*m*e-Commerce: An Infrastructure for Personal Predictive Mobile Commerce

Andreas Komninos, Peter Barrie, Julian Newman, Stuart Landsburgh
Department of Computer Science
Glasgow Caledonian University
Glasgow, UK
[ako2, pba4, jne,slands10]@gcal.ac.uk

Abstract

Given mobile phone penetration statistics and current mobile phone technical specifications, it is apparent that in developed countries, the majority of citizens carry not just mobile phones, but true mobile computing devices. These devices are still primarily used for telephony, although information access is slowly emerging as a popular service on these devices. Despite the availability of network connectivity and device characteristics that make Information Access possible, this is currently generally confined to accessing the WWW. While useful, this method is not the best way of providing information access to mobile devices. This paper discusses current research in the use of mobile services and proceeds by presenting a background on an infrastructure for a focused information access application for mobile commerce. Through this background, we discuss the need for embedding multi-dimensional context awareness into the design of applications that provide dedicated, targeted and personalised information access to users, and describe the dimensional vectors necessary for the acquisition of contextual information. Further to this, the paper highlights the challenges that must be overcome in obtaining contextual information on a mobile computing scenario, as required by the design we propose.

1. Introduction

Mobile Phone penetration is currently at a global average of 80%, with many countries such as Luxemburg and Ireland already above 100%[1]. While this statistic is interesting in its own right, it becomes even more important as an indicator when the characteristics of today's mobile phones are considered. Mobile phones have come a long way from being devices dedicated to telephony. In fact, it is now almost impossible to distinguish between a mobile phone and a PDA, as in may ways, both types of devices offer similar type of services, are programmable and can run applications and services over wireless networks. It is reasonable to say that most of today's mobile phones can be considered as true mobile computing devices, even though their use is still primarily for telephony. Surprisingly, still only a minority or applications and services designed for mobile phones are actually used. In Japan, where users are considered to be generally aware of high-tech services, Java applications, mostly games, are used by just over half of mobile users (51.2%)[2].

Of these applications and services, particular interest is presented by the models of Information Access currently available on mobile devices. Currently, traditional information access models make assumptions on a number of variables regarding the information source, type of user, access medium capabilities and available bandwidth. These models have been ported directly onto mobile devices, although with little success, as suggested by the usage statistics for Internet content (the largest and most widely accessible information repository) access on mobile devices. The reason of failure of adoption can be found by bearing in mind the background and age diversity of mobile phone users and their levels of computer literacy, the information access device capabilities (small screens, awkward input) which is incompatible or impractical for accommodating most standard information presentation layouts (e.g. website layouts) and high-cost low bandwidth connectivity.

[1] The Netsize Guide 2006: Small Screens, Global Vision, 3GSM World Congress at the World Trade Centre in Barcelona, February 2006

[2] Multifunctional Mobile Phones Used By More People, More Often, Survey on the use of mobile phones in Japan - January 2004, IPSe Marketing, Inc.

Despite these problems, current technology is at such a level that we believe it would be possible to overcome the challenges posed by mobile information access using facilities already incorporated in mobile phones. This needs to be accompanied by adapting application and service design in order to target the characteristics of the device users and devices themselves. However, from the analysis on the requirements of a system that supports a vast diversity of users, it becomes apparent that in order to make the service as easy and as non-intrusive as possible, a system of inversely relative complexity needs to be developed.

To support our position, we discuss a service model which makes use of existing connection technologies to bring targeted and useful information access onto a mobile device, requiring very little interaction or instruction from the user. We chose shopping as an application domain for our proposal, since it is an activity that is undertaken by almost all members of society and thus poses a significant challenge in understanding how to make information universally accessible on mobile devices. Further more, as explained in sections below, the latter goal provides interesting opportunities for research in several areas in order to allow simple and effective service levels.

