ENERGY EFFICIENCY OF CLOUD COMPUTING[§]
ENERGETSKA EFIKASNOST „RAČUNARSTVA U OBLACIMA“

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Abstract

The cloud computing model is based on the delivery of computing as a service, whereby storage, software, and information are provided to computers and other devices as a commodity over the Internet. The benefits of cloud computing – reduced costs, increased storage, and better flexibility – have motivated many companies in recent years to move their IT operations to the cloud. This paper considers the potential impact of cloud computing on energy savings.

Keywords: cloud computing, energy efficiency, data centers

1.INTRODUCTION

Cloud computing has received a growing amount of attention in recent years due to its promising computing service delivery model that requires a limited amount of resources on the customer's side. Cloud computing offers economic incentives to companies because they can reduce IT spending and benefit from more flexibility and scalability by using cloud computing. An overall financial benefit is also potentially increased by significant savings in the energy budget of a company.

Benefits of cloud computing have much to do with the economies-of-scale that cloud computing providers can achieve. Instead of having in-house computing resources for each company, one cloud computing provider by sharing its resources delivers services to multiple companies. Due to this multitenancy concept, computing resources can be exploited much more efficiently compared to in-house computing resources. More diverse remote users in different places allow for computing loads to spread over the day, thus allowing for increased equipment utilization. Typical in-house data centers rarely exceed a utilization rate of 20% (meaning that 80% of their capacity is being wasted), whereas cloud facilities for major providers are more in the 30-40% range.

Cloud installations use virtualization and other techniques to separate the software from the characteristics of physical servers. Using this approach it is often possible to optimize servers and reduce certain energy costly features. Cloud installations also have a substantial advantage

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by having departments devoted to efficiency. Technology changes so rapidly that it is hard for people not devoted to efficiency to keep up as well as those that are.

In summary, cloud computing is rapidly expanding as an alternative to conventional in-house computing because cloud computing has significant efficiency and cost advantages. Moreover, the large economic advantages (driven by the energy advantages) will over time translate into more and more pressure for companies to adopt cloud services.

2. WHAT IS CLOUD COMPUTING?

Most people are already interacting with various types of cloud computing services. If you are using Gmail and Facebook already, then you have had some experience with cloud computing. For example, if you have an email account with the web-based email service Gmail, instead of running an email program on your computer, you log in to your email account remotely. The software and storage for your account does not exist on your computer – it's on the email service provider's computer cloud.

The broad scope of cloud computing is all about where the computing resources reside, who manages them and how you access and pay for them. Cloud computing is a term that denotes hosted online services. These services are accessed via the Internet, which is metaphorically referred to as a “cloud”. The graphical user interface is usually provided by the client’s own web browser.

Traditionally, each company would have its own dedicated *data centers* with their own servers, software applications and development platforms. These have to be paid for, managed and maintained internally. There are high capital expenditures associated with purchasing the hardware and software, and it can be time intensive updating and maintaining these systems. Also these data centers are often underutilized as they must have the capacity to cope with the highest levels of processing needs, and this may only happen once a month or once a year.

Some large companies have adopted a *private cloud* approach, which means that they have consolidated all their disparate servers and applications into one company wide system which is maintained behind their firewall and can be accessed across their intranet i.e. they are sharing their resources between the different offices and business units. This means that they can make better, more efficient use of their resources because they are being shared by more people. It also means that their systems are uniform across the company.

However, the colloquial term cloud computing usually refers to *public clouds*, whereby companies buy necessary services from specialist cloud computing providers. Instead of owning and managing their own data centers, companies access the services they bought from anywhere via the Internet. Customer relationship management systems of a company, for example, may be run by one cloud computing provider and the information is stored in the provider’s data centers, while the company’s email system may be run by another cloud computing provider. These services can be provisioned remotely, quickly and in an on-demand, self provisioned manner and the company pays only for what it needs and uses.

The colloquial term cloud computing refers to the public cloud approach. Various factors have contributed to more and more widespread use of cloud computing, including the increased availability of broadband Internet, improved technologies such as virtualization and new models to deliver web-based services. The cloud computing provider bussines model is based on supplying infrastructure consisting of large pools of high-performance computing resources and high-capacity storage devices that are shared among the services offered by the provider [4]. Customers subscribing to the services have their data hosted by the provider, and have computing resources allocated on demand from the pool as required. The cloud computing provider's offering may also extend to the software applications required by customers. To be successful, the cloud computing model also requires a high-speed network to provide connection between customers and the cloud computing provider's infrastructure.

Main characteristics of cloud computing are the following [1]:

- Multitenancy – computing resources are shared between different customers
- Rented service delivery model – customers pay for the service instead of buying software licenses and hardware
- On-demand usage/flexibility – cloud services can be used almost instantly and can easily be scaled up and down
- External data storage – a customers' data is stored externally at the location of the cloud computing provider

The cloud computing service model is a sound business model from both provider's and customer's perspectives. The cloud computing providers invest in the necessary infrastructure and management, and in return receive a regular income stream from the investment by means of service subscriptions [6]. Since at any one time, substantial numbers of customers are inactive, the provider reaps the benefits of the economies of scale and can charge lower subscription fees. The customers in turn see convenience benefits from having data and services available from any location, from having data backups centrally managed, from the availability of increased capacity when needed, and from usage-based charging [2], [3].

3. ENERGY SAVINGS BY CLOUD COMPUTING

Many studies have found that cloud computing is a more energy-efficient choice in general compared to running in-house IT operations. The studies confirm that among other benefits, cloud computing delivers multiple efficiencies and economies of scale, which contribute to the reduction of energy consumption per unit of work.
One report [7] released by Pike Research anticipates that much of the work done today in in-house data centers will be outsourced to the cloud by 2020. This will lead to a 38% reduction in worldwide data center energy expenditures by 2020, thanks to a reduction of 31% in data centers electricity consumption (from 201.8 terawatt hours (TWh) in 2010 down to 139.8 TWh in 2020).
Another report [5], released by research firm Verdantix, estimates that cloud computing could enable companies to save $12.3 billion off their energy bills. That translates into carbon emission savings of 85.7 million metric tons per year by 2020.

The findings from a study [8], commissioned by Microsoft and conducted by Accenture and WSP Environment & Energy, demonstrate that businesses that choose to run business

applications in the cloud can help reduce energy consumption and carbon emissions per user by a net 30% or more versus running those same applications on their own infrastructure. The reduction goes even to as much as 90% for the smallest and least efficient businesses.
However, other studies have also found that cloud computing is not always the most energy efficient computing option, and under some circumstances cloud computing can be more energy intensive than traditional in-office computing. In [4], it is found that cloud computing can indeed save energy, but looking at three different applications of cloud computing – storage, software, and processing – energy efficiency savings are negated in some instance. For example, one such scenario when cloud computing may consume more energy than conventional computing is when companies use cloud computing for storing data and when the number of downloaded and accessed files becomes larger.

4. CONCLUSIONS

The issue of energy efficiency across the entire information and communications technology (ICT) sector has become very important in recent years because the overall computing requirements have accelerated rapidly over the last ten years. Cloud computing is an emerging computing service delivery model whose benefits include not only growth in productivity but also a reduction in energy consumption for computing services.
This paper has reviewed the potential impact of cloud computing on energy savings. The analysis provides supporting evidence on the cloud's environmental benefits and shows that cloud computing is overall more energy efficient than traditional in-house computing. The growing energy consumption of the data centers and connected devices will only continue to grow, so energy efficiency trends will only continue to become more important.

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