Exploiting incidental interactions between mobile devices

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ABSTRACT

Not all human–computer interactions are directly derived from the concious intention of a user. There are a class of interactions which occur as a side effect of the user's current goals but which nevertheless, provide a useful modality for interacting with mobile applications. This paper discusses the use of these '*incidental interactions*' in mobile applications, particularly those that rely on the notion of co-presence. This paper presents three projects that exploit incidental interactions: The first, *Amigo*, is a application that uses Bluetooth to construct a representation of a user's social network and associate these with calendar events; the second project, *Co-presence Communities*, takes the Amigo concept further by mining the co-presence data to discover reoccurring group meetings; and finally, *BluScreen* is a pervasive public display that utilises co-presence data to provide feedback to an agent-based marketplace, which is responsible for allocating the time slots for each presentation.

Categories and Subject Descriptors

H.5.2 [**User Interfaces**]: Interaction styles; H.4 [**Information Systems Applications**]: Miscellaneous

Keywords

Incidental interactions, Co-presence, Mobile social applications, Bluetooth

1. INTRODUCTION

Traditional literature in the field of human–computer interaction assumes that the user has a particular goal in mind when they start interacting with a computer. This is often characterised by Norman's interaction model [11], which consists of two primary phases: execution (including planning) and evaluation. That is, the user begins with a goal in mind, executes a plan to achieve this and then evaluates the results against the intended state. This model accounts for the majority of computer interfaces but it has the disadvantage of requiring the user's attention for the planning, execution and evaluation phases. Whilst this may not be a problem when the user is fully occupied by the task, there are circumstances where the user is neither capable, nor required, to switch their attention to the computer. This 'attention scarcity' is more prevalent with mobile phones, where the user is typically required to devote at least part of their attention to other tasks. In contrast, applications on a desktop computer are assumed to be the main and primary focus of the user.

This paper advocates an interaction model for mobile devices that co-opts the user's intentional actions for one task, as inputs towards an entirely different goal. An example, elaborated throughout this paper, is the goal of building a representation of your social network. A traditional system would allow a user to input the names of their contacts and perhaps note when, where and how they maintained that relationship[1]. Our proposal, explored throughout this paper, is that the goal of building the social network representation should be a by-product of the *actual social interactions*. So, the action of a user meeting someone would automatically update the corresponding entries in their profile.

This paper begins with an introduction to '*incidental interactions*' (in Section 2) and specifically to Co-presence as a form of interaction (Section 3). Section 4 provides a brief description of three current research projects which employ incidental interactions. In particular, Section 4.1 presents *Amigo*, a web-based social networking site, that uses information derived from incidental interactions. Section 4.2 introduces *Co-presence Communities* as an extension of the Amigo project that provides a richer analysis of a user's social network. *BluScreen*, in Section 4.3, is a public display that uses the incidental interactions of viewers to influence the future content. Finally Section 5 concludes this paper.

2. INCIDENTAL INTERACTIONS

In contrast to the Norman model of intentional actions, Dix has proposed *'incidental interactions'* to describe those actions that are co-opted by a system to serve a different goal from that which the user was currently undertaking [3]. Dix defines incidental interaction as the situation "*where actions performed for some other purpose, or unconscious signs, are*

[1]indeed, this is the model for all 'social networking services' currently available on the Internet

interpreted in order to influence/improve/facilitate the actors' future interaction or day-to-day life" [2]

This emphasises the user's focus on one task, whilst the system is surreptitiously using those interactions to actually fulfil a different goal. The canonical example of an incidental interaction is the interior light of a car: When the user opens the car door, the interior lights are activated. The user's goal is to enter or exit the car, but the system uses the interaction with the car door to fulfil the unstated goal of illuminating the car interior. Note that 'incidentalness' does not imply that an action or subsequent goal is unintentional, just that the user may have previously specified it to the system and not be consciously thinking about it whilst performing the actions. Incidental interactions also differ in the feedback that the user receives. Whereas a traditional application would provide direct, explicit feedback to the user regarding their actions, feedback from an incidental interaction will often be minimal, unobtrusive and delayed. The de-emphasis of explicit user interaction and feedback provides incidental applications with a strong requirement for autonomous software, and an obvious connection to the field of agent-based computing [10].

3. CO-PRESENCE

Co-presence refers to the spatio-temporal conditions under which people can interact with each other. Goffman defined it as the condition when people "*sense that they are close enough to be perceived in whatever they are doing, including their experiencing of others, and close enough to be perceived in this sensing of being perceived*" [7]. Co-presence (or more formally, *corporeal* co-presence [14]) is the condition under which two or more people are in the same place, at the same time. In general, co-presence is not an intentional action by itself but rather a by-product of some other goal, which makes it a useful form of incidental interaction.

