

# Green Cloud Computing: Greedy Algorithms for Virtual Machines Migration and Consolidation to Optimize Energy Consumption in a Data Center

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*Abstract*— Cloud Computing provides services on the Internet or intranet. There are three types of services in cloud computing: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). In cloud computing, customers do not need to have their own dedicated resources; cloud providers provide services they need on the Internet or intranet. Therefore customers only pay for services and they do not spend for hardware, software, and communication resources. In cloud computing, customers and providers negotiate and agree on an acceptable level of quality of service; and after that, utilizing resources, scaling-up or scaling-down resources, and generally managing resources is one of the most important tasks of cloud computing providers to satisfy customers. When there are more requests for services, adding extra resources is the simplest way to keep the quality of service. But this solution is in contrast to energy usage optimization in data centers. Energy is consumed in a data center by servers, storage devices, communication and network devices, and overhead equipments (like cooling and lighting). Studies show that servers consume about 30 percent of total energy consumed in a data center; so reducing number of servers in data centers not only affects on energy consumption directly, but also affects on overall energy consumption because of reducing overhead equipments utilized in data center. There are a lot of improvements in hardware technologies caused less energy consumption by hardware, but it is not possible to ignore the role of software in improving resource utilization and energy consumption. There are different software architectures used in cloud computing. Some of them provide a layer which is responsible for managing resources to optimize energy consumption. Different algorithms are designed and implemented in this layer and each one has some advantages and some disadvantages. This paper, first summarizes various ways of resource usage optimization, then focuses on algorithms used in energy-aware layer of architecture, and finally introduces some greedy algorithms based on different criteria to study allocating resources to virtual machines and applications.

*Keywords* — data center, energy consumption, greedy algorithm, green cloud computing, resource management.