Content Delivery Networks: An Introduction

White paper

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May 2002

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Introduction: What are Content Delivery Networks?

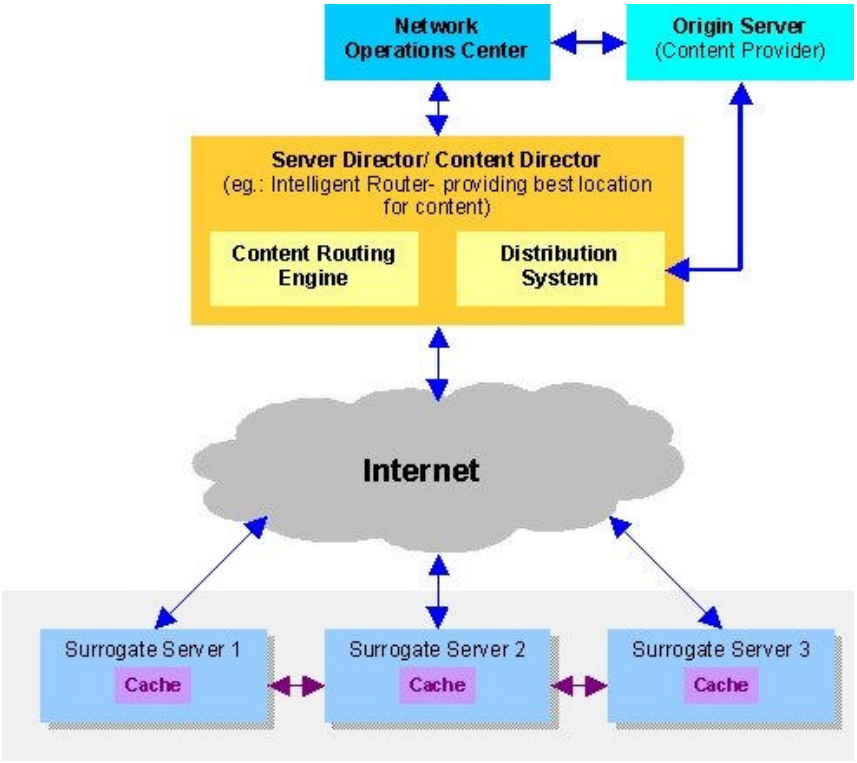
Content Delivery Network, as the name suggests, is a network of machines which delivery content, which may be static or dynamic data on the web. CDN encompasses many different technologies, all with a common goal of improving the Internet performance. CDNs require the ability to detect changes to existing data or to detect availability of new content at origin servers.

CDN is necessarily a complex system with many components. These components are distributed across different nodes of a network in a possibly heterogeneous environment. These components are servers with replicated content in them all over the world. CDNs typically take care of redirecting customer requests to a server topologically placed *near* the customer. Thus, customer gets the advantage of getting data requested at a much faster rate, from the nearest server.

Two of the major concerns addressed by CDNs are ensuring efficient content distribution and freshness of content given to the customer. An enterprise of ISPs would never accept misses on certain objects. Retrieving large objects across the Internet during bandwidth-constrained hours could result in unacceptable latencies. Pushing time-sensitive data (e.g. news, share prices, entertainment, live sporting events) to servers to ensure fresh content is a challenge, which CDN solution providers face. Most important of them is efficient distribution of all content to the respective servers.

Typical CDN Architecture

Essential infrastructure for CDNs would typically follow the ideology that it is necessarily a complex system with many components. This requires a management entity (i.e. network operations center), which intelligently monitors and manages the whole system.



Then there are servers (i.e. shown as surrogate server 1, surrogate server 2, surrogate server 3 in the diagram) cache associated with them. The cache actually cache the data so that when a customer views the same content next time, it is furnished fast. In case the content is not present in the cache, it is the responsibility of the respective server associated with cache to get content from a source which is topologically nearer to it.

Metrics for redirecting requests could include network proximity derived from network routing tables (e.g. border gateway protocol), topological proximity (i.e. depending on region), load balancing with servers (i.e. finding out the server with less load in a particular region). In case the respective server finds that content is not actually present in nearby locations, it sends a request to origin server and gets content. CDNs also process logs from these servers and use it for billing purposes.

