Realising Context-Sensitive Mobile Messaging

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Abstract. Mobile technologies aim to assist people as they move from place to place going about their daily work and social routines. Established and very popular mobile technologies include short-text messages and multimedia messages with newer growing technologies including Bluetooth mobile data transfer protocols and mobile web access. Here we present new work which combines all of the above technologies to fulfil some of the predictions for future context aware messaging. We present a context sensitive mobile messaging system which derives context in the form of physical locations through location sensing and the co-location of people through Bluetooth familiarity.

1 Introduction

The *mobile space* is broadly defined as the technologies designed to support people on-the-move, people who are moving from place to place as part of their business or leisure pursuits and who need technology to support them in their interactions with work, and/or as part of their social lives. Because this is a lucrative area of business there are already technologies which are commonplace, have widespread deployment and are mature, and there are others which are still emerging. Examples of mature technologies to support users on-the-move are voice telephony and mobile messaging, both text (SMS) and multimedia (MMS), and examples of emerging technologies are location tracking, mobile access to the web and web services, location-based web services and digital signage.

From the earliest science fiction books and movies, people have been predicting a future where wireless, mobile devices used for communications are an integral part of our lifestyle and some of these have already been realised. Yet we are capable of going much further with our mobile communications. In this paper we are concerned with exploiting *context* as much as possible in giving us advanced functions based on mobile communications.

Exploiting context as part of mobile communications is not a new idea and there have been many attempts at predicting, and building prototypes to illustrate the different types of context and how it can be usefully exploited. Many of these predictions of the future have not been realised, yet, because the stumbling block has always been the absence of scalable and robust technologies to capture and use such context, especially context related to a user's location. A trend seen in other context aware work is that many present mock-ups or restricted forms of technology rather than being suited for more widespread use. In this paper, instead of predicting a future and hoping technologies will develop to support it, we examine the current status and limitations of some technologies for capturing contexts. We present a system which uses users' environmental contexts in order to deliver SMS messages or to present messages on public digital signs. We use a definition of *user context* which is based on detecting and recording specific location and co-location information through Ubisense location sensors and/or through Bluetooth signatures from a person's mobile phone.

The rest of the paper is organised as follows. In the next section we present some of the background technologies relevant to our work and we look at the strong trends evident in this area. We then describe our context-sensitive messaging system, covering the message types, user interaction options, system architecture and how it operates in practice. We conclude the paper with yet another set of predictions of what will happen in this area but this time based on a system we have actually built for context-aware messaging.

2 Background Work

2.1 The Technologies

Although it seems that mobile messaging has been around forever, the text-based short messaging service (SMS) was originally defined as part of the GSM standard only about 20 years ago and was quickly followed by multimedia messages (MMS). Logica CMG who are one of the largest developers of software for supporting the relaying of SMS messages estimate that over a trillion SMS messages were sent in 2005 alone. One of the advantages of SMS and MMS messages is that they are close to instant in their delivery time, so much so that we can almost have conversations, yet this is also one of their limitations in that their delivery cannot be conditioned in any way on any outside parameters such as date/time, location, or the presence of other people whom the recipient may be in company with. We shall return to this point later.

Digital signage is a technology that involves the use of large-format computer displays in public spaces, either indoor or outdoor, and it is becoming increasingly popular as the costs of manufacturing the displays decrease. The developments in display technology mean that we now have daylight viewable colour LCD screens which are large enough, bright enough and have high enough resolution to present high definition content in broad daylight. Digital signs displaying advert messages are appearing as in-store and store front messaging and advert servers, in public places for presenting public messages, in entertainment especially when used as part of video walls, and so on.

