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Evaluation of the CDN architecture for Live Streaming through the improvement of QOS

Case study: Islamic Republic of Iran Broadcasting

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Abstract

Over the last decades, users have witnessed the growth and maturity of the Internet. As a consequence, there has been an enormous growth in network traffic, driven by rapid acceptance of broadband access, along with increases in system complexity and content richness. CDN, provides services that increases the efficiency of the network bandwidth, and increases the access and maintains the accuracy of the information during transmission. One of the most important requests in the context of the Internet is watching video live streaming with techniques that can be transferred. The aim of this study is to enhance the QOS and increase the efficiency of the transfer of the content in the context of the Internet. The results of this research in the form of diagrams in order to compare the advantages and disadvantages of using a CDN will be shown at the end of the review proposals. Finally we concluded that the use of this technology in the context of the Internet in Iran can increase the QOS and customer satisfaction levels.

Keywords: *CDN, Live Streaming, QOS, Delay, Jitter, Packet loss, surrogate.*

1. Introduction

Limited access to the network and computational resources can become the arena for competing service centers with one another. High availability and optimal answers provided the key to success in this arena. At the same time the influx of high volumes of users to a Web site and creation of a high traffic, became one of the challenges of this the realm. Some of the problems resulting from this situation are as follows:

- Since content must go through several long distances and backbone passes for the relocation the transmission speed is going to greatly decreased.
- Traffic along with issues related to backbone peering, causes issues with the proper delivering of content.
- The parent site's bandwidth limits the usage of the users.
- High traffic, packet loss and narrow channels of broadcast decrease the quality of the content significantly.

In light of the discussed issues and the endless growth of Internet usage in the past few years, providing services such as Live Television programs, On-demand clips and music, and social networks such as Facebook and YouTube simultaneously to thousands of users has become a challenge. CDN network providers use companies as a tool in terms of sharing the content at the discretion of the user. Reduce in the video quality and lack of access associated mainly resulting from the long loading (download) can be tiring and boring for the users. Companies make great profit from e-commerce on the Internet, and would like to create a suitable experience for visitors to their website. Therefore, in recent years, the goal to improve the quality of technology for sending content through the Internet has grown dramatically. The content networks try to increase the quality of services by using different mechanisms. But unfortunately no company in Iran has invested in this field yet. The only Web site that is located on the CDN is live.irib.ir, which is owned by the Islamic Republic of Iran's Broadcasting and it uses a few CDNs in foreign countries to transfer the content and its central server inside the same country offers services to users inside the country. A CDN is a collaborative collection of network elements spanning the Internet, where content is replicated over several mirrored Web servers in order to perform transparent and effective delivery of content to the end users [1]. By maximizing bandwidth, increasing accessibility and repeating content, CDN's reduce the response time to the user's request, and therefore lead to greater network productivity. It is predicted that by employing the technology in our country, we will witness better network performance in content delivery.

This paper proposes the architecture of CDN in Iran with Content Re-distribution Function to overcome the limitations of watching live streaming in the Internet, and

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it explains about QOS factors and clients satisfaction based on Content Delivering Network (DCDN).
In the rest of the sections, first we discuss the architecture of CDN, live streaming and Islamic Republic of Iran Broadcasting's website.
Then we introduce the proposed CDN architecture in Iran, content re-distribution algorithm and RDCDN transmission algorithm that make a more stable transmission performance to clients. Finally we present the simulation results which prove our proposed model, and the conclusion.

