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A Comprehensive Model Incorporating Mobile Context to Design for Mobile Use

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ABSTRACT

Context and mobility are two core criteria to consider when designing mobile systems. On a technical level, context and context awareness have been studied extensively, particularly with location awareness and various sensor technologies. However the definition utilized by this view is narrow and it is essential to broaden the concept of context for the development of systems for mobile use. It is further necessary to evaluate how mobility should be addressed during mobile system design. In this paper, we highlight the complexity associated with both mobility and context. We postulate from this review on the process of requirements elicitation for mobile systems and describe how we applied concepts, theories and models embedded in context and mobility literature within an Australian school. The theory and practice of this study has resulted in a structured method of noting context and mobility in the requirements elicitation process and a design model to highlight the pertinent concepts and aspects of design that require consideration and incorporation into the skeleton of solutions for mobile systems. The main contributions of this paper are the case study experience and the design model.

Keywords

Context, Mobility, Design, User-Centered Design, Requirements Elicitation

INTRODUCTION

Wireless computing has created considerable interest in "context" and "context-aware" applications. Though context has been studied in the past, attempts to realize visions of ubiquitous computing as pictured by Mark Weiser (1996) have led to extensive emphasis on context within the design of systems. This renewed interest in context however has revived the debate about a seemingly simple concept: what is context? Wireless computing introduces the notion of mobile contexts, in which mobility is an essential factor. Mobility provides the ability for users to "get connected anywhere, anytime". The complexity of defining context increases when mobility is added as a design consideration because the contexts of mobile users are constantly changing and at times are neither predictable nor in controlled environments. Hence a thorough understanding of the varying contexts is essential, particularly in designing mobile systems to ensure their efficient use.

Defining context is a challenging task. Attempts have led to vague, even ambiguous answers (see for example Beyer & Holtzblatt 1998, Dey 2001, Morse et. al. 2000, Seddon 1994). Context constitutes a large spectrum that makes it difficult to define. Furthermore, there is no definitive method of ordering context that avoids potential overlap or confusion of hierarchical structures when multiple categories of contextual elements are taken into account. For instance, the context of user 'A' could be the time and place that A is located at a given moment. At the same time, the people that A communicates with, and the relationships between them, also constitute the context of A. Reviewing definitions from various researchers highlight an array of characterizations. Some define context as location, identity, time, and environment (Wang et. al. 2003)), while others describe context as culture, communication, relationship and behaviours (Suchman 1987). Simply combining these definitions would lead to a plethora of parameters which would not be appropriate for the design of computer systems. However, a broad categorization can be extracted from various definitions in literature to outline a generic guideline of what constitutes to be context. They are *technical*, *use* and *social* context. These categorizations are discussed in the next section to substantiate the summarization.

The complexity of context increases when mobility is added to the framework of systems design. Mobility is not only identified by the geographical disposition of individuals but also by the nature and role played by

mobile objects, temporality, symbols and communities that surface and "move" within the wireless environment (Kakihara and Sørensen 2002). Concepts of mobility follow the section on context in this paper, highlighting facets outlined in mobility literature.

Alongside all the above mentioned aspects of mobile context, additional points made in relation to context include the influences of past practice or history, pre-existing knowledge or skill, culture and the environment itself. Discussions on *how* to acquire contextual information or even present contextual information are prevalent in design and context literature (Beyer & Holtzblatt 1998). However, identifying *what* to include as part of the contextual boundary seem ambiguous and overwhelming as the various definitions on context. The primary objective in our research is establishing a guideline to design for mobile use, given the complexities of a mobile context as outlined.

