Chapter 13
Hands-On Learning of Cloud Computing

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ABSTRACT

Professionals with deep knowledge about cloud computing are in high demand in the industry these days. This knowledge should comprehend concepts related to models, technologies, techniques, frameworks, interfaces and tools needed to design, develop, deploy, integrate and manage cloud-based architectures. Universities are trying to offer different undergraduate and graduate courses teaching these contents at different levels, aimed at students' development of strong practical skills to deal with the new paradigm in real-world environments. In this chapter, a hands-on learning approach is proposed to achieve this goal, considering an essential element of this approach - the use of cloud simulators. A survey of open source cloud simulators is provided, presenting an exhaustive comparison of the existing alternatives and determining an appropriate set of criteria to decide the best simulator for each learning objective. Furthermore, two examples of hands-on contents are presented using these simulators.

INTRODUCTION

In recent years, educators have faced the challenge of training their students for a world in which the cloud paradigm is increasingly widespread. The cloud model is not a revolution but an evolution which implies advancement in technology, management and business (Buyya, 2011). While the involved technologies are not completely new, there is a strong need of academic education related to their integration and use in the new environment.

Future, professionals need skills and capacities in their curricula which allow them to deploy systems and to develop applications on a cloud, to design and to program algorithms taking advantage of the paradigm, to make decisions regarding the applicability of cloud computing in different scenarios or to evaluate the suitability of certain models and providers, to mention only some examples.

Many university courses about cloud computing have appeared last years, but most of them focus on fundamental concepts that help the students in understanding the new paradigm but may not provide them with practical skills which prepare them to face the typical challenges of their future positions in the industry and to succeed in a rap-

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idly evolving field. In other words, considering the usual levels of mastery, the current courses achieve the level of familiarity but not the levels of usage or assessment.

Hands-on learning, i.e. learning by doing, has therefore become a very interesting approach to teach cloud computing in STEM (Science, Technology, Engineering and Mathematics) university programs. Although there are a plethora of definitions of hands-on learning, it can be assumed that a hands-on approach requires students to become active participants in their learning process instead of passive agents who listen to lectures or attend to seminars. Laboratory exercises and activities are traditional methods of giving students hands-on experiences.

But, how should a cloud laboratory be designed? How can students have hands-on experiences with the different service models and service deployments? Ideally, they should be able to work with private, hybrid, and public clouds at infrastructure, platform and software levels. The problem is that such complete laboratories represent a too important investment for many universities. The TCO (Total Cost of Ownership) of an ideal cloud computing laboratory includes the total cost of acquisition but also its operating costs, and it makes this type of practical teaching unviable in many cases.

This chapter presents different alternatives to overcome these difficulties, focusing specifically on open source cloud computing simulators, making the proposal of this chapter relevant to a variety of institutions. The most widespread cloud simulators are presented, including a thorough comparison of their features. And a set of general criteria is provided for choosing the most appropriate tool depending on the learning objectives for each course.

The rest of this chapter is organized as follows. Section 2 discusses the usual contents related to cloud computing in the academic curricula and summarizes the approaches of some interesting courses about cloud concepts in different universities. Section 3 presents current alternatives to propose hands-on experiences to students learning about cloud computing. Section 4 analyzes the most important open source cloud simulation tools currently available, while Section 5 compares all these solutions, proposes a set of decision criteria and evaluates the current limitations of these tools. Section 6 gives two examples of hands-on learning contents designed using these simulators. And finally Section 7 summarizes the most important lines for future work and conclusions.

BACKGROUND AND CONTEXT

One of the most important initiatives to establish international curricular guidelines for undergraduate programs in computing is the IEEE/ACM Computer Science Curricula. In its last version (Computer Science Curricula, 2013), this document states that, at a broad level, the expected characteristics of a computer science graduate should include awareness of the broad applicability of computing, understanding platforms ranging from embedded micro-sensors to distributed clouds.

The Computer Science (CS) curricula build a curricular structure through a tiered set of core topics, where Tier1 topics are considered essential for all CS programs, Tier 2 and Elective topics can be covered or not. The uncovered topics are usually included in the advanced courses of graduate and master programs. Considering the proposed body of knowledge, Cloud Computing is included explicitly (as Topic 1, Topic 2 and Elective contents) in the following knowledge areas:

- Information Assurance and Security.
- Networking and Communication.
- Parallel and Distributed Computing.
- Social Issues and Professional Practice.

In addition, the areas of System Fundamentals and Operating Systems include the most important