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Broadcasting systems: A focus on quality internet video broadcast

*AlaoRithwanOlatunji
Corresponding Author: AlaoRithwanOlatunji

Abstract: *Video compression, streaming options for video server, quality of service and securing video content are very important when it comes to internet streaming. Although computers are capable of processing large data, it is impractical for large video files to be stored and streamed over the internet because these require large storage space, processing time and bandwidth. Therefore it is ideal for video files to be stored in a format that requires smaller space compared to the actual file as this improves the efficiency of video streaming and supports the techniques used in maintaining the quality and the security of video files. In this paper, we discussed how quality and reliable broadcasting of video over the internet can be achieved while considering video compression, streaming option for video server, quality of service and the security of video content.*
Keywords: *Compression, Streaming, QoS, Security*

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I. INTRODUCTION

Video and audio are the generally accepted natural way of communication between different parties. This has encouraged the development of technologies that allow video streaming over an IP network. Many companies and people transport videos while making use of the internet and this keeps increasing the popularity of video broadcasting. Several companies have now moved from the popular VCD and DVD based video delivery system to internet video delivery systemeither for entertainment or educational purpose. As the number of internet video consumers increase every day, the need for companies providing this service to provide them with quality video with no errors noticeable by the consumer and to meet up with individual requirement of each and every consumer [1]. To achieve this, issues such as how the videos are being compressed, video streaming, security of the video content and provision of satisfying quality of service while the video is being transported from the provider to the consumer becomes very importance. With compression, the actual size of a video content can be reduced to a smaller size and this helps reduce the processing time require for streaming to be completed. Since the internet is designed to support several traffics, quality of service must be considered so that video traffic which is sensitive to delay can be prioritized over other traffic when moving across the internet. The internet remains an open technology that can be easily accessed by several users with both good and bad intensions,therefore, providing adequate security during streaming to prevent unauthorized access is necessary.

II. VIDEO COMPRESSION

Without the compression of video images which are moving images, it would have being impossible to transport videos across the internet. This is because video images utilise a lot of space and require much bandwidth when video files are transmitted in the original format. Therefore compression which is the process by which encoding techniques are used to reduce the amount of video data to be transported is very important in any form of video streaming [8]. Decoding software such as Web browser, VLC and Windows media player can then be used to view the video on the consumers end. Basically, compression can be lossy or lossless and comes in various techniques. For example **"HHHHAAAA"** can be reduced to **"4H4A"**. This is considered as a lossless compression because the file can be restored back to its original format without losing any data and this is mostly used in compressing text or executable files in which any loss will make the actual information meaningless when decompressed [12]. However, video compression is considered aslossy because some information will be missing when the files are being decompressed back to its original format. This is because codecs used in video compression take advantage of the fact that human eyes are less sensitive to differences in colour compared to differences in brightness. Therefore the changes caused by the lossy compression are not noticeable. There are different types of video compression but MPEG-2, MPEG-4 and H.264 are discussed in this paper.

MPEG-2: This succeeded MPEG-1 and has being widely used for DVD production and television broadcast. MPEG-2 offers a high video quality with less bandwidth. This is possible because it uses a temporal compression by compressing a video over time between frames compared to compression of a frame as a unit [3]. It encodes signals up to 180 times compared to the actual size and the original size can be viewed by an end user by decoding it through available set-top box, PC or phone. This has help broadcasters to transmit about 10 times the service they use to offer without an additional requirement for bandwidth.

MPEG-2 is a lossy compression technique that specifies different levels and profiles which allow users to decide the degree of compression they require to support their applications. The level determines how many pixels per frame and refers to the screen size and resolution. These levels are:

Low level- supports 352pixels by 288lines picture size at 4Mbps maximum.
Main level- supports 720pixels by 572lines picture size at 15Mbps maximum.
High-1440 level- supports 1440pixels by 1152lines picture size at 60Mbps.
High level- supports 1920pixels by 1152lines picture size at 80Mbps.

The profiles determine how complex the encoding will be. They include simple, main, 4:2:2, signal-to-noise ratio (SNR), spatial and high profile.

MPEG-4: This is an open global standard with tools for multimedia delivery. This compresses multimedia video and audio using lesser bandwidth and small file size for transmission across the internet or over an IP based network while making use of digital media devices such as broadband set-top box for high definition television (HDTV), PDA and cell phones to access the content.

MPEG-4 is built on two standards which are MPEG-4 part2 video codec which offers better efficiency of compression with improved coding tools compared to previous video standards and Advanced audio coding (AAC) audio codec which offers better compression than MP3 and still delivers a good quality like an uncompressed audio file with a low bandwidth utilisation despite that it is a lossy compression [6]. MPEG-4 is highly utilised in application areas such as Digital TV, TV production, Mobile multimedia, games etc. and it is the first standard designed for video streaming over the internet. It is also useful for video storage on blue-ray disk. All these attributes makes MPEG-4 a better compression technique compared to MPEG-2 and it's still undergoing series of development.

