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Enhanced Server-Client Framework for Optimizing QoS in Video Streaming Over Diverse Networks

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Abstract: Traffic on the transmission channel has rapidly increased due to the exponential inflation in the number of users and their availability on the internet for a range of applications, such as video on demand (VoD), video streaming, and e-learning. Video service providers are taking much care in sending the video packets at a faster rate to ensurenice service quality for the customer; also, the presence of traffic in the transmission channel makes the provision of uninterrupted video streaming services with minimum delay and minimum packet loss a daunting proposition. When it comes to QoS characteristics like playout delay at start and end, delivery ratio, and throughput for various data rates, buffer sizes, bandwidth, and the number of failed servers, the performance of the suggested framework is compared with the present architecture.NS2 Simulator is used to simulate the proposed work. According to the experimental findings, the end-to-end latency and delivery ratio for changing data rates have decreased by 10% and increased by 10%, respectively. At the same time, for varying buffer sizes, the End-to-End delay has been lowered by 12%, and the delivery ratio has grown by 7%. Additionally, the throughput has grown by 17% in terms of changing buffer sizes.

Keywords: Server Selection, Quality of Service, Resource Allocator, Streaming Rate estimator, Buffer Management, Congestion Evading, Heterogeneous network, Energy Efficiency

1 Introduction

The Internet's origins date back to the 1960s, inspired by ARPANET in the U.S. Defense Department. It connects various devices like computers, printers, routers, and sensors, allowing data transfer based on specific protocols. Contrary to popular belief, it's not limited to computers alone but includes Internet of Things components [1,2,3]. A popular alternative analogy to explain the Internet is to consider itself as an Interstate Highway System. The Internet consists of many networks that are owned and maintained by different companies, but they all use the same protocol to communicate with one another. This gave rise to the term 'Information Superhighway', which people commonly use while referring to the Internet. Today's Internet is much more complex than it used to be, with the devices connected to the Internet being more than the human population itself,

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and some devices form their network, hence creating a network of networks [4,5].

A video is a series of images displayed rapidly over time, creating the illusion of motion. The speed of these images, called frame rate, is measured in frames per second (fps) and applies to both displays and recording devices like cameras. Typical frame rates are 15fps to 30fps. Users can receive video from a server through simple download or streaming. In simple download, the entire file is downloaded before viewing, causing delays and using more space. Streaming allows users to watch videos without downloading the full file, as data is sent in small chunks, reducing wait time and enabling simultaneous access for multiple users [6,7,8].

One-way streaming, such as movie clips and broadcasts, faces fewer challenges than videophone applications, which require data rates of 20 to 384 kbit/s and strict delay limits. Videophones must maintain video delays between 150-400 ms and audio-video synchronization under 100 ms to avoid issues. This study proposes strategies to enhance Quality of Service (QoS): (i) Resource allocation and buffer optimization for smooth playback, (ii) Intelligent congestion avoidance to adjust streaming rates and reduce packet loss, (iii)Optimized packet transmission for reliable delivery, and (iv) Dynamic server selection to prevent disruptions during server failures or mobile use.

2 Related Works

This research focuses on improving the Quality of Service (QoS) between the client and server during normal and detached conditions, with key factors being delay, throughput, and packet loss. Multimedia applications are delay-sensitive and loss-tolerant, unlike elastic applications like email or FTP [9,10,11]. The study classifies multimedia into real-time, stored, and live-streaming and reviews various techniques to enhance QoS on the client side, especially under detached conditions (Figure 1).

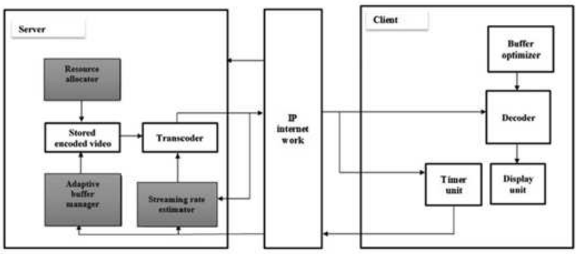

Fig. 1: Existing architecture of video streaming

Figure 2 clearly distinguishes between the categories under which the proposed techniques fall.

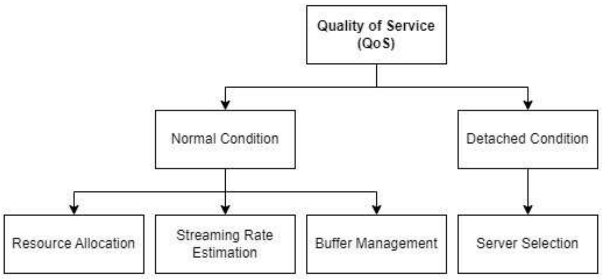

Fig. 2: Various categories to increase QoS

The techniques are explained further under the categories under which the techniques come.

