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ORIGINAL RESEARCH ARTICLE

QoS based meta-heuristic algorithm for path selection in the peer-to-peer network video streaming

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ABSTRACT

The P2P (peer-to-peer) networks have numerous difficulties as it pertains to video streaming. Among these, there is an absence of specific algorithms which may determine the most optimal path for data transmission and reception among nodes. This research suggests a strategy which combines the optimisation power of the PSO (particle swarm optimization) with the high speed and accuracy of an algorithm to handle this problem. The data packets needed for high-quality video streaming could be sent and received using this technique. The suggested approach considers the fact that each particle in the search field adjusts its position to find the optimal spot. By the application of programmes like MATLAB, a simulation may be run to verify this approach. The study's findings demonstrate that the suggested strategy is more effective as compared to the alternative approaches. Additionally, it executes better than the GA meta-heuristic method.

Keywords: PSO (particle swarm optimization); shortest path; video streaming; P2P networks

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1. Introduction

The bandwidth problem is the main obstacle to video transfer implementation in the internet architecture. Unfortunately, the exorbitant cost and lengthy deployment period of this technology made this strategy impractical[1]. Using application layer multicast is one of them. Overlay multicast is the term most often used to describe this technology[2]. Because it enables nodes to communicate information throughout the network, it is incredibly scalable. Its ability to perform tasks deal with central nodes is a major factor in its popularity[3,4]. In a peer-to-peer network, users send data directly to one another, doing away with the need for a central hub to act as a middleman. P2P networks have grown in popularity because they are simple to construct and can be scaled[5]. The ability to use and consume content released via P2P network is one of the main advantages of using P2P. A peer-to-peer network's numerous video streaming techniques are depicted in **Figure 1**.

VoD is a type of interactive media application that allows users to perform various functions, such as forward, backward, skip, in a similar manner to a VCR. A suitable media distribution system can be provided by implementing various tree-based and data-driven approaches. The primary drawback of tree-systems is their instability, which can be attributed to the quantity of peers. By using this technique, content from the parent tree can be sent to the child peer even in the event that it exits[6].

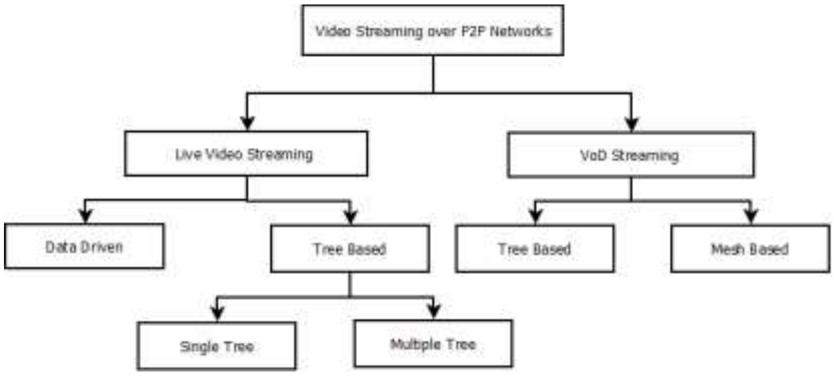

Figure 1. Video streaming approaches over P2P networks.

With mesh-based overlays, no peer needs to adhere to a tree-based structure in order to link to several other peers and share information simultaneously. A key component of network research has been ensuring that a network has the resources it needs to support its many applications[7]. To ensure optimal service, network operators must take into account multiple elements, including effectiveness, delay, and loss ratios. Video communication can also be facilitated by having a network with the proper quality.

Among the most difficult obstacles that suppliers of services must face in order to preserve the standards of the services they provide is making sure that their content is played quickly and precisely. One of the most widely used is the particle swarm optimization algorithm. PSO algorithm considers the population of the group and determines each particle's fitness quotient. Instead, they improve their social manner and move toward the destination more efficiently. This is because each bird has its own unique experiences and the other birds in the flock improve their social behaviour. The proposed PSO algorithm is compatible with the various problems we face in the field of computational engineering. It provides us with the accuracy and speed to solve them faster than other methods.

