

# IMAV: An Intelligent Multi-Agent Model Based on Cloud Computing for Resource Virtualization

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**Abstract.** As the availability of social media contents generated from users increases dramatically, the task of providing high-quality media contents in social media sites that need user contributions is emerging as an important issue in IT field. However, users have not obtained high quality SNS services in mobile environment because of the mobile data explosion and the limitation of hand device performance. To overcome these limitations in cloud computing supporting social media services, we have proposed an intelligent multi-agent model based on virtualization rules for resource virtualization (IMAV) to automatically allocate service resources suitable for mobile devices. Our model infers user's demand by analyzing and learning user context information. In addition, IMAV allocates service resources according to use types so that users are able to utilize reliable service resources.

**Keywords:** Cloud Computing, Multi-Agent, Virtualization, Social Media and Social Network Service

## 1. Introduction

Social media means media for social interaction, using highly accessible and scalable communication techniques [1]. In recent years, Social Network Service (SNS) based on social media contents has obtained a lot of interests from numerous users. In fact, 75% of Internet surfers used social media contents in the second quarter of 2008 by joining social networks and reading blogs according to Forrester Research [2]. Thus, SNS have played a significant role in revitalizing communication and social activities of participants [3][4]. In particular, SNS based on mobile and hand devices such as Facebook and Twitter is used a lot by users because of the advancement of Internet and communication techniques as well as the proliferation of mobile network infrastructure.

Social media services in cloud computing environment allocate service resources according to only user grades and limitations of service resource. This simplified approach to resource allocation has two problems. The first one is that administrators have to constantly monitor service resources in order to allocate available resources to users. Secondly, it causes the increase of server load or network load.

In this paper, to solve these problems, we suggest an Intelligent Multi-Agent Model for Resource Virtualization (IMAV) based on virtualization rules [5] that automatically allocates service resources suitable for mobile devices in cloud computing environment supporting social media services. The proposed model is able to monitor service resources in real time and learn serviced context information that is fundamental data for resource virtualization. IMAV learning user behaviour infers user on-demand and readjusts service resources for virtualization according to the type of usage so that users can use service resources with high reliability. This paper is structured as follows. In section 2, we introduce virtualization of cloud computing and multi-agent. The following section explains the structure of IMAV. In the last section, we conclude our research with future work.

## 2. Related Work

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## 2.1. Mobile Virtualization in Cloud Computing

By abstracting physical computing resources to logical resources, virtualization in cloud computing is able to provide flexibility in the use of computing resources [6]. The most useful and significant technique in cloud computing fields, especially mobile cloud, is virtualization. In particular, mobile virtualization in cloud computing environment requires technologies that support various services and applications including real time characteristics. In addition, it has to guarantee reliability in order to satisfy diverse needs that users want. The purpose of mobile virtualization is to provide suitable services to users by using resources such as processor, memory, storage and applications offered from server due to the fact that computing power related to physical resources of mobile devices is inadequate.

## 2.2. Multi-agent for context-aware

Multi-agent is being used actively in the fields correlated with the development of automation systems. Multi-agent has a knowledge base for learning users behaviour as well as the function to infer purposes according to services.

Multi-agent has four features: autonomy, intelligence, mobility and social ability. Multi-agent conducts message passing or shared memory techniques using ACL (Agent Communication Language) and transmits messages and protocol using QML (Knowledge Query and Manipulation Language).

Recently, many researchers have proposed multi-agent models combined with mobile computing environments using knowledge base that contains context information including social data and user's location information [7][8].

Figure 1 shows the agent platform of FIPA (The Foundation for Intelligent Physical Agents) [9]. FIPA is a platform for developing and setting computer software standards for heterogeneous and interacting agents and agent-based systems.