Humans experience co-presence through one or more sensory inputs but, since computational systems lack that capability, it is necessary to develop a technological solution to co-presence detection. If we take Goffman's view of co-presence, then any technological co-presence sense should be roughly equivalent to human sensory inputs. The class of technologies called Personal Area Networks (PAN) provide a good match with Hall's work on our sensory abilities [8]. In particular, the effective range of PANs corresponds to the distance at we can perceive individual characteristics in people. Most wireless PANs, such as Bluetooth, are effectively confined to a single room due to their short-range and limited wall-penetration abilities. Bluetooth also the advantage that it has been widely adopted in mobile devices, from laptops to PDA's and mobile phones. For the purposes of this work, the wireless 'bubble' formed by a Bluetooth device is used as a co-presence sensor and the presence of that device is assumed to indicate the presence of its owner. Whilst it is also assumed that there is one-to-one correlation between a mobile device and human owner, it is also accepted that individuals without mobile phones (or without Bluetooth activated) will not be discoverable.

A Bluetooth sensor attached to an individual allows the computation of co-presence to be embodied within the real–world [4]. This embodiment means that through the medium

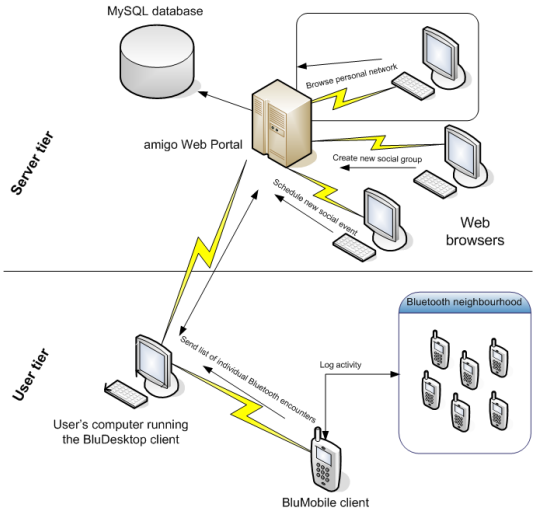

Figure 1: The Amigo architecture consisting of BluMobile client, BluDesktop and the Amigo web service

of real-world interactions, the user can participate in co-presence systems, without resorting to activities outside of their normal daily routine. This aligns well with Dourish's argument that embodiment "*does not simply mean 'physical manifestation.' Rather, it means being grounded in everyday, mundane experience... [embodiment] is the property of our engagement with the world that allows us to make it meaningful*". The real–world embodiment facilitated by a co-presence modality (i.e., that the interaction is "grounded in everyday, mundane experience") neatly matches the characteristics of an incidental interaction, which should result from some other real–world goal (that "mundane experience").

4. CO-PRESENCE PROJECTS

The three recent projects described in this section utilise a co-presence interaction modality in a similar way to previous applications (such as the selection in [1]). In particular, the Serendipity application [5] detects co-presence between two individuals using Bluetooth-enabled phones, attempts to match their two profiles and, if successful, provides an introductory service. This has obvious dating applications but the actual usage scenario was to enhance corporate collaboration. Moving beyond the immediate interaction, Eagle & Pentland have used Bluetooth phones as mobile sensors from which to determine a user's activity and location [6]. In another direct example of incidental interactions from co-presence, the Jabberwocky device used Bluetooth to determine a user's 'Familiar Strangers' [12]. This also demonstrated how a user might come to subvert the co-presence interaction by deliberately straying away from their usual patterns to seek out new pastures and avoid their familiar strangers.

4.1 Amigo

Amigo is an social networking service built upon real interaction data collected by Bluetooth phones. It keeps a history of co-presence encounters and a calendar of events, and uses these to infer social relationships and attach occurrences of

co-presence with particular diary entries. Amigo consists of three main components: a client application, BluMobile; a desktop application, BluDesktop; and the central Amigo web service. The architecture is sumarised in Figure 1.

