Multi-Agent Architecture-based Location-aware Service Project for Ubiquitous Learning

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Abstract: This paper describes the MAA-based (Multi-Agent Architecture) location-aware service project for supporting users learning in the ubiquitous/pervasive environment. The project plans to build a MAA-based learning environment with various agents have different abilities, for examples, the agent can sense the location where the user is at; the agent can plan the learning route for the user; the agent can guide the user traveling in the real world; and, the agent can search and access the learning map for the user. These agents communicate and cooperate with each others in the MAA-based environment. The project expects that the agents sense users' physical location automatically, find the suitable learning map out, plan the learning routed, and guide the users learning in the real world.

Keywords: Multi-Agent Architecture, Location-aware, Ubiquitous Learning, Pervasive Learning, Situated Learning

1. Introduction

In the mobile learning environment, the learners could receive the learning materials provided by system according to where they are when learning in a mobile learning environment [5][4]. Mobile learning strategy can actually achieve the goal, that is, learning at anytime and anywhere. Ubiquitous learning becomes an interesting and important issue in informal learning field recently [18], focuses on making learners can do learning with their interest topics transparently and immediately with their various devices whenever and wherever they want.

This paper reveals the project which plans to build a MAA-based ubiquitous learning environment and applies the positioning technologies to design some location-aware applications. For examples, the dynamic grouping system helps users to find a collaborative group when they are doing learning quests; the learning path planner arranges the learning routes for users when they arrive at a learning spot; and, the location-based guidance system uses human readable sentences to guide users traveling from one learning spot to another.

Section 2 introduces the related past research works that the project will use, for examples, situated learning theory, ubiquitous learning researches, MAA, positioning technologies, grouping technologies, spatial relation structures, and the landmark researches. Section 3 describes the main idea and design plan of project's MAA-based platform. In Section 4, we are talking about the location-awareness application, the grouping system. Section 5 focuses on the learning path planner and the guidance message generator, which are location-based applications. Finally, Section 6 makes a conclusion and discusses the possible future visions of this project.

2. Research Backgrounds

In traditional learning environment, the education is proceeding in classroom, which the teachers and learners must get face to face at the same time and in the same place. The learners could only get the learning materials prepared in advance from the teacher. As a result, the learning activities are limited in what teacher arranged and then materials and courses are difficult to be modified immediately according to students' learning status.

E-learning applies computer technologies and internet to assist teachers' teaching and learners' learning [2]. E-learning provides a new learning method to run the education process with e-mail, web-camera, and web-based testing, even if the teacher and learners are not getting together [14]. However, some courses need students learning through observation are not very easy to create by either traditional classroom teaching or web-based learning environment, for examples, the butterfly-watching course and plant-learning in biology domain [5][4][19].

Mobile learning extends the learning from indoor to outdoor, gives learners opportunities to understand the learning materials via touch, observation and feel the learning objects in real environment [13][23]. Furthermore, mobile learning can make learners get or apply what they've learned in real environment [7]. Mobile learning provides a new learning strategy in the e-learning field, however, there is still an unsolved research issue, which is flexible learning issue. The learners' learning activities will be limited in specific learning environment and/or specific domain knowledge arranged in advance.

The learners are not just passive receiving the learning materials from teachers as they doing learning. Students also could learn the concepts, knowledge, skill and ability via interacting with real learning environment [22]. Brown thinks that the concepts and knowledge are situation-based [3], and the learning will be influenced by teaching activity, situation and interactions which called situated learning. The ubiquitous/pervasive learning is leading the research direction then [20].

There are four characteristics in ubiquitous learning environment [11]: (1) **context-aware**, the learners' learning performances and the learning environment information can be known by the ubiquitous learning system; (2) **personalization**, the learning resources learners might need can be provided according to learners' profiles and learning status; (3) **seamless**, learners' learning activities will not be stopped in ubiquitous learning even though they move to another lace; and, (4) **calm**, the learning materials will be delivered to learners automatically to avoid interrupting learners with different devices.