2. Overview of the proposed system

Our work aims to investigate, develop and implement an infrastructure for retail environments which will support and facilitate the shopping experience in all its forms, whether planned or ad-hoc. The system will allow users to be reminded of shopping needs, alerted for items of possible interest and dynamically manage their shopping tasks according to the users' location and context. We call the concept of mobile, electronically assisted commerce "**m*e*-commerce**".

Let us imagine a world where products carry embedded sensors and chips, which can be used to convey important information such as best-before dates, state ("clean", "drying") or recommended "product life" for each item. Every item that enters a person's home could identify itself to an electronic catalogue, which would contain every item a person owns.

Imagine now a person could have immediate access to this electronic catalogue from anywhere in the world, perhaps through a smartphone. All the details of all items could be immediately available but perhaps, most critically, processed information derived from that catalogue could be used to assist the person in their daily shopping needs. In such a future, where products are augmented to allow more services than their original purpose, a common framework will be needed that will allow the exchange of information between shops and the person's ownership catalogues.

As shopping areas within cities are reasonably well-defined, the notion of the e-shopping street could be defined as that of a commercially busy street where retail outlets can offer electronic services on a person's mobile computing device and enhance or facilitate their shopping experience. These services can be provided at a "street" or even "retail outlet" level and they would target the shopper who frequents the street, but also be valuable to the casual shopper who might be new to the city or is unfamiliar with the particular shopping area.

Let us consider the following usage scenario for our proposed system: A user's supply of milk has just gone past its expiry date. As the user leaves his home to go to work, his home inventory automatically updates his mobile device. A reminder to buy milk could be issued to the user at any time. However, the device takes into consideration the temporal, geographical and predicted future context of the user in order to make a decision on whether the issue of an alert is desirable. The device will notify the user that milk has to be purchased, only when it is likely that the user will be able to respond to that alert.

In this situation, the device considers the current time and activity list of the user, as described in their electronic calendar. Also, the geographical coordinates and speed are taken into account to predict the user's availability (e.g. driving, walking fast towards work, walking casually back to the car). When an alert is deemed worth issuing, models of user preferences and predictive models of the user's future location and path of movement, allow the organisation of available options in such a way that the user is more likely to encounter the options that are more interesting to him first.

Naturally, the possibilities of such a system are multiple. Predictions could be made not only for items that might be of immediate interest to the user, but also for such items that a user might need in the longer-term (e.g. shoes). Further more, a system could act as a shopping guide when a user indicates explicit interest for a particular item, helping the user locate and take advantage of deals or special offers on the e-shopping street. Perhaps the system might also help a user organise their shopping in such a way that they may complete it as quickly as possible or so that they don't spend more than a fixed amount on a shopping trip. Visitors who are unfamiliar with the shopping streets of a particular city could also be aided in their search for particular kinds of stores or entertainment venues, such as restaurants and bars. These are just some examples of possible usage scenarios for augmented, e-shopping streets.

3. Related work

3.1. Design of Location Based Services

Providing an information service to mobile phones is not a new concept, as SMS text services such as the AA Roadwatch[3] service and Sky News Updates[4] have been operational for many years. However, when combined with variable factors such as the location, preferences and needs of the user at a particular time, a much more interactive service can be offered. Many terms have been used by various authors (Samaan & Karmouch [1], Mankins [2], Katasonov [3], Kaasinen [4], Munson et al [5]) to describe such an application. Terms such as 'location-based', 'context-aware', 'proximity-triggered' and 'permission-based' have become common ways to describe an application that bases its content upon factors other than explicit user input.

Aalto et al [6] provide a clear definition of location based services: "A location-aware or location-based service is a service the behaviour of which is mostly driven by location information". As Kaasinen [4] states, the context of use of a device will vary depending on the environment it is in, with many external factors influencing the "usage session".