## 3. Design of Intelligent Multi-Agent Model for Resource Virtualization

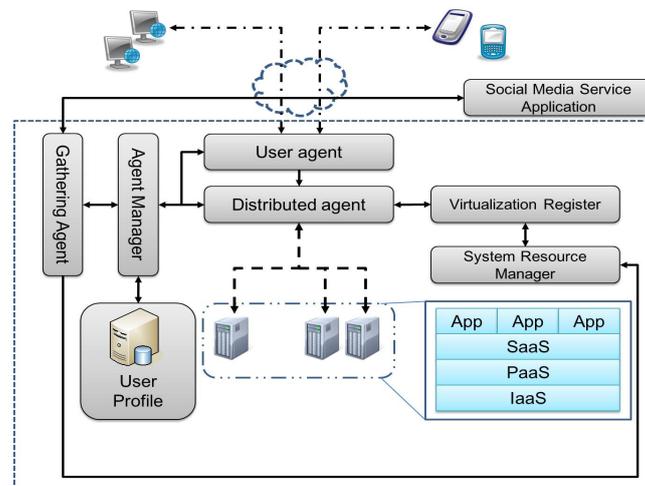


Fig. 1: IMAV (Intelligent Multi-Agent Model for Resource Virtualization)

IMAV (Intelligence Multi-Agent for Resource Virtualization) is a multi-agent model for social media service based on intelligence virtualization rules that configure service applications and resources suitable for users' situation. IMAV manages resources of cloud computing in real time and readjusts resources according to user behavior. Figure 1 represents the basic structure of IMAV.

In order to propose our model, we assume that service environment is based on the system that provides mobile cloud service. Another assumption is that real-time social media services are provided by mobile devices. To solve the problem with recording user situation in real time in mobile devices as well as the mechanical problem with processing big data of users, agents except for mobile agents are managed at the server. Mobile agents record and manage location information of users as well as log files including personal information, service history and request signal for accessing the cloud service system. In other words, when users execute cloud applications, the mobile agent checks service information in the log files. These log files provide the basic information with respect to recommendation for configuring new services.

## **4. Structure of IMAV**

### **4.1. User Agent**

The main role of user agent is to receive information provided by mobile agent. It calculates correlation for virtualization of social media service applications appropriate for user situation. The calculated information becomes the data for learning user actions as well as information for effective virtualization.

The user agent analyzes service types and access types of services. It is possible to grasp access type via user location and data transfer rate. Service types can be seized through applications of social media service or requested information by executing applications. The provided information is integrated into user context.

The integrated information with system state information offered from agent manager is applied to intelligence virtualization rules. In order to adequately allocate system resources according to intelligence virtualization rules, the results are sent to distributed agent. User agent also provides scope of services to users. That is to say, user agent creates users' context that integrates devices information connected by users and user connection information. The purpose of access, user behavior and service access patterns can be analyzed through the created context data. As a result, it is possible for our system to virtualize service resources according to the purpose of service access and service usage patterns

### **4.2. User Agent**

Distributed agent can allocate social cloud service resource by considering correlation between users and services. Furthermore distributed agent supports intelligent virtualization of service resources by constantly learning services requested by users and state information. Distributed agent uses MLP (Multi-Layer Perceptron) and SVM (Support vector machine) to virtualize services resources of system. It includes virtualization module that verifies and processes information with respect to service resources.

The information used by distributed agent to virtualize service resources consists of user context information transmitted by user agent and system context information transmitted by system resource manager. The user context information contains coefficient of determination that decides service to be provided to users. If physical resources of system are exceptional, distributed agent recommends replaceable systems and resources. To support and maintain reliable services, lists of service resources concentrated on specific users with relocation rank are notified to system administrators. Relocation of system resources can expand physical resources and perform clustering through system context information. It is possible to adequately perform virtualization by transmitting configured system resources per user to virtualization module. Virtualization information including virtual ID is registered in virtualization register. Distributed agent sends user states and monitoring information with respect to virtualization depending to time line to agent managers.

### **4.3. Gathering Agent**

The role of gathering agent is to collect service information and social media data necessary for systems. Service information is gathered at the content sites that provide social media service as well as service data related to applications registered in cloud system. The scope of gathering data is restricted within social sites such as UCC, Blog & Micro-Blog, SNS and News. Gathering agent applies Trend Watching (Media tablet) as searching engine of gathering agent. In addition, we also apply MapReduce based on Hadoop to process large amount of data in parallel.