In this paper, we start by reviewing various models and definitions of context and mobility. Using the established concepts and summarizations derived from this literature review, we describe how we applied this knowledge acquired within a case study conducted in an Australian independent secondary school to identify the possible use of mobile applications/devices within that environment. The research was conducted using qualitative research methods in which one of the authors immersed herself in the secondary school environment and observed three teachers in their day to day tasks. Aspects of mobility and the influence of context were focused upon when observing Joe, Bret and Carl (all pseudonyms to maintain anonymity) and were evaluated. We conclude by presenting a) examples of scenarios where the above mentioned concepts were observed and the result of the evaluations, and b) a model that we developed based on the knowledge synthesised from varying concepts of mobility and context that exist in isolation within the mobile context literature and our experience in applying these concepts in a real-world case study. The case study experience and the model presented are the main contributions of this paper.

CONTEXT

Context, if considered from a very broad perspective is "any information that can be used to characterize the situation of an entity, where an entity can be a person, place, or physical or computational object" (Dey, 2001). Noting "any" information can result in extensive knowledge of the environment or context but pose a challenge in abstracting *what* are the essential factors for consideration within the design of an application. The key factors that impact the design are ones that influences the process of a user's activity or task as well as the outcome of a user's initial objective, intention or need. For example, if user X is caught in a traffic jam and is running **late** for a meeting, the circumstance of being late and needing to **communicate** his **delayed status** to those **attending the meeting** are amongst the important context data that need to be identified and captured. Those attending the meeting are within X's context boundary and will be affected in their **decisions** on whether to go ahead with the meeting or **delay it**. The keywords in bold indicate the essential context metadata that involve communicating X's status to those in X's group (as far as the meeting is concerned). Abstraction of these relevant contexts is what is needed within requirements elicitation.

Definitions of context and context aware in the literature encompass the more tangible elements of context, such as physical proximity or location and time, as well as some less tangible and less predictable aspects, such as culture, preferences or cognitive intentions. Dourish (2004) highlighted that context in ubiquitous computing systems can be used in two ways. The first is a technical approach that allows systems developers to perceive "human action and [the] relationship between that action and computational systems to support it." The second, drawn from the social sciences, is a way to focus on social settings. Schmidt, Beigl & Gellersen (1999) indicated that "there is more to context than location", identifying a hierarchical context feature space with its base categories as human factors and physical environments. While these definitions cover all possible aspects of context, without a framework for design of mobile systems, the process of identifying, acquiring, translating and mapping this contextual information into requirements specification may be a continuous and endless effort. Kensing (2000) introduced the concept of generalizing context into three broad categories for commercial IT (Information Technology) projects: technical, project and use context. These categories of context are very useful to highlight broad groups of taxonomy for context. The categories however need to be changed to take the specifics of mobile technology into consideration. Therefore, we exclude project context, which specifically highlight a concern for commercial IT projects. We find that in place of project context, the inclusion of social context as a classification in this broad summary is more appropriate and consistent with Schmidt et al's (1999) perspective of what is context.

In the following sections we summarize the various definitions of context that have been developed in the literature. We find, as argued above, that mobile context can be broadly grouped in three main categories: technical context, use context and social context. Each of these broad classifications is further divided into sub-contexts (see Table 1 for an overview).

Technical Context

The original definition for technical context identified two sub categories system and platform context (Kensing 2000). These aspects mainly deal with the system specifications and particular details as to how and what it runs on. While this categorization is fitting and covers the technical aspects in the development of systems, mobility

and issues related to mobility that are essential to ubiquitous and mobile computing are not included in this definition.

Location is a central focus when studying mobile context. Location, proximity, and the detection of these aspects using sensor technology are keys to building context-sensitive systems. Research that focuses on location and proximity as context centers on the use of technology to detect and interpret a user's context (Abowd et. al. 1997, Want et. al. 1992, Ward et. al. 1997). This leads us to establish that context identification with relation to the geographical location of a user is technology driven. Aspects associated with the site of a context have a close relationship with technical specification and properties.

