Chapter I
For Those About to Tag

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ABSTRACT

The recent evolution of mobile auto-identification technologies invites firms to connect to mobile work in altogether new ways. By strategically embedding "smart" devices, organizations involve individual subjects and real objects in their corporate information flows, and execute more and more business processes through such technologies as mobile Radio-Frequency Identification (RFID). The imminent path from mobility to pervasiveness focuses entirely on improving organizational performance measures and metrics of success. Work itself, and the dramatic changes these technologies introduce to the organization and to the role of the mobile worker are by and large ignored. The aim of this chapter is to unveil the key changes and challenges that emerge when mobile landscapes are "tagged", and when mobile workers and mobile auto-identification technologies work side-by-side. The motivation for this chapter is to encourage thoughts that appreciate auto-identification technologies and their socio-technical impact on specific mobile work practices and on the nature of mobile work in general.

INTRODUCTION

Mobile work is everywhere; and despite claims by vendors and organizational consultants mobility is neither new nor particularly novel. On the contrary, many traditional occupations have always been highly mobile, including the work of taxi-drivers, policemen, traveling merchants, entertainers and trades people, to name a few. Their degree of mobility may differ, but what mobile workers have in common is a fluid arrangement of workspaces, times and contexts. Despite a long tradition of mobile work arrangements, for example Hackney carriage drivers started in London, UK in 1622, the phenomenon of mobility has not received much attention by organizational scholars over time.

The advancement of modern mobile technologies from the heavy, transmission-weak and battery-hungry, expensive mobile phones of the 1980s to the omnipresent devices of today have raised mobility to the fore of both industry and

academia. Interaction among mobile workers, but also with location-dependent colleagues, superiors and clients is carried out via technologies that allow subject-object-subject communication, with the device as a tool that facilitates the exchange of voice, video or data.

Surprisingly, until recently, the success of the mobile phone has not brought many radical innovations forward. Improvements of mobile technologies are seen primarily as incremental, with no new breakthroughs or killer-applications in sight. However, emerging mobile auto-identification technologies invite firms to connect in various ways to their mobile landscape. By strategically embedding technologies with a very small footprint, events involving individual subjects and real objects can be included within organizational information flows. Mobile radio-frequency identification (mobile RFID), for instance, allows firms to place transponders (i.e. tags) and transceivers (i.e. readers) throughout the terrain they cover to initiate object-to-object communication and drive mobile business processes.

In light of these developments, industry and academia have predominantly examined the increasing embeddedness of such context-aware technologies in terms of their impact on the information content of work. The imperceptible object-object interaction enabled by auto-identification technologies is hailed as a dramatic improvement for logistics and supply-chain management. However, along this path from mobility to pervasiveness, work itself, and the dramatic changes these technologies introduce to the organization and to the role of the mobile worker have so far been neglected. The introduction of mobile RFID is discussed here as an example of many auto-identification technologies that mark the move from a mobile landscape, in which mobile workers communicate at will with others as they navigate their terrain, to a pervasive ecosystems that exists as an interactive system between its living, human participants, the objects that shape their work and the environment in which they exist.

The motivation of this chapter is to discuss the fundamental difference of mobility and pervasiveness, with a focus on the user-technology relationship which, in today's attempts to optimize organizational effectiveness and efficiency through embedded technologies, has been entirely overlooked.

The aim of this chapter is to unveil the key changes and challenges that emerge when mobile landscapes are "tagged", and to prepare the reader for the impact that tagging technologies can have on mobile work environments. This chapter should be useful for developers of mobile technology, but also for application developers. Most importantly, this chapter is aimed at "those about to tag" – at practitioners who contemplate the adoption of auto-identification technologies to improve their organizational information flows.

MOBILE LANDSCAPES

The term and concept of mobility is difficult to delineate; and in many ways are any attempts to define mobility too restrictive or not focused enough to be meaningful in any way (Kristoffersen & Ljungberg, 2000). However, a discussion of changing mobile environments requires the delimitation of mobility and location. In this light, common approaches conceptualize mobility and mobile technologies as the opposite of the fixed-location devices.

