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Trust in mobile guide design: exploiting interaction paradigms

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Abstract

Trust is an important issue in the design of context-aware mobile guides. Here we draw on the field evaluations of two different mobile guides to explore trust related incidents. Important factors in trust relationships are user expectations and managing the user's sense of vulnerability. However, uncertainty is currently unavoidable with mobile guide systems. Consequently, given the user's expectations, evidence of the system providing incorrect information (e.g. caused by uncertainty in location due to limited network coverage) is likely to adversely affect the user's trust in the system. We argue here that the interaction paradigm supported by the system can play a crucial role in managing the user's trust. Furthermore, we argue that personified interaction paradigms (Local, Guide, Chaperone, Buddy, Captain) can act as a useful tool for designers developing mobile guides.

Keywords

Context-aware computing, User studies and fieldwork including ethnographic methods

INTRODUCTION

Trust is important when managing interaction with mobile guides. Trust among people is valuable because it enables us to handle risk, engage in social interaction and coordinate and communicate (Corritore et al., 2003:738). Trust is defined as (Corritore et al., 2003:740): "an attitude of confident expectation in an online situation of risk that one's vulnerabilities will not be exploited." Too often trust is forgotten when designing interaction for mobile systems. For example, in mobile guides, the focus until recently has been on technical and interaction design. Kray and Braus's (2003) review of mobile guides describes five dimensions characterising guides: basic features, such as the positioning technology deployed within the system; situational factors, such as the user's ability to select content; adaptation capabilities, such as the system's adaptability to user position; interface and user interaction; and architecture or the network and system technology used to develop the guide. However, the interface and user interaction dimension does not include any element of trust. Indeed, in the mobile domain Schmidt-Belz is one of the researches to have explored the trust issue in any depth and argues (2003) that understanding and investigating trust for mobile guides is worthy of investigation as distrust can damage and even be fatal for an information service which an electronic guide may utilise.

Designing for trust is difficult, even when considering single users, using desktop systems in predictable situations. Perhaps this is because designing systems for ongoing, unfolding action involving complex relationships is difficult. These trust relationships are complex because the "confident expectation" (Corritore et al., 2003:740) is highly individual and qualitative. Designing systems for trust is even more difficult when the user is 'in the wild', where understanding the nature of an individual's or group's ongoing, unfolding relationships is essential. The use of ethnographic approaches has striven to meet the challenge of understanding the user's experience in journeying for example (e.g. Brown and Laurier, 2003). With such approaches *translation* of rich, thick descriptions into fodder for design can be difficult. Approaches to this problem include the use of descriptive patterns (Martin and Sommerville, 2004) or "a resource for multiple stakeholders involved in actual projects to communicate some sense of the application domain as a tool for thinking about how this impinges on design considerations" (Martin and Sommerville, 2004:83).

The challenge for designers becomes even greater when the systems themselves have some "intelligence": understanding interaction is more akin to understanding a partnership in which trust plays a very important part. In such complex partnerships, uncertainty is likely. Recent studies (e.g. Benford et al., 2003, Cheverst et al., 2003a) have shown that lack of accuracy of such systems' positioning data, for example, is a reality. Acknowledging this as part of the ongoing experience of the interactants is important: indeed, instead of attempting to eradicate it, uncertainty can be exploited and become a feature of the experience. Benford et al. (2003) have managed uncertainty in a location-based game based on city streets exploiting wireless network connections and global positioning system receivers. Specifically they hid uncertainty, validating game players' positions so they could not be placed in impossible locations. However, they also revealed uncertainty through, for example, providing information about the estimated accuracy of the technology to the game players, much like a mobile phone makes available information on signal strength. Cheverst et al. (2003a), when implementing a location-aware mobile guide, employed the same two strategies: hiding uncertainty through careful wording, such as "You are in the castle cell" instead of "You are at the castle". They also revealed uncertainty through the use of interrogatives such as "Sorry I cannot determine your current location, can you see the castle?" and by employing familiar metaphors on the GUI such as "bars of connectivity" (Cheverst et al, 1999:198).

In this paper, we report on experiences drawn from two cases in order to better understand and design for trust. The mobile guides described here are evaluations of guides or "systems that guide mobile users by providing local and location-based services, such as navigation support and tourism information" (Schmidt- Betz, 2003:1). The projects through which these systems were developed have been completed and the systems themselves have different degrees of context awareness and utilise different interaction paradigms. We regard an interaction paradigm as a theme characterising the experience of interacting with a system: the driving force behind the interaction design. Our aim here is to examine the results of the field evaluations with a view to understanding key issues when developing context-aware mobile systems for trust.

