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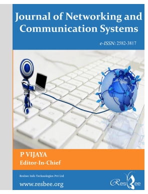

Chaotic Butterfly Optimization Algorithm for Resource Allocation in Cloud Gaming

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Abstract: One of the dangerous death-causing diseases called cancer can be cured by exploiting a renowned technique called chemotherapy. In cloud platforms, cloud gaming is a new technique that assembles video games and transmits aiding the game streams to the users via the network. In addition, the users might possess diverse requirements on Quality-of-Experience (QoE), like the prominent quality of the video, minimum delay, etc. In this situation, in order to assure the basic fulfillment for all users with restricted cloud resources is an important problem in the cloud. The main aim of this work is to acclimatize game theory to formulate a new technique to meet the basic requirements of users with minimum cost. Therefore, in order to discover the optimum solutions the cloud gaming approach with resource optimization is formulated to solve the resource allocation problem. In this paper, resource allocation is carried out with an optimization approach as the optimal option of task presents improved effectuality in cloud computing. To improve the effectiveness of cloud computing systems for resource allocation Chaotic Butterfly Optimization Algorithm (BOA) is presented for optimal resource allocation. Here, the objective function is highly formulated by considering the definite QoS parameters that include the Quantified experience of players (QE), fairness index, and Mean Opinion Score (MOS).

Keywords: Cloud platform, Cloud gaming, Network, QoS parameters, Resource allocation, Users.

Nomenclature

Abbreviations	Descriptions
QoE	Quality-of-Experience
CSP	Cloud Service Provider
MIPS	Million Instructions Per Second
CC	Cloud Computing
SG	Stackelberg Game
MOS	Mean Opinion Score
ANNs	Artifcial Neural Networks
NE	Nash Equilibrium
VM	Virtual Machine
FPS	Frames Per Second

1. Introduction

In modern society, Cloud computing is well-liked information technology; it obtains a huge concentration from academia, government, as well as industry. Recently, cloud services possess shown numerous accidents, for instance, many deceitful occurrences have scratched the transaction subjects' interests, as well as brought an enormous trust disaster to online transactions [1]. For cloud services, because of few incentives, privacy protection models, as well as punishments few nodes might link with others to create mutual cheating behavior. Hence, in order to resolve the issue of collaborative trust, set up a fair as well as credible service network as well as minimize the risks which are represented as the important problems in the cloud service applications implementation [3].

Cloud gaming is indicated as the novel manner to bring computer games to the users, wherein in powerful cloud servers the computationally complex gamers are implemented, over the internet, the provided game scenes are streamed to gamers within slim clients on heterogeneous devices as well as the from input devices the control events are transmitted back to the cloud for communications [11]. On cloud servers, a cloud gaming platform is hosted in one or multiple data centers. The computer game programs run on the cloud gaming platform that is approximately partitioned into the two most important modules such as game logic which is act as the transformed gamer commands to the in-game communications and in real-time the scene rendered which produces the game scenes [12]. From the command interpreter, the gamer commands occur as well as video capturer captures the game scenes into videos that are subsequently compressed using the video encoder. In the cloud gaming platform, the video capturer, command interpreter, and video encoder are all executed. The video frames transmit to the receiver using the cloud gaming platform as well as the receiver attains the user inputs from the clients which are performed by the gamers in order to play the games. It is represented as the thin client due to the merely two minimum complexity modules are needs a) receiver that links to the game controllers like joysticks, gamepads, keyboards, and mouse, and b) a video decoder that can be comprehended by exploiting the largely generated i.e., reasonably priced decoder chips [15]. The collaborations among the thin clients as well as the cloud game platform are within the optimal attempt internet that in order to create the aids in real-time computer games relatively challenge [13].

The reasonably priced platform model on the basis of the gaming can present the user possesses elevated QoE is considered an enormous confronts. There are numerous issues stated in the complete procedures. Initially, conversely to the existing services, in the cloud, the gaming is highly supportive as well as responsive to delays. During game playing the online game, players are not enduring as well as responsive as well as form the communication delay. Therefore, the cloud gaming service providers must change resource provisioning to resolve problems associated with the delay. Then, there are several genres in the game which impose diverse requirements on communication delay. Such requirements on communication delay differ considerably amid diverse game genres. There are various researches relating to cloud gaming in [1] [2].