The motivation of this study video streaming technique for sending and receiving video over a P2P network. Finding the path that will move the video from one end of the network to the other is one of the greatest important steps in this procedure.

The rest of the paper is organized as follows. Section 2 deals with the related work regarding the recent advancements in the on demand video streaming. Section 3 deals with the particle swarm optimization algorithm for video streaming. Section 4 explains about the simulation results. Finally, section 5 concludes the research work.

2. Literature survey

The video content that is sent and received from sources is then converted into a format that is suitable for the end users. This type of stream is different from the traditional media format, which is usually published in a packet or compressed form. It is also different from the network features that are used to distribute the video content, such as the available bandwidth and the size of the packets. There are two types of video streams that are available through peer-to-peer (P2P) networks[8–10]. On demand and live streaming are two different forms of media that allow users to watch a video while it is being downloaded. On demand streams are similar to YouTube videos[11]. Live streaming, on the other hand, allows users to watch the stream while simultaneously downloading the compressed and packet versions.Due to the nature of the content, users tend to watch it in pieces. For instance, they can watch an online conversation between two individuals through platforms such as Skype or ooVoo[12–14].

One of the most successful streaming systems that can be used for on-demand video is DirectStream. It uses a tree structure to provide a P2P service while also supporting VCR interactions. With the tree structure, one can easily watch a video and fast forward or stop it.

A high-quality streaming video should be able to handle the interactions between various applications and its users. This system is composed of various components, such as clients, content servers, and AMDirectory service. The client side of a video streaming system is composed of its users, who are usually service providers and requesters. The client side of AMDirectory is focused on providing the searching capabilities of its users[15]. The ZIGZAG system is a single-tree framework that enables the transmission of video data between different nodes. However, it suffers from various issues such as service interruption, tree rebuilding, and the lack of coverage for leaf nodes. One of these is the issue with the width of the nodes needed to receive the data. This is because the system doesn't have the necessary coverage for the entire tree[16]. Another type of streaming system that is commonly used is peercast system, which is composed of single tree coverage nodes. When a new node is created, it sends a request to the root of the system, which then accepts it as a child. If the root node cannot support enough requests, it will reroute the requests to one of its child nodes. The update process will continue until the other nodes' parents are found[17].

3. Particle swarm based video streaming

The rise of video streaming services has been attributed to the increasing number of portable devices and the availability of wireless networks. This demand is also caused by the increasing number of games and smartphones. Approaches for locating the peers is shown in **Table 1**.

Table 1. Approaches for locating the peers.

Approach	**Peer status**	**Server status**	**Search guarantee**	**Single point of failure**
Gossipbased	$O(\log N)$	$O(\log N)$	Yes	No
Flooding	$O(1)$	$O(1)$	No	No
DHT	$O(\log N)$	$O(1)$	Yes	No
Hierarchical overlay	$O(\log N)$	$O(1)$	Yes	No
Centralized	$O(1)$	$O(N)$	Yes	Yes

Through studies on layered video streaming, we discovered that this method can be used to improve the quality of videos by adapting to the various network status changes. A P2P network uses a virtual overlay topology on top of a physical one. This allows nodes within the network to act as a subset of its physical nodes[18]. Although data is still transmitted over the traditional method, it is not stored on the network, it is now able to be sent and received through the application layer's logical overlay links. These links are each associated with a path that goes through the physical network. An overlay is used in a P2P system to allow peer discovery and indexation. It eliminates the need for the physical network topology to be changed. However, one of the challenges in this process is determining the location of the providers of resources. In video streaming, finding the right resources for each request is very important to ensure that the service quality is maintained. Each peer must find other resources with enough bandwidth to guarantee the best possible service. **Table 1** shows the common approaches employed in the P2P streaming.

