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AN EFFECTIVE INVESTIGATION FOR QUALITY OF SERVICE ENHANCEMENT OF CONTENT DELIVERY NETWORK FOR HTTP LIVE STREAMING USING H.265

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Abstract. In the contemporary era, the prevailing trend among individuals is the widespread utilization of streaming technology to indulge in audio or video content emanating from a server. This innovative approach negates the necessity for downloading the content beforehand, allowing users to seamlessly revel in the material through the streaming mechanism. However, this cutting-edge technology mandates a substantial bandwidth to uphold its Quality of Service (QoS) at an optimal level. Challenges may arise, such as packet loss, attributed to the restricted bandwidth provided by the network service provider, thereby compromising the delivered content's quality. To address this issue, one viable solution is the integration of CDN (Content Delivery Network), a technology proven to enhance the quality of content delivered through streaming services. This research endeavors to elevate the quality of live video streaming by leveraging CDN. The HTTP Live Streaming (HLS) format for content streaming, the study empirically demonstrates that CDN significantly improves the Quality of Service. As a result, the proposed method Content Delivery Network (CDN) using H.265 plays vital role in live video streaming. The result shows that live video streaming with CDN outperforms without CDN. Specifically, the live video streaming experience with CDN showcases a remarkable throughput average of 5899.7 kbps, coupled with a minimal packet loss ratio average of 0.05%. This stands in stark contrast to the version without CDN, which exhibits a comparatively diminished throughput average of 5287.3 kbps and a higher packet loss ratio average of 0.22%. These empirical findings strongly emphasize the effectiveness of CDN in elevating the Quality of Service for live video streaming. The tangible enhancements in throughput and the reduction of packet loss achieved through CDN implementation contribute significantly to an enriched user experience. The evidence supports the notion that integrating CDN technology not only optimizes the technical performance of live video streaming but also plays a pivotal role in enhancing the overall satisfaction and engagement of users with the content delivery system.

Key words: QoS, 5G, Content Delivery Network, HTTP Live Streaming, Throughput, Packet Loss Ratio.

1. Introduction. Data consumption is increasing day by day. Demand for improved technology is growing, and as a result, network capacity will grow as well. As a result of this requirement, network technology has enabled users to experience faster data speeds with lower latency. This has encouraged users to increase their data usage even more. Digital media and video traffic are becoming increasingly important in Internet and network usage. According to the Cisco Visual Networking Index Global Mobile Data Traffic Forecast Update, video usage accounts for approximately 82% of all IP-based Internet traffic today and is expected to rise to 91% by 2025. Large-scale industry research is being done on emerging trends like wireless technology, which focuses on 5G technology [2]. Delivering Ultra High Definition (UHD) quality video to the audience is now simple with the advent of the new 5G video file codec, a High Efficiency Video Codec (HEVC) or H.265 [6]. The majority of products on the market today have high definition screens, such as 4K. In the future, this might increase to more than 8K. These cutting-edge technologies offer the framework for on-demand video or real-time broadcast alternatives to be accessed whenever and from anywhere in the world [1]. L. K. Pulasthi Dhananjaya Gunawardhana [1], discusses the scalable H.265 video standard is used in the 5G SELFNET and QoE use case for UHD video streaming. In this challenging situation, Pablo Salva-Garcia and colleagues [3] present a unique 5G-UHD framework to provide adaptive video streaming and open the door for 5G UHD streaming that is self optimization oriented. A feasibility study of live video streaming using the top video codecs (H.264/MPEG-AVC, H.265/MPEG-HEVC, and VP9) over current commercial acoustic modems is presented by Filippo Campagnaro et al. Wella Edli Shabrina et al. [4] conduct research to enhance the live video streaming experience over CDN.

