Context-Aware Pervasive Computing at Large: Three Example Applications

Seng W. Loke

Department of Computer Science & Computer Engineering,

La Trobe University

s.loke@latrobe.edu.au

http://homepage.cs.latrobe.edu.au/sloke

Pervasive Computing / Ubiquitous Computing

•mobile computing + ubiquitous computing

•Mobile devices and devices (embedded) in the environment (and surrounding users) working together

•Journals:

- IEEE Pervasive Computing
- Pervasive and Mobile Computing, Elsevier
- Journal of Pervasive Computing and Communications, Traubador
- etc...
- •Conferences:
 - Pervasive
 - PerCom
 - Ubicomp
 - Mobisys

•Related topics: invisible computing, ambient intelligence, intelligent environments, disappearing computer

Research in Pervasive/Ubiquitous Computing?

"The research method for ubiquitous computing is standard experimental computer science: the construction of working prototypes of the necessary infrastructure in sufficient quantity to debug the viability of the systems in everyday use, using ourselves and a few colleagues as guinea pigs. This is an important step towards insuring that our infrastructure research is robust and scalable in the face of the details of the real world."

-Mark Weiser, "Some Computer Science Issues in

Ubiquitous Computing", Communications of the ACM, 36(7), 1993

Context-Awareness in Pervasive Computing

•Started in Schilit's PhD thesis on context-awareness for mobile computing in 1994

- •What is context?
 - Context of a person, software agents, things, situated devices, etc
 - Context: location, time, etc... -> information that can be used to recognize a situation
- •Related concept: the situation
- •What is a context-aware pervasive computing system?

A system that can respond intelligently to contextual information about the physical world acquired via sensors and information about the computational environment. •Related topic: sentient computing (Hopper, 1999)

Context-Aware Pervasive Computing Applications

- Context-Aware Services
- Context-Aware Devices/Appliances/Artifacts
- Context-Aware Information Retrieval
- Context-Aware Security
- Context-Aware Messaging
- •Context-Aware Environments (rooms, etc)

•....

Basic Context-Aware system:
 Sensing+Reasoning+Acting
 More?



Pervasive Computing Lab - Current Work

Scaling up Context-Aware Computing

How to live efficiently and effectively in increasingly complex, dense, dynamic, inhabited environments, i.e. places?

Hypothesis: Place Knowledge Bases can help...

How to enhance the physical world with digital information that adds value and meaning to our lives?

Hypothesis: Physical annotation systems can help...

How to interact with the ever increasing complexity of collections of devices and ubiquitous services?

Hypothesis: Task-oriented abstraction can help...

But in all,

context (information that tells us about the physical world of people and things) is key...!

Smart Places: Place as Context, Context-Aware Mobile Applications for a Place

With Anh-Tuan Nguyen, Seng Loke, Torab Torabi, Hongen Lu

- Place? meaningful location/space... varying granularities
- What can we do if we have detailed knowledge about places?
- What knowledge about a place should we have? (static, dynamic/ real-time, historical, etc)
- Outline:
 - Place-Based Virtual Communities
 - The scenario
 - System Architecture
 - The PlaceAware Ontology









Place-Based Virtual Communities

- Place-Based Community where communications happen at a place and are mediated by computers
- Community is supported by place-specific digital services
- Environment awareness is supported by sensing devices
- Ontology-based shared knowledge about a place: people (and their relationships), places, objects (and their relationships), etc... history (who was here?), movements, etc... (a place knowledge base)





Scenarios

- Airport Pickup: by detecting pre-known bluetooth devices
- Friend Finder: by executing SPARQL query to the *place knowledge base*
- What happened there/here?
- What is happening there/here?
- Who were there/here?

System Architecture

- The system uses JADE/LEAP to support agents on mobile devices
- On stand alone mode: using JSR-82 for Bluetooth API
- Protégé, Jena,
 Sesame API is used for SPARQL queries



A snapshot of the PBVC Ontology in a tool called PlaceAware



PlaceAware software



Finding people





Finding Things (Devices, etc)

- When friends' devices appear, their names and id is listed.
- If we choose the listing all mode, not only friends' devices, but also other devices can be detected.