Unfortunately, many optimization algorithms do not have the necessary performance optimization to find the optimal solution[19]. With the increasing complexity of the problems, the execution time of these algorithms can get out of hand fast. A good approximation algorithm can help find the most effective solution to a given problem. An approximation algorithm can be divided into three types: heuristic, super-heuristic and meta-heuristic. There are two main problems that tend to arise in these algorithms when it comes to solving problems at the right points. Meta-heuristic methods are commonly used in algorithms to solve various problems. They can be utilized in diverse applications. It can also be used to outsource the optimization process. The position of the other particles in the cluster affects the search quality of the individual particles. As a result, they move toward their preferred locations. In this social manner, learning from each other helps them find their best neighbours. The goal of the algorithm is to find the best possible location for each particle in the search space. The algorithm takes into consideration the location of other particles within the cluster and the best position in the neighbourhood. One of the most important steps in the process of finding the best possible location for a particle is to send a video to a receiver. The nodes that are connected to the receiver and sender are considered as the route. The selection of routes is a challenging problem due to the variety of routes. In this paper, we show a model that takes into account the various constraints that affect route selection. The algorithm PSO is used to select the routing path that can be presented in Algorithm 1. **Figure 2** shows the overall process of on demand video streaming over mesh network.

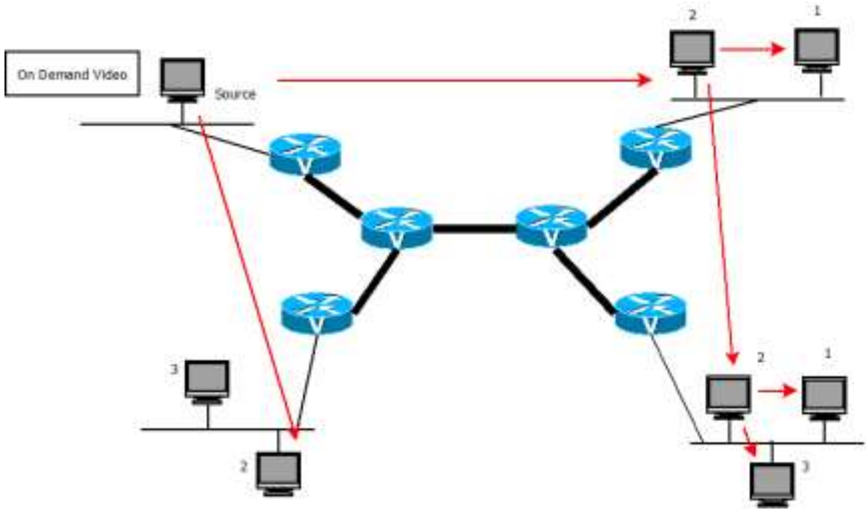

Figure 2. On demand video streaming over mesh based overlay network.

Algorithm 1 Selection of optimal route using the PSO algorithm

Begin
N_p-> Number of Particles
w-> Inertia Weight Constant
V-> Velocity of the particle
r_1, r_2-> random values {0, 1}
c_1,c_2 -> weight factors
X-> current location
Repeat
for k in 0 to N_p do
V_k= $wV_k+r_1c_1(pbest_k-X_k)+r_1c_1(gbest_k-X_k)$
If V_k != V_{th} then
Adjust the V_k
End if
F_k=$F(X_k)$
If f_k<F($pbest_k$) then
$Pbest_k$=X_k
End if
If f_k<F(gbest) then
gbest=X_k
End if
End for
Until Terminate
End

Sometimes the location framework can be changed, or the particle can use its prior measured velocity to execute the translocation. Every particle has a best value (*p*best) and (X_k) current position. This procedure compares the different attempts made by each particle to determine the optimal solution. The particles in the group possess the best solutions regarding their corresponding *g*best, and the *p*best values. $F(pbest_k)$ and

$F(g\text{best})$ are the functions that are used to calculate these values. To find the best solution, the $F(X_k)$ fitness value of the kth element is also considered.

