Chapter 37
Design and Implementation of Optical Cloud Networks: Promises and Challenges

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ABSTRACT

Cloud applications have witnessed significant increase in their development and deployment. This has been driven by the low cost and high performances that can offer cloud paradigm for enterprises to implement innovative services. However, cloud services are constrained by the available transmission rate and the amount of data volume transfers provided by the current networking technologies. Optical networks can play a key role in deploying clouds with enhanced performances, thanks to the high bandwidth and the very low latency provided by optical transmission. Nevertheless, the implementation of optical cloud networks faces many challenges and obstacles, such as the user-driven service nature of cloud applications, resource virtualization, and service abstraction and control. This chapter addresses the design and the implementation of optical cloud networks. Therefore, different issues related to the integration of cloud platform in the optical networking infrastructure are described. Then, current progress achieved to overcome these challenges is presented. Finally, some open issues and research opportunities are discussed.

INTRODUCTION

Since a few years, cloud computing paradigm is becoming widely adopted as a novel mode to deploy large scale and distributed services. It consists in the use of networking infrastructure, such as the Internet to provide computing, storage, and even networking resources as a service to community of users. Many cloud computing applications, classified as scientific applications, business applications, and consumer applications (Develder, et al., 2012) have emerged. Scientific applications allow access to powerful computing facilities, large collection and distribution of experimental data. Business applications are mainly targeting professional users and enterprises. Some types of

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business applications are transactional systems, collaborative tools, multimedia applications and data mining. The development of these applications will require responsiveness and protection. Finally, consumer applications are used by non-professional users and are based on distributed infrastructure. Examples of consumer applications include personal content management, gaming, augmented reality, and interactive TV. The tremendous growth of cloud computing has encouraged many companies to deploy their own cloud platforms to provide storage, computational, and connectivity services. One can mention among the most important platforms Amazon EC2, Google App engine, Microsoft live Mesh, and Sun Grid.

Common characteristics of cloud applications include their reliance on distributed components that are interconnected through a networking infrastructure and their need for higher data transfer capacities with reduced latency. Optical networks are considered as a valuable solution to meet such requirements and implement cloud computing applications. Indeed, optical transmission technology can achieve higher capacity connections with a cost-effective way. This is due to its ability to transfer huge volumes of data with very low latency. Consequently, optical networking techniques are considered as the best alternative to connect data centers providing computing and storage services in the cloud computing environment. Moreover, the concept of optical cloud networks has been introduced to achieve full integration of cloud platforms in the optical network. Nevertheless, before this concept can become a reality, many issues concerning the deployment of clouds over optical networks must be addressed.

The objective of this chapter is to discuss design and implementation challenges of optical cloud networks. In particular, it focuses on the interconnection of data centers based on wide area optical networking technology. The optical interconnection within the data center is out of the scope of this chapter. Indeed, the main target is to provide to different categories of users, a distributed and integrated access to storage, computation, and optical transmission resources. These resources can be managed and distributed overall the cloud infrastructure. Therefore, user service requests can be processed by multiple data centers which may belong to different domains interconnected through the underlying optical network. In addition, the optical networking infrastructure should enable dynamic provisioning of optical resources in order to optimize resources utilization and to satisfy performance parameters constraints of various cloud applications. Consequently, to allow an efficient development of integrated and distributed cloud services over the optical network, many issues related to optical access and switching technologies, resources provisioning and utilization, routing, control and management, virtualization, and security must be investigated.

The chapter is structured as follows: the second section discusses the challenges for enabling cloud applications over optical networks. Section three describes the optical technology and addresses mainly optical access and switching techniques. Section four presents resource virtualization schemes and service abstraction and control architectures. Section five deals with routing techniques required to optimize the service delivery over optical clouds. Section six investigates some open questions related to the deployment of optical clouds. Finally, the last section concludes the chapter and summarizes its content.

CHALLENGES FOR ENABLING CLOUD APPLICATIONS OVER OPTICAL NETWORKS

The performances of cloud infrastructures depend greatly on the networking technology that is used to interconnect distributed resources. Indeed, most of cloud applications require large transfer capacities and constrained Quality of Service (QoS). To satisfy these requirements, an optical network architecture must evolve from being

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