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Mobility Aware Weighted Clustering Algorithm for Maximizing IOT Network Lifetime by Harnessing Routing Energy

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***Abstract:** The Internet of Things (IoT) is considered as evolved form of Internet in the present scenario. Due to the prediction that large amount of data could be generated by billions of devices connecting to the Internet, requires data to be routed and processed rapidly by harnessing IoT devices energy. Energy constraint IoT devices consume more energy due to mobility of nodes and results in minimizing network lifetime. Motivated by this challenge, mobility aware weighted clustering algorithm (MAWCA) for maximizing IoT network lifetime by harnessing routing energy is proposed to find the optimal cluster head (CH) for mobile nodes in the IoT network. MAWCA considers degree difference of the node, sum of differences between neighbors, cumulative time, nodes mobility and delay in choosing a CH as weighting factor during CH election process. Simulation results shows that the proposed MAWCA outperforms in respect to network energy, delivery ratio, alive nodes count, packet loss ratio and network lifetime in par with similar existing algorithm. The uniqueness of the paper lies in selecting potential cluster head to maximize IoT network lifetime.*

***Keywords:** Clustering, Energy conservation, Internet of Things, Mobility, Network Lifetime, Routing.*

I. INTRODUCTION

IoT is a part of future Internet, which covers most of the health care, industries, transportation, smart city, structural monitoring and many other applications. As a result of these applications generates large amount of IoT data resulted by machine to machine and machine to human communication [1]. IoT devices make physical things to perform tasks by sensing, seeing, thinking, communicating together to share data and to coordinate decisions. IoT revolutionizes traditional objects into smarter objects by making use of embedded devices, pervasive and ubiquitous computing, various communication methods and different protocols of Internet [2]. These smart objects assigned with specific task provide domain specific applications, whereas ubiquitous computing results in application services independent from their domain. In IoT these domain specific will communicate with domain independent services to fulfill the desired objective. Providing smart connectivity to the existing network and using context aware computing in the network are prominent factors for IoT. Context awareness helps to choose suitable services in multiuser computing application to optimize the performance. With the energy awareness in WiFi, Bluetooth Low Energy (BLE), and LTE makes conventional mobile computing structure which consists of smart phones and other portable devices to be more energy efficient and provides connection to the everyday tasks continuously. It is prime requirement to establish flawless communication between IoT devices. To achieve these IoT devices should communicate and exchange data between various heterogeneous devices in a heterogeneous network. Interoperability among protocols in the heterogeneous network results in establishing extensive connectivity among devices and appropriate connection is required to exchange context related information between heterogeneous devices. Appropriate mechanism is required to send packets in the network to perpetuate resources. To fetch and to read data whenever and wherever we go in the world requires data from the wireless sensor Network (WSN) devices to connect into Internet thus making these devices part of IoT network [3]. IoT consists of large number of resource constraint devices which constitutes in sending data from one or more source device to one or more BS.

Reducing energy consumption by IoT devices has become a major requirement. Many applications require IoT devices to work autonomously with limited battery capacity to provide consecutive services and work independently for longer period of time [4]. But the IoT nodes will no longer able to achieve this objective due to limited battery capacity and improper energy management in the network. Thus conventional WSN and IoT devices require energy aware architecture and mechanism. Nodes in conventional WSN and IoT are deployed in two ways. Resource constraint nodes are deployed in huge numbers and abundant resource nodes are employed in known places. Increasing packet delivery success rate and minimizing energy utilized by packets, network lifetime can be enhance by heterogeneous nodes. Heterogeneous WSN can be used in complicated applications to monitor larger areas for longer duration when compared to single network. Network utilizes its own power and computing resource while cooperating with adjacent nodes [5]. Conventional clustering method is an effective method to enhance overall network energy efficiency and to maximize network lifetime [6]. In clustering, network consists of different groups, known as clusters. Every cluster consists of one leader termed as CH. CH collects the data sent by member nodes within the cluster and aggregates these collected before sending it to BS through other CHs or by direct communication.

