Design and Implementation of Multimedia Service Management Agent on Home Networks Environment

Won-Joo Hwang,

Dept. of Information and Communications Engineering, Inje Univ., Korea

Summary
Recently, a demand of adaptive multimedia service, which supports multimedia service migration according to user's location and characteristics of user device, is increased. In this paper, we propose a service migration system, which becomes aware of user device using intelligent agent. And we design and implement the ontology-based intelligent agent, which is aware of the context in its environment. Moreover, we implement a context reasoning system using location information.
Key words:
Ontology, Intelligent Agent, Location-Awareness, Multimedia Service.

1. Introduction

Recently, in ubiquitous computing environment, it is an important issue for context-awareness, which is aware of context and reasons appropriate service according to the context. Particularly, it is expected that home network adopt ubiquitous computing first of all and provides variable context-aware services. Among context-aware services, location-aware service is one of the key context-aware computing[1].

In digital home network, it is expected that multimedia service such as the watching of television programs or movies is major service. This multimedia service can be used with context-aware service[2]. Especially, an example of this service is to offer location-aware automated service for television channel seamlessly when the user roams from living room to another. To realize this service, adaptive multimedia service migration is required, which provides a service that is adequate for computing power of user device. Adaptive multimedia service migration using location-aware service decides a device for service according to user's location, and provides a multimedia service that is suitable for selected device.

A number of works in multimedia service migration have motivated our work. However, existing works considers multimedia service migration among homogeneous devices only, that do not consider heterogeneous devices. In this paper, we propose intelligent service using a agent, which offers adaptive multimedia service migration among heterogeneous devices. Moreover, we propose context reasoning system, which can provide a service according to complex context information simply.

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To show proposed system, we design and implement a prototype model that provides negotiation and message exchange among agents to support adaptive multimedia service migration. Agents uses rule-based JESS[3,4], and multiple agents use JADE[5] for communication among them. Their design follows FIPA[6] standard. Our system provides location-aware automated multimedia service that is suitable for user device without direct intervention of user. The remainder of the paper is organized as follows. In section 2, we discuss key ideas and problems of existing works. Following that, in section 3, we design the ontology-based agent and a model for adaptive multimedia service migration using the agent. In section 4, we show the test results using implemented prototype application. Finally, we conclude this paper and refer further works.

2. Related Works

In this section, we discuss a model or system for multimedia service migration in ubiquitous environment as well as fundamentals for ontology and the agent.

2.1 Ontology

Ontology expresses a set that defines components in specified domain, that is, it expresses conceptualizations precisely[7]. An example of components is context information and that of conceptualizations is reasoned rules. Conceptualizations is useful for development of knowledge-based system because it can express knowledges in knowledge base definitely[8-16].
In home networking environment, all attributes of context and context itself are expressed in specific domain and moreover, rules for event-aware change of the attributes are required, therefore we can use ontology to define all context in home networking environment.

2.2 Agents

Agents are aware of context of itself, reason context using that information, acts of itself and communicate with other agents. And agents react to user action or context, and they have reasoning and learning ability as well as proactivity for knowledge. Moreover, they perform autonomously action that user needs and have social ability for cooperation among multiple agents.

2.3 Limitations of related works

A number of model or systems for multimedia service migration in ubiquitous computing environment have proposed. ICEBERG(Internet-based core for Cellular networks Beyond the third Generation) project[17,18] of UC Berkeley is able to provide variable data service adaptively for user's preference or needs without user location or range of connected network. Ubiquitous video of MCCB(Multimedia Computing, Communications and Broadcasting)[19] supports user mobility, so it serves video streaming continuously despite of device, time and location. However, both of them cannot support communication among heterogeneous devices.

For commercial system services, there are TiVoToGo[20] application of TiVo and SlingBox application of Sling Media: TiVoToGo application is for real-time CD making of television broadcasting, and SlingBox application is for streaming service of television broadcasting through Internet. Both of them support multimedia service migration, however, they have following limitations: in case of TiVoToGo, user can use devices with CD-rom only as well as makes CD of himself, and in case of SlingBox, it can not support intelligent service.

