Improving LEACH based concept by using MGSA approach in Wireless Sensor Network

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Abstract:
One of the most tedious tasks is the achievement of energy efficiency in WSNs. The energy consumption limitation is the major problem and it‟s required to address based on reliable and effective solutions. Clustering is the best technique for reduction of energy consumption in WSNs. The CHs have been selected after formation of clusters in a network based on clustering methods. But, theyhave some limitations like increased network overhead, and higher execution time for larger scale networks. As improper node selection is resulted in the unnecessary energy usage among sensor nodes, it‟s essential to perform the optimal relay node selection for energy saving. Both clustering and optimal relay node selection procedures have been optimized withtheuse ofa combinedalgorithm.The ModifiedGravitationalgorithmfor optimalnodeselection, i.e. MGA-ONS, which is a new energy-efficient management technique has been introduced for CHs selection according to different parameters, such as probability value, residual energy, and theclosersensornodestotheSINK.Theunnecessaryenergyutilizationislimitedbyconsidering the sensor node distance to SINK. For selection of relaynodes, the proposed MGA is considered significant parameters, such as delay and residual energy in the links, and nodes‟ distance from their respective CHs. The improved energy consumption is achieved using the proposed algorithm in comparison with the existing methods, such as LEACH.

Keywords: LEACH, Network lifetime, Cluster head selection, WSN, Relay node selection, Gravitational Algorithm, Energy efficiency.

I. INTRODUCTION

In the wireless communication, WSNs are playing a crucial role as they have used in different applications [1], such as military, healthcare, and civil applications. The sensor nodes of WSNs have an ability of sensing the humidity, pressure conditions, and temperature level. The sensor nodes can be collected the data about physical area that will process and transmit to the Base Station (BS).

A group of sensors and actors of a network is the wireless sensor and actor network (WSAN), which makes the collection of data via sensing data and appropriate actions that have been performed by the actors that process the received data. The limited resources, like transmission power, capability, battery, and limited capabilities of wireless communication that involving in the sensor nodes.

Actor nodes refer to the resource rich nodes [2, 3]. The decision making of routing tasks andtheir execution is the major issue of the wireless sensor and actor network. The timely data delivery is another issue at an actor node of WSANs for applications, such as home automation, detection of chemical and biological attacks, battlefield surveillance, environmental monitoring, and activation of alarm and water sprinkling system in the fire accidents.

WSANs have been faced the issues, like reliability and energy efficiency. The significant application requirements, like less delay, energy efficiency, and higher data reliability may satisfy by the data collection protocol in WSANs. However, these requirements can be fulfilled with the use of multiple energy-efficient intelligent routing methods. The random deployment of sensor nodes is done over a dynamic environment of WSANs [4]. Because of these dynamic changes of wireless links‟ quality, the packets are dropped. The other causes for packets dropping are nodes‟ residual energy, the wireless links‟ bad quality, and the non-availability of free buffer at the intermediate notes. Additionally, these packets that have been dropped to be resend to assure the data reliability. As a result, more energy consumption and delay are caused. The above-mentioned issues might be solved using the energy-efficient routing protocols based on the efficient decisions of routing that consider link quality, availability of buffer, and node‟senergy.

WSNs have been played a key role in the IoT paradigms. WSNs are dominated the IoT framework for data collection due to their autonomous, resilience, and energy-efficient traits [5].

The BS aggregated data transmit by CH in a network by allowing the cluster head (CH) for information exchanging by the sensor node. In CH, the sensor node‟s aggregation data is occurred because of its fusion role that leads to the reduction of sending data to the BS. It leadsto the saving of energy and bandwidth resources. But, the formation of clusters can be crucial in the network with the use of clustering as they play a key role in the organizational based applications. Toachieve thebenefits,likecorrelationsandminimized redundancyfor readingsof a sensor, the natural technique has been utilized for integration of sensor nodes that are closer to each other spatially [6].