In its early days, mobility indicated that a particular application could be carried out at different but specific geographical localities, whether within urban spaces or at remote sites. This notion of connectivity at different locales was of enormous significance when devices were first networked in a wireless fashion, and mobility referred more closely to the concept of portability of devices. Remember working on laptop computers and having to find a wired access point (in an Internet Café, possibly) to send your emails? How about the early adopters of mobile telephony,

who were plagued by poor signal reception and widespread dead spots? Those were the days of portable technology, when the worker used to travel to the data. Under mobility today, at least in urban environments with the adequate infrastructure, users are less concerned with where they are. With GSM, 3G, GPRS etc., data travels to the mobile worker, and as conquering a larger terrain becomes less of a novelty, mobile connectedness across space, time and contexts becomes more of a necessity to the contemporary worker.

Space

The essence of *spatial mobility* 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, p. 238) facilitated through mobile technology.

In pursuits of higher degrees of spatial mobility, many seemingly new devices are introduced to 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, artifacts 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 that span spatial boundaries.

For practitioners, this often means that their workers are equipped with mobile technology, and that work that had to be pre-planned before could now be arranged more dynamically and on the fly. For many, the mobile phone is seen as a silver-bullet that enables mobile workers "to exchange and retrieve information they need quickly, efficiently and effortlessly, regardless of their physical location" (Hansmann, Merck, Nicklous, & Stober, 2003, p. 13). However, despite all of the new networking and communication choices, the concept of mobility does not suggest the "death of distance" (Cairncross, 1997), or more importantly that location may become inconsequential. 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 & Robey, 2005), at a particular place, at a particular time (Wiberg & Ljungberg, 2000).

Accordingly, more and more people and devices are on the move, requiring more and more information to cross spatial boundaries. Nonetheless, mobility has not solved all of the problems. Many mobile activities are emergent, any upcoming tasks in the field might not even be known by mobile workers themselves, let alone their remote colleagues (Kakihara & Sørensen, 2001). Managing schedules, for example, has become much more difficult for on-site movers who move about at a specific work site, yo-yos who occasionally work away from a fixed loca-

tion, pendulums who work at two different sites, nomads who work from many sites and carriers who work on the move (Lilischkis, 2003). While their work can be managed more flexibly, this flexibility requires increased communication between mobile workers and their peers. As a result, mobile work is most important for purposes of data exchange and communication but is still seen 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 not only plays an important role in the examination of where and how mobile work is carried out, but also in the mobile management of time.

Time

In addition to bridging spatial boundaries, mobile information and communication technologies allow people to communicate across temporal constraints. Particularly synchronous technologies have of course shaped interaction with workers in the field, and the mobile phone continues to be the communication medium of choice in most instances. Asynchronous technologies such as mobile email are also important, especially for those who work from areas that do not provide sufficient signal strength for mobile telephony or instant messaging. Either communication option allows mobile workers to plan their tasks with less of a focus on time, as site visits etc. can be rearranged flexibly with supervisors, colleagues or clients. Similarly, mobile workers can now use their time away from their real work to be productive. Mobile technologies are heralded as reviving dead time, time spent at airports, in traffic, or between meetings, thereby surpassing both the spatial and the temporal constraints of fixed-location technologies.

Context

Spatial and temporal dimensions of mobile communication are the more obvious improvements introduced through modern technology. Both are based on the objective affordances (Gibson, 1977) of the devices, infrastructures and supporting technologies. A more subjective affordance (Dourish, 2001) refers to how people and mobile technologies interact in different contexts (Perry, O'Hara, Sellen, Brown, & Harper, 2001). A call in the middle of a meeting, for instance, requires the businesswoman to shift from her work context to the context of being a mother, a text message during a security guard's site visit interrupts his work and requires him to shift contexts and pay attention to his mobile phone. With features such as call waiting, incoming calls even interrupt ongoing calls, requiring mobile workers to juggle two calls, and contexts, at a time, perhaps even while driving or carrying out some other mobile work tasks.

