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An optimized congestion control protocol in cellular network for improving quality of service

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Abstract

In recent decades, Cellular Networks (CN) have been used broadly in communication technologies. The most critical challenge in the CN was congestion control due to the distributed mobile environment. Some approaches, like mobile edge computing, congesting controlling systems, machine learning, and heuristic models, have failed to prevent congestion in CN. The reason for this problem is the lack of continuous monitoring function at every time interval. So, in this present study, a novel Golden Eagle-based Primal–dual Congestion Management (GEbPDCM) has been developed for the Long-Term Evolution (LTE) Ad hoc On-demand Vector (AODV) network. Here, the Golden Eagle function features will afford the continuous monitoring function to monitor data congestion. Hence, the main objective of this research is to improve the Quality of service (QoS) by optimizing congestion controls. Here, the QoS is measured by different metrics, such as delay, packet delivery ratio (PDR), throughput, packet loss, and energy consumption. Initially, the nodes were created in the MATLAB environment, and the GEbPDCM was activated to predict the data load and estimate the node density to measure the node status. Then, the high data overload was migrated to another free status node to control congestion. Finally, the proposed model efficiency was measured regarding delay, packet delivery ratio (PDR), throughput, packet loss, and energy consumption. The proposed model has scored high throughput at 97.1 Mbps and 97.1 PDR, reducing delay to 67.4 ms and 50.6 mJ energy consumption. Hence, the present model is suitable for the LTE network.

Keywords Quality of service · Golden eagle optimization · Data load · Node density · Data migration · Node creation

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1 Introduction

The pattern of modern civilization is that it becomes more costly as time passes, and goods become cheaper [1]. To develop a society consistent with this, a global network infrastructure must be established to provide immediate information and communication [2]. As the network is the primary information repository, mobile communication must integrate as cheaply as feasible with the industry's basic structure, including its broadband and quick trafficking capacity [3, 4]. It was the key idea underlying the creation of LTE cellular communication [5].

The research on communication efficiency over LTE networks is thus of major importance [6]. The mobile LTE wireless system is described in Fig. 1. Network and communication technologies have grown substantially [7]. Concurrently, different communication parameters have raised the desire for greater-quality wireless systems [8]. Rapid growth has occurred in using customer services and apps to satisfy consumers [9]. So far, meeting such demands has been difficult for scientists [10]. Among these requests, improving voice clarity and data transmission speeds are the most important factors in maximizing the wireless system [11]. The LTE network is mainstream with extensive performance goals [12]; hence, it is vital to test the functionality and reliability of this current scheme at a preliminary phase to facilitate its seamless and cost-effective implementation [13]. The modeling routing techniques explore difficulties associated with traffic behavior in data broadcasting channels [14, 15].

The network communication traffic has conjugated with another LTE network activity, leading to data overload [16, 17]. Hence, the latency of data transmission has increased [18]. Several models, such as edge computing [19], latency controlling mechanism [20], etc., already exist to improve the QoS of the LTE network [21]. However, the dynamic

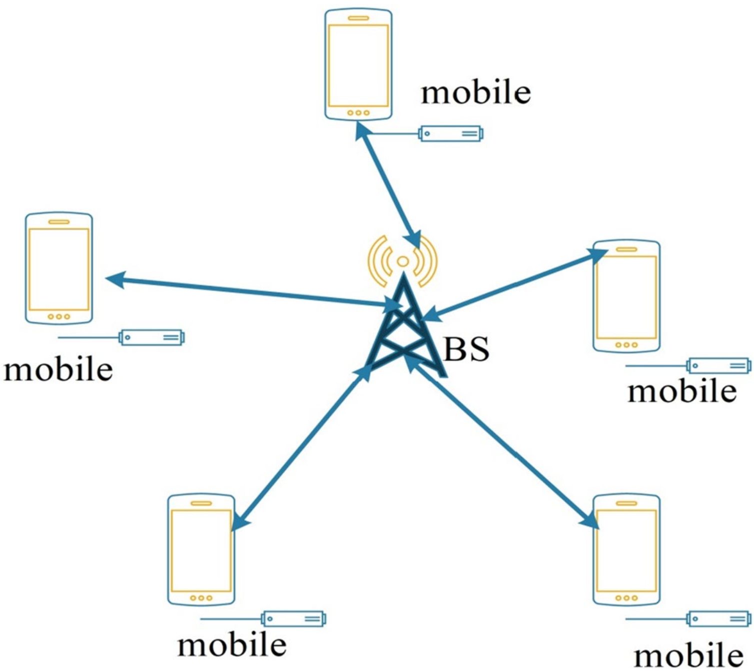


Fig. 1 Mobile LTE wireless system

behavior has caused difficulties in offering the proper resource allocation and data transmission rate. It tends to cause poor data delivery with high packet loss [22]. These reasons have motivated this study to implement the optimized routing strategy for optimal resource allocation. The key contribution of this research was summarized as follows,

- The required number of wireless nodes was initially created in the MATLAB environment.
- Consequently, a novel GEbPDCM was designed with optimal parameters like congestion control and resource allocation in the AODV.
- To check the effectiveness of the designed model, the video data is given as the input, and the data broadcasting function has been started.
- Then, the optimal parameters were activated for predicting node status and to balance the data overload by performing a data migration.
- Finally, the LTE parameters were calculated and compared with other models regarding delay, throughput, packet drop ratio, packet delivery ratio, and energy consumption.

The remainder part of the article was listed in several sections. The literature survey was described in Section 2. The existing methodologies are illustrated in Section 3. In Section 4, the proposed method is explained in detail here. Section 5 describes the details of the experimental study. Section 6 ended with conclusions or future work.

2 Related works

Several recent related works carried out for the LTE network were determined here.

The critical process was reducing the delay and energy consumption in the LTE network, so Caiazza et al. [19] introduced an edge computing model with restricted energy and Delay parameters. Then, the data transmission function was performed, and the communication parameters were noted. Finally, the improvement measure of the designed LTE model is compared with other conventional models, and the performance was noted. The developed edge-based model has recorded high QoS performance. However, it has required more resources to design.

Amjad et al. [20] have introduced the latency-controlling mechanism for the 5G LTE network. Hence, the modules like latency monitoring and the controlling unit have been designed in the LTE model. Therefore, the designed LTE is known as a narrow-band network. Hence, the narrow-band network is organized in three phases: latency monitoring, controlling latency, and measuring latency reduction. Thus, the latency reduction system is modeled systematically and has recorded the finest latency minimization outcome. However, this model has taken more time to execute.

Congestion controlling protocol was implemented in the LTE network by Haile et al. [23] and was proposed for diminishing the transmission of data delay and data traffic. The developed congestion-controlling technique performance was verified in a dual CN that is 4G and 5G communication. Finally, the delay was measured for the 5G and 4G networks, in that 4G communications recorded the maximum delay compared to the 5G model. Hence, this congestion control protocol needs more features to execute this process.

The delay often occurs due to the users' improper resource allocation. So, Kazemifard et al. [24] have introduced the resource allocation module in the LTE network. Moreover, this resource allocation strategy is executed based on mixed linear functions.

The outcome has described that 90% of the delay rate was minimized by performing the resource allocation strategy. However, high energy utilization is recorded.

He et al. [25] have introduced the LTE network for Device communication to measure the application needs of cellular communication. Here, based on device parameter constraints, resource requirements varied. In addition, optimal parameters were utilized to optimize the device constraints. Moreover, the devices that have been considered in this study are mobiles. Henceforth, the resource has been optimized but has required more time to execute.

Naqvi et al. [26] have made developments to the deep learning reinforcement control agents' deployment, particularly to the intervals, transport protocols, and intervals that are monitored. Throughput performance is nonetheless traded off as a result of these modifications. The policy model has been retrained using ns-3 as the gym setting and a modified reward function to compensate for the loss. The suggested approach lowers packet loss in cellular networks by as much as 50.7x, decreases central processing unit (CPU) consumption by 4.13x, and boosts throughput by 6.94%. It requires significant computational resources and time.