3 Design of Agent System

Service mobility is classified into service selection, service migration, and service adaptation. Service selection is divided into two methods as follows: First method is user active method that user selects a service himself, and second method is user passive method that provides a service according to user context by pattern recognition of for user action. Service migration is to provide a migration from currently offered service to a service for other device, and service adaptation is to provide a service that is suitable for the device when attribute of previously used device and that of migrated device is different. Our agent system offers adaptive multimedia service migration among heterogeneous devices according to user location using ontology-based agent, which is for middleware that satisfy user active service selection, service migration, and service adaptation.

3.1 Ontology

Our agent system follows FIPA standard (Fig. 1). To communicate with other agent in same platform or remote platform, it is registered for at least one platform, and has to belong to a container that includes AMS(Agent Management Service), DF(Directory Facilitator), and ACC(Agent Communication Channel).

Especially, when platform is executed, the container that is registered first is called 'main container'. Main container provides functions as follows for communication among agents.

- AMS(Agent Management Service) : includes naming service that provide unique name for each agent in platform, and manages life cycle of agents using creation and elimination of a agent.
- DF(Directory Facilitator) : offers yellow page service to search a agent for specific service.
- ACC(Agent Communication Channel) : provides smooth communication without intervention among agents. Message exchange among agents is the type of ACL(Agent Communication Language) message that is defined in FIPA and it is transmitted among agents in same or different platform. Performative slot in the message contains the type of the message (for example, INFORM, CFP(Call for Proposal), PROPOSE, ACCEPT, and REFUSE), and Context slot in it contains information (for example, context information) that is needed.

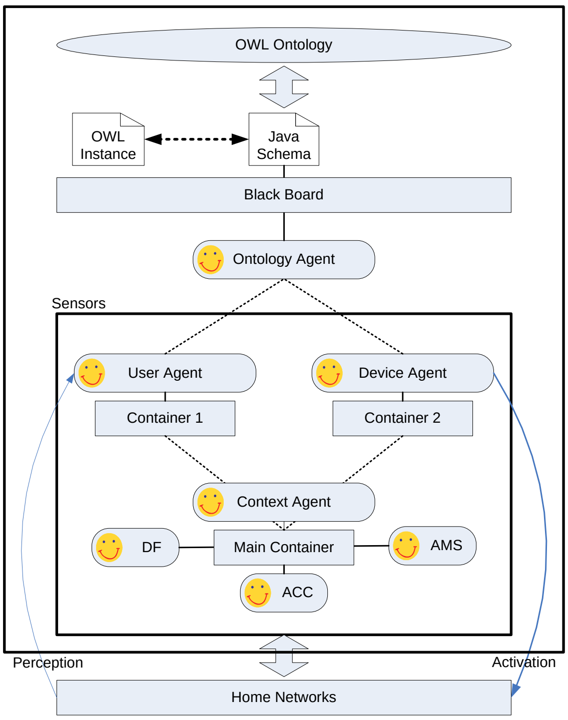

Fig. 1. Architecture of agent system

3.2 Architecture of the Agent

When a agent receives a ACL message from other agent, it saves as knowledge base using ontology modeling. Reasoning engine induces appropriate to the message using saved knowledge base and rules, and then forwards the message to other agent.

- Knowledge base : ontology is storeroom for messages modeled by ontology, and uses memory of the device, which a agent is working.
- Rule : induces a context-aware service and defines a services that is offered according to variable context condition.
- Reasoning engine : derives appropriate service from knowledge base with the rule.

3.3 Message processing of a Agent

Message processing rule is as follows in Fig. 2.