This project uses positioning technologies and multi-agent architecture to reach the four characteristics of ubiquitous learning. With positioning technologies' help, we can know the user's position and his/her surroundings, and the grouping agent can realize other learners' positions and help them gether together; the learning path planner can provide personalized learning route; the location-based guide agent can use human readable message to lead the user traveling from one learning spot to another; and, the multi-agent architecture can offer the user a calm environment via agent communication language, although this project does not consider the teaching material delivery for now.

In order to reach the project goals, we did survey on several important research domains. There are four related domains, including Multi-Agent System (MAS), agent & its communication language, positioning technologies, grouping technologies, spatial relation structures, and the landmark researches.

Java Agent Development Environment – Lightweight Extensible Agent Platform (JADE-LEAP), was chosen to develop FIPA-compliant MAS in mobile devices because JADE has a run-time for J2ME-CLDC (Connected Limited Device Configuration) and CDC (Connected Device Configuration) platforms [12].

The MAA architecture allows great flexibility and scalability in the integration of components. It provides a simple yet extensible and powerful software layer to develop further pervasive learning environments, while simultaneously running multiple stationary and mobile agents on a CLDC/MIDP equipped resource-limited mobile device [1]. JADE-LEAP serves as the agent platform.

Ubiquitous learning can use mobile device as the terminal to access digital contents via the cellular networks or other wireless communication network. It offers a dynamic, anywhere and anytime accessible learning environment for students in education. In cellular communication network, location based service (LBS) is one of its essential components. Because the location of each mobile device relative to the network is maintained within the network [15], mobile learning was born with other exciting characteristics, location awareness while inherited most of the e-learning features. Integrating mobile device's location awareness provides unique and powerful potential, i.e. the location-based services in the online learning environment.

In this project, the location-based service is applied for online optimal grouping. The service groups the individual mobile learners into mobile learning groups based on the identification of their geographic locations and the incorporation of their learning behaviors etc. With this grouping service mobile learners can take the advantage of collaboration learning in conventional education environment. It will enhance the learners' learning in the ubiquitous learning environment.

In general, a location-based service can be defined as triggered and user-requested. Triggered LBS relies on a condition set up in advance that retrieves the position of a given device (e.g. passes across the boundaries, emergency services). In a user-requested, the user is retrieving the position once and uses it on subsequent requests for location-dependent information. This location-based service type involves personal location (i.e. where you are) or services location (i.e. where is the nearest) [6]. The location-based optimal grouping service falls into the first category of LBS as the location information will be automatically retrieved by a client agent on a mobile device according to its pre-set configuration.

In regarding to the location information format and standard, the geographic information system (GIS) industry has developed a set of XML description standard proposals. There are two types of geography-related information - static (rives, mountains. etc) and dynamic (events, moving objects). They can be captured by geography mark-up language (GML), the point-of-interest exchange mark-up language (POIX), the navigation mark-up language (NVML), and the SkiCAL mark-up language for event information [6]. The location-based optimal grouping agents might use a combination of the XML-based formats by using XML namespaces.

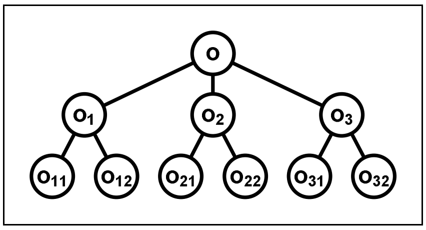

Figure 1 Spatial structure hierarchy

Regarding the guidance message generator in this project, the spatial knowledge is an important research issue. Mohan and Kashyap have proposed an object-oriented model for representing the spatial knowledge in tree form [16]. All the objects in the real world can be represented in hierarchy form as Figure 1 shows. There are two benefits of using object-oriented representation to store the spatial knowledge: (1) it is easy to describe the relations among objects; and, (2) the structure can be changed to various forms simply.

Del has discussed the spatial relationships in geometry and he has classified the relationships into directional relationships and topological relationships [8]. Directional relations include in front of, back of, right, left, east, west, south, and north. Egenhofer and Fransoza have proposed a 9-intersection spatial model [9]. The 9-intersection model involves 29 topological relationships. The 29 topological relationships can be categorized into eight categories, including "DISJOINT", "MEET", "INSIDE", "EQUAL", "CONTAINS", "COVERS", "COVERED BY", and "OVERLAP".

