishers.

Chandler, D. (1994). Semiotics for Beginners. http://www.aber.ac.uk/media/Documents/S4B/ Date Accessed: April 2005.

Checkland, P. (1981). Systems Thinking, Systems Practice. Chichester, UK, J. Wiley.

Chesbrough, H. W. (2003). "The Era of Open Innovation." MIT Sloan Management Review **44**(3): 35-42.

Christensen, C. M. (1997). The Innovator's Dilemma: When new technologies cause great firms to fail. Boston, MA, Harvard Business School Press.

Ciborra, C. (1997). "De Profundis? Deconstructing the Concept of Strategic Alignment." Scandinavian Journal of Information Systems **9**(1): 67-82.

Ciborra, C. (2004). The Mind or the Heart? It Depends on the (Definition Of) Situation. London, London School of Economics.

Ciborra, C. U. (2002). The Labyrinths of Information: Challenging the Wisdom of Systems. Oxford, UK, Oxford University Press

Cohen, W. M. and D. A. Levinthal (1990). "Absorptive Capacity: A New Perspective on Learning and Innovation." Administrative Science Quarterly **35**(1): 128-152.

Cole, M. (1996). Cultural Psychology: A once and future discipline. London, The Belknap Press of Harvard University Press.

Collins, P., S. Shukla, et al. (2001). "Activity Theory and System Design: A View from the Trenches." Journal of Computer Supported Collaborative Work (Special Issue): 1-22.

Conway, S., O. Jones, et al. (2001). Realising the Potential of the Network Perspective in Innovation Studies. Social Interaction and Organizational Change: Aston Perspectives on Innovation Networks. O. Jones, S. Conway and F. Steward. London, UK, Imperial College Press.

Cooper, R. B. and R. W. Zmud (1990). "Information technology implementation research: A technological diffusion approach." Management Science **36**(2): 123-139.

Corner, J. and J. Hawthorn, Eds. (1989). Communication: Definition and Approaches. Communication Studies. London, Edward Arnold.

Cousins, K. C. and D. Robey (2005). "Human Agency in a Wireless World: Patterns of Technology Use in Nomadic Computing Environments." Information and Organization **15**(2): 151-180.

Cousteau, T. (2004). Mobile Guarding and Response at Morrison Patrolling. J. Kietzmann. Manchester.

Daft, R. L. and R. H. Lengel (1984). Information Richness: A New Approach to Managerial Behavior and Organizational Design. Research in Organizational Behavior. L. L. Cummings and B. M. Straw. Greenwich, CT, JAI Press: 191-233.

Daft, R. L., R. H. Lengel, et al. (1987). "Message Equivocality, Media Selection, and Manager Performance: Implications for Information Systems." MIS Quarterly **11**(3): 355-366.

Daft, R. L. and K. E. Weick (1984). "Toward a Model of Organizations as Interpretation Systems." Academy of Management Review **9**: 284-295.

Dahlbom, B. and L. Mathiassen (1997). "The Future of Our Profession." Communications of the ACM **40**(6): 80-90.

Davis, F. D., R. P. Bagozzi, et al. (1989). "User Acceptance of Computer Technology: A Comparison of Two Theoretical Models." Management Science **35**: 985-1003.

Davis, J. and T. Devinney (1997). The Essence of Corporate Strategy: Theory for Modern Decision Making. Australia, Allen & Unwin.

Davison, R. M., M. G. Martinsons, et al. (2004). "Principles of Canonical Action Research." Information Systems Journal **14**(1): 65-86.

Decortis, F., S. Noirfalise, et al. (1997). Activity Theory as Framework for Cooperative Work. CHI97, University of Liege.

Dix, A. (2000). "Exploiting Space and Location as a Design Framework for Interactive Mobile Systems." ACM Transactions on computer human interaction (TOCHI) **7**(3): 285-321.

Dourish, P. (2001). Where the action is: The foundations of embodied interaction, MIT Press.

Eason, K. (1996). "Division of labour and the design of systems for computer support for cooperative work." Journal of Information Technology **11**(1): 39-50.

Ehn, P. (1993). Scandinavian Design: On Participation and Skill. Participatory Design: Principles and Practices. D. Schuler and A. Namioka. Mahwah, NJ., Lawrence Erlbaum Associates: pp. 41-77.

