An Architecture for a Fully Decentralized Peer-to-Peer Collaborative Computing Platform

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We present an architecture for a fully decentralized peer-to-peer collaborative computing platform, offering services similar to Cloud Service Provider's Platform-as-a-Service (PaaS) model, using volunteered resources rather than dedicated resources. This thesis is motivated by three research questions: (1) Is it possible to build a peer-to-peer collaborative system using a fully decentralized infrastructure relying only on volunteered resources?, (2) How can light virtualization be used to mitigate the complexity inherent to the volunteered resources?, and (3) What are the minimal requirements for a computing platform similar to the PaaS cloud computing platform? Previous research on the *volunteer cloud computing* paradigm, focused on providing various service models and even full-fledged volunteer cloud computing infrastructures. Whereas previous literature on *peer-to-peer collaborative systems* expressed the requirements inherent to the peer-to-peer resource collaboration problem. Bridging these two fields of research, we evaluate two major projects offering a volunteer cloud computing infrastructure, *Cloud@Home* and *Peer-to-Peer Cloud System*, using the requirements identified for peer-to-peer collaborative systems. This thesis shifts the perspective from peer-to-peer collaborative systems, to their use as the underlying foundation of volunteer cloud computing infrastructures.

The architecture proposed is composed of three layers: the *Network layer*, the *Virtual layer*, and the *Application layer*. We propose to implement the *Network layer* using two novel abstractions: the *Ring*, for the public peer-to-peer networking primitive, and the *Fellowship(s)*, for the private application networking primitive. We also propose to use *light virtualization* technologies, or containers, to provide a uniform abstraction of the contributing resources and to isolate the host environment from the contributed environment. Then, we propose a minimal API specification for this computing platform, which is also applicable to PaaS computing platforms.

We showcase the architecture with a proof of concept, a distributed web calculator, and by presenting a more complex application for *Multi-Document Text Summarization using Genetic Algorithm*. Both examples demonstrate how intuitive it is to develop an application with this computing platform using an event-driven programming model, but it also demonstrate how minimally intrusive it is to re-factor existing applications.

The findings of this thesis corroborate the hypothesis that peer-to-peer collaborative systems can be used as a basis for developing volunteer cloud computing infrastructures. We outline the implications of using light virtualization as an integral virtualization primitive in public distributed computing platform. Finally, this thesis lays out a starting point for most volunteer cloud computing infrastructure development effort, because it circumscribes the essential requirements and presents solutions to mitigate the complexities inherent to this paradigm.