The major aim of the work is to formulate a new cloud-based gaming approach by assigning optimal resources to cloud platforms. In this paper, for the cloud game, a game theory is used to meet the requirements of players with minimum cost. Therefore, to ascertain optimal solutions, a cloud gaming approach with resource optimization is exploited to identify resource allocation problems. In cloud computing, resource allocation is done with the optimization approach as the best option for the task that presents improved effectuality. The resource is allocated by exploiting the Chaotic Butterfly Optimization Algorithm (BOA). In addition, the objective function is highly formulated by taking into consideration the MOS, QE, as well as fairness parameters. The optimization by means of game theory helps out data center to effortlessness weigh down which includes gathering network information and handling enormous datasets.

2. Literature Review

In 2021, Pan Jun Sun [1], developed a game model on the basis of trust prediction. In the service game procedure, diverse participants possess a diverse purpose as well as benefits. Initially, the Bayesian formulation was exploited to forecast the behavior attribute trust level and furthermore present the trust attribute weight approach as well as trust decision function to assure the precise by utmost dispersion law. Next, the survival probability of game equilibrium was explained; the dynamic game technique was established from the short-term advantage of the user. Finally, a tripartite game technique that has multiple probable equilibria was established which can be transformed into a mixed approach in particular general circumstances from the long-term advantage of the CSP.

In 2021, Mingwu Wang et al [2], developed a new classification model on the basis of the combined linked cloud technique as well as game theory. Moreover, in order to demonstrate the fuzzy indicators arbitrarily distributing infinite intervals as well as concurrently exemplify the significance as well as indicators inherent information in harmony. Specifically, initially, the theory of link numbers, as well as the game theory on the basis of the linkage weighting technique, was used to collective the association cloud technique of individual indicators.

In 2021, PanJun Sun [3], developed a trust prediction game approach constituted of the manager, CSP, as well as the user. Initially, Bayesian formulation was exploited to forecast the behavior trust attributes as well the weight approach as well as the trust service map function was proposed using the utmost dispersion law. Then, a two-party dynamic game approach was established as well as survival prospect of game equilibrium was discussed on the basis of user viewpoint. Finally, a tripartite game approach was established, quite a few probable equilibria were analyzed, and attain the equilibrium scheme from a mixed viewpoint on the basis of the CSP viewpoint.

In 2020, Agnieszka Jakóbik [4], developed the SG on the basis of the approach to automate security decisions in CC. The developed approach was set up to portray the attack-defense cases. The game integrates two kinds of players opposing each other such as an attacker as well as a defender and here, the cloud provider was represented as the leader and it was permitted to play his scheme initially. Then the second player was the hacker, attacker, or other malicious individuals and they were grouped. To calculate the scheme of the attacker, this work proposes the black box technique. Here, by using various pipelines of ANNs, the utility function was attained. In addition, the technique presumes the information escapes regarding the attacker scheme as well as sleaze over the conventional SG techniques.

In 2020, Komal Singh Gill et al [5], developed a game-theoretic approach named GTM-CSec. The developed technique intelligently chooses the majority of appropriate components out of anomaly, signature, and honey-pot-based discovery to perceive the attack. The assortment of an exacting discovery component rather than exploiting all in parallel not only tends to minimization of energy utilization but additionally maximizes the complete competence of the defender system. For both attacker as well as defender schemes were estimated and the optimal one was described with NE.

3. System Model

A high-quality link association is exploited for cloud gaming which makes it easy for the users to possess the petite processing capability to play qualitative games. By means of not downloading or else installing the games software games can be played and also, there is no need for the user requirement to upgrade hardware incessantly. Therefore, utilizing minimum costs of hardware and software, they can play numerous games. The disseminated data centers are exploited by the service providers of games to present their services to users. If the cloud gaming infrastructure receives a request from a user subsequently, the user's request is transferred to an exacting repository based on the particular technique and allocates the VM to perform every user's requests. Therefore, the streaming encoded game is utilized by the VM to the user. The resources are assigned by the cloud technique for a particular time to the user tasks in order to complete the tasks before the deadline. The synchronization is presented by the resources allocator amid the cloud service provider as well as the user. The several configurations are utilized by the VM resources with diverse power, storage as well as memory. The entire control of cloud functions is posed by the resource component allocation, little performance creates the infrastructure of cloud unsuccessful. Therefore, a resource allocation formulation is important. While the VM load status is in normal condition, tasks are developed usually, and once the system senses an overloaded state, a resource allocation approach is used in order to assign the tasks from over-loaded VMs to under-loaded VMs.