Ehn, P. and M. Kyung (1987). The Collective Resource Approach to System Design. Computers and Democracy: A Scandinavian Challenge. G. Bjerknes, P. Ehn and M. Kyng. Aldershot, England, Avebury.

El Sawy, O. A. (1985). "Implementation by Cultural Infusion: An Approach for Managing the Introduction of Information Technology." MIS Quarterly **9**(2): 131-140.

Elichirigoity, F. (2004). Embedded Mobilities. The Life of Mobile Data: Technology, Mobility and Data Subjectivity, University of Surrey, UK.

Engeström, Y. (1987). Learning by Expanding - An Activity Theory Approach to Developmental Research. Helsinki, Orienta-Konsultit Oy.

Engeström, Y. (1990). Learning, Working and Imagining. Helsinki, Orienta-Konsultit Oy.

Engeström, Y. (2001). Expansive Learning at Work: Toward an Activity Theoretical Reconceptualization. London, Institute of Education.

Engeström, Y., K. Brown, et al. (1991). "Coordination, Cooperation and Communication in the Courts." The Quarterly Newsletter of the Laboratory of Comparative Human Cognition **13**(4): 88-97.

Engeström, Y. and R. Engeström (1988). Seeking the Zone of Proximal Development in Physicians' Work Activity. First International Congress on Activity Theory, Berlin.

Engeström, Y., R. Engeström, et al. (1999). When the Center Doesn't Hold: The Importance of Knotworking. Activity theory and social practice: Cultural-historical approaches. S. Chaiklin, M. Hedegaard and U. Jensen. Aarhus, Denmark, Aarhus University Press.

Ferscha, A. (2000). Workspace Awareness in Mobile Virtual Teams. IEEE 9th International Workshops on Enabling Technologies.

Fichtner, B. (1984). Co-ordination, co-operation and communication in the formation of theoretical concepts in instruction. Learning and teaching on a scientific

basis: Methodological and epistemological aspects of the activity theory of learning and teaching. M. Hedegaard, P. Hakkarainen and Y. Engeström. Aarhus; Aarhus Universitet, Psykologisk Institut: 207-227.

Fischer, G. (2001). Communities of Interest: Learning through the Interaction of Multiple Knowledge Systems. IRIS24, University of Bergen.

Fleck, J. (1988). Innofusion or diffusion? The nature of technical development in robotics., Edinburgh PICT Working Paper (4).

Floyd, C., W.-M. Mehl, et al. (1989). "Out of Scandinavia: Alternative Approaches to Software Design and System Development." Human-Computer Interaction **4**: 253-350.

Fontana, E. R. and C. Sørensen (2005). From Idea to Blah! Understanding Mobile Services Development as Interactive Innovation. In 2nd CONTECSI: International Conference on Information Systems and Technology Management, Sao Paulo, Brazil.

Fortunati, L. (2001). "The Mobile Phone: An Identity on the Move." Personal and Ubiquitous Computing **5**(2).

Francis, J. (2004). Container Services at Grizzly Waste Management. J. Kietzmann. Manchester.

Galliers, R. D. and F. F. Land (1987). "Choosing Appropriate Information Systems Research Methodologies." Communications of the ACM **30**(11).

Garfinkel, S. and B. Rosenberg (2006). RFID: Applications, Security, and Privacy, Addison-Wesley Professional.

Gibson, J. J. (1997). The Ecological Approach to Visual Perception. Hillsdale, NJ, Lawrence Erlbaum.

Goodman, D. (2004). Waste Removal at Grizzly. J. Kietzmann. Manchester.

Gough, N. (2005). The Effect of Wireless Telecommunications on Economic Development in Africa, American Enterprise Institute for Public Policy Research.

Graham, J. M. (2002). An Exploration into New Forms of Organizing: Building a Theory and Process Model to Enhance Understanding of Innovating Firms and Organizations. School of Business. Washington D.C., George Washington University. **PhD**.

Granovetter, M. S. (1983). "The Strength of Weak Ties." Sociological Theory **1**(1): 201-233.

GSM-Association (2005). Growth of the global digital mobile market.

Hansmann, U., L. Merck, et al. (2003). Pervasive Computing: The Mobile World. Heidelberg, Springer Verlag.

Harrop, P. J., N. Eberhardt, et al. (2004). Total Asset Visibility. Cambridge, UK, IDTechEx Ltd.

Heron, J. and P. Reason (2001). The Practice of Co-operative Inquiry: Research 'with' rather than 'on' People. A Handbook of Action Research. London, Sage Publications: 179-188.