Sabeeh et al. [27] have introduced a hybrid approach that combines transmission power control (TPC) with decentralized congestion management to lower network channel load. It presents a novel method for adjusting channel load that is based on the continuous difference between upper and lower channel load bounds. The findings demonstrate that adaptively adjusting gearbox power and reception threshold in response to the demonstrated channel load change dramatically enhances system performance but requires high computational resources.

Han et al. [28] This research suggested that User-cell Association (UA) networks transfer queued traffic from cellular networks to unmanned aerial vehicle networks to increase system access capacity. The superiority of the offered technique is verified using low-complexity stochastic-geometry (SG) techniques. The findings demonstrate that the SG-based approaches demand user density rather than precise user location, have a reduced computing cost, and validate the convergence of derived expressions. The network dynamically alters association tiers in the congestion-aware UA scheme, which makes it appropriate for places with unequal traffic distribution but fails in security concerns.

Aragão et al. [29] have offered a method to mitigate the effects of the machine to machine communication on the long-term evolution of advanced networks and specifically examined the bankruptcy issue in modeling the distribution of random access resources across various device types. Game theory has been proposed to turn the bankruptcy issue into a transferable utility game, and an axiomatic approach has been used that considers certain factors while allocating resources. The simulation outcomes indicate gains in energy efficiency but limits in scalability.

Righetti et al. [30] have examined the current constrained application protocol (CAP) congestion-control methods that are appropriate for the 6-time slotted channel Hopping design (6TSCHD). Results indicate that the Scheduling Function utilized to distribute communication resources across nodes significantly impacts the performance of the investigated algorithms. The investigation highlights that in 6TSCHD networks, Advanced CAP congestion control offers no discernible benefit over the default approach. When the network is congested, it improves the Transaction Delivery Ratio of up to 15% and the End-to-End Transaction Delay of up to 25%. The drawback is it has limited resources for offering continuous monitoring.

By surveying the recent literature, the main issues in the cellular LTE network are congestion management. If the congestion is not controlled, it results in poor scalability, delay, high energy consumption, and poor PDR. Considering these drawbacks, the congestion controlling concept is kept as the prime objective of this study, and the continuous monitoring scheme is introduced for the regular congestion monitoring process.

3 System model and problem statement

QoS defined the network carriers' capability to provide service in CN. The services included voice quality, signal strength, and high data rates for data and multimedia applications. These services were conveyed by the Base Transceiver Station (BTS) to the Base Station Controller (BSC). The essential requirements to develop high-speed data networks were QoS provided with its packet delay constraints and data rate. This process was the most necessary task in the wireless link network.

Additionally, the wireless channel (WC) quality varied among several users and was modified randomly with slow and fast time scales. Also, the capacity of the wireless link was a scarce resource that was used effectively. The system enables services with strict latency and reliability requirements. The cellular network operation could be taken, which has several sequences of events. Here, various events are associated with poor performance, lack of resources, or failures.

To identify efficient ways for this system to support QoS in real-time data, including video and audio streams via WC in the CN. The data was transmitted between the endpoints, which enabled the Voice over the Internet Protocol (VoIP) by the Session Initiation Protocol (SIP) signaling process. The global mobile communication type (GSM) system would manage the BSC; it was also the cellular switching center. The difficulties of the traditional model are described in Fig. 2.

The moving behavior of the cellular device reduced the QoS due to poor resource allocation. The involvement of users in the cellular wireless system was dynamic; their needs also differed based on its target. So, more than allocating equal resources for all cellular devices, it was sometimes needed. Considering these drawbacks, the present study introduced a novel optimized route protocol system for allocating resources based on the user login priority. Hence, if the resource allocation priority was scheduled, then the QoS had been maximized.

4 Proposed GEBPDCM model for optimizing congestion control to improve QOS

A novel Golden Eagle-based primal–dual Congestion management (GEbPDCM) has been proposed for the LTE AODV network. The vital process of this research was diminishing the latency and improving the throughput ratio in transmitting multimedia data by performing the conjestion management. The overview of the developed GEbPDCM is described in Fig. 3.

Initially, the required number of cellular nodes with limited resource constraints were created in the MATLAB environmnet. Moreover, the fitness of Golden Eagle is used to predict the node status, if the node is available with high data load then the half of data is shared to other free nodes. Thus the conjestion was managed and the communication latency was reduced with better throughput and PDR.

4.1 Measuring node status

In the proposed GEbPDCM, the nodes were created to measure its status for reducing latency during multimedia transmission. Here, several nodes were essential for broadcasting the video data to the target user and reducing the latency, which would check the effectiveness of the designed model. The node creation process was determined in Eq. (1).

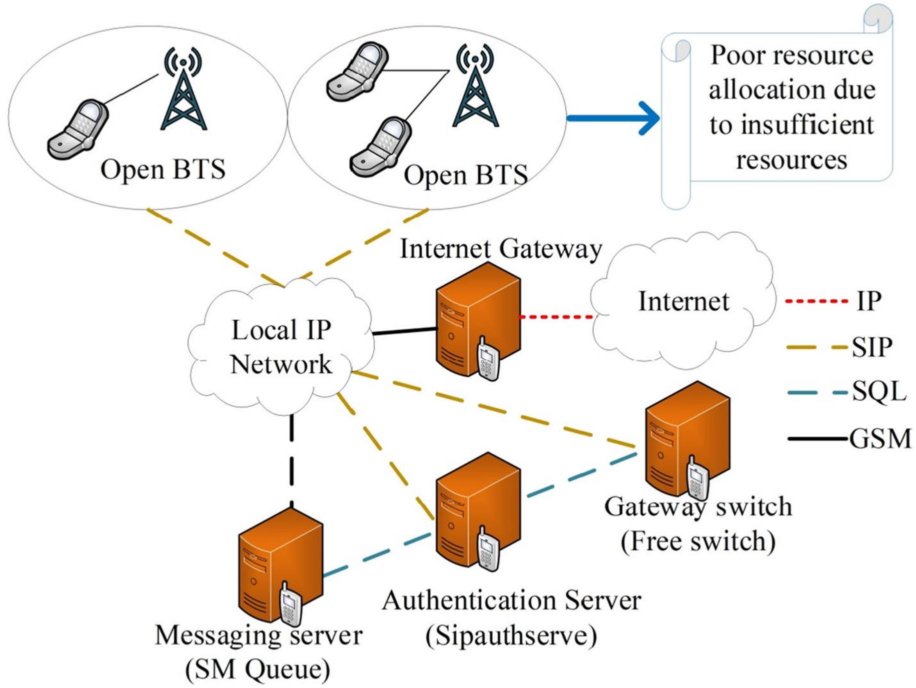


Fig. 2 System model with problems

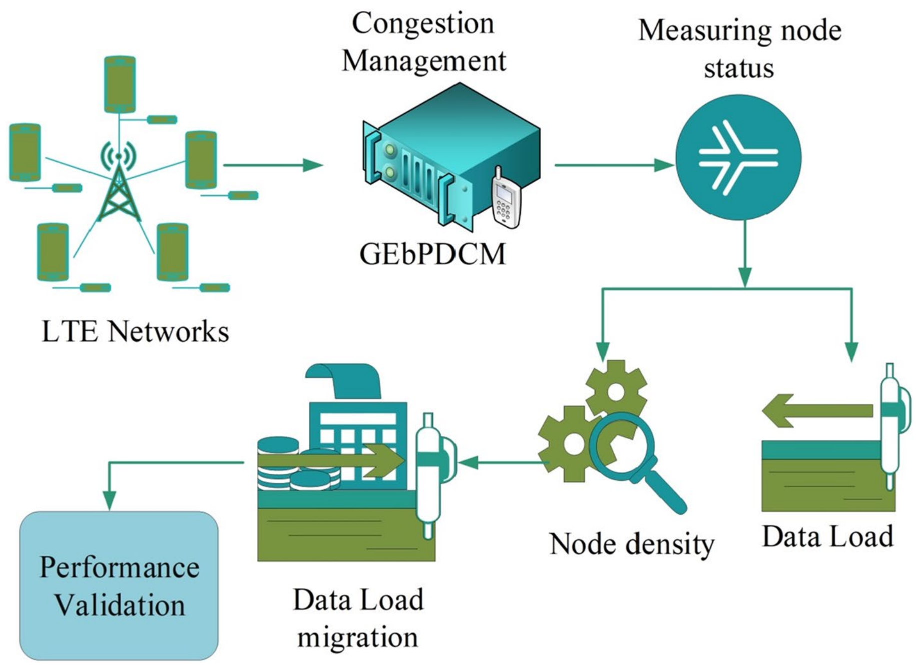


Fig. 3 The overview of the developed GEbPDCM

$$N_c = \{No_1, No_2, No_3, \ldots .No_n\} \tag{1}$$

Here, N_c indicated as the Node creation process $\{No_1, No_2, No_3, \ldots .No_n\}$ is represented as the nodes used for multimedia transmission through cellular networks. Thus, the nodes were created with limited resource constraints. Then, the node's status was measured with the required optimal parameters, such as congestion control and resource allocation in AODV.