The main aim of the formulated technique is to ascertain the optimal resources which are efficient in assigning resources to every game which is a demand by the user. Consider a cloud environment that consists h PMs, as well as their illustration as $M = \{M_1, M_2, \cdots, M_g, \cdots M_h\}$; $1 \le g \le h$, as well as all PM, comprises numerous VMs. Let VMs comprised in g^{th} PM indicated as $N = \{N_1, N_2, \cdots, N_k, \cdots, N_l\}$; $1 \le k \le l$, wherein l represents the total VMs in g^{th} PM. In a round-robin way, each user's requested games are allocated to the VM which is indicated as $G = \{G_1, G_2, \ldots, G_p, \ldots, G_q\}$, wherein q represent total games assigned to VM. $U = \{U_1, U_2, \ldots, U_p, \ldots, U_q\}$ represents the user's wish to play the games. The 3D video game is turned into a remotely indistinctly from distant data centers as well as the game screen is shown to users in real-time via internet connectivity in cloud computing. In order to judge cloud computing quality, video resolution is a very important factor. $B = \{B_1, B_2, \ldots, B_p, \ldots, B_q\}$ represents each frame bit rate and $V = \{V_1, V_2, \ldots, V_p, \ldots, V_q\}$ represents the video frame rates for each game. $Q = \{Q_1, Q_2, \ldots, Q_s, \ldots, Q_t\}$ indicates the game played QoE by the user history. For resource allocated each VM chosen is configured on the basis of a few parameters such as processors, memory, bandwidth, and MIPS which is stated in eq. (1), wherein, $Y_{g,k}$ signifies memory of k^{th} VM in g^{th} PM, $R_{g,k}$ signifies count of processors of k^{th} VM in g^{th} PM, $P_{g,k}$ signifies count of MIPS in k^{th} VM in g^{th} PM, $C_{g,k}$ signifies bandwidth in k^{th} VM in g^{th} PM. The parameters $R_{g,k}, Y_{g,k}, C_{g,k}, P_{g,k}$ increase a value that ranges from 1 to a constant f . For each game resource unit is stated in eq. (2). User preference level is stated as [0, 1] in which 1 signifies more predilection and 0 signifies no predilection. T denotes VM initialization time.

$$N_{g,k} = \{R_{g,k}, Y_{g,k}, C_{g,k}, P_{g,k}\} \quad (1)$$

$$K = \{K_1, K_2,, K_p,, K_q\} \quad (2)$$

In order to resolve the issue, a game theory is utilized for resource allocation in cloud gaming as well as to assist service providers to minimize the maintenance cost. Because of the decentralized system feature, game theory inclusion is very important. In the cloud, because of lesser resources, the users are strained and therefore they are automated in equivalently satisfying conditions. Additionally, an optimization based on game theory helps data centers to alleviate complex centralized management burdens. In addition, the main aim of the players is to play several games as well as obtain an enhanced experience on the basis of the QoE. To analyze the resource competition, the game theory can be exploited by different players with diverse games. Therefore, to discover the optimum solutions the cloud gaming approach with resource optimization is formulated to resolve allocation issues. In this work, resource allocation is carried out by an optimization approach as the best option for tasks that presents improved effectuality in cloud computing. In a cloud computing system, the developed model is presented for the allocation of resources. The main aim of the allocation of resources with optimization is to select the best tasks appropriate to specific resources. Fig. 1 illustrates the architectural model for the resource allocation approach by using the adopted optimization model

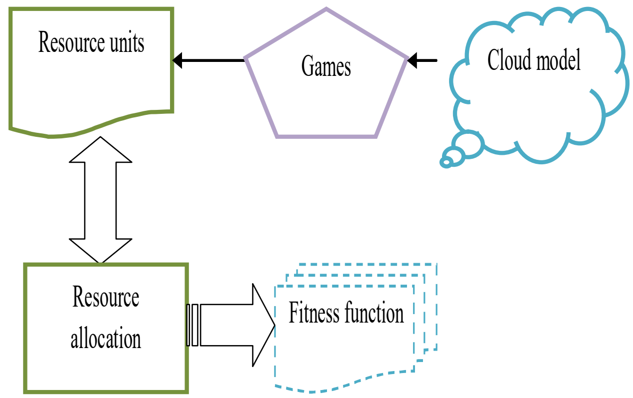


Fig. 1. *Architectural model for resource allocation approach by exploiting the adopted optimization model*