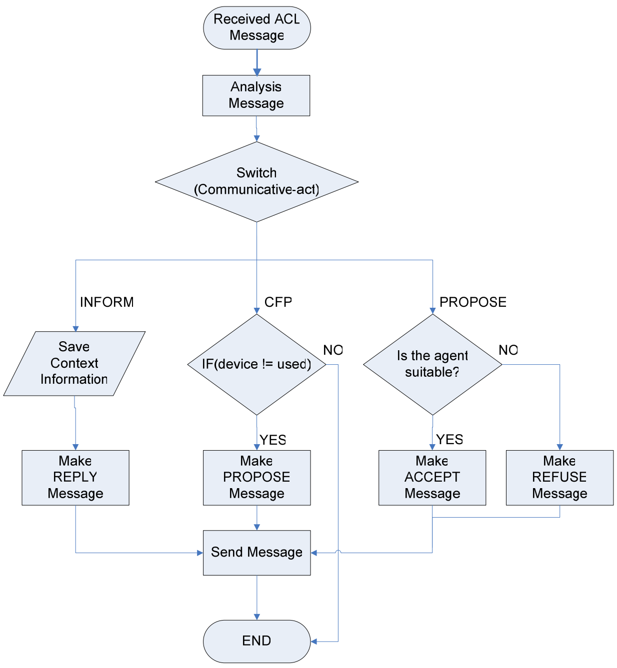

Fig. 2. Message process flow

The agent starts execution of the rule after ACL message is received. It checks whether received message is correct or not, and then analyze information in Performative slot in the message. Appropriate rule is performed according to information in Performative slot, and the rule is completed after message for the rule is created and transmitted. If Perfomative slot indicates 'INFORM', the agent saves context information in ACL message and sender/receiver agent in knowledge base, and then transmits acknowledgement message. If Perfomative slot indicates 'CFP', a device agent that receives the message evaluates whether it can be in use or not, and transmits PROPOSE message to request for a grant of use in case that it can be in use. If Perfomative slot indicates 'PROPOSE', it evaluates sending device agent whether the agent is suitable for currently serviced multimedia service or not: If it is suitable, the agent transmits a ACCEPT message, otherwise, the agent transmits a REFUSE message. All agents have all rule, that is, each agent contains partial rules only for the delegated system.

Messages are saved in knowledge base using ontology modeling. From this ontology, the agent can keep knowledge for message information, which is saved in knowledge base using ontology modeling. For example, Fig. 3 shows the result when a control agent receives a INFORM message.

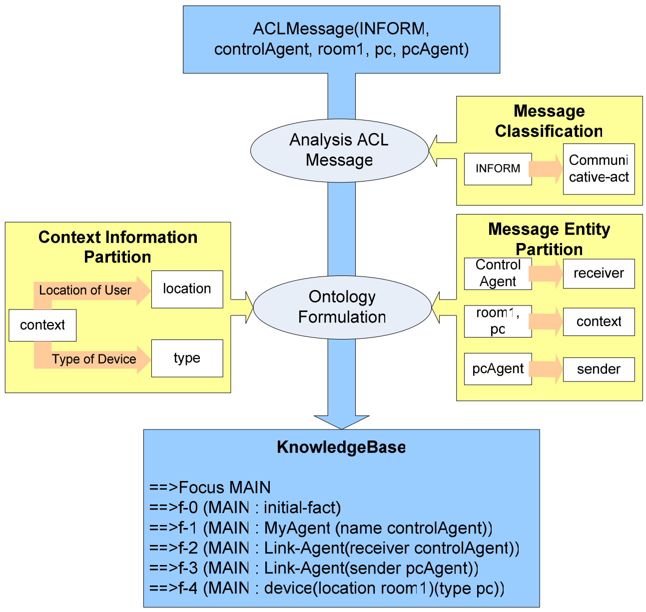

Fig. 3. Example of the message saved in knowledge base

User in watching the television roams from living room to room1, where contains a personal computer. Location-aware system informs change of user location using a ACL message. This message is set to contain change information in the message, and it includes the name of sender agent and receiver agent. And context information in the message are that user location is room1, and pc exists in room1.

On receiving the message "ACLMessage(INFORM, controlAgent, room1, pc, pcAgent)" from other agent, receiving agent analyze the message: it recognizes the type of the message from Performative slot and checks 'communicative-act'. After this, the message is modeled as ontology by ontologic formulation. The agent classifies message components into receiver, context and sender, and then it divides location and type of device using context information. Device information is from context information, that is, in a example of Fig. 3, device location is room1, and device type is pc. This ontological-modeled information is saved as knowledge in knowledge base storeroom. Stored information consists of name and context information for agents connected by ACL message, as well as initialization data and own name of an agent.

