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Research paper

Multicast Stream Builder Based Video Service Using Adaptive Bitrate Streaming and Content Delivery Networks

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Abstract

Currently, the delivery of multimedia content like video and live programs, not only happens via cable networks and DTH (direct to home), but are increasingly moving towards IP (internet protocol) based delivery of multimedia content. Consumers today may seek for a personalized & interactive video watching experience. MPVDs (Multi-programming Video Distributors) are increasingly switching to IP based video or any multimedia content delivery, to build an immersive video viewership base. MVPDs provide both live and on demand video services to consumers based on both subscription and transactional business models. Even though MPVDs are gaining in market share and provide a large volume of video services today, there are still several challenges that they need to overcome such as network congestion due to the downstream network bandwidth, unpredictable network loads since in most cases the MPVDs do not control the network they deliver content. Also, improving the access to network bandwidth alone will not solve the problem of network congestion, since the “core” and “aggregate” networks usually have fixed bandwidth pipes. However, in spite of several advancements in multimedia content delivery technologies, delivering best-in class video quality over IP networks, especially for live video streaming, still presents a host of challenges. Significant amongst these challenges are network delays/jitters and packet losses due to network congestion. Across any multimedia content delivery pipeline, a multimedia content streaming losses occur in the network where the content is delivered from the CDN (content delivery network) edge caches to consumer devices viz. mobile phones, tablet form factors, Smart TVs and/or STBs.Moreover, it is much more tedious and cost prohibitive to perform regular network upgrades for bandwidth expansion.MPVDs (Multi-programming Video Distributors) are increasingly switching to IP based video or any multimedia content delivery, to build an immersive video viewership base.

However, in spite of several advancements in multimedia content delivery technologies, delivering best-in class video quality over IP networks, especially for live video streaming, still presents a host of challenges. Significant amongst these challenges are network delays/jitters and packet losses due to network congestion. Across any multimedia content delivery pipeline, a multimedia content streaming losses occur in the network where the content is delivered from the CDN (content delivery network) edge caches to consumer devices viz. mobile phones, tablet form factors, Smart TVs and/or STBs. Adaptive Bitrate Streaming (ABR) partially addresses the streaming challenges on networks with uncertain bandwidth. The core problem of preventing downstream network congestion due to an increased traffic in proportion to a number of users (streams increases proportionately with increase in user request) and consequently there is a reduction in available bandwidth. ABR is largely a mechanism that helps improving user perception of content quality, in networks with uncertain bandwidth by switching to lower bitrate streams smoothly but does not address the core problem of minimizing traffic congestion for live streaming. Further, unlike on demand streaming over IP, live streaming does not necessarily require dedicated unicast streams all across the delivery networks, typically 1 per user per device. This system of unicast delivery may be avoided. Currently, live streaming techniques such as ABR relies on HTTP as a streaming protocol. Though HTTP based streams can easily be delivered over CDN (Content Delivery Networks) through cache-replication, they render themselves difficult to be delivered over multicast (UDP based protocol).

So, this paper introduces a Big Data Analytics driven SDN based multicast based stream builder video service that monitors real time video quality of service associated with a bit rate traffic from a plurality of client devices, wherein the quality of service associated with the bit rate traffic are associated with a plurality of network topologies. Our system ensures that multicast delivery of ABR profiles be made available as closer to the user as possible, by polling the network conditions and user activities, and making the network components programmable to ensure the delivery. The state of the network conditions, ABR profiles being served to users, number of concurrent streams being delivered at any time are all fed back to the Big Data analytics system in real time. Intelligent real time insights from the Big data analytics platform are fed to the SDN controller ensures that video streams are fetched through the most optimal multicast route to ensure optimal video delivery to clients.In addition to this, this paper introduces a system to create/update existing multicast network rings to optimally route traffic ensuring better video QoS for subscribers. It also dynamically adapts to prevailing network conditions and active decisioning to construct optimal end to end multicast traffic throughput driven by the SDN controller.Thus the process helps to improve the quality of the video also minimize the network congestion problem when compared to the traditional video services provide method. The excellence of the system is evaluated with the help of experimental results and discussions. Thus the multicast stream based content delivery networks with bitrate profile live video transmission process obtained 97.8% accuracy when compared to the traditional Cloud-based Video Streaming Service (CVSS).

