Chapter 17

Intelligent Clouds: By Means of Using Multi-Agent Systems Environments

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ABSTRACT

This chapter describes the similarity of intelligent clouds and multi-agent systems. It also explains why intelligent clouds are useful and important. It gives detailed descriptions on how to incorporate intelligent abilities such as learning, negotiation, collaboration, and communication to cloud systems by using IAs. It also details the application of intelligent clouds in e-learning.

1. INTRODUCTION

Cloud Computing System (CCS) is emerging as a new distributed system that works towards providing reliable, customized and Quality of Service guaranteed dynamic computing environments for end-users (Weiss, 2007). It is primarily based on service-level agreements that provide external users with requested services. The success of achieving this goal in propert time (efficiency) and/or to obtain higher quality results (effectiveness) in these dynamic and distributed environments depends on implementing an appropriate collaboration model between service providers in the cloud. Moreover, this collaboration mechanism should include intelligent abilities such as learning capabilities for the use of previously acquired experiences (from situations that occurred in the past) in order to improve newly required collaborations.

In the same order of ideas, Web Service (WS) is one of the most important technologies based on the Service Oriented Architecture (SOA) concepts, which is extensively used generally at present for the design of development models of Internet systems, particularly cloud systems. According to the W3C, “a Web service is a software system designed to support interoperable machine-to-machine interaction over a network” which means that WS can be considered an option to be used for nodes to communicate in a distributed system.
On the other hand, Intelligent Agent (IA) systems have already been the subject of intense research over the past years. They observe the environment, maintain an internal representation of the world, make decisions, perform tasks, learn, etc. This was pointed out by Muller (Muller, 1996) with the phrase “agents are autonomous or semi-autonomous hardware or software systems that perform tasks in complex, dynamically changing environments.” Similarly to what happens in WS-based systems, in Multi Agent Systems (MAS) the IAs cooperate with each other to accomplish their particular objectives or the main system’s objectives and common goal.

Therefore, WS-based systems and MAS share a motivation in trying to find the information systems to be flexible and adaptable. That is why it is natural to consider a conceptual relation among these technologies in the following common themes (Dickinson & Wooldridge, 2005):

- No conceptual distinction: there is no conceptual difference between a WS and an IA because both are active building blocks in a loosely-coupled architecture.
- Bi-directional integration: IAs and WSs can interoperate with each other by initiating communications.
- IA invokes WS: WSs are invoked by agents as component behaviors, while the IA level is represented by autonomy and intent.

Aiming to define appropriate collaboration mechanisms for enabling effective service collaboration in cloud systems and based on the same motivational issues that WS and IA share it is possible to talk about the development of intelligent clouds. Moreover, it is possible to talk about intelligent clouds based on MAS.

This chapter focuses on explaining the way in which cloud systems can be defined and implemented by using MAS, later becoming intelligent clouds. Section 2 of the chapter consists of a brief introduction of MASs and a motivational explanation of what intelligent clouds are and why they are useful and important. Different issues associated with the state of the art related with the subject of intelligent clouds in general and IA in cloud systems in particular are presented in Section 3. Section 4 contains details in how to incorporate intelligent abilities such as learning, negotiation, collaboration and communication to cloud systems by using IAs. Some details of the model called AMBAR-C (Awareness-based learning Model for distributive collaborative environment applied in Cloud environments) (Paletta & Herrero, 2010b) are also included in this section. Additionally, this chapter includes in Section 5 two case studies related with e-learning and using AMBAR-C. The specific topic in these two case studies is the Unified Modeling Language (UML) for the first one and the design of packages of combined trips for the second one. Finally, Section 6 has the corresponding conclusions of this chapter.

2. MULTI-AGENT SYSTEMS AND INTELLIGENT CLOUDS

This section presents a brief introduction of CCSs and MASs. After that the section shows how cloud systems can be improved by using MAS, an important technology related with agent theory.

2.1 Cloud Computing and Web Services

As this is a book related with Cloud Computing, we can surely find many corresponding definitions for it. Let me add some more definitions given by different authors, including (the last one) a definition given by the National Institute of Standards and Technology (NIST):

- “Cloud is a parallel and distributed computing system consisting of a collection of inter-connected and virtualized computers that are dynamically provisioned and pre-