Chapter 11
Volunteer Clouds:
From Volunteer Computing to Interconnected Infrastructures

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ABSTRACT
Cloud Computing (CC) offers simple and cost effective outsourcing in dynamic service environments and allows the construction of service-based applications extensible with the latest achievements of diverse research areas. CC is built using dedicated and reliable resources and provides uniform seemingly unlimited capacities. Volunteer Computing (VC) on the other hand uses volatile, heterogeneous and unreliable resources. This chapter per the authors makes an attempt starting from a definition for Cloud Computing to identify the required steps and formulate a definition for what can be considered as the next evolutionary stage for Volunteer Computing: Volunteer Clouds (VCl). There are many idiosyncrasies of VC to overcome (e.g., volatility, heterogeneity, reliability, responsiveness, scalability, etc.). Heterogeneity exists in VC at different levels. The vision of CC promises to provide a homogeneous environment. The goal of this chapter per the authors is to identify methods and propose solutions that tackle the heterogeneities and thus, make a step towards Volunteer Clouds.

INTRODUCTION
Compute capacity is either used or wasted. Unused capacity cannot be stored for later use. The term cycle scavenging refers to (distributed) systems that utilize these idle computing cycles of connected computers. Desktop Grids (DGs) cycle-scavenge institutional desktop computers to solve compute intensive problems. On the other hand Volunteer Computing utilizes the idle resources (i.e., CPU cycles and storage) of private donated computers. These are typically home desktop computers behind firewalls and routers that can be considered even more heterogeneous and volatile. Cloud Computing offers simple and cost...
effective outsourcing in dynamic service environments and allows the construction of service-based applications extensible with the latest achievements of diverse research areas, such as Grid Computing, Service-oriented computing, business processes and virtualization. CC is built using dedicated and reliable resources and provides uniform seemingly unlimited capacities. Heterogeneity exists in VC at different levels. The vision of CC promises to provide a homogeneous environment. The goal of this chapter per the authors is to identify methods and propose solutions that tackle the heterogeneities and thus, make a step towards Volunteer Clouds.

This chapter is intended to systematize, extend and streamline the previous papers of the author regarding Volunteer Computing and Volunteer Clouds (Marosi, Kovács, & Kacsuk, 2012; Marosi, Balaton & Kacsuk, 2009; Marosi, Gombás, Balaton & Kacsuk, 2008; Marosi, Kacsuk, Fedak, & Lodygensky, 2010; Marosi, Gombás, Balaton & Kiss, 2008; Balaton et al. 2007). The chapter is divided into four main sections with related work discussed at each section. The first section defines scenarios and methods for interconnecting VC. The second section details a previously defined scenario: hierarchy of desktop grids in institutes and universities. The third section discusses Volunteer Clouds. Finally the last section concludes the chapter.

**INTERCONNECTING VOLUNTEER COMPUTING**

The term federation is used as a specific method for interconnecting distributed computing systems. For a generic interconnection the Inter-* phrase can be used. For example for the generic interconnection of clouds the term Inter-Cloud was created and formulated by the Global Inter-Cloud Technology Forum (Global Inter-cloud Technology Forum, 2010). This definition can be adapted for the notion of interconnected volunteer computing systems:

**Definition 1:** Inter-Volunteer Computing is a volunteer computing model that, for purpose of guaranteeing service quality (e.g., performance), allows on-demand transfer of workload through the collaboration of volunteer computing systems based on the coordination of each users requirements for service quality and the use of standard interfaces.

Based on this definition Figure 1 shows the different possible interconnected architectures for volunteer computing adapted from cloud construct architectures defined in (Grozev & Buyya, 2012) separated into two groups: In multi-constructs the different volunteer computing systems are accessed in a centralized manner which can be either a multi-access service (see a. in Figure 1) where users can access multiple VCSs through a single service or a meta-middleware library (see b. in Figure 1) that users can use to develop their own brokers to access multiple infrastructures. In contrast federations allow the infrastructures to collaborate with each other. This can be achieved either by using a central component (see c. in Figure 1) to facilitate workload distribution or by directly in generally using some peer-to-peer manner (see d. in Figure 1). While multi-constructs can be established by third parties using APIs or tools provided by the different VCSs, federations are mainly volunteer formations that require the agreement between the two or more parties. Basically a federation is established when a set of providers interconnect their infrastructures to share resources among each other (Rochwerger et al., 2009):