2.1 Normal Condition

This condition mainly deals with network problems such as video streaming congestion with no transmission channel changes.

2.1.1 Survey on Resource Allocation

Effective resource allocation is crucial for ensuring good Quality of Service (QoS) in video streaming. Wu et al. [12] proposed an Energy efficiency and Goodput Optimized CMT solution to balance energy consumption and performance. Wang et al. [13] introduced Buffer Driven Resource Management (BDRM) for mobile networks using HTTP Adaptive Streaming (HAS) to reduce re-buffering. Chen and Zhang [14] developed a QoS framework that dynamically adjusts video quality based on network conditions. Xu et al. [15] created a Delay-Aware Resource Allocation (DARA) method to optimize slot allocation for delay-constrained streaming, ensuring deadline-consistent delivery.

2.1.2 Survey on Streaming Rate Estimation

Network congestion is a key issue in video streaming, often caused by packet overloads on transmission channels. Yang et al. [16] suggested a multicast streaming system with in-network adaptation, enabling adaptive switching to manage bandwidth and reduce congestion. Kim et al. [17] proposed an admission control policy using Markov Decision Process (MDP), rejecting idle sessions during congestion to optimize performance. Wu et al. [12] introduced concurrent multipath transfer with unequal frame-level scheduling to reduce delays in wireless networks. Xiang et al. [18] developed a dynamic programming solution for rate adaptation, optimizing playback based on real-time bandwidth inference [19,20,21].

Kuo and Wang [22] proposed Inter-session Network Coding (INC) with queue-based scheduling to maintain optimal throughput during downlink. Lübben and Fidler [23] analyzed network protocols and queuing models to enhance TCP efficiency and reduce delays. Rahman et al. [24] developed an adaptive algorithm that adjusts bit rates based on network conditions, minimizing interruptions and improving video quality. Qadir et al. [25] introduced a parameter 'beta' to balance video rates and QoE, effectively managing multiple sessions [26,27,28].

Sterca et al. [29] created a framework for controlling congestion in TCP-friendly networks by adjusting transmission rates based on media characteristics. Joseph et al. [30] proposed a method to balance rate variability, user capacity, and utility rates in adaptive video streaming. Though it relies on complete network knowledge, D'Aronco et al. [31] suggested a network-assisted HTTP adaptive streaming system to improve bandwidth utilization [32,33].

These methods address congestion and QoS issues, offering solutions that enhance user experience and ensure smooth video streaming across various network conditions.

2.1.3 Survey on Buffer Management

The buffer at the server side plays a critical role in streaming videos online, and controlling this buffer is a key challenge for video service providers. Zhu et al. [34] proposed a model that conserves energy in wireless networks by using separate queues for incoming and outgoing multimedia frames. Their AP Priority scheme improves power efficiency and reduces frame-dropping probability, outperforming Basic Power Management (BPM). Scalosub et al. [35] introduced a framework to manage inter-packet dependencies, with algorithms that select which packets can be dropped during intense traffic, offering performance close to the best offline algorithms [36,37].

Harinath [38] proposed dynamic buffer scaling algorithms for 802.11 networks, which adjust buffer size to reduce queuing delays and prevent packet loss under high network load. Seetharam et al. [39] examined a scheduling scheme for transmitting multiple videos to mobile clients, using a greedy algorithm to assign transmission slots and minimize stalling by evenly distributing delays among clients [40,41].

Yao et al. [42] developed a comprehensive buffer management policy (UBM), incorporating caching, passive and proactive dropping at the receiver side, and sender-side scheduling. Their approach demonstrated reduced latency and higher delivery rates in simulations. While these approaches improve buffer management, they lack an efficient scheme for prioritizing video packets, a limitation across the proposed methods [43,44].

These solutions offer various strategies to improve buffer management at the server side for streaming, focusing on energy efficiency, delay reduction, and traffic handling, though further work is needed on packet prioritization.

2.2 Detached

This condition occurs when the user or the client is disconnected from the server due to external factors such as internet dis-connectivity or due to the client being in motion.

2.2.1 Survey on Server Selection

Streaming videos online makes the selection of the best server for the client to stream from imperative. There would be a lot of servers with a copy of the streaming video, and the nearest server to the client would mostly produce the best service. Various authors' ideas for the selection of the required server are discussed below.

Bello et al. [45] proposed a distributed multimedia synchronisation technique based on logical mapping to meet logical and temporal interdependence in real-time data sharing. The computation of message deadlines using just relative time points and partitioning the processing stage to accomplish synchronisation using an asymmetric design concept are the two key components of the protocol given by the author [46,47,48].

Lee et al [49] have eliminated two significant problems, one being the frequent disconnections faced by mobile networks that are moving around continually and the other being the inability of mobile devices to handle overload issues. This allows a drastic reduction in the number of times the device gets disconnected from the network, thereby improving the Quality of Service and stream multimedia content from the cloud without any interruptions in a seamless manner.