### **4.4. Agent Manager**

The main role of agent manager is to manage creation, registration, event and deletion of each agent. In addition, agent manager offers knowledge-base to each agent, monitoring the whole agents according to types of usage of social service resources. It includes the ability to control activity of each agent. The function of monitoring is to record event state and value between agents as well as to provide fault data of system to administrators.

Agent manager obtains only relational information from user log information and context information from user agent. This information decides the event of creation of distributed agent and service items to be provided to users. The event of creation, activity and deletion of distributed agent are regularly generated by

agent manager according to the system time line. The structure of control signal consists of agents' ID, control information, MAC, TAG and Trap.

Control signal of user agent is made up of SIP, RequestID and Trap. SIP is an index including the occurrence information of user agent. RequestID is the request information for the management of context information and for services. The role of trap is to control the action state of user agent. Trap consists of the creation and deletion of agents and signals that distinguish types of events.

Control signal of distributed agent is composed of UA (User Agent) index, RequestID and TRAP. UA index includes virtualization ID provided to users and information that matches it. RequestID is offered by user agent. Finally, Trap contains the action state value of distributed agent as well as state value regarding the information event received the system.

#### 4.5. Virtualization Register

Virtualization register registers and manages virtualization information of social resources that are distributed by distributed agent. In addition, the utilization rate of service resources and the state of system resources are managed and provided to administrators. It regularly analyses log information of virtualization, supporting efficient management of system resources.

Virtualization Registrants synchronized with distributed agent manage log data from the creation of virtualization to its destruction. Log data of virtualization register consists of virtualization resource ID allocated to users, lists of service resource, priority information and correlation weight. The correlation weight can decide the priority of system resources provided to users when system is virtualized. The utilization rate ( ) is calculated through the following formula. UC is user context. SR is the system resources configured by UC.

$$r_s = \frac{\sum_{i=1}^n (SR_i \times UC_i)}{\sum_{i=1}^m MSE(UC_j)}$$

The updated correlation weight is used as learning weight of multi-agent. Therefore, multi-agent can predict the way of virtualization in advance when service resources are reallocated. It also can provide reconfigured service resources to users. In addition, the reconfigured services and the whole users are recorded in system service history. Multi-agent is able to set service levels by comparing system service history with service resources provided to other users.

#### 4.6. System Resource Manager

The information recorded in the lists of virtualization register is controlled by system resource manager. System resource manager have a function that controls the management of resources provided to users according to the correlation information in the lists of virtualization resister so that administrators can obtain distributed state monitored by system resource manager and can directly or indirectly control system resources.

The structure of system resource manager is composed of system usage rate analysis domain, system context management domain, system level analysis domain, system resource classification domain, system management information DB. It is able to monitor and manage physical and logical resources of the cloud computing system. The system usage rate analysis domain uses MAXMIN algorithm for its analysis. The following formula is for system usage rate.

$$v_s = \min(\max \left[ \frac{(\sum_{i=1}^n SC(r)_Z^Y \times r_s \times n_Y)}{\sum_{i=1}^n SC^Y} \right])$$

System context management domain makes fundamental data to analyze system levels. The formed context information is data that reconfigures system state depending on the user situation. System level analysis domain sets the level or rank of each resources offered to users. System level is the result to analyze amounts of specific resources provided to users among the whole resources. That is to say, by analyzing the availability of system resources, system level analysis domain decides system grades according to whether

resources have high or low availability. The determined level which is provided to users supports to decide additional decision making of system resources. System management information DB is managed by timeline. Furthermore, it provides regular reports and is monitored by administrators.

## 5. Conclusion

The purpose of this paper is to propose intelligent multi-agent model for resource virtualization (IMAV) that automatically allocates service resources suitable for mobile devices in cloud computing environment supporting social media services. The proposed model is able to recommend efficient virtualization by analyzing user context and the state of system. In addition, our model analyzes social media service resource in real time, learning user context for virtualization. Cloud systems can prevent resource bottlenecks and enhance resource availability. In addition, users are able to use reliable services because multi-agent model provides appropriate services for users depending on user situation.

In the future work, we will build our model into SaaS and PaaS of cloud computing. Furthermore, we are going to focus on developing upgraded model for recommendation service that is able to search large amount of data in real-time in mobile environment.

## 6. Acknowledgements

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