# An Open Streaming Content Distribution Network

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## INTRODUCTION

Motivated by the increasing availability of media content in the Internet, improvements of network bandwidth in the Internet backbone and the availability of faster "last mile" connections, such as cable modems and DSL (digital subscriber lines) services, users are becoming increasingly interested in watching movies or TV broadcasts, listening to radio or music, or viewing lectures over the Internet. Consequently, streaming media content (i.e., audio and video) is becoming a significant fraction of the total traffic in the Internet and demands for effective as well as efficient media delivery infrastructures. To this purpose, the streaming content distribution networks (SCDNs) have lastly conveyed huge interest. An SCDN is an overlay network aiming at improving the streaming-based delivery of content to the end users (or clients) in the Internet, in which popular content may be cached or replicated at a number of servers, placed closer to some of the client populations. Being an emergent technology, SCDNs have to face several technical open issues related to the internal content distribution infrastructure, content management policies, content discovery mechanisms, redirection mechanisms, and delivery of media streaming.

The main goal of this article is to provide an overview of the state-of-the-art related to SCDNs, and, in particular, to describe a deployable architecture of a SCDN and the related use scenarios. The proposed architecture serves as an open SCDN platform that aims at delivering both static Web objects through bulk transfer and rich media through streaming in an efficient way. The open SCDN is endowed with the following features:

- User requests redirection mechanisms based on distributed network monitoring.
- JAVA-based development targeting a multi-platform deployment.
- Scalability to build small, medium, or big CDN systems.
- COTS (commercial off-the-shelf) technology.
- Integration of the Darwin Streaming Media Server (2004) for video/audio streaming, which is an open source version of the server-side Apple QuickTime.

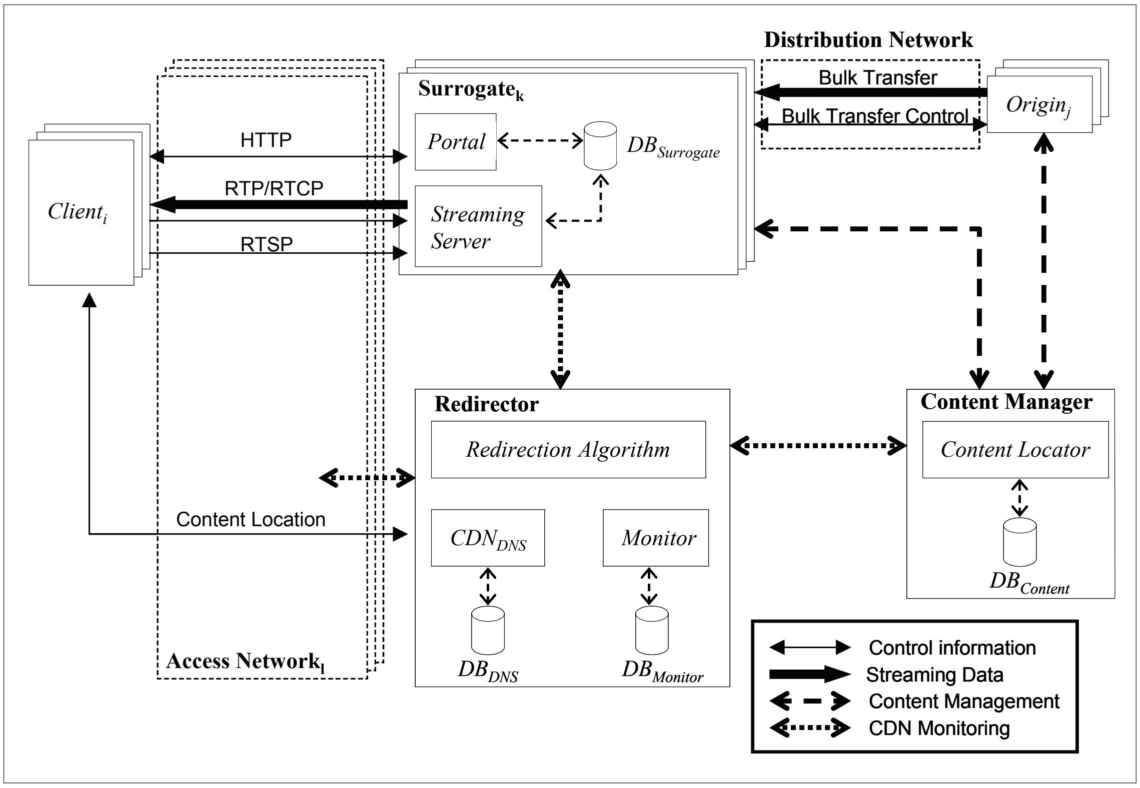
The rest of the article is organized as follows. In the *Background* section, the state-of-the-art of SCDNs is overviewed. In the *Open SCDN* section, the architecture of our SCDN is described in detail. The *Future Trends* section elucidates the current international research efforts and development directions in the area of SCDNs. Finally, the *Conclusions* section summarizes the main contributions of the proposed work.