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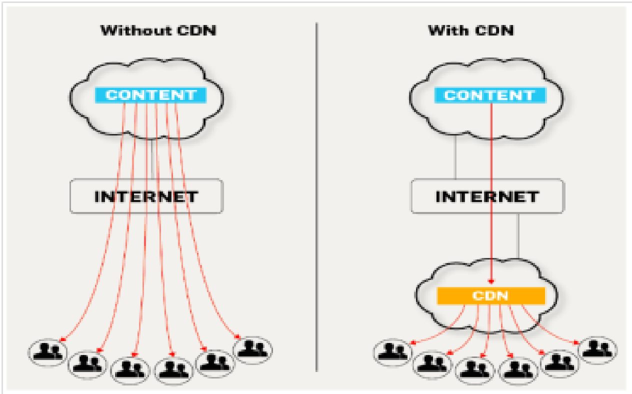


Fig. 1.1: CDN Caching Mechanism

Amazon Web Services (AWS) supports the global CDN infrastructure known as Cloud Front. For content streaming, the HLS format is used. It has been proven that CDN can raise the calibre of delivered content. The results show that live stream broadcasting with a CDN outperforms live streaming without one.

Muhammad Arslan Usman et al. [13] presented a novel no-reference video quality metric that assesses the impact of frame freezing in video streaming networks due to packet loss and delay. Because the non-live scenario is more comparable to common video streaming platforms that can use an advanced encoding process, Steve Goring et al., [10] discussed the live scenario. In general, a number of factors, including human, system, context, and others, affect gaming quality of experience, much like they do in the classic video streaming scenario. There are aspects unique to gaming video streams, in addition to more common factors like content characteristics that affect encoding or the final product quality.

One of the main goals as we move closer to 5G is to increase Quality of Experience and achieve a more dependable experience for users throughout the existing system (QoE). This paper focuses on usage of H.265 broadcasting over 5G technology. Existing works have not examined how well video services can be delivered in 5G/beyond-5G networks with variety of user arrivals or used H.265 compression properties, especially in terms of extracting the temporal inter - dependence between frames within coding structures [14].

Streaming technology is a popular method of enjoying audio or video content. Generally, high bandwidth is required for video or audio streaming. This requirement is required to prevent the content delivery service's quality from deteriorating. Some mechanisms for improving content delivery QoS could be implemented. Caching is one option. The proxy server is a technique that is similar to data caching in that it facilitates rapid data access for temporary storage by reusing data. The issue comes, though, when data, such as that connected to video material, is kept in excess of the cache's capacity. Delays are common because received video content cannot be cached. The CODEC is another element that contributes to the sending of content. It must be loaded by the user application in order for video streaming to concretize [3].

It is necessary because consumer applications, like Smartphone, sometimes have limited computing power. The architecture exists that employs a pattern similar to the proxy server, it's a Content Delivery Network (CDN). Up to now, it has been a well-liked method of enhancing video streaming services. For streaming video data, there are two possible techniques. On-demand is the first, and live streaming is the second [5].

The issue with live streaming is greater than with on-demand. This occurs because real-time maintenance is required for the delivery service. There is a common format that can be used for live video streaming, such as HLS. The mechanism of CDN is depicted in figure 1.1 [4]. It is a collection of nodes that are linked together and serve as the backbone of a computer network. A website or a video, such as streaming video, can be reproduced [5]. This streaming protocol enables direct delivery of a live video broadcast.

When client tries to access web content, CDN mechanism gets activated for main server. In response to the client's request, the server will deliver web content to the client. In addition, the origin server duplicates web content and sends it to CDNs. CDNs will update their cache storages when the content on the origin server

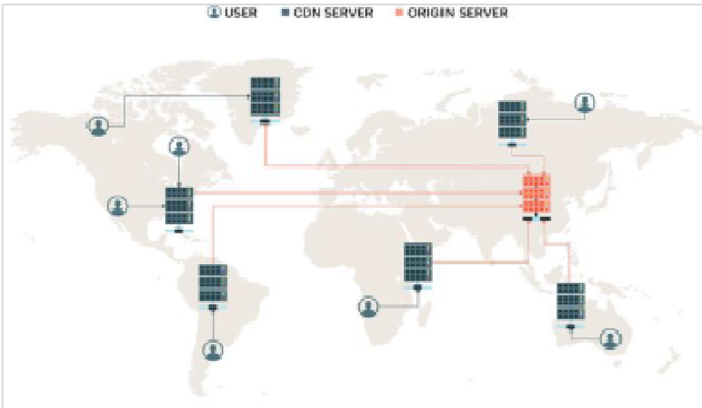


Fig. 1.2: The proposed system architecture

changes. As a result, every individual CDN server acts like a content provider but, whichever CDN close to client gets better opportunity to be service provider.

