Sustainability in Cloud Computing Operation

A Postdoctoral Research Work

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Abstract

Cloud services are provided through data centers facilities which are distributed around the world. The size and quantity of data centers are continuously raising as cloud services become vital in today's business. From environment point of view, this expansion raises some environmental concerns which are exactly caused by the energy consumption of data centers. This consumption also escalates the operational cost. Hence, the need for energy management algorithms/methods to address this situation has recently become among the hot research topics. Generally, these algorithms address two specific issues which are *(a) high energy consumption* which provokes CO2 emission from the energy production process and increases operational cost; and *(b)* the use of *non-renewable energy* such as fossil fuel which emits directly GHG. Subsequently, a holistic greenery can only be achieved when such algorithms are implemented effectively in all the levels of cloud infrastructure (component such as sever, set of severs (data center), set of data centers (cloud system) and set of cloud systems (intercloud)). Unfortunately, most of the current energy management algorithms focus only on a particular level in the cloud infrastructure.

In this work, we investigate the sustainability/greenery problem in cloud computing operation and present a new green cloud computing operation framework.

In the first case, we model cloud computing technology into layers to visualize its components and their interaction from energy consumption context. We then identify the causes of energy concerns in each layer and pinpoint the sustainability requirements that should be met to address the energy concerns. We model the green cloud computing operation domain from the layered cloud model, sustainability requirements, and green methods. Particularly, we identify the relationship between these items and how they can evolve with the future change on could technology. Afterwards, we classify the green methods in cloud operation according to the green cloud operation domain model and present the current green methods based on that. Finally, we highlight the challenges of the current efforts in meeting the sustainability requirements and set the future research direction of this domain.

While in the second case, we introduce the concept of green-as-service to support both cloud providers and users to promote greenery in cloud transactions and operations. The service

provides a cost-effective and specialized on-demand monitoring, analysis, and continuous feeds for energy use and savings in all the levels which can be exploited by both providers and consumers to meet energy targets. We describe a decentralized architecture model for implementing the GaaS and we discuss its constituent components. The architecture leverages on SOA and publish-subscribe model to provide an effective solution for wider adoption of the vision and to render an inherently scalable solution. The service has the promise to provide transparency in the way energy and long-term sustainability are linked to the business objectives along with its cost and revenues.