3.4 Components of the Agent System

Proposed agent system organizes as follows. First of all, main container that offers AMS, DF, and ACC services are registered to a platform. The system consists of location-aware agent, control agent, and device agent: All agents is included in a container for each room.

- Location-aware agent : location-aware agent calculates current user location using location information from location-aware system, and then transmits to control agent using the result.
- Control agent : control agent in home server is aware of current user location using ALG message from location-aware agent. And it negotiates with each agent that exists in same space with user, selects a device, and then offers multimedia service that is suitable for selected device.
- Device agent : device agent controls basic functions of a device, negotiates with control agent, and performs adaptive multimedia migration service. Device information is included in Context slot in ACL message and transferred to control agent. Device agent includes information appliances, and it is classified into PDA agent, television agent, pc agent and audio agent.

3.5 Message exchange among agents and system configuration

Message exchange and configuration of middleware system is showed in Fig. 4.
First of all, we show configuration of middleware system. Agent platform that organizes home network consists of multiple container, which is installed in each space such as room, living room, and rest room. A container that exists in same space with home server becomes main container, provides AMS, DF, and ACC service, and moreover includes control agent that controls other agents. A container for each room has built-in device agent to control devices in the room.

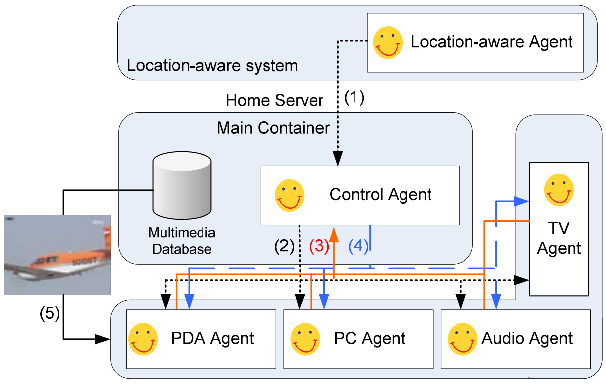

Fig. 4. ACL message flow

Next, we explain message flow among agents.
(1) When user location is changed, location-aware agent transmits INFORM message to control agent to inform that user is moved. (2) Control agent transmits CFP message to negotiate with each device agent in space that user moves. (3) Each device agent with available resources transfers PROPOSE message to control agent, where this message contains available multimedia service type in Context slot of ACL message by considering computing power of a device. (4) Control agent transmits ACCEPT message if a device among devices that transfer PROPOSE message can support a service that is similar or more to current multimedia service served, otherwise it transmits REFUSE message. (5) Device agent receiving ACCEPT message, for example in Fig. 4, PDA agent acquires appropriate multimedia service from multimedia database of home server, and then it can offer multimedia service from previous space to currently moved space continuously to user.
Multimedia database provides adaptive transcoding for multimedia stream according to device type: When a device is powerful, it provides optimum streaming service. Otherwise it provides differentiated streaming service according to computing power of a device.

4 Prototype Implementation of Agent System

4.1 Prototype environment

Using prototyping, we validate message exchange between device agent of a device in space that user moves and control agent to confirm adaptive multimedia service migration. We implement prototype application using JESS version 6.1p8q and JADE version 3.2. JESS is list structure and is same as LIPS. This is called by JAVA, and it provides ontology-based rule and knowledge base storeroom. JADE is a library for communication among multiple agents following FIPA standard: JADE provides AMS, DF, and ACC service, and provides applications to search registered agents in dummy agent, message sniffering, and DF agent.

4.2 Empirical Scenario

As showed in Fig. 5, television is in living room, pc is in room1, PDA is in room2, and audio device in room3.

① User roams from living room to room2 while watching the television. PDA is in room2, multimedia service is served continuously using PDA by negotiation with PDA agent and control agent. At this time, home server applies transcoding for multimedia stream to be suitable for PDA because PDA can accept multimedia stream of television originally.

② User roams from room2 to room1. Multimedia service that PDA is offering continues using pc in room1. Then multimedia stream using PDA is transcoded to high-quality multimedia stream continuously, because pc can accept multimedia service served using PDA fully.

③ User roams from room1 to living room. As television is in living room, multimedia service is offered using television as same quality with multimedia stream served using pc.