In order to ascertain the optimal solution, the fitness is estimated by exploiting the solution set. For the adopted model, the objective function is formulated on the basis of three metrics that include the quantified experience of players, fairness, and MOS. On the basis of the loss of gaming experience the quantified experience of players On basis of loss of the gaming experience, the players quantified experience represents the target optimization function. In order to initiate cloud computing, the solution fitness is represented as the maximization function therefore the optimal allocation of resources is carried out. Eq. (3) indicates the objective model of the adopted optimization model, wherein MOS simplifies mean opinion score, QE simplifies players' quantified experience, and J^T simplifies fairness. The maximization issue is considered as the fitness for that MOS must be maximum, QE must be maximum, as well as Fairness must be maximum. Eq. (4) indicates the mean score opinion [8], wherein V_k represent game running video frame rate in k^{th} VM B_k represents the bit rate of the game which runs in k^{th} VM and L_k represent resource parameters. Eq. (5) formulates the resource parameters to improve Quality of Service (QoS), wherein, X^C represents the sum of bandwidth, X^Y represents the sum of memory usage, X^R represents the number of processors, and X^P represents the number of MIPS used for the allocation of resources.

$$F = QE + MOS + J^T \tag{3}$$

$$MOS = \frac{1}{1}\sum_{k=1}^{1}\left(B_k * L_k + V_k * L_k\right) \tag{4}$$

$$L_k = \frac{1}{4}\left(\frac{X^R + X^Y + X^C + X^P}{\max\left(X^R, X^Y, X^C, X^P\right)}\right) \tag{5}$$

In order to integrate the frame per second, delay as well as resolution, gaming experience loss *GL* of the player is formulated in eq. (6) that is the target of each player, wherein, U represents delay, W^1 represents experienced FPS, μ_1, μ_2 as well as μ_3 represents constant parameters, and N represents gaming video quality.

$$GL = \mu_1 U - \mu_2 W^1 - \mu_2 N \tag{6}$$

Since VM with games is created as well as insolvent in an active way there might exist a replica delay amid the user p that represents the delay in initialize service. O represents the writing speed on a hard disk for effortlessness by saving the games in the repository.

Eq. (7) indicates if a player chooses a game by exploiting a file size x_k, total delay [1] is represented regarding initialization time of VM T, wherein, O represents hard disk writing speed, x_k represents game file size in k^{th} VM, and T_k represents initialization time of VM.

$$U = \sum_{k=1}^{l} \frac{x_k}{O} + T_k \tag{7}$$

The FPS [6] practiced by the gaming users is an explanation experience metric to pact with the cloud case. Basically, FPS is identified with GPU, RAM, as well as CPU by taking into consideration of physical server. Eq. (8) formulates the FPS in cloud gaming, where, ω_1, ω_2 and ω_3 represents the approximation parameters. Eq. (9) indicates the game video quality [6] wherein, ω, ℓ and ω_o represents constant, and N_k signifies game video resolution in j^{th} VM. Eq. (10) indicates the fairness.

$$W^l = \sum_{k=1}^{l} \frac{\omega_1}{1 + e^{\omega_2}\left[\frac{1}{5}\sum_{k=1}^{l} \vartheta_k + L_k\right] + \omega_3} L_k \tag{8}$$

$$N = \sum_{k=1}^{l} \left(\frac{\omega}{\upsilon} \log_2 \left(1 + \frac{\ell N_k}{\omega_o + \sum_{k=1}^{\ell} \ell N_k} \right) \right) \tag{9}$$

$$J^T = \frac{1}{l \times t} \sum_{k=1}^{l} \left(\sum_{s=1}^{t} Q \right) * UPL \tag{10}$$

wherein, Q represents the QoE scores of games played by history users as well as UPL represents user preference level.

4. Proposed Chaotic Butterfly Optimization Algorithm for Resource Allocation

The resource allocation is performed by exploiting the new optimization approach, named Chaotic Butterfly Optimization algorithm [10]. It is evident that this approach carries out fault diagnosis with improved classification precision.

In the proposed model, three diverse strategies are exploited. Initially, chaotic functions are used in sensory modality as well as power exponent values before constant values to integrate arbitrariness as well as dynamical properties to accelerate the optimization approach convergence as well as avert early convergence to local minima. Next, a novel local search notion is developed with aid of quantum wave theory to improve the effectiveness as well as BOA convergence speed in order to set up particles to search for the search domain accurately. At last, an approach to choosing the global else local search is enhanced by using a rank collection principle.