Miller et al. [50] have overcome the two main problems of data transmission by using conditional integration to reduce saturation due to constraints due to bandwidth and bit rates and stabilize the system. Several heuristics have been used to stabilize the design system, which can help overcome Quality of Experience issues.

Hassan and Farooq [51] have recommended a method that is the initial step to analyze all the available paths in our network from the source to the destination using a gray relational analysis. Identification of the quality of our paths helps in the prediction of the path that is highly error-prone to data and also the degree of loss of quality of the video content. The use of this helps the server of the right path through which the data is to be transmitted. This solution has been experimentally verified to achieve better performance at various kinds of network channels.

Abu-Lebdeh et al. [52] devised and constructed an architecture that addresses the issue of maintenance in mobile surveillance system QoS needs by using a 4G packet core for speedy data transmission between the media server, QoS enabler, and machine-to-machine gateway systems. Even a delay quite higher than with the existing systems is acceptable when it comes to maintaining the QoE requirements. It has been successfully implemented at many real-time systems with a high success rate.

Nadembega et al. [53] suggested a Mobility Prediction aware Bandwidth Reservation (MPBR) strategy to maintain a new call-blocking rate while decreasing the rate of hand-off calls. The MPBR is made up of three schemes. The first technique, Hand-off Time Estimation (HTE), seeks to estimate the time frame every time the user makes a hand-off along the path to his goal. The second approach, the Available Bandwidth Estimation scheme (ABE), estimates the available bandwidth that the user will traverse to his destination ahead of time. The third approach, Efficient Call Admission Regulate (ECAC), tries to control bandwidth distribution in network cells. The experimental findings of the MPBR system outperformed the old scheme in terms of having a reduced rate of hand-off calls.

The client's ability to select the best server is one of the important factors ensuring good QoS during an error or service disruption. Several authors who have investigated the problem and its solutions have mentioned it. However, the ability to select the best server for a particular user is found to be lacking in the above-discussed works.

2.3 Summary

The literature review referred to above shows certain limitations. These relate to resource allocation, buffer management, streaming rate determination, and server selection. The assigned resources are not dependent on the channel state and waste some available resources. The buffer management schemes' performance and the determination of dynamic streaming rates are subpar. The selection of the server in the event of failure for each separate user is found to be not optimized.

3 Proposed Work

The proposed architecture comprises modules such as Resource allocator, Adaptive buffer manager, Streaming rate estimator, and Server Selection (SS) to achieve better QoS. The architecture proposed by QoS to help stored audio/video applications is shown in Figure 3.

3.1 Server-Side Optimization

A dynamic resource assignment methodology is used for streaming multimedia data in heterogeneous networks, with a Hidden Markov Model predicting channel conditions. The channel state, determined by received power and noise variance, dictates whether video streaming continues or is buffered. A buffer optimization module broadcasts video in smaller intervals to optimize server load. Subchannels allow simultaneous streaming to multiple users. A fuzzy logic congestion controller adjusts the streaming rate based on congestion levels, while the GSTS algorithm optimizes buffer thresholds. A priority-based buffer management scheme ensures higher-priority packets are transmitted during congestion, maintaining QoS.

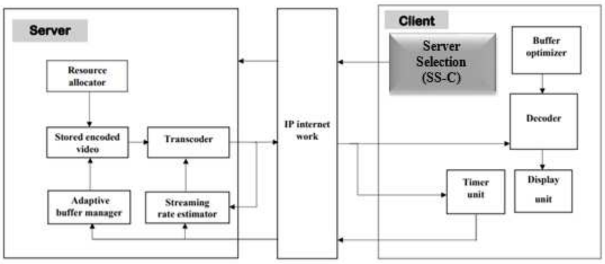

Fig. 3: Proposed Modules of Video Streaming Architecture

3.2 Server Selection using Cat swarm optimization (SS-C)

Many service providers face the challenge of providing video service even after a network or server failure. Provision of a good QoS may not be possible even after re-establishing the connection to the server. As a result, the quality of multimedia streaming is maximized through Server Selection using Cat swarm optimization, which optimizes the selection of servers. This chapter contains various sections, problem methodology, proposed technique details, experimental results, and performance analysis.

Numerous algorithms have been presented to resolve optimization problems, and many of them are based on swarm intelligence, which is the collective behavior of self-organized systems. Some methods, including ant colony optimization, particle swarm optimization, and cat swarm optimization, use Swarm intelligence. Swarm intelligence is used for optimization in the cat swarm optimization technique, which is based on the behavior of cats.These algorithms have been used in many fields to find optimal solutions for vehicle routing problems and traveling salesman problems.