A definition of context and context-awareness that is used often and relates closely to ubiquitous/mobile computing is Dey's definition that identifies context as "any information that can be used to characterize the situation of an entity, where an entity can be a person, place, or physical or computational object". Dey further elaborates this definition to include the notion of shared cues from gestures, facial expressions, relationships to other people and objects in the vicinity, as well as shared histories. Dey's definition of context encapsulates a very broad array of aspects to be considered when focusing on acquiring, understanding and incorporating context, but lacks definitive guidelines or categorization. As a general definition, this provides an overall perspective of "what context is" but poses difficulties for designers and researchers when they need to identify specific contextual data relating to a system. Furthermore, research based on this definition is restrictively focused on location, proximity and sensor based aspects (for example, see Abowd et. al. 1997, Bloomberg et. al. 1996, Chalmers et. al. 2004, Want et. al. 1992, Ward et. al. 1997). Facial expressions and gestures are not really included in this general definition. This suggests that the focus is predominantly on technical aspects of context in a given scenario. Granted this importance, we find it appropriate incorporating *site context* as one of the sub-categories of technical context. Site context includes information about the geographical places and individuals or objects in the surroundings, amongst others.

Use Context

Use context refers to the environment in which a specific technology or system is used. Kensing's (2000) concept of use context incorporates aspects of work practice and strategy. Work practice relates to how things are done within the work environment, such as the processes involved in executing a certain activity or task; strategy relates to perspectives on achieving business goals through an IT system. These sub-categories, as observed and discussed further in the case study, apply to a mobile setting as well. The study of use context is identified in several works within the Human Computer Interaction (HCI) and Computer Supported Co-operative Work (CSCW) areas using a variety of methods or approaches, such as participatory design, contextual inquiry and work place studies (Beyer & Holtzblatt 1998, Bloomberg et. al. 1996, Greenbaum & Kyng 1991, Kyng & Mathiassen 1997, Simonsen & Kensing 1997). The approaches have been used to understand and define the culture, users' behaviours, work practices and relationships between individuals, groups and their surrounding or use context in order to achieve systems that are able to support users in their work environments. In HCI and CSCW, the study of use context has resulted in a better understanding of how applications should be designed for use.

Social Context

The central focus of a system is the user. The user of the system communicates with a group or with members of various groups to carry out his or her work/activity. Identification of what and how individual users have an impact on the various work or social groups further informs the designers of the user's activity pattern. This is important and necessary in determining how an application can help support a user in his/her context as well as help the user adapt to various changes in the context. The nature of how we communicate with the people we are in contact with or work with influences the flow and work practices that we carry out. In a mobile setting, this social interaction is heightened and evident in the seamless switching between 'work' and 'play' contexts. Hence it is essential that we make the effort to inquire, acquire and gather information regarding the social disposition of users and the relationships established within their context(s). We have therefore identified sub-context categories of the social context as individuals, groups (referring to social group at work or in their personal domains) and the organization. These all impact on the way an individual will behave or carry out his/her work. Table 1 summarizes what we view to be a base framework to use when defining and identifying context.

In our study, the research aim was to identify the association and influence of context in designing mobile systems. We therefore discuss in the next section two archetypes of mobility. These models formed the basis of mobility within our case study (discussed further in the Case Study section).

Table 1: Summary of Contexts and Sub-contexts

Context	Sub-Context
Technical	System
	Platform
	Site
Use	Work Practice
	Strategy
Social	Individual
	Group
	Organisation

MOBILITY

A common perception of mobility is characterized by the perspective of geographical movement. Kristoffersen & Ljungberg (1998) developed a model of I.T. use in a mobile computing setting which clearly highlights this perception In this model, the environment, application and modality (referring to various types of mobility) are three aspects that impact the use of I.T. in a mobile setting. Three modes of mobility were identified: wandering – defined as "an activity characterized by extensive local mobility", referring to users that spend a considerable part of the working day wandering around office premises and buildings; traveling – defined as "an activity that takes place while traveling in a vehicle" and visiting – defined as "an activity that happens in one place for a coherent but temporal period of time (sic)" (Kristoffersen & Ljungberg 1998).

