# Enhanced Active Queue Management-Based Green Cloud Model for 5G system using K-Means

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**Abstract**

The most unique and important design considerations in 5G cloud computing are the delay, energy consumption, and throughput. Therefore, most recent studies focused on boosting delay and energy consumption, and throughput using edge computing. The active queue management-based green cloud model (AGCM) is one of the most recent green cloud models that decreases the delay and sustains a stable throughput. Also, Mobile edge computing (MEC) is an essential cloud computing model for mobile users to meet the continuous growth of data requests. Thus, we offer a handoff scenario between the AGCM and MEC to assess the possible benefits of such collaboration and enhance its effects on the fundamental cloud restrictions such as delay and throughput. Accordingly, the proposed algorithm is named Enhanced Active queue management-based green cloud model (EAGCM). The proposed EAGCM regards incorporation between Kmeans and AGCM. The simulation results indicate that the proposed EAGCM serves mobile users efficiently, enhances the throughput, and reduces latency compared to AGCM and the cloud for 5G systems.

**Keywords:** Active Queue Management-Based Green Cloud Model (AGCM); Mobile edge computing (MEC); K-means; 5G.

## 1. Introduction

In recent years, internet-of-things (IoT) devices causes a substantial load on the network infrastructure. Therefore, 5G new technologies have furnished a promising solution to satisfy these demands and enable the fortune of wireless communications [1]. Mobile Edge Computing (MEC) is a new technology that promises to obtain cloud computing to the edge of wireless access networks. Therefore, MEC will contribute fresh perspectives in the 5G wireless infrastructures. It can offer services with minimal latency and high availability. But compared to cloud computing, it uses resources for computation and storage, which yields a rise in latency and energy consumption [2]. So, energy efficiency, latency, and throughput have become key considerations in MEC design to achieve the high performance of 5G systems [3].

As a result, the authors introduced an active queue management-based green cloud model (AGCM), an energy-efficient cloud typical to lower energy waste and delay at both the cloud and mobile devices by minimizing the congestion in the cloud. The AGCM offers a hand-off technique with MEC to investigate its influence on the cloud's fundamental restrictions [4]. The AGCM employs congestion control to handle energy efficiency. Even though there is a strong correlation between congestion, delay, throughput, and energy in particular, it is rarely explored as a way to increase energy efficiency. Also, the AGCM suggests an energy-efficient technique with low latency and without adding more costs or varying the cloud infrastructure by lowering the retransmission requests.

Consequently, AGCM and MEC are not considered a single solution for a single application. The AGCM and MEC are expected to be an infrastructure for a wide range of utilization. In this regard, this paper achieves the



DOI: https://doi.org/10.54216/IJWAC.060206
Received: September 08, 2022 Accepted: November 25, 2022

collaboration between MEC and AGCM. Consequently, this paper investigates a proposed model that merges the MEC and AGCM strategies in the 5G networks by using K-means. The K-means is one of the most preferred unsupervised machine learning algorithms. Also, the K-means stops developing and optimizing clusters. The proposed strategy is named Enhanced Active queue management-based green cloud model (EAGCM). The proposed EAGCM deploys the AGCM and the MEC as two solutions to the same problem (i.e., low latency and high throughput). In the proposed EAGCM algorithm, the MEC implements at the edge of the 5G network into the radio access network (RAN), where mobile devices will offload their tasks to be computed. When the MEC server at the edge is inadequate, the tasks will route to the core cloud, where AGCM is executed [5].

The remaining sections of the paper are organized as follows: Section 2 discusses the related works. Section 3 presents the proposed EAGCM. Section 4 introduces the simulation results and discussion. Finally, section 5 concludes the paper.

## 2. Related Works

Most researchers study different aspects of low energy, low latency, and high throughput in-depth without influencing the 5G system execution. Through placing servers on the network edge, the MEC and AGCM techniques can improve latency, throughput, and power consumption. Accordingly, we require drastic modifications in network architecture (i.e., core and radio access network (RAN)) to optimize latency, throughput, and energy consumption. Therefore, a comprehensive study of the emerging technologies of 5G cellular networks is studied in [6] to attain low latency communications regarding three various solution domains: RAN, core network, and caching. Also, software-defined network (SDN), network function virtualization (NFV), caching, and mobile edge computing (MEC) capable of satisfying latency and other 5G necessities are surveyed.