2. Content Delivery Network Architecture

Content Delivery Network (CDN) is one of the new popular technologies which are used for distributing content on Internet. With this technology, corporations and institutions can increase the speed of uploading and browsing their sites. As you know, faster uploading site to optimize the site for search engines (SEO) is currently very important in terms of e-commerce and also has positive results.
Internet Corporations for controlling traffic of the sites and Internet services use multiple servers around the world for storing and distributing their information. This makes it possible for all users around the world to have the same condition while using this service and using the closest server of corporation with highest speed. This will bring many advantages that will be described in the following sections but what about the smaller companies and the Internet users who have shared their personal sites on the Internet?
Usually these sites keep their data on a single server (their host) and service the users and the visitors around the world and carry out their work with their server limitation such as low bandwidth, low transmission speed and etc. [1]
CDN can be efficient and help small business owners and private sites to act like corporations. This service keep a copy of downloadable information of your site (like CSS code files, java scripts code files, multimedia files, etc) on different nodes or servers around the world and service many sites at the same time. At this time when client want to browse your site, information will deliver from the closest available server to him and because these information were already cached, exchange rate has changed dramatically.
Figure1 can help to better understand the concept of CDN in the world of internet [2].

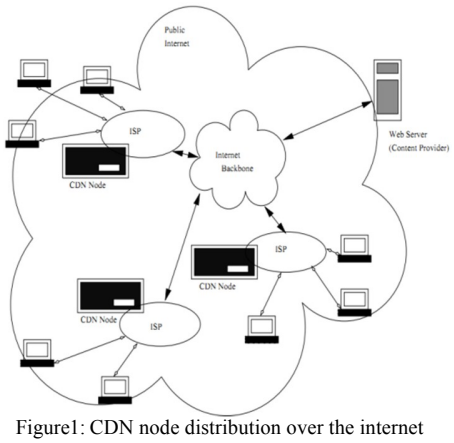

Figure1: CDN node distribution over the internet

3. Functions and Structure of CDN

As mentioned before, CDN is a technology with its Internet corporations control traffic of the sites and Internet services. With this technology users can connect to the nearest server and achieve their desired content.
For further explanation about CDN's construction, some concept must be defined:

3.1 Surrogate server

CDN consist of several edge servers (surrogate) which keep a copy of provider's contents so they called cache servers too. Client's requested content will deliver to nearest surrogate server. Every cluster consists of set of surrogates which are located in same geographical region. The number of surrogates is too important because they should be in appropriate number and also they should be in appropriate location [2].

3.2 Content server

Content server: content providers upload client's requested content in content servers.

CDN is a set of network elements which combine together to deliver a content to clients in a more efficient way.
A CDN provides better performance through caching or replicating content over some mirrored Web servers (i.e. surrogate servers) strategically placed at various locations in order to deal with the sudden spike in Web content requests, which is often termed as flash crowd [3] or SlashDot effect [4]. The users are redirected to the nearest surrogate server to them. This approach helps to reduce the network impact on the response time of user requests. In the context of CDNs, content refers to any digital data resources and it consists of two main parts: the encoded media and metadata [5]. The encoded media includes static,

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dynamic and continuous media data (e.g. audio, video, documents, images and Web pages). Metadata is the content description that allows identification, discovery, and management of multimedia data, and also facilitates the interpretation of multimedia data.

3.3 Components of CDN

The three key components of a CDN architecture are content provider, CDN provider and end-users. A content provider or customer is one who delegates the URI name space of the Web objects to be distributed. The origin server of the content provider holds those objects. A CDN provider is a proprietary organization or company that provides infrastructure facilities to content providers in order to deliver content in a timely and reliable manner. End-users or clients are the entities who access content from the content provider's website.
CDN providers use caching and/or replica servers located in different geographical locations to replicate content. CDN cache servers are also called edge servers or surrogates. The surrogates of a CDN are called Web cluster as a whole. CDNs distribute content to the surrogates in such a way that all cache servers share the same content and URL. Client requests are redirected to he nearby surrogate, and a selected surrogate server delivers requested content to the end-users. Thus, transparency for users is achieved. Additionally, surrogates send accounting information for the delivered content to the accounting system of the CDN provider [1].
Figure 2 shows a typical content delivery environment where the replicated Web server clusters are located at the edge of the network to which the end-users are connected [1]. A content provider (i.e. customer) can sign up with a CDN provider for service and have its content placed on the content servers. The content is replicated either on-demand when users request for it, or it can be replicated beforehand, by pushing the content to the surrogate servers. A user is served with the content from the nearby replicated Web server. Thus, the user ends up unknowingly communicating with a replicated CDN server close to it and retrieves files from that server.
CDN providers ensure the fast delivery of any digital content. They host third-party content including static content (e.g. static HTML pages, images, documents, software patches), streaming media (e.g. audio, real time video), User Generated Videos (UGV), and varying content services (e.g. directory service, e-commerce service, file transfer service). The sources of content include large enterprises, Web service providers, media companies and news broadcasters. The end-users can interact with the CDN by specifying the content/service request through cell phone, smart phone/PDA, laptop and desktop [1].