Server Director/Content Director

This intercepts all requests and directs them to servers topologically nearest to the client or end-user. Server director avoids situations where access to Internet is impossible as a result of server problems. Assuming content is present in three servers in a region (i.e. surrogate server1, surrogate server 2 and surrogate server 3) and a request comes from a client topologically nearer to surrogate server 1 with the requested content. When request arrives, assume that surrogate server 1 is down.

In a situation like this, server director would not let the request go to surrogate server 1. Instead, it passes on the request to surrogate server 2 or surrogate server 3 depending on factors like topological proximity, network proximity etc.

Server director keeps track of health of all servers in the server farm and is able to detect failure immediately and take appropriate action. Server director handles directing requests to a least loaded server. In case all servers are out of service, then requests should be sent to origin server. There could arise a situation where content is being fetched from one of the origin servers, and at this instant, one of the servers in server farm comes up. During this time, server director should be able to switch/redirect the request to the server with the content cached and has come up. This leads to efficient utilization of bandwidth and faster access of content to client.

Mechanism for direct access to origin server

Many a times it happens that client needs access to updated information (e.g. financial news). In such a case the server director would have a mechanism to redirect all requests to origin servers.

Single point of control

Server director needs to take care of all servers, which would be distributed over great distances from a single point of control. All servers in server farm have a cache associated with them, which cache content delivered over HTTP, FTP or NNTP. These are characterized by having some proportion of static content. Essentially, servers should potentially be able to detect whether content requested is present in cache or not. Based on this, server should pass on the request to origin server. On getting response from origin server, the content should be delivered to end-user, and should cache a copy of it in server's cache.

Efficiency with cache

With the increase in usage of Internet on a day-to-day basis, we realize that cache hit rates are growing exponentially with respect to growth of web content. It is also unlikely

that capacity of cache increases with respect to growth of web content. So efficient utilization of cache is a must for better performance and with hundreds and thousands of caches over the Internet, performance improvement could be substantial.

Effective cache management involves finding out the objects which are to be present in cache and which need not. Most of algorithms which come into picture here take into account the probability of the requested object being accessed a number of times in recent past.

The CDN advantages

- Faster response time due to factors like geographical proximity, network proximity etc.
- Providing support for different types of content including on-demand, streaming media
- Providing support for secure delivery of content
- Efficient distribution of content to all the resources (typically all the servers in the content delivery network)
- Provide unique ways to improve performance of network thereby providing ways to utilize bandwidth efficiently

CDN service providers

Some of the service providers who specialize in content delivery networks:

Akamai	: www.akamai.com
Digital Island	: www.digitalisland.com
Globix	: www.globix.com
Mirror-Image	: www.mirror-image.com
Ibeam	: www.ibeam.com
CacheWare	: www.cacheware.com
Inktomi	: www.inktomi.com
Cache Flow	: www.cache-flow.com

Peering between CDNs

Content peering allows multiple content delivery network solution providers to inter-operate with each other. It is very much possible that two CDNs are do not have the same underlying technology / architecture implementation. It is also highly unlikely that a single CDN solutions provider is spanning multiple geographies. From this, it is obvious that content peering or CDN peering is a must in terms of current trends.

Assume that there are two CDNs peering. Both CDNs would have their own independent content directors, which handle request routing, load balancing, and surrogates furnish data to client or end-user. For peering to take place, there has to be some form of communication between components of independent CDNs. This requires a gateway for communication.

