View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by VBN

Aalborg Universitet

AALBORG UNIVERSITY
DENMARK

Indexical Representations for Context-Aware Mobile Devices

Graham, C.; Kjeldskov, Jesper

Published in:
Proceedings of the IADIS e-Society 2003 Conference

Publication date:
2003

Document Version
Early version, also known as pre-print

Link to publication from Aalborg University

Citation for published version (APA):
Graham, C., & Kjeldskov, J. (2003). Indexical Representations for Context-Aware Mobile Devices. In Proceedings of the IADIS e-Society 2003 Conference International Association for Development, IADIS.

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

? Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
? You may not further distribute the material or use it for any profit-making activity or commercial gain
? You may freely distribute the URL identifying the publication in the public portal ?

Take down policy
If you believe that this document breaches copyright please contact us at vbn@aub.aau.dk providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from vbn.aau.dk on: April 24, 2017

INDEXICAL REPRESENTATIONS FOR CONTEXT-AWARE MOBILE DEVICES

Connor Graham
Department of Information Systems, University of Melbourne
Parkville, Victoria 3010, Australia
cgraham@unimelb.edu.au

Jesper Kjeldskov
Department of Information Systems, University of Melbourne
Parkville, Victoria 3010, Australia
jesper@cs.auc.dk

ABSTRACT

Wireless mobile devices present a present a huge design and representational challenge for the discipline of human-computer interaction. Past approaches have focused on user, task and artifact. This paper argues that in addition to these factors an understanding of context can assist with meeting design challenges for mobile applications. It proposes a matrix of eight dimensions of context drawn from existent taxonomies in ethnography, socio-linguistics and human-computer interaction. The dimensions are described as time, absolute location, relative location, physical objects, activity, social setting, environment and culture. These are used to drive the design of interface representations for a route planning tool for use on the Melbourne public transport system. Central to the representations of information on the interfaces is the concept of index borrowed from semiotics and the idea of indexicality as an interface property. This paper illustrates how this concept can be used to develop interfaces for mobile devices and considers further applications and limitations of this approach.

KEYWORDS

Mobile applications, Human-Computer Interaction, context, indexicality

1. INTRODUCTION

A highly likely feature of any e-Society in the near future will be the widespread use of mobile devices and wireless technology. A key feature of such devices and technology will be context-awareness, whereby content and functionality are adapted to the user's situation. However, designing services for such context-aware mobile devices involves major challenges in terms of both defining use context as well as developing appropriate concepts relevant to the design of contextual information on mobile interfaces. This paper extends the concept of index discussed in Kjeldskov (2002) to inform the concept of context for mobile representations.

1.1 Background

The Gartner Group identified ubiquitous computing as a key trend that will emerge in Information Technology (Roberts, 2002). The group conducted a ranking exercise on "technologies that are not yet widely adopted and that will have the biggest impact on enterprises between 2002 to 2007" (Roberts, 2002) and rated "always-on wireless data and communications devices" as one of these technologies. They have made a further prediction that "some 70 per cent of what it calls "office productivity workers" will own at least three mobile devices, while IT budgets will increase by 10 to 15 per cent every year to support enterprise wireless technologies and services" (Financial Times, 2002). The predictions do not end there. The Economist (Manasian, 2003) cites Forrester Research as predicting that 14 billion embedded and mobile

devices will be connected to the Internet by 2010. Such data indicates such technology will be a defining element of e-Society.

Historical data from Human-Computer Interaction has taught us that the role of context is critical in the understanding and development of information systems. Indeed a definition of Human-Computer Interaction quoted by Preece (1994:7) describes it as "a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of the major phenomena surrounding them." This asserts the importance of context in understanding interactive computing systems along with the recent use of ethnographic approaches in system evaluation (e.g. Braiterman & Larvie, 2002).

Bannon (1991:27) critiqued HCI research in the 1990's, asserting that within Human Factors "the human is often reduced to being another system component with certain characteristics…" The issue here is that a human is an actor within an environment and that the actor possesses a certain "thrownness in a situation" (Winograd and Flores, 1986:145). Winograd and Flores (1986:143) assert that "'Doing' is an interpretation within a background and set of concerns". This means that user actions cannot be isolated from the environment in which they take place and, more radically, that actions cannot be understood without a context. They critique the conception of decision-making by a manager within an organization as a formal, structured activity, identifying this as "highly restrictive" (Winograd and Flores, 1986:145). They also identify two key issues: "thrownness in a situation, and the importance of background." The problem posed to system development is that decisions are often not structured and we cannot map out all possibilities within a given context: "We are seriously misled if we consider the relevant space of alternatives to be the space of all logical possibilities." Winograd and Flores (1986:149).