Keywords:*Over the Top Video Streaming Service, Multi-Channel Video Programming Distributor (MVPD), content delivery networks (CDN), Multicast video streaming, network congestion.*

1. Introduction

Broadband & broadcast Video delivery plays an important role in different ecosystems, it has been provided by different distributors based on user subscription. Depending on the various distributors, one of the leading Multichannel video programming distributor (MVPD) [1] United States that typically provide more than one channel to the user based on the user subscription. The distributor includes [2] the satellite provider, direct broadcast, wirelinevideo provider, television systems and so on. These distributors request the video service from the distributed server for making the one of the effective video service delivery process. Among the various distributed servers, content distribution network [3] in one of effective geographically located network which has collection of high availability and high performance videos in the form of text, graphic, scripts, internet content and web objects and so on. This CDN has to deliver video and data services in terms of cloud intelligence, multi-CDN switching process, CDN performance, caching and load balancing process. The main intension of the video service process is to deliver the quality of services [4] to the client depending on the requirement. During this process, the network faces several issues such as downstream network congestion, limited bandwidth utilization also, the quality of the live video service is difficult to predict.

So, several traditional techniques [5] such as cloud video stream service (CVSS), Software Defined Networking (SDN) and so on has been used to provide the live video service to the user for maintaining the quality of video services. Based on these methods different researches opinions are discussed as, XiaoyuDuan et al., [6] developed software defined networking resource management procedure for managing the networks while allocating the resources to the offloading traffic in the WI-FI network, establishing the quality requirements to the user. The author developed SDN system effectively examines the resources based on the user requirements with effective manner. Then the efficiency of the system is analyzed with the help of experimental results that is compared with the partial data offloading algorithm. V. Vasanthi et al.,[7] examined various digital device service based user request in the cloud environment. During the analysis, the system utilizes the different streaming servers, streaming software as services for providing the services to the user with effective manner. These streaming based services examine the quality metrics, resource information while allocating the services to the user request. Then the excellence of these streaming services is analyzed using the experimental results.

Wei Chen et al.,[8] developed the closed loop approach based video streaming process for satisfying the user request also maintaining the quality of the services with reasonable cost. The loop approach successfully monitors the data center according to the feedback of the video stream services which helps to provide services depending on the user's demand just in time. The feedback from the customer is continuously examined for avoiding misleading services in the multi-cloud environment. Then the efficiency of the services is examined in terms of quality as well as cost. Then the author introduces a system that maintains the video quality with minimum cost. SaurabhGoel et al.,[9] investigating the cloud video stream services in the mobile aspects such as iPhone, Android, Smart Phones, Blackberry phones and windows. This process analyzes the user request and the request based video path has been collected from the central data center. The collected information is compared with the user demands and optimized service is provided to the user for making the effective cloud services via the mobile platform. According to the various discussions, cloud stream services provide effective online video services to the user based on the demands. Even though the streaming methods provide excellent service, the network bandwidth, cost and time is still one of the major difficulties which are need to be considered while establishing the services. The core problem of preventing downstream network congestion due to the increased traffic in proportion to the number of users (streams increases with increase in user request) and consequent reduction in available bandwidth is still being addresses in silo. ABR is largely a mechanism that helps improving user perception of video quality, in networks with uncertain bandwidth by switching to lower bitrate streams smoothly but does not address the core problem of minimizing traffic congestion for live streaming. Further, unlike on demand streaming over IP, Live Streaming does not necessarily require dedicated unicast streams all across the delivery networks, typically 1 per user per device. Current live streaming techniques such as ABR relies on HTTP as a streaming protocol. Though HTTP based streams can easily be delivered over CDN (Content Delivery Networks) through cache-replication, they render themselves difficult to be delivered over multicast (UDP based protocol). So, in this paper introduces a system for optimizing live video delivery in a bandwidth constrained downstream network.This system distributes live and on-demand video through active subscription to multicast ring networks on the core-aggregate & network access layer based on not only user consumption and state of network traffic but also factors in video QoS experience of usersbased on a SDN controller that leverages Big data analytics for real time insights on video traffic in the multicast network and viewership behavior.This system leverages existing CDN networks to deliver ABR video profiles to the edge and use multicast to stream video on core-aggregate-access networks based on active network conditions and state of traffic at that point in time monitored through SDN controllersThe method establishes the services using the bitrate profile values and the excellence of the system is examined using the java platform based results. Then the rest of the paper is organized as follows, section 2 deals that the Adaptive Bitrate Streaming and Content Delivery Networks based Video Service Deployment model, section 3 evaluates the efficiency of the live video service system and concludes in section 4.