In any case, an absence of bandwidth could degrade the quality of a data and communication service. The CDN can be utilized to ensure high QoS when broadcasting live video. To reduce the likelihood of packet loss, the position should be as close to the target user's location as possible. HLS has been chosen as the live video streaming format. CDN is a set of nodes connected to each other and acts as content replication placed in the backbone of the computer network. The content replicated can be a web page or video, including media streaming [10].

The CDN mechanism is started when the client requests web content from an origin server. The server is going to respond to the client requesting by sending the web content to the client. The illustration of CDN servers is shown in figure 1.2. In addition, the origin server produces the duplications of the web content and it forwards them to the CDNs. Every content changing in the origin server, it is going to be updated by CDNs in their cache storages. So, each CDN server can act as a content provider. However, the CDN closest to the client has a bigger chance to do the service.

By performing CDN, the requested content placed is not as far as to the origin site, but it is in the nearest CDN server. The H.264 video compression standard has been utilized for the past 14 years in (CDNs) all over the world to enable quick, widespread, and affordable video encoding.

2. Problem Definition. A difficult service is live video streaming. It requires ongoing attention to its packet delivery process. Getting the latest news from other countries or around the world is a desire for people who live abroad. However, very few companies use live transmission. This study makes use of live HLS streaming video. The CDN infrastructure is carried out to uphold the quality of the sent content using AWS Cloud Front. Throughput and packet loss ratio are the primary study findings. When using a CDN, the transmission of live video streaming using the H.264 codec has an average throughput and an average PLR. Without a CDN, it offers average throughput and average PLR, which are insufficient for live streaming in a 5G network.

3. Proposed System. This investigation delves into the HLS live video streaming service, with a specific focus on two contrasting schemes: one integrating CDN and the other without, facilitating a comprehensive comparison of their functionalities and outcomes. Wireshark is used to monitor the two systems (with CDN and without CDN) performances. Wireshark is a tool used to sniff message live broadcasts in a network. For observational purposes, the recorded data can be examined. Throughput and PLR are the variables that the study explores. The figure 3.1 depicts the setup comprises a video recording camera as its foundational element. The captured video undergoes a transformative process involving encoding and conversion facilitated by OBS and AWS MediaLive.

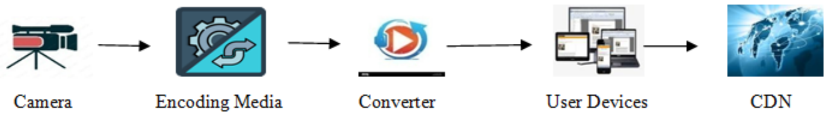


Fig. 3.1: The illustration of CDN servers

Subsequently, the processed video is directed through AWS MediaStore, adopting the HLS (HTTP Live Streaming) video output format for optimal delivery and compatibility. This sequential workflow ensures a comprehensive and efficient handling of the recorded video content, leveraging a combination of OBS and AWS MediaLive technologies within the AWS ecosystem. For encoding purpose H.265 with Lagrangian Encoder is used. AWS MediaLive will be used to encode and transcode the footage.

An AWS MediaStore will then process the video and output it in HLS format. The CDN is utilized as a content delivery cache. Live streaming is the mode of transmission.

- The international CDN service is AWS CloudFront, and AWS is the cloud service provider used.
- With a frame rate of 30 frames per second, the encoded streaming video has a resolution of 1280x720. The protocol input is Real-Time Messaging Protocol (RTMP) (H.264), which typically operates at a bit rate of 4500 kbps [14]. The transmission protocols utilized for output are RTMP and HLS. Using AAC and 44.1 KHz, the audio is encoded.
- Customers consume 48 Mbps and 110 Mbps of bandwidth (upload). A Windows 2016 AWS instance of the t2.micro type is running and being used by the clients. For downloads, the broadcaster uses 18.1 Mbps, and for uploads, 5.8 Mbps of bandwidth. [5].