Mobile devices and applications are particularly susceptible to contextual change and the user's interaction with that context. An analysis based on activity theory reveals the complexity of the relationships involved: the relationship between an object (e.g. a plan) and a user mediated by a tool, (Engeström, 1999), in this case the device. The relationship between a subject and a community is in turn mediated by rules and the relationship between an object and a community is mediated by division of labour. In this matrix, the layers of role that the user can play pose a design challenge. People, work, environment and technology can often not be separated. Preece (1994) implies this complexity when describing key factors in understanding a conceptual model for HCI as "people, work, the environment and technology" (Preece, 1994:43) and that "each component within the model interacts with the others…" (Preece, 1994:44).

These issues begin to provide an account that is relevant to mobile systems. A key attractor for mobile technologies among young people is usefulness and disappropriation criteria have been shown to include the technology being "unusable" (Carroll et al, 2001). Key usability problems encountered in the design of applications for such devices are that displays on mobile devices are small, means of input are limited and use-contexts are very dynamic (Kjeldskov, 2001). Thus Cheverst et al., (2001) identify three main ways of simplifying user interaction with a system: reducing the need for input, reducing the quantity of output and reducing the complexity of the user's understanding of the system. The complexity of context is an additional factor to deal with: in a dynamic environment an actor may be behaving as an individual or as part of a community.

Previous work (Cheverst et al., 2001:9) describes how by carrying a mobile GUIDE unit, visitors to the city of Lancaster in England "can receive up-to-date information about the city's attractions while following a structured tour of the city tailored to their specific requirements." This system used the visitor's location and the location of attractions within the city as context information. The developers recognized the importance of not being over-deterministic when designing user interaction with the system. It is argued at this point that an operational understanding of context can be useful in developing a system which is both flexible and useful. It is recognized, however, that there is a danger of over deterministic when presenting just-in-place information (Kjeldskov, 2002) through context-awareness.

However, Goodwin and Duranti (1992:2) note that defining context is very difficult and that one definition of context does not seem and may not be possible. This paper is firstly, an attempt to define context for mobile applications. We approach this through establishing a working definition and then by describing key dimensions of context. Even when context is defined and described, however, the definition may not be useful. Thus, this paper is secondly, an attempt to operationalise the dimesions of context to inform interface design for mobile applications. The concept of indexicality, based on an understanding of indexical type in linguistics and indexical representations in semiotics, is posited for this purpose.

The contribution of this paper is to utilize a definition on context within a mobile, context-aware device that is both rich enough to help with actual design and pragmatic enough to be used in real design activities

for mobile applications. This paper also aims to define the concept of indexicality for the first time and to illustrate how this property of an interface can be used to overcome some of the problems encountered when designing representations for mobile interfaces. Indexicality is rationalized as an important concept in designing for context. Then a design case that utilized both the understanding of context developed and the concept of indexicality is described.

2. CONTEXT, INDEXICALITY AND INTERFACE DESIGN

2.1 Context

Dey (2001:5) characterizes context in the following way: "Context is any information that can be used to characterize the situation of an entity. An entity is a person, place or object that is considered relevant to the interaction between a user and an application, including the user and the application themselves." We argue that this definition is quite complete, although it fails to capture some of the key dimensions of context that can be useful in an operational definition. In addition, some key notions are not apparent: for example, work. Critical to an understanding of context is the idea of tacit knowledge and Norman's (1990) concept of knowledge-in-the-world. The latter links the actor with the surroundings and is important in contexts which are highly dynamic as it offers an opportunity to associate interface with surroundings. It also suggests a relationship between the environment and an entity similar to that relevant to deictic words in linguistics such that three important concepts emerge: the referent, the "pivot" or origo relative to which the referent is identified and the relationship between the referent and the "pivot" (Hanks, 1992). Although this does not encapsulate all possible situations, we claim that these concepts are useful in producing an operational definition of context.