Most communication devices function in a binary fashion; based on signal reception they either render their users are generally available or not accessible to everyone. For the practitioner, this means that mobile workers need to be more flexible, and manage potential interruptions and the danger of communication overload through screening incoming phone-calls and selecting whom to answer or to ignore, prioritizing 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 & Sørensen, 2000). As a result, individuals' work schedules, their tasks' start and completion times are harder to predict (Perry, O'Hara, Sellen, Brown, & Harper, 2001).

Today, context shifts and interruptions with email and particularly with mobile telephony raise expectations of responsiveness, and mo-

bile workers spend a great portion of their days replying 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 information and communication technologies (ICTs) change the contexts in which people communicate and interact on a personal and professional level.

The following scenario is a common account of mobile work today, and the reader likely recognizes how mobile technology is deployed to span spatial, temporal and contextual constraints. It shows how the use of mobile ICTs is dramatically shaped by the situation in which this communication occurs, but also shows how mobile interaction shapes the mobile work activity itself.

VIGNETTE A: MOBILE WORK AT MORRISON SECURITY PATROLLING

Simon, a security guard for Morrison Patrolling starts his shift at 6pm, five evenings per week. He arrives at the main office, where he collects a worksheet that contains the various stops for his shift, a vehicle and a mobile phone. Throughout his twelve-hour shift, Simon does not return to the office. He patrols the assigned premises and ensures they are secure. In the event that they are not, he calls his superior to inform him that he will be late for his remaining stops. In the event of an emergency at a different site, a dispatcher calls Simon on his mobile phone to direct him away from his scheduled visits and towards the more urgent matter. For all activities, Simon keeps a paper-based log with the pertinent details. Of course, as security guards spend their days away, it is very difficult for the superior or dispatcher to know where Simon and his colleagues are throughout their shifts. As a result, guards, supervisors spend an enormous amount of time on the phone, inquiring and reporting on mobile workers' progress, location or upcoming stops. Moreover, Morrison's customers, who never know if their sites have been checked and if they are secure, continuously call Morrison's managers, who then need to call the mobile security guards before they call their customer back with the respective information.

Communication involving mobile workers like Simon, in most cases, suggests that the communication is not carried out face to face, but via a mediating tool, a mobile communication device. This requires that any information from the field needs to be needs to be sourced, worded and communicated by the respective mobile workers in the field. Not only does this suggest that this information is highly subjective, but also that the mobile worker has a high degree of discretion with which he can shape the information passed on to others. In one instance, a mobile security guard could mistakenly report that a site was secure, when in fact it had been compromised. In the scenario above, the mobile worker could knowingly pretend to be at a different location to circumvent being sent to an emergency by the traffic dispatcher. As a result, the mobile worker is at the heart of mobile communication, in charge of mobile interaction even to the point where he could simply ignore an incoming call. In the mobile landscape, the mobile worker is in charge, not only of his work activities but also of communication with others (see also Kalakota & Robinson, 2002). The objects that shape the mobile landscape, including the tools the mobile workers uses and the sites he visits are marginalized, and details of mobile work are only communicated through subjective representations, via the phone or through documents, composed by the mobile worker (Kietzmann, 2008a).

THE MOBILITY OF THINGS

Mobility mostly refers to the extension of people's geographical reach, spanning both time and context. The mobile landscape is the result of communication carried out between different subjects, with the help of mobile phones, for instance, that enables and mediate the subject-object-subject interaction from a distance. Accordingly, mobility mostly refers to people who navigate the mobile landscape. But what happens when objects start to talk to each other? How does this influence mobile communication?

The movement of objects 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 traveling (Kakihara, 2003). In discussions of mobile interaction, objects often refer to activity-supporting objects, including paper and pen, but also technological artifacts such as mobile phones, PDAs and BlackBerry terminals. Traditional mobility 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 mobile RFID and Near-Field Communication are giving life to objects.