4.1. Chaos Maps

In the proposed model, the chaos functions are used to show better performance when compared with the other chaos functions.

Logistic map

$$y_t = r y_{t-1}(1 - y_{t-1}) \tag{11}$$

In eq. (11), r indicates growth rate, as well as y_t indicates the value in any iteration t that can use values from 3.0 to 4.0.

Iterative map

$$y_t = \sin\left(\frac{P\pi}{y_{t-1}}\right) \tag{12}$$

P value chooses between 0 and 1, as well as outcome y_t represents a chaotic variable that uses a value from 0 to 1 in the iterative map.

Tent map

$$y_t = \begin{cases} \dfrac{y_{t-1}}{0.7} & y_{t-1} < 0.7 \\ \dfrac{10}{3}(1 - y_{t-1}) & y_{t-1} \geq 0.7 \end{cases} \tag{13}$$

The value of sensor modality value is modified as below:

$$c - mod(t) = \left[c - mod(t-1) + \frac{0.025}{c - mod(t) * T} \right] * y_t \tag{14}$$

wherein $c - mod(t)$ indicates the enhanced value of sensor modality in any iteration t.
Likewise, the power exponent constant value overall iterations in conventional BOA is changed as below:

$$a\,mod(t) = 0.15 * y_t \tag{15}$$

4.2. Quantum Wave Concept

In the quantum wave concept, a particle is presumed to move in a one-dimensional well, as well as particle location Y can be computed as below:

In (16), $p^t_{i,j}$ represents the local attractor point at time t.

$$Y^{t+1}_{i,j} = p^t_{i,j} + \frac{1}{2} L^t_{i,j} \left(\frac{1}{u} \right) \tag{16}$$

The local attractor point can be stated as an arbitrary average of local as well as global optimal particles in the swarm as below.

$$p^{t+1}_{i,j} = \Phi P^t_{i,j} + (1 - \Phi) G^t_j \tag{17}$$

where Φ indicates an arbitrary number with a uniform distribution function with intervals among "0" as well as "1". $L^{t+1}_{i,j}$ is stated as below:

$$L^{t+1}_{i,j} = 2\alpha \,|\, C^t - Y^t_{i,j} \,| \tag{18}$$

Here, C^t indicates mean an optimal location that is the mean of the optimal location of each and every particle participating in quantum calculating.

$$C^t = \left(C^t_1, C^t_2, \ldots\ldots\ldots C^t_D \right) \tag{19}$$

The CE coefficient is sensitive to a number of iterations as well as population size and can be fixed to a constant value or varied in a stated limit. Note that the parameter α must be minimized at the time of the sequence of iterations as below.

$$\alpha = \alpha_0 + (T - 1) * \left(\frac{\alpha_1 - \alpha_0}{T} \right) \tag{20}$$

where, α_0 and α_1 $\alpha 0$ represents staring as well as final values of α, correspondingly, T represents the total number of iterations.

Ranking and Search Type Decision:

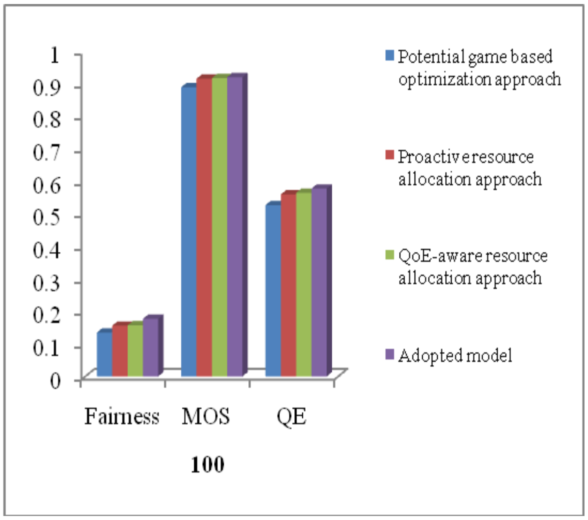
The ranking is represented as association amid two mathematical values, wherein every value can be lesser than, bigger than, or equivalent to a conditional value. The exploitation and exploration factors change along with the below equation:

$$C_{explore} = (90 - 5) \times \exp\left\{ \left(\frac{-1.5t}{t_{max}} \right)^2 \right\} + 5 \tag{21}$$