II. LITERATURE SURVEY

Neamatollahi et al., [7] were proposed a novel technique of fuzzy-based hyper round policy for restricting the issue of reclustering overhead of WSNs. Byusing the particle swarm optimization and fuzzy logic, the cluster head selection policy was proposed for prolonging the network lifetime [8]. To determine the hotspot problem of WSNs, a fuzzy-based unequal clustering techniquewasdesignedaccordingtotheunequalclusters‟formationandcluster‟sproper selection. The delay and energy-aware routing method has been proposed with a fuzzy logic system and a

heterogeneous sensor actor network under variable states of a network.
Pantazis et al., [10] were focused on investigating variousenergy-efficient routing techniques for WSNs. In a wireless mesh network, the link quality and relative ordering of wireless links are taken into account for estimation of path cost based on the number of link layer transmissions. Rout et al., [12] have been introduced the network coding based probabilistic routing method for cluster-based WSNs.

Zhang et al., [13] have been proposed the energy-balanced routing technique, in which the selection of next node is performed according to the forward energy density and link weight. In [14], the opportunistic routing protocol was proposed based on a forwarder selection algorithm for a duty cycled WSN, which considers the nodes‟ residual energy. In [15], the ant colony optimization routing method has been proposed based on different parameters, like residual energy, transmission direction, and communication transmission distance of nodes. The optimal routing decisions have been performed using the routing parameters, such as availability of free buffer, link quality, distance, and residual energy.

Sindhwani and Vaid (2013) have been addressed the LEACH protocol issues and a vice cluster head low-energy adaptive clustering hierarchy has been proposed for providing the vice cluster head to each cluster. It minimizes the new cluster head selection with a higher amount when the cluster head damages and the data will receive at the BS. However, the lifetime of a network is increased [16].

Liao and Zhu (2013) were used the LEACH protocol and improved the energy-balanced clustering algorithm. According to the remaining energy and distance agents, the selection strategies have been developed, including the selection of optimal cluster head [17].

Bakaraniya and Mehta (2013) have presented the K-LEACH protocol using the normalclustering based on the scaling of entire network capacity and a k-medoids algorithm among all of the active nodes for network lifetime enhancement. The normal clustering of nodes is assured that provided with the suitable location of CH. After completing 50% of random round operations in a network, the CHs selection, maximum criterion of remaining energy, and the clustering union have been used while providing the total random selection of CHs based on a LEACH protocol. Thus, it results in the CHs‟ poor selection and an energy maintenance with a higher degree and lifetime reduction over a network [18].

Mostafa Mirzaie and Sayyed Majid Mazinani (2018) [19] have introduced the fuzzy logic based algorithm for heterogeneous nodes‟ clustering in the WSNs (MACHFL-FT). The heterogeneous sensor nodes‟ clustering is performed using MACHFL-FT in different rounds, each of which involves the selection of best nodes as the clusterheads. With the use of proposed technique, the better results are obtained in terms of prolonged network lifetime and reduced consumption of energy.

Amer O. Abusalem and Noor Shudifat (2019) [20] have been improved the LEACH protocol for efficient cluster routing to overcome the issues of WSNs, such as energy and network lifetime. The power consumption of cluster nodes reduces by determining the cluster head with the consideration of lowest degree distance from Base Station. The simulation results prove that the enhanced LEACH can able to decrease the consumption of energy and improve the lifetime of a network.

III. ProposedFramework

To perform the even distribution of energyload across the network, the energy-efficient protocol isproposedbasedontheclusters,i.e.MGA-ONS,whichisperformedtheoperationsusingthe (i) selected cluster head based on distance between SINK and node and residual energy, and (ii) an inter and intra cluster multi-hop communication, where the multi-hop path is selected if it has minimum communication cost from every node of a network to CHs.

The greater residual energyand a minimum distance to SINK of nodes have been selected as the cluster heads while sending information towards the cluster members. The multi-hop routing paths are used to transmit the data aggregation by cluster heads to the BS. For data transmission, the significant parameter is used, i.e. node distance from SINK. By reducing overhead of inter cluster communication for cluster heads that are nearest to the BS, causing of earlier death for cluster heads will be restricted. The overall cost of a data packet is reduced by sending the data via a path of minimum communication cost using sensor nodes. These factors will be improved energy efficiency and enhanced the network lifetime.