We acknowledge that "…good real-world design revolves around pragmatism" (Martin and Sommerville, 2004:86). We also agree with Cheverst et al. (2003b:12) concerning there being no "'silver bullet' for design". However, given that pragmatism demands that explorations of the problem space have to be translated into design at some point (Martin and Sommerville, 2004) we believe it crucial to consider appropriate mechanisms to facilitate this process. We regard the interaction paradigms described here as such 'mechanisms' and as performing a similar function to constructs such as metaphors, affordances and mappings: a useful bag of tools assisting in the business of design. We also acknowledge that characterization of interaction paradigms has already been useful when addressing particular design problems for particular users completing particular work in particular contexts (e.g. forms for Web search engines). We believe these interaction paradigms can usefully leverage the understanding drawn from the field evaluations described here.

TRUST IN MOBILE GUIDES

Trust has emerged as an important issue in the design of e-commerce Websites (Riegelsberger et al., 2003; Egger, 2001), online health sites (Sillence et al., 2004), mobile commerce systems (Siau and Shen, 2003) and mobile guides (Schmidt-Belz, 2003). Trust is defined as involving "two parties: the trustor and the trustee, reliant on each other for mutual benefit", "uncertainty and risk" and the trustor's "faith in the trustee's honesty and benevolence" (Siau and Shen, 2003:92). A more technology-specific definition describes trust as "a multilateral relation, involving the technology…social partners in a direct interaction…a social context…experts, who have designed and developed a system,…who control a system, or who help the public to become aware of risks and trustworthiness" (Schmidt-Belz, 2003: 3). Riegelsberger et al. (2003:122) critique current understandings of trust as focusing on cognitive aspects of trust and suggest that trust encompasses both cognitive and affective dimensions. Central to an understanding of Corritore et al's (2003) understanding of trust of systems, described above, is the dis-embedding (Giddens, 1990) of interactions from situations where personal relationships and local context provide a background against which a trust relationship can be developed.

Given this short review, as one might expect, trust in the mobile guide arena appears to involve more than one party, with particular cognitive and affective peculiarities, involved in interaction, a technology and a social context. This 'social context' refers to consumer-provider relationships in the context of local service provision. However, in situations of use, this context may be more complex. Reeves and Nass (2004: 251) describe how media, including computers, are more than just tools, but are more akin to actors: "Media are treated politely, they can invade our body space, they can have personalities of their own, they can be a teammate, and they can elicit gender stereotypes. Media can evoke emotional responses, demand attention, threaten us, influence memories, and change ideas of what is natural. Media are full participants in our social and natural world."

With an intelligent mobile system, such as a mobile guide with engineered context-awareness and adaptivity, trust would seem to be unidirectional: the user is relying on the system for benefit (such as directions, guiding her) with no reciprocity involved. In addition, there is uncertainty and risk involved in the trust relationship, as the system could be wrong, e.g. the GPS technology may not be entirely accurate (Benford et al., 2003). This kind of system can also be also regarded within the broader context of who is providing the service: thus faith in the system and reputation are important. For a context-aware mobile guide, the key relationship for the ongoing trust relationship seems between the user and the guide within a social context, with other factors (such as using branding to describe who designed the system) acting as important background issues. Central to managing this relationship is managing the user's "confident expectation" that her vulnerabilities, such as not knowing where she is, will not be abused (Corritore et al., 2003). This is the view we will take in this paper although we acknowledge that an intelligent mobile guide could also be regarded as an actor capable of relying on the user for accurate information, such as the proximity of a landmark, in order to obtain information about the user, such as her location.

Here, we will examine trust issues in situ. We have chosen to concentrate on two field evaluations to explore trust issues. Clearly, a major factor influencing the user's expectation is the perceived role of the system she is interacting with. Different roles bring different kinds of user expectation. For example, if the role of the system resembles a knowledgeable guide or curator of an art gallery, such as with the Peach system (Zancanaro et al, 2003) the user may expect the system to know her current location and the salient artefacts in her current vicinity. If these expectations are not met (e.g. because the system cannot accurately sense the user's location) the user may experience a gap between what she experiences through the system and what she experiences in the art gallery and feel vulnerable. This is likely to result in loss of trust. One way in which the system might be designed to mitigate against this problem is to make the user aware of its inadequacies through, for example, making visible the fact that the system is not currently able to accurately predict her location. This is analogous to the user being able to see when a human guide is distracted and therefore less aware of the user's situation.

