

# Place-Based Virtual Community – A New Approach for Context-Aware Applications

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## **Abstract**

*When a new mobile device joins pervasive computing environment, it has to discover the environment structure so it can best integrate and can be served by the environment. Development of appropriate “device joining” mechanism for such environment is one of the major issues in pervasive computing. This PhD proposal introduces a Place-Based Virtual Community (PBVC) as a new approach for solving the device joining problem in the context-aware environment. The PBVC is considered as a virtual world that is superimposed on the physical world. Services in PBVC Community can be coordinated to support members in a flexible way. Hence, this research will attempt not only to define and formalize the PBVC community but also to investigate the necessary services inside such community.*

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## **Problem Statement and Research Question**

### ***What is the problem the research you do is going to solve?***

The availability of wireless network connections and powerful mobile devices has made the pervasive computing become real. However, the process of helping devices to be known by the environment as well as finding the best way to integrate them into the environment is still an open issue [19] . In addition, the goal of pervasive computing is to find a better way to integrate the computer into human activities [17] . Hence, users should be informed about their environment so that they can be served by services within the environment without any distraction.

This research will build a mechanism for new devices joining the context-aware environment as well as people joining the virtual community built on that environment. In addition, this research also focuses at the service coordination in the environment for helping users better.

### ***What is the central research question? (i.e. What do you want to find out?)***

How can new devices and people be recognized and served by the context-aware environment?

I would like to develop a mechanism which will provide support when devices and users joining or leaving the context-aware environment. When becoming a member of a community, users can be served by services in that environment. The services to the users can be improved and used more effectively if the services are coordinated.

### ***What will we know after your thesis that we did not know before? (i.e. What is novel?)***

In the context-aware environment, the number of objects or people in the environment is constantly changing. For example, the numbers of people or devices varies greatly in university campuses, at train stations or in public places at a specific time. Mobility in the context-aware environment is very important.

This thesis will provide a mechanism for solving the dynamical problem by building the context-aware environment that can deal with many devices and people moving in and out

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dynamically. In addition, services in that environment can be coordinated to produce a bigger context-awareness goal.

The innovation here is we give the definition of a Place-Based Virtual Community that is superimposed on the physical environment. In that community, we will treat devices or users as a member/non-member of the community. The problem of how to integrate new devices into the environment as well as how to let people use services in that environment now can be solved by building a joining/leaving mechanism in the community. When using the community, we also think of the social networks related to that community.

Another innovation here is services can be coordinated to produce a bigger context-awareness goal instead of a set of discrete services.

**Why does it matter? (i.e. Why should someone care about this research?)**

The dynamic in the context-aware environment is very high. Contexts are changing, people are moving in and out the environment with their mobile devices. This issue must be considered when building a context-aware application.

There is a lot of research on service coordination for fixed networks, but not much research on service coordination for pervasive computing [6]. Because of the dynamical, the diversity of devices and the different types of context [1], services must be coordinated to best support users in the environment.

**Approach and Methodology**

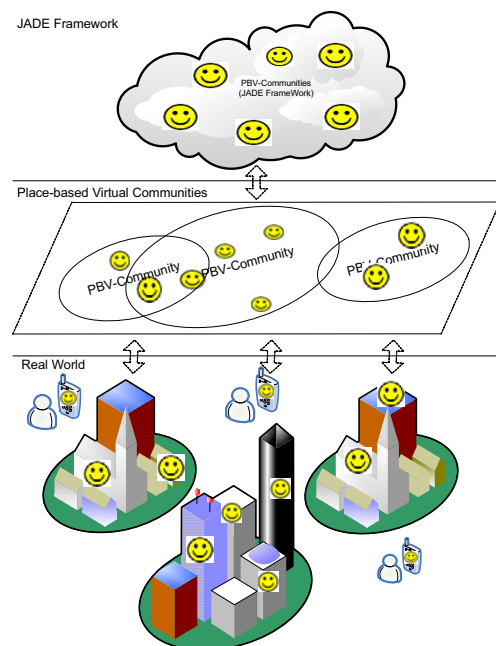
**How do you (or plan to) conduct the research? Is it experimental or theoretical?**

This is an experimental research. For solving the problem, first we define the Place-Based Virtual Community (PBVC):

*“A place-based virtual community is a group of people, objects or agents, sharing common interests, attributes, and knowledge, that may share a common physical place at a specific time. The object can be a computational device or just a sensor, or a tag. The community is managed and operated by autonomous agents. Agent communications and co-operations are based on protocols and policies that give benefit to the members”.*

The PBVC is built on top of a multi-agent system<sup>2</sup> where members are managed by agents. Applying PBVC can help us build a reusable framework for developing context-aware applications. The technology-rich environment is considered a virtual community. The PBVC is considered as a virtual world that is superimposed on the physical world as illustrated in Figure 1. Members in that community are managed by agents. Based on the policies and goals of the community, users are served in a aware-way depending on their contexts. By definition, the PBVC can be applied to various environments such as university campuses, shopping malls, home and open environments.