This model looks at mobility strictly from a spatial perspective, emphasising the nature of a user's geographic movement. Discussions on mobility place great emphasis on geographical mobility (Kakihara et. al. 2002); however, mobility should also be linked to the "interaction people perform" (Kakihara et. al. 2002). The use of wireless technologies provides one with the ability to overcome geographical barriers and be present 'anywhere, anytime'. This factor has changed the way people go about their work and daily lives and are discussed by Lyttinen & Yoo (2002) Lyttinen et. al. (2004) and Middleton et. al. (2005) The ability to be 'anywhere, anytime' has a significant impact on the work, tasks and social interactions practiced by individuals today, re-enforcing the need for designers to understand and identify the concept of mobility as more than a geographical movement or a change of position.

Kakihara and Sørensen (2002) extend the notion of mobility to three different dimensions that are interrelated: spatial, temporal and contextual. Though spatial mobility is identified in this work, the notion of spatial mobility differs from Kristoffersen & Ljungberg and is discussed beyond geographical movements. Table 2 outlines a summary of these definitions.

Table 2: Dimensions of Mobility (Kakihara and Sørensen 2002)

Dimension	Description
Spatial	The most prominent dimension of mobility that is reflected in the "nomadic" nature of mobile users/workers. Three aspects of spatial mobility are highlighted: • Mobility of objects – referring to objects that are carried by humans in their movements and travels. • Mobility of symbols – status symbols, communicating symbols, visual images such as logos or information signposts to be conveyed beyond geographical borders. • Mobility of space – the existence of a mobile space, such as a virtual community that is mobile in terms of geography/location, temporality and situation or circumstance.
Temporal	The impact of technology on when tasks are performed and its related influence on human interaction. Drawn from concepts discussed by Barley (1998), temporality is distinguished by the following characteristics: • structural – consisting of largely objectified parameters, among which sequence, duration, temporal location and rates of recurrence are particularly important • interpretive – how people interpret the change of those structural parameters Barley inspired by Hall (1959, 1962) describes temporality using the dichotomy: *monochronicity* - situations where people seek to structure their activities and plan for events by allocating specific slots of time to each event's occurrence, and *polychronicity* - situations where people place less value on and accept divergence of structural and interpretive attributes of the temporal order.
Contextual	The circumstances and manner in which a task is conducted by users. Extension of this dimension include identification of context being: • unobtrusive vs. obtrusive • ephemeral ("only exists in the flux of unfolding activities,") vs. persistent ("leaves behind a trace for further inspection and discussion")(F. Ljungberg and C. Sørensen 2000) • Weakly or strongly tied social network

Within this model, context is identified as a dimension of mobility. Identification of characteristics of context is highlighted; however, description of *what* context is within the contextual dimension is very broad. The challenge lies in identifying the following: what aspects should designers pay attention to when attempting to identify the contextual dimension? Evidently, mobility is a complex aspect that is not just about geographic movement of a user but also includes movement of objects, symbols and space as well as temporal and contextual influence.

The next section describes the case study at WINMO Secondary School. In our research, we focused on the "wandering" mobile worker. We observed secondary school teachers who primarily performed their work within the premises of the school, wandering from building to building. We further narrowed our mobility focus to spatial mobility as described in Table 2.

Mobility and Context in WINMO

In this section we present our research work used to investigate the validity of the design framework proposed. We first provide an overview of WINMO and the participants of the observation, followed by a description of the approach used to acquire data for the development of requirements specification. The final sub-section outlines key aspects of our observation.