3.2.1 Overview of Server Selection

To prevent stack difficulties, multi-server systems have replaced single servers for data transmission. However, multi-server systems cannot ensure the accuracy of the data sent to the end user. After passing through several servers, the information is delivered from the source to the server and eventually to the end users.

In the general model as depicted in Figure 3 of multi-server structure, the information transmission or exchange is performed by the end clients or from the source to the client. In any case, the server gushes the instantaneous video packets into the server. The video packets are also transmitted to the end clients and different servers after a brief time.

In the multi-server network depicted in Figure 4., take into account S1, S2, S3, and S4 as senders, Sr1, Sr2, and Sr3 as servers, and U1, U2, U3, U4, U5, and U6 as end users.

Data can be shared between source S1 to servers Sr1 and Sr2; source S2 and source S3 independently share the data with servers Sr1 and Sr3, respectively; Source S4 shares the data with servers Sr2 and sr3. End-user U1 receives the data from server Sr3; End-user U2 receives the data from servers Sr1 and Sr2; End-user U5 receives the data from Server Sr3; end-user U6 receives the data from server Sr2. End-users U3 and U4 are idle since they have not requested data from the servers.

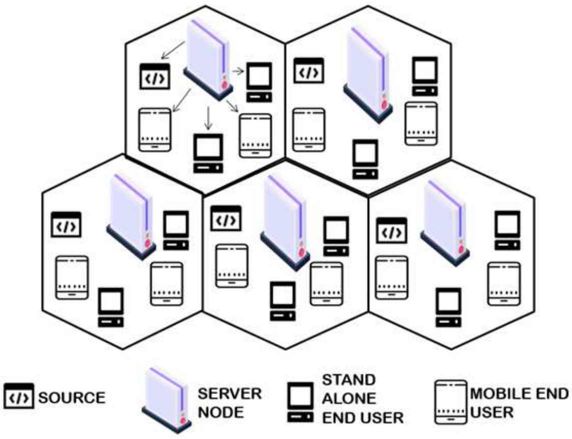

Fig. 4: Network model with a straightforward source-server-user link

For instance, if Server Sr2 develops a problem, End User U2 still receives data from Server Sr1 without any problems, but End User U6 does not. This problem may be solved by choosing the best servers, and since servers Sr1 and Sr2 are connected, as shown in Figure 5, end user U6 can receive data delivery from server Sr1.

The proposed algorithm replaces a faulty server by searching and selecting the optimal server among the other servers in the multi-server environment, as shown in Figure 6.

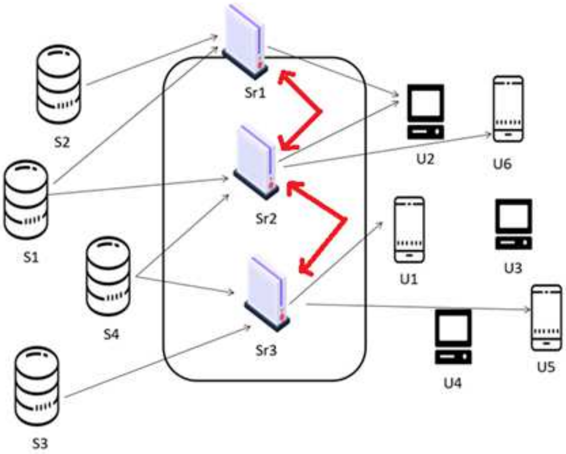

Fig. 5: Simple Multi-Server Network Scenario

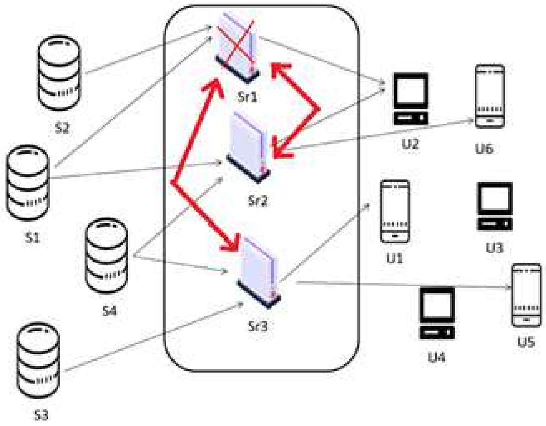

Fig. 6: Multi-Server Network in case of failure

The information from all the servers, including both essential and custom estimations, is assembled in all the servers. Then, the servers are separated into disappointed servers and new servers. The information accessibility checks for the server address the information on demand. The requested video is sent live to the client without being stored on the hard drive. The video packets can be played at a constant rate soon after their receipt. Once the server is about to crash, an alternate server is selected using the fuse number relationship. Equation (1) is used to compute the average distance (Avg_d), which is the average of the distances between all potential servers (Ser_p) and failed servers (Ser_f).

$$A_d = A_{Avg_d} = \frac{1}{Sr_n}\sum_{Ser_p}^{Sr_T} dis(Ser_p, Ser_f) \qquad (1)$$

Where: Avg_d: Average Distance, Ser_p: All Possible Servers where a=1,2,...n, Ser_f: Failure Server, Sr_T: Total Number of Servers.