Mobile Radio Frequency Identification

Traditional, non-mobile Radio Frequency Identification (RFID) is an auto-identification technology that has been available for several decades, perhaps with the first remarkable use in WWII, when the Royal Air Force employed RFID to differentiate between friendly and enemy aircraft. The planes of the Allied Forces were equipped with bulky RFID active transponders (tags) that received power on board. On the ground RFID transceivers (readers) sent out signals that would communicate with these tags. When a plane was approaching, and a communication between these components could be established, it was assumed that it was a friendly plane. If however, the signal sent out by the reader did not trigger a response from the tag, the assumption was that it was an enemy aircraft that should be attacked.

Applications today still rely on similar communication between RFID tag and reader; although now the tags are miniscule microchips attached to an antenna, and are generally passive. This means, the tags do not have a constant power-source, but are powered by an electromagnetic field emitted by the reader. In most cases, radio signals inform nearby readers of a serial number stored on the tag, which uniquely identifies any item that bears it. So-called Smart Tags are used to track or trace objects everywhere. Think of the readers at the exit of a retail store that sound an alarm when an unpaid item is taken out of the store. Especially high value items, but also those that are popular store-loot are tagged, and the tag needs to be disabled at the register before they can be taken out of the store. Similarly, worldwide, such tags already help keep track of more than 100 million pets and 20 million livestock (Booth-Thomas, 2003).

The Auto-ID Center, initially established as an academic research project headquartered at the 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 attached to every imaginable item, and even people, are revolutionizing logistics, supply chain and inventory management around the world, based on three main advantages of RFID over current alternatives (e.g., barcode). First, RFID can identify items from a distance, without line of sight requirements. This means no

more optical scanners at supermarket checkouts, for instance. Second, RFID can read multiple items at once. A truck can drive through the gates of a warehouse, and the inventory of the warehouse is automatically updated with all the items arriving at or leaving the premises. Third, RFID is unique. Barcode describes batches of items, for instance soda-cans from the same flat carry the same information. With RFID, each can can be uniquely identified and traced. Together, these three properties lead to a dramatic shift of interaction with and between objects. Especially when readers and tags communicate from a distance they transform subject-object-subject communication to object-object interaction.

But all of the readers mentioned above are stationary, attached to a store or a warehouse, and the tags are mobile. What would happen if the readers were mobile, too?

Mobile RFID was introduced only a few years ago, and surprisingly has so far stayed under the radar of industry and academia. Unlike other mobile technology developments, mobile RFID introduces entirely new affordances and interaction possibilities to mobile work. Mobile RFID utilizes 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 centimeters). Passive tags, for instance, are able to initiate communication once they are in the proximity of a reader, and vice versa. Imagine the following:

VIGNETTE B: WORK WITH MOBILE RFID TECHNOLOGY

For Morrison Patrolling, tagging the mobile landscape and supplying the mobile security guards with mobile RFID readers promised to overcome many of the mobility-related difficulties. Simon and his mobile colleagues were trained to use the mobile reader, tags were positioned throughout their work environment, and Simon's office-bound co-workers were shown how to use the data coming from the mobile RFID driven system. Mobile guards then read tags attached to many objects within their mobile landscape (e.g., at gates, doors and windows) and selected status responses from the menu on their mobile phone. For instance, when a property was secured and checked, a security guard placed the reader close to the tag on a door and selected "all ok" from the phone's menu. This information was synchronously sent to the back-office. In other events, temperature sensors were attached to tags, and once a security guard with his reader was nearby, the tags queried him to conduct certain safety checks. In even more complex setups, a connected sensor measured the temperature in a room, and once it exceeded its allowable limit, it sent a text message to the mobile worker or even left a voice message, asking him to come to the room's rescue immediately. The auto-identification properties and the mobility and synchronicity of the RFID system virtually eliminated manual logs and work-sheets and drastically reduced the time guards had to spend on the phone to report on their whereabouts. Managers, too, had to spend much less time manually locating and coordinating the security guards, reports could be drawn up within minutes and Morison's customers could access RFID-events via extranet sites.