Digital signage systems have only very recently started to take advantage of being connected to the internet. A US company, RippleTV [13], have started to allow clients to place their own video or image adverts to be displayed on specific digital screens running entertainment TV and adverts at times and in places where their target audience is known to gather and to wait for something for example in petrol stations while people are filling their cars or in coffee shops while their coffee is being made. These represent a limited form of context-sensitive advertising which target people on-the-move and where the context is the time and place, but the trigger for displaying each advert is hard-coded by the client placing the advert so the context is fixed in advance. In the work reported here we have a more flexible and dynamic definition of context.

Finally, Bluetooth is a short-range wireless protocol which provides users with a mechanism for exchanging information over short distances with other enabled devices. It is increasingly included in devices from home computers to portable laptops, mobile phones, PDAs, keyboards and headphones. Today there are over 1 billion Bluetooth equipped devices in use and it is expected that this number will double by 2009 [3] so it offers enormous potential for ubiquitous networked applications. For example, we are also seeing Bluetooth exploited in advertising with a small number of billboard installations now automatically sending advert related content directly to the mobile phones of passer's by [7].

2.2 The Trends

Technologies are not the only influencing factors on implementations of predicted technologies. Trends in context aware systems, the exploitation of mobile technologies for tasks which go beyond their initial functionality and social activity trends in the mobile space have all shaped the types of context aware systems that are now emerging. We now examine each of these in turn.

Context awareness or sensitivity is defined as a knowledge of situational information. Dey and Aboud, [5], define context as any information that can be used to characterise 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.

In context aware systems, situational information is used in order to adapt an application or system using event-based or environmental triggers detected through the use of sensors. The 'Forget-me-not' system [9] presented ideas for a handheld memory prosthesis device where memory notes or reminders would appear on a handheld device based on the user's location, and co-location with others. The technology used to realise location-awareness was the 'Active Badge System' [16] which was deployed in a single office building. This operated by the user wearing a battery-powered device that emitted a unique radio signal every 15 seconds which was picked up by an array of sensors and from that the wearer's location could be pinpointed. Other examples of location-aware services based on active badges were automatic re-routing of phone calls to different handsets, which allowed wearers to move around the building and have their phone calls routed to them, or diverted to voicemail if they happened to be co-located with several others inferring that a meeting was likely to be taking place. The 'Shopping Guide' [4] is a PDA-based system that would give a shopper directions through a shopping mall on the basis of their shopping preferences and purchases to date, and also based on their location in the shopping mall. PlaceIt and the hospital specific message system [11] both rely on location awareness to drive their messaging service. PlaceIt [15] relies on simple location detection through GSM technology to trigger reminder messages and Munoz et al [11] developed a hospital messaging system which takes into consideration time, staff roles, artifact states and location to trigger its messages. Finally, 'SenSay' [14] is an adaptive mobile phone which uses readings from a range of wearable sensors to modify the status of a user's mobile phone, for example switching to *active* if the user has a high level of physical activity and the phone ringtone is then set to loud. While not location-sensitive per se, this does however exploit co-location with others as the phone is set to *uninterruptible* if the user is involved in a conversation with others, as determined by analysis of sounds picked up by the phone's microphone.

With the advent of internet services such as MySpace, Facebook and Digg, we have become increasingly familiar with the term '*social networking*'. However, despite its new-found popularity, it is far from a new concept. Social network analysis stems from early sociology research into group behaviour and dynamics and the term was originally coined by Barnes in 1954 [1]. Social network analysis attempts to determine the social structure of a person or group of people. It is often used to make determinations such as the social circles and associations which exist within a connected set and the level of cohesiveness that they present. Social network analysis borrows heavily from graph theory as it "*provides a vocabulary which can be used to label and denote many social structure properties*" and provides a formal basis to measure such properties [17].

The MIT Media Lab's Reality Mining Project has explored the application of social networking concepts within the the mobile space. As part of the project, 100 participants were provided with mobile phones which logged all activity including phone calls received and made, cell towers the phones connected to, text messaging and application use. Using this mobile context data they were able to infer social relationships between participants, build detailed maps of a participants social network and even predict participant behaviour [6]. devices.