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BS is connected to Internet to store or to view data anytime and everywhere. Clustering provides various advantages as 1. Discards redundant data sent by multiple member nodes in CH level due to data aggregation, which provides energy conservation by reducing data sent from each sensor node in the network. 2. Maximizes scalability of the network. 3. Reduces congestion in the network. With all these advantages due to clustering technique, attention should be given while selecting proper and optimal CH since this plays vital role in extending lifetime of the network, energy efficient data routing and to conserve member nodes energy.Devices or the sensor nodes which wants to join the network requires unique address in case of IoT, where WSN nodes can be included. In ad-hoc network member nodes along with BS establishes interaction between user and the nodes. Hosting WSN nodes data into Internet extends the flexibility of data availability and can be retrieved whenever they want. Since the location of the nodes is not known, hence WSN nodes should have self organizing capability. Coordination between nodes is very important due to the fact that network computation is dependent on the processing power of the nodes. Energy of the nodes is drained more during the communication in the network and it is prime requirement to reduce the energy consumed during the routing. Hence, it is certain to consider topology type, minimizing power required, memory and many other factors during the designing stage of the protocol. In this paper, more attention is given in selecting the CH by considering mobility of nodes before cluster formation. Proposed method effectively selects CHs among various member nodes present in the network.

The contribution of this work is briefed as follows:

- Mobility of nodes is considered to avoid disconnection due to link failure.
- MAWCA prolongs the network lifetime by considering delay, remaining energy of the nodes, energy needed for future transaction, link lifetime and distance between nodes after random mobility.
- Proposed method is simulated and compared with existing algorithm to prove the efficiency of this method.
- In case of densely deployed scenario overlapping of clusters is reduced by establishing cluster boundary between the member nodes.

Structure of the paper is furnished as follows. Section II discusses various related works in context to energy conservation. Section III provides the problem statement. Section IV explains the proposed method. The Experimental evaluation is presented in Section V and conclusion has been explained in Section VI along with future directions.

II. RELATED WORK

Many clustering algorithms on basis of heuristic approaches are proposed for WSN. Amid all LEACH [7], is a familiar clustering type algorithm wherein cluster head are selected based on threshold function. LEACH is simple in selecting CH and improves energy efficiency of network and member nodes. But LEACH has a probability of selecting low energy node as CH which dies quickly, thus impair the network performance. To overcome from this disadvantage many improvement has been proposed to default LEACH protocol, PEGASIS [8], is proposed in which nodes are arranged in the form of chain wherein nodes sends and receive data packets from its adjacent nodes. CH is randomly selected from the chain, this method conserves energy more than default LEACH but not suitable for large network with many nodes. Many algorithms have been proposed to improve network lifetime. V-LEACH [9] protocol wherein some of the CHs are designated as vice CHs together with main CHs. Vice CHs acts as main CHs whenever main CHs dies due to lack of residual energy. Thus, V-LEACH efficiency is more than standard LEACH but the limitation in this protocol is it requires extra computational energy while selecting vice CHs. M-LEACH [10], in which CH forwards the data to next hop instead of BS in standard LEACH protocol. This algorithm is better energy efficient than standard LEACH but, this method considers clustering phase which limits this algorithm. E-LEACH [11], is an extended form of standard LEACH which uses minimum spanning tree at cluster heads. If the nodes residual energy is highest than that of other nodes then that will be designated as root node. This method takes more time in tree formation which results in slower cluster formation. There are many clustering algorithm based on nature inspired approaches. LEACH-C [12] is centralized form of LEACH where cluster creation process occurs at the BS to choose K efficient clusters. Nodes with higher residual energy than that of average energy is considered as CHs. But this method is not efficient in selecting best CH since base station is given selection job. FL-LEACH [13], considers fuzzy logic into the standard LEACH protocol. This method increases energy efficiency when compared to LEACH but, introduces additional complexity problem results due to the process of fuzzification and defuzzification. Dhumane et al. [14], have proposed multi-objective fractional gravitational search algorithm (MOFGSA) to prolong network lifetime by conserving energy required during routing. This method considers multiple parameters such as delay, distance between nodes, energy and lifetime of the link. Simulation results show better performance in conserving the overall energy of the network. However, this method fails to consider mobility of the nodes while considering the clustering of nodes and during the selection of CH. To choose optimal CH in the network authors in [15], have proposed cluster based Particle Swarm Optimization (PSO). This method minimizes the finding cost of the head nodes in the cluster and has very good transmission rate during packet transfer. But, this method fails to perform well in case of heterogeneous environment. Authors in [16], have proposed multi-particle swarm immune cooperative algorithm (MPSICA) to select CH based on the routing. This method provides best recovery scheme whenever the routing path has broken in the network. But the limitation of this algorithm is that it requires more parametric values in order to reduce energy requirement of the network.