Trust of technology has been found to evolve and have discrete stages of development (Egger, 2001, Siau and Shen, 2003; Sillence et al., 2004). These phases are generally agreed to involve short-term or initial trust and long-term trust or ongoing trust. Sillence et al. (2004), within the context of online health sites, propose that users engage in rapid screening of sites, subsequent evaluation of content and an ongoing process of integration of information sources and longer term evaluation. This model has implications for both how trust formation and continuance for context-aware mobile systems should be investigated and what statements can be made regarding trust from evaluations. The field evaluations reported on here typically involve short periods of interaction (up to a maximum of 90 minutes) and thus we will focus on initial trust formation.

CASE DESCRIPTIONS

This paper draws on two projects: the GUIDE Project at the University of Lancaster, England and the TramMate Project at the University of Melbourne, Australia. The field evaluations of both systems will be described here. As described below, the GUIDE system exhibited sophisticated context-awareness and adaptivity, whereas the TramMate system exploited simulated location-awareness.

GUIDE

The GUIDE project (described in more detail in Cheverst et al. (2002)) developed and deployed a tour guide application for the City of Lancaster. The GUIDE system integrated the use of hand-held computing technologies, wireless communications (used to provide both positioning information and information updates) and adaptive hypermedia (triggered by changes in both user and environmental context) in order to support the information and navigation needs of visitors to the city of Lancaster. The evaluation of the system utilized expert review and three field trials. These trials involved direct observation with users encouraged to think aloud and subsequent semi-structured interviews. Over ninety users, between the ages of 10 and 70, used the system in these trials. No set tasks were given to the user and users were invited to use the system only for as long as they wanted to. The trials took place around Lancaster castle in Lancaster.

TramMate

The TramMate project resulted in a functional prototype through the integration of wireless communications, simulated location-awareness, a geospatial data service and a database of tram route information. Thus the system represented an integration of many services (Smith et al., 2004), but had limited location-awareness. The system supported journey planning for and travelling on the tram network in Melbourne, Australia. The system was developed by the Department of Geomatics at the University of Melbourne and designed to run within a PocketPC Web browser and is described in more detail in Smith et al. (2004). The evaluation of the system was conducted through the Department of Information Systems at the University of Melbourne and involved a field evaluation, laboratory evaluation and heuristic evaluation (Kjeldskov et al, 2004). We will report on the data from the field evaluation here. This evaluation involved five users aged between 21 and 42. Three were female and two were male. These users were asked to complete route planning tasks involving tram travel in the Melbourne CBD. Their interaction with the system was video-taped. As the user was encouraged to think aloud and asked questions during the evaluation, audio as well as video data captured. All the users were frequent computer users, had some experience with using mobile devices and were familiar with the Melbourne Central Business District.

Analysis

A grounded analysis (Strauss and Corbin, 1998) of the TramMate data was conducted. This involved abstracting patterns (themes) from transcriptions of the video data of the field evaluation in conjunction with the video data itself. These descriptions (themes) were then refined and confirmed through member checking and peer debriefing (Guba and Lincoln, 1989). Two criteria were appealed to for this confirmation: fit and understanding (Strauss and Corbin, 1998). In other words we addressed if the themes mapped onto the reality being described and if themes were comprehensible to respondents and evaluators. After the themes had been refined using these criteria they were discussed by one researcher from each case and compared to experiences from the GUIDE project's field evaluation. From this comparison central issues emerged as important. An issue emerged if it had occurred across both cases and if at least one situation involving a user could be drawn from each case. This completed Stage 1 of the analysis. In Stage 2 of the analysis the TramMate data was examined again. Themes relating to the definitions of trust presented here that had emerged from the grounded analysis were identified. The video transcripts were then used to amplify the detail surrounding these situations. Finally these situations were then related to the issues that had emerged from the first stage of the analysis.

FINDINGS FROM ANALYSIS

Stage 1: mapping issues

The *mapping issues* (issues concerning the relationship between the system and the real world as experienced by the user) that emerged from Stage 1 of the analysis, are presented in detail in Graham and Cheverst (2004) and will thus only be briefly described here and illustrated through a scenario. The six issues that emerged were: *indexicality*, *determination*, *transparency*, *accuracy*, *predictability of content* and *predictability of behaviour*.

