Building Content Distribution Network: A Solution to achieve QoS on Internet

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Abstract—**Content Distribution Network (CDN) involves several technologies, rather than just one technology working alone. CDN is another method to provide Quality of Service (QoS) to different applications and deliver different types of media content to end-users over the Internet. Since it is important to improve Internet performance in recent years, CDN has been an approach providing better Internet services. There are a number of technologies and components included in the CDN, and also several challenges needed to be considered for its performance. This paper presents basic components of CDN and summarizes the challenges and issues analyzing the development of CDNs towards QoS.**

QOS; Content Distribution Netowrk(CDN); ISP; ASP

I. INTRODUCTION

Current Internet transporting data, voice, and video streams, faces significant drawbacks involving congestion and bottleneck due to mismanagement of resources and improper configuration of network devices. To solve these problems and support QoS, various approaches have been proposed in the past two decades. In spite of all such efforts, current Internet is still lack in achieving desired QoS metrics involving applications. Integrated Services (IntServ) approach with Resource reSerVation Protocol (RSVP) reserves resources from end to end before sending the actual data over Internet and guarantees QoS, but lacks scalability. Differentiated Service (DiffServ) classifies traffic into different classes, assigning Per Hop Behavior (PHB) and configuring routers to behave accordingly without any resource reservation. Though this achieves scalability, but lacks achievement of end to end QoS due to PHB mismatch across multiple domains. Content Distribution/Delivery Network (CDN) has been discussed and researched for last few years now. CDN is defined as a system, which places several copies of data in different surrogate servers from the origin servers, and deliver them to end-users on behalf of origin servers, when receives a request from a client or an end-users in the network. In [1], CDN is referred as a "networked infrastructure", which means that several technologies are connected to work together over Internet. Popescu, A. in [3] describes that CDNs need several "high-layer network intelligence" to deliver traffic over Internet, which means that some higher-layer technologies are involved.

This paper mainly focuses on CDN components involving placement and selection of servers or content. We discussed caching problem in Section 2, and content management and performance measurement in Section 3. Management of different CDNs are presented in Section 4 with a conclusion in Section 5.

II. EVOLUTION OF CDNS

The initial approach to improve Quality of Services is to over-provide networking hardware, such as the high-speed processor, more memory, and physical link with higher bandwidth. But, this method is also the worst case with wasted resources. In [1], Mauthe, A. and Plagemann, T. pointed out that caching was introduced and successfully utilized in the HTML over Internet in the late 1990s. Caching proxy servers provide better Internet delivery for the end-users with narrow bandwidth or limited hardware resources. In [2], Chochliouros I. and Spiliopoulou A. discussed the difference between CDNs and existing caching proxy servers. The existing caching proxy servers are used as a form of a "gateway" between enterprises's LANs and the Internet. Also, the authors in [2] argued that caching proxy server can temporally store networking content based on clients or users frequent requests within the LANs. On the other hand, CDN servers can cache great quantities of content, and cooperate with each other to deliver content to end users across a large scalable area. Caching has a critical role in managing content in CDNs, which will be discussed in later section of this paper.

P2P based CDNs, as a type of CDN mentioned in [1], has its own advantage, with more users downloading same data, it achieves better efficiency for service providers. However, P2P networks are aimed at file sharing among self-interested end users or peers, and they lack the consistency between cached contents. The goal of CDNs is to provide more efficiency for individual companies, and such CDNs require much stronger cache consistency between replicated content than the P2P systems.

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Additionally, in [2] and [3], authors considered CDNs as overlay networks or modules with examples, such as Akamai, Digital Island, Speedera, and so on. This paper will provide some fundamental characteristics on CDNs. The basic components of CDNs are presented in Section 3 with an emphasis on content and performance managements in CDNs.

III. COMPONENTS AND FUNCTIONS OF CDNS

Content Distribution Network companies are more like Application Service Providers (ASP) rather than Internet Service Providers (ISP). Each CDN company can deploy their CDNs in different ways, but, they all share some basic components and offer similar functions or services, by using different technologies and policies, such as: where to place the surrogate servers, how to choose the contents from which servers, and how to measure or monitor the CDN system.

The architecture of a CDN system consists of four main components: content delivery, request routing, content management (also called distribution component), and performance measurement (also called the accounting component) [2, 3, 6] as presented in Fig. 1. Content delivery involves the origin servers and several surrogate servers, and the delivery process between them and the end-users. Request routing deals with sending right content to end-users from right servers (origin or surrogate servers). Content Management transfers contents from the origin servers to the surrogate servers maintaining consistency of the contents. Finally, performance measurement will monitor and record the usage and performance of CDN servers, and then get some feedback or logs.

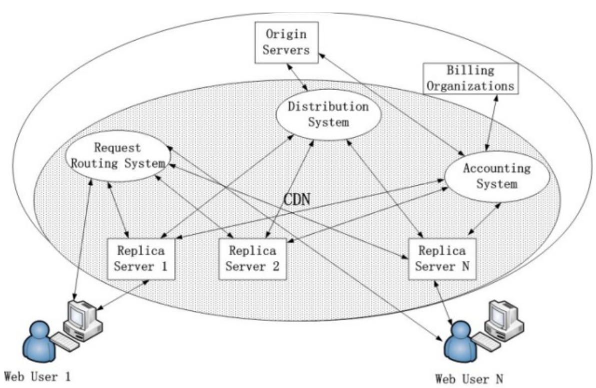

Figure1. Basic components

The fundamental function of CDNs is distributing contents to cache servers located close to end-users or to the edge of networks, thus reducing the latency of delivery and improving Quality of Service. CDNs can maximize bandwidth usage; minimize jitter and delay, which is a better solution to provide QoS than over-provisioning. A CDN provider will place several cache servers (surrogate servers) on multiple locations around the world, and maintain contents copied from the origin server in surrogate servers. Those surrogate servers will cooperate with each other, transparently moving content among them to deliver content for users. Therefore, in [3] and [4], the authors agreed that, in CDNs, the traditional client-server communication flow is replaced by two communication flows. One happens between the origin server and the surrogate servers, and another occurs between the surrogate servers and the clients. Although this can reduce the response time to users, it also cause some complicated problems and challenges, such as where to place the surrogate servers, how to select the content from different servers.

