

# *iCampus*: A Connected Campus in the Ambient Event Calculus

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## Abstract

*iCampus* is a prototype multi-agent system whose goal is to provide the ambient intelligence required to connect people in a university campus and make that campus inclusive and accessible. Software agents called *guides* run on mobile phones to help students with information about people, places, and events, thus providing people real-time, location-based advice that makes them more aware of what is going on in the campus. The work outlines how to specify *iCampus* in the Ambient Event Calculus and implement it using the agent environment GOLEM to deploy guide agents over a campus network. The work is illustrated by showing how *iCampus* improves the mobility of blind or partially sighted students within a campus, which has been the main motivation behind the work.

*Keywords*: Ambient Event Calculus; Connected Campus; GOLEM; Software Agents

## 1 Introduction

John is a visually impaired university student in his 1st year. Although his university is small, the university's campus has 72 areas between buildings and park areas in which John has to learn to find his way. During term time, teaching takes place in different buildings and, many times, John has to move quickly from a building to another in order to find his way to the classroom. Once he finds the classroom, he may have to wait outside the class until the previous lecture has finished and once the class is empty, enter the room and find out where to sit.

Many tasks can be complicated for John and the practice so far has been to assign to him a helper, typically another student. However helpers are not constantly present, therefore John relies mostly on his memory and on people nearby. Due to the fact that he has only partial information about his surroundings he is faced with problems such as how to find a new building or a classroom, especially if the map and the information board in the entrance of the building are not accessible. He is also facing problems such as how to find where his best friend is standing in the class, including deciding when to enter the class and where to sit.

We study how to use Ambient Intelligence (Sadri & Stathis, 2008) to help people like John. For this purpose we are experimenting with *iCampus*, an ambient intelligence system where John downloads a guide, a software agent that works proactively to help the student with its everyday activities within the campus. His activities typically involve discovering the current location of friends, places, and events within the campus, not necessarily only teaching. As a result of using *iCampus*, John is able to find the location of lectures, people who are nearby but he cannot see, building entrances and other information that can help him within the campus.

*iCampus* assumes a mobile phone with GPS and bluetooth capabilities based on a campus map. In the case of John the mobile is equipped with an additional screen reader library, which reads to him the information that is visualised on the screen of the phone. When John is outdoors, the *iCampus*

uses the GPS service to provide him information about the outdoor environment, while indoors the campus contains access points that provide indoor information using the bluetooth services of his mobile device.

In the remainder of the paper we first discuss the *iCampus* concept and how a user can interact with the application, then we show how we have organised the interaction of guide agents in the GOLEM platform, where we also outline our current implementation. We conclude with an evaluation of the application and our plans for future work.

## 2 The Concept of *iCampus*

*iCampus* maps the physical environment of a campus to an electronic environment with people's avatars, guide agents, places, events, and objects (Stathis et al., 2005). The kind of information offered on demand by *iCampus* agents include discovery of people e.g. a friend, identification of the location of places and objects within them e.g. a building or a board in a room, and happening of events e.g. whether a lecture has started or not. *iCampus* also supports requests that provide functionalities such as path finding, alerts for the user and personalisation operations which allows the user to specialise the application with his/her own profile (Mamdani et al., 1999).

“Who is around” queries allow the user to see other people that are nearby. Locality is based on the location of the user and the specified radius for the area of interest. Users can see each other if they make available their position to others. Figure 1 shows how John searches his friend Visara. John can locate Visara because she has published her location as visible. Similarly, “What is around” queries examine the current place of the user including objects such as electronic boards, projectors, or sub-places such as rooms, corridors, and lecture theatres. Once people, places, or objects have been discovered, “Where is” queries find the exact location of a person, place, or object. Once an object/user is localised, *iCampus* provides any additional information that is associated to it. As shown below, for brevity of interaction “Who is around” and “What is around” can be combined to one query.

