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"Smart Guiding": Using Location Awareness and Egocentric Navigation to Attract and Guide Customers

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1.INTRODUCTION

In the near future, most tourists will carry mobile devices of some sort enabling them to access and browse wirelessly distributed "information clouds" (WiFi in particular). Such information clouds can be used to enhance how tourists explore and experience cities (e.g., Cheverst et al. 2000). We are particularly interested in dynamic aspects of tourism settings and how visitors can be made aware of them.

The city of Darwin (like many other cities) features a number of interesting aspects that may be difficult to recognize and explore for someone not familiar with the city. Examples include nice restaurants hidden in boring looking alleys and cosy pubs not co-located with other popular venues. It is important to note that value and even existence of these "attractions" may change over time whereas more traditional attractions (e.g., castles, churches, museums) considered in related research are unlikely to change.

Furthermore, there are a number of aspects or *events* that are dynamically changing in time and place (e.g., pub "happy hours", lunch specials, evening live performances, Sunday afternoon Jazz). Such events are notoriously difficult to track for tourists. Supporting tourists in exploring these dynamic aspects of the city requires:

1. informing tourists about businesses of interest as well as dynamically changing attractions ("events"), and possibly
2. guiding them to the location of the business or attraction.

We are interested in ways for businesses and event organizers to push relevant information and way descriptions into information clouds accessed by tourists. Work most relevant to this workshop is the use of location-aware egocentric navigation for "smart guiding".

2. SMART GUIDING

"Smart guiding" means tourists are encouraged to approach a location of their choice by following a particular path illustrated by their mobile device on the basis of location and navigation information available in the information cloud.

Considering the user's current location and the desired destination, path options may include the shortest way, the nicest way (perhaps considering the time of the day, sunsets etc.), ways that come along other businesses of interest, and so on.

We are especially interested to what extent egocentric navigation support can be used to address orientation problems as described by Brown and Chalmers (2003) in their study of tourists exploring Edinburgh. Research indicates people communicate route information using egocentric perspectives whether or not describer or recipient is in the environment (e.g. directions in a phone call: "go right at the junction and on for 50m until you see a post-box"). Referring to an egocentric perspective does not require mutual referral to extrinsic frames of references (e.g. aerial perspectives map) and appears less prone to the intersubjective and cultural constraints of a map's symbolic traditions (see Bidwell and Lueg 2004 for details).

We also introduced way descriptions as a community-authored resource and explored the intersubjective transfer of individuals' egocentric perspectives of locational information in unfamiliar environments. Suitability of resources for wayfinding has been verified in a unique pilots and orienteers race (Bidwell 2004). In the context of this smart guiding, introducing way descriptions to some extent as community-authored resources means people may not only use descriptions provided by businesses but also alternate ways created by peers.

In Lueg (2004) we suggest using an emerging infrastructure, such as PlaceLab, for *beaconing* information relevant to the user's current location in addition to "pure" location information. A similar mechanism could be used to offer WiFi-based "information clouds" as described by Heinemann et al. (2003), in turn enabling location-aware egocentric navigation.

3.BIOGRAPHY

Christopher Lueg holds the Computer Sciences Corp. (CSC) Chair of eBusiness at Charles Darwin Univ., Australia. He has a background in CS and theoretical medicine (Univ. of Dortmund, Germany) and a doctoral degree awarded by the Univ. of Zurich, Switzerland. Prior to his appointment in Darwin, Christopher was with the Univ. of Technology, Sydney (now an hon. associate).

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Augmenting Observation of Location-Aware Systems

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ABSTRACT

A system was developed to improve understanding and evaluation of system behaviour in mobile location-aware systems, using dynamically configurable logging on each device and aggregate visualisations to provide a synchronised replay of an entire experience for post-hoc analysis. These replays can also facilitate designers by providing insight towards the areas of a system which would benefit most from debugging and redevelopment.

BIOGRAPHY

Paul Tennent is a PhD student reading computing science at the University of Glasgow under Dr Matthew Chalmers.

INTRODUCTION

It is often difficult to evaluate large mobile computing experiences. Variations of connectivity and errors with positioning systems such as GPS make for potentially inconsistent data, while video evidence alone often fails to provide a coherent view of what a system is doing at any given time. To address this, a system has been developed to create synchronised customisable replays of systems, created from multiple device logs, to aid post-hoc analysis. These replays can be exported to video files for concurrent examination with trial videos, or used as a means of confirming hypotheses; searching for specific events; or establishing the system's state out with the scope of the video. Other visualisations such as spatial distributions are available and numerical data can be easily drawn from the replay for statistical analysis.

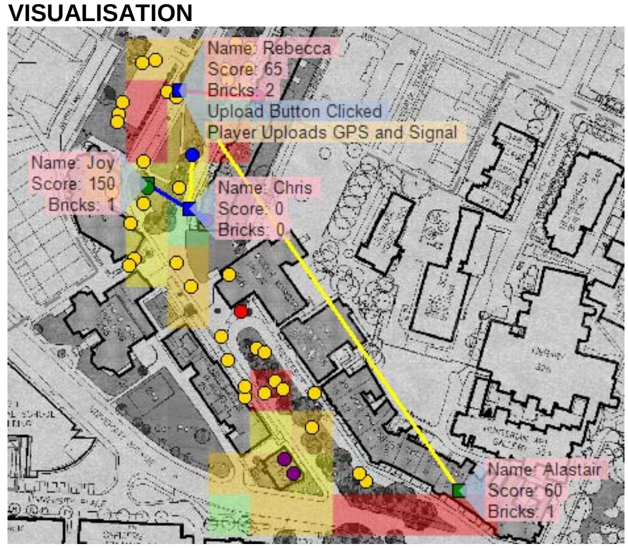
INSTRUMENTATION

The system allows easy instrumentation of code from within the Microsoft Visual Studio .NET integrated development environment. Instrumentation can be directly applied to individual methods and variables or a whole class or even solution can be instrumented with a single click, creating a consistent output style. Because the instrumentation is inserted visibly into the code, it can be modified to suit specific situations. A toolset is also provided to allow remote FTP collection and organisation of logs.

QCCI – GATHERING DATA IN ITS NATURAL HABITAT

QCCI (Quickie) is a tool designed for use during evaluation. It provides a low-tech method of synchronising trial videos and stills with the system clock. It also records the position of the evaluators, allowing this to be added to subsequent replays. Finally it allows audio notes to be recorded. These notes are labelled with the time and place of their creation, so can also be used in replays.

VISUALISATION



Screenshot of a visualisation of Bill – A mobile computing experience developed at Glasgow University. Yellow Lines indicate discrepancy between GPS position recoded on local device, and that available to the shared data space. Coloured overlay shows WiFi signal strength.