Every particle must take into account its present position X_k, velocity (V_k), and distances X_k to both the *p*best and *g*best. The change in particle velocity is shown in Equation (1).

$$V_{kl}(q+1) = wV_{kl}(q) + r_1c_1(p\text{best}_{kl}(q) - X_{kl}(q)) + r_2c_2(g\text{best}_{kl}(q) - X_{kl}(q)) \quad (1)$$

where, $V_{kl}(q)$ represents the l-th next velocity of the particle with q-th frequency. $X_{kl}(q)$ represents the l-th next location of the particle with q-th frequency, r_1 and r_2 are the random numbers, w represents the inertia weight, c_1 and c_2 represents the weight factors. $p\text{best}_{kl}$represents the l-th next *p*best. $g\text{best}_k$represents the *g*best available in the existing group. The particle's new location is shown in Equations(2) and (3), respectively, by adding its past location.

$$X_{kl}(q+1) = X_{kl}(q) + V_{kl}(q+1) \quad (2)$$

$$V_{kl} = \text{sign}(V_{kl})\min(|V_{kl}| \times V_{\max}) \quad (3)$$

It is observed that, in the Algorithm 1, it is composed of three main parts. First one is the particle mass with accidental weight factor which is defined as $V\times w$. The second one indicates the best particle approaching by the particles which are acts like crossover operation in the genetic algorithm.

It is indicated with$r_2c_2(g\text{best}_{kl}(q) - X_{kl}(q))$. The existence of this factor prevents the particles from accepting the lower values of the previous values. As the value of this factor increases, it makes it harder to achieve the optimal values. The value of w is taken as at most 1. If the algorithm reaches the value of w to 1, then the algorithm is optimized. The algorithm is simulated and presented the results in the following section.

4. Simulation analysis

Due to the success of P2P video streaming protocols, many academic and industry organizations have started to look into their applications. This paper aims to introduce a method that can be used in a laboratory environment to evaluate the various aspects of this technology. Due to the complexity of the Internet-based network, it is not possible to perform real time experimental conditions on the algorithms. The proposed method will use a simulation software called as MATLAB R2020a to perform this process. The test run is done 20 times and each time the intermediate communication will affect the nodes. **Figure 3** shows the simulation procedure of the proposed method in MATLAB. **Table 2** shows the simulation parameters considered for the experimentation.

Table 2. Simulation parameters.

Parameter	**Value**
Node count	1000
Internal links available bandwidth	10 Mbps
External links available bandwidth	50 Mbps
Count of Internet service providers	4
Buffermap exchange time	2 s
Peer count	100–300
Video stream length	30 min
Video bit rate	600 kbps
Substream count	5
Average on time	1000 s
Average off time	400 s
Video PSNR value	36.30 dB

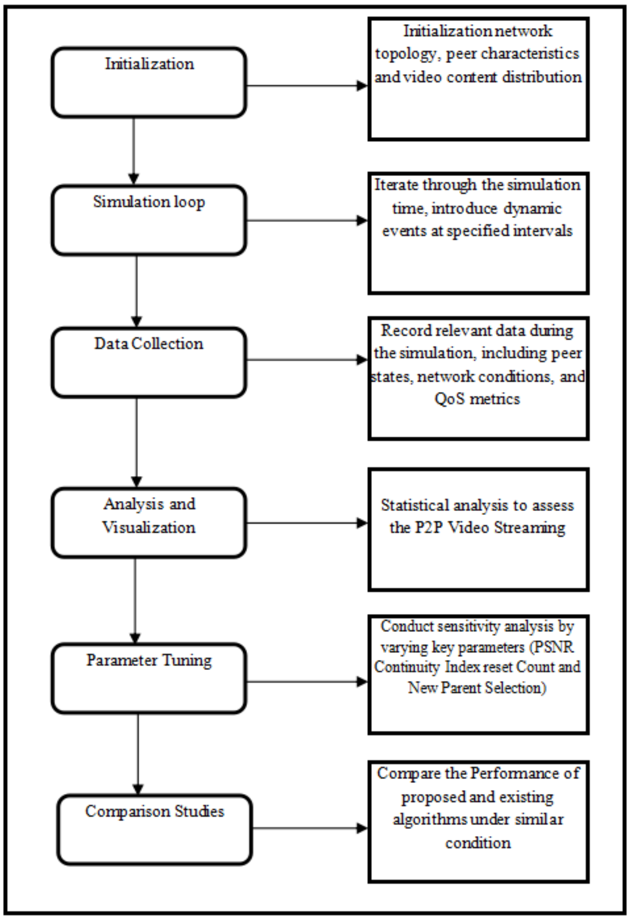

Figure 3. Simulation procedure of MATLAB.