These advantages are compelling, and "those about to tag" have been convinced that auto-identification will solve their current mobility-related information flow problems. However, introducing mobile RFID, for example, is not just about adding a more advanced technology – it is a big organizational intervention. It is often unclear that everyday objects, as a result, become more active participants in mobile communication; they adopt an increasingly important role in our discussions of mobility.

While some might argue that this interaction is simply machine-to-machine interaction, mobile RFID still involves human participation. However, the important change is that in many cases

it is the human involvement that is on-demand, requested by objects in motion, not the other way around. Mobile objects increasingly assume a heightened level of agency in mobile interactions that increasingly rely on mobile data, or information. 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 organizational data transmitted is immense. In addition to wired artifacts (e.g., landlines, desktop computers), or fixed-location wireless devices (e.g., satellites), mobile devices supply an ever-growing share of data transmissions. Thanks to mobile phones, BlackBerry terminals, pagers and even short-range Bluetooth enabled devices, the need to be at specific locations to transmit, broadcast and receive data is at a decline. Moreover, wireless local-area networks, often open to the public or inviting customers at a minimal charge, and wireless broadband connections (e.g. WiFi cities) are increasingly popular, adding to the mobility of data and objects and bringing us ever closer to a truly pervasive ecosystem.

TOWARDS PERVASIVE ECOSYSTEMS

In order for auto-identification technologies to become useful for mobile work, they need to "know" more about the mobile context they are supporting. Basic mobile technologies are off-the-shelve devices that support workers across all possible activities, regardless of the context of their mobile landscape. A mobile phone knows nothing about its environment, and does not respond to unique changes other than signal reception. In a pervasive ecosystem; however, different technologies (e.g., embedded tags, sensors, webcams) must to varying degrees "understand" which environmental and use characteristics to reveal (e.g., the temperature of a room, users' facial expressions) (Höök, Benyon, & Monroe, 2003) and when to involve the human participant.

For the practitioner, this raises many new challenges. IT directors, systems designers, who previously often worked on technology outside of its future application, now increasingly focus on embedding technologies within their specific use 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 behavior to intent" (McCullough, 2004, p. 50). Thus argued, industry need to move from linear to more complex and interactive ways of viewing both technology and its future use. For pervasive environments, professionals have to learn how to capture, codify and represent mobile work contexts most appropriately, to "disregard irrelevant details while isolating and emphasizing those properties of artifacts and situations that are most significant" (Brooks, 1991, p. 53). Developing and implementing context-aware mobile auto-identification systems is tremendously difficult, and many developers of mobile information systems might find that they are not well suited for the challenge. In a different paper, the author of this chapter outlines an innovative approach to understanding mobile work and an interactive way to developing mobile information systems accordingly (Kietzmann, 2008a). In this discussion of tagged environments, the focus is more on the impact the technology will have on its users and their communication practices.

A Mobile World

In a mobile landscape, the interaction depends on the mobile worker's discretion and willingness to conduct mobile work accurately 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. In Simon's case, his patrolling logs were composed in his own language, according to his frames of reference. The resulting

reports formed the most important representations of his mobile work, the only common objects shared by mobile workers, mobile colleagues and their remote supervisors. The worker's discretion and the accuracy of his representations of otherwise purely cognitive accounts of their work determine the overall reliability and validity of the interaction and its context. However, such subjective, imprecise evidence of details of mobile work requires extensive synchronization with other logs and legacy systems to replicate the chain of events of mobile actions and operations.

Who does not remember the countless calls that were necessary between manager and mobile worker to understand what had happened in the field? How about those necessary to understand the reports written by mobile workers? Some are illegible because they have been written in a moving vehicle; others are unclear because they refer to specific objects that are well known to the mobile worker, but not his manager. Due to this inherent ambiguity of details of mobile activities, the drawback of asynchronous representations and the challenge of interpreting others' externalizations, 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.