Background

WINMO Secondary School is an independent Australian school that caters for both primary and secondary education; however, this project focused on the senior school. Currently the electronic communication systems include the Internet, Intranet, email and some other related applications. The school is also equipped with a wireless network mainly used for laptops and note-books. Several staff members and students already had their own Personal Digital Assistant (PDA) which is mainly used to organise daily schedules and take notes from time to time. The aim of the case study was to identify how the theory and understanding of context and mobility can inform design through observation; hence we were trying to identify requirements for possible mobile applications that could support the wandering mobile workers, i.e. the teachers. The scope of the research consisted of three senior school teachers – Joe, Brett and Carl - and did not involve any direct observation of students or other staff members. It did however include observations of the specific teachers who took part as subjects of the study with their respective professional and social groups, which included students and other staff members. The teachers were between the ages of 30 and 50, computer literate, and owned a PDA. Joe taught geography, I.T. and Christian Education. Brett was the school reverend and taught Christian Education and Bible Studies. Carl was a Mathematics teacher.

Research Approach and Methodology

We conducted a two phased approach in establishing the requirements of the system and identifying what mobile applications would be suitable for this context. We first conducted a discussion-cum-interview session, a common practice in system development, to gather requirements from the users to support their work whilst mobile and developed a set of specifications. This was used to compare with the requirements specification acquired through the observations conducted in phase two. The comparison provided a basis to verify if the observation techniques and context taxonomies were useful in improving the requirements elicitation process and in better informing the design of the mobile applications. In phase two, we spent approximately 50 hours over a period of four months accumulatively observing and "shadowing" these three teachers to gain an understanding of their work and context to establish what applications might best help them with their work.

The initial discussion-cum-interview session led to the identification of two applications: a roll-taking system – to mark the student's attendance and a student/parent/teacher feedback system – to enable parents to view a student's progress and to communicate with teachers with regard to their child's progress. The main motivation behind the roll-taking system was to automate the manual task of noting absentees and sending a student to the school secretary to update the attendance status.

We then proceeded to phase two of our requirements elicitation process – observing and shadowing the users. Throughout the time we shadowed the user, we maintained a diary of their activities and further questioned them whenever clarification was needed, either during or after an activity, incident or event occurred. Key aspects of our observations in contrast to the discussion-cum-interview session in phase one are highlighted in the next section.

Observation

In phase one, it was established that computers were widely used by students and staff. Each classroom was equipped with a computer for students to use and the entire school had wireless access points at several areas that covered most regions within the premises. Aside from the computer laboratories, the library too was equipped with computers for student and staff use. However, upon close examination, it appeared that although the environment supported the use of computers and technology, the users did not utilize the technology as such. The computers in the class room, which potentially could be used to run roll-taking systems and send the attendance sheet to the school secretary, was most of the time unused and untouched.

We also found that our understanding of the application specification evolved as we spent more time within the environment. Our understanding of the system improved and allowed us to gain an insight into the importance of certain materials and approaches in the school. One example of this evolving understanding was with the teacher-student/teacher-parent feedback system. The initial understanding was that teachers marked individual

students' work on the worksheet itself and when students took their work home, parents could review them. However, the observations highlighted that it was not the homework itself that is shown to the parents but that feedback was communicated through the school record book through a comments page. Effectively, in this situation, the record book functioned as a communication medium between the teachers and the parents, facilitating a system whereby the WINMO community at large (this includes teachers, parents and students) could communicate promptly and effectively. The role of the record book did not end here. The days that followed revealed that the school record book was an integral part of every staff and student at WINMO. Aside from being a communicating medium between teachers and parents, it was a very detailed diary with records of sports practices on a daily basis right up to inter school competitions. It also served as a rules book, had a section to account for daily homework and notes made in class, identified the important point of contacts in various events, as well as served as a song book during assembly. Every student, teacher and staff member carried it with them around school and was observed to make constant reference to it. A unique feature of the school's routine was that the school functioned on a six day school cycle from Day 1 to Day 6 as opposed to a five day Monday – Friday cycle. Therefore, the record book was essential in assisting the community at WINMO to plan their schedules and daily activities based on the school calendar system.