2. Adaptive Bitrate Streaming and Content Delivery Networks based Video Service Deployment

In this section we discuss the Big data analytics driven SDN controller based Multicast Live Video service deploymentwhereLive HTTP based ABR streams are delivered by the media encoder-packager systems over to the CDN origin (currently deployed architecture on most video delivery networks). Further, Multicast server is adapted to transmit sets of video streams to media devices via connection or network. The method works according to the concept of the multicast video stream process [10] which fetches the video frames from the content delivery networks because it is one of the geographically distributed in the different servers that includes the collection of video service and other data's such as media files, text, graphic, script, software documents, live streaming media and on-demand streaming media services. The fetched video services are processed by applying the multicast video stream master, slave and client with effective manner. The processing video service high level structure is shown in the following figure 1.

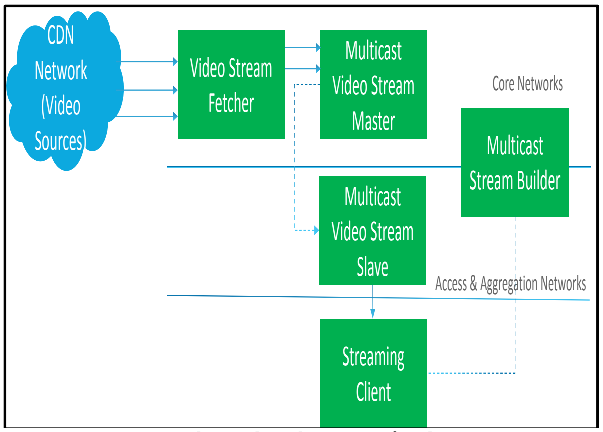

Figure 1: High Level Architecture of Video Service

The above figure 1 represents that the sample block diagram of the optimized live video delivery bandwidth constrained downstream network. The system includes the collection of components such as memory, processor, volatile memory, readable medium, random access memory and so on which helps to process the user requests with effective manner. During the process, the network uses the video streaming technologies along with the Adaptive Bitrate Streaming based media content delivery process which is done by using the multicast server. The server includes the various media devices that connected via the network; each and every component has been explained as follows.

Video Stream Fetcher Module:

This module is hosted in the "CORE" network, pulls all the individual ABR profiles from the CDN origin and cache all the individual profiles.

Multicast Video Stream Master Module:

The master module adapt with the multicast video channel that includes the ABR profile rate. In addition to this, the master module works depending on the software defined network (SDN) [11] that collect and monitor the entire network details which is aggregated with the core network information. This module service reside in the "CORE" network, and is adapted to streams multicast video channels for all individual ABR profiles viz. 1 channel per bitrate profile. Further, it publishes the video master manifest information that provides map of multicast channel versus video bit rate profiles mapped for each video channel that is being streamed.

Multicast Stream Builder

This module is based SDN Controller for monitoring the entire "CORE", "Aggregate" & "Access" networks constantly to profile the video traffic demand from users. It fuses this profile information with the real time traffic insights coming in from the SDN enabled switches and routers in the "Core", "Aggregate" & "Access" networks through pre-defined business rules. It determines which aggregate and access nodes to notify for subscription to the multicast channel services specific to the video being requested.