4.2 Data load

The data loads were assumed to be scheduled at the gateway, and the computation requirements were provided through entire computing nodes. The optimizer's fitness helped to select the required load with the most remaining computations. The fitness feature of the golden eagle optimizer was determined in Eq. (2) to predict the necessary load for each user.

$$P = N_c + h\left(\sum_{i=1}^{n} Dl_i\right) \tag{2}$$

Here P was the load prediction process for each user node using golden eagle optimizer, h which was represented as the monitoring process of each one of the data loads and Dl indicated as the data load for each node. Thus, the data load could be predicted for each user node.

4.3 Node density

The Device to Device (D2D) link controller for each D2D link estimates the required number of resource blocks (RB) for the uplink and the downlink bands. To balance the load, the node density should be lower; using this process, the node status could be measured. However, many mobile users in the LTE network increased the communication channel's data traffic, which increased the Quality of service rate. Based on the priority of the user login, the data broadcasting process was started by predicting the higher data load, and half the load could be shared with other free nodes for the broadcasting process. The Node density for the transmission process was determined in Eq. (3).

$$N_d = Dl + N_n\left({}^{P_{\max}}\!/_{P_t}\right) \tag{3}$$

$$N_s = P + N_d \tag{4}$$

The node status was determined by Eq. (4). Where, N_s determined as the node status, N_d represented as the node density parameter, Dl indicated as the data load parameter $P_{\max}$ was the maximum interference node at the receiver, and P_t was the transmitter node. Besides the node density variation with the routing protocol, the optimal parameters like congestion control and resource allocation were kept constant to analyze the performance change because of the node's status change. Then, assume a constant area was the relationship between the number of nodes and the field's surface. Since the field surface was constant, the node density was high, meaning less distance among nodes for the transmission process. The data load and node density combination could thus measure the node status.

4.4 Data load migration

For the benefit of the QoS performance of broadcasting the video data based on the user login priority. Here, the optimal parameters were activated by predicting the node status and balancing the data load through migration. Data migration was transferring the data load from one location to another. The proposed model moved the data by controlling the congestion for an efficient process. Congestion enables the best usage of the shared network infrastructure, which protects the entry-level data packets into the CN and avoids the congestive collapse of the broadcasting process. The Fixed Host (FH) sends the data into the Mobile Host (MH) through the BS. The snoop would change the routing code of BS and monitor the packet transmission. When a new packet arises from FH, the packets are passed to the routing code, and the MH tracks the whole node. Then, packet loss was sent to the MH again if the packet loss. Thus, the loss of packet hides from FH to the BS, and unnecessary congestion control was prevented during the multimedia transmission.

The congestion score was determined in Eq. (5),

$$CS_{node}\begin{cases} congestion\ doen't\ happen & if\ 0 \leq CS_{node} < 0.5 \\ congestion\ threshold & if\ 0.5 \leq CS_{node} < 1 \\ congestion\ happens & if\ 1 \leq CS_{node} \leq 2 \end{cases} \tag{5}$$

where CS_{node} represented as the node's congestion score; if it the CS between 0 and 0.5, the congestion does not happen, and if it CS is between 0.5 to 1, the node lies on the congestion threshold. If congestion does not occur, data is sent from the start node to the end node. Also, the techniques helped reduce latency and ensure that there was no data traffic during the transmission process. Next, the data was transferred based on the user login priority. The login priority can be done by Eq. (6).

$$U = N_s + P\left(CS_{node}\right) \tag{6}$$

$$S = \begin{cases} U \geq 1; & First\,user \\ U \leq 0; & Other\,user \end{cases} \tag{7}$$

User login priority was indicated as U, S representing the searching process for the first user login. The first login user was suggested as having a value greater than or equal to 1, and the value less than or equal to 0 means the remaining users based on the priority with the help of a threshold value. The search process was determined in Eq. (7).

$$R_a = \begin{cases} P > O_l; & share\ half\ load \\ P < O_l; & not\ shared \end{cases} : \tag{8}$$

where R_a was the resource allocation parameter O_l represented as the optimal load for the transmission process. Eqn did the resource allocation. (8). Finally, the resource was broadcasted because the predicted data load exceeded the optimal load. Then, the half load was shared with other free nodes with a value of 325 Mbps based on the user login priority and the congestion control of the node, which would improve the QoS.

Algorithm 1 GEbPDCM

Start

{

Measuring Node status()

{

int N_c, N;

// initialize the node creation variable

$N_c \rightarrow creation(N)$

// the nodes had been created using Eqn. (1)

}

Data load ()

{

int P, Dl, h, N_c;

// initialize the data load variables

$P \rightarrow fitness(N_c, Dl)$

// the data load was predicted using Eqn. (2)

}

Node density ()

{

int $N_d, DL, N_n, P_{\max}, P_t, P$;

// initialize the node density variables

$N_s \rightarrow status(N_d, P)$

// the node status and node density were determined using Eqn. (3), (4)

}

Data load migration ()

{

int U, N_s, P, S, CS_{node};

// initialize the data migration variable

If $(U \geq 1)$

{

First user

Else if $(U \leq 0)$

Other users

}

Resource allocation ()

{

int R_a, P, O_l;

// initialize the resource allocation variable

If $(P > O_l)$

Shared half load to nodes

Else (not shared)

}

}

}

End

The detailed steps and processes were presented in the designed model in algorithm one and Fig. 4. Based on these step processes, execute the MATLAB code and verify the results. The algorithm incorporated all mathematical function parameters in the pseudocode format.