Beside the spatial knowledge structure and relations researches, the landmark research is also necessary for developing the guidance message generator. Landmark is the essential thing to human to find way out, might more important than orientation [10]. There are three basic elements to guide a human being moving in the real world: orientation, actions, and landmarks [21]. Sorrows and Hirtle (1999) have proposed three landmark categories: visual, cognitive, and structure [17]. Every landmark categories have to use different navigation methods.

3. Multi-Agent Architecture

Each learner is running the front-end of a learner agent on his/her own mobile phone or PDA supporting J2ME with the Mobile Information Device Profile (MIDP) 1.0 or greater APIs and Bluetooth JSR-82 or Wi-Fi APIs. A Back-end Mediator in the JADE-LEAP architecture, running on a host with a known, fixed, and visible address, can automatically manage the back-ends of all front-ends active on the learner's device. Figure 2 shows the Multi-Agent Architecture for ubiquitous learning

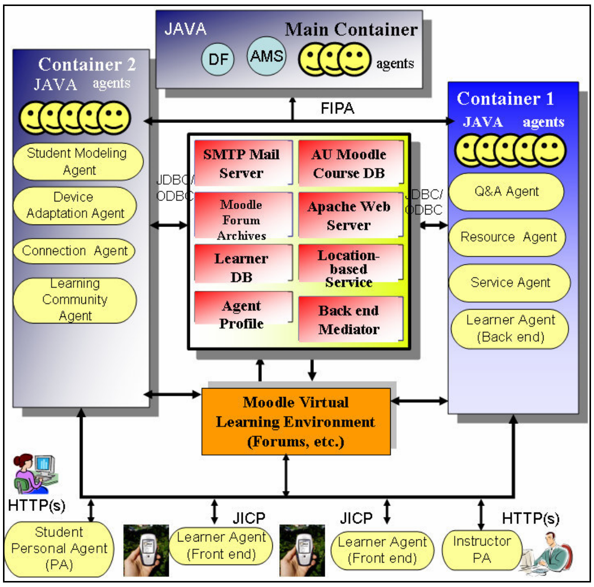

Figure 2 Multi-Agent Architecture for Ubiquitous Learning

4. Location-based Optimal Grouping

The location-based optimal grouping service is to group geographically near by students to together to create ad hoc online learning groups. In this service, the positioning accuracy is not critical. Proposed conceptual system architecture for the grouping service is shown in Figure 3.

For the project, a client agent will be developed as a J2ME application to run on Java enabled mobile device. The client agent's adaptation to other operating environments of mobile devices will be implemented later. The client agent needs to,

- acquire the location information on the mobile device from the cellular network;
- identify if there is GPS coordinate available on the mobile device;
- if the GPS coordinate is available then obtain the GPS coordinates; and

- send the GPS coordinate with the location information from the cellular network to the location server agent