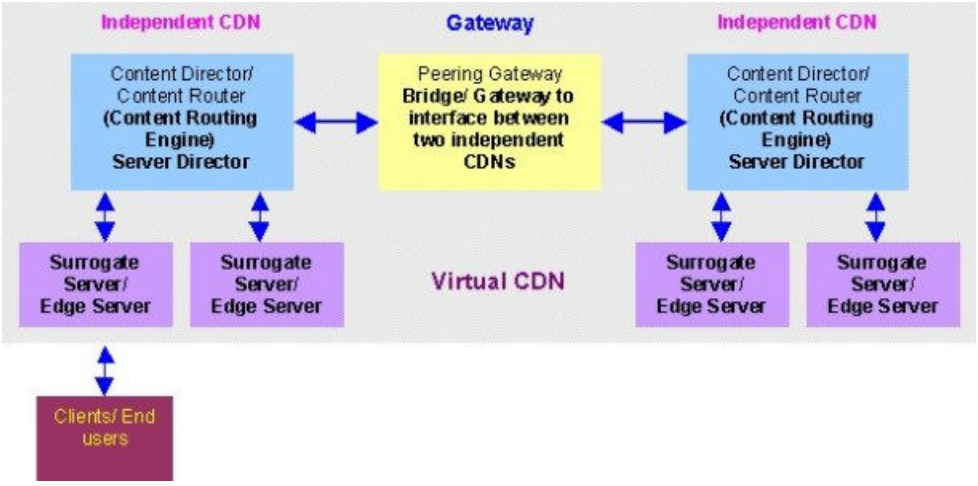
The end-result would be a virtual network in which all components of different CDNs have work in unison to deliver content to end-users. There is an alliance of service providers and content providers namely content alliance, which created content-peering group. The content-alliance was formed to facilitate interoperability of independent CDNs. Although content alliance group is focussed on standards that would help CDNs peer, the content-bridge alliance is focussed to new models that offer content providers optimal performance and network reach.

On the industry alliance front, a working group called Content Distribution Internetworking Working Group was formed, jointly led by representatives from Content Bridge and Content Alliance. Initial areas of focus include content distribution/injection, request routing and accounting, with subsequent aim to create a common set of protocols for content peering.

Typical architecture between peering CDNs

Reference:

http://www.ietf.org/internet-drafts/draft-green-cdnp-gen-arch-03.txt (IETF Internet Draft)



Accounting in a CDN

Log collection

Accounting information is in the form of log files for each of individual components in CDN environment. There is generally a mechanism by which logs for all components are collected, logically broken down into chunks and results analyzed. A CDN solution provides content providers with accounting and billing information. All the data is collected over CDN's administrative domain. Peering between CDNs introduces the need to obtain similar accounting data from a foreign domain. This requirement means that customers of a peered CDN service (publishers, clients, and CDNs) must now have a generalized or standard means of obtaining accounting information to support current as well as planned business models.

For example, to implement business models such as "Pay Per View" there should be a mechanism for authenticating and authorizing clients at the delivery point in a foreign domain. In a typical CDN environment, a server is required to handle accounting and billing requirements. This server provides means for collecting data from individual components of a CDN.

CDN accounting and billing mechanism should have access to individual component logs and statistics which would provide a way to generate customer specific reports. This mechanism has an interface generally given to the customers/content providers to access accounting and billing information.

Access to content distribution between various components and management of these components is generally protected via authentication mechanisms. Customers (i.e. content providers, ISPs) would be provisioned to have access to their own content and resources.

CDN solution Provider bills content-Provider on the basis of quality of content delivered, speed of delivery, amount of content delivered and performance over the period of time accounting is done. ISP bills content provider on resources used (i.e. surrogates and caches used) and bandwidth savings.

Terminology used in content networking

Browser cache

Comes into picture when end-users hits the “back button“ to visit the page already seen. This content would generally be stored in a section of hard disk and is generally referred to as browser cache.

Cache

Cache is a local copy of data accessed over a network, which makes subsequent access to the same data faster. When data is read from, or written to main memory, a copy is also saved in cache. When a request comes for content already present in the cache, it is given immediately to the client. Note here that the data won’t be read from main memory but from the cache (needless to add here that cache is built from faster memory chips than main memory).

Content consumers

Users requesting a page.

Content peering

No individual CDN could span geographies across the Internet. Content peering allows diverse CDNs to interoperate whereby resources of individual CDNs could be combined to have a larger reach.

Content provider

Origin servers from where content is being requested by end clients/users. CDN vendors provide different kind of solutions to these content providers who are their customers.

Domain name

Domain name is a portion of naming-tree hierarchy that refers to general groupings of networks based on organization type or geography.

Domain Naming System (DNS)

DNS is a database of host information. A DNS name server resolves hostnames to IP addresses mapping queries. Queries may come from DNS clients or from other DNS name servers.