In [7], learning-to-rank algorithms are implemented to decrease latency at the edge servers of the 5G MEC system. An application of inhomogeneous Poisson point processes with hard-core repulsion to model possible MEC infrastructure deployments in 5G and reduce multimedia services latency is investigated in [8]. In [9], the prioritized traffic shaping for MEC is suggested to control the forwarding of downlink MEC/Internet traffic at the MEC and lower the latency of MEC Flows. A Radio access network-aware proxy-based flow control mechanism (RAPID) is proposed in [10] to reduce delay in both Line-of-Sight (LOS) and Non-LOS (NLOS) situations and maintain high throughput in both 4G and 5G by employing MEC services and packet arrival rates. An Enhanced Green Cloud Based Queue Management (GCQM) system for 5G networks is introduced in [11] to solve the issues related to throughput, latency, energy consumption, and normalized overhead in the MEC system. A Multi-user Queue Offloading multi-dimensional game algorithm (MQO) is suggested in [12] to boost the performance of both overhead and offloading numbers with the growth of users and optimize the energy consumption and time Delay in MEC. In [13], computation offloading to achieve great tasks, reduce the energy consumption of the mobile device, and satisfy the latency restriction is recommended for single-user-single-server MEC systems. A novel hybrid strategy based on Particle Swarm Optimization (PSO) and Grey Wolf Optimizer (GWO) to optimize resource assignment and minimum energy consumption is investigated in [14]. An energy-efficient cloud benchmark with the MEC approach is introduced in [15] to diminish the latency, energy consumption, and throughput at both the cloud and mobile devices for the 5G system.

## 3. The Proposed Enhanced Active Queue Management-Based Green Cloud Model (EAGCM)

The suggested system model is focused on showing how congestion control techniques can best suit big data in the cloud. Therefore, we offer a handoff scenario between the two cloud models, MEC and AGCM, to get insight into the possible benefits of such collaboration and assess its potential effects on the fundamental restrictions of the cloud (i.e., latency and throughput). The proposed model is named Enhanced Active Queue Management-Based Green Cloud Model (EAGCM), in which EAGCM shows a significant enhancement in delay and throughput over either model when employed separately.

Congestion is one of the main three layers of Data Centre Networks (DCN) restrictions. Therefore, the proposed EAGCM motivates to lessen the congestion and its consecutive effects. Figure 1 shows the three major cases of congestion in the 5G network, which are Femtocell, MEG, and EAGCM cloud. The proposed EAGCM handles the congestion issue by executing an AGCM algorithm to organize the incoming packets from mobile nodes in the aggregation layer within the three layers architecture in the DCN. Consequently, decreasing the congestion leads to more minor delays and losses. Also, the serving time and the energy consumption reduced. Furthermore, the proposed EAGCM organizes a virtual list for each node inside the core smartly to prioritize and serve the packets. The virtual list performs as a cached copy or as a buffer for each transmitted packet from all mobile nodes. Thus, it supports all the packet information (i.e., packet type, source IP, destination IP, length of package… etc.). The



DOI: https://doi.org/10.54216/IJWAC.060206
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proposed EAGCM adjusts the operational environment of the cloud core and executes the model within the MEC to meet the upcoming 5G growing service demands while maintaining lower energy consumption for a better green environment. In the proposed EAGCM, the mobile packet scheduling is performed using the mark probability method, which improves the packet's success rate during the connection with minimum delay.

The flow chart for the proposed EAGCM is shown in figure 2. The detailed illustration of the steps of the proposed EAGCM is as follows:

1.After every mobile packet arrival, congestion is checked (e.g., initiate stage).

2.If congestion is detected, ENRED (Queue Management) begins the second stage, where ENRED forms the target value depending on the maximum and minimum threshold and estimates the dropping probability.

3.If no congestion is detected, the virtual linked list performs with the K-means algorithm. The K-means divides the packets into groups inside the virtual linked list, which serves a larger number of packets.

Consequently, the performance of storing all information is enhanced, mobile packets are recovered quickly, and latency and throughput are boosted.