Using a combination of the logs created from the outputs of several devices, a variety of different visualisations can be created. A set of generic visualisation methods is offered, with a simple visual interface for their creation. It is unrealistic to assume that generic visualisations will be appropriate for every situation, thus the visualisation tool is component based, and able to support custom visualisations created for certain application specific situations. All visualisations can be exported to movies or stills for later examination.

CONCLUSION

Location-aware mobile systems are by their very nature difficult to evaluate. Combining logs from multiple sources to create a coherent view of a system state, can prove to be of great value when performing post-hoc analysis of a system however this usually requires considerable effort and often custom built tools. This system aims to simplify this process by providing a generic toolset for the creation and visualisation of log data, applicable across a wide variety of applications.

Let's Rendezvous: Application of Location-Aware Computing

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POSITION STATEMENT

Our current project focuses on the use of location-aware computing during social activities. The particular social activity we are investigating is rendezvousing (two or more people meeting at a time and place). A body of research [1, 2, 3] has identified rendezvousing behaviors through diary studies. Our focus is the integration of handheld technology and location-aware devices to aid in the act of rendezvousing.

Most technologies (cell-phones, instant messaging clients, etc.) used for rendezvousing do not implicitly provide users with an awareness of location. The awareness of location comes from one person being able to textually or verbally describe a location to another. This is problematic as the communication of instructions or descriptions between persons may be ambiguous, misinterpreted or misunderstood. People may not even know their current location. Location-aware computing avoids the complications associated with verbal and textual communication by providing visual cues and references. For example, a digital map on a location-aware device could be annotated or overlaid with location information. Each participant in the rendezvous would be able to visually see the location of the prearranged rendezvous as well as the location of other participants.

The annotation of a digital map with location-aware information is not new or particularly innovative. The exciting aspect of our rendezvousing project is our exploration of the social impact location-aware devices will have on rendezvousing. Given that each participant will have a visual indication of the relative location of their partner, how will this affect their decisions and actions during the rendezvous? For example, if one person is late and another is waiting at the prearranged location at the specified time, how will each person react? Will the late person pick up their pace or will the waiting person abandon the prearranged location and re-negotiate a new location? The implications of location-aware computing on social navigation are vast and we hope to make some initial observations concerning its social impact.

In addition to exploring the implication of location-aware computing during a rendezvous, we are hoping to explore the effect of revealing emotional and state information. Using a non-descript dot or arrow to indicate position on a location-aware device does not convey information beyond relative locations and possible direction. Seeing that a person is located within a given area (such as a specific shopping store) does convey possible information about personal interest, yet it does not reveal anything about the current emotional and physical state of a person. Stress [2] has been identified as a primary outcome of rendezvousing. It is anticipated that conveying emotional information will have an impact on the outcome of a rendezvous and the behavior of the persons participating.

Our studies exploring the use of handheld technology and location-aware devices in rendezvousing are currently in progress. The results will be available at the time of the 'Applications of Location-Aware Computing' workshop.

BIOGRAPHY

David Dearman is a graduate student in Computer Science and a member of the EDGE Lab, Dalhousie University, Nova Scotia, Canada. His current thesis research focuses on the use of handheld technology and location-aware devices to aid in the social act of rendezvousing. Interests include the social and personal impact of location-aware computing, annotating physical locations with virtual information (specifically emotional information) and co-located/non-co-located computer-supported collaborative work. David is working under the supervision of Dr. Kori Inkpen.

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Combining Augmented Reality and Sentient Computing

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INTRODUCTION

Augmented Reality (AR) is an augmentation of human perception (visual, tactile or olfactory) with extra and otherwise undetectable information. Strict interpretations of AR demand that rendered augmentations, such as superimposed 3D graphics, are registered in 3D and updated at highly interactive rates such that users perceive the augmentation to be indistinguishable from real objects.

Ubiquitous Computing (Ubicomp) has focussed on making computers invisible. Their functionality is instead embedded into otherwise mundane everyday objects. In contrast, AR aims to enhance a user's experience by revealing what is hidden or invisible, thereby creating new forms of human-computer interaction. Interfaces are hands-free, and provide an in-situ visualisation of the task, registered in 3D.

Differences between Ubicomp and AR applications are also reflected in the different ways they are usually implemented. One Ubicomp approach, Sentient Computing [1], uses sensors to update a model of the world, that encapsulates environmental state. These sensors are typically cheap, numerous and deployed on a large-scale. They provide low volumes of data of modest accuracy with high latency. Nevertheless, *location-aware* applications can be developed that respond to a user's actions by querying the world model.

Classic AR applications could be described as *location-needy*, voraciously consuming high bandwidth streams of data valued purely in terms of the accuracy, latency and update-rate required to provide accurate 3D registration. The tracking sensors generating these data streams are more specialised than those in sentient environments: they are expensive, provide coverage over small areas and may even be tethered, compromising mobility.

MOTIVATION

Earlier work [2] has had some success in exploring the domain where the fields of AR and Ubicomp overlap. However, the particular sensors deployed approached the limit of what could usefully be used to provide a user with a meaningful AR experience. To overcome this, we propose a more general approach for the dynamic formation of heterogeneous sensor networks to accommodate the diverse sensors and trackers capable of enabling further convincing and compelling scenarios given existing technology (see below).

Large bike races, such as the *Tour de France*, already invest heavily in technology — particularly telemetry and communication equipment. Future plans, to equip riders with GPS receivers, will provide team managers with unprecedented data concerning details like breakaways and rider biometry (e.g. pulse rate). Sports fans will receive broadcast transmissions supplemented by the real-time perspectives of their favourite riders. Riders could be equipped with heads-up-displays to obtain tactical cues concerning their immediate rivals, warnings of upcoming sprint bonuses and team instructions. Registered 3D graphics could provide warnings of hazards such as pot-holes without demanding a shift of attention from the road to a handlebar-mounted computer.

A system capable of tracking large numbers of people with moderate accuracy throughout a museum could offer new ways to interact with exhibits. The system could infer from the position of a visitor relative to an artifact, what they are currently looking at. Given user histories and profiles the system could then provide personalised narratives and tours tailored to age, gender and specialist interests. A digital tour guide could range from conventional multimedia presentations to fully registered stereoscopic 3D graphics using head mounted displays. Collaborative applications, such as treasure-hunt games provide still further motivation.

CONCLUSION

In order to provide AR and Ubicomp services, a distributed system is required that can automatically configure, fuse and aggregate networks of sensors in response to client queries. We call this approach Ubiquitous Tracking and have developed a formal basis and proof-of-concept implementation [3]. Complex and large scenarios, like those mentioned, above have not yet been implemented; however, initial results are very encouraging. The development of location-aware AR applications is possible, and offers many exciting opportunities in industrial, office, recreational and domestic settings.