The “place” in the definition of PBVC makes it different from traditional virtual community which is defined by Rheingold [14]. We would like to use the



**Figure 1. Place-based virtual community superimposes physical world**

<sup>2</sup> Jade - Java Agent DEvelopment Framework <http://jade.tilab.com>

word “place” instead of “location” because when referring to a “location”, it is usually a reference to a single point in the coordinate system. Furthermore, people usually refer to “place” in normal conversation [2] ; for example, people usually invite their friends to come to their place not to their location. In addition, according to Cressewell, the place is a meaningful location, it somehow refers to ownership or some connection between a person to a specific location [5] .

The context-aware environment is as dynamic as a community with many members joining or leaving during a period of time. In our previous work, we defined the simple joining/leaving protocol (Figure 2) to help users and devices travel between PBVCs [10] . With this approach, we believe that the context-aware environment can be modelled as a community. The dynamic problem can be solved by applying the idea of a place-based virtual community.

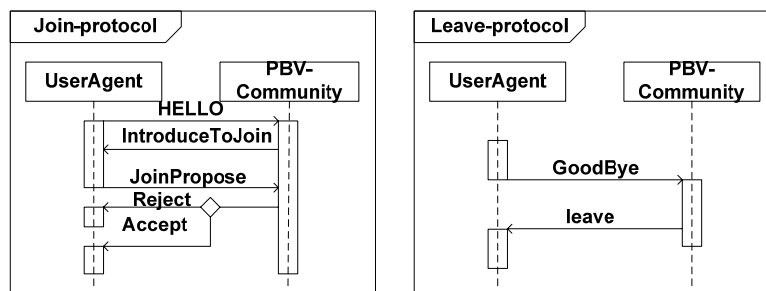


Figure 2. Join/Leave protocol

Secondly, the reason for applying the idea of community is the characters of the community are awareness and collaboration. Members are aware of the presence of each other. Members are able to interact with each other and have some basic knowledge about each other. Such knowledge about members includes member’s properties or context. The context might be the location of each member, member’s interest-profile or tasks. The awareness character of the community can help with service coordination. For example, if the user in the PBVC searches for a book “Place: A Short Introduction” in the library. The user’s request then can be passed to a coordinate-agent to help user find the book not only in library, but also in bookshop nearby. If the book was not found but found in the bookshop, the system can recommend the user to buy it from the bookshop.

In consequence, when working with knowledge sharing and coordination, we found that ontology is a very important part need to be included to make this research possible. The most relevant ontology is SOUPA [4] . For this research, we inherit some ontologies from SOUPA. Meanwhile, we also develop PBVC ontology to support our system. This ontology is the heart of the system. It will be the knowledge base for members, agents, services and protocols in the PBVC.

To sum up, we plan to do this research by giving a definition of Place-based Virtual Community for solving the entering environment of devices and users. When building the PBVC, we found that services coordination in the PBVC is important for helping users. Because the communication and coordination between members in the PBVC need a sharing knowledge base so we build the ontology.

***How will you know that you have succeeded? (ie What is your plan to demonstrate the validity of your claims?)***

The idea of virtual community applied to pervasive computing was first mentioned in the Weiser paper “Some Computer Science Issues in Ubiquitous Computing” [18] . The use of a multi-agent system for developing context-aware applications has appeared in many projects [8] , [15] . We plan to continue to improve the prototypes of PBVC in the previous work ([10] , [11] ) to support the research direction.

***Explain briefly why your approach is appropriate in the context of your work.***

Our approach is appropriate because the main character of the community is dynamic, where members go in and out frequently. Therefore, the modelling devices joining/leaving the community

are appropriate. Another character of the community is the awareness between members and community. When the system is organized as a community, the coordination can be solved.

In consequence, to make that system work, ontology is needed for sharing the knowledge as well as fundamental background for doing reasoning and coordination.

This research also aims to the re-usable goal. By considering the environment as a community, we can apply for many different type of community such as a campus community, street community, hospital community or shopping mall community

The approach of using agent and communities has recently become aware of research community such as the Workshop on Agent Technologies for pervasive communities-ATPC<sup>3</sup> in conjunction with Percom 2008 conference and Workshop on Context-Aware Pervasive Communities: Infrastructures, Services and Applications<sup>4</sup> (CAPC 2008) held in Conjunction with Pervasive 2008

***What alternatives would there be and why are you not using them?***

Of course there are other alternatives such as building a set of services for the context-aware environment, not use any concept of virtual community or multi-agent system. It can build a system similar to our prototype but it will be very difficult for adding new services and coordination of services to support a bigger goal. Furthermore, if using this approach, we must rebuild the system for the specific environment.

