Beyond The Cloud, How Should Next Generation Utility Computing Infrastructures Be Designed?

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1 Context

The success of Cloud Computing has driven the advent of Utility Computing. However Cloud Computing is a victim of its own success: In order to answer the ever increasing demand for computing resources, Cloud Computing providers must build data centers (DCs) of ever-increasing size. Besides facing the well-known issues of large-scale platforms management, these new DCs have to deal with energy considerations that limit the number of physical resources that one location can host. As a consequence, several proposals suggest building next generation DCs in strategic locations close to the polar circle. However, this approach is far from solving all issues. In addition to requiring the construction and the deployment of a complete network infrastructure to reach each DC, it exacerbates the inherent limitations of the Cloud Computing model:

- The externalization of private applications/data often faces legal issues that restrain companies from outsourcing them on external infrastructures, especially when located in other countries.
- The overhead implied by the unavoidable use of the Internet to reach distant platforms is wasteful and costly in several situations: Deploying a broadcasting service of local events or an online service to order pizza at the edge of the polar circle leads to important overheads since it can be assumed that a vast majority of the users are located in the neighborhood of the event/the pizzeria.
- The connectivity to the application/data cannot be insured by centralized dedicated centers, especially if they are located in a similar geographical zone. The only way to ensure disaster recovery is to leverage distinct sites[1].

Although hybrid or federated Cloud solutions [1] that aim at extending the available resource delivered by one Cloud with another one can partially tackle the two former points, the latter one requires a disruptive change in the way of managing UC resources. Deploying a broadcasting service of local events or an online service to order pizza at the edge of the polar circle leads to important overheads in terms of energy footprint, network exchanges as well as latency since it can be assumed that a vast majority of the users are located in the neighborhood of the event/the pizzeria. According to some projections of a recent IEEE report [2], the network traffic continues to double roughly each year. Bringing the IT services closer to the end-users will become soon crucial to limit the energy impact of these exchanges and to

[1] "Amazon outages – lessons learned", http://gigaom.com/cloud/amazon-outages-lessons-learned/ (valid on Oct 2013, the 15th)

save the bandwidth of some links. Similarly, this notion of locality is also critical for the adoption of the UC model by applications that should deal with a large amount of data as getting them in and out from actual UC infrastructures may significantly impact the global performance [3]. The concept of micro data centers at the edge of the backbone [4] may be seen as the complementary solution to hybrid platforms in order to reduce the overhead of network exchanges. However, the number of such micro data centers will stay limited and the question of how federating a large number of such facilities is still not solved.

2 Chapter Proposal

In this chapter, we propose to introduce a new generation of UC platforms that can be seen as an extension of the concept of micro datacenters in somehow: instead of building and deploying dedicated facilities, we claim that next UC platforms should be tightly coupled with any facilities available through the Internet, starting from the cores routers of the backbone, the different network access points and any small and medium-size computing infrastructures that may be provisioned by Internet Service Providers (ISPs), governments and academic institutions. From the physical point of view, network backbones provide appropriate infrastructures, that is, reliable and efficient enough to operate UC resources spread across the different point of presences. In a perfect model, UC resources may directly take advantage of computation cycles available on network servers, i.e. the one in charge of routing packets. However, leveraging network resources to make external computations may lead to important security concerns. Hence, we propose to extend each network hub with a number of servers dedicated to host VMs. As we can expect that the distribution between network traffics and UC demands would be proportional, larger network hubs will host more UC resources than the smaller ones. Moreover by deploying UC services on relevant point of presences, a LUC infrastructure will be able to natively confine network exchanges to a minimal scope, minimizing both the energy footprint of the network as well as the latency impact. From the software point of view, the main challenge is to design a complete distributed system in charge of turning a complex and diverse network of resources into a collection of abstracted computing facilities that is both reliable and easy to operate.

Although it involves radical changes in the way physical and virtual resources are managed, locating computing and data on facilities close to the end-users is the only way to deliver highly efficient and sustainable UC services.

The chapter will describe how such a LUC infrastructure can be delivered through advanced system and P2P mechanisms. After outlining the key objectives that should drive the design of these mechanisms, we will present the premises of what could be a LUC Operating System, allowing end-users to launch virtualized environments (VEs), i.e. a set of interconnected VMs, throughout a distributed infrastructure as simply as they are used to launch processes on a local machine, i.e. without the burden of dealing with resources availability or location.

By designing and implementing the LUC OS, ISPs as well as academic and private institutions in charge of operating a network backbone will be able to build an extreme-scale LUC infrastructure with a limited additional cost. Instead of redeploying a complete installation, they will be able to leverage IT resources and specific devices such as computer room air conditioning units, inverters or redundant power supplies that are already present on each hub of their backbone.

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