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BIOGRAPHY

The author previously worked on Ubicomp and AR at AT&T. He is currently a PhD student at the Vienna University of Technology developing Ubiquitous Tracking.

Position statement

System design and preliminary experiments on supporting citizens using a cellular phone with GPS and a browser.

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ABSTRACT

Purpose of our research is to design and develop systems that can support collaborations between senior citizens and people with disabilities. We developed a prototype system that can record positions of the participants who hold cellular phones with GPS and a camera. The server also keep comments and photographs together with the position information..

INTRODUCTION

The prototype system we are presenting in this paper is for senior citizens and people with disabilities. When they have problems in some facilities and environments in daily life, they can send photographs or information of them and share with other people by cellular phones with cameras that can be carried. The purpose of the system is to send and share all kinds of information of problems, easily, in real time. These problems can be as small as a gap in a sidewalk or as dynamic as a construction detour.

Conventional geographic information systems (GIS) integrates such local information into the central server and utilizes it for city improvement planning. Some information can be seen on the Internet under maps. As we mentioned, however, conventional GIS is not enough to give appropriate advice or the most valuable information to the people where problems arise in their local communities.

Concept and purpose of Kokomemo(Here-memo)

We decided to use a cellular phone currently on the market in Japan as a terminal equipment because we don't need special apparatus. However, it has to have functions to send and receive e-mails, photography and GPS.(In Japan we can buy and use the cellular phone with these functions as the same price range as other normal ones.)

We built the prototype system based on the concept that users share the information as if they put memos in the air and others nearby can easily check the information. We will explain about its mechanism and procedure in the next chapter.

They can put memos of whatever they noticed in daily life as "a memo at the time at the place", so they can share not only advice to avoid missteps one another, but also the positive information like the beauty of flowers they saw in the flower bed. This system is also expected to lead the communication enriching our lives and minds. Because every one can easily dispatch and share their ideas by the use of IT devices.

Field research

We made a demonstrational experiment of this prototype system in the field. Ten members of a local NPO took part in the demonstrational experiment. After the experiment, we interviewed all participants and analyzed the experiment and criticized the system. We could collect various information on memos such as roads, construction sites, traffic signs and advertising displays. Because each member has different view points. They could find so tiny problems that they usually ignore because they could make memos of information by handy terminals whenever they noticed it. They also sent comments to others' comments, and they complemented information and solved their problems by themselves..

Conclusion and challenges for the future

It is important to build a data base to reuse the information collected by participants because it covers very wide range. We need to consider how to classify it under what condition because of less information. And the mechanism to automatically collect and accumulate the environmental information around the position would be possible.

We also need to improve the way to reuse the collected information. If we have more information, it would become more difficult to find the only necessary information on the small screen of cellular phone. The function to sort the necessary information for users is necessary in some way.

We could not offer the collected information to sight-restricted people because we used cellular phones without phonetic function. We need to develop terminal equipment easy to use not only for sight-restricted people but also senior citizens and people with disabilities in the future. It is also important to deepen cooperation among relevant organizations, for example offering gathered data actively to administrations for the city planning.

Tele-Reality in the Wild*

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We are moving toward a world of ubiquitous personal networked video cameras. I have created a tele-reality solution called RealityFlythrough that harnesses wirelessly networked cameras in the "wild", allowing users to naturally explore remote locations live and in real time.

Of the many possible applications for RealityFlythrough perhaps the most compelling application is disaster response. Consider, for example, first responders equipped with head-mounted wireless video cameras encountering the chaos of a disaster site. As they fan out through the site, they continuously broadcast their location, orientation, and what they see to a RealityFlythrough server. The responders' central command virtually explores the site by viewing these video feeds to get a sense of the big picture. Medics can be directed to the injured, firefighters to potential flare-ups, and engineers to structural weaknesses. As more people enter the site and fixed cameras are positioned, the naturalness of the flythrough is enhanced until ultimately the entire space is covered and central command can "fly" around the site looking for hot spots without constraints.

Much research has been done by the graphics and vision communities in texturing virtual reality with photos, with a focus on creating photorealism at every point in space [2]. These systems require extensive preprocessing of the images and special cameras, rigs, scaffolding, and lighting to achieve the effect. They are solving a different set of problems and are operating under a different set of assumptions. These approaches will not work in the wild, where cameras are moving, and the images are live video feeds that cannot be preprocessed.

RealityFlythrough addresses these problems by relaxing the requirement for photorealism [1] during the transitions between images. Transitions are a dynamic, real-time blend from the point of view of one camera to the point of view of another, and are designed to help the user generate an internal conceptual model of the space. See video for examples. Although it is possible to stop mid-transition to see a novel view, the emphasis is on displaying the real images captured from cameras. The transitions from camera to camera are provided mainly to help the user make sense of how the images are related to one another spatially.

* This work supported in part by gifts from Microsoft Research and the HP University Mobile Technology Solutions program.

Central to the success of our work is a reliable and reasonably accurate positioning system. RealityFlythrough places some additional stresses on existing locationing technology because of the need to know the position and orientation in three dimensions of all cameras. The more accurate the position information, the better. We have used consumer GPS with good results, although this limits us to outdoor locations that have a clear view of the sky. RealityFlythrough is tolerant to position inaccuracies because of the way that it transitions users between camera views, but this tolerance relies on image overlap. Indoor spaces tend to restrict a camera's field of view so higher camera density is required to achieve the image overlap and thus greater positioning accuracy is desired. The orientation information of each camera can be easily obtained from compasses and inclinometers; the primary obstacle we face is the dearth of cameras that come preconfigured with the necessary instrumentation.

We built an initial RealityFlythrough to show that tele-reality can be made to work while relaxing the constraints of a tightly controlled environment; that is, to work in the wild, affordably. Our system consists of consumer GPSs, inexpensive web cameras, laptops, and standard video conferencing and graphics software. We found that a pair of research subjects remotely exploring a physical space had a compelling experience and were able to determine key facts about the activities going on there.

Crucial are the sense-making qualities of the transitions we designed and the comfort the user has with viewing them. Early results from a more controlled study reveal that user behavior is on the whole more like operating a true flythrough, and less like operating a multi-camera security system.

Biography: I am a 4th year PhD student in Computer Science at the University of California, San Diego working in the ActiveCampus group under William G. Griswold.

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New Lessons from an Old Location Technology

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The purpose of this short paper is to tell of a granddad. The patriarch is the 20 year old Automatic Packet Reporting System (APRS) developed and in widespread use by the amateur radio community. APRS is an ad hoc mobile communication protocol for exchanging location information between large numbers of mobile users. APRS's popularity has soared in the HAM community, not really because of the technology which is actually quite straightforward, but because of the new applications and capabilities it has enabled. This paper discusses three lessons from the success APRS that have implications for general location-aware computing.