Katasonov [3] looks at reasons why location-based services have not already gained widespread acceptance among mobile users. Several factors are identified, including "content quality, software reliability, interface quality and algorithm appropriateness", which can lead to a flawed system which will struggle to gain any credibility amount users. The conclusion that user acceptance is the biggest obstacle to overcome is true, although some other statements are less accurate when considered in the context of today's technologically superior world. Questions raised about locating the device can be resolved with triangulation with GSM masts, or by simply acknowledging the device when it is within 'sight' of a short range transmitter, as with Bluetooth and 802.11 access points.

The dependability, or integrity of the information supplied via the LBS is also questioned in this work, with regard to simple 'Yellow Pages' directory services which can become outdated and invalid if they are not well maintained. With regards to user's acceptance of location-aware services, spurious or out-dated information will have a detrimental affect, making it less likely that the service will be used consequently. It becomes therefore clear that the provision of up-to-date, reliable and accurate information is critical to the success of the service.

To provide a location-based service where information is edited by the people who use it would be a great advantage in helping to maintain up-to-date information, thus improving the integrity and reliability of the data which can be accessed. The system held data could also be updated automatically by other computers, such as is the case of automated home inventory updates sent to the user's mobile.

Location Aware Services imply that location needs to be somehow obtained in the first place, before these services can be provided. In a key paper, Ashbrook and Starner [7] prove that it is possible not only to learn locations that are significant to the user (such as "home" or "work"), despite the inherent 15-meter accuracy in commercial GPS, but to also predict the user's movements using GPS data, using Markov chain prediction models. This technique achieves circa 80% probability of prediction for a 2nd order model. Further work by Zhou et al [8] and by Bhawalkar et al [9], seems to confirm the findings regarding learning important locations from GPS data.

Kaasinen [4] provides results from interviewing users that tested the Benefon Esc! For GPS phones, Sonera Pointer for WAP phones, Cebit2001 Guide and Vindigo PDA systems. These systems were chosen to test the users perception of the various forms of location finders, and their attitudes towards location-aware services. Empirical studies were carried out with users who were given possible location-aware service scenarios which helped or hindered the users daily routine, and interview them about their thoughts towards the technology. The study group was mostly male users, and 90% of the group were mobile phone owners. From the studies and the test, several conclusions were reached with regards to how the users see location-based technology useful. Most respondents thought positively of the system when used in scenarios where they were looking for help, or for a service such as information of detours, or location of parking lots. Contradicting to the first attitude identified, many of the users then claimed that the technology would be obtrusive and beyond the needs of most people, saying that it may be more useful for "some businessmen". The ultimate outcome of user attitude was that they wanted solutions to make their life easier, but they had no real desire for such a system.

This must be considered when designing any LBS system, as it is apparent that it must be functionally easy to use on a mobile device, providing the user with relevant data in a timely manner. The global scale Place Lab vision by Schilit et al [10], was maybe optimistic, but also emphasises the point for ease of use by pointing out that "To be widely adopted, location-aware computing must be as effortless, familiar and rewarding as web search tools like Google". Inherent to the application, should be personalization, which was identified by

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[3] AA Traffic alerts: http://www.aatrafficalerts.co.uk/

[4] Sky News SMS alerts: http://www.sky.com/skynews/fixed_article/0,,91086-1200007,00.html

the users as a feature that would greatly improve the usability of the system. This in turn implies the necessity for the tailoring of information provided to suit the individual preferences and needs of the user.

Ciavarella et al [11] produce a context aware application to give users further details about museum artworks via mp3 audio files which were activated by IR transmitters next to the relevant piece. Users responded that they enjoyed this way of learning more about the artwork file being able to observe it freely. The information infrastructure was built around the basis that tracking a user's movements throughout the premises would require a large number of beacons to provide a blanket of coverage. Instead, the IR beacons only activated devices that were in range.

When evaluating the project, the user skill level was used to segment the users into novice and expert categories, for people who had never used a PDA before and people who had, respectively. This allowed better evaluation of the interface design, and produced responses from novice users that the system should be easier to use. Other features users expressed an interest in included maps, and a path finder feature which could locate a certain piece of artwork, and a drawback was that there was no preference features built into the system.