Another observation was with the roll-taking. The initial interview led to the identification of the roll-taking manual system as something that should be automated, i.e. to allow teachers to mark the roll from their mobile devices so that they do not need to send a student to inform the secretary each time roll is taken. Roll is taken twice a day, once in the morning, and once after lunch. The roll-taking system, when observed from a spatial mobility perspective, however, played a more significant role in the school's context. The main intention in this activity was to account for the students and enable a teacher to identify and relate to a student's whereabouts and progress. Students are allowed to be late or absent from a class with a valid explanation but it is absolutely essential for teachers to be aware and be informed of these reasons. The attendance status of the student is viewed as a symbol that is required to be communicated so that teachers can account for every student in their classes. When trying to ascertain the student's attendance status, teachers often make a mental note to verify why a student was late or absent for their class. Though this is not a requirement with the roll taking system, it was practiced by all teachers that we observed. This method assisted them in keeping track of the students' whereabouts and performance in school generally. These 'mental notes' are an indication of an increase in the cognitive load of the teachers when at work.

Discussion

Case Study

Based on our understanding of context and mobility, we observed the teachers to identify applications that supported mobility within the context of WINMO as well as noted several design issues to consider when designing mobile systems. First and foremost, the emphasis on the record book showed that the daily routine of WINMO functioned around the record book. The initial interview session did not reflect any need to build a 'mobile record book'; in fact incorporating the record book that already functioned properly in the current paper based system as a mobile application might have seemed redundant or trivial. However, given the culture at WINMO that we observed, it would be a vital implementation. The record book served as an important mediator in facilitating communication between teachers, students, school administrative staff (in the form of records of specific school activities scheduled on certain days), as well as parents. The record book is also a clear example of a mobile object that exists in the school. This record book facilitates the communication within the community, identified in the mobility models as mobility of space.

The roll-taking system was not designed to merely automate the act of recording or reporting a student's attendance in class, but rather to communicate a student's attendance status throughout the school. A student's attendance in class directly relates to the student's well-being and indirectly relates to the student's performance in the school. Both of these factors are primary responsibilities of the school. Hence, the need to communicate the student's attendance status, i.e. mobile symbols of being present, absent, late, at music class or out for an excursion is essential in accomplishing this task of marking the student's roll. The objective of the task is not just to record the student's attendance but to communicate this status throughout the school – once again, involving the aspect of mobility of space.

From a context viewpoint, this need to account for a student at WINMO is an example of the social context. The organizational objectives of WINMO include combating truancy among its students, and the personal objectives of the teachers at WINMO include monitoring students' behaviour and progress based on their attendance pattern. These aspects complement each other.

Design Issues

Design methodologies can be viewed from three major perspectives: attitude, method and tool (Simons, 1987). This research study focuses first on establishing what the attitude of designers should be when eliciting requirements for mobile systems and further outlines taxonomies to be used as a framework when acquiring data. Design issues discussed in the area of mobile and ubiquitous computing address context or mobility separately as aspects that to consider for design of mobile systems. Some research in

the area of context-awareness focuses on context as a design issue for mobile and ubiquitous systems (Abowd et. al. 1997, Chalmers et. al 2004, Dey 2001, Dey & Abowd 2000, Morse et. al. 2000, Schmidt et. al. 1999). Others, such as Kakihara & Sorenson (2002) as well as Kristoffersent & Ljungberg (1998), highlight the need to understand the various levels and types of mobility whilst embracing context as part of mobility. What we found through our study is that these two aspects – mobility and context – are very much interconnected with each other and to a large extent have an equal importance in the design of systems. The interrelationship between context and mobility further highlights the complexity of developing mobile systems.

Mobility affects the way in which we as humans interact with one another, and with devices. It also affects how we perform tasks, further highlighting the constant, intertwined relationship between mobility and context. Furthermore, mobility from a spatial, temporal and contextual dimension has a major impact and influence on the task itself. In a given scenario, a user aims to achieve a task, and the context that surrounds the user and the task will impact the nature and outcome of the task. From a mobile context point of view, we postulate that a designer must maintain the user and the task as the central foci in order to better inform designs for mobile systems. The context taxonomies identified in Table 1 are suggested as a basis within the contextual dimension of mobility to design for mobile systems.