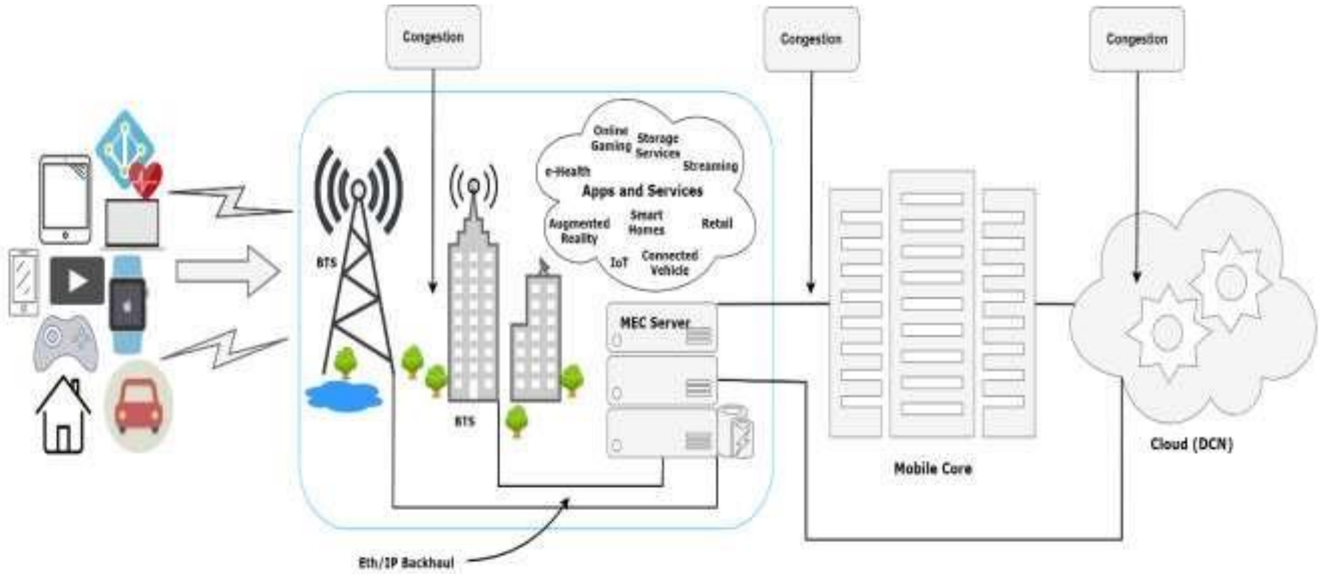


Figure 1: The cases of congestion in 5G cloud network.