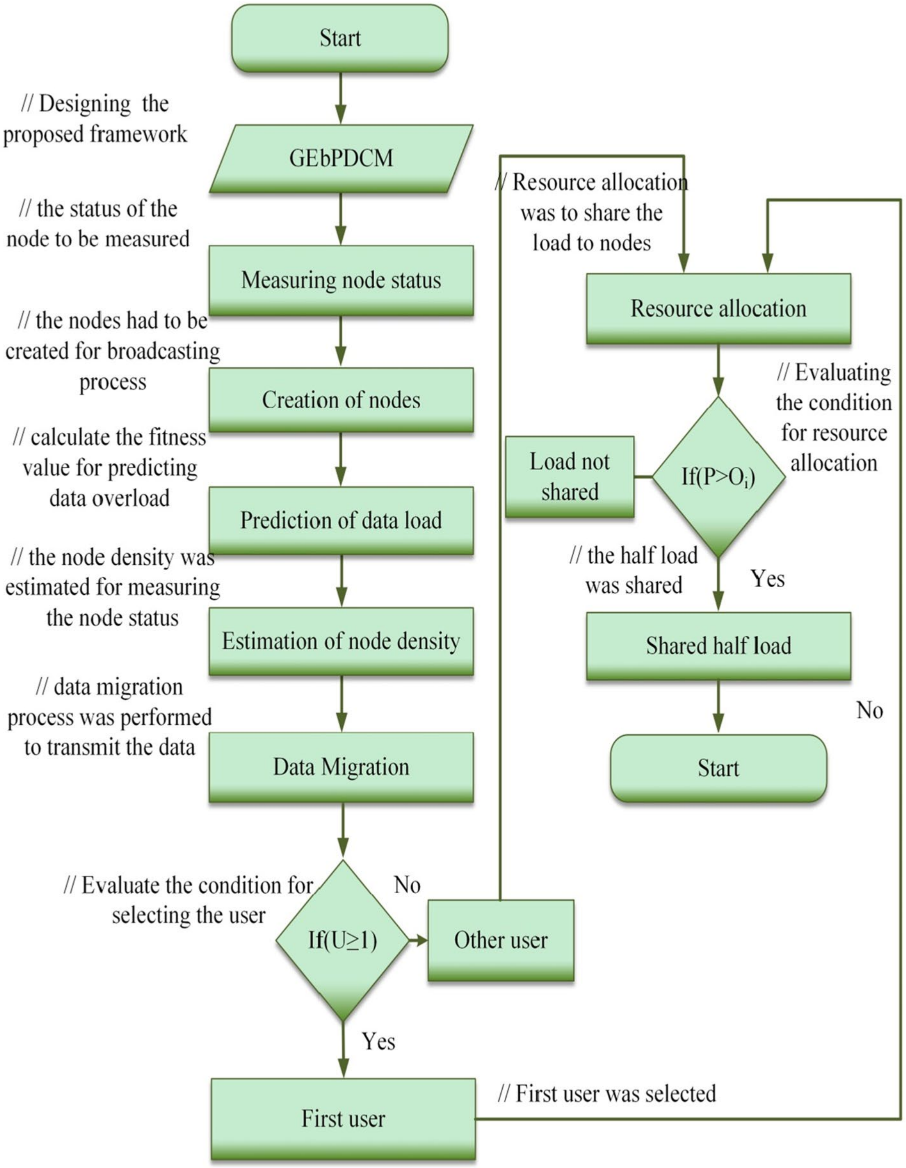


Fig. 4 Flowchart of GEbPDCM

5 Result and discussion

The implementation of the designed framework was checked in the MATLAB platform. Then, the Windows 10 operating system was used for this implementation process. The strategy for this operation is to reduce the latency during multimedia transmission. In addition, Table 1 provides data on the used parameter specification.

5.1 Case study

This research used a novel system named GEbPDCM to perform congestion control and reduce latency during multimedia data transmission. Meanwhile, the case study was analyzed to elaborate on the GEbPDCM. Hence, the proposed model was needed to optimize congestion control in the cellular network to improve QoS.

The wireless nodes were created to optimize the congestion control and improve the QoS during multimedia data transmission. There were 100 nodes created in this network, with the BS and the receiver. With the help of the BS, the transmission process was performed from start to end. The wireless nodes created in the CN are depicted in Fig. 5.

The cellular network's data load was used to reduce the latency during the multimedia transmission. Here, the data was loaded to transfer to the receiver with the help of BS. The data load in the cellular network is illustrated in Fig. 6.

Data load migration was the phenomenon of data load transmission from one location to another. The data load was transferred using the efficient proposed model to control congestion. The data load migration from the source node was in the place of 75 node ranges at 338 Mbps, and the destination node was in the position of 21 node ranges at 325 Mbps within a limited time. Based on the user login's priority, this system is used for receiving data to the end node. The data load migration between source and destination is illustrated in Fig. 7.

The overload is transmitted to other free wireless nodes based on the predicted data load value. Based on this value, the half load is shared with the free wireless nodes compared to the optimal data load. The sharing of overload to nodes is illustrated in Fig. 8.

Figure 9a, b evaluates the delay of packets in the cellular network with different node speeds and packet size environments. The proposed model had gained the value of delay (ms) with varying node speeds (m/s) of 10, 20, 30, 40, and 50 were 25.9643, 34.0352,

Table 1 Parameter Specification

Parameter Specification	
Area	1000 × 1000
Nodes	100
Base station location	[500,450]
Data	Video
Transmission range	300 m
Data rate	(3.1086–49.0946) Mbps
Bandwidth	27.175 Mbps
Jitter	6.4 ms
Mobility	10(m/s)
Packet size	1 Kb
Simulation time	100 s