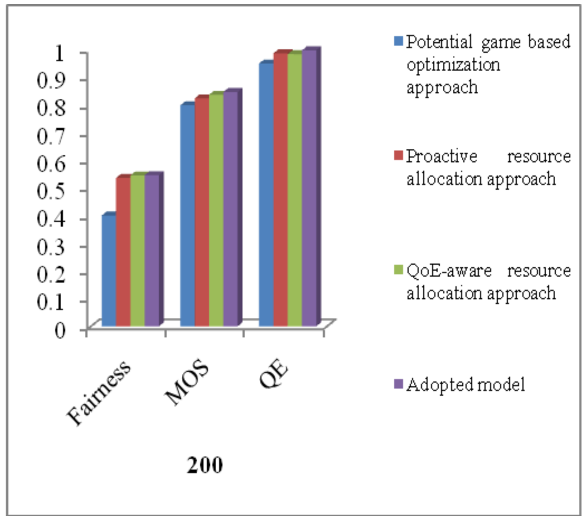
$$C_{exploit} = 100 - C_{explore} \tag{22}$$

5. Result and Discussion

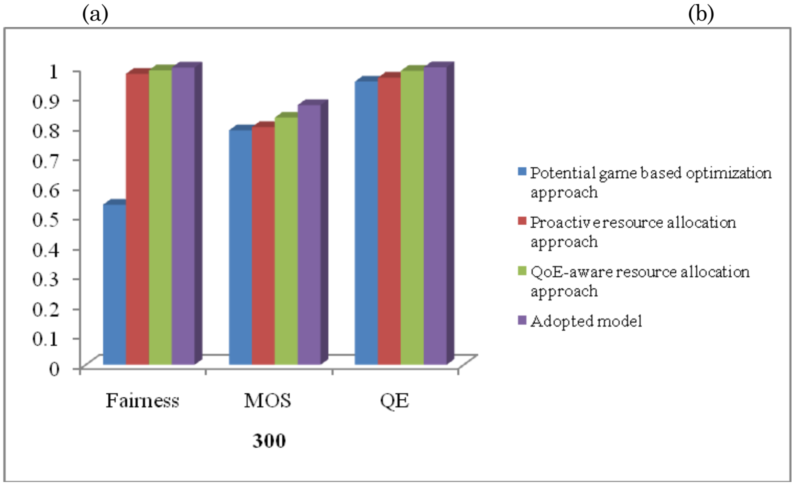
The efficiency of the adopted chaotic Butterfly Optimization Algorithm was experimented within this section by exploiting QE, MOS as well as Fairness. Here, the evaluation was performed by taking into consideration of diverse game sizes such as 100, 200 as well as 300.



(a)



(b)



(c)

Fig. 2. *Analysis of the proposed and conventional models regarding game size (a) 100 (b) 200 (c) 300*

Fig 2 demonstrates the comparative evaluation of the proposed model with the conventional models regarding MOS, fairness, as well as QE by exploiting the game size 100, 200, and 300, correspondingly. Here, the proposed model is compared with the conventional models such as the Potential game-based optimization approach, proactive resource allocation approach, and QoE aware resource allocation approach. The performance enhancement on the basis of the fairness by an adopted model with a QoE-aware resource allocation algorithm is better than the conventional models for game size=100. It is evident that the adopted model presents a better performance in allocating resources with cloud infrastructures with maximum fairness, MOS, and QE through the analysis.

6. Conclusion

The main aim of this work was to formulate a new cloud-based gaming approach by assigning the best resources in order to fulfill the requirement of players with minimum cost on the cloud platforms. Moreover, to determine the optimal solutions the cloud gaming approach with resource optimization was formulated in order to identify the resource allocation problem. Therefore, the optimization algorithm was presented to enhance the effectiveness of cloud computing systems for resource allocation. Here, the objective function was formulated by taking into consideration of definite parameters that include the Experience rating, fairness index, as well as MOS. In-game theory, the adopted optimization model aids the data center to ease load which includes the gathering of user's network information and managing enormous datasets. The simulation analysis of the adopted model was carried out by exploiting the parameters by taking into consideration of diverse game sizes. The performance analysis was evaluated with both the adopted optimization model and the existing models.

Compliance with Ethical Standards

Conflicts of interest: Authors declared that they have no conflict of interest.

Human participants: The conducted research follows the ethical standards and the authors ensured that they have not conducted any studies with human participants or animals.

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