H.264: This is also referred to as MPEG-4 part 10 or Advanced Video Coding (AVC) and it is another standard for Video compression in the MPEG Family [6]. It is a powerful set of compression technique for natural images with more efficient compression. This is the most recent video coding standard. It has an efficient and improved coding performance compared to the previously discussed MPEG-2 and MPEG-4. This is as a result of new techniques implemented into it. With these techniques, it is capable of compressing at half the size of MPEG-4 compression and still provides a quality video with a low bit rate. It is widely used for blue-ray disc. Most internet video streaming web sites such as YouTube uses H.264 [9]. It supports many applications such as Adobe flash player, windows media player, VLC player and also supports High Definition Television (HDTV) broadcast.The real fact is most media players now support H.264 generally. It has four profiles described below.

Baseline profile- offers little processing rate. Used in mobile TV and video conferencing
Main profile- known as consumers profile with more bandwidth compared to baseline. Used in TV broadcast and video storage.
Extended profile- has better coding techniques compared to baseline and main. Used for internet video streaming.
High profile- combines all the qualities of the above named profiles with improved qualities for video storage and broadcast.

RECOMMENDATION

The three compression techniques are all industrial standards that support many applications. They are all good standard depending on what you are willing to use them for. But taken a critical look at the three, one will see that as they are introduced one after the other as listed above, the bit rate required for compression and the size of compressed file decreases with the introduction of a more recent technique. However, since streaming over the internet is our priority, MPEG-2 is not considered because it wasn't designed for this purpose compared to MPEG-4 and H.264. However, H.264 is recommended above MPEG-4 because of its lower bandwidth utilisation and the level and quality of compression which will make video streaming deliverable to more customers in a short period of time and supports several applications to meet the demand of the end users [5].

III. STREAMING OPTIONS FOR VIDEO SERVERS

Video streaming is the process by which videofiles that have been compressed into smaller files are transmitted via the internet and viewed at the destination after being decompressed [10]. The availability of the internet in almost everywhere around the globe has prompted many multimedia companies to adopt streaming as a means of delivering video content through an IP network to their consumers.This can be a live or recorded

video broadcast. Withstreaming over the internet, the number of users accessing internet video files through various terminals such as PC, Set-Top box, IPTV and Mobile phones etc. are rapidly increasing and this has encourage the deployment of video streaming for purposes such as training, advertising, entertaining, corporate communications, electronic and distance learning etc.Every user views these video files in different ways for different purposes [1]. Discussed in this section are some common ways in which video can be streamed.

TRUE STREAMING: This is also referred to as real time streaming. This could be a pre-encoded video on the provider's server which is being rebroadcasted just like an old football match being shown on TV and it could be a live event being delivered as it occurs just like a live TV broadcast. It could also be an interactive application based such as video phone and video conference [11]. The duration of streaming is equivalent to the time taken to finish the activity being streamed. In true streaming, anyone who did not view the video from the beginning can only start viewing from wherever it is before joining the network and cannot playback. Since it is a live streaming, compressed video packets from the source are delivered to the customer's computer continuously and played immediately on arrival [1]. To achieve this, the bandwidth of the customer's internet connection must be greater than the data rate of the packets being received. True streaming does not provide any room for storage of the video files on the receiver's device to be viewed later. This is an advantage for the provider to control access to the video file.

DOWNLOAD AND PLAY: In download and play streaming option, the entire compressed video file must be downloaded and saved on the customer's device. This can then be seen at any point in time he or she wishes to see the video [1]. The time taken for the download to take place depends on the bandwidth of the receiver's internet connection and the length of the video. A receiver with higher bandwidth will receive faster compared to one with a lower bandwidth. The major advantage is that every receiver can have access to the content but will just be delivered over different period of time. This option is utilised by online video stores such as iTune. Once a customer pays for a video, he can download it and play at his own convenience.

PROGRESSIVE DOWNLOAD: This is the process by which compressed video files are downloaded from the provider's server to the client's computer hard drive. The video files are broken into smaller segments which are transferred to the client's device one after the other in a particular order. Once a segment is fully downloaded and saved on the hard drive, it can be played and viewed while the next segment keeps downloading and saved, then played accordingly [9]. This makes it look like true streaming. The receiver can playback the video while downloading is still in progress and cannot fast forward when that part has not been downloaded. In a situation whereby a certain segment being played is finished and the following segment is not fully downloaded, the video pauses and continues to play once the next segment is completely downloaded. This is called buffering. If a client decides to skip a video, the skipped parts are not downloaded and downloading starts from the desire point and therefore loosing segments. To avoid repeated buffering, the bandwidth of the receiver's connection must be more than the data rate of the encoded files. Progressive download and play has the benefit of passing through firewalls while also delivering the speed and lower storage requirement of true streaming[9]. Since the file does save on the client's computer, it can be copied easily. YouTube and CNN are examples of site that make use of this option.