Determination describes the appropriateness of information provision and the constraints imposed on interaction with the system (Thimbelby, 1990). This will often translate into a context-aware system determining the information the user needs and how she can get it. *Indexicality* or "a property of an interface representation that is defined as having a context-specific meaning" (Graham and Kjeldskov, 2003), describes the broad contextuality of information: if the information is provided in a context where it makes sense and in an appropriate manner given that context. *Accuracy* describes the correctness of information: if the information provided actually maps onto the physical world given the user's situation. The issue of accuracy is related to uncertainty (Cheverst et al., 2003a), or the system's inability to track a user's situation exactly. *Transparency* in this context describes the level of "honesty" that the system expresses and the visibility of its relationship with the physical world. *Predictability of content* can be regarded as relying upon the system providing compatibility at some level between the expectations of the user (gained through previous interactions and experiences with the system) situated in the real world and the information presented by the system. *Predictability of behaviour* can be understood as relying on the system providing compatibility between the expectations of the user situated in the real world and how and when the information is presented to the user.

Illustration of mapping issues

The Day-in-the-Life (Reimann and Bacon, 2004) scenario below, based on the field evaluation of the prototype in the Trammate project, describes a realistic and frequent usage situation and some of the problems that emerged with the system. This scenario serves to illustrate each of these *mapping issues* described above. This scenario has been verified for authenticity by two users and two evaluators involved in the study. The screens presented in Figure 1 are taken directly from the system evaluated during the TramMate evaluation (Smith et al., 2004).

Scenario 1

Kieran is an IT consultant and is trying to get to a meeting in the Melbourne CBD. He is on a tram travelling north along Swanston Street. He is sitting, looking out the window. The noise level in the tram is quite high but there are not many people on it. Kieran knows the city quite well so he knows he has to disembark somewhere near the next main intersection in order to catch a tram east up LaTrobe Street. He decides to use his new route planning application again so he takes out his PDA and looks at the information on tram routes he had checked earlier. The tram route information is still on the screen (see Figure 2a). He has been using the system for a while and so he knows that the first line of the display means that he has to take the 64 tram (rt64) from stop 1 (s1) to stop 6 (s6), the second line means he has to disembark and change and the third line means he then has to catch the 23 tram (rt23) from stop 3 to stop 4. He knows he is currently on the 64 tram but is not *sure about his current location. He is not sure where to catch the second tram from, so he clicks on "interchange" (see Figure 1a). The display provides him with some instructions: "Disembark at the intersection of LA TROBE ST and SWANSTON ST (stop 6) and walk to stop 3 on LA TROBE ST." He then clicks "View Map" to get more information. A map at a low level of detail appears (see Figure 1b). He knows the star symbolises where he has to disembark and the tram icon is where he has to embark the next tram. He's a bit confused though: the second tram he has to take also seems to be on Swanston Street, except going in the opposite direction (see Figure 1b), and the system seems to be asking him to catch a tram for one stop only (see Figure 1a).*

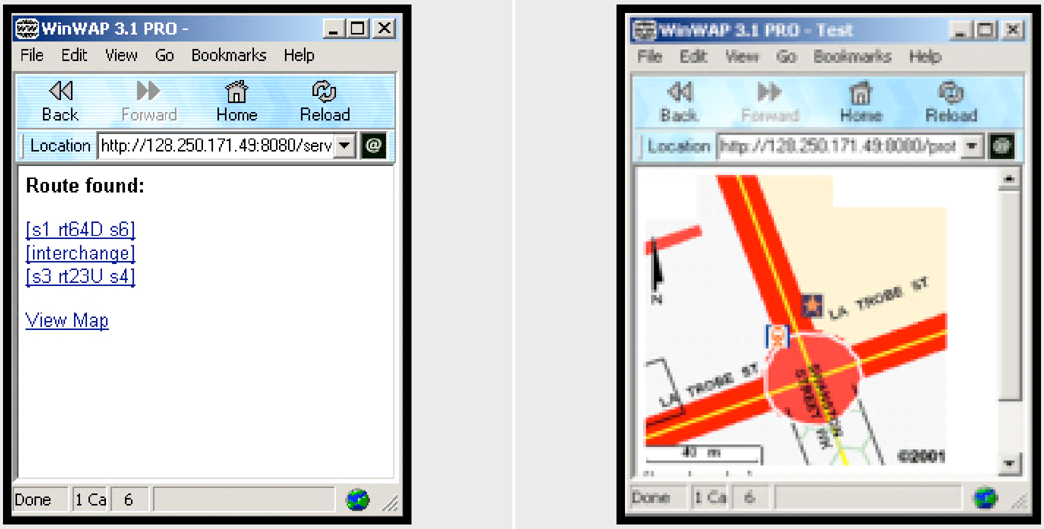

Fig 1a: Route information showing 2 trams

Fig 1b: Intersection map showing 2 stops

Figure 1: Two screens from Kieran's PDA (Smith et al., 2004)