I begin with an ARRS technology introduction. An APRS node consists of a GPS unit connected to an APRS codec box connected to a 144.39MHz VHF transceiver (in North America). Some modern transceivers have APRS codecs built in. Nodes send their position to other nodes. Nodes can also act as "digipeters" to relay packets and increase the network span. Many places have high power digipeters located on mountains or tall buildings. Full fledged APRS nodes using a PC-class device as the codec box can display maps showing the position and status of all nodes within radio range as well as send short text messages between nodes. Many digipeters are now hooked to the internet resulting in services like findu.com allowing anyone to query the position of any APRS node (Go ahead. Track my car. You know you want to. My call sign is KD7MTZ). Naturally, you must have an amateur radio license to run an APRS node.

Being an application workshop, the focus in this paper is on a couple lessons 20 years have revealed about location-enhanced computing and communication using APRS.

The power of location information comes not from knowing your position, but from sharing it. I usually know where I am, but APRS allows me to aggregate the location metadata of a particular group. For exactly this reason, APRS has made a huge impact on managing teams and events. I use it to estimate my HAM friends' positions while skiing. Search and rescue manages the operations of deployed teams. Marathon coordinators can see the positions the volunteers' lead and chase cars. APRS avoids some of the repeated calls for "What's your 20?" (i.e. Where are you?), the most frequent question in wireless communication. APRS has proven most effective with groups engaged in a shared task. The lesson for general location-aware applications is to look for applications involving a team with shared goals before applications focusing on individuals or unaffiliated groups.

There is no "killer" location-aware application. Rather, the utility of location information is in a collection of simple, low complexity applications. Over the years people have built hundreds of small apps around APRS ranging from weather stations which broadcast their position, to location tagged text messaging, to location annotated vehicle cameras, to the guy whose truck could be triggered when stolen to send the police a URL showing its position and heading. Taken together, these applications give APRS immense value and encourage development and deployment of the infrastructure, but few are significant enough alone to justify a private sector investment in equivalent infrastructure. The actions of commercial entities are consistent with this philosophy. Companies like Kenwood and Motorola which sell APRS-like infrastructure sell it only as part of massive integrated systems with many linked applications like Automatic Vehicle Location (AVL), 911 dispatch, and city-wide location-aware communications.

For privacy, try an off switch first. APRS users are allowed to blur the precision to which they reveal positions by reducing the number of decimal places in the reported latitude and longitude or more complex randomization. In practice, these features are rarely used. Most amateurs think it is far better to simple have an off switch. HAM radio enthusiasts are of course not representative users. Being technologists they may be less (or is it more?) concerned about privacy. Nonetheless, the lesson from APRS is that rejection of an off switch as a privacy solution must precede creation of more complex privacy mechanisms.

BIOGRAPHY

Jeffrey has been a member of the research staff at Intel Research Seattle since August 2004. His research interests are in employing devices, services, sensors, and interfaces so computing can calmly fade into the background of daily life. Specifically, he investigates location-aware computing and works on the Place Lab project.

“I’m here”: improving voice location tools with Cell-ID

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ABSTRACT
Mobile phone market is still lacking a satisfactory location technology, i.e. a technology which is accurate, but also economic and easy to be deployed. Nowadays, most of proposed technologies with a good accuracy, require substantial technological and financial efforts. Our work show how the simple and economic Cell-ID location technique can be effectively exploited to implement more effective and efficient voice location services.

Keywords
LBS, Cell-ID, VXML.

INTRODUCTION
The current push for location-based services in North America started in 1996, when the U.S. Federal Communications Commission passed the Enhanced 911 (E911) mandate. U.S. mobile operators, motivated by E911 requirements, are experimenting new and effective location techniques (GPS, A-GPS, TOA, E-OTD, etc.). Nevertheless, all these techniques require substantial technological and financial efforts. E112, the European equivalent of the American E911, does not impose any accuracy or technology mandate in delivering location capabilities. For this reason, most of E.U. wireless carriers are first expected to use the economic Cell-ID positioning. This very basic form of location technology uses latitude and longitude of the antenna handling the communication as an approximation of the actual phone position. Cell-ID is simple and economic and it does not require any upgrade of handsets or network equipments, but since the handset can be anywhere within a cell, accuracy depends on cell size (ranging from few meters to few kilometers). This poor accuracy strongly limit the use of Cell-ID. Indeed only very basic form of Location Based Services (LBSs) have been deployed on the market. Nevertheless in the next section we briefly show how Cell-ID can be effectively exploited in the context of Voice LBSs.

IMPROVING VOICE LBSs WITH Cell-ID
In this section we present a new Voice-XML (VXML) platform which takes a great advantage from the knowledge of the approximate user location estimated by Cell-ID. VXML allows a user to interact with the Internet through a voice-recognition/synthesis technology. Using VXML, users interact with voice browser by listening to audio output and submitting audio input through the user's natural speaking language. The audio input recognition process is performed by the ASR (Automatic Speech Recognizer), which uses a grammar to recognize words or sentences from the user's spoken speech. The recognition process effectiveness and efficiency strongly depends on the grammar size. Consider the following scenario: a user calls a VXML server and says “I'm in via Margutta 45”. In such a case, the number of addresses, and consequently the recognition grammar size, would be possibly made of thousand of entries. The knowledge of the Cell-ID can be used to limit the grammar size, thus improving recognition process, to only the addresses in the cell handling the user communications. Indeed by cell-ID we can reduce the research domain from all the addresses in a city to all the addresses in a specific cell (i.e. a circle with an average radius of about 500m). In order to better evaluate how Cell-ID can improve VXML LBSs, we ran some experiments in Rome. We ran our experiments over 720 Cell-IDs. If we limit our attention only to correct and complete inputs the full grammar is made of about 3400 addresses (see Table 1). The VXML server takes about 7 sec. to upload the grammar and 2 sec. to answer a query. Using Cell-ID information we can reduce the grammar size to an average of 21 addresses and therefore reduce T(upload) and T(query) by an order of magnitude. These advantages are even more evident if users are allowed to provide even partial addresses. The WLAB exploited this technique in the development of a novel multimodal LBS prototype.

	Addresses	T(upload)	T(query)
FULL	3405	7sec.	2sec.
REDUCED	21	0.6sec.	0.6sec.

Table 1: Results on correct and complete inputs.

SHORT BIOGRAPHY
Andrea Vitaletti, Ph.D. at the University of Rome “La Sapienza” is contract professor at the same university. Research interests: wireless and sensor networks, LBS, VXML, algorithms. Some papers in international workshops and journals. In 2003 he founded the WLAB Ltd. a startup mainly focused on innovation and applied research in the wireless area. He is consultant for some Italian and U.S. companies.