The bandwidth availability of external and internal links is shown in order to indicate the remaining amount of traffic that can be sent and received through these links. The video bit rate in simulation is 600 kbps. In order to arrange the original video for 30 min, it takes into account the PSNR factor 36.30 dB and the video's overall length. In simulation, the video stream is divided into 5 sub-streams. The control messages and video packets are delivered using the TCP protocol. The delay between nodes varies depending on their location. For internal links, the available bandwidth is 10 Mbps, while for external links, the bandwidth is 50 Mbps. The network consists of approximately 1000 physical nodes, and the video's duration is 1800 s. Quality of service is a concept that refers to various factors that affect the performance of a network. Although it can help improve network performance, it does not guarantee the user experience. The QoE (quality of experience) and QoS (quality of service) are the 2 primary scales utilised to assess the QoS. Whereas it concentrates on elements that impact network efficiency, QoE concentrates on elements of the network that impact the experience of users.

Numerous investigations have been conducted to evaluate the suggested approach against alternative approaches. The study's authors present a parallel algorithm that uses a performance-approach to find the shortest path through a network. The study's conclusions demonstrate that the shortest path timing of the network can be enhanced by using this approach. The researchers of put forth a technique that can be applied to a hybrid push-pull system that chooses pathways using P2P streaming. The disjunction of routes among partners as well as peers was the initial area as the writers investigated. The parents with the greatest number of disconnected routes were then identified using a GA method.The problem can be resolved by applying the self-adjusting algorithm by which the researchers suggested. The study's conclusions proved that the recommended approach was the best way to resolve the shortest path dilemma.

The PSNR is used to measure the signal strength with noise ratio. If the ratio is higher, the image and sound quality will be better. Noise generated by an image can reduce the detection capabilities of the image displayed in the monitor. In the graph below, The *X*-axis is represented by the number of nodes, while the *Y*-axis is measured using the PSNR. **Figure 4** show that the proposed method has the highest performance when it comes to the detection of the PSNR factor. However, the results of the other two methods, which are used to select the path and the main frame, have inappropriate performance.

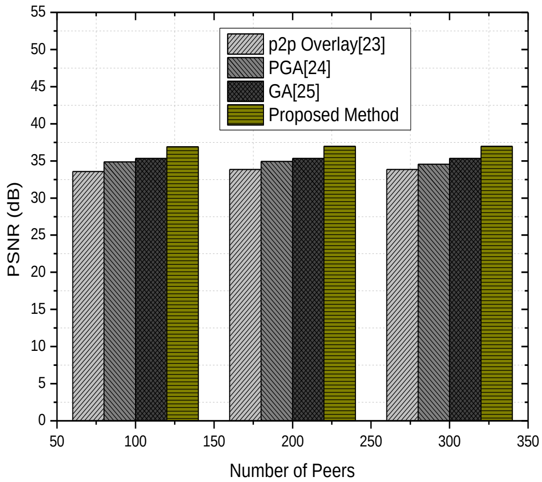

Figure 4. Number of peers vs. peak signal to noise ratio.

Figure 5 illustrates the average continuity of the video packs. It shows the total number of packets that were received before the deadline. The efficiency of the proposed method is also taken into account. The graph shows the *X* and *Y* axis with the average values in the *Y* axis. The maximum continuity index shown in the **Figure 5** is related to the proposed and genetic approaches. The proposed algorithm's efficiency decreases if there are more pairs of nodes. The proposed algorithm has lower convergence rates with the genetic approaches. In addition, the P2P overlay performed poorly against other algorithms.