While Bluetooth was originally designed to facilitate information exchange between mobile devices, it offers mobile applications other affordances. The Bluetooth protocol allows a device to scan for other Bluetooth-enabled devices in its vicinity, the results of which can be used to infer social presence within a proximal space. With this, we can continuously monitor the presence of nearby devices and gather extremely detailed context information on the activity within the space around a device. The presence information results in a description of what devices (and thus which people) have been co-present, when they were co-present and for how long. The Photo Loi application [12] already uses Bluetooth presence information to make a determination of who might have been present in photos and annotates media captured on a mobile device with this information.

While presence information is useful, it does not on its own convey the importance of the devices we encounter. Without an understanding of the importance of individual devices encountered an accurate depiction of a device owner's social network cannot be accurately gained.

In previous work [10] we developed a robust mechanism for automatically calculating a measure of familiarity for encountered Bluetooth-enabled devices as an extension of the proposed concept of *familiarity.* Bluetooth familiarity has a wide range of applications, relevant to context-messaging including context-aware information retrieval and content delivery, social networking, and privacy and security for Bluetooth interaction [10]. Our earlier work demonstrates that social context can be drawn from general encounters with Bluetooth-enabled devices and suggests that there are three main types of Bluetooth-enabled devices that are encountered: *familiar* devices (which belong to a familiar individual), *familiar stranger* devices(which belong to individuals encountered on a somewhat regular basis) and *strangers* (that belong to a rarely encountered individual). This results in a measure of familiarity relative to the other encountered devices calculated based on duration of presence at intervals throughout the day. Lavelle *et al*'s mechanism has been shown to be effective at rating familiarity for encountered devices and scales to operationally realistic sizes.

3 Context Sensitive Messaging

As an attempt to determine whether advances in mobile technology are ready to give us some of the predicted context aware systems, we developed a Context Aware Mobile Messaging System, CAMM. CAMM is a context-triggered system which delivers messages (SMS, MMS and digital signage messages) to users when their geographical location and/or their co-location with others satisfies the context requirements of messages specified by senders. CAMM affords users an enhanced level of control over their messages by allowing them to specify requirements for a message's delivery such as a time frame, location or group and allows a user to set reminders which instead of being time-based are triggered by location or co-location events. CAMM relies on up-to-the-minute mobile and location-based technologies to provide a user-friendly and highly accessible framework for communication. CAMM is in the early stage of development but exploits SMS, MMS, ubisense and Bluetooth presence with plans for GPS.

3.1 Message Types & Scenarios for use

In CAMM we identified scenarios and message types which are most beneficial to mobile messaging. Four message types were identified and implemented in the CAMM system; reminders, notification, presence and storage. Messages can be either SMS or MMS, can have explicit expiry times, single or multiple recipients, location or co-location triggered or both and are either public or private.

Reminder messages serve to aide human memory through digital messages, however the reminder functions on many current mobile phones are very restrictive. CAMM's presence messages allow users to put location and co-location constraints on their reminders so that the reminder is set for when a users arrives at a location or meets a named person rather than at a particular time.

CAMM also allows us to set reminders for others, so for shared tasks, reminders of deadlines etc. can be set by any group member for others based on location or co-location.

Notification messages allow a host of information to be sent in the form of public or private messages. Reviews can be left outside restaurants, tourist information at cultural sites or messages between groups of friends at meeting points or simply whereever they get together. Notification messages can also take the form of advertising. Shops can advertise sales, restaurants their new menu etc. in the area outside their premises or on digital signs across a city. Figure 1 shows the sending and receipt of a public message in a university environment.

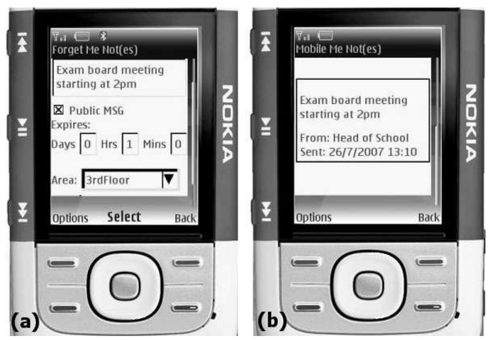

Fig. 1. Application showing (a) message creation and (b) SMS message received.