Design approaches and methodologies for mobile systems should incorporate techniques and notations that attend to mobility as well as context. In order to achieve this, a designer needs to: a) have a good understanding of the various aspects of mobility, b) have a good understanding of the various aspects of context and c) relate them to each other in order to identify suitable and appropriate mobile systems and applications.

As for the method used to inquire into context, user-centered design and other methodologies such as Participatory Design and Contextual Inquiry advocate probing during observations to gain an understanding of what is taking place as well as questioning and identifying the "hidden meanings" in specific actions or situations (Beyer et. al. 1998). However, these approaches do not highlight how these "hidden agendas" can be identified, captured and translated into design requirements. The ability to understand what is being observed and questioning what is uncertain will only give us an understanding of the context and mobility aspects – a leap to design is missing in this approach of conducting participatory design and contextual inquiry. This missing link or leap to design is a major gap in existing design methodologies to incorporate context and mobility for systems design. We have synthesised various concepts of context and mobility to present an overview of a requirements elicitation approach and context taxonomies that potentially could be used as a base foundation in mobile systems design. This design approach and taxonomies are viewed to be the starting point of defining a methodology that incorporates context and mobility in systems design. We have further developed a model to represent the concepts and design philosophy appropriate when designing for mobile use. This model is presented and elaborated upon in the following section.

Recording and Tracking Mobile Context

The study conducted initially commenced by focusing on the various aspects of context and mobility largely in an isolated manner. As we progressed further with the observations, the intertwined relationship of mobility and context surfaced prominently. In order to record and note the various metadata of a mobile context in a structured and guided manner, we devised a design checklist as shown in Table 3, 4 and 5. The checklist – a simple spread sheet - would exist in various levels, as is evident in Structured Design approaches using Context Diagram to represent the higher levels and Data Flow Diagrams to represent the inner workings of the processes and systems. UML uses a similar concept in the use case diagrams with the business use case providing an overview of the entire system and each use case describing scenarios which can be further expanded into more detailed use cases.

Table 3: Mobile Design Checklist

User/Task	Mode of Mobility	Spatial Mobility	Temporal Mobility	Contextual Mobility

The first column in Table 3 is used to record which specific user and/or task is being evaluated. Corresponding to the focal task or user, we then evaluated the mode of mobility of the user, followed by spatial, temporal and contextual mobility as indicated in the following columns. At the next level, we have the mobility checklist. In this, we record specific mobile objects, symbols, space observed, nature of temporality as well as the various influences of technical, use and social context. This is shown in Table 4.

Table 4: Mobility Checklist

Spatial Mobility			Temporal Mobility		Contextual Mobility		
Ob	Sym	Spc	PolyC	MonoC	Tech	Use	Soc

** Legend:*

Ob – Object *Sym – Symbol* *Spc – Space*

PolyC – Polychronicity *MonoC – Monochronicity*

Tech – Technical *Soc – Social*

The contextual mobility column can then be further expanded as shown below in Table 5 to note the influences of specific technical, use and social context elements.

Table 5: Context Checklist

Technical			Use		Social		
Sys	Plf	Site	WP	Strategy	Ind	Group	Org

** Legend:*

Sys – System *Plf –Platform* *WP – Work Practice*

Ind – Individual *Org – Organisation*

Notations and records of observation and evaluation of all the above components and aspects require attention to whether a specific user or task is affected by certain aspects of mobility as well as identifying if context influences the impact further and vice versa. These impacts/influences can also be given a priority or importance level such as high impact or low impact. High impact would signify that the level of collaboration and cohesion between the components in question require extensive attention and perhaps thorough evaluation, whereas low impact would signify minimal importance on the specific components or aspects.