[1] This work is partially supported by WLAB s.r.l (http://www.w-lab.it) and WebMinds FIRB project.

Location Aware Multimodal System: a prototype

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ABSTRACT

In this statement, we introduce the motivation for the development of a multimodal support system to location aware applications. We also show the promise of such an approach through the brief description of an implemented prototype and its main features.

Keywords

Location awareness, multimodal interaction, usability.

INTRODUCTION

The actual usability of current location aware applications for ordinary users can be improved by the possibility of accessing the applications' functionalities in a fast and simple manner, increasingly integrated on more human senses and interaction modes. In particular, the pursuit (and reaching) of modern pervasive and ubiquitous computing envisaged among the others by early works of Mark Weiser can be helped by the effort of providing location aware applications with at least the following characteristics: 1) the ability of automatically and transparently tracking users (both indoor and outdoor) at a customisable level of accuracy; 2) the availability of a reliable and fast multimodal interaction with services and content. However, it still seems possible to detect in most of the location-based mobile solutions currently offered in the market a few limitations. Firstly, users are still forced to explicitly communicate with often cumbersome mechanisms the information about the site they are in and/or the one they are willing to go to. Moreover, input/output information is mainly exchanged visually and therefore not in a very suitable format while on the move when location aware applications are instead mostly useful. In general, it seems that there is not yet a full exploitation of available location-based services in a simple fashion and through intuitive and really easy to use interfaces. In our opinion, this has also contributed to prevent location awareness to be eventually perceived by users as an actual "plus" and an added value for real services and applications.

THE SYSTEM

Recent experimental activities in the WLab have been focussed on the main objective of developing a multimodal support system to location aware applications. This system should include: a) a plethora of location techniques (Cell-ID, GPS, A-GPS, TOA, E-OTD) which can be arbitrarily selected (automatically by the system or manually by the user depending on configuration choices and profiles) and with different levels of coverage, accuracy and measured performance; b) the possibility of a visual, voice and touch-based interaction (both strictly sequential and integrated in a synchronized way) with location-based services and content. The main experiments with such a system have been carried out emphasising the analysis of potential benefits for location aware applications arising from two main issues. On one side, the impact that explicit information about users' location have on a multimodal interaction and on the other side, the added value that a multimodal interaction can provide to location-based information.

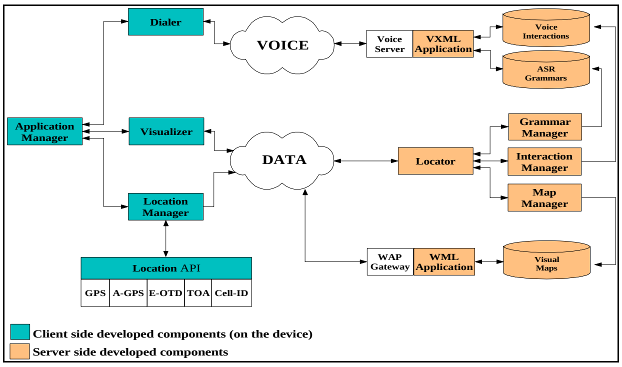

Figure 1. System architecture

The current prototype, whose overall architecture is depicted in figure 1, allows a voice retrieval of location specific visual information. In particular, it is possible for a user through a Symbian OS application (and a J2ME one soon) to speak up on the cell phone the name of the street where she happens to be and to receive on the display the map of the area surrounding the street at a desired level of accuracy, accompanied by specific recognition grammars, voice comments and indications. The following features have been explored and used so far: Cell-ID location technique; visual and voice sequential interaction; background transparent communication of location information on either voice or data channel; the use of location information to customise ASR voice recognition grammars with ad hoc algorithms developed in the WLab.

BIOGRAPHICAL NOTE

Stefano Puglia received a MSc in Computer and Software Engineering and a MEng in Cooperation Engineering for Development both from the University of Rome "La Sapienza". Former member of the Middleware & Mobile Applications research group at Telcordia Technologies (ex Bellcore) Applied Research, USA, he is now supervisor of R&D projects at WLab Ltd. in Rome, Italy and consultant at the University of Rome "La Sapienza". He is a member of the IEEE, the IEEE Computer Society and the ACM.

Location Spoofing

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Current research involves investigating the possibilities of providing middleware for scalable location-aware computing using spatially distributed object graphs to represent entities, relations and locations. Richard Glassey is a PhD student attending the University of Strathclyde, Glasgow, where he previously achieved a B.Sc. (Hons) in Computer Science.

2. OPINION

At present, it is possible with existing infrastructure to determine the location of people, with varying degrees of precision. Authorities, should they wish too, can monitor mobile phone movements, CCTV footage, ATM transactions and various other means of locating someone. Effectively the Orwellian nightmare so vividly described by the media is all but in place. However people do not yet have reasonable access to their personal location information for their benefit. Public resistance to new developments in location awareness, such as protests against tagging of products in supermarkets, reduces the chance that people will ever see the benefits. Despite this caution it is possible to look into the near future, when we begin to fully realise the implications of an information saturated age, where location plays an increasingly important role in making sense of it all.

One aspect of interest is how people, given the responsibility of access control, will manage their location information. Rather than lament about the possible misuse of location for malevolent reasons, this short note discusses how location spoofing, that is, to blur or lie regarding one's location, can be used for benevolent reasons.

To Blur

Fundamental to encouraging the uptake of location-aware applications is relinquishing the responsibility of access control to the end user. Further, the degree of access must allow for a spectrum of control from no access to full access. Whilst there will be more than one aspect to access control, the most prominent is controlling the resolution of location information, effectively blurring what is presented.

Given a choice of location resolution, city, street, less than 20 metres, less than 5 metres, not everyone will choose the same level. This level will certainly change depending upon the context we may be in or application we may be using. If we consider a location-aware city guide, the ability to tune the level of location information in terms of resolution becomes a very effective way of filtering relevant information. At the city resolution we have access to more abstract information such as an overview of public transport, areas of importance and city-wide services. By choosing this level we filter information that we are not interested in, such as restaurants and shops, within our immediate surroundings. However, the converse is also useful when we are attempting to locate a nearby service based on our location. At a street resolution we only receive information concerning our immediate vicinity, thus reducing the effort to find what we require.

Not only will the ability to blur the resolution of location information reassure people that they are in control, it will also serve a very useful purpose when it comes to filtering large quantities of spatial information we will have to face.

To Lie

At first glance the proposition of lying about one's location, to serve a legal purpose, seems ridiculous. What decent law abiding citizen would ever want to lie about where they are, assuming they are willing to take part in an onymous location system? Surely they must be up to no good. Take the example of the employee who removes their RFID badge, pins it to their office chair and proceeds to spend the rest of the working day relaxing in the park. Short of the rather unpopular implanted ID chips it is very easy to fool the system regarding your location in this example. So just how could the ability to lie about your location prove useful?