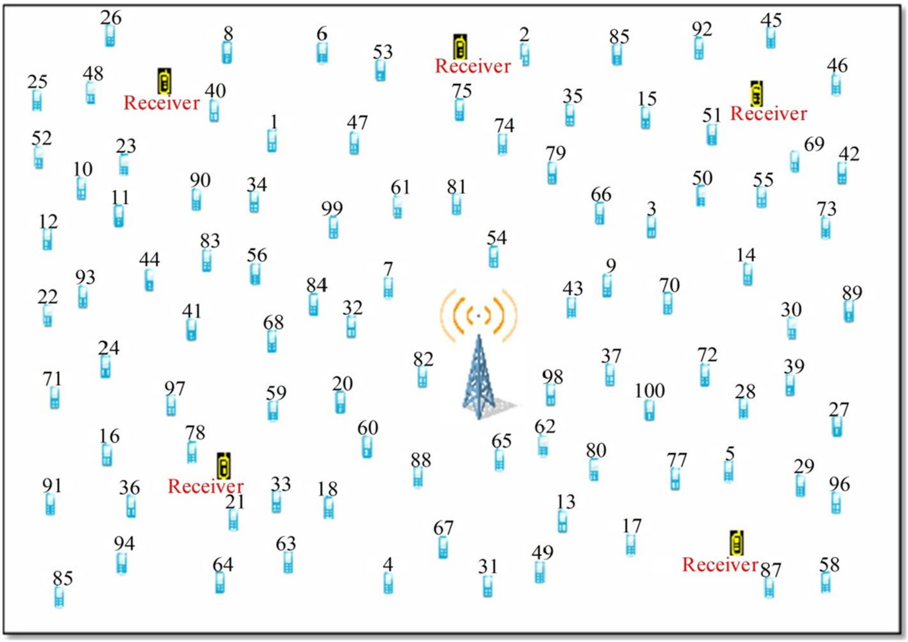


Fig. 5 Creation of wireless nodes in the cellular network

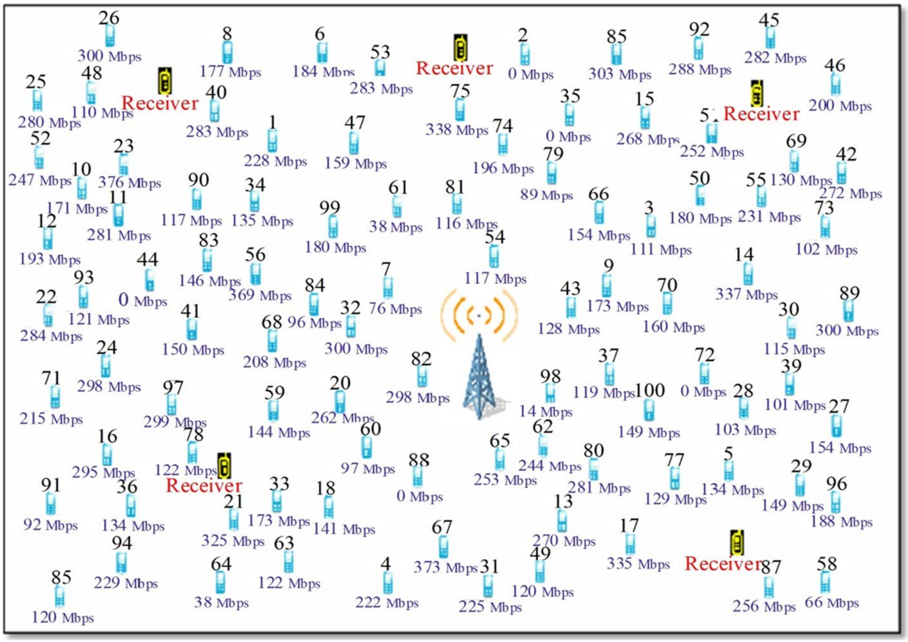


Fig. 6 The representation of data load in the cellular network

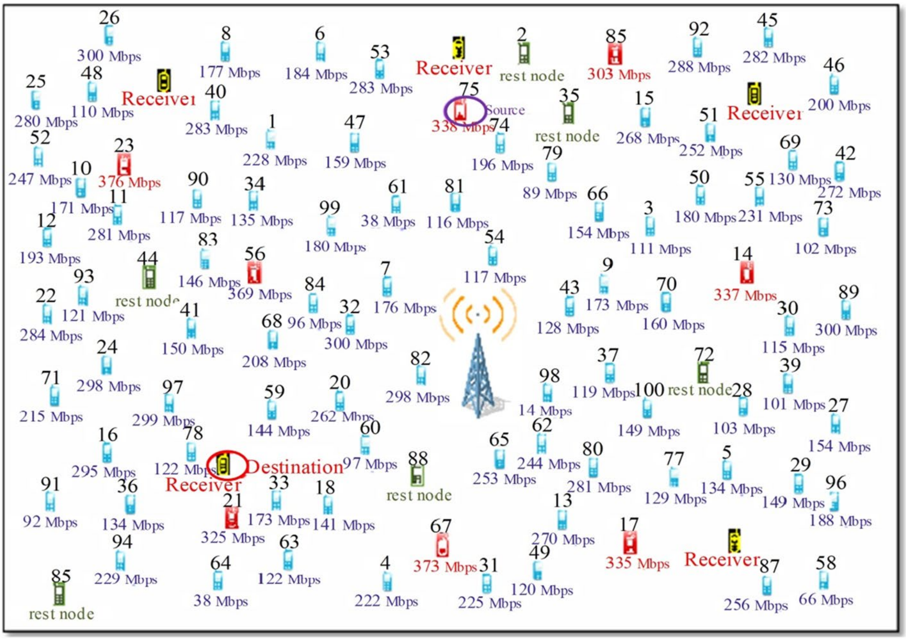


Fig. 7 The data load migration between source and destination

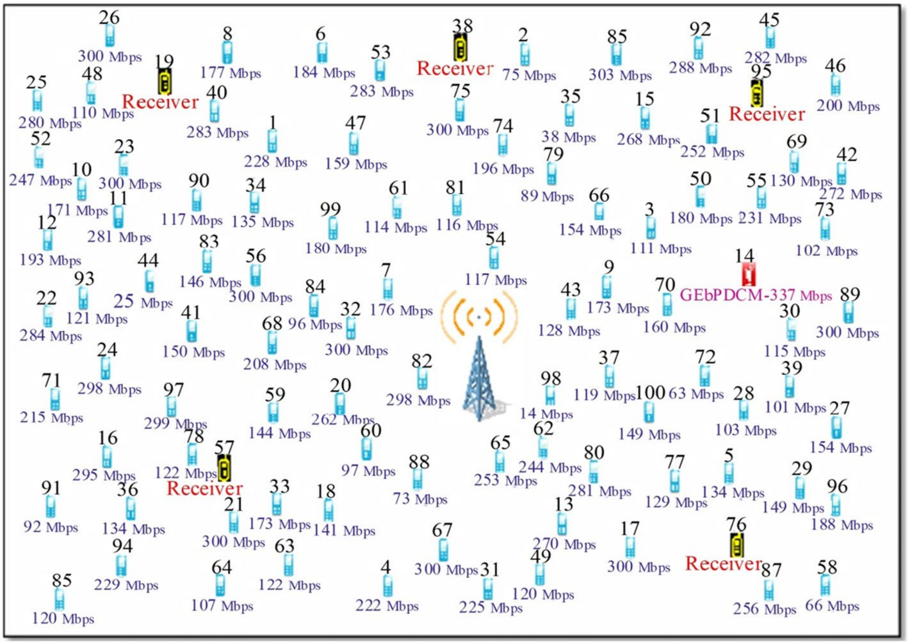
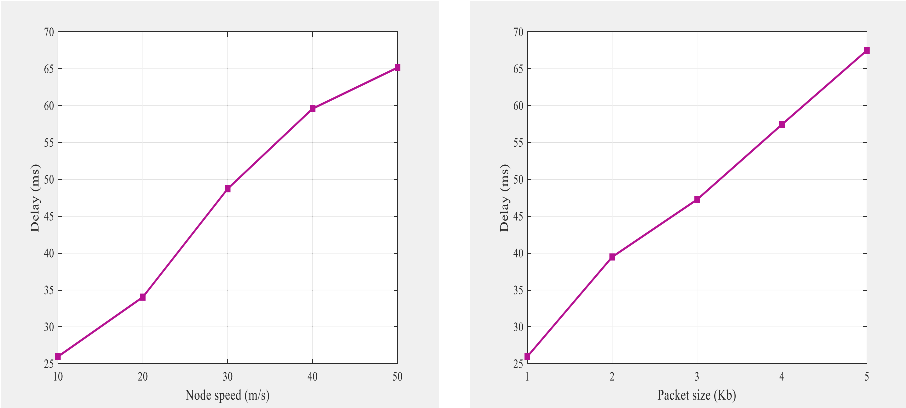


Fig. 8 Overload sharing to other free wireless nodes



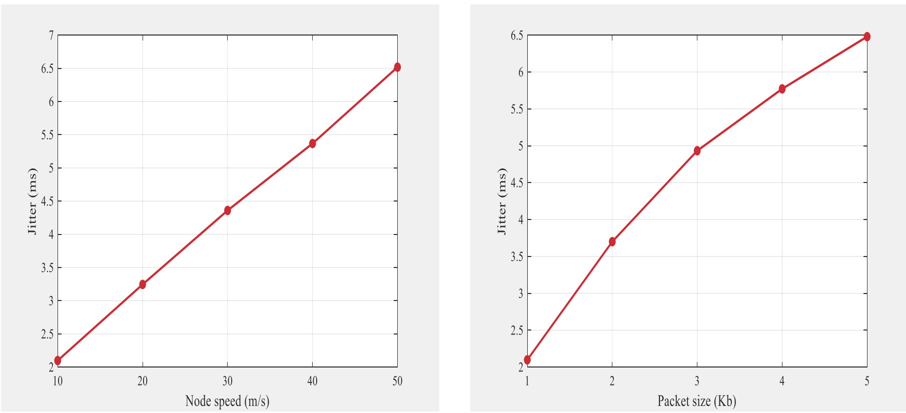
(a) (b)

Fig. 9 **a** Delay with Node speed variation and (**b**) Delay with Packet size variation

48.7338, 59.6007, and 65.1544. Delay (ms) values with varying packet size (Kb) of 1, 2, 3, 4, and 5 were 25.9643, 39.484, 47.268, 57.456, and 67.498.

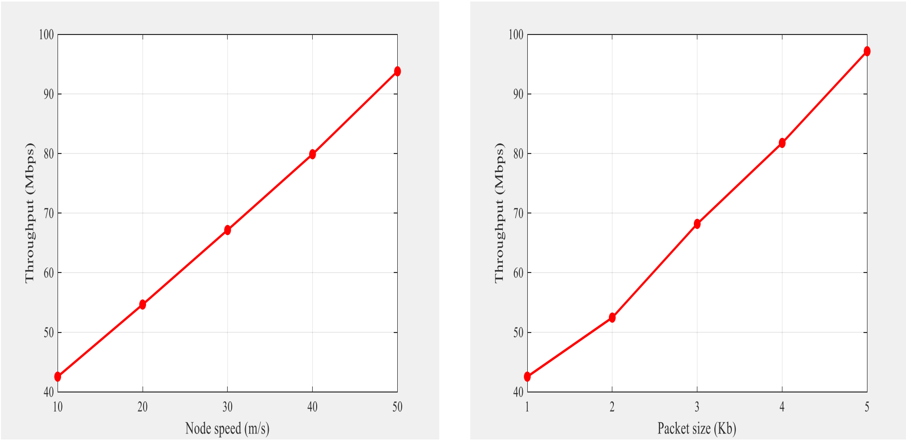
Figure 10a, b determines the jitter of packets in the cellular network with different node speeds and packet size environments. The proposed model attained the jitter (ms) value with varying node speeds (m/s) of 10, 20, 30, 40, and 50, which were 2.0986, 3.2452, 4.3589, 5.3671, and 6.517. The jitter (ms) values with varying packet size (Kb) of 1, 2, 3, 4, and 5 were 2.0986, 3.7, 4.9326, 5.7715, and 6.4788.