Multicast Video Stream Slave Module

This module services residing in "Aggregate" and "Access" networks subscribe to the multicast channels(corresponding to ABR profiles) of the video channel and cache the video profiles corresponding to the user demand and available network bandwidth [12]. This module also update the master manifest with new multicast slave server IDs corresponding to the ABR profiles and pass it down to the clients.

Streaming Client Module

This module or app on the end customer device determines the optimal bitrate profile to stream content based on heuristics from its available network bandwidth and CPU & buffer usage [13]. Based on the above modules or component details, the working process of the bitrate profile rate based video service establish process is explained as follows, that has been used to reduces the network congestion with effective manner [14].

Steps for optimizing live Video Delivery in a bandwidth constrained downstream network

This section discusses about the detail steps regarding the optimized live video delivery process along with the bandwidth constrained downstream network consideration.

Step 1: Analyze the Content delivery networks and get the bitrate profile information and buffer all individual profile values.

Step 2: Collected profile information has been fed into the multicast channel for mapping the each video channel to steaming process.

Step 3: Monitor the user demands and maintains the core, aggregate and access value depending on their demands

Step 4: Then multicast video stream slave subscribe the channel of live video channels.

Step 5:Analyze the network bandwidth, CPU usage, buffer size and determine the optimal bitrate profile from the collection of ABR profile.

Step 6:retrieve the live video service from the multicast server according to the optimal bitrate profile depending on the user demands.

Step 7: At last the selected stream has been delivered via the RTP/RTCP protocol which guarantees the quality of the services in terms of "Exits before Video Start", Rebuffering Ratio, Average bitrates being streamed etc by Multicast Video Master and Slave services at the "CORE", "Aggregate" & "Access" network layers.

Thus the above process successfully delivery the live video services in the defined bandwidth process also minimize the downstream network congestion process. Then the implementation process of the content delivery network based bitrate profile video service process has been developed as follows.

3. Implementation Process of Optimized Live Video Streaming Process

1. *Analyze the Content delivery networks and get the bitrate profile information and buffer all individual profile values-* The ABR streams get delivered over the CDN. The Video Stream Fetcher talks to the Video Stream Master to figure out which profiles are being streamed the most and device platforms that are actively streaming. It then pulls the corresponding ABR profiles from CDN origin and caches

these individual profiles so that multicast channels can be created for these individual profiles.

2. *Collected profile information has been fed into the multicast channel for mapping the each video channel to steaming process*-The Video Stream Master is a SDN controller based application that has the current view of the entire CORE-AGGREGATE & ACCESS network and builds a map of multicast channels being streamed concurrently at any point in time. It also publishes the video master manifest information that provides map of multicast channel versus video bit rate profiles mapped for each video channel that is being streamed
3. *Monitor the user demands and maintains the core, aggregate and access value depending on their demands*-Multicast Video Stream Master tracks the video bitrate profiles that are most actively streamed along with device platform profile information. It also maintains a real time view of network latencies, packets per second, active versus inactive multicast routing nodes, failed nodes, video throughput and video frame losses in the network, which is leveraged by the Video Stream Builder Service, load on each multicast server, no of active versus available multicast servers, popular titles and channels being watched, no of concurrent and active subscribed users on each multicast group etc. Additionally, it Monitoring the entire "CORE", "Aggregate" & "Access" networks constantly to profile the video traffic demand from users.
4. *Multicast video stream slave subscribes to the channel of live video channels*- The multicast stream builder creates the multicast channel and provides the master manifest containing network topology to traverse, multicast server Ids per profile to Multicast Video Stream Slave. Multicast Video Stream Slave maintains a current view of no. of clients subscribed to each multicast channel and makes new subscription to multicast channels from Stream Builder based on available bandwidth and content popularity.
5. *Analyze the network bandwidth, CPU usage, buffer size and determine the optimal bitrate profile from the collection of ABR profile*-The Multicast Stream Master also instructs the multicast stream Slave to provide real time information on video QoS such as exits before video start, rebuffering ratio, average bit rate, concurrent streams played etc as part of the RTP/RTCP session reports. This is used by the Video Stream Master to maintain a real time Video QoS state across all multicast video channel groups. It publishes a master manifest with updated set of multicast server Ids on the aggregate-access networks and the network topology to traverse for the streaming clients.
6. *retrieve the live video service from the multicast server according to the optimal bitrate profile depending on the user demands*- Video Streaming client subscribes to the appropriate multicast channel group from the master manifest file published by multicast Stream Slaves based on available bandwidth and starts receiving the channel/program/movie stream
7. *selected stream has been delivered via the RTP/RTCP protocol which guarantees the quality of the services in terms of "Exits before Video Start", Rebuffering Ratio, Average bitrates being streamed etc by Multicast Video Master and Slave services at the "CORE", "Aggregate" & "Access" network layers.* – Multicast Video Stream Slave creates multicast streams based on available bandwidth. However based on client session reports on video QoS parameters such as exits before video start, rebuffering ratio, avg bit rate, concurrent plays, multicast network delays/jitters, stability of multicast route path, relative cost of network deliveryetc it creates new multicast streams making adjustments to ABR profiles to stream based on available bandwidth and network traffic conditions.