Hildreth, P., C. Kimble, et al. (1998). Computer Mediated Communications and International Communities of Practice. Ethicomp '98, Erasmus University - The Netherlands.

Hirschheim, R. (1985). Information Systems Epistemology: An Historical Perspective. Research Methods in Information Systems. E. Mumford, G. Fitzgerald and A. T. Wood-Harper. Amsterdam, North-Holland: 13-38.

Höök, K., D. Benyon, et al., Eds. (2003). Designing Information Spaces: The Social Navigation Approach. Computer Supported Cooperative Work. London, Springer-Verlag.

Hosbond, J. H. and P. A. Nielsen (2005). Mobile Systems Development: A Literature Review. IFIP 8.2, Cleveland, OH.

Huneycutt, J. L. (1996). The World Wide Web: Relevant Issues in the Diffusion of an Innovation. Department of Education. Charlottesville, University of Virginia. **PhD:** 188.

Izadi, S., C. Pedro, et al. (2002). "The FUSE Platform: Supporting Ubiquitous Collaboration Within Diverse Mobile Environments." Automated Software Engineering **9**(2): 167-186.

Jenssen, J. I. and G. Jørgensen (2004). "How do Corporate Champions Promote Innovation?" International Journal of Innovation Management **8**(1): 63-87.

Jones, M. L. W. (1995). Where do you want to go tomorrow? Shaping alternative technological futures via ethnographically informed participatory design. School of Communication. Vancouver, Simon Fraser University. **M.A.:** 231.

Kakihara, M. (2003). Hypermobility: Emerging Work Practices of ICT-Enabled Professionals. PhD Thesis, Information Systems. London, London School of Economics and Political Science. **PhD.**

Kakihara, M. and C. Sørensen (2001). "Expanding the 'Mobility' Concept." Siggroup Bulletin **22**(3): 33-37.

Kakihara, M. and C. Sørensen (2002). Mobility: An Extended Perspective. Hawai'i International Conference on System Sciences, Big Island, Hawaii.

Kakihara, M. and C. Sørensen (2002). 'Post-Modern' Professionals' Work and Mobile Technology. New Ways of Working in IS: The 25th Information Systems Research Seminar in Scandinavia, Copenhagen Business School, Copenhagen Business School.

Kalakota, R. and M. Robinson (2002). M Business: The Race to Mobility, McGraw-Hill.

Kallinikos, J. (2001(a)). The Age of Flexibility. Lund, Academia Adacta AB.

Kallinikos, J. (2005). "The order of technology: Complexity and control in a connected world." Information and Organization **15**(3): 185-202.

Kaptelinin, V. and B. A. Nardi. (1997). "Activity Theory: Basic Concepts and Applications." Retrieved May 8, 2003, from http://acm.org/sigchi/chi97/proceedings/tutorial/bn.htm.

Khazanchi, D. and B. E. Munkvold (2000). "Is Information Systems a Science? An Inquiry into the Nature of the Information Systems Discipline." The DATABASE for Advances in Information Systems **31**(3).

Kim, S., H. Cho, et al. (2003). "Interoperability between UMTS and CDMA2000 Networks." IEEE Wireless Communications **10**(1): 22-28.

Kim, T.-G. (2004). Mobile SMS spam surpasses email spam in Korea. The Korea Times.

Klein, H. K. and K. Lyytinen (1985). The Poverty of Scientism in Information Systems. Research Methods in Information Systems. E. Mumford, R. Hirschheim, E. Fitzgerald and A. T. Wood-Harper. Amsterdam, North-Holland.

Kleinrock, L. (1996). "Nomadicity: Anytime, Anywhere in a Disconnected World." Mobile Networks and Applications **1**: 351-7.

Kristoffersen, S., J. Herstad, et al. (1998). Developing scenarios for Mobile CSCW. First Workshop on Human Computer Interaction with Mobile Devices.

Kristoffersen, S. and F. Ljundberg (1998). "Mobile Informatics: Innovation of IT Use in Mobile Settings." IRIS 21 Workshop Report - SIGCHI Bulletin **31**(1): 29-34.

Kristoffersen, S. and F. Ljungberg (2000). Mobility: From Stationary to Mobile Work. Planet Internet. Lund, Studentlitteratur: 137-156.