In order to operationalise this understanding of context, Table 1 describes possible referent-origo relationships. Hong & Landay (2001) have described context as knowing the answers to the "W" questions, such as Who is speaking. The y-axis of Table 1 is an articulation of those questions. The dimensions have been drawn from a number of approaches to defining context. Hymes (1972) defines context as part of a speech act or minimal communicative unit in his ethnographic analysis of language. He describes sixteen components of speech acts. The components relevant to our proposed dimensions have been reproduced here. Ochs' (1979) four dimensional discussion of context focuses on defining context as a discrete concept, as he sees context as uniting language form and function. Fitzpatrick (1996) described five aspects specific to the interaction of social worlds to promote better understanding of collaborative environments. Dix (2001) offers a four-tiered taxonomy of context, more specific to computing and mobile devices and Agre (2001) offers three levels of context, again specifically aimed at analyzing wireless information services.

Rephrased as "W" questions the dimensions on the y-axis would become: 1. When?; 2. What position?; 3. Where?; 4. What else?; 5. What work?; 6. Who?; 7. What conditions?; and 8. What culture? Thus the first dimension addresses the time of day, the second the origo's position, the third the origo's position in relation to other people or objects, the fourth whether other devices are in the same space. The fifth dimension captures the goals, actions and operations of the origo the sixth the number of people present and the social occasion. The seventh dimension considers the physical environment and the eighth the cultural environment. Two additional dimensions were considered initially: strategy or plans (How?) and motivation (Why?). It was considered that these were captured by "Activity", however. In addition, like Fitzpatrick's (1996: 3) Locales, it was also considered that each of the dimensions could be applied to the context internal to the device (Fitzpatrick's (1996) virtual domain) and also to the context external to the device in the physical world (Fitzpatrick's (1996) physical domain).

We argue these dimensions of context can be utilised to assist designers in making decisions concerning the delivery of just-in-place (Kjeldskov, 2002) information to users moving through dynamic contexts. These dimensions offer a mechanism for translating requirements into representations for mobile devices.

Table 1. Dimensions of context

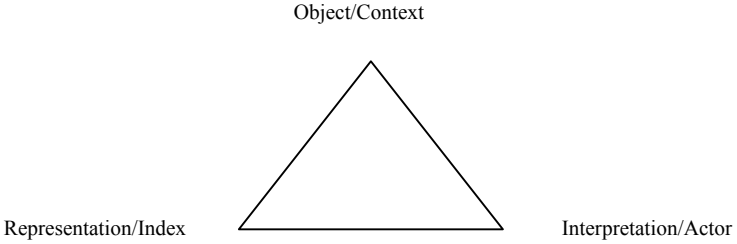
Dimension	**Hymes (1972)**	**Ochs (1979)**	**Fitzpatrick (1996)**	**Dix (2000)**	**Agre (2001)**
1. Time	Setting	Setting	Interaction trajectories		
2. Absolute location	Setting	Setting	Locale foundations	Physical Context	Architecture
3. Relative location	Setting	Setting	Locale foundations	Physical Context	Architecture
4. Physical objects	Setting	Setting	Mutuality	System Context Infrastructure Context	Architecture
5. Activity	Purposes – goals Purposes – outcomes	Language Extrasituational context	Interaction trajectories	Domain Context	Practices
6. Social setting	Speaker, addressor, Hearer, Addressee Norms of interaction Norms of interpretation	Behavioural Environment Language	Locale foundations Individual views	Domain Context	Institutions Practices
7. Environment	Setting	Setting	Locale foundations	Physical Context	Architecture
8. Culture	Scene Norms of interaction Norms of interpretation	Behavioural Environment Language Extrasituational context	Civic structures	Domain context	Practices Institutions

Notably Hymes' (1972) components and Ochs' dimensions are clustered around social setting and culture and to some extent activity. This is not surprising as understanding language within these contexts presents a considerable challenge. Along with Fitzpatrick (1996) they group several dimensions of context together; under "Setting" and "Locale foundations" respectively. We have separated these into distinct dimensions as we believe they will inform design more effectively instantiated in this way. Dix's four tiered taxonomy focuses on technology-specific issues including the relationship of the origo to other devices, applications and users (System Context) and the device-specific contextual issues such as network bandwidth available (Infrastructure Context). Agre's three level analysis acknowledges the loosening of the connection between activities and physical places by placing the emphasis on social and cultural constructs in the form of Practices or "the ensemble of embodied routines that a particular community has evolved…" (Agre, 2001:5) and Institutions or "the ensemble of social roles and rules that constitute those [human] relationships" (Agre, 2001: 5). This focus on practices and institutions is mirrored in Fitzpatrick's (1996) Locales Framework, which utilizes social world or "locales" as a primary unit of analysis.