A. Placement and Selection of Servers

Since the goal of building a CDN is to maximize performance and minimize the cost, latency, jitter, and bandwidth usage these should be considered as critical factors when deciding the placement of servers. A good placement plan should place sufficient servers to meet the clients' requests, and also, limit the number of surrogate servers needed. In [3], the authors presented a few examples of placement algorithms, including Greedy, Hot Spot and Tree-Based Replica.

Another issue, presented in [2], is whether the surrogate severs should be positioned in a single or multiple ISP. In the single ISP scenario, ISP should be able to cover globally to achieve CDN's efficiency, but that would make placing users in a near distance from servers difficult. However, its advantage is easily managing content, keeping consistency among servers. Request routing is responsible to route and redirect the requests from clients to appropriate surrogate servers, by using some policy or protocols, such as choosing the closest surrogate sever. Walkowiak K. in [5] presented a situation when the nearest server doesn't have the content that client asked for, the requests will be redirected to other surrogate servers. Popescu in [3] discussed different policies for selecting servers, e.g., cooperative push-based, uncooperative pull-based, cooperative pull-based. Furthermore, in [5], the authors focused on MPSL-based CDNs, which use MPLS to route the CDN requests. The placement and selection of servers/content are closely related to the content management and are important for the performance of CDNs and Quality of Service.

B. Management of Contents

In [1] and [6], both Mauthe A. and Pathan M. presented that the encoded data includes static, dynamic, and continuous media data, for example, audio, video, documents, images and Web pages. Metadata is content description, which identifies, locates, and manages different media content. Metadata should be used to manage content, thus improving the performance of CDNs and Quality of Service. In [7], Pathan A. K. emphasized that content management is dependent on the caching used in the surrogate servers in CDNs. Caching techniques include cache maintenance and cache update. Although caching technology has been used since the late 1990s, CDN needs new forms of caching to fulfill the goal of CDN. The authors in [8] presented segment data stream, and combined dynamic caching with self-organizing, and also use cooperative caching techniques.

C. *Performance Measurement*

In terms of QoS improvement, a special component of CDNs is performance measurement. Performance measurement of a CDN depends on some metrics estimation to measure CDN's ability to support QoS. Cache hit ratio, bandwidth consumption, latency, surrogate server utilization, and reliability and scalability, must be considered by CDN providers. Current Internet is best-effort. So if CDN aims to provide better service, it should be able to monitor the network conditions, and measure metrics, and provide feedbacks.

The authors in [2], presented a combination of hardware- and software-based probes distributed around the CDN to gather QoS information for the CDNs. Most CDN providers use internal measurement by using network probing and traffic monitoring to achieve QoS.

IV. MULTIPLE CDN MANAGEMENT

Since commercial CDN company has successfully offered their CDNs for clients, the present trend by researchers and organizations is to interconnect content networks and manage multiple CDNs. Multiple CDNs may be able to cover a larger client population and a broader geographic area. Compared to single CDNs, interconnection of multiple CDNs can provide high QoS to end-users without resources over-provisioning or extensive costs.

CDN peering, a approach to achieve interconnecting multiple CDNs, includes a set of autonomous CDNs from agreement, and cooperate through a mechanism to share their resources with the advantage of its larger scalability. Every CDN provider in the CDN peering arrangement still responds to their own user requests, unless when it cannot handle or do not have sufficient resources. Fig. 2 in [7] showed, the primary CDN is responsible for C2, and P2 and P3 CDN, provided by multiple CDN peers, answer the requests C1 and C3 respectively.

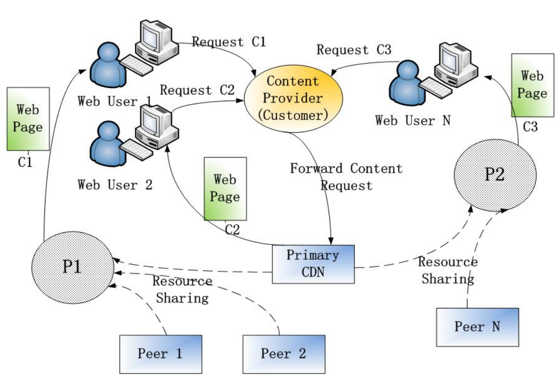

Figure2. Interconnection of multiple CDNs

With the development of multiple data stream (video, audio), multiple CDNs interconnection can better organize network resource with less cost than single CDN, and achieve better QoS.

V. CONCLUSION

CDN have already made some contribution in the real business world, especially in the area of Web site performance improvement. According to Akamai in [10], over 2,000 enterprises have signed contract with Akamai to improve the performance and reliability of their Websites, content, and applications. Nevertheless, CDNs are still in an early phase of development, and they still have some issues to address.

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