In any event, the mobile worker maintains control over the technology and 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). 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; the human remains at the core of the mobile activity.

A Tagged World

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 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.). For this, "no revolution in artificial intelligence is needed – just the proper embedding of computers into the everyday world" (Weiser, 1991, p. 3). As technology is becoming increasingly embedded and context aware, for instance through RFID or sensor technology, mobile and stationary people and objects can interact, collect and receive data from a distance. The embeddedness of pervasive technology meets current demands for an increased time and data-sensitive understanding of the contexts of mobile work, as employers of mobile workers 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 resulting pervasive ecosystem

provides cohesive, context-specific information directly to the tag-reading device. 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 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 landscapes, in pervasive ecosystems, objects 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., gates and doors) 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 pervasive ecosystem, this interaction and embeddedness, that determines mobile behavior 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, & Ljungstrand, 2000), but through a pervasive ecosystem (see Figure 2) in which "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, p. 10).

FOR THOSE ABOUT TO TAG

In pervasive ecosystems, all participants, human or not, are directly coupled and their activities are highly cohesive. In other words, mobile work practices are no longer communicated selectively and by the choice of the individual, but by object-object interaction. This, of course, has a tremendous impact on the mobile worker, her mobile and stationary colleagues, and their long-established communication protocols. Pervasive ecosystems query a number of details with each tag-reader interaction in the field, and synchronously communicate the results via an interaction server to the back-office. While this interrogation sounds highly complex, it is actually quite simple.

Once a system learns about four dimension of a mobile activity, it can provide a highly contextual picture of mobile work. Location, identity, status and time form the basis for this "individual pervasiveness" (Kietzmann, 2008b). For our security guard, this means that each time he approaches a gate, for instance, and tag and reader connect, information is sent to the back-office that contains the identity of the object (and hence its location), the identity of the worker, the status of the object ("all ok"), and the time of the event. Similarly, superiors or even objects can reverse this information flow and impose a "pervasive order" (ibid.) onto mobile work (e.g., a machine can call the worker, or traffic managers can liaise a message through a tag to the worker). This object-driven information flow changes mobile work, particularly as it relates to elements of transparency, control and discretion.

For those about to tag, this raises the following questions.

First, is the mobile landscape one that can be understood at all? Can the complexity of what mobile workers accomplish every day actually be captured and translated meaningfully into a context-aware auto-identification system?

Second, who owns the information that needs to be captured so that it can be codified? To a large extent, this will likely be the mobile workers, as they usually are the only individuals who know the mobile landscape in detail.

Third, why would these mobile workers support the new system? Why not? These are questions of control and discretion. If the mobile work environment was heavily regulated before, the new order that the pervasive system will introduce might not pose a great threat to mobile workers (e.g., heavily controlled occupations like bus drivers). If the mobile workers were left to their own judgment before, like taxi drivers, they might refuse to use the system outright. This relates to the second question. If the mobile workers are the only individuals who understand the context of their work, and if they resist the notion of working in a more closely controlled environment, where will the necessary context-information come from? Will it be reliable?

Fourth, how is agency affected by the tagged environment? In a mobile landscape, as outlined above, communication rests with the mobile worker and the phone and other interaction tools are simple conduits. In a pervasive ecosystem, the communication is driven increasingly by these tools, and the person becomes the conduit. If mobile workers like this new arrangement, the tagged environment has a much higher chance of success. Under pervasiveness, the mobile worker has much less control over the type of information revealed, and over the content that becomes visible to others. A previously sovereign mobile worker all of a sudden becomes dependent on the information system, and the discretion with which he carries out his work is now not up to the judgment of the worker but to the embedded knowledge and pre-programmed logic of the context-aware system. A security guard who previously used his expert-knowledge to navigate through traffic and might have changed the sequence of the stops along his route now is required to follow the sequence ordered by the mobile RFID system.

