Chapter 30
Cloud Computing Networks:
Utilizing the Content Delivery Network

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ABSTRACT

Cloud Computing has the potential to trigger a major computing model transformation for the IT industry. This chapter briefly describes the business and technical benefits of Cloud Computing and explains the technical challenges in Cloud Computing, such as the network bottleneck. One of the solutions to address the network problem is the Content Delivery Network (CDN). Here, the basics of the Akamai CDN technology is digested. Then, the authors conduct a CDN experiment in the Microsoft public cloud, Windows Azure, to demonstrate the benefits of CDN integration with the cloud. The results show significant gain in large data download by the utilization of a CDN. Finally, a couple of academic research ideas are summarized for future improvements on the CDN model.

CLOUD COMPUTING OVERVIEW

Cloud computing has become a significant technology trend in the recent years. Simply put, the goal of cloud computing, in its early stages, is to achieve utility computing, i.e., the delivery of IT as a service. Cloud computing represents the third major business computing model for the IT industry, with mainframe computing being the first major model, and client/server computing being the second. Cloud computing typically involves the provisioning of dynamic, scalable and often virtualized resources as a service, to be delivered over the Internet.

From the business perspective, cloud computing is a subscription model, using services over the Internet. If one can use a web browser somewhere and pay a fee online to obtain a service, then one can use cloud computing. This broad definition is well described in (Armbrust et. al., 2009).

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From the technical provider's perspective, cloud computing has a more narrowed definition. To be qualified as "cloud," certain characteristics, delivery models, and service models have to be met. For instance, as defined by the National Institute of Standards and Technology (Jansen & Grance, 2011), the five essential characteristics associated with cloud computing are on-demand self-service, broad network access, resource pooling, rapid elasticity and measured services.

OPPORTUNITIES AND CHALLENGES OF CLOUD COMPUTING

Migration from client/server computing to cloud computing is a major computing model transformation. There are great opportunities for both business and technical innovations. However, tremendous challenges are also present.

Business Opportunities and Challenges

On the business side, cloud computing is to make the business more agile, by utilizing resources more effectively to achieve lower cost of ownership. From the cloud provider's perspective (Armbrust et. al., 2009), the formula in Box 1 is used, to describe the profit model for cloud service providers.

The left-hand side represents the expected profit from using cloud computing. The right-hand side represents the expected profit from using the traditional data center. Both sides perform the same calculation by multiplying profits per user-hour by the total user-hours.

Because the resource utilization in cloud computing is 100% (fully utilized), and the resource utilization in the traditional data center is less than or equal to 100% (fully utilized), the true cost of the traditional data center is greater than or equal to the cost of cloud computing. This formula reveals that cloud providers have a better control over the cost per user-hour, and therefore a better opportunity to gain more profit.

From the cloud customer's perspective, applications or services with the following workload patterns are to enjoy great benefits by the adoption of cloud services:

- **Unpredictable Bursting:** An event may trigger heavy usage of resources: normally, the customer would have to scale the design considerations to try and predict what this resource usage requirement could be;
- **Predictable Bursting:** Using Dominos Pizza as an example, the store is very busy on Friday nights. In most days of the week, demand is much less. Even though the additional load is to be maintained, it is expensive for this extra capacity, because it is under-utilized when demand is lower;
- **On and Off:** Similar to Predictable Bursting, On/Off can have seasonal or time-bounded workloads where it is either all or almost nothing processing requirements. Important enterprise workloads that are run monthly, quarterly and annually exhibit this type of behaviour;
- **Fast Growing:** This is interesting in the case of smaller start-up companies or groups in larger companies. It can also be associated with new development. How to

Box 1. Equation 1

$$UserHours_{cloud} \times \left(revenue - Cost_{cloud}\right) \geq UserHours_{datacenter} \times \left(revenue - \frac{Cost_{datacenter}}{Utilization}\right)$$