## **Related Work**

***Briefly summarise the 4 most important publications for your research.***

There are many context aware applications for campus life such as ActiveCampus [7] and MyCampus [16] . The ActiveCampus explores wireless context-aware computing in campus environment to support “learning community”. ActiveCampus provides students PDAs that can exchange information and explore the campus with “x-ray glasses” to see the digital-graffiti. The application is an array of services on the Apache web server (PHP enabled). The client is a web browser on the PDA that has wireless connection. The project does not approach community oriented computing. Similar to ActiveCampus, the MyCampus project aims to assist students in different tasks such as planning an evening, organizing a study group, recommending places of interest and filtering messages [16] . The context in this project includes places/locations, power and scalability of the environment which are derived from an ontology. However, MyCampus does not discuss the learning community in the campus environment.

The NEXUS<sup>5</sup> spatial world model focuses on creating a spatial world model with mobile and stationary objects [12] . It integrated virtual objects and representations of real-world objects to form the augmented-world model. The project also introduces the Augmented World Modelling Language (AWML) is used to describe the object in the augmented world. In our project, the augmented world is the PBVC where objects in the real world are mapped into agents in the architecture.

The well-known framework for developing context-aware application is ContextToolkit [1] . The context-toolkit is a pipeline of data from sensors to the application. The data can be aggregated and interpreted to become meaning full for human perception. The project uses the concepts of widgets, which retrieves data from the sensors and send to the applications through aggregator or an interpreter. This can be seen as the pipeline from the sensors to the applications.

To support the context validation and reasoning, the Context Request Broker Architecture – COBRA provides the middle layer for context querying and reasoning for context-aware application. The SOUPA ontology introduces the concepts for describing context in context-aware

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<sup>3</sup> <http://aser.ornl.gov/events/atpc2008/index.htm>

<sup>4</sup> <http://hercules.infotech.monash.edu.au/EII-CAC/CAPC2008>

<sup>5</sup> <http://www.nexus.uni-stuttgart.de/en/organization/rg/ipvs-eks/eks-sfb.en.html>

applications including action, agent, BDI, device, location, policy, person space, and time [4] . In my project, there will be an ontology for the common use PBVC and ontology for specific PBVC such as university campus environment or shopping mall environment. These ontologies will inherit the SOUPA ontology but will extend some items to support the PBVC definition.

The place-based electronic communities concept from the Loke's book "Context-aware Pervasive System: Architectures for a New Breed of Applications" gives the fundamental knowledge about community oriented computing [9] . The concept of PBVC is developed based on the place-base electronic community. Using multi-agent approach where the physical world is modelling by an agent architecture. Agents communicate to each other, can coordinate their tasks to make a bigger goal of community [6] . This project will explore many location technologies such as GPS, sensors (ibuttons<sup>6</sup>), RFID and signal strength for location detection. The ontology will be the heart of the system for communication and coordination.

## **Preliminary Results**

### ***What is your contribution to the field?***

This research can contribute a mechanism for integrating new devices into the environment and a mechanism for coordinate services in the context-aware environment

### ***What have you found out so far? What are your results?***

We have developed the PBVC prototype and demonstration the scenario that users join/leave communities with the PDA [10] . The meaningful place notation was used instead of location. I also demonstrate the agent communication, and service negotiation within the PBVC to serve users based on their context [11] .

### ***How do you proof your results? Why should we believe these results?***

This is the first step of the results. The result can be proof by running the prototype in the simulation environment. I am using JADE/LEAP for develop PBVC agent architecture and agent running on mobile devices. The approach using JADE/LEAP for demonstration is widely accepted by many researchers.

## **Conclusions and Future Steps**

### ***What are the next steps? What do you need to address?***

In conclusion, I have defined the place-based virtual community and prototyped an application for proof of concept. We have also explained the case for a multi-agent approach combined with a PBVC for solving the computational aspects of our concept. This research is going to build a mechanism for new devices joining the context-aware environment as well as people joining the virtual community built on that environment. This approach can help the process of service discovering and utilizing easier.

### ***What research has to be done?***

An ontology can help to clarify the structure of knowledge or lay out assumptions about the content of entities, i.e. about "what is there?" in a certain concept [3] . The ontology is also used to provide a general means of describing different place-based virtual communities. In our implementation, there are many agents communicating with each other, if we have no ontology, there cannot be common vocabulary for representing information in the protocols used. To make the agents in the system understand each other, we should design ontology for each PBVC and for messages in the protocols. We plan to develop and refine our ontology of PBVCs, and to implement more such PBVCs at varying scales, and investigate their coordination.

### ***Where do you need additional (external) expertise? Where would you like to cooperate with others?***

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<sup>6</sup> <http://www.maxim-ic.com/products/ibutton/ibuttons/>

I need additional expertise in narrowing or shaping my research direction. I would like to cooperate with researchers in multi-agent and ontology field to learn skill and knowledge that support my research.

***Where would you appreciate guidance and advice?***

I would appreciate guidance and advice from experts in ontology and multi-agent fields

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