Analysis of scenario 1 using mapping issues

In the scenario above what is delivered to Kieran is not highly *determined* or *indexed* as the system does not heavily constrain how Kieran gets information and information is not presented based on his current context. The *accuracy* of the information, such as the stop locations is medium, but this is not tested from Kieran's perspective. The positioning of one tram icon (the star in Figure 1a) does cause Kieran some difficulty though. The *transparency* of the system with regard to its own accuracy is medium as there is a scale on the map but the degree of *accuracy* of the positioning of the icons on the map, for example, is not clear. The *predictability of content* and *behaviour* are high as he is not surprised by what he experiences, despite the system being relatively new to him: it serves up information based on pull and according to set, prescribed patterns. However, the underlying algorithm determining the route recommended would deliver different tram information depending on the time that Kieran queried the system. This change in route information caused some problems relating to *predictability of content* for some users in the field evaluation.

Issues from stage 2 of analysis

After the *mapping issues* described above had been identified, we examined transcripts of the video data and the themes emerging from these again. Through discussion, it became apparent that both positive and negative trust trust-related issues emerged. All users seemed to begin trusting the system. One user seemed to trust the system throughout the evaluation. Another user seemed to have quite a consistent lack of trust of the system, bar a period in the middle of the evaluation when this user noticed that the system was accurate. The other three users' level of trust in the system seemed to vary as the evaluation progressed. Further analysis of the transcripts showed that trust breakdown was caused by lack of accuracy, lack of ambiguity, over-determination, lack of appropriate indexicality, lack of predictability of content, lack of predictability of behaviour and lack of transparency. The most common causes were lack of accuracy, lack of appropriate indexicality and lack of transparency. Notably three users trusted the system when it was inadvisable for them to do so. As the evaluation involved about 90 minutes in the field using the guide it was not possible to evaluate long term trust development.

Under-*accuracy* caused problems for four users, with one user commenting: "Yeah, I don't think that's right because Exhibition Street's only two stops…So I can't really rely on that." Another user when asked about the orientation of streets on a map replied: "Ahh, well that means that Bourke Street is actually Swanston Street." Lack of *indexicality* caused problems for two users. One user questioned the trustworthiness of the maps in the system due to under-indexing: "It's just that I didn't trust the map telling me where I was at the moment." If information had been indexed to the user's current location, this lack of trust may have been avoided. Lack of *transparency* caused problems for two users, with one user commenting: "…but I wonder how accurate it's likely to be because we're going such a short distance." Another user commented "No the metres is, uhh, only if you think in metres but 7 metres is really hilarious. That means like just get up and go there. Get off and where you are, think if you got off at the back of the tram or the front of the tram that could be a whole lot of metres already used up. And maybe you wouldn't know whether you were allowed to walk past the front of the tram or not." In this example, the over-precise wording and measurement in the system contributed to under-*transparency* concerning the *accuracy* of the mapping.

In the GUIDE system, precise wording did help regain trust: "….walk left past the bollard on your right but be careful of the awkward step down…" Although this could be read in a guidebook with little reaction when user's were presented with this highly indexed information, just as they passed the bollard, users reacted to the apparent accuracy of the system's understanding of the situation by commenting on their high trust of the system at that particular point. However, as described above such trust can be short-lived.