Figure 11a, b evaluates the throughput of packets in the cellular network with different node speeds and packet size environments. The proposed model scored the value of throughput (Mbps) with varying node speeds (m/s) of 10, 20, 30, 40, and 50 were 42.55, 54.6549, 67.154, 79.8744, and 93.7887. The value of throughput (Mbps) with varying packet sizes (Kb) of 1, 2, 3, 4, and 5 were 42.55, 52.457, 68.1874, 81.7715, and 97.1545.



(a) (b)

Fig. 10 **a** Variation of node speed with jitter and (**b**) Jitter with Packet size variation

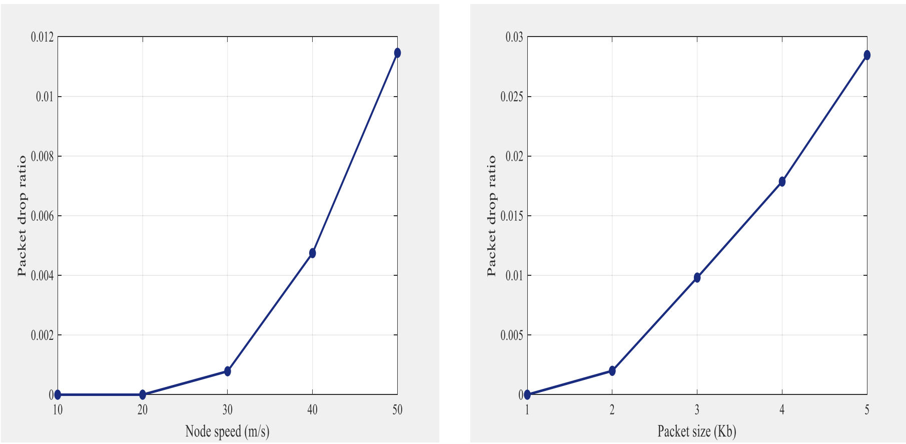


(a) (b)

Fig. 11 **a** Throughput with the variation of Node speed and (**b**) Throughput with varying Packet size variation

Figure 12a, b determines the packet drop ratio in the cellular network with different node speed environments. The proposed model gained the value of packet drop ratio with varying node speeds (m/s) of 10, 20, 30, 40 and 50 were $1\,e^{-16}1\,e^{-11}$ 0.0007854, 0.004746, and 0.011459. The value of packet loss with varied packet sizes (Kb) of 1, 2, 3, 4, and 5 were $1.154\,e^{-13}$ 0.002, 0.0098152, 0.01786, and 0.02846.

Figure 13a, b evaluates the PDR in the CN with various node speeds and packet size environments. The proposed model attained the value of PDR with different node speeds (m/s) of 10, 20, 30, 40, and 50 were 1, 1, 0.99921, 0.99525, and 0.98854. The value of PDR with various packet sizes (Kb) of 1, 2, 3, 4, and 5 were 1, 0.998, 0.99018, 0.98214, and 0.97154.



(a) (b)

Fig. 12 **a** Packet drop ratio with Node speed variation and (**b**) Packet drop ratio with varied Packet size

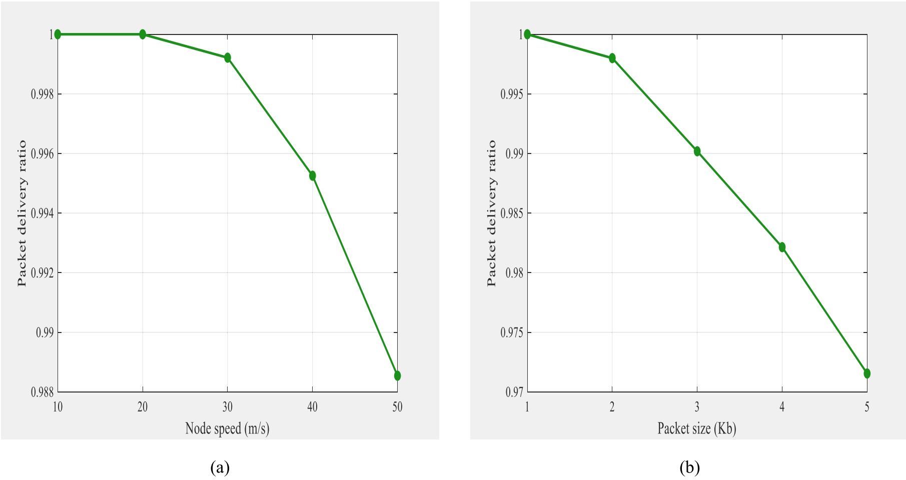


Fig. 13 **a** Various node speed with its PDR and (**b**) PDR with varied packet size

Figure 14a, b determines the energy consumption in the cellular network with different node speeds and packet size environments. The proposed model had gained the value of energy consumption (mJ) with varying node speeds (m/s) of 10, 20, 30, 40 and 50 were 28.5466, 34.254, 40.1254, 45.654, and 49.5645. The energy consumption (mJ) values with varying packet sizes (Kb) of 1, 2, 3, 4, and 5 were 28.5466, 36.0487, 41.0487, 47.6871, and 50.688.

The packet size was determined as the specified number of bytes for each measurement packet. Figure 15 evaluates the Bandwidth in the cellular network in varying packet-size environments. The proposed model has gained the value of Bandwidth (Mbps) with varying packet sizes (Kb) of 1, 2, 3, 4, and 5, such as 7.0718, 10.874, 14.7898, 18.0477, and 21.175.

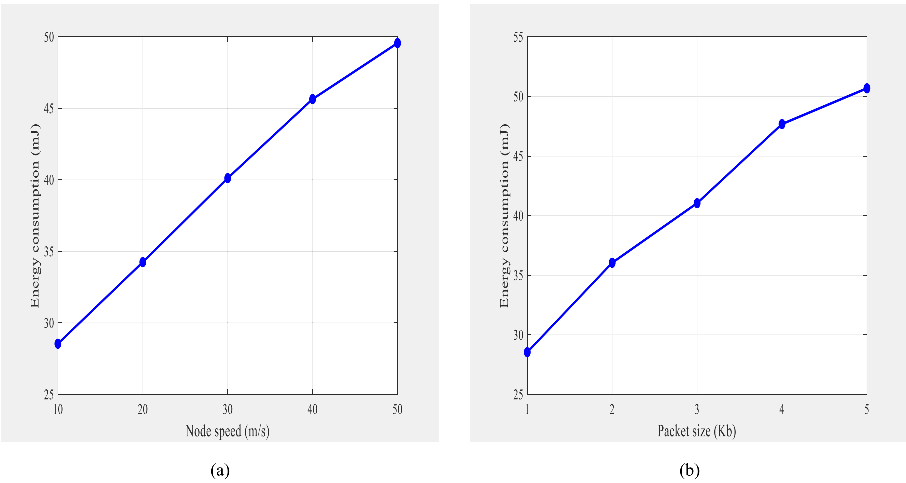


Fig. 14 **a** Energy consumption with different node speeds and (**b**) energy consumption with various packet sizes

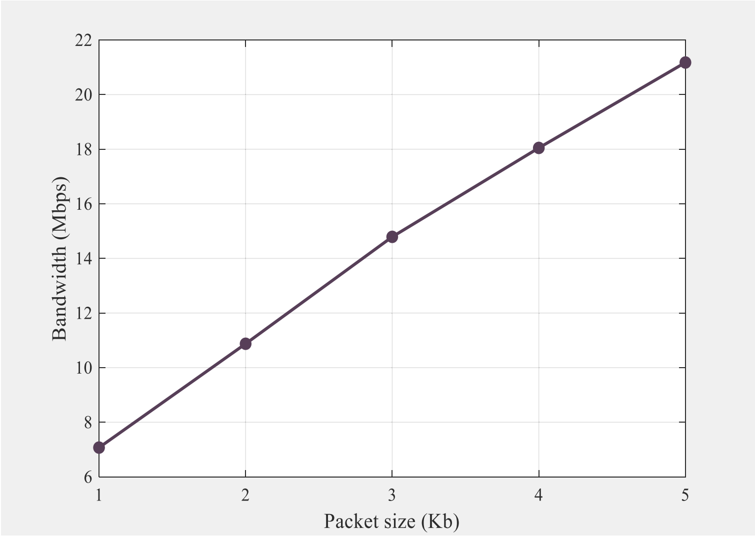


Fig. 15 Varying packet sizes with varying bandwidth

Figure 16 evaluates the Bandwidth in the cellular network in varying node speed environments. The developed model had scored the value of Bandwidth (Mbps) with varying node speed (m/s) of 10, 20, 30, 40, and 50, such as 6.5445, 7.854, 11.4789, 12.6548, and 17.542.