III. SYSTEM MODEL

A. Network architecture

WSN nodes and many other device types connected to Internet through wireless medium constitutes IoT network. Fig. 1 shows the IoT network architecture, wherein *m* represents normal nodes number in the IoT network with CH being cluster head and *CB* as base station.

Each node is dispersed in an area of L_i and H_i terrian size. Nodes are equally distributed in the terrain and these nodes are identified by unique ID. Cluster consists of group of IoT nodes and location of sink node is fixed at 0.5 L_i, 0.5 H_i to receive all the all data symbols forwarded by nodes in the IoT network. IoT nodes location is represented by L_t and H_t coordinates. CH receives the data from these nodes and forwards it to the cluster head or base station finally. Each cluster group consists of CH_m set of cluster, means that each IoT network is partitioned into CH number of cluster. Hence, normal nodes count is given *m*-CH. Once the clustering process has started and clusters have been grouped then data is forwarded to corresponding cluster head HC from every normal node HN in the network. These collected data sent by the nodes are then delivered to base station CB by the cluster head. Location of the IoT nodes are fixed in the network and distance between nth normal node to the mth cluster head is represented by $d_{(}n, m)$ and a_m provides the distance between mth cluster head and sink node CB.

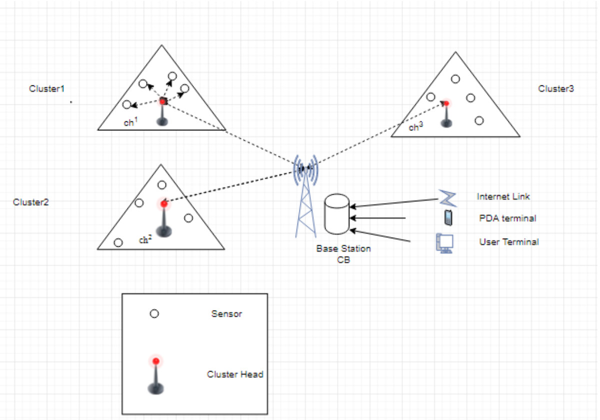

Fig. 1. Network architecture

B. Energy model

Let initial energy of the IoT nodes is considered as Y_0, here energy model of [17] is refered. In IoT network each nodes deployed will have transrecievers, amplifiers for communication between them and the energy drained out by these compunents will be accounted. Hence energy is calculated when normal node sends P_s bytes of data is shown as

$$Y_{dis}(HN^x) = Y_{el} * P_s + Y_{fd} * P_s * ||HN^x - HC^n||^4$$

$$if\, ||HN^x - HC^n|| \geq k_0$$

$$Y_{dis}(HN^x) = Y_{el} * P_s + Y_{fs} * P_s * ||HN^x - HC^n||^2$$

$$if\, ||HN^x - HC^n|| k_0$$

$$k_0 = \sqrt{\frac{Y_{fs}}{Y_{fd}}}$$

Here, energy dissipated by electronic components is given by Y_{el}, whereas multipath and free space energy is given by Y_{fs} and Y_{fd}. Hence energy of the electronics is given by

$$Y_{el} = Y_{TR} + Y_{DA}$$

Here energy dissipated by the transmitter is given by Y_{TR} and energy consumed during aggregation of data is given by Y_{DA}. Distance gap from node to cluster head is given by $||HN^x\text{-}HC^n||$. Energy dissipated while receiving P_s data bytes is shown as

$$Y_{dis}(HC^x) = Y_{el} * P_s$$

Every IoT nodes residual energy is updated when data is exchanged between the nodes and the cluster head. Is given by

$$Y_{u+1}(HN^x) = Y_u(HN^x) - Y_{dis}(HN^x)$$

$$Y_{u+1}(HC^x) = Y_u(HC^x) - Y_{dis}(HC^x)$$

Exchange of data continues until the energy of the nodes reaches zero and nodes are considered as dead nodes when energy reaches zero.