MGA-ONSoperationhasbeencategorizedintoround,eachofwhichcontainstwodifferent phases:

- Steadystatephase
- Set-upphase

From each cluster member to CHs and BS, the multipath selection is carried out in the set-up phase, in which clusters are also organized. Steady-state phase involves the data transmission. The longer duration is taken by the steady state phase to reduce the network overhead than the setup phase.

Set-upPhase:
Itincludesthebelow-mentionedmethods,such as:

- Clusterformation
- Clusterhead selection

Clusters creation, selection of cluster heads, and choosing multi-hop path from every clusterhead to BS have been carried out in the setup phase.

ClusterHeadSelection:

The distance from SINK node is estimated by each node at the initial stages of set-up phase and the details about residual energy and distance are shared to the neighbour nodes. The random value between 0 and 1 is used to determine the probability value for all sensor nodes.

The determination of a distance between SINK and node is performed based on Euclidean distance as follows:

$$= \sqrt[2]{(xpos \quad - xpos_{node} \ )^2 + (\qquad - ypos_{node} \ )^2} (1)$$

Where, $ypos_{node}$ and $ypos_{sink}$ represent the y position of the node and sink while $xpos_{sink}$ and $xpos_{node}$ indicate the x position of the sink and node respectively.

Belowequation(2) isused todeterminetheresidual energy:

$$RE = E_{initial} - E_{consumed} (2)$$

Where,$E_{initial}$representsthesensornodes‟initialenergy.

The node would become the CH when its residual energy is more and the distance is minimum towards SINK than the other remaining nodes of a network.

ClusterFormation:

Once the cluster heads are chosen, the message of CH_ADV (cluster head advertisement) sends to the neighbours from BS and it is transferred outwards based on the cluster heads. The signal strength of CH_ADV received messages decides the selection of cluster head that is nearer to each member node. If the cluster head is not there to be joined as a sensor node and direct communication cost is less in regarding the base station, the data send towards the BS directly. Or else, it has been decided to join in the cluster, which includes the nearest cluster head. The node is used to send the JOIN message towards the cluster head after choosing the cluster based on each node where it belongs to. The communication schedule is created that would be broadcasted to all member nodes if JOIN message receives by the cluster head from all sensor nodes that would have been joined in the cluster. Therefore, all clusters have been organized.

Steadystate phase

This phase involves the occurrence of data transmission based on inter and intra cluster communication and multi-hoppaths in a network. There laynodes have been chosen by MGSA, which is introduced as the optimal relaynode selection technique based on modified approach of gravitational search for data transmission

.Each factor of the gravitational search approach (GSA) is experienced for three steps for every iteration. The adjustment is the primary step, in which the influence and efficiency parameters have been adjusted. The detected factors have been cooperated in the second step of cooperation while these parameters compete each other to achieve the increased lifetime in the competition step, which is the third step of the algorithm. The optimal route is determined using the GSA based on various metrics, like minimum delay, distance to CH, and residual energy.

Gravitationalsearch algorithm

Astochasticoptimizationalgorithm,i.e.GSAhasbeendeveloped byconsideringtheinspirations from law of motion and law of gravitation. According to the Newton‟s universal law of gravitation, the objects are attracted to each other with a force (F) in the universe and the masses of objects M1 and M2 are directly proportional to F, which is not directly proportional to the square of distance between them. It is demonstrated using below equation (3):

$$= \frac{1. \ 2}{2} \quad (3)$$

Where, R represents the Euclidean distance between M1 and M2 and G indicates the gravitational constant.