The average user distance is calculated (Ad_u) the average distance between the failure server (Ser_f) and end-user (E) using Equation (2)

$$Ad_u = \frac{1}{Sr_T} dis(Ser_f, E) \tag{2}$$

Where: Ad_u: Average User Distance, Ser_f: Failure Server, E: End User, Sr_T: Total Number of Servers.

The total delay calculated as depicted in Equation (3)

$$T_d = \sum_{Sr=1}^{n} (Avg_d + Ad_u) \tag{3}$$

Where: T_d: Total Delay, Avg_d: Average Distance, Ad_u: Average User Distance.

The collected custom metrics do not meet all the requirements. To facilitate the optimization of the time-varying metrics, a server selection method utilising the cat swarm optimization algorithm is suggested.

3.3 Cat Swarm Optimization (CSO)

Each cat's size of seeking memory, which represents the points the cat is seeking, is determined using SMP. The rules would dictate how the cat chose a point from the memory pool.

The mutative ratio for the chosen dimensions is announced by SRD. When a dimension is chosen to change in searching mode, the difference between the old and new values won't be outside of the SRD-defined range.

The CDC reveals how many variables will be changed. All of these elements are significant contributors to the searching mode.

The Boolean variable SPC determines whether or not the cat will travel to the spot where it is now standing. The value of SMP will not be impacted by whether the SPC value is true or not.

3.3.1 Server Selection Process with CAT Swarm Optimization

(A) Server Allocation Modes

(i) Search Mode:

1. If SPC is true, set j to SMP; otherwise, set j to SMP-1.
2. Replicate the current position of server Ck j times.
3. Adjust the SRD value up or down based on the CDC value.
4. Calculate the Fitness Value (FV) for each candidate position.
5. If the FV values are not identical, convert these FV values into selection probabilities using Equation (4):

$$P_i = \frac{|FV_i - FV_b|}{FV_{max} - FV_{min}} \tag{4}$$

Where: i: ranges from 0 to j, FV_b: can be set to either FVmax or FVmin depending on whether the fitness function is being maximized or minimized.

6. Replace server Ck's current position with one of the candidate points selected randomly.

(ii)Tracing Mode:

Step 1: Update the velocity for each dimension based on the following Equation 5:

$$V = v + r * c * (Xbest - X) \tag{5}$$

Where: d: ranges from 1 to M. Here, $Xbest, d$ represents the position of the server with the best fitness value, $X_{k,d}$ represents the position of server k, $c1$ is a constant, and $r1$ is a random value between 0 and 1.

Step 2: Ensure that each updated velocity remains within the maximum velocity limit. Set the velocity to the maximum allowable value if it exceeds this limit.

Step 3: Update the position of server k based on the Equation 6:

$$X_{k,d} = X_{k,d} + v_{k,d} \tag{6}$$

This approach optimizes server selection by efficiently navigating the solution space through a combination of search and tracing modes, adapting based on real-time conditions until an optimal configuration is achieved.

(B) Proposed Algorithm

Step 1: Begin by setting up and initializing M servers.

Step 2: Randomly position these M servers within an N-dimensional solution space, ensuring that each server's speed corresponds with the maximum velocity, denoted as Vmax.

Step 3: Allocate servers into two modes: search mode and tracing mode, according to the predefined Mixture Ratio (MR). A portion of the servers will be designated to search mode, while the remaining servers will operate in tracing mode.

Step 4: Calculate the fitness value (FV) for each server by applying the server's position ($X_{k,d}$) to the fitness function.

Step 5: Update the server's position depending on the flag value. If a server is in tracing mode, apply the tracing mode algorithm; otherwise, use the search mode algorithm.

Step 6: Reassign the servers based on the Mixture Ratio (MR), adjusting their modes as needed.

Step 7: Continue to iterate through steps 4 to 6 until a specified termination condition is met.