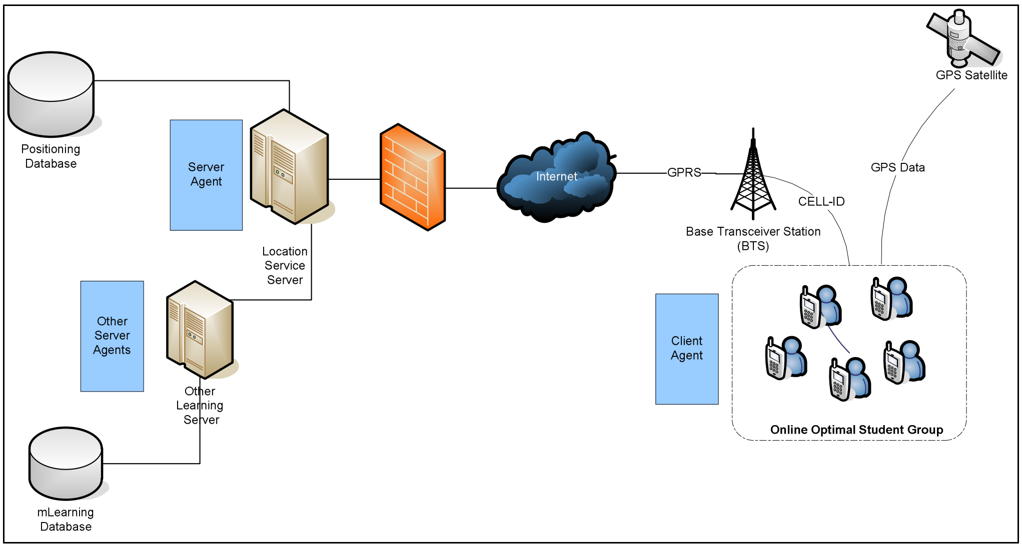

Figure 3 The Conceptual System Architecture

The client agent has to be able to obtain the data from the mobile device as the basic location information for the grouping service. With all the location based data, a simple matching method could be used to group the mobile devices by determining the amount of sharing similar location information. This simple grouping approach could group online mobile students within the radius of 500 – 1500 meters in urban area and 15 km in rural area.

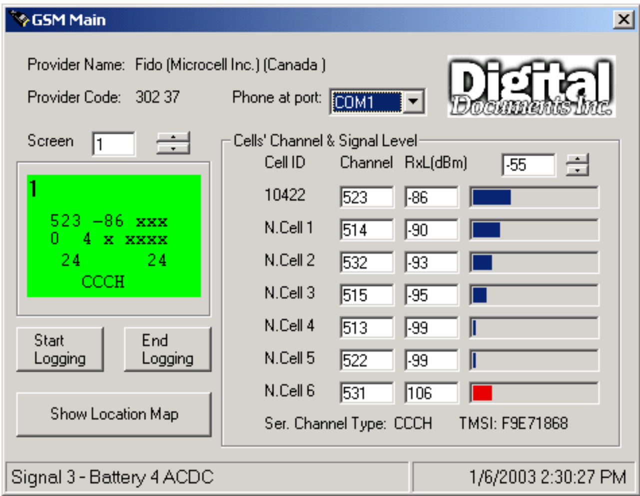

Figure 4 GSM Cellular Network Data

Since GPS embedded mobile devices have become more and more popular, therefore, the client agent has to be able to work with this type of mobile devices. However, the GPS technology also has its own drawbacks. The GPS positioning is not available inside buildings even between tall buildings which restrict the view of the sky, and it also increases battery consumption and data-acquisition time. Therefore, it is very important to sufficiently use the GPS location data to update the cell geographic location information database and to enrich and correct the existing location database, eventually to enhance the over all location accuracy and the grouping performance. The fundamental step of the client agent is to obtain the GPS coordinates from a mobile device. There are various software programs doing this job. The cellular phone manufacture also provides the data communication solutions, such as Nokia's PC Connectivity serial programs as high-level data communication development kits. Figure 4 shows a cellular network data communication software, which works on Nokia GSM phones whose compatible with Nokia FBUS protocol, DAU-9P data cable. This application software was developed by one of authors previously.

5. Learning Planner and Guidance System

This section focuses on the design of the learning path planner and the guidance message generator in the project. First of all, the operation flow of the guidance message is describing and showing in Figure 5. Second, we design a two-phase way to apply the learning path planner into the informal ubiquitous learning, as Figure 6 shows. At last, Figure 7 shows the operational flow design of the guidance message generator in this project.