Therelationshipbetweentheobject‟smassM,forceF,anditsacceleration,„a‟hasbeengivenby the law of motion as mentioned in Equation (4):

$$= \quad (4)$$

The acceleration would be larger for the smaller masses and vice versa. GSA has included these laws while considering each object as an agent that has the position, acceleration, mass, and velocity. Based on the GSA and smaller (lighter) agents towards the bigger (heavier) ones, the attraction of agents is included among there via the gravitational force of attraction. All agents‟ attraction will be towards the heaviest agent. The performance of agent determines using its mass.However,heavymassisindicatedastheoptimalsolutionforagivenproblem.Thebelow-mentioned phases are defined the basic GSA algorithm, such as:

- Initializationof population

Theagents‟initialpositionsarepopulatedattimetinthisphaseusingthebelowequation(5):

$$X_i(t) = (x_1, x_2, \ldots\ldots\ldots x_n) \quad (5)$$

- Fitnessevaluation

The fitness function determines for each agent location. For a minimization problem, the least oneandthehighestonewouldbethebestfitnessandworstfitnessvalues,respectivelyamongall fitness values of all agents.

$$= \min \quad (\ )$$

$$=\max \quad (\ )$$

- Updateand Calculations

Thevelocity, mass, andforceofagents areupdated usingthedetermined values offitness.

ModifiedGSAalgorithm

To select the optimal relay nodes for distribution of nodes across the network, the proposed multi-objectivefitnessfunctionisused.Different performance metrics,suchasdelay, distance to CH, and nodes‟ energy have been used as objectives in the maximum fitness function using the MGA. With the providing of maximum value, the fitness function is satisfied by each node for choosing a sensor node as a relay head. The multi-objective fitness function is expressed using below equation:

$$fitness(n)=\{Dist_{n-CH}+E_{res}(n)+D(n)\}(6)$$

Where, $E_{res}(n)$ is the node n‟s residual energy, $Dist_{n-CH}$indicates the node distance n from the respective CH, and D(n) refers to the sensor node n‟s total normalized delay. In the fitness function, the multi-objectives are demonstrated as follows:

Delay: It is described as the summation of present delays in each node of WSN. The delayshould be lower as much as possible for a node to be chosen as the optimal relay. The node‟s delay relies on different factors:

- Thenetwork‟stransmissiondelay
- Node‟spropagationdelay
- Nodesexpectedtransmissioncount (ETC).

Thesensornode‟sdelayhasbeenexpressedusingthebelowequation:

$$D(t)=\sum_{=}^{n} \quad (\ + \ )(7)$$

Where, PD_n refers to the node n‟s propagation delay, TD indicates the total network transmission, and ETC_n refers to the sensor node‟s expected transmission count (ETC).

Distance to CHs: The second objective of the fitness function is to achieve the lower distance between cluster heads and nodes for effective communication. The distance is represented using below Equation (8):

$$= \sqrt[2]{(xpos \quad -xpos_{node} \ )^2+(\qquad -ypos_{node})^2} \qquad (8)$$

Where,$xpos_{node}$and$xpos_{CH}$;$ypos_{node}$and$ypos_{CH}$indicatethexpositionandypositionofthe node and CH respectively.

Energy: As shown in the Equation (2), the residual energy of sensor nodes is determined while selecting the higher energy of node as the cluster head.

The optimal relay nodes have been chosen for routing process by evaluating the multi-objective parameters.

IV. Resultanddiscussion

Experimental Setup

Thesimulationhasbeen performedfortheproposedmethodtoanalyzeitsperformanceusingthe NS2. The simulation of multicast protocol, UDP, and routing support have been provided for all wireless network. The network model has been used in this work that includes the network"s homogeneous types of fixed sensornodes that haveincluded similardevices ofradio-transmitter, same capabilities, uniform deployment, same initial energy, and constrained power resources. However, the Base Station is considered as fixed and should be detached from the sensor nodes. This project simulation tests have been conducted according to the plane coordinates and static nodes. After usingthe initial energyof nodes, the data transmission or reception could be limited because the nodes are assumed as limited energy resources.

PARAMETER	VALUE
Applicationtraffic	CBR
Transmissionrate	1024bytes/ 1ms
Radiorange	250m
Packetlength	1024 bytes
RoutingProtocol	AODV
Simulationtime	100s
Numberofnodes	50
Area	1000 x1000
Routingmethods	Proposed,MACHFL-FT,EN-LEACH
TransmissionProtocol	UDP
InitialEnergy	100j

Table1:Simulationtable

Simulationresultandanalysis

The simulation results have been presented for various scenarios in this section. The attackmodel implements in the simulation over the network of 50 nodes with the area of 1000*1000m^2.