Summary: trust issues

Based on the data from the two field evaluations, we conclude that trust in the context of mobile guides is dynamic: users' trust can be gained and lost and regained over a short period of time. In addition, lack of trust emerged when the system was under-accurate, under-indexed and under-transparent. Of these issues most trust-related incidents in the TramMate project field data related to accuracy: either the system was too accurate or else clearly wrong when matched with the real world or against the user's knowledge and experience. These findings inform the definitions of trust previously presented. This data supports trust involving two parties, in this case the system and the user. The findings also show that trust is dependent on what the user knows and that the trust relationship is one-way: the users brought their own knowledge to the use situations and relied on the system to provide them with appropriate information. The uncertainty and risk in the field evaluations was caused by the usage situations and, very importantly, by the act of relating the information in the system to the real world and vice versa. When this *mapping* was not perceived as adequate users no longer had a "confident expectation" (Corritore et al, 2003:738) they could rely on the system in a situation where some uncertainty was involved. This inadequacy was accentuated by under-transparency, which, along with appropriate accuracy, could have assisted with the management of trust in these situations.

Thus we have demonstrated that trust development and maintenance is related to *mapping issues*. We now describe five possible interaction paradigms drawn from these issues, developed to meet the challenge of designing for trust. Our suggestion is not that the characterisation of these paradigms is suitable for all context-aware systems. Nor are we suggesting that one particular paradigm is suitable for all situations. We are proposing instead that interaction paradigms are useful tools for designing interaction and for matching appropriate interaction styles with particular situations or groups of situations.

Drawn from the field data described here, we consider two aspects of situations to be important for context-aware systems: *stability* (how likely a possible situation is to remain constant and not change) and *complexity* (how difficult the possible situation is to model for the system). We do not claim that these are the only aspects of situations that are relevant for the design of these kinds of systems. Rather than speculate on the appropriacy of particular paradigms across situations we explore the use of the paradigms in a scenario with a view to redesigning a prototypical mobile guide for trust. This scenario is representative of one used by a design team.

PROPOSED INTERACTION PARADIGMS

Given the coupling between perceived role of the system and trust it is useful to consider the different roles that a mobile guide may exhibit. We now present five interaction paradigms, representing roles. The aim of the paradigms below is to facilitate the discussion of trust issues when designing guides. The paradigms are: *Local, Guide*, *Chaperone*, *Buddy* and *Captain* and are described in more detail in Graham and Cheverst (2004). These paradigms can be thought of as descriptive of possible mobile guides and useful abstractions for use in the design of future paradigms for mobile guides to help ensure that trust is at least considered during the design process.

A local is "an inhabitant of a particular area or neighbourhood" (Pearsall, 2001). The *Local* paradigm acts like an information repository and can be compared to a local expert on a particular geographical area. The *Local* tends to be more passive than a guide: local experts often have to be sought out. *Locals* respond when queried, passing all initiative to the user during dialogues. Limited intelligent filtering of information is used when responding to queries. The TramMate system exhibited characteristics of a *Local* paradigm: it accessed extensive tram timetable information and CBD geospatial data.

A guide is "a person who advises or shows the way to others" (Pearsall, 2001). The *Guide* paradigm acts like a decision support system and can be compared to a guide on a hiking tour. A guide exhibits "intelligence" through proactively making recommendations, and providing assistive information for example. The *Guide* paradigm also passes some initiative to the user during dialogues and filters information presented to the use. The second design of the GUIDE system, exhibited *Guide*-like characteristics: it pushed the user information on a given attraction, such as the city castle, as the user approached the attraction.

The *Chaperone* paradigm acts like an expert system and can be compared to a guardian (Cheverst et al, 2003a). When adopting the role of a guardian a system may only interact with the user if she is doing something wrong. *Chaperones*, like locals, tend to be passive. However, the *Chaperone* will take initiative away from the user under certain circumstances, e.g. when the user takes a wrong turn when navigating to a given destination. Thus, a high level of "intelligence" is required to present information to the user. The *Chaperone* is not really designed to be queried. The GUIDE system, for example, could have interacted with the user through using a *Chaperone* paradigm by stating "You are taking the wrong turning, you ought to go left, not right here." *Chaperones* require a high level of positioning accuracy to make such highly critical and highly indexed assertions.

A *Buddy* is "a working companion with whom close cooperation is required" (Pearsall, 2001). With this paradigm, the idea of cooperation and shared responsibility for completing the user's work is important. A *Buddy* has elements of the expert system, decision support system and information repository. The *Buddy* utilizes mixed initiative dialogues, sharing control of the interaction with users. A *Buddy* exhibits a high level of "intelligence" concerning its interaction with the user. A later version of the GUIDE system acted like a *Buddy* through asking questions such as "Can you see the castle?" This interrogative helped resolve uncertainty regarding the user's current location and resembles asking a friend to help with orientation, perhaps remotely over a mobile phone link. Thus it adopted a cooperative stance when interacting with the user and exploited ambiguity in its dialogue.