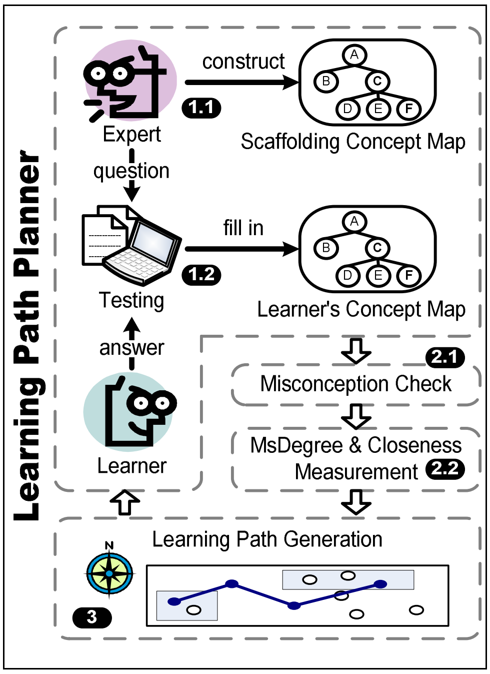

Figure 5 Flow of the learning path planner

Before making the learning path planner works, domain experts have to construct their own concept maps, which are so-called scaffolding concept maps (the step 1.1 and 1.2 in Figure 5). What are the differences between the expert's and the learner's concept maps are easy to check with comparing two concept maps and find out the misconceptions the learner (the step 2.1 in Figure 5). After the misconceptions are found out, the planner uses misconception degree and closeness as criteria to decide the feedback sequence for individual learner (the step 2.2 in Figure 5). With the feedback sequence, the learning path planner is then able to generate the navigation path with consider both the misconceptions and learning objects in the real world (the step 3 in Figure 5).

How to apply the learning path planner to the informal ubiquitous learning? According to the operation flow of the planner, there are two main phases and five steps to learners as Figure 6 shows. In general, the operation flow of learning in the real world is: first, learners have some knowledge background via three ways and take a look at something they are interesting with; then they will move to next learning spot when complete their observations; and, repeat above steps until finish all they want to do. So, Figure 7 shows the operational flow of the location-based guidance message generator.

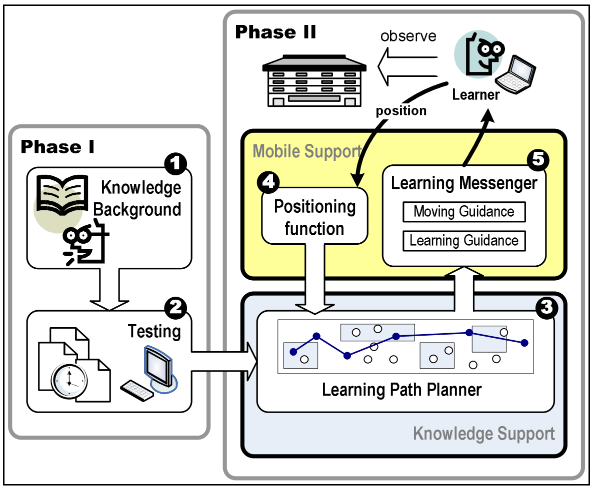

Figure 6 How to apply the learning path planner to the informal ubiquitous learning?

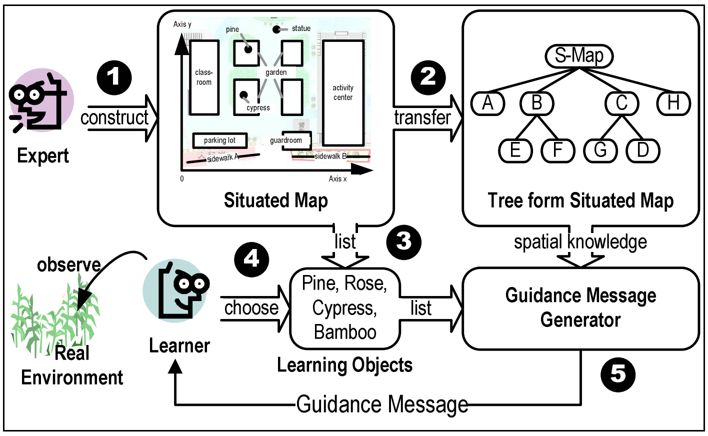

Figure 7 Flow of guidance messages generation

6. Conclusion

This paper reveals a MAA-based location-awareness service project for ubiquitous learning. The project uses multi-agent architecture as the platform and designs different agents with different abilities. The agents can communicate and collaborate with each other via agent communication language.

The project applies the positioning technologies to design several applications for ubiquitous learning, including dynamic grouping, learning path planner, and guidance message generator. The project is still going on, which means, there are more applications might come out in the future and the currently designs of the systems/agents might also get improvement in the future.

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