2.2 Indexicality

From a semiotic perspective, there exists a dynamic among an object, representation or interface and interpretation or subject: the object's interpretation is mediated by the representation. In the same way, we argue that the context's interpretation can be mediated by index. Indexes are ways of representing information with a strong relation to contextual information (Kjeldskov, 2002). These relationships are illustrated in the figure below.

Figure 1. Semiotic triangle showing mediation of relationships



Thus index has a critical role to play in communicating information valuable in a particular context. Horn (1988:116) describes indexicality in the following way: "the interaction between the context of utterance of an expression and the formal interpretation of elements within that expression constitutes a central domain of pragmatics, variously labeled deixis, indexicality or token-reflexivity." Here we define indexicality as a property of an interface representation that is defined as having a context-specific meaning. This means that it is dependent on a referent with which it has a relation for its meaning. For example, if a digital display in a Metro carriage in Lisbon reads "Baixa-Chiado" when approached Baixa-Chiado Metro station it is indexical, because it has a proximity-based relationship (a relationship based on relative location) to the station and has a full meaning of "Baixa-Chiado is the next station". An interface element that has the property of indexicality can only be understood in a particular context. If an interface element exhibiting indexicality is extracted from its context the meaning of the element will be compromised. For example, if "Baixa-Chiado" appears when leaving Baixa-Chiado station it has a completely different meaning.

Thus, including indexical-type representations can not only mediate context in interface design, but also exploit knowledge-in-the-world thereby maximizing the communicative power of representations.

2.3 Using Indexicality for Mobile Representations

The definitions and dimensions of context and the concept of indexicality discussed above were used to inform the representation of information on a context-aware mobile information system. In order to exemplify the mediation of context through indexicality in the representation of information on a context-aware device, a number of central characteristics of this design are described in the following sections.

2.3.1 The TramMate Project

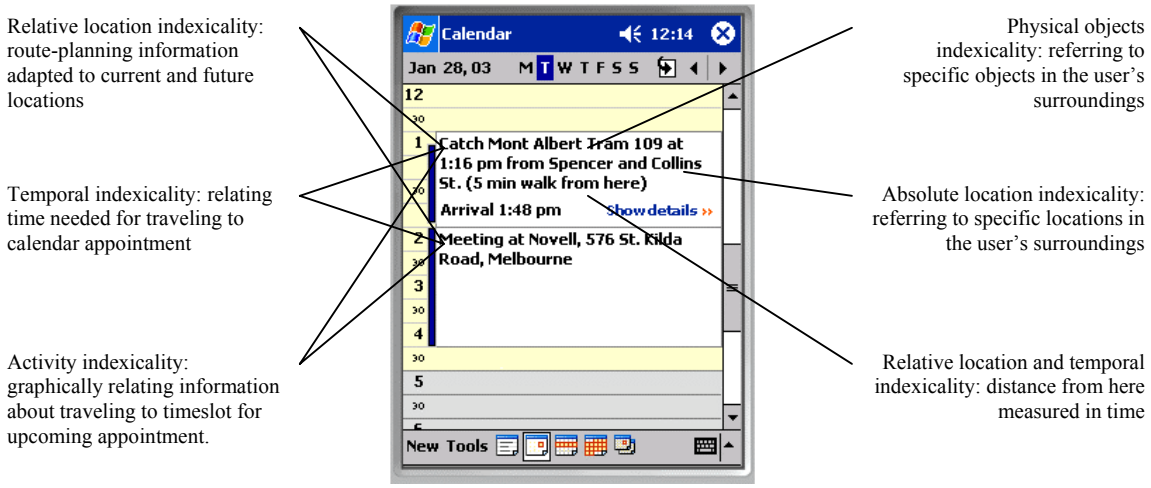
For the purpose of supporting the use of public transport systems in Melbourne, Australia, we have designed and are currently implementing a functional prototype of TramMate. TramMate is a mobile information service that provides users with a route-planning tool integrated into an electronic calendar on a PDA. The design of TramMate was based on field studies on the use of transportation by business employees who, during a typical workday, have to attend appointments at different physical locations. As an example of a potential context-aware mobile device application of future e-Society, TramMate intends to support the use of public transportation by keeping track of contextual factors such as the user's physical location, upcoming appointments and real time information about trams and traffic conditions. TramMate thus exemplifies what a context-aware mobile application might offer and look like by exploring the dynamic use context of mobile information services in interface representations.