The BluMobile client is a J2ME application that can be installed on a Bluetooth-equipped mobile phone (a W800i was used in our trials), and regularly scans for other Bluetooth devices in the vicinity. These encounters are logged to the phones internal memory and may be displayed in a textual or graphical form. However, the main purpose of BluMobile is not the visualisation of these co-presence encounters, but as a means of collecting the co-presence data. Due to the storage and processing limitations of mobile phones, the co-presence data is then transferred to the user's PC for processing by the BluDesktop client. BluDesktop acts as the user's main store of co-presence data, calendar entries (in RDF iCal format[2]), and social network representation (in FOAF format[3]). The representation of the user's social network is built from the co-presence data, using the simple rule that any person who has been co-present with the user for more than a specified total amount of time (default: 1 hour) is considered a 'friend' [4]. Anyone who doesn't meet the criteria of 'friendship' is just considered to be a casual encounter. A mapping between calendar events and the people associated with it is constructed by considering any person who was co-present with the user for more than a specified percentage of the event's duration (default: 20%) to be related to that event. These event-person connections are used to form a representation of the event's social group. The resulting user profile, which incorporates the social relationships and event groups, is created as an RDF document and uploaded to the Amigo web service. This profile is used by the Amigo site to provide a mechanism for browsing the profiles of those members of the user's social network (where authourised) or the co-presence history by events, time or device.

Amigo is an example of an application based upon incidental interactions because the act attending of a social event (e.g. Salsa dancing) has the incidental effect of building up a representation of the social group around that event. Another functionality of BluMobile is the ability to be notified, through an audio or vibration alert, when one of your 'friends' comes into range. Admittedly, this isn't a terribly useful feature with the typical 10 m range of Bluetooth, however it does highlight the incidental effect of a co-presence interaction: as the user approaches a friend (for whatever intentional reason), their phones will incidentally vibrate.

4.2 Co-presence Communities

Co-presence Communities is a project that aims to discover socio-temporal patterns from co-presence data (much like Amigo) but relies on the user to add contextual information (whereas Amigo utilises calendar information). An initial algorithm for discovering these co-presence communities has been developed that incorporates a feature extraction routine and conceptual clusterer [9]. However, the details of that algorithm are outside the scope of this paper.

[2]http://www.w3.org/2002/12/cal/ical.rdf
[3]http://xmlns.com/foaf/0.1/
[4]A 'friend' in this sense is the simple binary relationship provided for by the FOAF representation rather than any deeper sociological construct

Figure 2: The BluScreen installation

A **Co-presence Community** is formed by the repeated co-presence between a *group of individuals* at approximately *the same time period*; a Monday morning project meeting or a daily coffee break at 3:00 would be two examples. These co-presence communities are probabilistic representations that cluster together co-presence events on both temporal (start and end times) and membership dimensions. A community may be stable to a varying degree across these two dimensions. For example, the co-presence community formed by weekly project meetings would have stable membership and temporal dimensions (the same group of people at the same time interval). In contrast, the community formed on a commuter bus might have a stable temporal dimension (because you always catch the same bus) but an unstable membership (because it's not always the same people on that bus). By obtaining these community memberships via wireless sensors, it is be possible to build a dynamic, self-updating model of the people that a user is normally in the proximity off at any given time.

AIDE, the Ambient Information Dissemination Environment, is one possible application of co-presence communities. AIDE allows users to distribute content in a peer-to-peer manner, using their co-presence communities as a self-updating distribution list. The advantage of co-presence communities for this application is that they allow dissemination in different contexts: sharing jokes with strangers on the commute home (i.e., a time-stable community) or disseminating the latest call-for-proposals to a research group (a fully stable community formed by weekly meetings). AIDE ambiently determines which community a detected device belongs to and transfers the selected content in the background, based on the source user's specified preferences. With the AIDE application, the user is expected to pursue their normal goals and the dissemination of their content (being a longer-term goal) is carried out as a side-effect of their daily routine.

4.3 BluScreen

BluScreen is another project that derives its functionality from the incidental interaction between co-present devices. However, in this case, the co-presence activity is used to auction off display time for a pervasive public display to autonomous advertising agents [13]. Figure 2 shows one of the BluScreen installations mounted near a major thoroughfare.

The user's interaction with the screen (such as pausing to view the contents) is co-opted by the BluScreen to incidentally provide feedback to the agent marketplace about your implied preferences, and thereby change the content you receive in the future.

5. CONCLUSIONS

This paper has concentrated on a class of interaction which is not normally considered interesting in HCI research: those interactions that are incidental rather than being explicitly intentional. These incidental interactions are more important to mobile applications since the user's attention can be productively directed at other tasks. The examples and projects discussed in this paper are all based on co-presence interactions: Amigo uses them to build up a semantic representation of a user's social network; Co-presence Communities exploit the interactions to build a more comprehensive social model and, through the AIDE application, allow content to be disseminated without repeated, explicit, intentional actions; finally, the BluScreen project uses the co-presence interaction between viewers and a pervasive display device to enhance the quality of the displayed content. For some mobile applications, the focus needs to be moved away from the traditional modalities of the mobile phone and towards less attention-demanding, more autonomous, and more context-aware, interactions.

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