A captain is "a person in charge of a team" (Pearsall, 2001). The *Captain* acts like an expert system and uses an interaction paradigm similar to an on-board navigation system in a car. Thus, the *Captain* takes initiative during dialogues (and can indeed appear fairly dictatorial) and utilizes intelligence to filter information presented to the user heavily. TramMate exhibited the *Captain* interaction paradigm at times: it presented the user with directions which were termed in an imperative fashion e.g. "Go along Bourke Street for 7 metres." The GUIDE system also utilised this paradigm when providing the user with a series of highly indexed instructions to assist him or her in navigating from one attraction to another, e.g. "From the caste gate walk left past the bollard…"

	Local	*Guide*	*Chaperone*	*Buddy*	*Captain*
Determination	Low	Medium	Low	Medium	High
Indexicality	Low	High	High	High	High
Accuracy	High	High	High	Medium	High
Transparency	Low	Low	Low	High	Low
Predictability (content)	Medium	Medium	Low	Low	Medium
Predictability (behaviour)	High	Medium	High	High	High

Figure 2: Interaction Paradigms With Respect To Mapping Characteristics

The table above describes how the *Local* interaction paradigm has low determination, indexicality and transparency and exhibits quite high predictability of content and high accuracy and predictability of behaviour. The *Guide* interaction paradigm is highly indexical and accurate, not very transparent, and exhibits quite high determination, predictability of content and behaviour. The *Chaperone* interaction paradigm has low determination, transparency and predictability of content and high indexicality, accuracy and predictability of behaviour. The *Buddy* paradigm has medium determination and accuracy, high indexicality, transparency and predictability of behaviour and low predictability of content. The characteristics for the *Captain* paradigm are all high, bar transparency, which is low, and predictability of content, which is quite high.

REDESIGN OF A MOBILE GUIDE USING INTERACTION PARADIGMS

This section will use the interaction paradigms above to firstly describe issues with a proposed implementation that build on the TramMate study and secondly, to propose improvements.

The scenario below is, again, drawn from the TramMate field data and is representative of an artefact that was used in a design team to build a system responding to issues that emerged from the TramMate field study. Thus the scenario below is similar to a Concept Sketch (Reimann and Bacon, 2004). The authenticity of this scenario has been verified by two members of the design team. The screen shots below are based on the prototype of a context-aware route-planner (TramMate 2) that emerged from this exercise. This system was implemented as a desktop emulation of the proposed system and utilised a Java user interface to interact with a context simulator.

Scenario 2

Sarah is standing on a tram travelling south along Swanston Street towards Flinders Street. The tram is very noisy and full: thus she has not been able to get a seat. Sarah is new to Melbourne and is really not sure where she should disembark: she wants to go to Federation Square. She has recently started to use a tram route planning application running on her PDA. She looked up the tram route to get to Federation Square earlier in the day and switched on location-awareness. Thus when she takes out her PDA it informs her of her current location via a tram icon and her destination via a star (see Figure 3a). The display informs her that she should get ready to disembark at Stop 13 (see Figure 3a). She really has no idea where that is! She hopes the PDA will give her more information, but there don't seem to be any options. She anxiously looks at the display and tries to move towards the window to see a street sign. Suddenly her PDA updates and displays a picture of a sand-coloured building (see Figure 3b). She can't see it from the left hand window. She has to disembark now! She quickly pulls the cord and disembarks from the tram.