## BACKGROUND

Historically, content was hosted on huge data centers located at a single geographical location. This solution hinders scalability and reduces response times for all clients. Therefore, Internet services and resources are often replicated over geographically and topologically different locations to improve performance, fairness, and availability. In fact, with the growing population of users, new application environments and increasingly more complex data of different types and origin has led to the adoption of different solutions for scalable content delivery: clusters (Sayal & Vingralek ,1998), Web caching (Gadde, Chase, & Rabinovich, 2000), content distribution networks (CDNs) (Verma, 2002) and, more recently, P2P infrastructures (Liben-Nowell, Balakrishnan, & Karger, 2002). However, the architecture of these overlay systems differs significantly, and such differences affect the deployment, performance, and accessibility of these systems.

This article focuses on CDNs, overlay infrastructures that improve performance and availability of Web and media content by both pushing the content towards network edges and providing data replication and replica location services. CDN services accelerate client access to specialized content by improving efficacy in four basic areas: (1) speed, (2) reliability, (3) scalability, and (4) special events (Gadde et al., 2000). CDN design tries to improve two performance metrics: response time and system throughput (Sariou, Gummadi, Dunn, Gribble, & Levi, 2002). The first metric is important for clients and assumes the case of primary marketing for these systems, whereas the latter represents the average number of requests that can be satisfied each second. The

*Figure 1. The architecture of the open SCDN*




key elements in a CDN are (1) surrogates, which perform as proxies that serve cached contents directly, with the corresponding content manager tracking the contents and their locations; (2) the content management policy of the CDN, which determines the amount of information kept by each surrogate; and (3) the redirection mechanism that sends each client request to the optimal surrogate, which serves this content within low response time boundaries, at least compared to the time required to contact the original site (Barbir et al., 2001; Cardellini, Colajanni, & Yu, 2003).

A CDN therefore offers a global scale-out approach to reduce network latency by avoiding congested paths. Leading CDN companies have placed from hundreds up to thousands of servers throughout the world, thus providing content from the nearest surrogate. Previous research has focussed on the performance of CDNs, which is largely determined by its ability to direct client requests to the most appropriate server (Jung, Krishnamurthy, & Rabinovich, 2002), while others have addressed DNS effectiveness from the standpoint of overhead incurred in the request redirection process (Johnson, Carr, Day, & Kaashoek, 2000). Other studies have evaluated the accuracy of the server selection algorithm when choosing the optimal server (Akamai, 2005; Doyle, Chase, Gadde, & Vahdat, 2002; Kangashaju et al., 2000).

Of the available open CDNs, some, such as Globule, creates an overlay network by introducing object-oriented replication between peers, thus establishing a user-centric CDN (Pierre & van Steen, 2001). In contrast, the Application CDN (ACDN), which is based on the RaDaR system developed by AT&T, is an environment for distributed program execution (Karbhari, Rabinovich, Xiao, & Douglis, 2002). SPREAD is another replication system but not a CDN, as content is replicated through the interception of network traffic (Rodriguez & Sibal, 2000). CoDeeN (Park, Pai, Peterson, & Wang, 2004) is a CDN developed at Princeton University, which only works on the PlanetLab platform (PlanetLab, 2005). Other CDNs, such as Akamai (2005) represent proprietary solutions.

Several reports have integrated CDNs and media streaming. PRISM provides content naming, management, discovery, and redirection mechanisms to support high quality media streaming over an IP-based CDN (Karbhari et al., 2002). TVCDN, although still in early stage of development, is based on an existing CDN infrastructure and, in particular, offers a content management system for TV distribution (Basso et al., 2000). While not based on a CDN, MARCONINet (Dutta, Schulzrinne, & Yemini, 1999) offers an infrastructure for audio delivery to mobile and fixed users using multimedia

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