Kuutti, K. (1996). Activity Theory as a Potential Framework for Human Computer Interaction Research. Context and Consciousness: Activity Theory and Human Computer Interaction. B. A. Nardi. Cambridge and London, MIT Press: 17-34.

Landau, S. (2004). Traffic Management at Grizzly Waste Management. J. Kietzmann. Manchester.

Lave, J. and E. Wenger (1991). Situated Learning: Legitimate Peripheral Participation, Cambridge University Press.

Lee, A. (1999). "Rigor and Relevance in MIS Research: Beyond the Approach of Positivism Alone." MIS Quarterly **23**(1).

Lee, A. and R. Baskerville (2003). "Generalizing Generalizability in Information Systems Research." Information Systems Research **14**(3).

Lee, S.-G. (2004). Integrative Study of Mobile Technology Adoption. Management, University of Nebraska.

Leontiev, A. N. (1974). "The Problem of Activity in Psychology." Soviet Psychology **13**(2): 4-33.

Leontiev, A. N. (1978). Activity, Consciousness, and Personality. Englewood Cliffs, NJ, Prentice-Hall.

Lesser, E. L. and J. Storck (2001). "Communities of Practice and Organizational Performance." IBM Systems Journal **40**(4): 831-841.

Lilischkis, S. (2003). More Yo-yos, Pendulums and Nomads: Trends of Mobile and Multi-Location Work in the Information Society. STAR Project Issue Report N. 36, STAR.

Lindgren, R., O. Henfridsson, et al. (2004). "Design Principles for Competence Management Systems: A Synthesis of an Action Research Study." MIS Quarterly **28**(3): 435-472.

Ling, R. (1998). She calls, [but] it's for both of us you know: The use of traditional fixed and mobile telephony for social networking among Norwegian parents. R&D Report 33/98. Kjeller, Norway, Telenor.

Ljungberg, F. and C. Sørensen (2000). Overload: From Transaction to Interaction. Planet Internet. K. Braa, C. Sørensen and B. Dahlbom. Lund, Studentlitteratur: 113-136.

Lyytinen, K. and Y. Yoo (2002). "The Next Wave of Nomadic Computing." Information Systems Research **13**(4): 377-388.

Mahajan, V. and R. A. Peterson (1985). Models for Innovation Diffusion. Beverly Hills, CA, Sage Publications.

Mahaux, I. (2004). Gas Engineering at Grizzly Waste Management. J. Kietzmann. Manchester.

Mann, S. and H. Niedzviecki (2002). Cyborg: Digital Destiny and Human Possibility in the Age of the Wearable Computer, Doubleday Canada.

Mark, G., J. Haake, et al. (1997). "Hypermedia Use in Group Work: Changing the Product, Process, and Strategy." The Journal of Collaborative Computing **6**: 327-368.

Marshall, C. and G. B. Rossman (1995). Designing Qualitative Research. Thousand Oaks, CA, Sage.

Mårtensson, P. and A. Lee (2004). "Dialogical Action Research at Omega Corporation." MIS Quarterly **28**(3): 507-536.

Mathiassen, L. (2002). "Collaborative Practice Research." Scandinavian Journal of Information Systems **14**: 57-73.

Mathiassen, L. and C. Sørensen (Forthcoming). "A Theory of Organizational Information Services." Under Review for International Journal.

McCullough, M. (2004). Digital Ground: Architecture, Pervasive Computing, and Environmental Knowing. Cambridge, Massachusetts.

McPhee, R. D. and M. S. Poole (2000). Organizational Structures and Configurations. The New Handbook of Organizational Communication. F. M. Jablin and L. L. Putnam. Thousand Oaks, Sage Publications, Inc.: 503-544.

Merriam-Webster (2005). Innovation.

Metcalfe, R. (1995). Metcalfe's Law: A network becomes more valuable as it reaches more users. Infoworld.

Meyrowitz (1994). Medium Theory. Communication Theory Today. D. Crowley and D. Mitchell. London, Polity Press: 55-77.

Miller, N. (2004). Mobile Guarding and Response at Morrison Patrolling. J. Kietzmann. Manchester.

Mingers, J. (2001). "Combining IS Research Methods: Towards a Pluralist Methodology." Information Systems Research **12**(3): 240-259.

Mitchell, W. J. (2003). Me++ : the cyborg self and the networked city. Cambridge, Mass., MIT Press.

Moore, G. A. (1991). Crossing the Chasm. New York, HarperBusiness.