C. Mobility model

IoT nodes movement is based on mobility model [18], where nodes acceleration, velocity and location is considered. This mobility model regulates the network performance by controlling data transmission in the network during routing. Consider *a* and *b* be the IoT nodes with initial position as (p_1, q_1) and (p_2, q_2) respectively. Nodes move to new position say (p_1', q_1') and (p_2', q_2') at time *t*=1 with angle θ_a and θ_b . The distance D_1 and D_2 be the measured distance of the nodes for every time interval. Euclidean distance in between the nodes $a(p_1, q_1)$ and $b(p_2, q_2)$ at time *t*=0 is provided by

$$D_{(ab,0)} = \sqrt{|p_1 - p_2|^2 + |q_1 - q_2|^2}$$

Let us consider IoT nodes moves with the velocity w_a and w_b in θ_a and θ_b direction. So the distance D_{a1} and D_{b2} are the distance traveled by the node in time *t* is provided individually as

$$D_a = w_a * t$$

$$D_b = w_b * t$$

At time *t*, node $a(p_1, q_1)$ moves with velocity w_a and $b(p_2, q_2)$ moves with velocity w_b with angle θ_{a1} and θ_{b2} respectively.

New location of the node *a* at a distance D_a is

$$p_1' = p_1 + w_a * t * cos(\theta_a)$$

$$q_1' = q_1 + w_a * t * sin(\theta_a)$$

Position (p_2', q_2') of *b* at distance D_b is given by

$$p_2' = p_2 + w_b * t * cos(\theta_b)$$

$$q_2' = q_2 + w_b * t * sin(\theta_b)$$

Thus the IoT nodes distance with each other at any time *t* in new location is given as

$$D(t) = \sqrt{|p_1' - p_2'|^2 + |q_1' - q_2'|^2}$$

(p_1', q_1') and (p_2', q_2') are new position obtained by the IoT nodes a and b respectively.

IV. PROBLEM STATEMENT AND CHALLENGES

A. Problem statement

Nodes of WSN based IoT are limited in terms of energy, transmission range, memory, CPU capacity and physical size. This limitation makes nodes to be energy constriant in the network to monitor the intended area of the application to longer time and to maximize network lifetime. In [15], energy efficient cluster head selection algorithm based on PSO is proposed in order to increase the lifetime of the network. PSO is nature inspired algorithm and uses the technique of swarm behavior exhibited by animals and birds while collecting and searching for the food. In this method best positions are considered based on the static nodes and considers density of the nodes in the cluster as uniform. Authors in [14], have proposed MOFGSA by integrating fractional theory into standard GSA. Here the nodes previous position value is considered during the clustering process. Authors in this method done a fair job in considering multiple parameters like delay, distance, energy and lifetime of the link for static nodes. This method failed to consider the mobility of the nodes and densely arranged nodes types.

To address the aforementioned challenges, MAWCA is proposed to prolong the nodes lifetime. This method initially separates low quality signal nodes and high quality signal nodes and later into high mobility nodes and low mobility nodes in order to restrict low signal quality and high mobility nodes to become CH. Low signal quality and high mobile nodes have higher rate of packet loss ratio, more energy consumption and are less reliable compared to high signal quality and low mobile nodes. This method considers degree difference of the node, sum of differences between neighbors, cumulative time, nodes mobility and delay in choosing CH as weight factor. Considering the high signal quality and lower mobile nodes while electing CH will improves MAWCA performance in par with MOFGSA.

B. Challenges

- Transmission of data in the network is a challenge task in case of WSN based IoT scenario. In this network has to be energy efficient, robust to the changes, minimize delay, reduce the packet loss and dynamic to the topological changes.
- The nodes have very limited energy so the routing method should consider method to reduce the energy consumption as the main objective.
- Routing of packets in highly varying network due to the mobility of the nodes is more unreliable and requires more energy.
- Energy of the nodes is drained at higher level if the distance between the nodes is more.
- To choose cluster when nodes are densely arranged which will results in overlapping of clusters.