In association with the Department of Geomatics at the University of Melbourne, a location-aware trip planning functional prototype was evaluated in parallel to the design of TramMate. The objective of this evaluation was to inform the implementation of TramMate. The application evaluated exploited a global positioning system, tram timetable, stop and network information and maps to serve up WML pages in a PDA browser. Trip planning algorithms acted as the middle layer between the tram data and the representation of information. Field, laboratory and expert evaluations were conducted on system and the results are currently under analysis. Work is currently underway developing an agent-based prototype to capture context variables.

2.3.2 Example Interfaces

The interface of TramMate was designed with the concept of indexical information representation in mind and exemplifies how indexicality can be used for exploring and mediating different dimensions of the user's context discussed above in interface design for mobile devices. The overall aim of the TramMate mobile information system was to support the use of transportation for attending appointments at different locations and times. Given this, some of the dimensions of context discussed above immediately seemed more important than others. Thus, decisions concerning the relevance of certain dimensions to a design situation were made on the basis of the initial requirements gathering exercise and the user's key activities. In the situation of catching the right tram for example, cultural and environmental context seemed less important than time, location and desired activity. In other situations or applications, however, this is likely to be very different.

Figure 2. Exploring contextual indexicality in mobile device interface design: Calendar view of TramMate



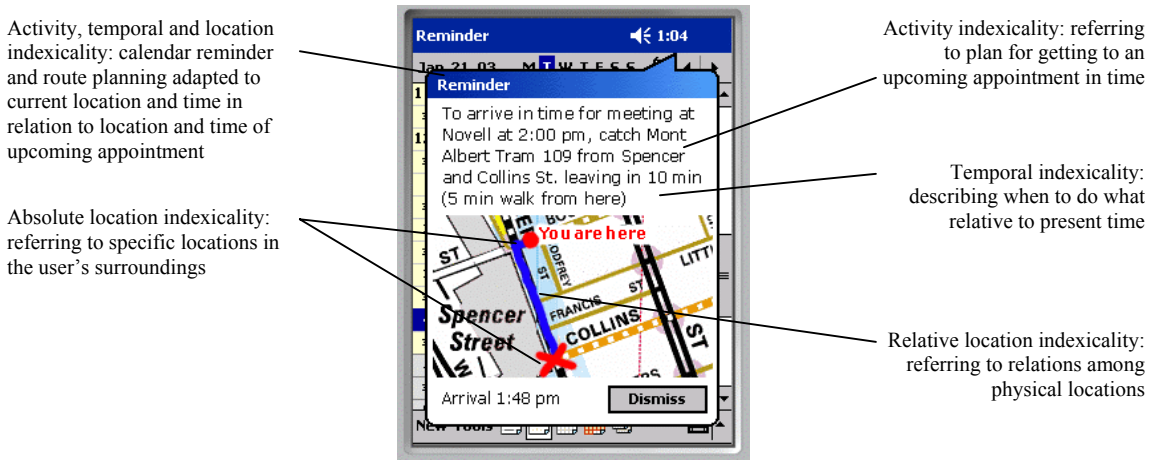
The idea behind TramMate was not to reduce the complexity imposed on the user in terms of need for input and quantity of output as suggested by e.g. Cheverst et al. (2001). To accomplish this, we designed a possible extension to PDA-based calendars, providing dynamic route planning information directly related to the user's schedule for the day. TramMate thus requires very little additional interaction other than using a calendar. The driving contextual dimensions for TramMate are instantiated in the user's schedule for the day in terms of activities at specific times and locations. When a new activity is arranged in the form of an appointment, the user is asked to specify its time and physical location. Following this, TramMate automatically schedules a special time slot for getting there. When an appointment is due, this timeslot adjusts itself in accordance with the location of the user and the estimated time needed to get there, based on information about the public transport system (figure 2 above). User location information can be captured using a GPS and related to data describing tram routes and locations (Smith et al., in press). Apart from specifying the first step of the route plan to an appointment, the calendar also provides direct access to additional details on the suggested route: estimated travel time, required walking distance and the number of times the user has to change routes. The latter features are currently implemented within location-aware trip planning application described above.