④ User roams from living room to room3. As audio device is in room3, multimedia stream using television is offered using audio device continuously. At this time, a audio service continues among from multimedia database of home server by negotiation between audio agent and control agent.

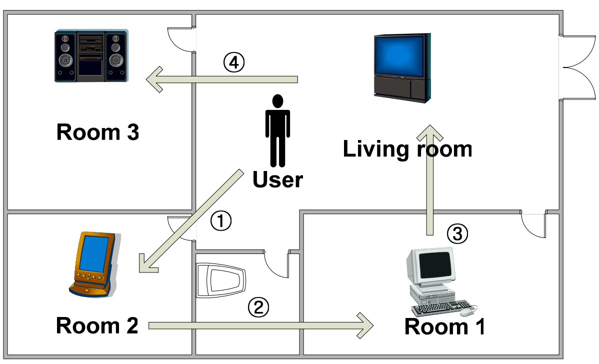

Fig. 5. An example of scenario

4.3 Implemented results

We implement one control agent and four device agent (television agent, PDA agent, pc agent, and audio agent) using JESS. To explore ACL messages among agents, we use message sniffering agent from JADE. Location-aware agent is implemented using dummy agent, which transmits user location to control agents using Context slot of ACL message, and then it confirms behavior of each agent.
Fig. 6 shows message flow during each agent is working. A agent in living room that home server exists belongs to main container, a agent in room1 belongs to container-1, a agent in room2 belongs to container-2, and a agent in room3 belongs to container-3. 'da0' agent is location-aware agent, which transmits changed location information (INFORM) to control agent. Control agent negotiates with device agent in a container of each room (sending/receiving of CFP, PROPOSE, and INFORM), and then selected device receives appropriate multimedia stream from multimedia database in home server.

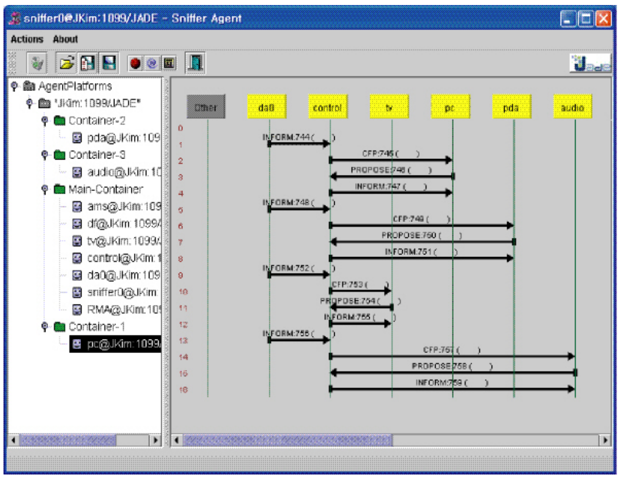

Fig. 6. Implemented Agent System Snapshot

5 Conclusion

Till now, multimedia service migration supports multimedia service migration homogeneous devices only, and that system can not provide location-aware services adaptively. In case of simple context that is limited to location, the service can be implemented using general object-oriented language only. However, this method is not enough to implement the service for complex context.
To provide multimedia service intelligently, we propose and implement middleware system to support adaptive

multimedia service migration using ontology-based agents. Our system uses agents for intelligent service, and offers multimedia service migration among heterogeneous devices. Agents adopts ontology for context-aware services, and then it can induces more variable and complex services using context-aware reasoning engine. In this paper, we implement prototype system using JESS and JADE following to FIPA standard, and evaluate ACL message exchange among agents to provide location-aware and context-aware multimedia services.

For further works, considering home networking or ubiquitous computing environment, it is needed for service reasoning for more complex context, which includes other context information as well as location. Moreover, it is necessary for agents of the system to provide knowledge base and rules using this learning as well as to learn user action.

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Won-Joo Hwang received the B.S. and M.S. degrees in Computer Engineering from Pusan National University, Korea in 1998 and 2000, respectively and Ph.D. degree in Information Systems Engineering from Osaka University, Japan, in 2002.

He is an Assistance Professor of Information and Communications Engineering at Inje University, Korea. He conducts research in the area of home networks, wireless sensor networks and optimization of communication systems.