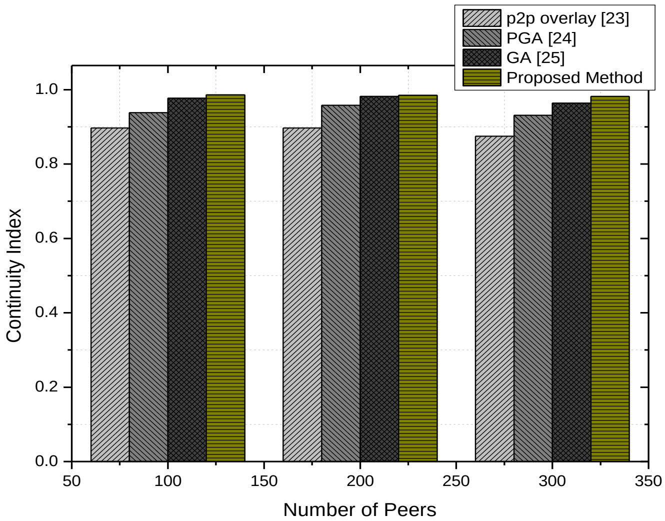

Figure 5. Number of peers vs. continuity index.

Figure 6 shows the reset count parameter of the proposed and existing methods. The reset count is used to check the network efficiency in the proposed and existing methods. In the graph below, *X* axis is measured with number of nodes and the reset count values are shown in the *Y* axis. The reset count is shown in the **Figure 6** which is related to the existing and proposed methods. In **Figure 5**, it is observed that the P2P overlay mechanism is recorded 132 at the 300 peers PGA and GA recorded the 24 and 51. The proposed method recorded 17 as the reset count. The proposed algorithm clearly outperforms the other algorithms.

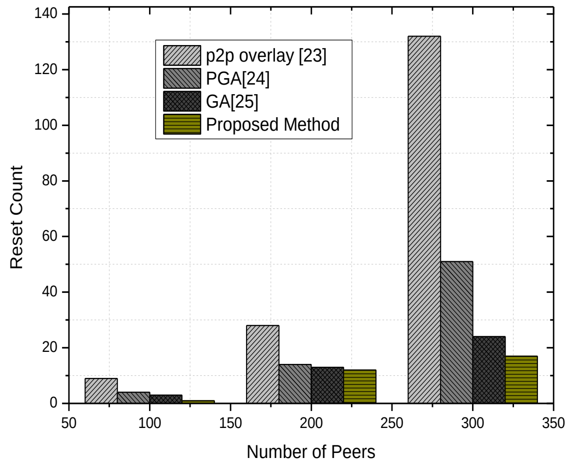

Figure 6. Number of peers vs. reset count.

Figure 7 shows the new parent requirement which is a measurementfor topology convergence. Peers are responsible for ensuring that their parents are following proper parental rules to avoid playback lag and packet loss. The parents failed to meet these requirements. In order to fix this issue, they need to change the methods. The proposed method performed similarly to the one used in the experiment when there were only 100 pairs. But, as the number of pairs increases, it becomes more efficient. In addition to the proposed algorithm, the other methods used, such as the genetic algorithm, are also efficient. They enable the final solution to be reached without the need for new parents. On the other hand, the P2P overlay framework method has the lowest performance.

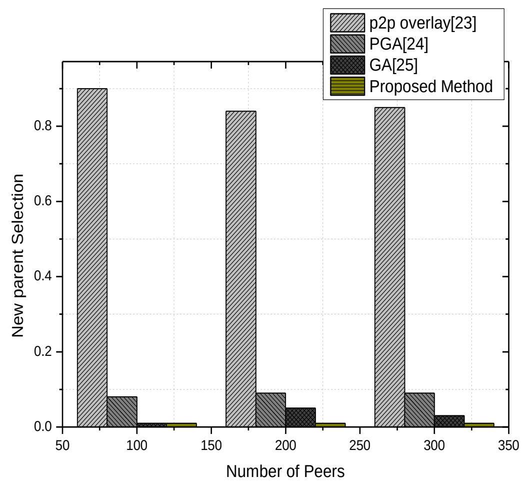

Figure 7. Number of peers vs. new parent selection.

To demonstrate the superiority of our proposed method, we conducted several experiments with different bandwidth values. The experimental results are shown below.