3.2.Mobile Commerce, Advertising and LBS Content

As mobile phone evolution facilitates and promotes more use of wireless networking, a new industry has spawned in the form of M-Commerce, the natural successor to the multi-billion pound E-Commerce industry that the Internet has facilitated since the early 1990's. Maamar in 2003 [12] defined the four basic features of mobile commerce (m-commerce) by firstly stating that in order to attract customers, it is necessary to be aware of their interests and preferences. Further more, he acknowledged the interaction problems with small form factor devices and proposed that assistance should be provided to the users in order to help them accomplish their interaction with the service provider without frustration. The importance of network connectivity and the responsibility of establishing, managing and handling the failure of it was highlighted and it was deemed necessary that all of these aspects are dealt with automatically by the user and environment computing devices. He finally discussed the need for secure transactions and payment, so that the users can be confident of their financial security when using m-commerce services. To the latter point, we would add that security is needed in all communications with trusted service providers, since the user personal profile and data are just as valuable and precious as their finances.

Taking some of Maamar's considerations in mind, Kurkovsky and Harihar [13] present the SMMART framework for m-commerce. Their system is based on maintaining and dynamically updating a keyword-based local preference profile for a user and presenting special offers that might be of interest to them, based on the profile.

A PDA grocery shopping assistants developed and deployed in supermarkets in the U.K. by Newcomb et al [14], who presented findings of their experimental implementation in 2003. In this study of mobile computing in retail situations, users were provided with a PDA client device which showed both special offers and item locations to customers. Market research studied for the project claimed that 60% of supermarket purchases were not premeditated, and a conclusion that because shoppers were more focused on the screen when shopping, they would make less impulse purchases. Interface design and situated interactions were identified as both the main obstacles for the project, and important design features which had an impact on usability.

The authors Cheverest et al [15] were "surprised by the high level of acceptability" when they, in conjunction with Lancaster Tourist Information, produced and tested an electronic tourist guide to the city. The user response indicated that if varying levels of functionality can be selected, a wider range of users feel comfortable with the operation of the system. The local business model is introduced into ideas for future work, where adverts could be placed alongside the tourist information being provided. This may seem like a logical approach, but there is a danger of using up too much screen 'real-estate'. The screen size of most mobile devices has been an issue for many mobile application projects.

M-commerce applications have been classified by Varshnay and Vatter [16], who present a special category, that of mobile advertising. The system we propose can be considered as an advertisement provider, in the sense that it presents offers from various vendors with regard to a particular item. Current research into mobile advertisement however shows that it revolves either around pushing messages to a particular user target group based on demographics [17], or their present location [18], irrespectively of the user preferences. Triki et al [19] described how direct mobile advertising has evolved from small SMS messages, and Barwise and Strong [20] explored the six types of advertising that the messages could be categorized into: brand building, special offers, media teasers, service or information requests, and competitions and polls. These simple, text only messages allowed the user to be contacted directly, but only with limited content. Possible problems with direct SMS marketing can be seen when compared to other direct marketing campaigns such as the traditional mail-shots delivered without consent to your home, or like the intrusive 'spam' problem that e-mail systems have faced since digital direct marketing techniques became available and were easily exploited.

The Bluetooth Mobile Advertising system, or B-MAD, developed by Aalto et al [6] incorporated permission-based and location-aware services along with the use of Bluetooth positioning and WAP to deliver messages to the users. B-MAD's operation used in-store Bluetooth sensors to locate any devices within range, discover the unique BD-ADDR address of the device which was then compared with predefined entries in a user-database, and the URL of advertisements that were deemed appropriate for the user were returned to the user's device. The reason that the authors claimed the system was permission-based was due to the fact that only the URL, or address of the advertisement was returned to the user via an SMS text message. Users could choose to reply to point their WAP browser to this address to view the advert if desired, otherwise it was discarded after a set time.