Second Scenario: PBVC Mode





SPARQL query

 The program on mobile device sends a query to the PBVC knowledge-base:

SELECT ?location ?person

WHERE {

?location rdf:type plc:Location.

?location pbvc:hasTimeInstant ?timestamp.

?timestamp pbvc:timestamp ?timevalue.

?location pbvc:belongtoPersonalContext ?PersonalContext.

?PersonalContext pbvc:createdByPerson ?person.

?person foaf:friendOf ?anotherPerson.

?anotherPerson foaf:name ?nameOfthatPerson

```
FILTER ((? timevalue >=t1 && ? timevalue <= t2) &&
```

(?nameOfthatPerson = "TuanNguyen"^^xsd:string) &&

(?location ="StaffRoom"^^xsd:string)) }

JADE/LEAP agents platform



Concluding this part, Future Directions, Issues

- Community and place have a significant relationship.
- PlaceAware provides users with a tool to discover people and devices in a place (and history at a place) according to time.
- Using an ontology, we can get a better understanding about the context and query knowledge about a community efficiently and effectively, as well as share knowledge across different context-aware applications at a place
- How to build such knowledge bases? We can utilise member/user contributed knowledge, automatically or manually contributed
- Other places with place knowledge bases? cafe (frequent, new, etc), meeting rooms, common areas, stadiums, university campuses, parks, disaster areas, shopping malls, hotels (and its subareas), night market, museums, streets, road segments, suburbs/towns/cities (large-scale?!)...
- Applications? guides, memories/history, social, security, retail, design & planning (how places are utilized...) → PlaceBrowser
- More types of knowledge about a place...?
- Scalability?

Now to 8 examples but no common ontology, ad hoc development, no proper place boundaries, and no proper querying paradigm... Smart Places

http://brightkite.com/



Location-based social networking is getting ready to take off. As smartphones proliferate throughout the population, getting offline becomes more difficult. So why not take advantage of being online all the time to see where your friends are?

Location-based social networking allows members of the communities to share their location through GPS, mobile email or text. You can add comments about a restaurant, let friends know you're going to a show downtown or just find out if anyone you know happens to be nearby and wants to meet up for a cup of coffee. RIM's BlackBerry already supports some of these networks and the pending release of the 3G iPhone will only raise its profile.

BrightKite

BrightKite is a location-based social network that acts a lot like Twitter. In fact, you can add your friends to the network by entering your handle when you register for the service. Featuring a Facebook-like friend feed, users can upload pictures and comments about where they are and what's going on. Log-in, check in and let your friends know what you're doing.

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http://www.crn.com/networking/ 208802663;jsessionid=W0CWLH1OWBBKPQE1GHPCKHWATMY32JVN

Thursday, 29 July 2010

http://citysense.com/



Currently, local discovery depends on proactive searching for relevant locations. Users are challenged to input specific location data into mobile interfaces with small screens.

Citysense eliminates the need to search

Instead, it evolves searching to sensing. Citysense passively "senses" the most popular places based on actual real-time activity and displays a live heat map. The application intelligently leverages the inherent wisdom of crowds without any change in existing user behavior, in order to navigate people to the hottest spots in a city. And it's not dependent on having a critical mass of users on the system.

Citysense is an application that learns

The application learns about where each user likes to spend time – and it processes the movements of other users with similar patterns. In its next release, Citysense will not only answer "where is everyone right now" but "where is everyone *like me* right now." Four friends at dinner discussing where to go next will see four different live maps of hotspots and unexpected activity. Even if they're having dinner in a city they've never visited before.

http://www.gypsii.com/



GyPSii

GyPSii is a location-based network that allows users to upload photos, videos and other information about what they're up to and then geo locate it. Geo location is when a user, for example, takes a photo of an ice cream stand, uploads the photo to GyPSii's service and then adds the GPS location to it. Once everything is tagged and loaded, GyPSii pushes the image out to other users with a location on an online map that lets friends see where you are and how to find the spot you took the picture.