There are times when we want other people to think we are somewhere we are not. One good example would be leaving our house unoccupied for any period of time. Attempts to spoof location currently only go as far as timed light switches or radios left playing, strategies that are easily defeated by burglars. Consider a smart home environment, designed to assist with daily tasks, that also records sensed movement and activity. This data is used to construct a model of behaviour for the home. If the occupants leave, the smart home can be instructed to use the model to derive reasonable sequences of behaviour to execute in their absence, giving the impression of somebody at home. Whilst this example is quite simple, other applications may also have to lie about the location of valuable assets for protection against theft.

The ability to blur and lie about our location does deserve consideration and should not be treated as entirely malevolent. It will be up to designers to allow the user to have full responsibility and freedom over the access control of their location information, rather than force adherence to uncomfortable regimes of dictated access control.

Building Attractive Location-Aware Applications

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ABSTRACT

The attractiveness of location-aware applications hinges upon development for a ubiquitous platform, mining existing data, and observing privacy issues. This position statement discusses ways to approach these issues, and motivates some example applications.

INTRODUCTION

Location information is a significant enhancement to many existing applications. GPS systems ease the process of navigation, and camera cell phones now enable people to blog anywhere they want. Precise location data can change the dynamics of how a person relates with his surroundings. However, location-aware applications are still not actively used by consumers. Several reasons for the lack of use and deployment are obstacles in platform development, lack of accurate locationing, setup time for each new application, and privacy issues.

APPLICATION ISSUES

Device and Platform

Cell phones continue to be the most ubiquitous devices available today. Today's phones are quite versatile, allowing users to play games, listen to music, and take pictures from phones the size of a person's hand. In addition to their size and functionality appeal, cell phones provide the most ubiquitous locationing based on nearby cell tower beacons. Unlike GPS, bluetooth, or wireless technology, cell tower locationing is available indoors and outdoors with broad signal range. The orthogonal appeal of cell phones makes it a highly attractive platform for application deployment. In addition, phones support Java development, and with each new generation of phones, a wider range of functionality is becoming available.

Unfortunately, development of location-aware applications on cell phones is stifled by a lack of manufacturer API support for developers to experiment with. Although a location API exists for the Java Micro Edition platform, not a single manufacturer supports the API. Moreover, service providers generally do not want this information available since they are able to capitalize on selling location information to users. This is frustrating to developers of location-aware applications when the desired information is available, yet in most cases, inaccessible. Fortunately, certain phones still exist where current cell information can be obtained providing coarse-grained location information.

Mining Existing Data

Location information by itself is not very helpful. External information such as maps, a list of friends, or nearby attractions needs to be coupled with the location information to build a compelling application. One area to mine existing data for location-aware applications is in the space of community relationships. High interest in online social networks, blogs, and instant messaging provides motivation to use this existing data and couple it with location information. This synergy of information avoids setup pains if a user wants to use a new application since he would only need to provide identification for where his information lies (*e.g.* social network username). With this external data, the traditional nearby buddy alert application is simple since the user has already created personal buddy categorizations. Another example application using external data is to provide a concept of "Shared Suffering". In a university setting, using a student's class schedule, information such as "Thirty people in the library are taking Introductory Biology" could be made available. Knowing there are twenty-nine other individuals possibly studying the same topic provides a stress comfort level in suffering together.

Privacy

Protecting a user's location information is essential in order to argue for embracing location-aware applications. The previous application description shows why it would be necessary to maintain the ability to blur location information. Exact location information could be dangerous when given to the wrong people, but quite helpful in other situations. Regarding the previous example, if one student is struggling with a homework problem, knowing precisely where other students are could provide a way to quickly obtain help, and possibly develop a study group community. However, some students may not want to be bothered at all, so maintaining a location blur is attractive. A solution to these opposite desires is to keep the information anonymous, and allow individuals to independently negotiate the release of their location.

BIOGRAPHY

Timothy Sohn is a PhD student at the University of California, San Diego. His research interests are in building location-aware systems and end user application development.

Low-Accuracy Applications

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INTRODUCTION

As location-based applications have been proposed in the research literature, a frequently studied research question has been "what's the accuracy?" Depending on the particular research strategy, the accuracy of the location system can vary by perhaps 5 orders of magnitude—from centimeters to tens of kilometers. Numerous papers have been published touting the better comparative accuracy of one system versus another, given some particular type of input, amount of calibration needed, or other factors. In this paper, we will argue that perhaps this is the wrong way around. Rather than improving our location system's accuracy, we should focus on the development of applications that are compelling, yet do not require a high degree of accuracy.

A key component of the case for low-accuracy application is privacy. Managing the user's privacy—giving him or her ability to control the disclosure of personal information—is crucial to the success of any location-based application. A key component to the design of Place Lab, for example, is that it is in principle a passive system so no data must be disclosed to the Place Lab infrastructure. Other technologies, such as cellular telephony, typically disclose the user's location to some type of infrastructure any time that they are in use. In either case, though, when a user's location is revealed, the question arises: "What has been disclosed and who has access to it?" We argue that if the information disclosed is of a very coarse grain, something like a city or town, then the potential for abuse of that information is less, although not zero.

We will define a low-accuracy, location-based application as one with a typical location estimation error on the scale of kilometers. Normally, such as in the case we describe below, these applications involve the disclosure of the user's location to other persons and we assume that the user trusts those to whom the data is being disclosed.

WHERE'S DADDY

"Where's daddy" is an application designed for people that travel a significant amount, such as the author. With this application the user can disclose their coarse-grained location to a website. This website takes their location information and does a variety of web-based searches based on that data. Interested parties, such as family members that are children, can look at the web page to not only see where the user has been recently but also to get other information about that location, such as language and currency.

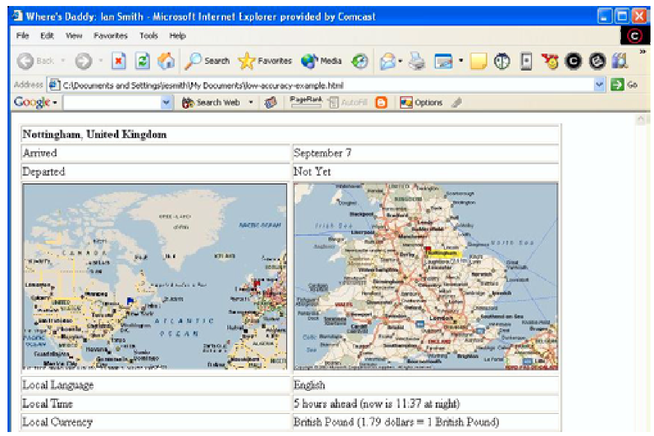

Figure 1: The Where's Daddy Application

In figure 1, we have shown a mock-up of what such an application might look like from the viewpoint of someone interested the user's location. This example shows that the user, Ian Smith, is currently in Nottingham, England. Maps are shown to aid the viewer in understanding where England is and how it relates to the viewer's home, shown with the blue flag in figure 1 as Quebec, Canada. Also, the data presented about the location in question as been customized based on the location of the viewer, such as computing the time relative the time at the viewer's location.