Thus the above process successfully develops the multi-cloud solution framework for delivering the quality of video services in low cost as well as minimizes the downstream network based congestion problem [15]. This bitrate profile and content delivery network based process improves the overall live video delivery efficiency with effective manner [16]. The excellence of the system is evaluated with the help of experimental results and discussions which is explained as follows.

Results and discussion

The excellence of the Big data Analytics driven SDN controller based Video Service Deployment process has been evaluated in this section. During this process following experimental setup has been used.

Table 1:. Parameter

Parameter	Original video file	Transcoded video file
Frame rate	29.97 fps	29.97 fps
Resolution	1280 × 720	320 × 240
Duration	3 min 19 s	3 min 19 s
Size	200 MB	60MB
Container	AVI	MP4
Codec	XviD	MPEG-4

The described experimental setup helps to analyse the content delivery networks based optimized live stream video process with reasonable time, cost and space. In addition to this, the error rate has been analysed for examining the efficiency of the system. The live video stream process has been implemented with the help of Java with JDK 1.6. which uses the java virtual machine with 1.55 GB runtime memory. Along with this memory, the system utilizes the 1.8GHz AMD process with Linux Server. According to the above experimental setup process, following metrics [12] are used to determine the excellence of the system.

$$\boldsymbol{TPR} = \frac{\boldsymbol{True\ Positive}}{\boldsymbol{True\ Positive\ False\ Negative}} \quad (\mathbf{1})$$

$$\mathbf{F}\boldsymbol{PR} = \frac{\boldsymbol{False\ Positive}}{\boldsymbol{False\ Positive\ True\ Negative}} \quad (\mathbf{2})$$

According to the above metrics, the obtained error rate of the CDN and ABR based video streaming process has been shown in the following figure 2.

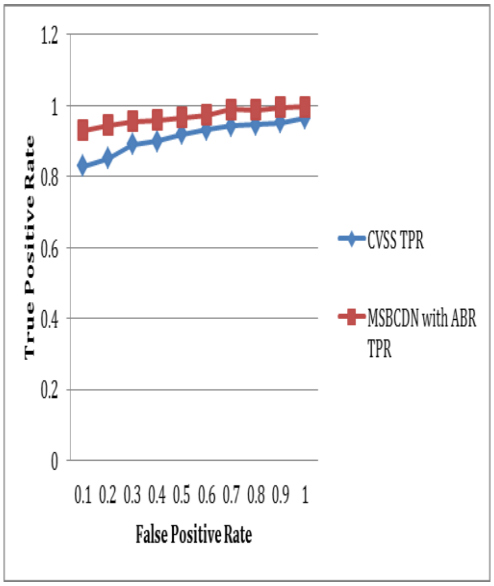

Figure 2: ROC Curve

The above figure 2 explains that the ROC curve of the transmitting video in the multicast stream based process. The introduces multicast stream based content delivery networks with arbitrate profile process successfully delivers the optimized video with minimum error rate when compared to the Cloud-based Video Streaming Service (CVSS). The minimum error rate leads to improve the overall accuracy of the video transmission which is shown in the following figure 3.