3.1. The Evaluating Scenarios. The first scenario involves performing HLS live broadcasting in the network without the use of a CDN. Direct data transmission from the broadcaster to the specified target client. The global CDN architecture is implemented in the second scenario. During live streaming, the CDN will reconstruct the content and send it to the client. Wireshark is used to record both the throughput and the PLR [5].

3.2. Parameters for Assessment. Several parameters are used to assess CDN performance. Wireshark is a tool that is used to capture packets. Among the parameters investigated are:

- The number of packets delivered to a client in a specific amount of time is referred to as throughput [8, 9, 10].
  The formula for throughput is:
  $$\text{Throughput} = x^* \times \left| \frac{\text{Amount of data delivered}}{\text{Duration of time}} \right| \tag{3.1}$$
  where $x^* = argmin_{x \in X} D + \lambda R$

  For a constant that determines the trade-off between distortion D and number of bits R, the Lagrangian parameter x is minimized [11].

- Packet Loss Ratio (PLR) measures the number of lost packets in relation to the number of delivered packets [9]. The formula for packet loss is:
  $$Throughput = x^* \times \left| \frac{P_l}{P_t} \right| \times 100 \tag{3.2}$$
  where $x^* = argmin_{x \in X} D + \lambda R$
  P_l = The number of lost packets.
  P_t = The transmission's packet number.

Table 4.1: The Throughput with CDN

Evaluation Scenario Observations	**Throughput(kbps)**	
	H.264	**H.265**
1	4862	5326
2	4952	5447
3	4741	5215
4	4721	5193
5	4781	5259
6	2878	3166
7	5449	5994
8	3368	3705
9	4623	5085
10	4171	4588
Average	4452.6	4897.8

Table 4.2: The Throughput without CDN

Evaluation Scenario Observations	**Throughput(kbps)**	
	H.264	**H.265**
1	1567	1724
2	4932	5425
3	5265	5792
4	5242	5766
5	5212	5733
6	4325	4758
7	3537	3891
8	4700	5170
9	1956	2152
10	3168	3485
Average	3990.4	4389.6

4. Results and Discussions. By putting the evaluation scenarios into practice, the thorough evaluation of HLS streaming live video is carried out. Each observation lasts for 5 minutes, and each assessment is performed 10 times.

4.1. The comparison of throughput recorded with and without a CDN. The table 4.1 displays the throughput recorded at the client location:

According to Tables 4.1 & 4.2, when the CDN architecture is used, the result of throughput for the HLS video format is greater than when the CDN architecture is not used. HLS live broadcast throughput with CDN is 4897.8 kbps on average. Conversely, HLS live broadcasting content delivered without a CDN has an average throughput of 4389.6 kbps.

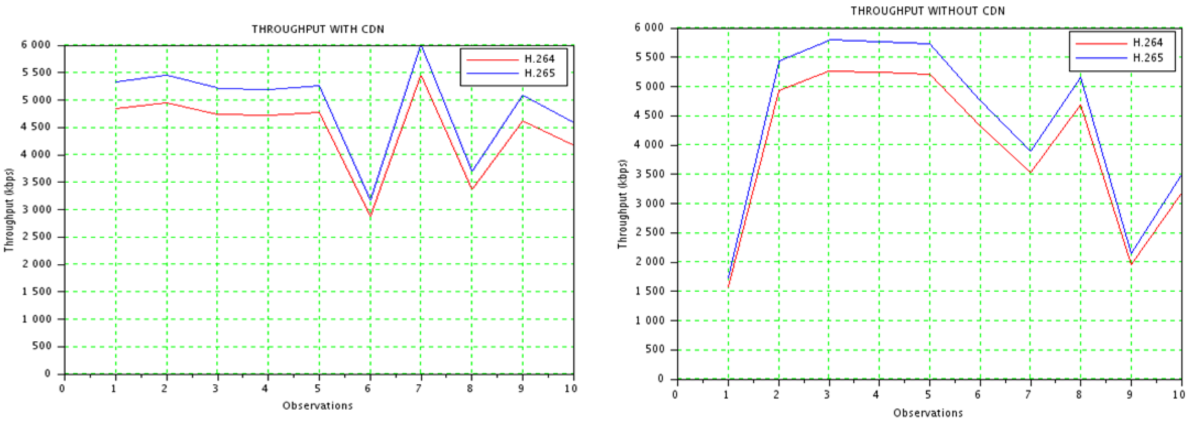
A summary of the average throughput for HLS live broadcasting is shown in figure 4.1.