It should be clear that this application does not need significant accuracy to be effective in its purpose as a teaching tool, yet there are still privacy issues to be addressed. The user that is disclosing their location needs to be "in the loop." This is not only to protect their privacy, but also to allow them to be an active participant in the teaching that the application offers, for example by choosing to disclose their location in Paris rather than the suburbs.

In this paper, we have argued that there are compelling applications that can be developed with quite coarse-grained or "inaccurate" location information. Further, these applications offer benefits because they allow the user to disclose information that is potentially beneficial to others without as great a risk to privacy.

Monitoring Visitor Behaviour at the Edinburgh Festival

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ABSTRACT

This position paper describes the Edinburgh Festival project, a three year project that is exploring mobile communication technologies and their use within the context of the world's largest arts festival. The definition of context used on the project is deliberately broad, encompassing geographical location as well as other aspects of the festival attendee's visit. The use of a PDA and digital camera as tools for capturing attendee behaviour is described.

Keywords

Location, Placelab, user-trial, context, arts festival, PDA

1. INTRODUCTION

The Edinburgh Festival project (EdFest for short) is in the first year of a three year research and development program that is exploring mobile computing technologies within the setting of the Edinburgh Festival. The Edinburgh Festival runs for three weeks in August and during this time over half a million people will watch more than ten thousand performances of thousands of different shows that are performed within hundreds of venues throughout the city.

Our definition of context is broad to include the typical behaviour of a festival attendee, i.e., the events they attend, the places they go and the information they generate and consume. Context contains a visitor's location within the city, but it also embraces other (sometimes temporal) activity such as their ticket purchases, the web pages they have used, the information they contribute back to the system and the activity of their "co-visitors", i.e., friends or family who are also attending the festival.

2. YEAR ONE

The main activities of conducting the trial in year one have been to collect some fundamental data on an attendee's behaviour as well as get to grips with the underlying technology. The attendee is given two devices, an iPAQ 5550 PDA, and a digital camera. The iPAQ 5550 contains a built-in wireless network card, a web proxy, and software developed by the Kelvin Institute and Intel's Placelab group that calculates an attendee's location based on their proximity to a number of wireless access points.

The Kelvin Institute's code plots the user's current location on a map of Edinburgh. As an attendee moves about the city, the dot is updated on the screen and the attendee's route is logged to a text file. If the user has access to a publically usable WiFi access point they can interact with the Web via the PDA. This interaction is via the web proxy, allowing EdFest to track the attendee's movement through the web. EdFest tracks both the movements of the attendee within the city and within the web which will be analysed post-festival for any interesting (e.g., correlated) behaviour.

The attendee uses the digital camera to periodically take time-stamped photographs of their location. This information is used to: check the actual location of the attendee; to test the accuracy of Placelab's location calculations as they are derived from GPS data which can be inaccurate; and to allow for a post-attendance interview that is based on photo-elicitation techniques [1].

The three-week trial will consist of data collected from twenty attendances of the festival. At the end of an attendee's day, the data on the devices will be backed-up and the attendee will be interviewed to discover where each photograph was taken, and to give them the opportunity to explain the choices they made during their festival attendance.

The main technical issue that had to be dealt with while developing EdFest was the speed with which the iPAQ's battery was drained. The iPAQ's WiFi card draws 50% of the battery's capacity, the other 50% is used to power the rest of the device. As the WiFi card is on continuously the battery that the iPAQ is supplied with lasts approximately 2 hours. Our current solution is to purchase batteries with double the capacity, however, a programmatic solution that switches off the WiFi card when it is not required will be considered for the next trial.

3. CURRENT STATUS

The EdFest software has been completed and the next stage is to run the trial, collect the behaviour data and analyse it.

In future trials, EdFest will be more integrated with the festival's back-end systems, supporting the user in finding and exchanging information with other attendees.

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A Framework For Mobile Computing

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ABSTRACT

Variation in mobile devices and the desire to provide location-aware applications to them presents challenges that location-unaware applications do not. No company can hope to support all mobile devices using current development strategies. With a small team of undergraduates over the summer, we implemented a framework for delivering tailored, location-aware applications. The techniques we developed are based on standards and can be easily adopted.

Keywords

application tailoring, mobile computing, location-aware

Introduction

With six undergraduates, and an advisor from the University of Alabama, we created a mobile computing framework, with an initial implementation for PalmOS [1]. In ten weeks, software for location finding, content delivery, and application tailoring was developed.

Location Finding

When a user is in an area where location information for visible WAPs is in a local Placelab database [3], our application searches the database for known WAPs, and maintains estimated position based on location and signal strengths of seen WAPs. We used the PlaceLab data and algorithms and wrote Palm native code, rather than Palm-unsupported J2SE code. The advantages of doing trilateration on a local database include speed of search and non-broadcast of location information. The disadvantages of this method include database size and coverage. The current size (2MB) will soon exhaust such constrained devices before covering more than a small amount of the WAPs world-wide. In the absence of the WAP database, the street address, if known, is used to query against a gecoding database[1]. DNS LOC records could also be used.

Application and Content Delivery

Once location is determined, it is sent in an http request to a query server, which decides what content is available and which application servers to query, using a PostGIS relational/spatial database. Content provided must be fresh, as stale content is deadly in a mobile computing environment [2]. As a solution, to ease the burden of administering such a system, a location-aware content management system was created.

Application Tailoring

To support diverse mobile devices, we also created a "write once, run anywhere" language. Casting location-aware applications as question-answer forms, we chose VoiceXML as a base. The VoiceXML file is translated by XSLT to J2ME, which is compiled and packaged for several different platforms—PalmOS and Blackberry— on demand by the application server. Most mobile phone vendors have similar packaging schemes. For more complicated programs, such as GUIs for larger screens, the J2ME low-level GUI toolkit is used, abstracting the windowing features on each platform.

Acknowledgments

We would like to thank the other members of our research group —Camille Leggett, Nick Sandridge, Harsha Tummala, Victoria Davis, and William Smith.

Biography

Scott Miller is a senior in Computer Engineering at Texas A&M University. He is interested in networking and the social impacts of computing. He is a member of IEEE. Joel Jones is an Assistant Professor at the University of Alabama. He received his PhD from the University of Illinois and his research interests are in applying compiler technology to mobile computing and software engineering. He is a member of IEEE, ACM, and UPE.