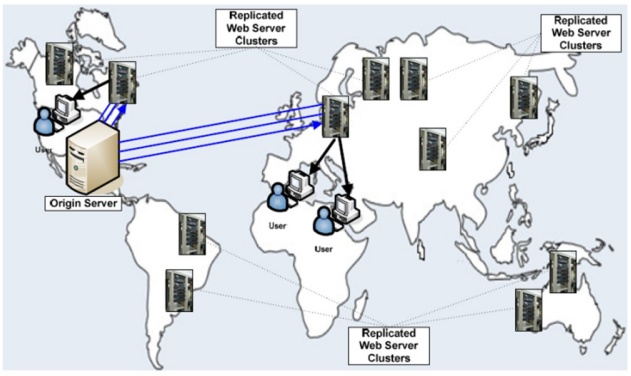

Figure 2: Abstract architecture of a Content Delivery Network (CDN)

Figure 3 depicts the different content/services served by a CDN provider to end-users [1].

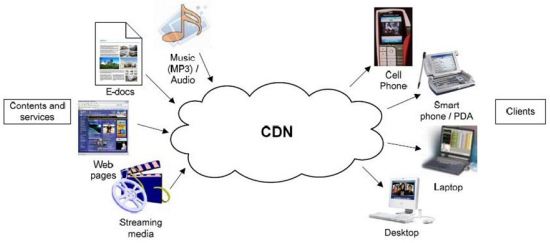

Figure 3. Content/services provided by a CDN

4. Live Streaming

Streaming media delivery is challenging for CDNs. Streaming media can be live or on-demand. Live media delivery is used for live events such as sports, concerts, channel, and/or news broadcast. In this case, content is delivered 'instantly' from the encoder to the media server, and then onto the media client. In case of on-demand delivery, the content is encoded and then is stored as streaming media files in the media servers. The content is available upon requests from the media clients. On-demand media content can include audio and/or video on-demand, movie files and music clips [1].
Streaming means sending data and this data usually is sound or video. It let users play the stream before receiving and processing the full stream and the live streaming protocols are used for control the transmission.

4.1 Components of Live Streaming

Here are the components of live streaming [6]:
- Video sources that produce the video.
- A Live encoder is a hardware/software capable of compressing the video source, in real-time, and send the

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compressed video to a media server in a specific format, using a specific protocol.
- The media server is a software that installs on a dedicated server and it is optimized/specialized in "serving" media content to the end users, through a WebTV (for example). The media server takes the compressed video supplied by the live encoder and broadcast it to the users.
- The players that connect to media server and play the content of media to clients.

5. Quality of Service in CDN

One major goal of CDN and in fact one of the reasons for its creation is increasing quality of service and customer satisfaction levels. The most important factors of increasing Quality of Service (QOS) are reducing Delay, Jitter and Packet loss. For a better understanding we will explain each of these concepts [7].

5.1 Delay

The time that a packet need to be transmit from the source to the destination in a network. It is calculated according to the following formula:

End-to-end delay=N[transmission delay + propagation delay + processing delay] (1)

In this formula “N” is the number of routers + 1

5.1.1 Processing delay

The time that the router needs to process the header of the packet to determine the next path. Processing delay in the network is usually measured in microseconds or even less [9].