FLEXIBLE STREAMING: Looking at the options discussed above, each has its advantages and disadvantages. While a client with high bandwidth connection can view a high data rate video file, it will be difficult for a client with a lower bandwidth. Therefore a company cannot offer video streaming using a fixed data rate [7]. Videos has to be compressed in different data rates since a streaming server is capable of processing streaming depending on the bandwidth every client isoperating from and provides each client with the quality that best fit the bandwidth and it is also possible for clients to request for the type of stream their connection can handle.

RECOMMENDATION

With the availability of an intelligent streaming server which can service every client's request based on the bandwidth available on their connection, this enables companies to have total control over the streaming video without any client being able to copy and save. This makes videos secure and provides a real-time streaming. Therefore,any of the streaming options is recommended depending on the type of video broadcast in question.

IV. TRANSMISSION ISSUES RELATING TO QUALITY OF SERVICE

Maintaining a satisfying quality of service when streaming video content through the internet is very important, however if this is not maintained by following the normal streaming standard with the right mechanisms in place and at the same time clients not having the necessary requirements to receive a stream, this

could result into issues such as delay, jitter, packet loss and packets arriving out of sequence. All these are discussed below.

DELAY: This is an unavoidable issue in any network. This occurs when packets are not getting to the destination as quick as expected. This could be due to reasons like time taken to compress or decompress the video. Two main sources of delay exist within an IP network. We have the Propagation delay which is the amount of time it takes for information to travel from one location to another. We also have Switching delay which occurs when there is a signal to be switched or routed within or out of the network [9]. In a one way broadcast, delay can be up to 5 to 10 seconds without having any effect on the viewer. But in a two-way or an interactive broadcast, delay cannot be tolerated because this can affect communication between the two parties. A prolonged delay leads to loss of packetsand this disturbs conversation between broadcasting ends.

JITTER: If the arrival of packets on the receiver's end during broadcasting can be maintained at a constant time interval, such broadcasting will be free of jitter. Jitter is coursed as a result of differences in the arrival time of packets on the receiver's end. In reality, the receiver's devices are built to tolerate jitter and the network must be designed to prevent the creation of lots of jitter to provide a good media for successful video transmission [4]. Buffering can be used to reduce jitter on the receiver's end by giving more time for late packets to arrive but at the same time, this could also add to delay. With a good connection, this problem can be minimised using adaptive buffering which makes buffer small and delay short.

PACKET LOSS: Packets are said to be loss when they are not received at the intended destination. This can be coursed by network failure and faulty network configuration, hardware or software problem, limited bandwidth, saturated network traffic etc. Video streaming can tolerate a very low level of packet loss [2]. But when it gets large, there will be a break in transmission of the video. NOTE that packet loss may also be used to maintain quality of service so as to provide more bandwidth for some other packets with higher priority in some situation.

PACKETS ARRIVING OUT OF SEQUENCE: This is referred to as packet reordering. This occurs when packets are delivered to the receiver in a different order from the order in which they were sent. This affects the quality of the video negatively and this is a reason why buffering is useful. It provides more time to allow packets to arrive or for packets to be reordered [10]. Multiple paths from source to destination can make packets take different paths to the same destination which can make them arrive at different time interval. Here we can see a situation where packet 2 arrives before packet 1. Network congestion is also a major course of packets arriving out of sequence.

V. SECURING FILES FROM ILLEGAL COPY AND PIRACY

Securing the content of a video is very important to prevent it from being illegally copied and pirated. The mechanisms used to provide security to control access to a digital content are collectively defined under a single policy referred to as Digital Right Management (DRM).Generally, the internet is an open technology available to anybody with the facility to access it [9]. Therefore access must be restricted when distributing confidential video content over the internet between authorized users. However, we should be aware that unauthorized users may also be interested in such content because they see access denial as a form of challenge and it could also be for the purpose of commercial piracy [1]. Therefore security must be deployed such that only authorized and authenticated users can gain access. This makes right management important when delivering content over the internet and this can be achieved through security mechanisms such as encryption and watermarking.

ENCRYPTION: This is the process by which contents are made unreadable or meaningless to everyone by encoding it and can only be decoded and made readable or meaningful to only the intended recipient [9]. The encoding is carried out with a key or keys which must be used at the decoding end with a decoder to retrieve the exact signal. This maintains the integrity and confidentiality of the content.

WATERMARKING: This is the process by which digital information is hidden inside a streaming signal. This is used to ensure the authenticity of the streaming signals and confirm the owner's identity or copyright ownership. This prevents video recorders from copying without authentication[1]. Watermarking has no negative effect on the streaming signal being transmitted.

VI. CONCLUSION

For videos to be broadcasted successfully across the internet between authorizedusers,it is recommended that the entire content of the product should be compressed while consideringMPEG4 or H.264 as the compression algorithm to be used. Also, with the availability of intelligent streaming server, video streams can be delivered to customer while making use of any of the streaming options depending on the bandwidth of the customer's internet connection. Companies must ensure that quality of service is properly implemented and maintained within their network and ensure that adequate security is maintained for the content to be streamed to avoid being stolen by unauthorized users while making use of the proper right management technique.

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