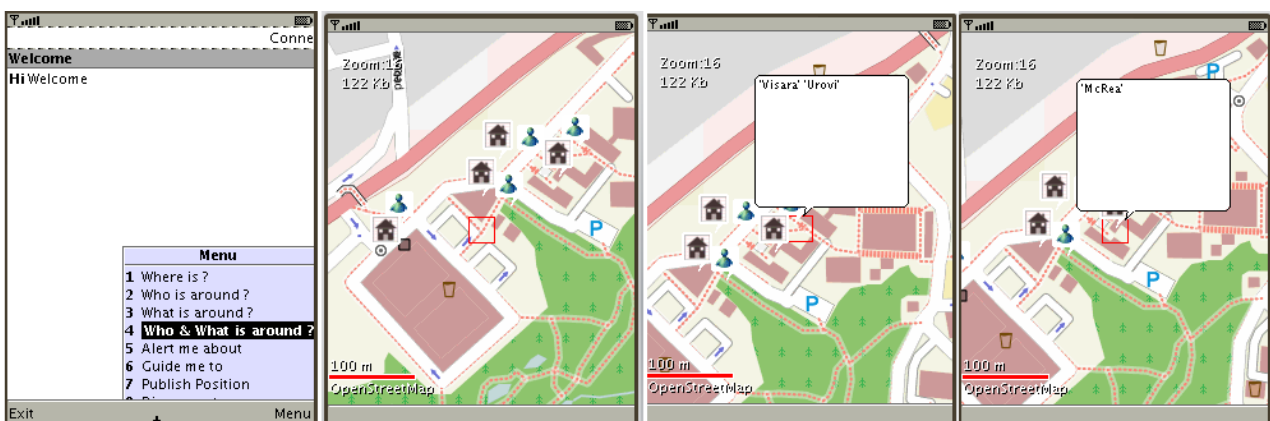


Figure 1. Screen shots of a mobile phone running *iCampus*. The first (leftmost) shows how a user runs a “Who & what is around” query, the second shows the results, and the third and fourth the names of people and buildings respectively.

Additional features of *iCampus*, include: “Guide me to”, which provides information about how to move from the current location to a destination one, “Alert me about”, which allows a user to register about events of interest in the campus, and “my *iCampus*”, which allows a user to personalise the system according to a user's needs. An example combining all these features

includes John who uses “Alert me about” inaugural lectures and listens to only the accessible routes using “Guide me to” because he has specified on “my *iCampus*” that he is partially sighted.



Figure 2. Screen shots of the “Guide me to query”.

Figure 2 shows how John requests “Guide me to” that will allow John to be guided to a location of interest. The path returned consists of a set of important reference points, which are read to John in order to guide him to the desired location.

Other items in the menu of *iCampus* allow the user to state his coordinates in the campus by selecting “Publish Position” and disconnect from the system, if required, by selecting “Disconnect”.

### 3 *iCampus* in the Ambient Event Calculus

We represent the physical environment of a campus with a distributed agent environment represented in the Ambient Event Calculus (AEC) (Bromuri & Stathis, 2009). This framework provides a formalism that allows us to perform distributed queries on the distributed agent environment and allows a developer to specify users or software agent interactions over a distributed network. The AEC assumes a number of system entities as follows.

- **Containers:** These entities represent a portion of the distributed agent environment running on a particular host computer, which in *iCampus* represent places in the map. They also mediate the interactions between entities running or better contained in it, such as users, agents, and other objects, whose interactions are specified in terms of events (Bromuri & Stathis, 2009). We organise the campus as a distributed tree of containers, where every container represents a key place in the campus. Outdoors, the users connect to the computers where containers are running by using their own mobile devices. When users are indoors, they are considered to be components in sub-places represented by sub-containers. For example consider a classroom (a sub-place) contained in the first floor (a sub-container) of a building in the campus (a container).
- **Avatars and Agents:** In *iCampus* we make use of software agents (Stathis & Toni, 2004) to make the ambient intelligent. Users connect their mobiles to a container by means of an avatar that forms part of the campus electronic environment. The interface enables the user to query the system using the operations as it was shown in the previous section. In *iCampus* we require three types of agents to support the user: (a) *avatars* that are allow users

to have presence in the virtual environment, (b) *guides* that are the personal agents specific to a user and (c) *location agents* that can answer queries regarding the information held in a container.

- **Objects:** passive reactive entities representing resources available to agents and avatars in a topology of containers. In the particular case of *iCampus*, objects represent external resources with a virtual presence like a projector or databases available to agents to proactively alert avatars and other agents about their personal schedule in outdoor and indoor environments. Moreover, in indoor environments objects can represent bluetooth connections to a particular host where a container is deployed.

We have used the Ambient Event Calculus to specify a platform for distributed agent environments called GOLEM (Bromuri & Stathis, 2007). GOLEM supports the deployment of containers, agents, avatars, and objects over a network. In particular, GOLEM enables inter-agent communication via message passing and interaction of agents with objects as well as agent mobility. We have used the deployment functionality of GOLEM to implement the required agent interactions in *iCampus*. Figure 3 shows the deployment of four containers representing places of buildings and rooms in the *iCampus* system.