5.1.2 Propagation delay

It shows the amount of time it takes for the head signal to reach the receiver from the sender
It will be calculated with the formula (2), where “d” is the length of the physical link and “s” is velocity in the medium

Propagation delay = d/s (2)

5.1.3 Transmission delay

The amount of time needed for all data packets in the wire to be sent. In other words, this delay is the given rate in the link. Transmission rate is directly related to the length of the packet, and is independent of the distance between the two nodes. This delay is calculated with Formula (3), in which “Dt” is Delay Time in seconds and “N” is the Number of bits (packet length) and “R” is the Rate, (bandwidth) in bits per second.

Dt = N/R (3)

5.2 Jitter

Jitter refers to the changes in delay, which is calculated through the variations in the length of delays in the network. A network with a constant delay rate, has no Jitter (calculated with Formula 4).

Delay jitter = Maximum time – Minimum delay time (4)

5.3 Packet loss

Packet loss means the loss of packet through transmission. One of the reasons that packet loss occurs is that the uplinks and switches of the network send more packets than the buffer packets; and another reason is the loss of connection. The easiest way to calculate packet loss is using the ping command [9].

6. Islamic Republic of Iran’s Web Site

Islamic Republic of Iran’s Web Site, with the address live.irib.ir, is the only web site in the country in the context of CDN that has shared its contents around the world. A content distribution network makes it possible for users in remote out of coverage areas to TV channels and radio broadcasting stations via their websites accessed by personal computers or mobile devices. This service must have access to the image files of the organization comply with security tips with the contacts to people around as well. The Islamic Republic of Iran Broadcasting has 6 main servers. One of the servers is in USA, two of them in Europe and also three servers in Asia and it as thirty surrogated servers which are scattered all over the continents.

7. Proposed CDN

In the short time that has passed since the birth of e-commerce in today's world, it has seen unprecedented growth in developing countries, and is predicted to expand enormously on a global scale in the near future. One of the businesses that large foreign countries have heavily invested into these days is providing CDN's, which has been described in some detail in previous sections. Unfortunately in our country so far, the company has not attempted to do this. Perhaps because of its multiple servers setup in money capital from all parts of the country, or it may be because of its high weakness of our telecommunication infrastructure or maybe because of

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uncertainty of getting this technology in the country. But given the very rapid progress of technology in our country, the existence of such technology will soon be needed and even essential. The establishment of virtual universities in the country is another advantage of advancing technologies, and as was mentioned in the previous sections, the spread of CDN in the country can be a great help to universities and scholars in increasing the quality of conduct for online classrooms. Today, using the internet to watch movies or listen to radios or other content sources has become ubiquitous, and as mentioned earlier, IRIB is the one and only content provider that uses CDN technology for distributing their media. This institution, due to the lack of CDN services in our country, resorts to using CDN from other countries. This is only ideal if a user requests content on the IRIB's website from another country, in which case they will be connected to the nearest server. If someone from Southern Iran requires access to this content, they must connect to the server in Tehran and receive their desired content despite all the difficulties and barriers, since it is all stored in a single server located in Tehran. However, if there was a CDN in the country and the content of this website were stored on the CDN's servers, this user could have connected to the nearest server containing the data, and had quicker and higher quality access to their desired content. In the next section, through the experiment that will be conducted, we will discuss whether the given suggestion will result in increased quality of service for customers or not, considering the aforementioned factors; and this suggestion will be tested on the server that IRIB's website is stored on.

8. Simulating proposed CDN in Iran

Now we simulate a CDN in Iran. The main elements of CDN architecture are [8]:
Content providers (in our simulation Islamic Republic of Iran's broadcasting), main servers and surrogates including main surrogates and sub-surrogates, and they are arranged in hierarchical order as in Figure 4.