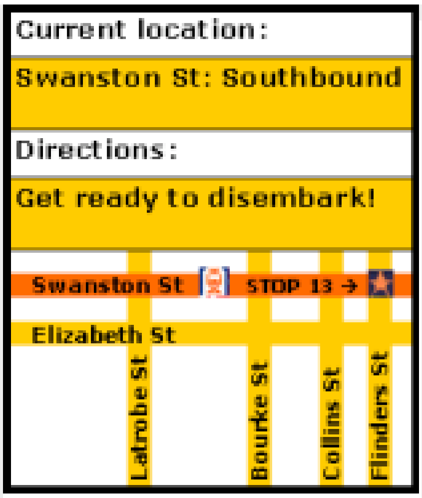

Fig 3a: "Pushed" location, instructions and map

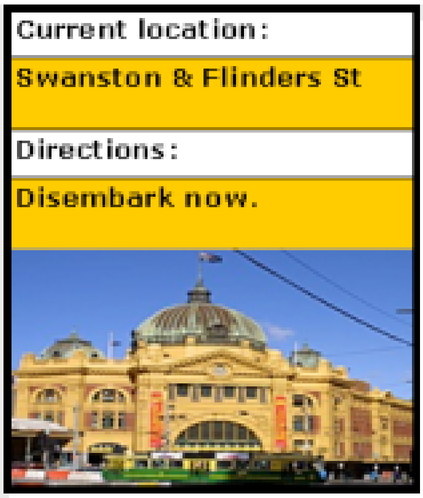

Fig 3b: "Pushed" location, instructions and landmark

Figure 3: Two screens from Sarah's PDA

Analysis of scenario 2

In the scenario above what is delivered is highly determined or indexed; the accuracy of the information (i.e. the stop locations) is high to medium, depending on the effectiveness of the GPS technology; the transparency of the system with regard to its own accuracy is low (the system is slightly late in delivering information to Sarah, but does not inform her of this); and the predictability of content is medium (Sarah does not know the city very well); and the predictability of behaviour is medium (Sarah is not sure exactly when information will be delivered to her). Sarah's situation is quite complex: she is travelling on standard tram routes and is using set roads and tram stops, but trams can run late and trying to model Sarah's view of the world as it moves by her is difficult. In addition, much of the environmental information Sarah needs to make sense of the display is hard to gather just-in-context: reading street names and tram stop numbers on signs while the tram is moving is difficult. Sarah also has the opportunity to engage in unanticipated action, like disembarking the tram at a stop the system does not expect. Thus modelling the situation is quite difficult for the system. The *stability* of the situation is low as the environment is constantly changing and Sarah is embedded in a public space that is in flux.

Conclusion from scenario 2

Through utilising Figure 2, we can see the Captain paradigm is exploited in this scenario. We can also conclude that the Captain paradigm may be effective in maintaining trust in quite complex, unstable situations. Notably, the paradigm's success in maintaining trust depended heavily on the accuracy of the GPS technology and on appropriate indexing The system's limited accuracy and the consequential uncertainty produced suggest that a question like "Can you see Flinders Street Station (pictured below)?" would have been appropriate towards the end of the scenario. In addition, the system chose to present Flinders Street station as a landmark, which is on the right hand side of the street, relative to a southbound tram traveller. A landmark on the left hand side of the street may have been more appropriate, given Sarah's likely orientation and position in the tram.

To overcome these problems the system could have employed mixed paradigms: switching to the Buddy paradigm when it sensed limited accuracy and high complexity. This switch could have managed Sarah's expectations better. If Sarah had been able to see Flinders Street Station and so respond that she could or could not, one would expect this to have a reassuring effect and reduce her sense of vulnerability and increase her trust of the system. This switch between paradigms was exploited by the GUIDE system and was found to be effective, although exploration of this issue was not the focus of the field trial.

CONCLUDING REMARKS

In this paper we have investigated the difficulties of designing for trust in relation to mobile guides. Using a refined definition of trust for mobile guides as involving the management of a user's confident expectation that technology can be relied upon in situations involving uncertainty, we have explored ways of designing to maintain trust. Specifically, we have evolved personified interaction paradigms, based on *mapping issues* drawn from our experiences in the field involving two systems. We argue that these paradigms are useful in responding to the difficulties with trust presented by context-aware mobile guides. We believe the paradigms can be used to understand difficulties with current systems and develop new systems through presenting a design response to the difficulties presented by user expectations and sense of doubt or vulnerability in different situations. We also show that mixed paradigms can be used to manage interaction involving changing situations: thus the context-awareness of the system can help determine the appropriate paradigm. We argue that when switching among paradigms transparency is critical.

We acknowledge that the speculations regarding the appropriateness of the paradigms for particular situations require more exploration through approaches such as scenario-based design or indeed further field based evaluation. However, these paradigms are a response to problems emerging from the evaluation of two mobile guides in the field. In addition, the effectiveness of the paradigms for supporting design has been tested through using a scenario based on a field evaluation to represent a design situation. We acknowledge there is a significant opportunity for further research investigating the effectiveness of these paradigms as design tools across different situations. We also acknowledge that we have chosen only a few aspects of situations through which to explore the use of the paradigms. The effectiveness of paradigms could also be investigated with regard to different aspects of situations, such as how frequently a situation occurred, for example.

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