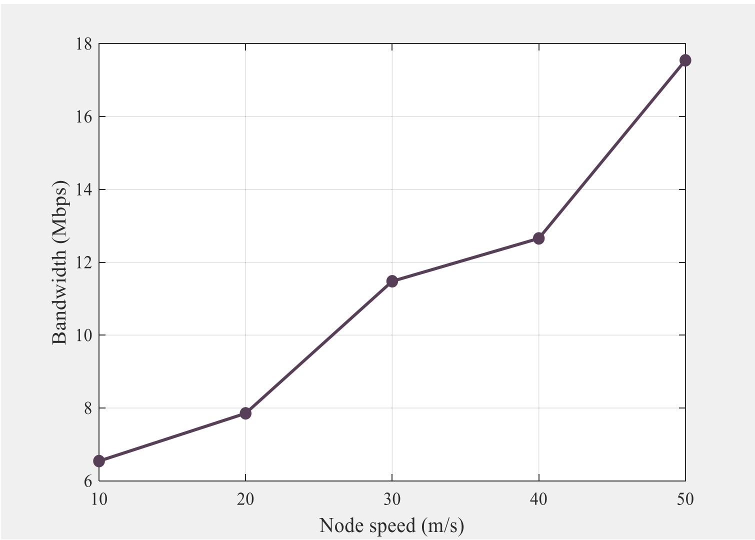


Fig. 16 Varying node speed with varying bandwidth

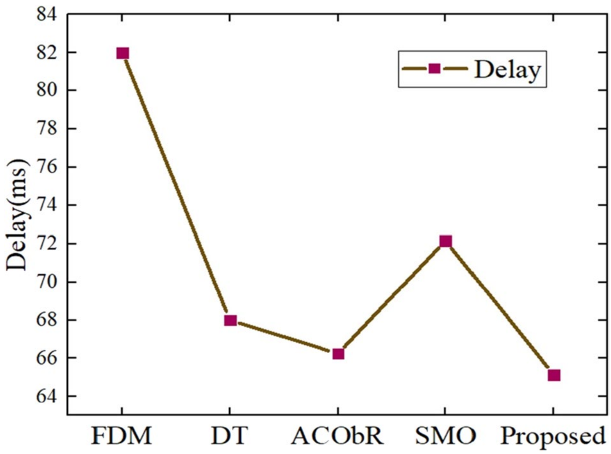


Fig. 17 Comparison of delay with several existing approaches

Table 2 Comparison of delay

Methods	Delay (ms)
FDM	82
DT	68
SMO	72.15
ACObR	66.25
Proposed	65.1544

5.2 Comparative analysis

The proposed GEbPDCM-validated performance assessment includes its Delay, throughput, PDR, packet loss, and energy consumption. The metrics would provide accurate results for transmitting multimedia data by optimizing congestion control to improve QoS, and they are compared with several existing mechanisms. Here, the new model was compared with several current models such as Fuzzy decision making (FDM) [31], Decision tree (DT) [32], Spider Monkey Optimization (SMO) [33], Ant Colony Optimization based routing (ACObR) [34], Named Data Networking (NDN) [35], Extended Kalman Filtering (EKF) [36], and Congestion Control Mechanism (CCM) [37].

5.2.1 Delay

The time for sending the data from the user node to the end node with a Delay of seconds was defined as delay. The delay between the packets sent via CN from source to destination. The estimation of delay was determined in Eq. (9).

$$Delay = \frac{Sum\ of\ time\ taken\ \ to\ deliver\ packet\ in\ receiver}{No.of\ packet\ received\ by\ reciver} \tag{9}$$

The delay value of the introduced GEbPDCM approach has been evaluated by prevailing mechanisms like FDM, DT, ACObR, and SMO, which are illustrated in Fig. 17 and

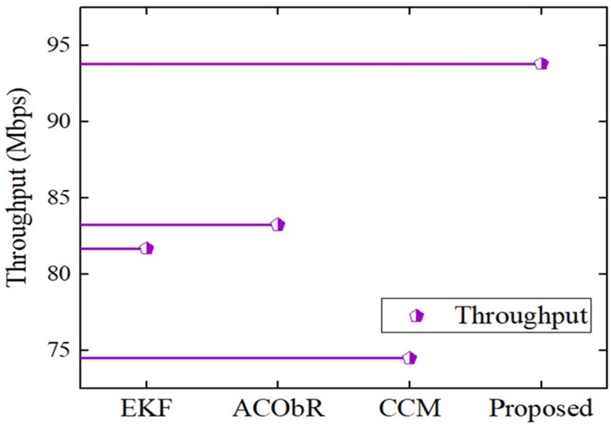


Fig. 18 Comparison of throughput with various existing techniques

Table 3 Comparison of throughput

Methods	Throughput (Mbps)
ACObR	83.25
EKF	81.7
CCM	74.5
Proposed	93.7887

Table 2. FDM and DT techniques have obtained almost 82 ms and 68 ms; the ACObR and SMO methods attained delay values of 66.25 ms and 72.15 ms. Moreover, the proposed approach has achieved a lower delay value than other approaches, which was 65.1544 ms.

5.2.2 Throughput

The average throughput was defined as the ratio of received packets at the destination user to the delay of the packet transmitting process. The average throughput was determined in Eq. (10).

$$Average\ throughput = \frac{number\ of\ packets\ received}{Delay} \tag{10}$$

The throughput value of the introduced GEbPDCM approach has been evaluated by prevailing mechanisms like EKF, ACObR, and CCM, as illustrated in Fig. 18 and Table 3. The technique EKF obtained almost 81.7 Mbps ACObR, and CCM methods attained throughput values of 83.25 Mbps and 74.5 Mbps. Moreover, the proposed approach has gained a higher throughput value than other approaches, which was 93.7887 Mbps.

5.2.3 Packet drop ratio

The ratio of the number of generated data packets from the user node that could not reach the destination node was defined as the packet drop ratio. If the loss was high, more packets were dropped during the transmission. The calculation of packet loss for transmitting the data was in Eq. (11).

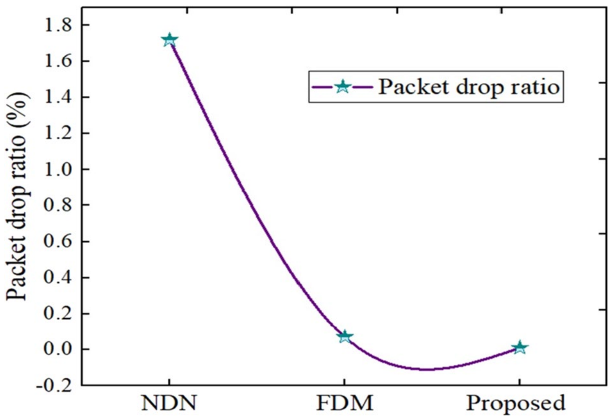


Fig. 19 Packet drop ratio compared with several existing methods

Table 4 Comparison of packet drop ratio

Method	Packet drop ratio (5%)
NDN	1.72
FDM	0.07
Proposed	0.01

$$Packet\ drop\ ratio = \frac{Number\ of\ Transmitted\ packets - Number\ of\ received\ packets}{Number\ of\ packets\ send} \tag{11}$$

The Packet drop ratio of the designed GEbPDCM method has been calculated by prevailing methods like NDN and FDM, as depicted in Fig. 19 and Table 4. The technique NDN had gained 1.72%, and FDM scored 0.07%. Furthermore, the proposed approach attained a lower packet drop ratio value than other methods of 0.01%.