Mumford, E. (2001). "Advice for an Action Researcher." Information, Technology & People **14**(1): 12-27.

Mwanza, D. (2002). Towards an Activity-Oriented Design Method for HCI research and practice. Human-Computer Interaction. Walton Hall, Knowledge Media Institute, The Open University: 298.

Myers, M. D. (1997). "Qualitative Research in Information Systems." MIS Quarterly **21**(2): 241-242.

Nardi, B. (1996). Studying Context: A Comparison of Activity Theory, Situated Action Models, and Distributed Cognition. Context and Consciousness: Activity Theory and Human-Computer Interaction, MIT Press.

Nardi, B. and V. O'Day (1999). Information Ecologies - Using Technology with Heart. Cambridge, MIT Press.

Nardi, B. A. (1995). Activity Theory and Human-Computer Interaction. Activity Theory and Human Computer Interaction. Cambridge, MIT Press: 4-5.

Nardi, B. A. (1995). Studying Context: A Comparison of Activity Theory, Situated Action Models, and Distributed Cognition. Activity Theory and Human Computer Interaction. Cambridge, MIT Press: 35-52.

Nardi, B. A., S. Whittaker, et al. (2001). "NetWORKers and their Activity in Intensional Networks." Journal of Computer Supported Collaborative Work(Special Issue).

National Institute of Standards and Technology (2001). Pervasive Computing. http://www.nist.gov/pc2001/.

Ngwenyama, O. K. and A. S. Lee (1997). "Communication Richness in Electronic Mail: Critical Social Theory and the Contextuality of Meaning." MIS Quarterly **21**(2): 145.

Nonaka, I. and N. Konno (1998). "The concept of 'Ba': Building foundation for Knowledge Creation." California Management Review **40**(3).

Norman, D. (1988). The design of everyday things. USA, Basic Books.

Norman, D. (1991). Cognitive Artifacts. Designing Interaction: Psychology at the Human-Computer Interface. J. M. Carroll. New York, Cambridge University Press: 17-38.

Norman, D. (1999). The Invisible Computer: Why Good Products Can Fail, the Personal Computer Is So Complex, and Information Appliances Are the Solution, MIT Press.

Odlyzko, A. and B. Tilly (2005). A refutation of Metcalfe's Law and a better estimate for the value of networks and network interconnections. Minneapolis, MN, Digital Technology Centre, University of Minnesota.

Oldfield, A. (2003). Mobility Seminar at LSE. J. Kietzmann. London.

Olson, G. M. and J. S. Olson (2000). "Distance Matters." Human-Computer Interaction **15**: 139-178.

Online-Etymology-Dictionary (2005). Innovation.

Orlikowski, W. (2000). "Using Technology and Constituting Structures: A Practice Lens for Studying Technology in Organizations." Organizational Science **11**(4): 404-428.

Orlikowski, W. and J. J. Baroudi (1991). "Studying Information Technology in Organizations: Research Approaches and Assumptions." Information Systems Research **2**(1): 1-28.

Orlikowski, W. and S. Iacono (2001). "Desperately Seeking the "IT" in IT Research-A Call to Theorizing the IT Artifact." Information Systems Research **12**(2): 121 -134.

Owen-Smith, J. and W. W. Powell (2004). "Knowledge Networks as Channels and Conduits: The Effects of Spillovers in the Boston Biotechnology Community." Organization Science **15**(1): 5-22.

Oxford-English-Reference-Dictionary (1995). Innovation. Oxford, Oxford University Press.

Patton, M. Q. (1990). Qualitative Evaluation and Research Methods Newbury Park, Sage.

Pedersen, P. E. and R. Ling (2003). Modifying Adoption Research for Mobile Internet Service Adoption: Cross Disciplinary Interactions. Hawaii International Conference on System Science, Big Island, HI, IEEE Computer Society Press.

Peltz, D. C. (1983). "Quantitative case histories of urban innovations: Are there innovation stages?" IEEE Transactions on Engineering Management **30**(1): 60-67.

Perrin, S. (2006). RFID and Global Privacy Policy. RFID Applications, Security and Privacy. S. Garfinkel and B. Rosenberg. Upper Saddle River, NJ, Addison-Wesley.

Perrow, C. (1999). Normal Accidents. Living with High-Risk Technologies. New York, Basic Books.

Perry, M. and J. Brodie (2005). Virtually Connected, Practically Mobile. Mobile Virtual Work: A New Paradigm? Berlin, Springer.