Presence messages allow users to gain knowledge of another person's location or co-location. By setting a presence messages to be delivered when others arrive at a location or are co-located, a sender can be informed when a colleague or friend arrives at a location. Obviously there are privacy issues with this type of message but those are beyond the scope of this paper.

Finally CAMM can operate as a personal or group *storage* facility where items are indexed for future retrieval based on the user's context. It has been shown that users naturally organise their memories around past events [2], remembering where they were and who they were with when an event occurred. CAMM allows users to store information in exactly those contexts and retrieve them at a later date through a web interface. This is obviously relevant to individuals but it is also useful to store information like the minutes of a meeting or schedule of future events in a particular location which is revisited by those concerned.

3.2 User Interface Options

As mentioned previously, CAMM offers the facility to send and receive public and private messages to a range of users and locations, and to exploit this functionality fully it was designed with both public and private message sending and display capabilities. Installing the CAMM application on a mobile phone provides users with an easy to use message sending facility. Users type the text of the messages or select digital content, select the context required (locations, co-locations recipients, expiry time, etc.) and the application sends the message via GPRS to the CAMM server. Users receiving messages get a regular SMS/MMS message delivered to their mobile phone, and Figure 1 shows screen shots of this.

Sending and receiving messages on mobile phones is part of everyday life for millions of people world wide. The key to sending regular SMS and MMS messages is their simplicity; create content, select recipient and send. CAMM requires users to provide a little more information to send messages such as location or co-location elements, as well as expiry time etc. Given the limited screen realty and the current cost of GPRS in mobile devices CAMM also offers users a web interface, which allows users to send and view messages online. Users can select locations to leave messages using maps, and exploit contact lists and past message information. Users can also view their personal messages and all public messages.

Depending on the environment in which CAMM is operating, display can also take the form of digital signage. For instance in the university environment, several public screens are used by CAMM to display public messages related to the area. The screens in private and semi private areas such as meeting areas can also be set to display messages relevant to the people in the vicinity of the screen. An example of this would be the minutes of a previous meeting when a current meeting is in progress. In outdoor environments CAMM can be deployed to display context-based advertising for local establishments on large screens in situ, bus shelters or billboards.

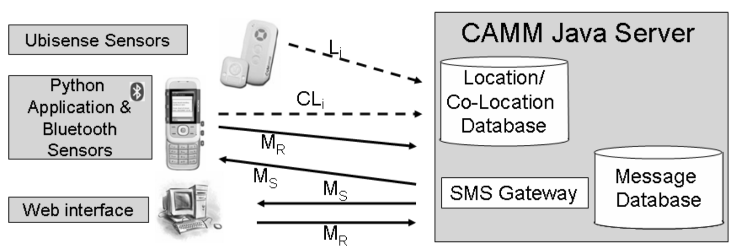

Fig. 2. CAMM Architecture

3.3 System architecture

CAMM is a Java based messaging system consisting of ubisense location sensors, Bluetooth co-location sensors and a Python series60 Symbian OS mobile phone application and a web interface, see Figure 2. The CAMM java server is in regular contact with both the ubisense location broadcaster and the Bluetooth co-location sensor in order to detect the location and co-location of its users. CAMM's server maintains an oracle database, exploits an SMS gateway to send messages and communicates with the python application via XML data sent over GPRS.