Fifth, who else is affected? Will everyone support the new system? Tagged environments not only change mobile workers' job description, but also affect everyone who works with data from the field. In the Morrison Patrolling case, superiors and traffic managers who were able to schedule their mobile workers and trusted that they completed their work independently now had transparent data that they could not ignore. Some RFID driven events even demanded that superiors form decisions, which were previously left up to the mobile worker. This requires a system-wide look at users, not just a look at the mobile workers. If good data comes from the field, but those in the back office have no reason to use it, the auto-identification system will fail to live up to its promise.

Lastly, the perception of auto-identification technologies requires some attention. On the technology front, many seemingly futuristic developments are possible, if not already underway. Imagine introducing a GPS sensor to the security guard's mobile RFID tool, or add a techograph to the equation. The iPhone has already shown what is possible. How about connecting all of the mobile RFID events to each other to populate an "internet of things" that adds transparency and extensive data-mining capabilities to all mobile events? While these questions are of a much bigger Orwellian nature, they might be on the minds of the mobile users who are critical to the development and adoption of a tagging technology. Especially users who are technology savvy might envision how the following emerging trends might be adopted next, and how, as a result, their role might continue to change if they support the adoption of auto-identification technologies today.

Emerging Technologies

Mobile RFID is only the beginning of many context-aware technologies. And, in their current form, pervasive ecosystems are not yet entirely location independent since their read-range is still quite limited. However, the pervasive ecosystem marked by mobile RFID technology already points at what will be presented by the inevitable improvement of technology. Reading ranges are already projected to approach 20 meters for more

stationary readers (Garfinkel & Rosenberg, 2006), on the mobile front this will only be a question of power management on the device. As more and more objects and tools of mobile work become embedded with tags and improved readers, we will witness a continuously increasing mobility with pervasive devices, ultimately approaching ubiquitous computing environments (Lyytinen & Yoo, 2002). Visions of the future home and retail organizations (Albrecht & MacIntyre, 2005), the next generation of cash (Angell & Kietzmann, 2006), interactive fashion and wearable computing (Mann & Niedzviecki, 2002) etc. contribute to the notion of a pervasive ecosystem.

Of course, improved devices alone will not change pervasiveness. Improved infrastructure and middleware technologies, including smart antennas, mesh networks and ad-hoc computing will elevate current networking technology towards pervasive data-throughputs, 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 (e.g., mobile phone) to function as a server and signals to hop from device to device. This increasingly location independence of computing occurrences will render a fixed-location infrastructure of senders and repeaters unnecessary, giving way to a truly pervasive and ubiquitous world.

CONCLUSION

Many developments are at the horizon, and some, including mobile RFID are already commercially available. Of course, only the positive impact of auto-identification technologies is advertised to organizations. And indeed, the synchronous object-object information from the field enables altogether new forms of managing mobile work. Rightfully so, practitioners might be convinced that these advantages will improve their organizational metrics and success measures. Particularly once mobile RFID becomes more standardized, the advantages of auto-identification technologies might suggest an even stronger positive impact of tagging the mobile landscape.

This chapter outlines some of these positive affordances of auto-identification, but also aims to raise a word of caution. Tagging is a very complex and complicated process, which requires that a number of critical questions are asked and answered. In many cases, these are not of a technical nature, but relate to the social and socio-political environment that is to be tagged.

Certainly, mobility and pervasiveness are not the same. Each has its unique advantages and drawbacks. As this chapter outlined, the arguments that once led organizations to adopt mobile technology must be different from those that drive tagging decisions today. It was the ambition of this chapter to illustrate how a tiny technology, such as a mobile RFID tag, can change mobile work practices and the nature of mobile work entirely. Hopefully, this chapter has provided "those about to tag" with a number of interesting questions to ponder, and has informed their decision in favor or against mobile auto-identification technologies. It was not the motivation of this chapter to suggest that mobile RFID etc. are bad choices, but to endorse critical thoughts among "those about to tag" that will help determine if, and how, auto-identification choices will transform their mobile landscapes into pervasive ecosystems.

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