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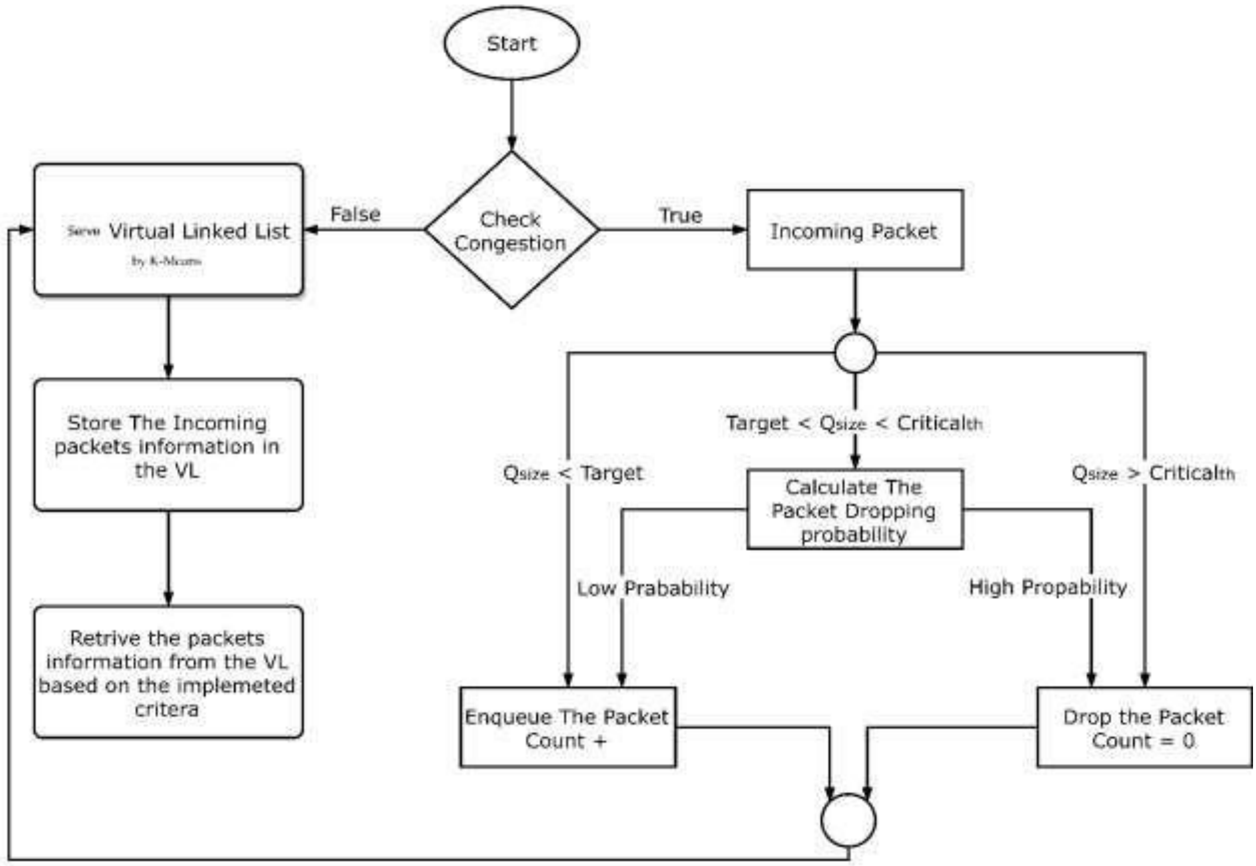


Figure 2: The flow chart for the proposed EAGCM.

## 4. The Simulation Results

The simulation results and discussions for both AGCM and the proposed EAGCM are introduced in this section. Figure 3 shows the summary of energy consumption during the simulation and data center loads according to simulation time. The proposed EAGCM assesses its performance by NS2 employed with the parameters in Table.1.

| | |
|---|---|
| Datacenter Architecture: | three-tier debug |
| Switches (core): | 10 |
| Switches (agg.): | 20 |
| Switches (access): | 8 |
| Servers: | 160 |
| Users: | 1 |
| Power Mgmt. (servers): | No |
| Power Mgmt. (switches): | No |
| Average Load/Server: | 0.2 |
| Datacenter Load: | 24.7 % |
| Total Tasks: | 1783 |
| Average Tasks/Server: | 11.1 |
| Tasks Rejected by DC: | 0 |
| Tasks Failed by Servers: | 0 |
| Total Energy: | 1839.6 W*h |
| Switch Energy (core): | 413.8 W*h |
| Switch Energy (agg.): | 827.5 W*h |
| Switch Energy (access): | 147.3 W*h |
| Server Energy: | 451.0 W*h |

Figure 3: the Energy summary for the dynamic proposed EAGCM.



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| Table. 1: The wireless network characteristics used by NS2 in simulation | |
|---|---|
| **Number of network nodes** | 50, 100, 150, 200, 250 |
| **Antenna model** | Omni directional |
| **Radio type** | 802.11b |
| **MAC type** | 802.11 |
| **Network protocol** | IPV4 |
| **CBR properties** | 512 bytes |
| **Energy model** | Battery |

The following metrics are used to compare the performance of both AGCM model and EAGCM model. The first metric is the throughput, which refers to the rate of received packets across the network during a time unit. The second metric is the delay, which indicates the time required for a packet to travel from source to destination. Delay is the most accurate measure of congestion. Figure 4 presents the delay characteristics, which can classify into three states. Firstly, when the load is much less than the network capacity, the delay is kept to a minimum. This minimum delay composes of propagation delay and processing delays (negligible). Secondly, when the load gets the network capacity, the delay increases sharply because of adding the waiting time in the queues (for all routers in the path) to the total delay. Thirdly, when the load is higher than the network capacity, the delay becomes infinity.