This design mediates contextual information by means of indexical information representation in a number of ways. The design utilises location indexicality by adapting the content of the special "time for traveling" timeslot to current as well as planned future locations. Temporal indexicality is utilised by adapting the actual graphical size of this timeslot to estimated travel time for the described route. Locating the timeslot for traveling graphically next to the associated appointment explores activity indexicality. Physical object indexicality is utilised by referring to specific objects in the user's surroundings (such as a tram). Finally, absolute location indexicality is explored through references to specific physical locations and relative location and temporal indexicality are explored through references about distance from current location measured in walking time.

Based on the time required to walk from the user's current location to the first tram stop on the route proposed, TramMate notifies the user when it is time to leave in order to make the upcoming appointment. The reminder contains simple information on the related appointment, what tram to catch, how soon it leaves, where it leaves from and how to get there (figure 3 below).

This second design utilises indexicality for mediating contextual information too. The design uses activity, temporal and location indexicality by presenting a calendar reminder adapted to current location, time and an upcoming appointment. The user's current and desired location is displayed on a map with instructions on how to get from one to the other. This utilises absolute as well as relative spatial indexicality. In the specific text of the reminder, the reference to getting to an appointment explores activity indexicality. Finally, displaying the relative time from now to the departure of the tram explores temporal indexicality.

Figure 3. Exploring contextual indexicality in mobile device interface design: Calendar reminder in TramMate



While traveling to an appointment, the TramMate timeslot continuously updates itself with information about the next step of the route, maintaining the activity, location and temporal indexicality of the information representations. On the tram, TramMate notifies the user when to get off and the next step to take by means of reminders indexed by activity, location and temporal aspects as shown above. Having arrived at the destination, a map provides the location of the appointment as well as the user's current position, thus maintaining the absolute and relative location information representation from the reminder.

3. CONCLUSION

This paper has described eight key dimensions of context for use in mobile application development. We do not claim that this matrix of dimensions is complete, merely that it is operational. Field work and, in particular, the results of recent evaluation of the location-aware trip planning application described above will help to establish the matrix's completeness. For instance, it is acknowledged that the temporal dimension lacks the richness of Fitzpatrick's (1996) "Interaction trajectories" and, more generally, that the dimensions fail to capture the individual's interpretation of context against a group's. This paper has also defined the concept of indexicality and utilised it in the development of a mobile route-planning application for use on public transport. Indexicality was found to be very useful in this regard. However, the ease of translating requirements into interface designs in all contexts using this concept has yet to be established or evaluated. In addition, through the utilization of Time as an indexing criterion it became apparent that Absolute Time was less useful than the user's time relative to a Physical Object.

Broadly, the design of TramMate illustrates how focusing on the dimensions of context discussed above can help inform the specific design of context-aware mobile devices interface through applying different types of indexical information representations to the user interface. The use of indexical representations not only strengthens the relation between information system and use context, it also reduces and simplifies the information necessary for an interface to make sense, as a vast amount of the information needed is implicitly given in the user's surroundings. This access to the user's tacit knowledge and knowledge-in-the world reduces the need for the representation of complex and extensive information on the user interface. As the graphical design space of mobile devices is typically very limited, this property may prove very valuable in future interface design for mobile and wireless devices. However, it has yet to be established if the use of indexicality will result in an over-deterministic (Cheverst et al., 2001) system where the wrong information is indexed at critical times. We believe results of the evaluations, in particular the field evaluations, of the functional prototype described above will provide further insight into the utility of indexical representations for mobile applications based on context awareness and further refine indexicality as a useful design concept for context-based representations for mobile devices.

ACKNOWLEDGEMENTS

The authors would like to thank colleagues on the TramMate project: Steve Howard, Jennie Carroll, Daniel Tobin, Frank Vetere and John Murphy as well as the Novell employees who participated in the field studies. Special thanks are reserved for the Department of Geomatics and for Jessica Smith and her generosity and assistance throughout the evaluation of her trip-planning system.

REFERENCES

Agre, P.E., 2001. Changing Places: Contexts of Awareness in Computing. *Human-Computer Interaction*, Vol. 16, 177-192.

Bannon, L. & Bødker, S., 1991. 'Beyond the interface: Encountering artifacts in use.' In Carroll J.M. (ed) *Designing Interaction: Psychology at the Human-Computer Interface*, Cambridge University Press, Cambridge, UK.