V. PROPOSED MAWCA APPROACH

A. Basic idea

In, MAWCA two selection level have been considered while selecting the CH. First one is SS_l to measure the quality or strength of received RSSI signal and second one to measure the level of mobility L_M. This received RSSI is compared with predefined threshold value SS_l to measure the link strength. These two attribute values helps to segregate highly mobile nodes having low signal strength contributing to delay, packet loss, energy consumption and other parameter which degrades the network performance. We presume mobility and it's RSSI will be determined by the every IoT node in the network. In this approach, random way point of nodes is considered and in clustering process most reliable node is selected as the CH based on the previously mentioned attributes. Here the stability of the nodes is measured by received signal strength and mobility.

B. Cluster head selection process

Selection of cluster head is made in two stages

Stage 1: Strength of the signal plays an important role in selecting the optimal cluster head and better signal strength guarantees the better packet delivery ratio (PDR).

Step 1: Every node in the network broadcasts hello message to search for its neighbor nodes. Neighbor Node's of a node defines degree of the node $NH_(n)$ is given by

$$NH_(a) = |NI(a)| = \sum_{b\in V, b\neq a} distance(a,b) \leq C_{range}$$

Where, C_{range} represents communication range. The energy consumed during sending and receiving of packets is given by

$$Y_c(n_a, \Delta t) = Y_{res}(n_a, t_0) - Y_{res}(n_a, t_1)$$

Step 2: Degree difference of node a is given by

$$\Delta_a = NH_(a) - \delta_a$$

Step 3: Sum of difference with all its neighbors DI_a of every node is given by

$$DI_a = \sum_{j\in NI_(a)} \mathrm{distance}(a,b)$$

Step 4: Strength of the received signal is given by RSSI and is represented by

$$RSSI(\mathrm{dBm}) = -10t_f \log_{10}(\mathrm{D}) + \mathrm{A}$$

Where A provides received signal strength in *dBm*, *D* is the distance in meters and t_f is the transmission factor which depends on propagation.

Signal strength level SS_l: Set the SS_l threshold to $\geq -85\mathrm{dBm}$.

Node with higher RSSI value than that of threshold SS_l is considered as reliable node because higher RSSI value results in better signal strength of the nodes.

Node with lower or equal to RSSI value than that of threshold SS_l is considered as malign node because lower RSSI value results in poor packet reception rate and these malign nodes are not considered while selecting CH.

Reliable nodes

Stage 2: In this stage, nodes having higher SS_i value will be considered and process of selection is given in the below steps

Step 5: Energy plays an important role in IoT network as energy conservation will directly increase the lifetime of the network. Many factors influence the increased energy consumption rate due to the mobility of the nodes. Hence, it is foremost requirement to select node having lower mobility rate in order to prolong network lifetime by conserving nodes energy. Nodes mobility is represented by N_m is considered based on heuristic method used in [19] and is given by

$$N_m = \frac{1}{C_t}\sum_{t=1}^{C_t}\sqrt{(p_t - p_{t-1})^2 + (q_t - q_{t-1})^2}$$

(p_t, q_t) and (p_{t-1}, q_{t-1}) are the coordinates of node *a* at time *t t-1* respectively and the equation provides the node's mobility at current time C_t.

• Level of mobility L_M: Level is fixed to 10 *km/h*

If the mobility of nodes exceeds or equals L_M are considered as malign node. This malign node will not be considered while selecting CH. Nodes having lower mobility with better signal strength will be considered for next step.

Step 6: Cumulative time CT_a, is the time during which node *a* acts as a cluster head. This provides amount of energy spent after becoming CH. Energy drained after becoming CH will more than that of normal node and is given by

$$CT_a = Y(a, t_0) - Y(a, t_1)$$

Where, t_0 is the time before node *a* becomes CH and t_1 is the time after node *a* becomes CH.

