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Energy-Efficient Virtual Content Distribution Network Provisioning in Cloud-based Data Centers

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Abstract: Cloud-based content distribution networks (CDNs) consist of multiple servers that consume large amounts of energy. However, with the development of a cloud-based software defined network (SDN), a new paradigm of the virtual content distribution network (vCDN) has emerged. In an emerging cloud-based vCDN environment, the development and adjustment of vCDN components has become easier with the aid of SDN technology. This transformation provides the opportunity to use vCDNs to reduce energy consumption by adjusting the scale of the vCDN components. Energy costs can be reduced by deactivating the commercial servers carrying the software components of the vCDN, such as replica servers, the firewall or routers. In addition, the CDN requires a high service level agreement (SLA) to respond to clients' requests, potentially consuming large amounts of energy. In this research, we focus on the issue of the energy savings of a CDN in a cloud computing environment while maintaining a high quality of service (QoS). We propose an approximate algorithm termed max flow forecast (MFF) to determine the number of software components in the vCDN. Additionally, we use a real traffic trace from a website to assess our algorithm. The experimental results show that MFF can produce a larger energy reduction than the existing algorithms for an identical SLA. We fully justify our research as a good example for the emerging cloud.

Key words: content distribution network; energy efficiency; cloud computing; service level agreement

I. INTRODUCTION

An Internet system often consists of numerous servers in data centers in different parts of the world. Such systems are offered as infrastructure as a service (IaaS) and can support the majority of applications, including electronic commerce, network news and social networking services (SNSs). These systems typically consume an enormous amount of energy due to the large-scale deployment of the servers [1], which has an adverse effect on the environment. According to [2], a large Internet system consisting of 100,000 servers can consume approximately 190,000 MWh per year, an amount of energy that can maintain 10,000 households for one year. These systems are responsible for 2% to 10% of the worldwide energy consumption [3], an amount that increases approximately 15% per year to support the rapid growth of new network services, such as data centers and cloud computing. Thus, energy management requires additional attention in a large Internet system.

A content distribution network (CDN) is a representative cloud-based large Internet system as an emerging cloud service. The purpose of a CDN is to improve network performance by transferring the content from source servers at a remote location to replica servers within a short range [4]. A typical CDN, such as the one provided by Akamai, contains more than ten thousand servers located across nearly 1000 data centers around the world [5]. As shown in Fig. 1, the components of a typical CDN include a source server, routers, a content gateway, and a firewall. All these components in a typical CDN are deployed in dedicated devices that are available continuously. As noted elsewhere [6], typical CDN components are designed to support the peak traffic of a network (such as a weekend night). On an average weekday, nearly 60% of the components of a CDN are unused. This amount constitutes massive waste because the CDN cannot dynamic adjust its component scale (i.e., it cannot deactivate unused components at a low-usage time) to optimally accommodate future traffic.

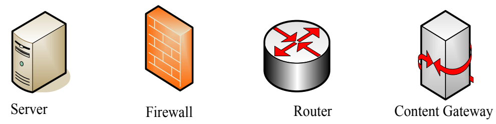

Fig. 1 Typical CDN components

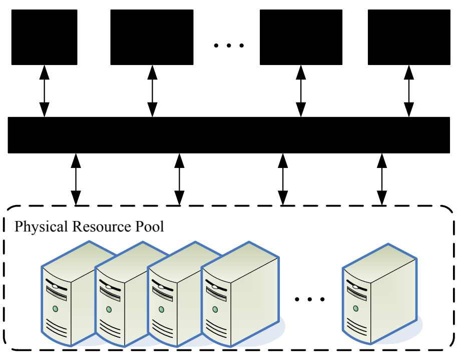

Fig. 2 Software components of a vCDN