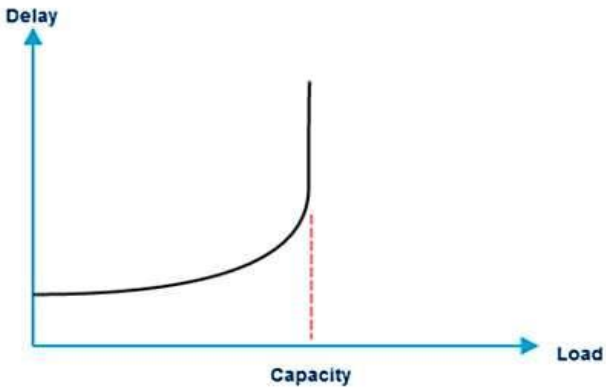


Figure 4: The delay characteristics over load capacity.

Table 2 provides the throughput values for the wireless network applied by the NS2 simulator for the proposed EAGCM, which offers better results compared to cloud throughput values and AGCM throughput values. By using number of packet requests =500, the throughput of the proposed EAGCM is higher than AGCM model by 7.479%. Also, increasing the mobile nodes and using number of packet requests =1000 gives an improvement in the proposed EAGCM throughput by 5.4% compared to AGCM model. Additionally, if the number of packet requests =1500, 2000, and 2500, the proposed EAGCM achieves higher throughput compared to AGCM model by 6.809%, 1.634%, and 1.675%, respectively. Also, the proposed EAGCM accomplishes much larger throughput values compared to cloud model. Figure 5 shows the previous results graphically.

Table 2: Throughput values of cloud, AGCM, and Proposed EAGCM models at different number of packet requests.

| **Number of Packet Requests** | Cloud (kbps) | AGCM (kbps) | Proposed EAGCM (kbps) |
|---|---|---|---|
| **500** | 914.79 | 4115 | 4422.76 |



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| | | | |
|---|---|---|---|
| **1000** | 1100.16 | 4665 | 4916.96 |
| **1500** | 1144.76 | 6200 | 6622.17 |
| **2000** | 1366.03 | 7255 | 7373.55 |
| **2500** | 1490.22 | 8200 | 8337.39 |

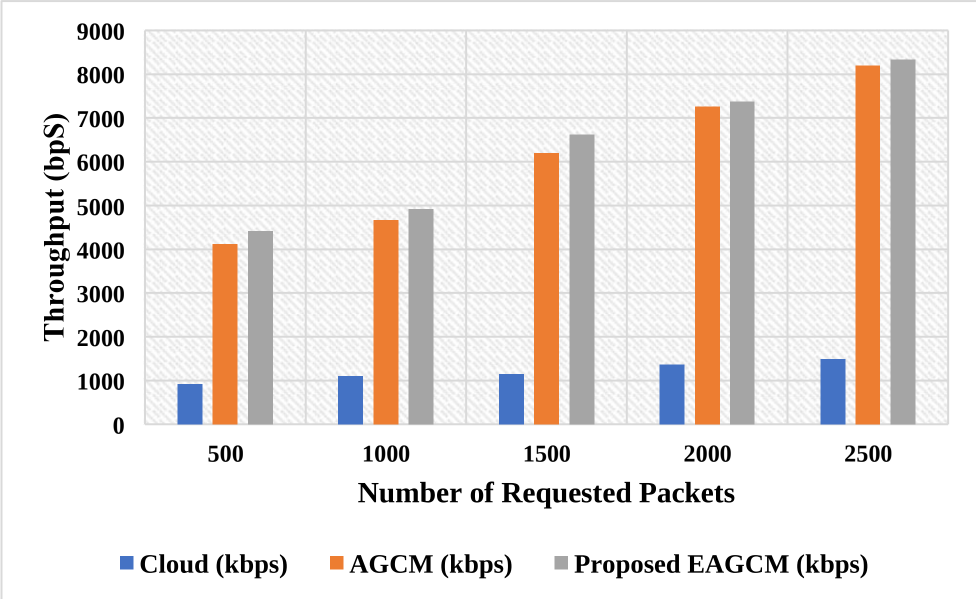


Figure 5: Throughput values at different number of packet requests for cloud, AGCM, and proposed EAGCM models.