The authors qualitative and quantitative studies of the system showed that the main user concern was where or when they received the message. 20% of the test users reported that messages were delayed often or always, meaning they had little relevance to the users current situation.

Several reasons for excessive latency were identified by the authors, most of which were due to the structure and operation of the B-MAD system. The "cumulative effects of positioning, Ad Server and Push SI" messages combined to give an average response time of over 33.3 seconds for over 73% of lab tests, the maximum time a user was likely to be within range of a particular sensor. Uncontrollable factors such as other wireless communications present in the lab test area were also a contributing factor to the latency time, as WLAN or WiFi networks operate on the same 2.4Ghz radio frequency, causing some interference for the B-MAD Bluetooth devices. However, the effect from this was minimal compared to the ad-server and WAP latency factors, and should not be a cause for much concern when implementing a solely Bluetooth information providing system.

As found by Aalto et al, 22 from the 33 users of B-MAD (Bluetooth Mobile Advertising) system responded that mobile ads would be a good way to receive offers and information in the high street, with two users familiar with the previous PDA based SmartRotuaari system [21] stating that it was far more useful when using a mobile device, such as the Nokia Smartphone used. Another finding of Aalto et al was that if they delay when receiving a message was large enough such that they were walking away from the premises before it was received, the relevance of the message was far less than if it had arrived when they were in close proximity of the sender. This should be addressed in line with the aim of contributing to the basis for a usable mobile advert manager application.

The effect that spam, or junk e-mail has had on users has undoubtedly had a knock-on effect for future mobile advertising and marketing methods, and recently the Mobile Marketing Association of the UK[5] issued a statement which warned unsolicited mobile messaging campaigns to be against European privacy laws. According to the code of best practice, the MMA declares that even initial requests to the user to receive further information could breach the privacy laws if there has not already been an agreement with the user and provider for messages to be delivered.

4. Details of proposed system

4.1. Research questions

From the findings of other researchers in the area discussed in the previous sections, it is apparent that a large number of design considerations need to be evaluated and incorporated into a usable system such as the one we propose. In order to maintain the user's perception of such services as ones that are actually beneficial to the user, rather than just another method of advertisement, care must be taken not to overload the users with unnecessary information, alerts that are not of interest or might no longer be appropriate. Thus some filtering should be applied to the recommendations so that only appropriate items are shown at appropriate times and in appropriate locations. The project would need to address and answer the following questions in order to achieve its goals:

- What are appropriate items, i.e. items that might be of interest to a user?
- What are appropriate times, i.e. when is a good time to interrupt a user with an alert?
- What are appropriate locations, i.e. where (on the e-shopping street) should a user be interrupted?
- What infrastructure will be necessary in order to allow the implementation of such services?

4.2. Determining the user's shopping needs

The reason why people go to shops is because they need to purchase an item which they do not possess (or at least they think they do), or for an item whose state is such that it requires replacement. To support the task of remembering which items may be

[5] Mobile Marketing Association UK: http://www.mmaglobal.co.uk/

good candidates for purchasing and are worth going to the shops for, a "smart" home should provide an infrastructure for storing information on all items that are currently owned and their state, and on items of similar nature that are not owned but might be required in the future. Consider for example a user's calendar reminder that a friend is coming home in two day's time for dinner and that the user would like to cook "spaghetti carbonara". The "smart home" will be able to check whether all the ingredients are in stock, whether some of them might have gone off and might update the user's shopping list with missing ingredients, or some that must be replaced.

It is not un-realistic to anticipate a future where all consumer goods will be tagged by RFID labels, which can indicate purchase date, expiry date, service status and all relevant information. In such a world, multiple object scanners could be embedded in item repositories (e.g. wardrobes, larders, fridges, cupboards, garbage bins). These scanners would identify objects as soon as they enter or leave the storage area and update a central home item database, which would then be responsible for updating the user's shopping list on their mobile device as soon as they exit the home. It might also be possible for a user to maintain multiple databases, for example one at home and one at work, which would communicate and exchange data in order to help the user either manage their shopping, or perhaps locate an item which might be lying around the house or the office.