Forward proxy

Forward proxy cache fetches content from origin servers in case content is not present in its cache. In other words, client requests bypass proxy cache and go to origin server only when the content is not cached locally in proxy cache. Objects stored in cache would be delivered faster. Objects not present in cache are fetched from origin server.

HTTP

Hyper Text Transfer Protocol (HTTP) runs over TCP/IP to transfer data over a network. HTTP defines how messages are formatted and transmitted and what action web servers and browsers should take in response to various commands.

ISP

An Internet Service Provider (ISP) is an entity that provides services on the Internet.

Load balancing

Distributing processing load evenly across a computer network in such a way that no single computer on the network is overloaded.

Proxy cache

LANs consist of many computers interconnected with each other and ultimately connected to Internet via a proxy, which could also function as cache. When using a proxy server, computers on the LAN are not connected directly to Internet. Only the proxy server would be directly connected to Internet.

Client software is then configured to connect through proxy-server. One example of proxy cache is Squid proxy cache. A proxy cache can help a web site load faster as the content is cached. Since a proxy cache has a large number of users behind them, they reduce latency involved in getting content. Also, since this proxy cache would be used by large number of users, it would also result in substantial reduction of utilization of bandwidth.

As the name suggests a caching proxy is a proxy, which also performs caching as part of its many activities. When content is requested from a browser, the caching proxy fetches the content, and saves a copy of the content in the cache. If another client requests the same content, the content is delivered directly from the caching proxy, instead of going to internet.

Request routing

Any client request would be redirected to a particular surrogate server depending on factors like network proximity, topological proximity, load balancing. This redirection is done by content director and is also called as request routing.

Reverse proxy

Reverse proxy is the name for certain alternate uses of a proxy server. It can be used outside the firewall to represent a secure content server to outside clients, preventing direct, unmonitored external access to the server's data. It can also be used for replication; that is, multiple proxies can be attached in front of a heavily used server for load balancing.

SLA

Service Level Agreements (SLAs) determine how the content is distributed in a CDN according to customer's preferences. It is an agreement with the customer and CDN solution provider, which might involve resource provisioning for the customer.

Surrogate servers

Surrogate servers are located on edge of the network. They are capable of handling HTTP requests and servicing them through cache associated with it. The responses are triggered from cache associated with surrogate server.

Transparent caching

Transparent caching is essentially a form of forward proxy caching in which there is no configuration required from the browser perspective. This kind of transparent caching is often preferred as it eliminates need for administrative support.

User agent

End-user tool that sends a request.

Web server

A web server is a process running on the operating system that enables users to access resources that have been published in form of web pages in a wide area network (i.e. Internet)

Conclusion: future market trends

Content delivery networks provide a platform and capability to manage all forms of communication. It helps in moving towards providing efficient ways of managing and distributing content across the edge and understanding customer needs. Content delivery solutions could be deployed to avoid performance bottlenecks, which result due to continuous upsurge of the applications on the corporate Intranets.

The goal of content delivery networks would essentially be to optimize bandwidth usage and to show improved response times relative to what would exist without the content delivery networks solutions in place. However, CDN solution now view newer opportunities in value addition, such as content adaptation, personalization of content, advertisement banner insertion, virus filtering and language translation. ICAP, an emerging content adaptation protocol has the potential for the above value-added services. A lot of content networking would depend on structuring the components involved.

References

IETF works-in-progress.

http://www.ietf.org/internet-drafts/draft-ietf-cdi-architecture-00.txt

http://www.ietf.org/internet-drafts/draft-ietf-cdi-aaa-reqs-00.txt

About HCL Technologies

HCL Technologies, with a revenue of US$ 297 millions, is one of India's leading IT services companies, providing a broad range of services to clients worldwide. Services include Technology Development, Software Product Engineering, Networking & Application Services and Business Process Outsourcing.

HCL Tech focuses on technology as well as research & development outsourcing, with the objective of working with clients in areas at the core of their business. The focus on such mission critical projects and the ability to provide services throughout the life cycle of client products, from conceptualization to ongoing development and maintenance, enables HCL Tech to build long-term relationships with customers. These include software and hardware companies as well as large and medium sized organizations, across diverse industries around the world. Market leaders like Cisco Systems, Novell, RSA Security, KLA Tencor etc. feature in the reputed list of clients of HCL Tech.

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