Perry, M., K. O'Hara, et al. (2001). "Dealing with Mobility: Understanding access anytime, anywhere." ACM Transactions on computer human interaction (TOCHI) **8**(4): 323-347.

Peters, M. (2004). Security Services and Dispatching at Morrison. J. Kietzmann. Manchester.

Pettigrew, A. and E. Fenton (2000). The Innovating Organization. Thousand Oaks, CA, Sage Publications, Inc.

Pica, D. and C. Sørensen (2004). "On Mobile Technology in Context: Exploring Police Work." Journal of Computing and Information Technology **12**(4): 287-295.

Pica, D., C. Sørensen, et al. (2004). On Mobility and Context of Work: Exploring Mobile Police Work. HICSS 2004, Hawaii.

Pierce, J. L. and A. L. Delbecq (1977). "Organization, structure, individual attitudes and innovation." Academy of Management Review **2**: 27-37.

Pierre, S. (2001). "Computing and Ubiquitous Computing: Concepts, Technologies and Challenges." Telematics and Informatics **18**: 109-131.

Pinelle, D. and C. Gutwin (2003). Designing for loose coupling in mobile groups. Proceedings of the 2003 international ACM SIGGROUP conference on Supporting group work, Sanibel Island, Florida, USA, ACM Press.

Plant, S. (2001). On the Mobile, Motorola.

Pooley, C. G., J. Turnbull, et al. (2005). A Mobile Century? Changes in Everyday Mobility in Britain in the Twentieth Century. Aldershot, Ashgate.

Porter, M. (2001). "Strategy and the Internet." Harvard Business Review: 62-78.

Porter, M. and V. E. Millar (1985). "How Information gives you competitive advantage." Harvard Business Review: 2-13.

Powell, W. W., W. Koput, et al. (1996). "Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology." Administrative Science Quarterly **41**(1): 116-130.

Raeithel, A. (1983). Tätigkeit, Arbeit und Praxis. Grundbegriffe für eine praktische Psychologie. Frankfurt am Main, Campus.

Rice, R. E. and U. E. Gattiker (2000). New Media and Organizational Structuring. The New Handbook of Organizational Communication. F. M. Jablin and L. L. Putnam. Thousand Oaks, Sage Publications, Inc.: 544-584.

Roberge, P. A. (2004). 'Killer combination not 'killer application' defines RFID and contactless in '05. RFID News and RFID Operations. http://www.rfidnews.org/news/2004/12/21/killer-combination-not-killer-application-defines-rfid-and-contactless-in-05/.

Robertson, M., J. Swan, et al. (1996). "The Role of Networks in the Diffusion of Technological Innovation." Journal of Management Studies **33**(3): 333-359.

Robey, D. (1981). "Computer Information Systems and Organization Structure." Communications of the ACM **24**(10): 679-687.

Rogers, E. (1983). Diffusion of Innovations. New York, Free Press.

Rogers, E. and A. Singhai (1996). Diffusion of Innovations. An Integrated Approach to Communication Theory and Research. M. Salwen and D. Stacks. Mahway, NY, Lawrence Erlbaum Associates.

Rogers, E. M. and F. F. Shoemaker (1971). Communication of Innovations. New York, Free Press.

Rogers, Y. and M. Scaife (1997). Activity Theory. CHI97, University of Sussex.

Rosander, C. (2000). Interactivity and Spatiality – Design of Future IT-enhanced Work Places. IRIS 23. Laboratorium for Interaction Technology, Uddevalla, University of Trollhättan.

Rothwell, R. (1992). "Successful Industrial Innovation: Critical Successfactors for the 1990s." R&D Management **22**(3): 221-239.

Rouvinen, P. (1999). Essays in Technology, R&D and Innovative Activity. Economics. Nashville, Tennessee, Vanderbilt University. **PhD:** 131.

Satyanarayanan, M. (1995). Fundamental Challenges in Mobile Computing. ACM Symposium on Principles of Distributed Computing, Philadelphia, PODC.

Scarbrough, H. (1995). "Blackboxes, Hostages and Prisoners." Organization Studies **16**(6): 991-1019.

Scarbrough, H. and J. Swan (2005). Developing the Process Perspective on Networked Innovation. Theorizing Process in Organizational Research. Santorini, Greece, European Group for Organizational Studies.