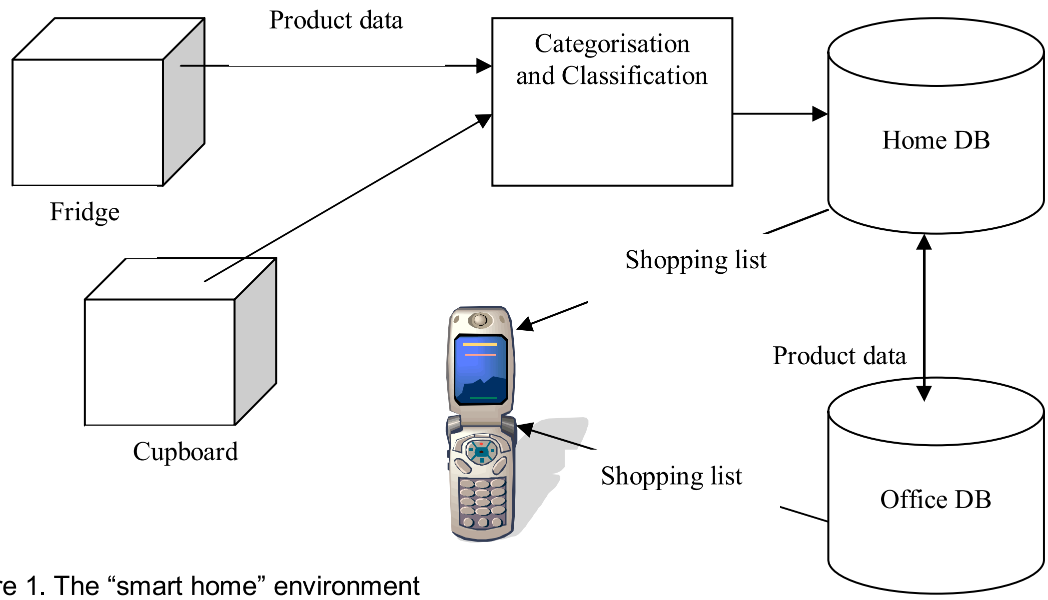

Figure 1. The "smart home" environment

4.3.The significance of context awareness and contextual information relationships

These research questions indicate that using mono-dimensional context awareness discovery techniques cannot provide a satisfactory solution to the problem of context acquisition for the given problem. It is not enough to ask "what time is it", in order to know whether to interrupt a user with an alert. The system needs to know the temporal, geographical and current activity context of the user, in order to be able to determine whether it is appropriate to interrupt them with an alert. Further more, the system needs to be aware of the relationship between contextual information, something that can be used to infer further information which might not otherwise be explicitly apparent. Consider this example: It is 1pm and the user is at a location of type "Restaurant" and has just interacted with an electronic service labelled "Menu Download". It can immediately be assumed that the user is about to have lunch, thus issuing a reminder for buying milk would be inappropriate at this time.

4.4.Context Acquisition

Temporal context can be acquired through the observation of the user's daily routine. Although initial assumptions could be made by the system based on standard cultural practices (e.g. most office workers people start working at 9am), the user should be able to configure the system's temporal-activity relationship model in order to better suit their actual schedules.

Obtaining location context is somewhat less straightforward since the accuracy of today's commercially available services is somewhat limited. GPS for example has an accuracy of around 15 meters, which could make distinguishing between the user's presence in front of one of two adjacent shops difficult to determine. This problem however could be solved by using triangulation on the signal of the wireless network which the e-street would use to deliver services (e.g. wi-fi or Bluetooth access points). Further to this, it is required that the system should not only be able to determine precise geographic location coordinates, but also to be able to determine what type of premise these locations actually represent. To fulfil this requirement, a precise database would need to be kept of business premises, their type and other details, such as the services or goods they offer.