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http://www.crn.com/networking/ 208802663;jsessionid=1PCGK3JRQ5N1JQE1GHPCKHWATMY32JVN?pgno=3₁

http://www.mobiluck.com/en/



MobiLuck

MobiLuck believes that location is the heart of your network -- online or off. The European location-based social network is similar to others. Users can locate and update friends with information about what they are up to and where they happen to be. MobiLuck also allows Symbian and Windows mobile smart phone users to chat with their MSN contacts and will soon have capabilities to support Yahoo, Gchat, AOL and Skype message services as well.

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http://www.crn.com/networking/ 208802663;jsessionid=1PCGK3JRQ5N1JQE1GHPCKHWATMY32JVN? pgno=4

http://www.loopt.com/



Loopt

Loopt recently teamed up with Verizon Wireless to enhance its location-based networking capabilities. Loopt's community is built on three basic principles. Connect, Share, and Explore. Connecting with people is easy on Loopt, because it turns your mobile phone into a compass. Installing the application allows a map on your phone to be populated with your friend's locations and spots they've visited. Users can leave comments on different locations and suggestions. Sharing is easy with a built-in support for instant messaging services, keeping friends close all the time. Users are encouraged to use Explore by checking out friend's reviews. Thinking about going to a restaurant? See what your friends had to say about it.

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http://www.crn.com/networking/ 208802663;jsessionid=1PCGK3JRQ5N1JQE1GHPCKHWATMY32JVN?pgno=5

http://plazes.com/



Plazes

Plazes thinks it's most important to tie location-based communities to locations. After joining Plazes, users are encouraged to fill out a calendar with things you're planning on doing and mapping it to the place where it's going to happen. Once that's done, you can spread the word by clicking the "Spread It" button, which will send the activity to all your friends on the service and to the email addresses of friends not on Plazes. The service recently added SMS capabilities to the service that allow users to add Plazes on the go. Currently, Plazes is supported on BlackBerry phones and an iPhone application is coming soon.

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http://www.crn.com/networking/ 208802663:jsessionid=1PCGK3JRQ5N1JQE1GHPCKHWATMY32JVN?pgno=6

http://whrrl.com/



Whrrl

Whrrl is similar to another online community, Yelp. Both services offer reviews of restaurants, bars, stores, etc. that are written by the people that actually go to the place and get great service or a cheap deal on new shoes. Whrrl ups the ante, however, by mapping everything onto Google Maps. Enter your location and a map will auto populate will local restaurants. Click on one that looks interesting and you'll get the distance from your current location and all the details about the establishment: when it opens, if it serves brunch, the type of payment options. And that's just the basics. Upload photos, write reviews, see what your friends think of the places in your neighborhood to really take advantage of Whrrl.

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http://www.crn.com/networking/ 208802663:jsessionid=1PCGK3JRQ5N1JQE1GHPCKHWATMY32JVN?pgno=7

http://www.ipling.com/english.html



iPling

iPling is a relatively new location-based social network developed exclusively for the iPhone. Launched in January of 2008, iPling is currently in private beta. Although, with the release of the new iPhone coming quickly it wouldn't be surprising if iPling flung the doors to the community open once the phone is on the market. Creating an iPling profile consists of, essentially, tagging yourself. When you add your interests to the community, iPling searches their network for people nearby who share your interests. Users have the option of looking for others with open profiles or restricting access to only friends.

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http://www.crn.com/networking/ 208802663:jsessionid=1PCGK3JRQ5N1JQE1GHPCKHWATMY32JVN?pgno=8

Annotating the Physical World with Ahmad Alzahrani

- Associate context with notes
- "Markup" for the physical world
- Associate things with notes
- Associate people with notes
- Associate space (and points in physical space) with notes

Indoor annotations...



-this building was built in 2001 -this was my first workplace

-road retarred in 2005 -part of my morning jog track

DOUL ST.

-the history of this man is that...

Outdoor annotations...

Annotating the Physical World

Associating Annotations with Things/Objects & Space

- Single object
- Collections of objects
- Single point in physical space
- Collections of points in physical space: e.g.,
 - a line
 - an area (define by a line joining a collection of points)

Technology

• 2-D bar codes

RFID technology



- GPS for outdoor
- WiFi positioning
- Bluetooth positioning
- GSM/GPRS positioning

Line could be a bicycle track, walking path, road segment, path...