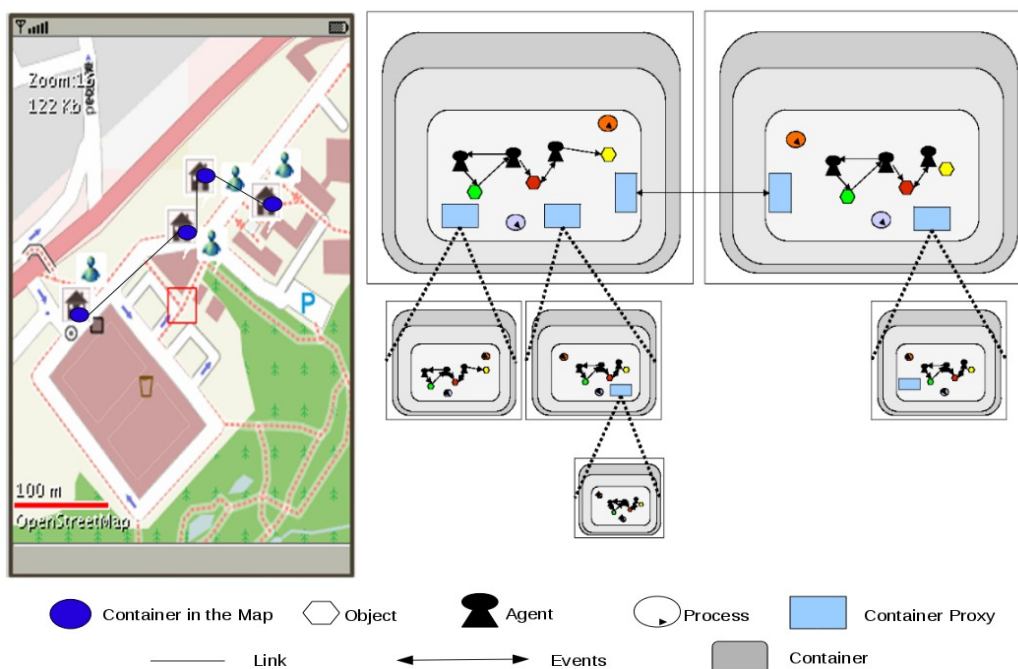


Figure 3. GOLEM Containers Topology in *iCampus*

In particular, GOLEM supports the hierarchical deployment of containers organised in a distributed topology. This topology represents all the physical locations of host computers where containers are needed to capture campus interactions. Given such a topology, queries in GOLEM are specified in the logic-based language supported by the AEC. We have tested our implementation on a specific campus network utilising host computers that run containers for one building and a GPS enabled Samsung Omnia HD8910 for which we developed a J2ME client for the user to connect to GOLEM. Using this implementation, to locate the position of someone that is currently connected to the network we use a query of the form:

whereis(Name, Surname, Radius, place, Pos, T) ←  
neighbour\_instance\_of(C, Path, Path\* , Radius, Id, avatar, T),  
neighbouring\_at(C, Path, Path\* , Radius, Id, avatar, name, Name, T),  
neighbouring\_at(C, Path, Path\* , Radius, Id, avatar, name, Surname, T),  
neighbouring\_at(C, Path, Path\* , Radius, Id, avatar, position, Pos, T).

Such queries make use of the primitive predicates of the AEC such as `neighbouring_at/9`<sup>1</sup>, which allows the developer to specify queries from one container to neighbouring containers in order to discover the position **POS** (longitude and latitude) of an avatar identified by a **Name** and a **Surname**. A detailed description of the AEC functionality is outside the scope of this paper; the interested reader is referred to Bromuri and Stathis (2009).

## 4 Conclusion and Future Work

*iCampus* is a prototype multi-agent system providing the ambient intelligence required for an inclusive and accessible campus. In this short presentation we have presented the main concept behind *iCampus* and illustrated how it can be used to help partially sighted students with information about buildings, objects, and people, by giving them real time location-based advice, and thus making them more aware of what is going on in the campus. We have also specified part of the current status of the *iCampus* in the Ambient Event Calculus, the platform GOLEM, and the combination of GOLEM with the GPS technologies and mobile phones.

Previous attempts to combine GPS technologies with mobile phones has been proposed by the Loadstone and WayFinder projects. Loadstone (2009) uses a GPS bluetooth receiver to guide users through geographical locations. Where no GPS is available, the user can monitor cellular phone sites for knowing roughly his or her position. WayFinder Access (2009) on the other hand is based on map systems and updated databases to provide information for pedestrians and vehicular navigation about locations of interest and proximity information. Other systems, like Hub et al. (2004), Ra et al. (2004), and Ros and Blasch (2000) focus on enhancing the perception range of the visually impaired users in the immediate surroundings, using wearable interfaces, or improving the capabilities of the cane by means of tactile or sound information according to the obstacles in the environment.

We focus on a high-level representation of a virtual environment, where the user is guided indoors/outdoors as in Loadstone with the additional feature of personalisation through intelligent agents that adapt responses according to the user's needs. Moreover, our system is distributed and updating does not involve the modification of a centralised database as in Wayfinder. Our approach is orthogonal to Hub et al. (2004), Ran et al. (2004), and Ros and Blasch (2000) that are easily integrated in our system.

Future work involves extending our guide agents to plan paths using the techniques described in Stathis and Toni (2004), enable agents to set up alerts for users, and consider the architecture that would allow GOLEM containers to be deployed in mobile devices.

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<sup>1</sup> In the logic-based representation of GOLEM the number following the backslash "/" after a predicate name indicates the number of parameters required for the predicate.

here would not have been possible.

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