The most difficult type of context to acquire, however, would be that of the user's current activity. One indicator of user activity could be their electronic calendar, as carried around on their device. To illustrate, consider a user's calendar contains a "Meeting" type of entry with a known friend, and the system determines that the current geographical locations indicate the user is in a cafeteria at the time indicated by the calendar entry. This would probably mean the user is meeting this friend for a coffee, and might not mind being interrupted as she moves away from the cafeteria at the end of the meeting. A calendar, however, could not provide all of the necessary information on a user's daily activities. Further to the problem of identifying the meaning of calendar entries, which are often cryptic in nature [22], many activities such as "driving" or "walking to work" would not be typically described in a calendar. Thus, the constant monitoring of data regarding the user's movement speed, surrounding environment, and perhaps vital statistics, might be required to discover the activity, level of workload or emotional status of a user, in order to determine whether an interruption might be appropriate. To this extent, it might be possible to devise methods of user observation which make alternative use of hardware embedded into mobile devices. In essence, however, what is being described here is a set of user-owned devices that communicate and exchange information, effectively forming a Personal Area Network where the mobile phone or PDA is the central processor of information. In such a PAN, observation data could be gathered from all devices continuously, or, as depicted in the schematic below, data sensors could be triggered by other sensors as necessary, according to a set of rules to determine activity indicators.

The multi-dimensional vector space of contextual information containing time, speed, geographical location and activity data can be used to make predictions for the anticipated user context in the near future, thus enabling the provision, or preparation for it, of services in a more timely and pro-active manner. To illustrate this concept, let us imagine the situation where a user, casually walking down the e-street, approaches a few stores which have offers on an item that is on the user's shopping list. The user's mobile device, can pre-initiate the connection to these stores, filter out the ones it thinks the user will not walk past and display only the relevant information to the user and at a location that will not impede the user from visiting these stores (i.e. not after they've walked past the store!). It is without doubt that the ability of the system to make informed decisions on the user's current context, and

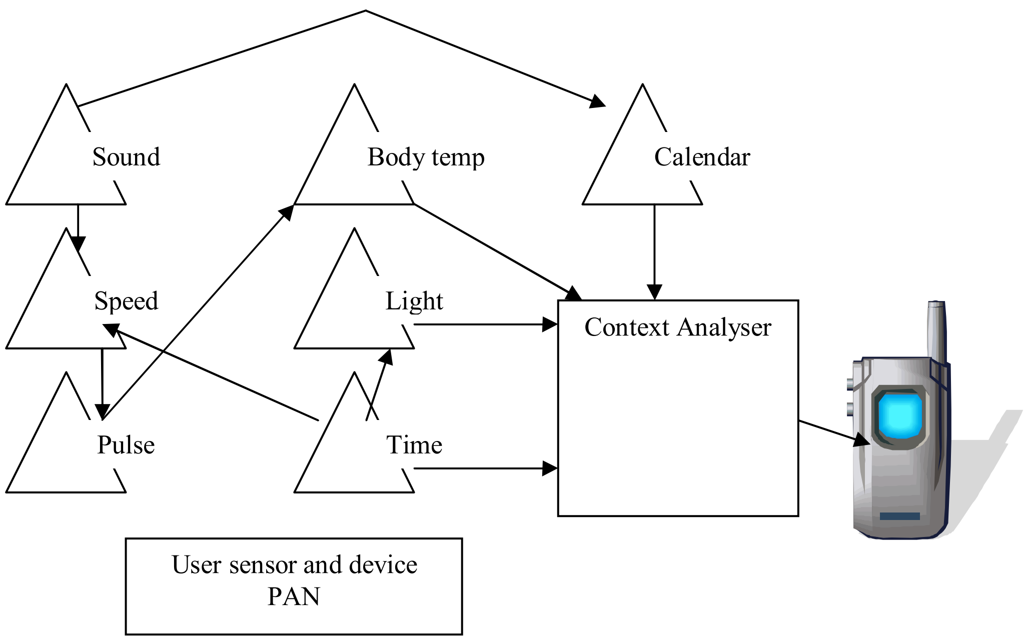

Figure 2: The PAN of sensors and devices

also on the user's near future context, will be critical to its success in determining when to interrupt the user and for which types of alerts.