Schaitel, R. (2004). Container Services at Grizzly Waste. J. Kietzmann. Manchester.

Schmidt, K. (1993). The Articulation of Cooperative Work — Requirements for Computer Support. Developing CSCW Systems: Design Concepts. Report of CoTech WG4, February 1993. K. Schmidt. Roskilde, Denmark, Risø National Laboratory: 37-104.

Schmidt, K. (1994). Mechanisms of interaction reconsidered. Social Mechanisms of Interaction. K. Schmidt. Lancaster, ESPRIT BRA 6225 COMIC, Lancaster University, England. http://www.comp.lancs.ac.uk/computing/research/cseg/comic/. 15–122.

Schultz, F. (2004). Mobile Monitoring and Response at Morrison Patrolling J. Kietzmann. Manchester.

Schumpeter, J. A. (1950). Capitalism, Socialism and Democracy. New York, Harper.

Seely Brown, J. and P. Duguid (1991). "Organisational Learning and Communities of Practice." Organization Science **2**(1): 40-57.

Senge, P. and O. Scharmer (2001). Community Action Research: Learning as a Community of Practitioners, Consultants and Researchers. Handbook of Action Research. London, Sage: 238-249.

Shah, S. and M. Tripsas (2004). When Do User-Innovators Start Firms? Towards A Theory of User Entrepreneurship University of Illinois Working Paper #04-0106.

Short, J., E. Williams, et al. (1976). The social psychology of telecommunications. London, Wiley.

Slappendel, C. (1996). "Perspectives on Innovation in Organizations." Organization Studies **17**(1): 107-129.

Smith, F. (2004). Gas Engineering at Grizzly Waste Management. J. Kietzmann. Manchester.

Sørensen, C. (2005). Beyond the Transaction Perspective for Knowledge Management Software Artifacts. New Frontiers in Knowledge Management. K. C. Desouza. UK, Palgrave: 117-146.

Sørensen, C., H. Fagrell, et al. (2000). Traces: From Order to Chaos. Planet Internet. K. Braa, C. Sørensen and B. Dahlbom. Lund, Sweden, Studentlitteratur.

Sørensen, C. and D. Gibson (2006). The Professional's Everyday Struggle to Ubiquitize Computers. Computerization Movements and Technology Diffusion: From Mainframes to Ubiquitous Computing. K. Kraemer and M. Elliott.

Sørensen, C. and D. Pica (2005). "Tales from the Police: Mobile Technologies and Contexts of Work." Information and Organization **15**(3): 125-149.

Springer, B. (2004). Container Services at Grizzly Waste Management. J. Kietzmann. Manchester.

Star, S. L. and J. R. Griesemer (1989). "Institutional Ecology, "translations" and boundary objects: Amateurs and professionals in Berkley's Museum of Veterinary Zoology, 1907-1939." Social Study of Science: 387-420.

Sternberg, R. (1988). The Nature of Creativity: Contemporary Psychological Perspectives. Cambridge, UK, Cambridge University Press.

Steward, J. (2005). Context Perspectives for Scenarios and Research Development in Mobile Systems. Mobile World: Past, Present and Future. L. Hamill and A. Lasen. London, Springer.

Straub, D. and E. Karahanna (1998). "Knowledge Worker Communication and Recipient Availability." Organization Science **9**(2): 160-175.

Street, C. T. and D. B. Meister (2004). "Small Business Growth and Internal Transparency: The Role of Information Systems." MIS Quarterly **28**(3): 473-506.

Suchman, L. (1993). Do Categories Have Politics? The Language/Action Perspective Reconsidered. ECSCW '93. Proceedings of the Third European Conference on Computer-Supported Cooperative Work, 13-17 September 1993, Milan, Italy. G. De Michelis, C. Simone and K. Schmidt. Dordrecht, Kluwer Academic Publishers: 1-14.

Suchman, L. A. (1987). Plans and situated actions. The problem of human-machine communication. Cambridge, Cambridge University Press.

Susman, G. and R. Evered (1978). "An Assessment of The Scientific Merits of Action Research." Administrative Science Quarterly **23**(4): 582-603.

Swan, J. and S. Newell (2000). Linking Knowledge Management and Innovation. European Conference on Information Systems, Vienna.

Swanson, E. B. and N. C. Ramiller (1997). "The Organizing Vision in Information Systems Innovation." Organization Science **8**(5): 458-474.