4 Results and Discussion

4.1 Server-side optimization

The ns-2 simulator is used to model the suggested architecture.The simulation environment is designed to test various parameters that are critical to the performance of the system The simulation environment that was utilized to execute the suggested modules are as follows:

1. **Mobile Nodes Count:** A total of 1000 mobile nodes have been deployed in the simulation environment.
2. **Network Topology:** The simulation is conducted within a 1000 m by 1000 m area, representing the overall size of the topology.
3. **Data Packet Size:** Each packet transmitted during the simulation is set to a size of 512 bytes.
4. **MAC Protocols:** The simulation leverages both IEEE 802.11 and IEEE 802.16 standards for the Medium Access Control (MAC) layer.
5. **Duration of Simulation:** The simulation runs for a total duration of 300 seconds to capture sufficient data for analysis.
6. **Transmission Rates:** Various transmission rates are tested, specifically 500 kbps, 750 kbps, 1000 kbps, and 1250 kbps.
7. **Traffic Patterns:** The simulation accounts for both non-real-time traffic and video streaming traffic types.
8. **Buffer Capacity:** The buffer sizes are set to correspond with the different transmission rates: 500 Kb, 750 Kb, 1000 Kb, and 1250 Kb.
9. **Signal Propagation Model:** The Two Ray Ground propagation model is utilized to simulate the signal behavior over the defined environment.

The proposed architecture of " Enhanced Server-Client Framework for Optimizing QoS in Video Streaming Over Diverse Networks" is compared to the existing architecture of "Enhanced QoS Through Optimized Architecture for Video Streaming Applications in Heterogeneous Networks" [54].

The Channel Condition Prediction and Resource Allocation algorithm deal with the allocation of resources required for streaming the video online through the use of a queuing discipline, which is decided on the basis of presence of congestion in the transmission channel. It is mostly utilized at the source to lessen video packet loss. Although with little benefit, it is also employed to lessen video packet loss in other locations.

In order to deal with dynamic variations in the transmission rate depending on the level of congestion in the transmission channel, the Optimized Multimedia Streaming and Congestion Control algorithm is utilized for streaming videos. This stops the packets from being dropped during the source-to-client transmission.

The Priority-based Proactive Buffer Management and Aggregated Streaming technique deals with selecting the queuing discipline that is applied to the buffer's storage of video packets. It has the ability to determine how many video packets are necessary to play a particular segment, making it possible to skip over those that are unnecessary and boosting the effectiveness of video streaming services while preventing delays in video playback during congestion.

The Server Selection using Cat Swarm optimization (SS-C) algorithm deals with the selection of a server that can provide the best service for streaming the video online, thereby avoiding servers which are far away from the client. This in turn, reduces the resources required for the transmission of the video packets from the source to the client. This algorithm is useful also in the event of any failure of the server.

Variable rates and buffer sizes have been used to examine QoS characteristics including latency, throughput, and delivery ratio of the proposed architecture of the video streaming service (Figure 2) and the existing design of the video streaming application (shown in Figure 1).

Table 1: Delay Analysis with Rate Variation

Rate (kbps)	End to end delay (ms)	
	Proposed architecture	Existing architecture
500	89.914	112.64
750	73.51	82.46333
1000	65.47667	74.57667
1250	56.54333	64.71667

The conclusion drawn from Table 1 is that the suggested architecture results in an End-to-End delay that is 10% less than that provided by the current architecture.

Table 2: Delay Analysis with Buffer Size Variation

Buffer Size (kb)	End to end delay (ms)	
	Proposed architecture	Existing architecture
500	53.38667	59.68667
750	60.69	69.79
1000	72.30333	83.14
1250	93.51	111.9167

Table 2 illustrates the impact of buffer size variations on the end-to-end latency and shows that the suggested architecture reduces the end-to-end delay by 12% when compared to the existing architecture.

Table 3: Analysis of the Delivery Ratio with Rate Variation

Rate (kbps)	Delivery ratio (%)	
	Proposed architecture	Existing architecture
500	85.6	76.66667
750	84.13333	73.33333
1000	79.1	71.2
1250	76.23333	69.96667

The delivery ratio for the proposed architecture increased by 10% when compared to the existing architecture, as indicated in Table 3 analysis of delivery ratio with respect to rate variation.

Table 4 illustrates the effect of buffer size adjustments on delivery ratio; the suggested architecture has a 7% greater delivery ratio than the existing architecture

Table 4: Delivery Ratio Analysis with Buffer Size Variation

Buffer size (kb)	Delivery ratio (%)	
	Proposed architecture	Existing architecture
500	78.8	72.5
750	80.76667	74.56667
1000	82.33333	78.53333
1250	86.13333	79.34

Table 5: Analysis of Throughput with Modification in Buffer Size

Buffer size (kb)	Throughput (kbps)	
	Proposed architecture	Existing architecture
500	491.067	387.467
750	596.033	482.367
1000	648.267	550.833
1250	675.433	576.7

The throughput analysis with various buffer sizes is seen in Table 5, which depicts the proposed architecture providing a higher throughput of 17% than the existing architecture.

4.2 Client-side optimization

In a simulation study using Network Simulator 2 (NS-2), the SS-C technique was analyzed within a network environment that spans 1000 meters by 1000 meters. The simulation was executed over a period of 300 seconds, with the base station transmission power set at 20 dBm. The IEEE 802.11n standard was used for wireless communication throughout the simulation. A total of 2000 users were simulated, corresponding to 2000 individual data flows within the network. The setup included 30 sources and five servers to manage the data transmission and reception.