5.2.4 Packet delivery ratio

The PDR was used to evaluate the delivery ratio of the packets transmitted from the start node to the received node. The PDR was maximized when avoiding the congestion routes. The PDR was determined as the ratio of packets received by the transmitted packets. The PDR was determined using Eq. (12).

$$PRD = \frac{Sum\ of\ packets\ received\ via\ receiver}{Sum\ of\ data\ packets\ transmitted\ by\ transmitter} \tag{12}$$

The PDR value of the proposed GEbPDCM system has been estimated by prevailing approaches like ACObR, FDM, and CCM, which are represented in Fig. 20 and Table 5. The ACObR had attained 96%, FDM had scored 95%, and CCM had gained 60%. Moreover, the proposed model achieved a high PDR compared with other methods of 98%.

Existing methods like ACOR and SMO have evaluated the energy consumption of the introduced GEbPDCM technique, as illustrated in Fig. 21 and Table 6. SMO obtained almost 72 mJ, and ACObR attained an energy consumption of 50 mJ. Moreover, the

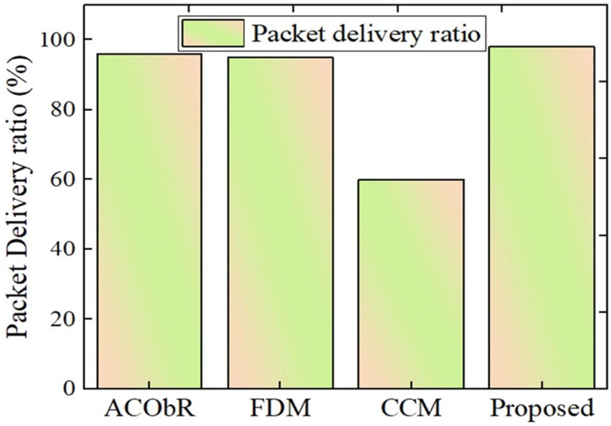


Fig. 20 PDR compared with several existing mechanisms

Table 5 Comparison of packet delivery ratio

Method	PDR (%)
FDM	95
ACObR	96
CCM	60
Proposed	98

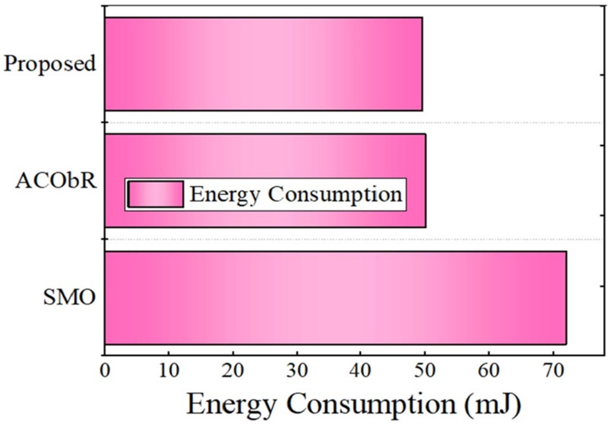


Fig. 21 Comparison of energy consumption with various existing approaches

Table 6 Comparison of energy consumption

Method	Energy consumption (mJ)
SMO	72
ACObR	50
Proposed	49.56

Table 7 Performance measurement of the developed method with varying Node speed

Metrics	GEbPDCM				
	Varying node speed (m/s)				
	10	20	30	40	50
Delay (ms)	25.9643	34.0352	48.7338	59.6007	65.1544
Jitter (ms)	2.0986	3.2452	4.3589	5.3671	6.517
Throughput (Mbps)	42.55	54.6549	67.154	79.8744	93.7887
Packet delivery ratio (%)	1	1	0.99921	0.99525	0.98854
Packet loss ratio (%)	$1\,e^{-16}$	$1\,e^{-11}$	0.0007854	0.004746	0.011459
Energy consumption (mJ)	28.5466	34.254	40.1254	45.654	49.5645
Bandwidth (Mbps)	6.5445	7.854	11.4789	12.6548	17.542

Table 8 Performance analysis of the proposed system with varying packet size

Metrics	GEbPDCM				
	Varying packet size (Kb)				
	1	2	3	4	5
Delay (ms)	25.9643	39.484	47.268	57.456	67.498
Throughput (Mbps)	42.55	52.457	68.1874	81.7715	97.1545
PDR (%)	1	0.998	0.99018	0.98214	0.97154
Packet loss ratio (%)	$1.154\,e^{-13}$	0.002	0.0098152	0.01786	0.02846
Energy consumption (mJ)	28.5466	36.0487	41.0487	47.6871	50.688

proposed approach has achieved a low energy consumption of 49.56 mJ compared with other existing techniques.

The performance analysis of the designed technique with varying Node speeds is in Table 7.

5.3 Discussion

The results discussed above establish the active region for the source node; hence, the performance of the GEbPDCM was the main efficient process to reduce the latency during multimedia transmission. Then, these metrics were used to execute the proposed model's finest outcome. The congestion control should be optimized to improve QoS in the cellular network through the proposed GEbPDCM model. With varying node speeds and packet sizes, the GEbPDCM packet delivery ratio performed better, improving the service quality. The performance assessment of the developed model with varying Packet sizes is in Table 8.

In Table 9, all methods were implemented in the same proposed platform to more accurately justify the proposed system's efficiency. Finally, the performance score was compared with the proposed model, shown in tabvle.9. the novel GEbPDCM has performed best in all parameter assessments, revealing that the proposed model is required for LTE communication.

Table 9 Comparative assessment

Comparative assessment					
Methods	Delay (ms)	Through-put (Mbps)	PDR (%)	Energy consumption (mj)	Packet loss ratio n (%)
Edge computing [19]	103	76	78.4	132	21
Latency Control mechanism [20]	89	82	84.5	97	15
Congestion controlling protocol [23]	97.2	79	75.4	82	24
Resource allocation model [24]	108	68	73	91.3	27
Mobile edge computing [25]	104	72	76.7	103.9	23
Deep learning reinforcement control [26]	98	87.8	90	69	10
Autonomous collision-free protocol [27]	112	76	83	78.7	17
UA with SG [28]	121	73	79	100	21
Long-term game theory [29]	123	78	82.7	107	17
6TSCHD [30]	97.7	88	91	89	9
Proposed	65.1	93.7	98.8	49.5	1

Application The implemented novel GEbPDCM is helpful for cellular communication and uninterrupted communication. So, the congestion-free environment helps to afford the better data range and throughput to share the communication between sender and receiver. Hence, the implemented study is more applicable to the mobile network system.

Advantages The chief advantage of this novel GEbPDCM is that it is a collision-free environment for mobile users, which can reduce communication delay, packet drop, and energy consumption. So, the data is received with high integrity between the mobile users.

Disadvantages The implemented model is vulnerable to attack due to the mobility environment and the absence of a security mechanism. Addressing this issue will give a more reliable LTE network system in the future.

6 Conclusion

This study offers a sincere evaluation of the cellular network for disseminating information and optimizing congestion control. The proposed method utilized a novel Golden Eagle-based primal–dual Congestion management (GEbPDCM) model to reduce the latency during multimedia transmission. Initially, the node's status was measured to load the data for finding the node density, which would help the data load migration. Half of the load was shared with the nodes if the predicted load was higher than the optimal load. Here, incorporating the Golden eagle function has provided continopus monitoring to check the data load status at different continuous time intervals, leading to better data migration and earning the best performance. Finally, by varying the packet size up to 5 Kb, performance parameters were noted as delay, throughput, PDR, packet loss, and energy consumption, such as 67.498 ms, 97.1544 Mbps, 0.97154%, 0.02846%, and 50.688 mJ. This technique needs more resources for multimedia transmission. In the future, an efficient routing protocol with an efficient optimization technique will afford the finest outcome without the data traffic. However, the proposed model has not been tested in large network environments. So, the reliability of the proposed system in the diverse wireless network is not studied. This is considered the main drawback of this current research study. In the future, testing the implemented system with different network environments by incorporating the security constraints will afford a better reliability score and confidential rate.

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Data availability Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Declarations

Ethical approval All applicable institutional and/or national guidelines for the care and use of animals were followed.

Informed consent For this type of analysis, formal consent is not needed.

Conflict of interest The authors declare that they have no potential conflict of interest. Statement of Animal and Human Rights.

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