Taylor, A. (2005). Introduction. Mobile Communications. R. Ling and P. E. Pedersen. Surrey, UK, Springer-Verlag UK.

Thompson, J. D. (1967). Organizations in Action. Social Science Base of Administrative Theory. New York etc., McGraw-Hill.

Tidd, J., J. Bessant, et al. (1997). Managing Innovation. Chichester, Wiley.

Topalian, A. (2000). "The Role of Innovation Leaders in Developing Long-Term Products." International Journal of Innovation Management **4**(2): 149-172.

Urry, J. (2000). "Mobile sociology." The British Journal of Sociology **51**(1): 185-203.

Vartiainen, M. (2005). Mobile Virtual Work - Concepts, Outcomes and Challenges. Mobile Virtual Work: A New Paradigm? M. Vartiainen and J. H. E. Andriessen. Berlin, Springer.

Von Hippel, E. (1988). The Sources of Innovation. Oxford, UK, Oxford University Press.

Von Hippel, E. (2005). Democratizing Innovation. Cambridge, MA, The MIT Press.

Vygotsky, L. S. (1978). Mind in Society - The Development of Higher Psychological Processes. Massachusetts, USA, Harvard University Press.

Walsh, M. (2004). Mobile Monitoring and Response and Morrison Patrolling. J. Kietzmann. Manchester.

Walsham, G. (1995). "Interpretive Case Studies in IS Research: Nature and Method." European Journal of Information Systems **4**(2): 74-81.

Walsham, G. (1995). "The Emergence of Interpretivism in IS Research." Information Systems Research **6**(4): 376-394.

Wartofsky, M. (1979). Models: Representation and Scientific Understanding. Dordrecht, Reidel.

Warwick, K. (2005). "What happens when a man is merged with a computer?" Retrieved July 20, 2006, from http://www.kevinwarwick.org/Cyborg1.htm.

Weber, R. (2004). "The Rhetoric of Positivism Versus Interpretivism: A Personal View." MIS Quarterly **28**(1).

Weinberg, J. (2006). RFID, Privacy, and Regulation. RFID Applications, Security, and Privacy. S. Garfinkel and B. Rosenberg. Upper Saddle River, NJ, Addison-Wesley.

Weiser, M. (1991). The Computer for the 21st Century. Scientific American.

Wenger, E. (1998). Communities of Practice. Cambridge, Cambridge University Press.

Whipp, R. and P. Clark (1986). Innovation and the Auto Industry: Product, Process and Work Organization. London, Francis Pinter.

Wiberg, M. (2001). In between Mobile Meetings: Exploring Seamless Ongoing Interaction Support for Mobile CSCW. Informatics. Umeå, Umeå University.

Wiberg, M. and Å. Grönlund (2000). Exploring mobile CSCW. IRIS 23. Laboratorium for Interaction Technology, Uddevalla, University of Trollhättan.

Wiberg, M. and F. Ljungberg (2000). Exploring the vision of anytime, anywhere in the context of mobile work. Knowledge management and Virtual organizations: Theories, Practices, Technologies and Methods, Brint Press.

Wiethoff, M., T. Meulenbroek, et al. (2005). Participative Design for Home Care Nursing. Mobile Virtual Work: A New Paradigm? J. H. E. Andriessen and M. Vartiainen. Berlin, Springer.

Wikipedia (2004). various terms.

Wikipedia (2005). Inventions.

Winters, J. (2004). Container Services at Grizzly Waste. J. Kietzmann. Manchester.

Wiredu, G. O. (2005). Mobile Computing in Work-Integrated Learning: Problems of Remotely-Distributed Activities and Technology Use. PhD Thesis, Information Systems. London, London School of Economics and Political Science. **PhD**.

Wood-Harper, A. T. and B. Wood (2005). "Multiview as Social Informatics in Action: Past, Present and Future." Information, Technology & People **18**(1): 26-32.

Zager, D. (2001). "Collaboration as an Activity." Journal of Computer Supported Collaborative Work (Special Issue).

Zaltman, G., R. Duncan, et al. (1973). Innovations and Organizations. New York, John Wiley & Sons.

Zmud, R. (1998). "Editor's Comments." MIS Quarterly **22**(2): xxxix-xxxii.

Zuboff, S. (1988). In the Age of the Smart Machine : the Future of Work and Power. New York, Basic Books.

Zuboff, S. (1995). Running in Place. B. Schultz, Network World Inc.