

# Location-Mediated Coordination of Web Services in Ubiquitous Computing

Akio Sashima, Noriaki Izumi and Koichi Kurumatani  
Cyber Assist Research Center, AIST / CREST, JST  
2-41-6 Aomi, Koto-ku, Tokyo, 135-0064, Japan  
sashima@carc.aist.go.jp, niz@ni.aist.go.jp, k.kurumatani@aist.go.jp

## Abstract

*A fundamental issue of human-centered coordinating services in Ubiquitous Computing is concerned with dynamic service coordination according to users' intentions. How can we coordinate the services to assist the user in receiving a coordinated service to maximize the user's satisfaction in an environment? In order to solve this issue, we have been developing a sort of agent-based coordination framework, called "location-mediated agent coordination," that orchestrates Web Services embedded in the real world and Web Services on the Internet. In this paper, we show a prototype application of the framework, context-aware information assist services in a museum.*

## 1. Introduction

Recently, computing frameworks that concentrate handling real world information and physical objects, such as Ubiquitous computing[7], have been received much interest in both research and application. Although the ubiquitous computing is promising frameworks of the intelligent services like context-aware information assists, they still have many research issues. A fundamental issue is concerned with coordination among services and users' intentions. When users encounter various information services (e.g. navigations, information retrievals, controlling information appliance, etc.) in an environment, how can we coordinate the services to assist a user in receiving a particular service to maximize the user's satisfaction? In other words, how can we dynamically coordinate the physically embedded heterogeneous services to be integrated into a consistent human-centered service according to a user's intention?

In this research, to solve this human-centered coordination issue in Ubiquitous computing, we focus on "Semantic Web agents [1]" that choose proper contents out of numerous contents derived from Web Services on the Internet on behalf of users, coordinate them for the users, and assist the users in accessing the contents.

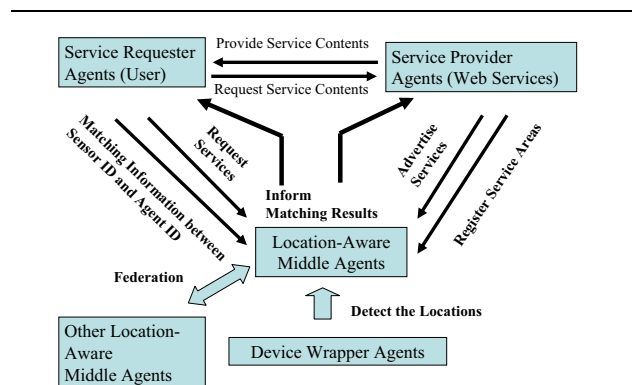


Figure 1. Location-mediated agent coordination

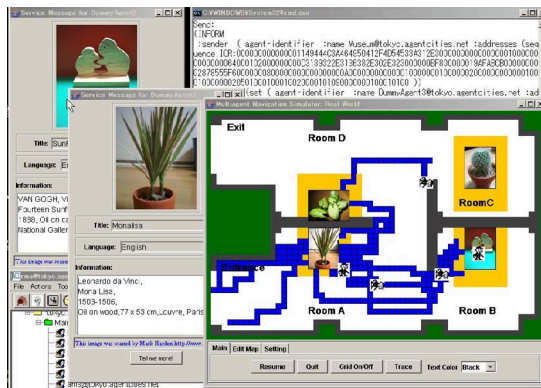
Inspired by this ability of the Semantic Web agents, we have been developing "location-mediated agent coordination", an agent-based coordination framework that orchestrates both the Web services embedded in Ubiquitous computing environments (e.g. sensor devices having Web services interfaces) and Web services on the Internet (e.g. Google Web service API [4]). Although BPEL4WS[2], WSFL [6] etc. are proposed for Web services coordination framework for the business process, the dynamic coordination of the Web services in the context of the ubiquitous computing have not been considered yet.

In this paper, we describe an outline of the Web services coordination framework and a prototype application: context-aware information assist services in a museum.

## 2. Location-mediated agent coordination

Figure 1 shows an outline of the location-mediated agent coordination. It consists of the following types of agents.

**Service provider (Service agent)** the agent wraps a Web service, asks a middle agent to register their capabilities and physical service areas, and provides other agents to the service.



**Figure 2. Monitor system of information assist services in a museum**

**Service requester (Personal agent)** the agent asks a middle agent to register their physical appearance, such as sensor signal ID, and requires service provider agents to perform some service (e.g. Web Services) on behalf of a human user.

**Location-aware middle agent** the agent plays match-maker between Service Providers and Service Requesters by considering their locations, capabilities and requirements; it then initiates their communication. They manage the spatial model of environments and reasoning about spatial relations of objects in the environments.

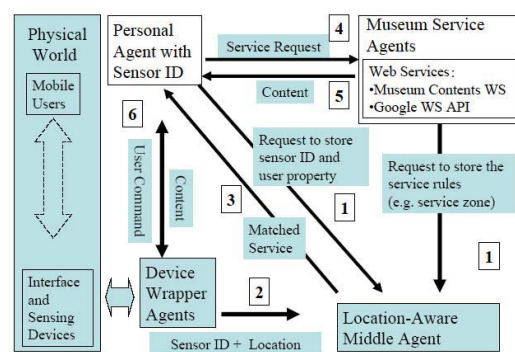
**Device wrapper agent** the agent wraps a sensor device having Web service interfaces; it also provides sensor information to the middle agent.

Although each of agents manages a specific type of information resource, their coordination enable users to access heterogeneous service resources as a seamless service resource.

### 3. Context-aware information assist services in a museum

Based on the above framework, we have implemented context-aware information assist services in a museum. In the service scenario, when a user is located near a painting, the user can receive information about the painting via the user's portable display device.

Figure 2 shows an image of the monitor system of the information assist services. A museum map is visible in a main window in the lower right side of the figure; it has two information windows with a graphic image. In the map, human icons represent current locations of the users. Each zone surrounding a picture represents service zones of the museum service agents. Each line after the users represents



**Figure 3. Agent communication in information assist services in a museum**

users' trajectories. Information windows correspond to the screens of users' portable devices. In this application, the users casually roam around the museum. If a user enters the service zone, an information window pops up in the screen to display the picture information. The information is derived from the matched service resources, Web Services managing museum contents and the Internet search engine: Google Web API. Figure 3 illustrates agent communication for the services. We have implemented the services by JADE[5], a software framework to develop the agent system that conforms to FIPA specifications[3].

### 4. Conclusions

This paper has shown semantic web agents in the context of ubiquitous computing and Web services. The proposed framework opens up a new application area of the semantic web agents, that is, managements of distributed heterogeneous resources of Web services embedded in the real world.

### References

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