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LAC 2004, September 7, 2004, Nottingham, England.

Adding Location-based Inference to Computer Supported Cooperative Care

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BIO

Anthony LaMarca is a member of the research staff at Intel Research Seattle. His research interests include location technologies, ubiquitous computing, distributed systems and human-centered design. He is currently working on a project to enable wide-scale device positioning using WiFi base stations. He has a BS in computer science from the University of California at Berkeley and an MS and PhD is computer science from the University of Washington.

POSITION STATEMENT

Researchers have adapted and applied the principles of computer supported cooperative work (CSCW) to the task of caring for the elderly and the infirm. Consolvo et al. have dubbed this area of research computer supported cooperative care (CSCC), and it is focused on helping a network of friends, family and professionals provide care for an individual [1]. This work builds on a variety of ubiquitous computing efforts to detect everyday activities in the home such as meal preparation [4] and the taking of medication [2], as well as ambient displays that allow concerned family members to monitor the state of a remote relative[1] [3].

As a rule, CSCC is not targeted at bedridden individuals requiring 24 hours care, but rather modestly active people that while requiring monitoring and care are still largely self-sufficient. Think, for example, of an early stage Alzheimer patient with occasional, mild dysfunction. One shortcoming of current systems is their inability to collect data about activities performed outside of the home. While these systems would ideally be able to automatically collect data on social outings, exercise, and visits to care facilities outside the home, current systems require that this data be entered by hand.

We would like to suggest that a large quantity of high quality activity data could be inferred by having the user carry a small device that periodically (say every few seconds) logs their location. We believe that a location-trace of a person's daily life could be used to infer many of the activities these CSCC systems would like to track and display. A location trace plus some basic algorithms would allow the system to infer:

- How far and for how long the user walked and whether they walked at the usual time, pace, route
- If the user went for a car or a bus ride and to what areas of the city
- How long they stayed at the various places they visited

These three alone would allow the system to determine a basic degree of activity, and any serious variations from an established pattern. Correlating the user's location trace with data from additional sources like Global Information Systems (GIS), Yellow Pages and personal calendars would allow the system to infer activities like:

- How many times a user went grocery shopping in a week
- If the user went on any social outings (bingo, movies, restaurant, dancing, bowling)
- If the user missed any of their doctor's appointments

This second group of activities holds more semantics and might suggest to their care givers social withdrawal or an improvement or worsening of symptoms. We would like to point out that these activities could be inferred with fairly coarse-grained (20-50m) location information, well within the accuracy range of GPS and possibly feasible with E911-quality location data. We would also like to point out that the device collecting the location trace does not need to be online at all times and could connect occasionally to upload its data (via the user's wireless network, for example). This suggests that this trace collection could be performed by a compact and inexpensive device and would not require a costly "always-on" data service.

In summary, we would like to challenge location-based application builders to go beyond first-order "Where's Waldo" uses of location data. In the CSCC context, pin-pointing Grandpa's location when he wanders off clearly *is* compelling. But a system that can extract a user's larger context and behavior and detect gradual shifts in social, leisure and consumer behaviors is also clearly valuable and complements more literal and direct uses of location data.

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[1] At first glance these technologies seem intrusive, and one's first reaction may be that surely elders and others would reject such systems. Our interview data suggests that instead, potential users weigh the intrusion of a ubicomp system with more traditional monitoring methods like round-the-clock personal visits and human monitored video cameras and can find it offers more privacy than the alternatives.

Categorising Location-Aware Applications

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1. INTRODUCTION

"Location-Aware Computing" is a term which has been used to describe a wide variety of ideas and systems. This position statement categorises location-aware applications into various "resolutions" of location. The ideas behind this work are due in part to the location sensing breakout group at the 2003 Workshop on Location-Aware Computing.

2. RESOLUTIONS

Location-aware applications span a wide range of location resolutions. This paper addresses the hypothesis that, because these applications are human-serving, they can be categorised well into natural human location scales (e.g. town, room).

2.1 Town

A town (or city or village) is a human unit often exhibiting the property that it is easier to move around inside a town than it is to move between places in different towns. This gives rise to a range of applications, such as yellow pages, which are built on this predicate. This is the largest scale which is useful to identify, because it is arguable whether one needs an automated location system in this context, since users change town infrequently enough to be able to manually input the town name without too much inconvenience.

2.2 Nearby

The "nearby" scale is useful for applications such as nearest-X services (e.g. transport, shops, entertainment), or friend location. These share the characteristics that the user is, for whatever reason, at a particular location, but may be wishing or willing to move slightly in order to, say, get to the nearest bus stop, or to meet up with a friend who also happened to be in the area. In many situations, "nearby" may be regarded as walking distance. At this scale, location sensing systems such as Place Lab, which is based on the triangulation of radio sightings such as WiFi base stations, are adequate.

2.3 Place

A "place" describes a region with a common use, e.g. a bank, a home, or a park. This notion is useful for applications such as asset tracking and access control. In addition, a place often describes a unit of context which humans may wish to be notified about, e.g. "Your child is at home." Note that, unlike in the "nearby" case, a place is rigidly defined, since being on the street outside a bank is very different from being inside the bank vault, despite only being 1m apart. This poses difficulties for location sensing systems, with one solution being to use sensors at ingress and egress points, e.g. RFID readers.

2.4 Room

A room scale is another natural human scale, and might be defined by one's field of view indoors, or one's hearing or visual range outdoors. Obvious applications including finding people (e.g. office location) or objects (e.g. nearest-printer). Other applications fall under the follow-me category, e.g. multimedia streams that follow the mobile user, or phone call forwarding depending on user location. Many room-scale location systems have been built, using phenomena such as infrared, vision, and sound.

2.5 Human resolution

Human resolution refers to the typical accuracy of a location specified by a human. This is obviously variable, and might range from a centimetre, as shown by the size of keys on a keyboard, to ten centimetres (e.g. point to a location in mid-air, spin around, and try to point to the same location again). Location on this scale is useful for novel user interfaces such as tangible or 3D interfaces. Location sensing at this accuracy has been accomplished using means such as ultrasound and vision; however, systems on this scale generally require more extensive hardware, whereas systems on wider scales have been proposed which re-use hardware present for other purposes. This presents a barrier to deployment of location-aware applications relying on location accuracy at this scale.

3. CONCLUSIONS

The categorisation of location resolutions is useful in identifying groups of applications with similar location requirements. It is also useful in the design and classification of location sensing systems.

4. BIOGRAPHY

James Scott is a Senior Researcher at Intel Research in Cambridge, UK. He is a manager and lead contributer for a number of projects including in the areas of cm-scale location sensing using commodity audio hardware, and location sensing on the mobile phone platform based on the radio "landscape" of visible Bluetooth and GSM cell towers.