The suitability of location sensitive technology for context aware systems is determined by the accuracy of the location information required. CAMM was designed to cover both indoor and outdoor locations in order to broaden its applicability, however at this time only the indoor functionality has been added. It is the immediate plan of the CAMM team to integrate GPS into the system. UCD School of Computer Science offices are equipped with a Ubisense real time location system which allows us to determine the position of people within the school by continuously broadcasting the the three dimensional coordinates of each user within the building. A Java application on the CAMM server parses and stores the broadcasted information and for all users. CAMM is equipped with a map of the building divided into areas and exploits the three dimensional ubisense data to decipher the location of each user on the map [18].The locations are organized in hierarchical structures, broken into buildings, floors and rooms. Thus when creating a message users can choose to leave it at different hierarchical levels of their current position. Co-location detection uses Bluetooth presence technology discussed earlier. The CAMM application installed on the users phone "sniffs" out other visible Bluetooth devices in its proximity at 1 minute intervals and reports back to the CAMM server with any changes to the list of co-located devices CL_i for that user. At this stage CAMM does not exploit the familiarity of other devices in order to decipher which users are important to individual users but this is also in our future plans.

CAMM operates its message sending on a cycle which is triggered by updates from the co-location detectors. Co-located and location information are used to determine if the context of any messages have been satisfied. So for a given a user, i, whose last know location is L_i and who is currently co-located with a set of users CL_i, CAMM checks to see if any messages M_S have been set which are constrained by the current time, CL_i and/or L_i. If so these messages are sent via an SMS gateway and marked as read in the database.

The CAMM engine receives messages M_R from users via the web or mobile phone and stores them according to contextual triggers in the database. The server must receive the message content, location and/or co-location information, a recipient list and an expiry time for a message in order to store in the database.

While there are currently some limitations to wideeprsad use of our CAMM system on a mobile device, these obstacles are far from insurmountable. The current CAMM system only allows for location messages within an indoor space. We have however architected our system in a way that it can leverage other location technologies including GPS. GPS can be used effectively in combination with the UbiSense to broaden coverage of the CAMM system to both indoor and outdoor locations and allow broader scenarios and contexts. It is anticipated that GPS support will be built into the majority of mobile phones within the next few years, however, we are already seeing availability in the latest Nokia releases, including the N95. While public billboard-size outdoor messaging is currently unsupported, it can be included easily.

Internet access costs on mobile devices are currently expensive and as the system regularly polls for collocated devices and receives message requests via the internet, the resulting cost of CAMM use on a mobile device can be high. However, there are a factors which are helping to overcome this. Data bandwidth can be minimised by storing messages for collocated delivery on the individual handset thereby requiring less frequent queries to the server and by performing familiarity calculations on the handset and in effect compressing the raw encounter data. Also there is a trend of mobile data access edging toward cheap high speed mobile internet access and this will additionally make our system more cost-effective in real-world scenarios.

4 New Futures

The work described here represents an important step on the road to the development of a new generation of interactive information systems, capable of responding to the context and preferences of individuals or groups of users in the real-world. A subject touched on earlier is that of exploiting Bluetooth sensing techniques as the basis for real-world user tracking and profiling. This data captures day-to-day social interactions and can be used as the basis for an individual's real-world social network and also as the basis for novel communication applications, beyond the messaging scenarios discussed above. Such social networks have an important role to play when it comes to the filtering and personalization of messaging and other forms of information. For example, the preferences of a user's social network can be used to filter messages and information that are likely to be of interest to the user by using a form of real-world collaborative filtering [8]. As a concrete example, this type of approach can be used as the basis for a form of personalized advertising by using Bluetooth sensing and adaptive billboards to deliver advertising content that is likely to be relevant to a particular user. For instance, as a target user is sensed approaching a billboard (using Bluetooth) advertising content can be selected based on adverts that have recently appealed to other members of the user's social network.

What this paper contributes to this vision of the future is a report of an operational context-sensitive messaging system for mobile users, where the context is defined as either location or co-location with others, or both. In developing and deploying this system we have discovered usage scenarios which we would not have envisaged had we not built the system, and this has shown us the benefit of being able to identify such new scenarios from actual observation of use.

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