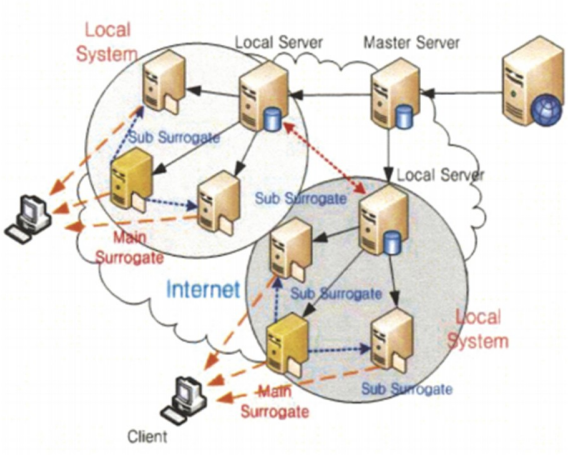

Figure 4. The Proposed Architecture of Iran CDN

This architecture is modeled from RDCDN architecture that was introduced in 2009 [8].
In this architecture, main surrogate can operate as a backup storage system controlled by local server. So, even though sub-surrogates delete their stored contents in the storage
spaces, the clients can continuously receive contents services from main surrogate, and sub-surrogates can receive the deleted contents from main surrogate to recover them without re-transmission of content provider.

8.1 Content distribution Algorithm

Content redistribution algorithm transfers contents to each sub-surrogate according to the features based on request rates of contents during the set-up time. Proposed content distribution algorithm manages all contents by grouping, and each sub-surrogate receives one content per groups at least. At that time, sub-surrogate which has the content that is the highest request rate in its group will receive the lowest content of next group [8].

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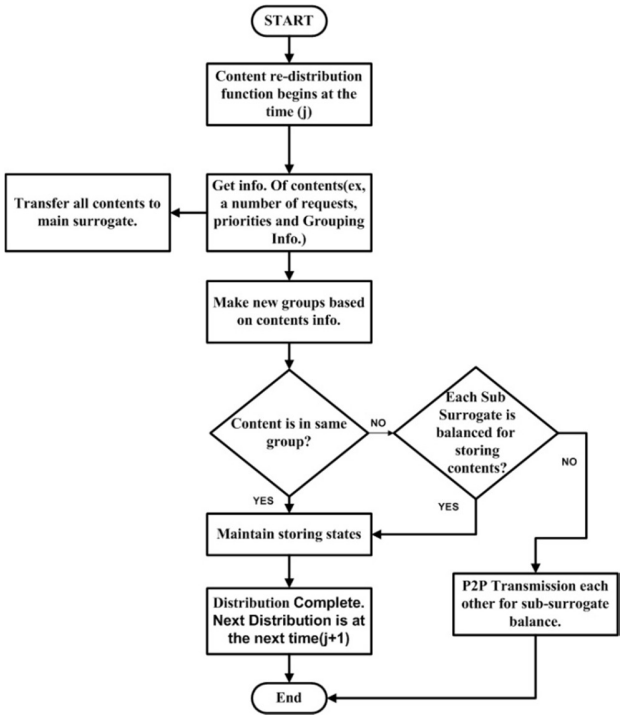

Figure 5. The Flow Diagram of Content distribution Algorithm

Figure (5) shows the flow diagram for content distribution algorithm. By this algorithm, sub-surrogates maintain their prior storing states if priority of contents is changed but group of content is not changed. Therefore, entire network load is decreased [8].

8.2 Simulating and results

To simulate the implementation of CDN in Iran and also to prove the efficiency of the offer, we consider the surrogated servers in three big cities of Iran, which are located in three different geographic areas. For example, surrogated servers are located in the cities of Tabriz, (North West), Mashhad (North-East), Isfahan (South). The main server (Media Server) of the Broadcast of Iran is located in the city of Tehran. According to the consideration of first factor in the CDN in transferring traffic, which is choosing closest server to the requested user, therefore, is expected for users to connect to the nearest server at the time of the request. In order to demonstrate the improvement in user experience in implementing this suggestion, a few users in different cities send packets to new servers and Tehran's server, which allows us to draw a conclusion and compare the new method with the person old methods using the QOS parameters. The CDNs server's physical views are shown in the figure 6.