Braiterman, J. & Larvie, P., 2002, Each sold separately: ethnography as a tool for integrating online and off line use of educational toys. *Proceedings of the HF2002 Human Factors Conference*. Melbourne, Australia.

Brown, J.S. & Duguid, P., 2002. *The Social Life of Information*, 2nd ed. Harvard Business School Press, Boston, USA.

Carroll et al, 2002, Each Just what do the youth of today want? Technology appropriation by young people. *Proceedings of the 35th Hawaii International Conference on System Sciences (HICSS-35)*. Hawaii, USA.

Cheverst, K. et al, 2001. Using Context as a Crystal Ball: Rewards and Pitfalls. *Personal and Ubiquitous Computing*, Vol. 5, 8-11.

Dey, A.K., 2001. Understanding and Using Context. *Personal and Ubiquitous Computing*, Vol. 5, 4-7.

Dix, A. et al, 2000. Exploiting Space and Location as a Design Framework for Interactive Mobile Systems. *ACM Transactions on Computer-Human Interaction*, Vol. 7, No. 3, 285-321.

Engeström, Y., 1999. 'Activity Theory and Individual and Social Transformation.' In Engeström, Y., Miettinen, R. & Punamäki, R. (eds) *Perspectives on Activity Theory*, Cambridge University Press, Cambridge, UK.

Financial Times., (2002, December 3) Untangling wireless in the workplace.

Fitzpatrick, G., Mansfield, T. and Kaplan, S. Locales Framework: Exploring Foundations for Collaboration Support. *Proceedings OzCHI'96*, Hamilton, New Zealand, 34-41.

Goodwin, C. & Duranti, A., 1992. 'Rethinking context: an introduction.' In Goodwin, C. & Duranti, A., (eds) *Rethinking Context : Language as an Interactive Phenomenon*, Cambridge University Press, Cambridge, UK.

Hanks, W.F., 1992. 'The indexical ground of deictic reference.' In Goodwin, C. & Duranti, A., (eds) *Rethinking Context : Language as an Interactive Phenomenon*, Cambridge University Press, Cambridge, UK.

Hong, J.I. & Landay, J.A., 2001. A Context/Communication Information Agent. *Personal and Ubiquitous Computing*, Vol. 5, 78-81.

Horn, L.R., 1988. 'Pragmatic Theory.' In Newmeyer, F.J., (ed) *Linguistics: The Cambridge Theory,* Vol 1: *Linguistic Theory*, Cambridge University Press, Cambridge, UK.

Hymes, D., 1972. 'Models of Interaction of Language and Social Life.' In Gumperz, Y., & Hymes, D. (eds) *Foundations in Sociolinguistics: An Ethnographic Apprach*, University of Philadelphia Press, Philadelphia, USA.

Kjeldskov, J., 2002, "Just-in-place" Information for Mobile Device Interfaces. *Mobile Human-Computer Interaction*: *Proceedings of the Mobile HCI 2002 Conference*. Pisa, Italy, 271-275.

Kuuti, K., 1996. 'Activity Theory as a Potential Framework for Human-Computer Interaction Research.' In Nardi, B.A. (ed) *Context and Consciousness: Activity Theory and Human-Computer Interaction*, MIT Press, USA.

Manasian, D., (2003, January 23) Digital Dilemmas. *The Economist* [online]. Available from: http://www.economist.com/surveys/displaystory.cfm?story_id=1534303 [Accessed 1 February 2003].

Norman, D., 1990. *The Psychology of Everyday Things*. Basic Books, New York, USA.

Ochs, E., 1979. 'Introduction: What Child Language Can Contribute to Pragmatics.' In Ochs, E. & Schieffelin, B. (eds) *Developmental Pragmatics*, Academic Press, New York, USA.

Preece et al, 1994. *Human-Computer Interaction*. Addison-Wesley Publishing Company Inc., Harlow, England.

Roberts, J. (2002, April 4), Is there a Next Big Thing?. *The Information Age* [online]. Available from: http://www2.idg.com.au/infoage1.nsf/all/F5A4077159B9DF5ACA256B9C0019517B?OpenDocument [Accessed 1 February 2003].

Winograd, T. & Flores, F., 1986. *Understanding Computers and Cognition*. Publishing Company Inc., Reading, USA.