[SRC: http://www.logsystems.hu/index.php? module=&menuid=2&subid=&id=&lang=en]

Stick 2-d bar codes and RFID tags on things...



Software system to...

- Allow users to leave annotations/notes, to "attach" a note to a thing, a collection of things, a point in space, a collection of points in space (or its semantic equivalent, i.e., a building, a field, etc) in the right context...
- Allows users to retrieve annotations/notes in the right context...

(where Context = Time x ObjectID/LocationID x UserID x NearbyObjects x ...)

Contexts x Things

Contexts x Point-in-Space <

Annotations/notes

Annotations/notes
Annotating the Physical World

Things can get complex - 1



Annotating the Physical World

Things can get complex - 2



Annotations for: -every floor -every shop on every floor -every shelf in a shop -every item on a shelf in a shop -every person has a different annotation for every item on every shelf in every shop on every floor -every person has a different annotation at a different time for every item on every shelf in every shop on every floor

Annotating the Physical World

"Spraying" RFID tags all over a city?

ucode (in the Tokyo Ubiquitous Technology Project)

But start with a zoo: http://www.tokyo-zoo.net/english/ueno/uc/ main.html

Or in you? swallow an RFID tag and annotate yourself ...

http://appft1.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PG01&p=1&u=%2Fnetahtml %2FPTO%2Fsrchnum.html&r=1&f=G&l=50&s1=%2220070008113%22.PGNR.&OS=DN/ 20070008113&RS=DN/20070008113

Kodak has developed an edible RFID tag, which they claim has many important benefits. The tags themselves are coated with a thick layer of soft gelatin which takes a while to dissolve. After dissolving the tags are intentionally fragile and will dissolve when exposed to gastric acids in the stomach. These tags can also be used in artificial joints, to help notify doctors when a replacement may be needed, and also these tags can be used on pills so that nurses can monitor if the patient has taken their medication or not.

http://www.trendhunter.com/trends/eidble-rfids



Applications?

- *personal memory* : when a person visits a place, or has a special moment, s/he may want to record this moment to remember later, or share it with friends
- tourist information : a new tourist may want to know more information about tourist attractions like the historical information of an old museum, or perhaps s/he would like advice about the best place to visit. So instead of asking people in that city, physical annotations could be an assistance.
- commercial uses such as shopping or advertising : PA systems provide many benefits for retailers. With this technology retailers are able to spread advertising around their shops.
- *warning or security* applications: some areas in certain times can become more dangerous.
- *game* s: gaming is a good example of using geographical information
- health indicators: persons with health issues could be annotated (or annotations triggered/ generated at emergency situation
- entertainment...

Annotating the Physical World

Making Spaces and Things Taskable with Chuong C. Vo, Torab Torabi, & Seng W. Loke What is a smart space?

Seamlessly integrating computational elements into the fabric of everyday life..." [Weiser 1991],

Everyday objects and environments are aware of their surroundings & peers and behave smartly.

The aims:

Support our activities, complement our skills, add to our pleasure, convenience, accomplishments [Norman 2007].

Taskable Spaces

Invisible Computers?

"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it." - Mark Weiser

Can we separate the interface from the computer?



Usability problems with smart spaces



- Complexity of use: Variety of devices, Uls, remote controllers
 - Requires too many buttons and menus on UIs, exceeds capacity of UIs for users to operate them intuitively [Rich 2009].
 - Users need to understand how to map devices' functions to their tasks & sub-tasks.

Usability problems (cont.)

- Invisibility & Overload of features
 - Technologies blend into environments.
 - Frequently adding/removing devices and services to/from the spaces.
 - -One device \rightarrow tens of features
 - Different combinations of devices
 - \rightarrow Hundreds of features



MediaCup [Beigl et al. 2000] C.C. Vo, T. Torabi, and S. W. Loke - La**Taskable Spaces** 31 University

Usability problems (cont.)

- Inconsistency of user interfaces
 - Brand identification, product differentiation [Rich 2009; Oliveira 2008]
- Inconsistency of task executions

 Same tasks but different operations/ procedures when being executed in different smart spaces.