Table 3 and Figure 6 introduce the measured delay values of the proposed EAGCM in comparison with cloud model and AGCM model. When the number of packet requests = 500, 1000, 1500, 2000, and 2500, the measured delay values of the proposed EAGCM is improved compared by AGCM model by percentages of 86.11%, 86.91%, 66.69%, 38.47%, and 46.53%, respectively. Also, this indicates that the proposed EAGCM gives a significant reduction in the delay values compared to cloud model and AGCM model.

Table 3: Delay values of cloud, AGCM, and proposed EAGCM models at different number of packet requests.

| **Number of Packet Requests** | Cloud (mSec) | AGCM (mSec) | Proposed EAGCM (mSec) |
|---|---|---|---|
| **500** | 0.95758 | 0.42 | 0.0583 |
| **1000** | 1.16761 | 0.45 | 0.0589 |
| **1500** | 1.05345 | 0.46 | 0.1532 |
| **2000** | 1.14136 | 0.57 | 0.3507 |
| **2500** | 1.28613 | 0.69 | 0.3689 |



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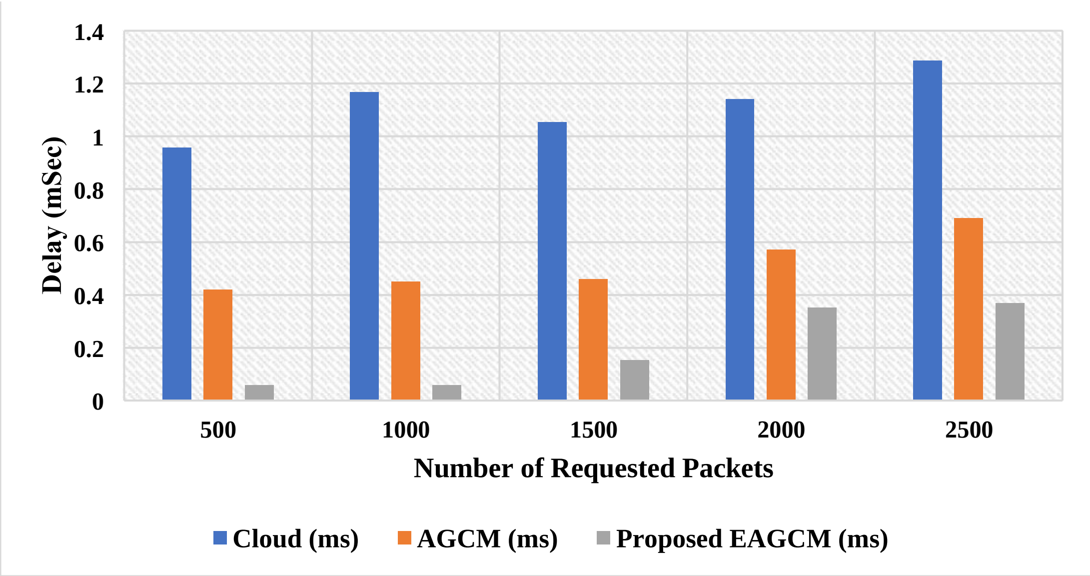


Figure 6: Delay values at different number of packet requests for cloud, AGCM, and proposed EAGCM models.

## 5. Conclusion

In this paper, we present a cooperation benchmark depending on AGCM, and MEC strategies by using Kmeans, to enhance latency and throughput in the 5G cloud network. The proposed model calls the Enhanced Active queue management-based green cloud model (EAGCM). The proposed EAGCM merges the AGCM with the MEC, which leads to smaller transmission line for offloading or lesser hops and nodes involved in the transmission. Additionally, the blocking probability and cloud congestion are decreased because the edge servers handle a part of the traffic. The simulation results demonstrate that the proposed EAGCM enhances latency and throughput compared to AGCM and the cloud.

**Funding:** “This research received no external funding”

**Conflicts of Interest:** “The authors declare no conflict of interest.”

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Received: September 08, 2022 Accepted: November 25, 2022

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Received: September 08, 2022 Accepted: November 25, 2022