Figure 6. CDN Server's physical location arrangement

For testing and calculation the conclusions, we consider one of the users that is located in the city of Shiraz (Fars province) in this article. Due to being closer to the Isfahan's server, it appears the connection to the Isfahan's server the user delay, takes less jitter and Packet loss than when the server is connected directly to Tehran. To ensure this issue, we connect to servers in both cities and we compare the listed parameters. To do this, firstly we send the packages with the size of 32 bytes and then the package with the size of 1024 bytes to Tehran and Isfahan servers and we extract the results. After the three main calculated factors of QOS, in Figure (7) we can see the differences of the delay when the user is closer to the nearest server (Isfahan) than to the main server (Tehran). Figure (8) can show the differences in connection of jitter when the user is closer to the nearest server (Isfahan) and the main server (Tehran).

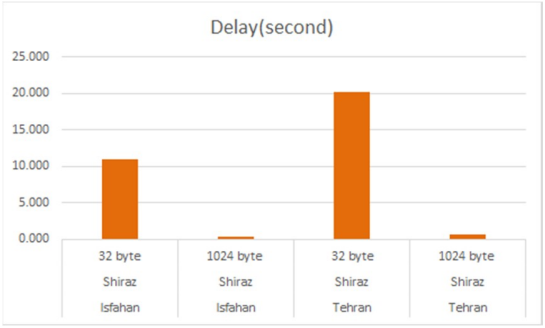

Figure 7. Delay of sending packets from Shiraz to Tehran and Isfahan's servers

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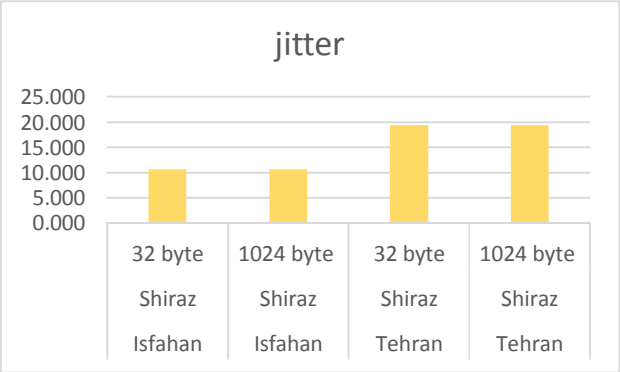

Figure 8. Jitter of sending packets form Shiraz to Shiraz and Isfahan's servers

Figure 9 shows the difference of connection of Packet loss when the user is closer to the nearest server (Isfahan) and the main server (Tehran) can be seen.

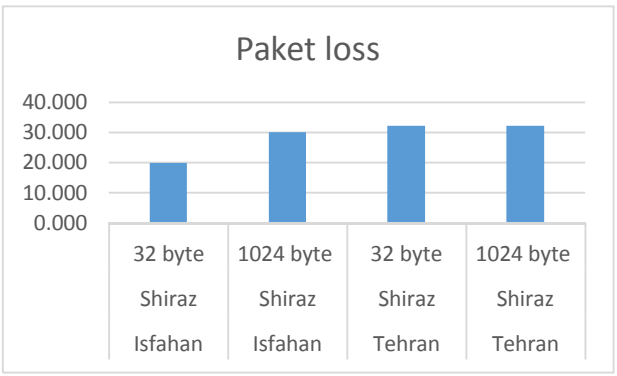

Figure 9. Packet loss of sending packets from Shiraz to Tehran and Isfahan's servers

This simulation has been tested on a few other cities and other users and the extracted results were almost the same. After reviewing these figures, it can be concluded that when the users after their request, they connect to the nearest server for receiving their content, the amount of delay of their Jitter and Packet loss would be significantly reduced.

9. Conclusion and Future work

According to the simulation, after doing the calculations, it can be concluded that the existence of CDN in Iran, when users request their content according to the existing algorithm that were introduced earlier would connect to the nearest server and consequently the amount of delay, Jitter and Packet loss will be reduced significantly. Items listed are the three basic calculations of the items of the quality of the services. So it can be said that this would enhance the quality of the services. The establishment of companies that are the founder of this technology in Iran, in addition to the benefits it has, they can make some kind of type and foster entrepreneurship in the country, and by that a very large amount of jobs can be created and also the companies can use from college graduates and professionals in the field. The above research can be extended and tested by more users in the future to ensure the function for the accuracy achieved.

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