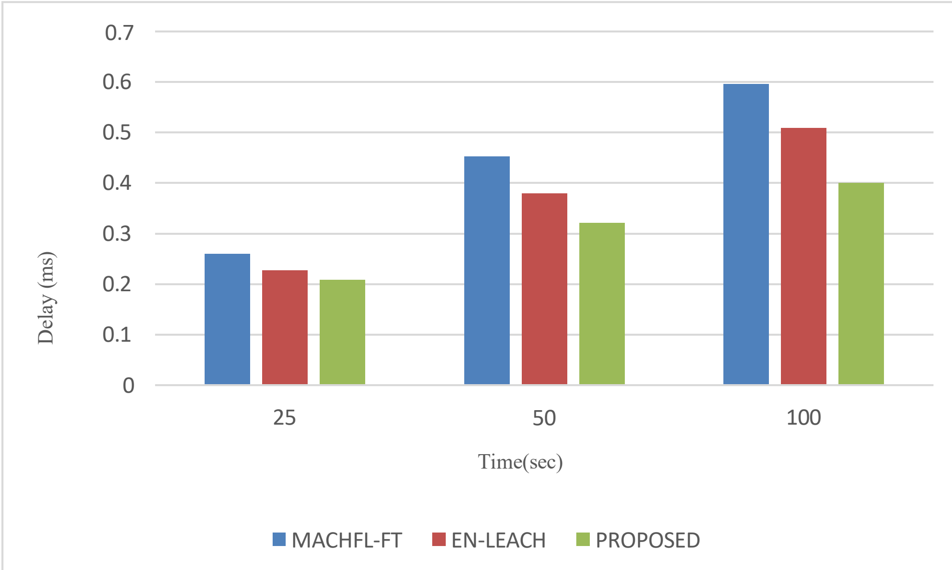

Fig.1:PerformanceonDelay

End-to-end delay of a network is correlated to the efficiency of a network, which means the increased delay reduces the network performance. As shown in Figure 1, the performance on delay for different methods, like proposed MGA, EN-LEACH, and MACHFL-FT is presented. The forwarder nodes are chosen in the MGA algorithm using the estimated distance between nodes and the multi-objective parameters. Thus, the end-to-end delay reduces while transmitting the information. The simulation results of end-to-end delay for proposed method is showed the reduced delay in comparison with the other existing methods.