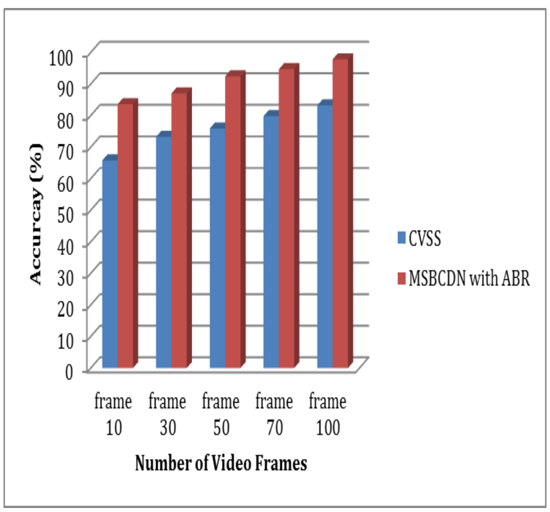

Figure 3: Accuracy

The above figure 3, describes that the accuracy of multicast stream based content delivery networks with bitrate profile live video transmission process of different frames. Then the proposed MSBCDN with ABR method ensures high accuracy from 83.6% to 97.8% accuracy of different server when compared to the Cloud-based Video Streaming Service (CVSS) method. Even though the method consumes minimum error rate and accuracy, the method must be transmit the video with minimum time and delay which is shown in the following figure 4.

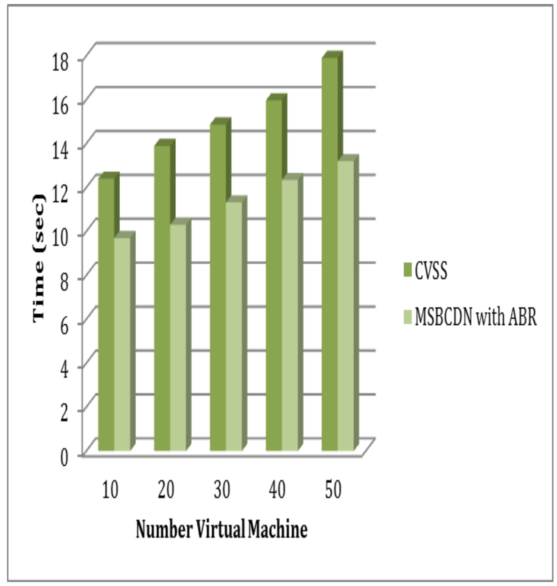

Figure 3: Time

Thus the above figure 3 clearly shows that the MSBCDN with ABR method successfully maintains the time while delivers the video using the different number of virtual machine when compared to the other Cloud-based Video Streaming Service (CVSS) method.

4. Conclusion

Thus the paper analyzes the Adaptive Bitrate Streaming and Content Delivery Networks based Video Service Deployment process. Initially all individual profile has been collected from the content delivery networks which have been stored in the buffer that used to process the multicast stream client request. The collected profile information has been analysed in terms of core, aggregate and access terms which are arranged in the optimized manner for providing the services to the client. Along with the descriptions, the network bandwidth, CPU usage, memory has been examined which helps to transmit the live video without making the delay to the customer. Based on the criteria, the user requested video is fetched which is transmitted to the user via the Rebuffering process and RTP/RTCP protocol. Thus the MSBCDN with ABR method consumes 97.8% accuracy while transmitting the video to the multicast stream client with effective manner.

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