5. Critical Assessment of the Model and Conclusions

While previous research has focussed on related issues such as mobile marketing and location-aware advertisement, it appears that a general trend exists towards "mass-messaging" users with special offers for items, irrespectively of their relevance to the user's circumstances, or indeed their actual needs. These efforts concentrate on the location of the user as the sole provider of context, which is insufficient. Despite this fact, a genuine interest on the behalf of users for such services has been discovered. A significant amount of related research, which includes considerations on the personalisation of services, can be found in more focussed applications, specifically those within a supermarket environment. Some work has also been presented which describes a recommender system for related retail stores (music and video) and a mobile advertising system which is based on a user profile and location, although the profile does not take into account the current user activities or temporal context.

However these encompass only a narrowly targeted shopping environment and provide little support for ad-hoc or spontaneous (impulse) modes of shopping, such as encountered frequently on high streets. It is our view that location or profile information alone are not adequate to provide users with a service that is truly context aware and can indeed provide useful, informative and non-disruptive recommendations.

We have described in this paper a framework for supporting users in their daily shopping needs and presented the complexities involved in the effort to make this system functional. By examining the seemingly simple problem of issuing shopping reminders to users at the correct time and place during the day, we discovered that the amount of contextual information required to provide a satisfactory solution is such that it makes the complexity of the solution inversely related to that of the problem statement, to a massively disproportional extent. What further complicates matters is that all the effort required in the capture of contextual information must be completely transparent to the user, which, in turn, places significant constraints and requirements to the low-level design and implementation of a system such as the one we describe.

The careful observer will note that our model thus far describes the life of a single individual and focuses around her needs and her actions to resolve those, for which it is assumed that she is solely responsible. Further complexities, which are not mentioned in this design, include those placed through social interaction and social organization. For example, in a family, a collaborative system would be required, where both parents might choose to undertake one or more of the responsibilities and would need to inform the other parent of this fact. Though we have chosen to focus on the single user at this early stage, we feel it is almost inevitable that the understanding of social relationships and requirements will inevitably require further analysis of the problem and add even more dimensions to the complexity.

Another concern which arises from our examination of the shopping reminder problem is that the solution, as presented in the design, seems to contrast with the fundamental principle of pervasive application design, which requires that pervasive computing devices, such as the mobile phone or PDA, should be used as information viewers, rather than processors and producers. In our model, the phone/PDA plays a central role in processing the information from the context sensors and by taking responsibility for the decision making process, it exceeds its role in the pervasive landscape. While opinions that mobile devices should simply be reduced-size multipurpose PCs exist, we believe that the single-purpose streamlined and task-oriented pervasive device paradigm is fundamentally correct. We would still be interested to investigate whether a design revision where the mobile/PDA acts as an information gateway that pushes context information to a server for processing and receives data for viewing might be a better alternative.

The model described in this paper thus far is a philosophical examination on the nature and complexities of a context aware system for the aid of daily tasks such as shopping. It cannot yet be argued that our proposed design offers an adequate solution to our problem description, however we believe that the examination of the complexity dimensions in the problem described herein offer valuable insight not only to the amount of work that this system requires for implementation, but also poses questions which address the fundamental nature of pervasive application and service design.

Currently we are working towards implementing a system based on the design described herein. Through this implementation, we anticipate to be able to present and discuss solutions to the complexities of context acquisition, information storage and retrieval and the network connectivity required by our underpinning model, in the near future. We also expect to be able to report results from testing the model as described in this paper against a revision which adopts a more purist pervasive application design.

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