Table 3 shows the PSNR value of the proposed and existing methods in different bandwidth conditions. It is observed that the proposed method has the highest PSNR value compared against the other algorithms in all conditions.

Table 4 shows the continuity index factor of the proposed and existing methods in different bandwidth conditions. When compared with the other methods, it is apparent that under all circumstances, the suggested technique offers the best continuity index factor.

Table 3. Internal bandwidth vs. PSNR factor.

Method/bandwidth	3 Mbps	6 Mbps	9 Mbps	12 Mbps
Proposed method	38.5	37.5	34.9	34.2
GA	37.4	35.8	34.5	33.2
PGA	34.9	34.7	33.2	32.7
P2Poverlay	34.8	33.9	32.8	31.9

Table 4. Internal bandwidth vs. continuity index factor.

Method/bandwidth	3 Mbps	6 Mbps	9 Mbps	12 Mbps
Proposed method	0.84	0.91	1.05	1.10
GA	0.81	0.90	1.02	1.07
PGA	0.80	0.88	1.00	1.04
P2P overlay	0.86	0.90	1.01	1.08

The reset count for both existent and suggested approaches under various bandwidth conditions are displayed in **Table 5**. When contrasted with the other methods, it is shown that under all circumstances, the suggested method has the best reset count.

Table 5. Internal bandwidth vs. reset count.

Method/bandwidth	3 Mbps	6 Mbps	9 Mbps	12 Mbps
Proposed method	15	17	20	23
GA	23	24	28	31
PGA	49	51	54	57
P2Poverlay	127	132	137	142

The parent selection factor for the suggested and previous approaches under various bandwidth scenarios is displayed in **Table 6**. When compared with the other algorithms, it is shown that under all circumstances, the suggested technique has the best parent selection factor.

Table 6. Internal bandwidth vs. parent selection factor.

Method/bandwidth	3 Mbps	6 Mbps	9 Mbps	12 Mbps
Proposed method	0.02	0.05	0.10	0.13
GA	0.07	0.10	0.13	0.15
PGA	0.10	0.12	0.16	0.19
P2P Overlay	0.83	0.87	0.93	0.97

In our studies, we employed simulation parameters to examine their impact on the research findings. The study outcomes demonstrated that the suggested approach worked effectively in every scenario. Apart from the standard elements like the new parent requirement and the continuity index, the outcomes also demonstrated that there was little variation in the simulation parameters. The outcomes of the research showed that modifications to the application layer of the network exert a greater impact compared to those made to the physical layer.

5. Conclusion

The PSO-video streaming technique for sending and receiving video over a P2P network was described in the study. Finding the path that will move the video from one end of the network to the other is one of the greatest important steps in this procedure. Finding the nodes that are linked to the sender and receiver nodes allows you to accomplish this. The sheer number of alternative routes makes the procedure of choosing a route difficult. The speed and accuracy of the communications are taken into account in addition to the route selection when it comes to sustaining visual quality. The particles in the problem modelling indicate the path they should travel to get their desired goal. Its translocation is influenced by its knowledge of its neighbours and the other particles in the search space. The search quality of a particular particle is influenced by the other particles' positions inside the cluster. The suggested approach considers the experience of its occupants and the knowledge of its neighbours to affect the particle's translocation. The search quality of a particular particle depends on subsequent position of the cluster. The information that the other particles have shared with one another facilitates their progress in the direction of their ideal neighbours. The suggested approach is intended to deliver a continuous flow of data regarding the position of a particle inside the search space. It considers the particle's optimal position as well as the environment around it. This approach's reliability was tested through a simulation. The suggested solution performed better than the other one that is previously utilized.

Author contributions

Conceptualization, MSR and PCR; methodology, MSR and PCR; software, MSR and PCR; validation, MSR and PCR; formal analysis, MSR and PCR; investigation, MSR and PCR; resources, MSR; data curation, PCR; writing—original draft preparation, MSR and PCR; writing—review and editing, MSR and PCR; visualization, MSR and PCR; supervision, MSR and PCR; project administration, MSR and PCR; funding acquisition, PCR. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare no conflict of interest.

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