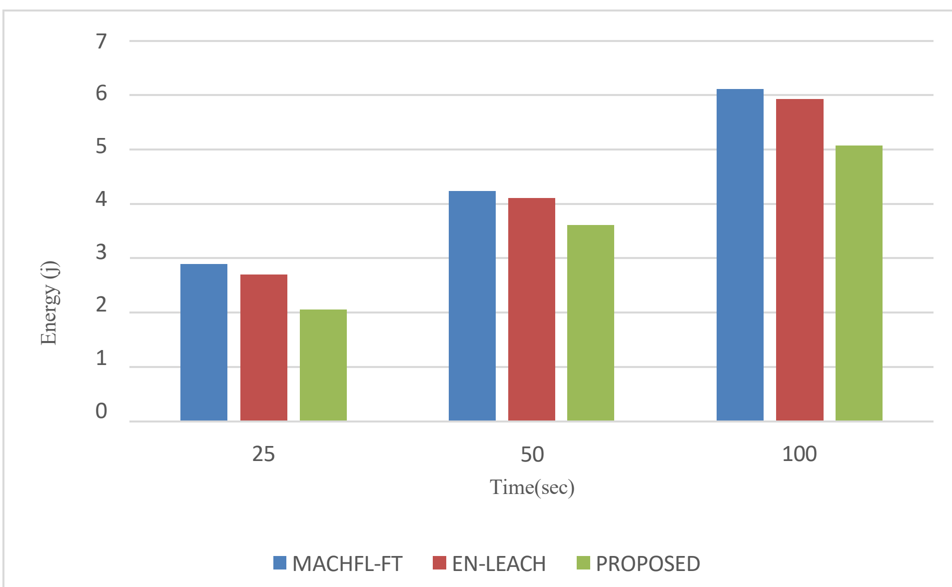

Fig.2:Energy consumption

The significant element of the sensor network is the energy to participate in the network activities. The network lifetime will be increased with the minimum consumption of energy. During the transmission of data, the network consumes huge amount of energy. By using the appropriate selection of sensor nodes, the energy consumption is reduced with the implementation of MGA forwarder node selection. Figure 2 demonstrates the energy consumption results that the energy conservation is optimized with the proposed technique than the other existing methods, like EN-LEACH, and MACHFL-FT.

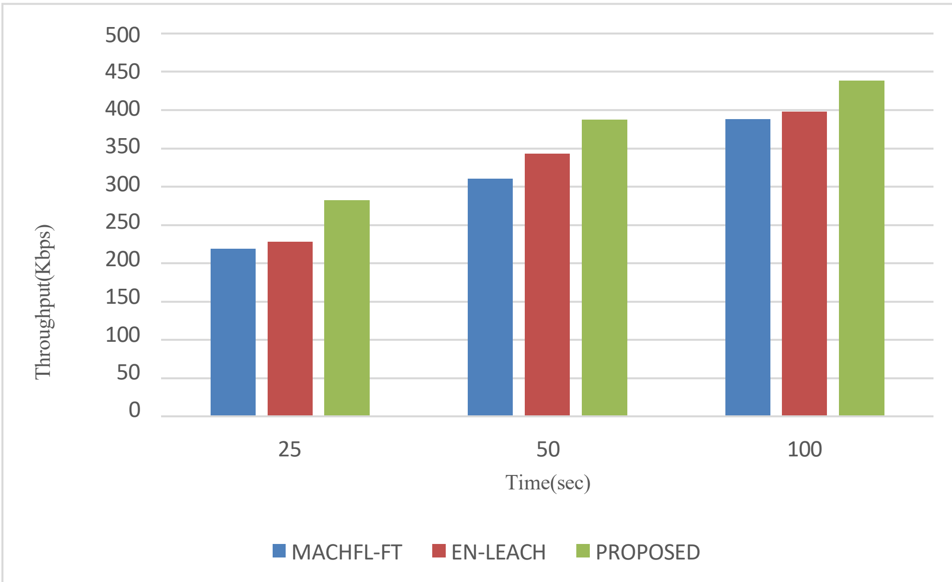

Fig.3:Throughput

Throughput is a measurement factor for successful data delivery rate. The data transmission is affected by different factors and they can be restricted through the effective node selection forwarding process.The data will deliver with lower delay using the MGA-ONS algorithm that chooses the forwarder nodes based on multi-objective criteria. Figure 3 shows the throughput simulation graphs and proves that the proposed MGA-ONS algorithm achieves increased throughput compared to the earlier methods, like EN-LEACH and MACHFL-FT.