The network was tested under various bandwidth conditions, specifically at 0.5 Mbps, 1 Mbps, 1.5 Mbps, 2 Mbps, and 2.5 Mbps. The focus of the performance evaluation was on two primary metrics: the initial play-out delay and the server failure ratio. The server failure ratio was particularly crucial, as it represented the proportion of services that were denied relative to the total number of service requests, providing a measure of the network's reliability and performance under the simulated conditions.

This evaluation focuses on contrasting the Server Selection - Cat Swarm Optimization (SS-C) approach with an established methodology, Enhanced QoS Through Optimized Architecture for Video Streaming Applications in Heterogeneous Networks. The comparison hinges on variations in bandwidth and server failure occurrences. Detailed test conditions are presented in the following Table 6

Table 6: Scenario Testing Overview

Scenario	Bandwidth Range	Server Failures
Test Case 1	0.5 - 2.5 Mbps	None
Test Case 2	2.5 Mbps	1 to 4 Servers

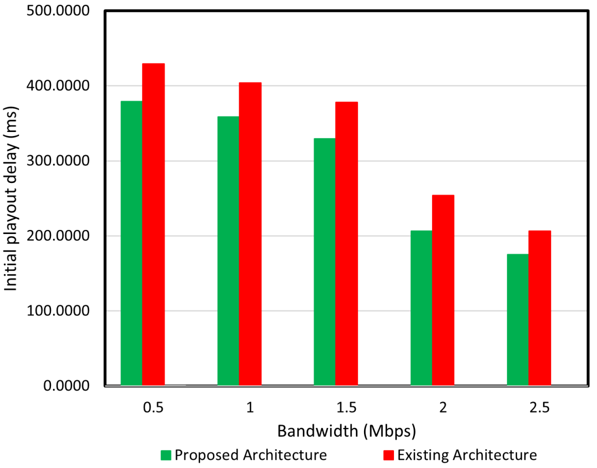

Fig. 7: Influence of Bandwidth on Initial Playout Delay (Proposed Architecture)

4.2.1 Performance Analysis with Bandwidth Variations

Provision of video streaming services with good QoS gets affected by initial playout delay, which cannot be eliminated for any video service though it can be reduced through a high bandwidth. As a result, high bandwidth ensures that the initial playout delay is kept to a minimum and the failure ratio is reduced. The experimental results are discussed further by varying the bandwidth.

An increase in bandwidth at the client end causes a decrease in the initial playout delay as shown in Figure 7. The threshold delay is 400 ms, above which delay starts affecting the QoS and a delay below leads to the inability to detect the threshold. Proposed architecture enables a 13% decrease in delay for the increase in bandwidth when compared to existing architecture.

An increase in bandwidth significantly induces a failure ratio, as shown in Figure 8. The proposed architecture provides an 18% lesser failure ratio than the existing architecture since the increase in bandwidth allows the acceptance of a large number of requests.

4.2.2 Performance Analysis with Variations in Number of Server Failures

Server failure results in a significant drop in QoS since the server can no longer provide the video streaming service for those users who are currently streaming. Server failure is mainly due to increased load or other external factors. This can be avoided through the use of

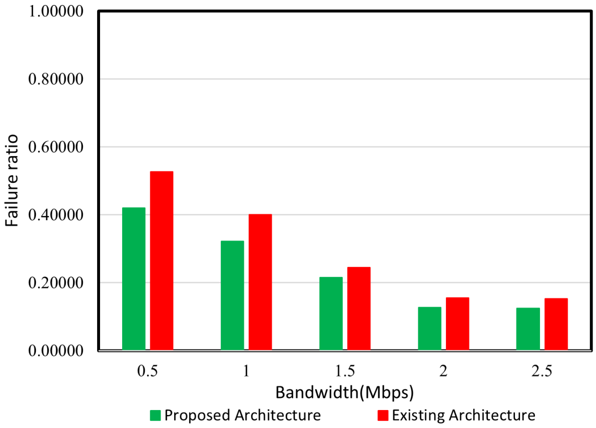

Fig. 8: Influence of Bandwidth on Failure Ratio (Proposed Architecture)

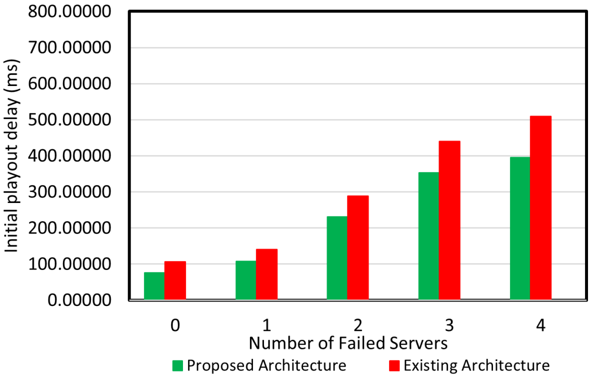

Fig. 9: Influence of Server Failures on Initial Playout Delay (Proposed Architecture)

more than one server to provide video streaming services. Therefore, decreasing the number of server failures helps reduce the initial playout delay and failure ratio thereby increasing the QoS. The experiments conducted through variations in server failures have provided further results.