This checklist guideline provides a structured approach to track and identify what aspects influence design of applications within mobile use. It is not indicative of rigidity within the design approach, but emphasises focus and identification of convergence within the unique domain of mobile context. In the next section, we outline a conceptual model comprehensively representing mobile context as discussed throughout this paper

A Comprehensive Model of Mobile Context

The four main components of mobility to consider when designing for mobile use is a) the user's mode of mobility, b) the spatial mobility, c) the temporal mobility and d) the contextual mobility. For each of these components, we expand the categorization to determine: a) if the user is a wandering, travelling, or visiting mobile worker; b) if we can identify mobile objects, symbols and space; c) if activities conducted are monochronic or polychronic in nature; and d) what elements of technical, use and social context influence the activities of the user. Figure 2 shows Mobile Context Wheel Model. Elements of mobile context influencing design for mobile use are represented within this wheel. The bottom half of the wheel is context on its own, whilst the top half of the wheel consists of the remaining elements of mobility, i.e. mode of mobility, spatial mobility and temporal mobility.

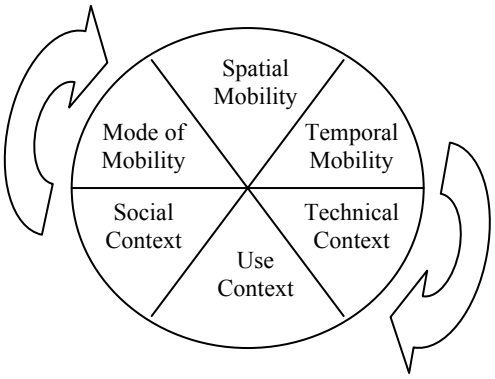

Figure 1: Mobile Context Wheel Model

Each of these components requires equal attention when gathering requirements. Each "pie" needs to be evaluated based on how it impacts and affects the adjacent or corresponding "pie" as well, and not just evaluated independently. Hence, evaluating and reviewing spatial mobility will have to relate to the type of mobile workers that are in question, the nature of the temporality as it relates to tasks conducted as well as the contextual characteristics, which include technical, use and social aspects.

Conclusion

Identification and understanding of a "context" is important in the design of systems, particularly mobile systems. Essentially, designers and developers should have the ability to define and determine the specific requirements or needs of a user. When the circumstances in which a user uses an application are not clearly identified it leads to applications that apparently "solve the problem" but do not solve them "conveniently". The real issue here is that solutions are outlined to deal with a symptom and not the problem. In our case study, this was directly observed when establishing and identifying the roll-taking system specification. Designers need to dive further into identifying the original problem and not base the design on symptoms that are identified.

As we highlighted at the start of this paper, many approaches have been described and suggested as appropriate methods to acquire contextual information and study the context of mobile use such as ethnography, contextual inquiry and acting out in context. These works describe methods and approaches on *how* to acquire contextual information, i.e. via observation techniques, interviews and so forth. Identifying *what* specific aspects of mobile context is relevant and important in the requirements elicitation process is lacking in these works. The identification of specific contextual parameters related to case studies within the works was highlighted but evidence of drawing some form of generic idea from these works were scarce. Hence in the above mentioned works a generic comprehensive guideline on what to look out for when acquiring contextual information was deficient.

In this paper, we present a design model that comprises of core components that influence the design of mobile systems and outline taxonomies to use as a fundamental basis when carrying out activities of requirements gathering to address the issue of *what* aspects and features to observe and identify during requirements elicitation. These taxonomies and approaches are rooted within the mobile context literature and have been applied to a real case study before finalising the model and specifications.

This model however has been validated within specific boundaries, i.e. amongst wandering mobile workers with a focus on spatial mobility, use and social context. Extension of this work would include using the model with travelling and visiting mobile workers as units of analysis as well as establishing design notations as extensions of existing notations such as UML.

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