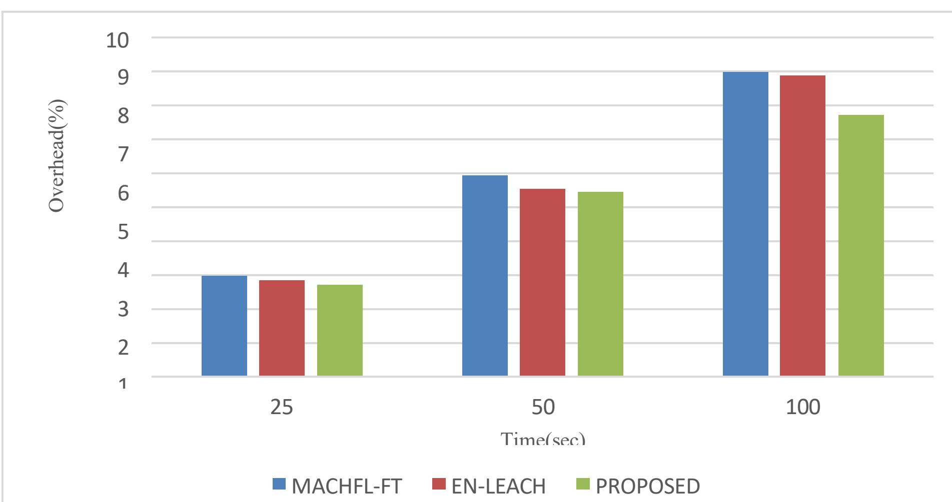

Fig.4:Routing overhead

Network routingoverhead is indicated as the amount of network complexitythat experienced for processing the algorithms. Good results would be obtained with the less overhead. The routing complexity reduces in the MGA based on the selected forwarder nodes using data aggregation method.Figure4demonstratesthesimulationresultsforroutingoverhead. Theproposedmethod showsthelessoverhead asthecommunicationoverhead reducesbetween CHandSINK thanthe other remaining algorithms.

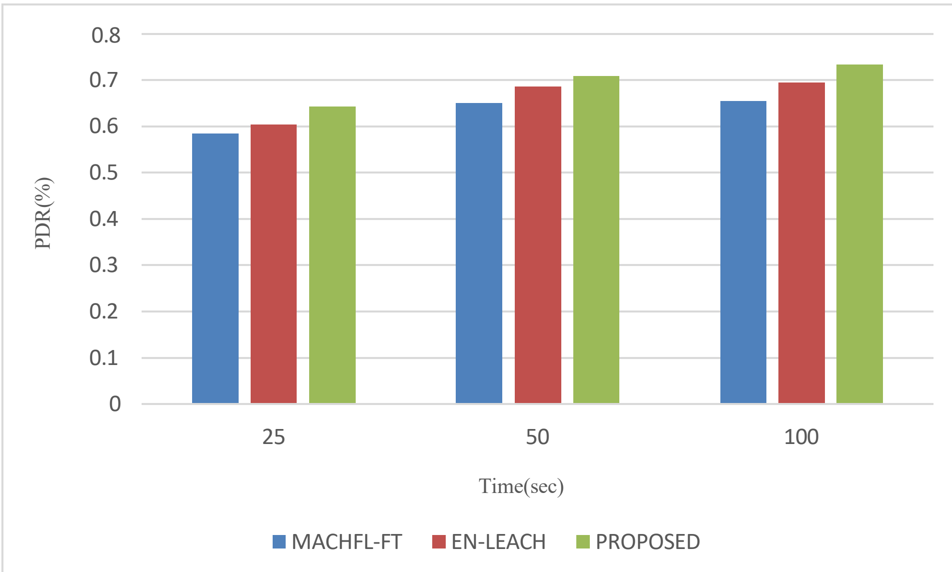

Fig.5:Packetdeliveryratio

PDR is described as the amount of successful data deliveries over time. The packet drops and delay affect the PDR due to the improper selection of forwarder node. This is restricted by the MGA-ONS and the forwarder nodes are chosen for data transmission. Figure 5 presents the packet delivery ratio results that indicate the proposed method is showed the higher PDR value than the other existing methods.

Conclusion

The modified gravitation search technique proposes using the multi-objective CH selection inthis paper to provide the selection of energy-aware CHs and optimal relay nodes. However, the main advantageofusingMGAis that it chooses theoptimal routewith theuseofmulti-objective parameters, such as energy, node distance to CHs, and delay. The optimized results are achieved with the CH selection based on parameters, such as probability, residual energy, and distance to SINK. The proposed multi-objective MGA-ONS technique is achieved the greater energy energy-efficiency results with lower overhead based on the evaluation of simulation results. Additionally, the improved throughput and data delivery rate have been reached for inter-cluster data aggregation because of the optimal selection of CHs with the distance between nodes and SINK. The higher efficiency results are proved by the MGA based on multi-objectiveparameters. The proposed technique MGA-ONS outperforms all other existing routing methods, such as MACHFL-FT and EN-LEACH based on energy consumption, PDR, throughput, and end-to-end delay.

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