Figure 9 suggests that although the increase in delay in the proposed architecture is reduced by 21% when compared to the present architecture, the rise in the number of failing servers has increased the initial delay as well. Due to traffic being sent to the operational server, which increases its load, the latency has increased.

The significant increase in failure ratio is shown in Figure 10 with an increase in the number of failed servers. The increase in failure ratio is due to the transfer of load to the working servers. The increase in failure ratio is smaller in proposed architecture by 16% in comparison with existing architecture.

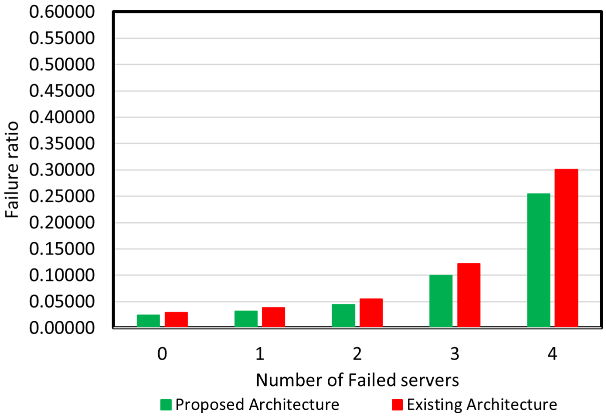

Fig. 10: Influence of Server Failures on Failure Ratio (Proposed Architecture)

5 Conclusion

The number of people who use the internet and have access to video streaming services is increasing exponentially in modern times. Congestion has also been caused by the enormous file sizes of videos, the simultaneous transmission of more videos, and their greater bandwidth requirements. Since the client-server architecture used in video streaming is the norm, server and client-based architecture optimization. Server-side optimization mainly focuses on three modules: resource allocation, streaming rate estimation, and buffer management. The process of assigning resources involves choosing a queuing discipline. Using HMM to estimate the congestion level will reduce source-side video packet loss. By assigning different transmission rates dependent on channel congestion the streaming rate regulator control module, which is based on fuzzy logic control, aids in preventing packet drops during transmission from the source to the client. Making video streaming services more effective while avoiding delays in video playing during congestion is the goal of proactive buffer management. As a result, attention is paid to providing QoS at each level. By adjusting the rate and buffer size with the current architecture, QoS parameters, including latency, throughput, and the delivery ratio of the proposed architecture of the video streaming application, are examined. As a result, server optimization maximizes the client's ability to receive the finest video streaming service. Compared to the old design, there is a 10% diminish in end-to-end delay, a 12% betterment in delivery ratio, and a 17% increase in throughput.The client-side optimization of the server section module is an area where the work can still be expanded. Here, external factors that affect the QoS that the client receives are minimized by the implementation of the suggested SS-C module at the client side of the design. These factors include server failure or internet disconnectivity. SS-C manages server failure by computing the fitness function and reduces the time between initial play-out and playback. With minimum bandwidth and the greatest number of servers in detached mode, the achieved initial play-out delay of SS-C is less than 400 milliseconds, which is an acceptable initial play-out delay for video streaming applications.Thus, the conclusion is that this approach uses four algorithms thatcanbe used in combination for the achievement of the most significant potential for giving the consumer the best video streaming service, the reason for the provision of high-quality service being that each of the proposed algorithms focuses on the optimization of the selected section of the architecture of video streaming. This ensures that all the factors that affect the QoS are taken into account in at least one of the algorithms, as mentioned earlier, thereby making it stable.

The future scope of this work is on the improvement of the quality of experience for the user. Quality of Experience (QoE) is a measure of the delight or annoyance of a customer's experiences with a video streaming service. There are three main factors that need to be taken into consideration for the improvement in the QoE that include the influence of human, system and context. The video streaming service provider would have the ability to affect the influence of the system to improve the QoE since the other two factors, namely, the influence of humans and context, depend upon the human and the video that is being streamed, respectively. Therefore the encoding and resolution of the video need consideration for the improvement in QoE.

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Conflict of Interest

The authors have no conflict of interest to declare.

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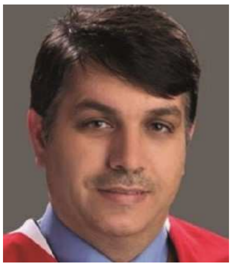

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