Chapter 11
Clouds of Quantum Machines

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ABSTRACT

This chapter continues previous studies in service-oriented architectures (SOA) on clouds of quantum computers, considering quantum entanglement and quantum teleportation of states of services as resources to deploy high production in IT environments and to guide studies on the implementation of intelligent behavior in server clouds. A way to preserve quantum entanglement is presented. Also, the chapter proposes a metalanguage to organize the topology of orchestration of services. This topology is embedded in the states of services and takes part in the information to be teleported from server to server. The creation of entangled states of information with the aid of the concept of progenitor is reviewed with some details.

INTRODUCTION

This work is a continuation of studies started at 2014. Since then, I improved some ideas about theoretical quantum machines interacting in cloud operation, as well as enhancements on the concept of quantum entanglement itself. Some recent works have been added to the original references, although the classic treatises remain in effect, given the slowness with which the subject progresses.

As we know, one of the great challenges in quantum computing is how to preserve quantum entanglement, since microphysical systems are extremely sensitive to external disturbances. It is one of my aims to show a way to minimize this problem. Moreover, a quantum orchestration metalanguage is introduced into a first schematic representation of the operation of a quantum cloud aiming to optimize further constructions of quantum algorithms. While it is essential that the reader becomes familiar with quantum mechanics, some parts of my first work are reproduced here in order to reduce the effort to understand the subject.

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BACKGROUND: SERVICES AND CLOUDS IN A CONTEMPORARY APPROACH

Services are cybernetic replicas of human practices, being evoked by well-established environmental motivations. In turn, SOA is an architecture that integrates in a standard manner several service units, each of them sending their features as sets of tasks over the network. Only service interfaces are exposed to consumers as exported methods (Nakamura *et al.*, 2004). Therefore, when services are requested, SOA seeks the best responses to those environmental motivations according to the internal logic of each service. In particular, this architecture is now strongly linked to the theme of "enterprise application integration" (EAI) in contexts where legacy applications already established are performed on different platforms.

The literature on SOA comprises several milestone contributions as the works of Nakamura et al. (2004), Erl (2005), Anderson & Ciruli (2006), Natis (2007), Sha (2007) and, markedly, Frenken *et al.* (2008) about device-level service deployment. On this latter subject, it is noteworthy that, in the process of architectural development, devices which access legacy applications are created and interact using a protocol defined by the system. In turn, the system returns the aggregated information from the various legacy applications, preferably without any additional code. The architectural development also takes care of the service interface, prescribing the information required to access the competences of that. It is worth remembering that the existence of interfaces and descriptions of accessibility is *sine qua non* for the implementation of SOA. More recent works show the state-of-art in services orchestration (MEF Forum, 2015; Lemos *et al*., 2015).

In SOA projects, the so-called Enterprise Service Bus (ESB) is thought to be the main component of the infrastructure layer. It is the mediator between provider and service consumers, and its responsibility is to provide integration and interoperability between different systems. Embedded in this responsibility is also the mission of cleaning the databases by a service that tracks and recognizes all of the systems which shall be linked. Connectors are created in the databases feeding a new datawarehouse completely normalized, such that any updates made on the original basis are automatically computed and reflected in the standardized repository.

As a logical consequence of the advent of the Internet and the concept of SOA, we can say that cloud computing is a cybernetic implementation by which all IT resources (hardware, software, networking, storage, etc.) are provided as services on-demand to consumers via Internet, remaining managed to ensure fast delivery, high availability, security and quality. In short, cloud computing is a model of computation by which those IT resources are randomly dispersed in the network, being offered as services paid as they are consumed. Although this subject promotes a lot of controversy about information security, everything suggests that the process of agglomeration of servers in clouds is irreversible.

Cloud computing and SOA have contributed significantly with one another and should remain so for a long time. In the words of David Linthicum, "SOA can be used as a key technology-enabling approach to leverage cloud computing" (Linthicum, 2009). Thus, the use of SOA can be galvanized by the cloud structure, since it allows on-demand delivery beyond the limitations imposed by the firewall constraints of the enterprise environment. A cloud computing system, whether formed by quantum machines and evolving to the point of hosting thousands or millions of servers, leads to a probabilistic approach of the states of each component as well as the states of information. As in quantum mechanics, where the physical position of a particle is random-dispersed until the intervention of an observer, the information is "nowhere", and, at the same time, "everywhere" until an objective request is done. This probabilistic approach of the cyber states of the cloud and their components is consistent with a vector representation in Hilbert space, just as the latter is used in quantum mechanics. With respect to the theoretical founda-