How to tackle these usability problems?

Our approach is based on *task-oriented computing*.

Task-oriented scenarios

- Pervasive city's scenario
 - "It's 7p.m., it's raining, and you're walking in the centre of Melbourne. You consult your phone and it suggests 'Dinner?', 'Taxi?', 'Bus?'.

Selecting 'Dinner?' will present restaurants you're apt to like and even dishes that you may want..."

- Pervasive university campus's scenario
 - "You're driving approaching La Trobe Uni. Campus, the LCD on your car suggests 'Campus map?', 'Find a place?', 'Parking spot?'. Selecting 'Parking spot' will guide you to find a parking spot."

Task-oriented scenarios (cont.)

- Pervasive personal office's scenario
 - "You enter your office. The lighting, heating, and cooling levels are automatically adjusted based on you electronic profile. The coffeemaker works to give you a cup of hot white coffee."
 - You look at your smartphone, and it tells you what tasks you can do with your phone here
 - You "point" your phone or bring your phone near to a device/artifact and the phone shows you a list of tasks you can do with the device/artifact (e..g, device is an audio system, artifact is a research paper, chair, etc)

Our long term aim is to realize these scenarios!

Task-Oriented Computing

- Our approach is based on task-oriented computing [Wang et al. 2000]:
 - A task is a user's goal or objective [Loke 2009].
 - Users interact with/think of the computing in terms of tasks instead of applications/devices' functionality.
 - Users focus on the tasks at hand rather than on the means for achieving those tasks [Masuoka2003].
 - Application function is modeled as tasks and sub-tasks.

Approach: a task-oriented framework

Problem	Proposed solution
Complexity of use	Task-based user
Invisibility & overload of features	Context-aware task recommendation
Inconsistency of UIs & task executions	Abstraction of task models

Location = La Trobe University Campus

Tasks

Find a path Find a place Find a parking spot

...





Tasks- Find a path Find a place	Location = Building PS1			
Find a parkin 	Enroll a	Location = Personal office PS1-219		
	Find a r	Task Make coffee Dim lights Watch TV 	Location = TV's zone Tasks Make coffee Dim lights Watch TV 	











Current implementation

Technologies for estimating locations



C.C. Vo, T. Torabi, and S. W. Loke – La**Taskable Spaces** University

Current implementation

Location-based task recommendation

3 🗢 5:21 PM © 89% 🛶	
University Campus. You may want to:	Personal office. You may want to:
Find a path within campus	Turn on lights
See the campus map	Turn off lights
Find a parking spot	Dim the light
Know where you are	Bright the light
Updated 17:21:41.	Make coffee
	Print something
	Turn FAN on
	Turn FAN off
Location = University campus	Location = Fersonal Officers

Current implementation

- Indoor pointing: uses Cricket system
- Outdoor pointing: uses iPhones with compass & GPS



Future work, Issues

- Design a comprehensive task description language
- Develop a graphical editor for authoring task descriptions
- Extend the task execution engine
- Develop mechanisms for effectively publishing and retrieving task models:
 - Indexing, matching, searching, composing, recognizing task models
- Address conflicts of task executions in multi-user environments....
- Transparent/Translucent task execution...
- Macro recording of complex tasks...
- Performance
- Stability

Conclusion

Applying the Idea of Context-Aware Pervasive Computing:

- Smart Places: place as context, place knowledge bases
- Annotating the Physical World: creating and retrieving annotations contextually
- Taskable Spaces: making it possible to do the right task in the right context

"The research method for ubiquitous computing is standard experimental computer science: the construction of working prototypes of the necessary infrastructure in sufficient quantity to debug the viability of the systems in everyday use, using ourselves and a few colleagues as guinea pigs. This is an important step towards insuring that our infrastructure research is robust and scalable in the face of the details of the real world." -Mark Weiser, "Some Computer Science Issues in Ubiquitous Computing", Communications of the ACM, 36(7), 1993

So, we keep building proof-of-concepts (or prototypes), evaluate the efficiency, feasibility, effectiveness, and usability of our systems, and understand better how to build such systems...

Questions?

Thank you!