Chapter 12
CLEVER:
A Cloud Middleware Beyond the Federation

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ABSTRACT
This chapter describes both the design and architecture of the CLEVER cloud middleware, pointing out the possibilities it offers towards enlarging the concept of federation in more directions. CLEVER is able to accomplish such an enlargement enabling the interaction among whatever type of electronic device connected to Internet, thus offering the opportunity of implementing the Internet of Things. Together with this type of perspective, CLEVER aims to “aggregate” heterogeneous computing infrastructure by putting together Cloud and Grid, as an example. The chapter starts with a description of the cloud projects related to CLEVER, followed by a discussion on the middleware components that mainly focuses on the innovative features they have, in particular the communication mechanisms adopted. The second part of the chapter presents a real use case that exploits the CLEVER features that allow easy creation of federated clouds’ infrastructures that can be also based on integration with existing Grids; it is demonstrated thanks to the “oneshot” CLEVER deploying mechanism. It is possible to scale dynamically the cloud resources by taking advantage of the existing Grid infrastructures, and minimizing the changes needed at the involved management middleware.

INTRODUCTION
Cloud Computing is considered a successful technology that covers distributed computation infrastructures, able to strongly leverage the concept of Virtualization of physical resources for actuating a useful economy of scale. The Future Internet of services aims to enable the deployment and delivery of complex and large scale services to consumers with agreements upon quality of service (QoS) (Rochwerger et al., 2011).

Nowadays, in the Cloud scenarios, one can notice strong attention paid to the interoperability
issues that need to be addressed for enabling cooperation among Clouds. This concept falls into a wide context of Cloud Federation and, in the near future, the dynamic setup of federated clouds will appear much more compelling.

Looking at these scenarios, this work describes a middleware able to build up an interoperable, heterogeneous cloud environment to accomplish resource federation: CLEVER (Tusa, Paone, Villari & Puliafito, 2010) has been designed and developed for managing virtual appliances (typically Virtual Machines). It is able to setup cross cooperating Cloud infrastructures, also using different VMMs technology. It allows for creating an abstraction layer during the management of virtual resources, even in clouds spread out on different administration domains. In particular, the middleware being introduced, presents several features enabling useful and easy management of private/hybrid clouds that, as will be pointed out in the last part of the chapter, can be also deployed on existing Grid infrastructures.

After a description of the current CLEVER architecture, in this Chapter, we will consider the opportunity of managing Virtualization Infrastructures exploiting Grid resources. Grid is identified as the progenitor of Cloud Computing technology and it had a wide consensus in using it for non commercial applications. Due to the intrinsic nature of Grid and its incapability to attract enterprises needs, during the time, it has merely been confined in scenarios even less challenging.

The father of Grid Computing, Ian Foster, in (Foster, Zhao, Raicu & Lu, 2008) has tried to figure out what the main differences are between Cloud and Grid. Foster describes Cloud Computing as a large-scale distributed computing paradigm that is driven by economies of scale, in which a pool of abstracted, virtualized, and dynamically-scalable, managed computing power, storage, platforms, and services are delivered on demand to external customers over the Internet. Although the two paradigms are quite similar, Cloud Computing is acquiring a predominant position. Figure 1 (Google Trends: Cloud Computing vs Grid Computing. http://www.google.com/trends, 2011) highlights how Cloud Computing is widely gaining the interest against Grid computing.

Right now, the new perspective is coming out, consists of merging together the two computing paradigms, that is GRID and Cloud. Such a situation is happening because many worldwide