4.2. The comparison of PLR recorded with and Without a CDN. The table 4.3 displays the PLR recorded at the client location:

Table 4.3 & 4.4 demonstrate that when the CDN architecture is used for the HLS video format, the PLR result has a lower value than when it is not used. With CDN, the average PLR for HLS live broadcast is 0.072%. The average PLR for HLS video format without a CDN is 0.297%.

A summary of the average PLR for HLS live broadcasting is shown in figure 4.2.

5. Conclusion. The deployment of H.265 in conjunction with CDN integration is shown to significantly enhance the Quality of Service (QoS) in video streaming. This combined approach effectively reduces packet loss



(a) Throughput with CDN (b) Throughput without CDN

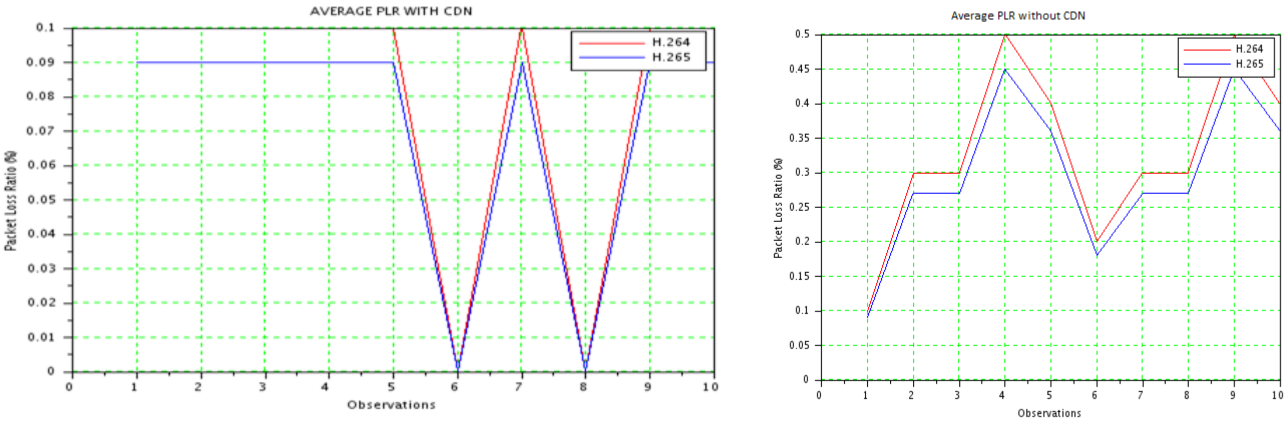
Fig. 4.1: Throughput average

Table 4.3: Average PLR with CDN

Evaluation Scenario	**Throughput(kbps)**	
Observations	**H.264**	**H.265**
1	0.1	0.09
2	0.1	0.09
3	0.1	0.09
4	0.1	0.09
5	0.1	0.09
6	0	0
7	0.1	0.09
8	0	0
9	0.1	0.09
10	0.1	0.09
Average	0.08	0.072

Table 4.4: Average PLR without CDN

Evaluation Scenario	**Throughput(kbps)**	
Observations	**H.264**	**H.265**
1	0.1	0.09
2	0.3	0.27
3	0.3	0.27
4	0.5	0.45
5	0.4	0.36
6	0.2	0.18
7	0.3	0.27
8	0.3	0.27
9	0.5	0.45
10	0.4	0.36
Average	0.33	0.297



(a) Average PLR with CDN

(b) Average PLR without CDN

Fig. 4.2: Average PLR

and optimizes throughput, resulting in a superior network performance for all parties involved. The utilization of AWS CloudFront, a pivotal component of the global CDN infrastructure, emerges as a strategic choice for elevating the performance of live video streaming. In comparison, the absence of CDN in HLS live video streaming is likely to result in a less efficient and inferior service delivery.

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