Step 7: Delay in selecting the CH will have a greater impact on network lifetime. This delay should be minimized and this is determined by member nodes in the cluster. If member nodes are less in the cluster then delay will be less. Delay is given by

$$delay_i = \frac{Max_{a=1}(CH_a^{CH})^{CH}}{m}$$

where, denominator *m* denotes number of nodes.

Step 8: Weight of each node is calculated by using below formula

$$WHT_a = wt_1 * \Delta_a + wt_2 * DI_a + wt_3 * CT_a + wt_4 * M_m + wt_5 * delay_i$$

wt_i are weighting factors and value of wt_1+wt_2+wt_3+wt_4+wt_5= 1.

Step 9: Consider network having NH nodes arranged in a geographical area of 500* 500 m^2 For *h* meters communication range of the node a, the area covered by individual cluster head is given by

$$CR = \pi * r^2 * m^2$$

Density of the nodes will determine the connectivity and is given by

$$\rho = \frac{H_n}{H_a}$$

Where H_n is the total number of nodes in the network and H_a is the total area in the network. In our case H_n=100 and H_a= 500* 500m^2

Therefore $\pi. h^2. \rho$ gives the upper bound limit for nodes in cluster size. In clustering some cluster have maximum size and some not. So this is the threshold for cluster size. Increase in cluster numbers and CHs will results in more energy consumption, higher complexity while monitoring and routing of data. Hence by considering threshold level while constructing cluster will help in conserving network energy.

Step 10: In clustering process nodes broadcast message and the node with lowest weight is selected as CH and selected CH are not allowed during election process.

Step 11: Repeat steps 1-8 for other nodes who has not selected CH or not assigned to any of the CH.

Step 12: Elected CH then broadcasts HELLO message carrying state information will be sent to all the member nodes in order to update information about their state.

Step 13: If two nodes lower weight value are equal, then CH is selected based on the nodes with largest residual energy

Malign nodes

Malign nodes are the nodes having high mobility speed and lower RSSI value when compared to threshold value T_{hol}.

Step 14: Malign node *a* joins the cluster head CH_m when it receives message from the CH and considers CH_m as its cluster head.

Step 15: If two clusters CH_m and CH_n are in node communication range and sends message to node *a* then the node chooses the cluster head who has got more weight or signal strength of the invitee CH and is given by

$$Sweight_{CH_m} > Sweight_{CH_n}$$

Where *Sweight* is the weight or received signal strength of the invitee cluster head.

$$Sweight_{CH_m} = Sweight_{CH_n}$$

Then CH is selected on following basis

$$Eweight_{CH_m} > Eweight_{CH_n}$$

Where *Sweight* is the invitee cluster head residual energy.

Step 16: End.

C. Connection management

Mobility is the main source for energy consumption in WSN based IoT nodes. Mobility of nodes will give rise to connection loss. Mobility poses challenge for IoT nodes moving out of the cluster after selection of CH. In order to overcome from this challenge we have proposed a method in which each elected CH_m will periodically broadcasts *Join-Request* message to all its member nodes to check the existing of connection and waits for certain period of time for confirmation message from its member nodes to know their connectivity status. If node *a* failed to respond for more than one time for *Join-Confirm* acknowledgement message then such nodes will be put under blacklist. Node will be taken out from the nodes member list if the missed message sent by the CH_m will crosses more than predefined MAX lost message rate. After losing connection from CH_m, node *a* can join other nearest cluster head say CH_n by sending *REQ-REAFFIL* request message.

In this way connection between member nodes and cluster head is maintained.

VI. Experimental Evaluation

This section provides simulation settings and simulation results and performance analysis of the proposed protocol MAWCA is compared with existing MOFGSA. Different performance metrics compared here are packet loss rate, PDR, network energy and network lifetime for different simulation rounds.

A. Simulation Settings

The simulation of the proposed and MOFGSA method is evaluated using event driven NS-2 simulator. An IoT network is setup in an area of 500 x 500 m^2. Mobile nodes varying from 32 to 100 numbers are deployed randomly throughout the network and random way point model is considered as mobility model. Each node moves randomly in this model and moves within the defined terrain after they hit to the defined boundary. Two-Rays ground reflected model is used as propagation model in our simulation, in which model predicts the path loss during line of sight between transmitter and receiver. Speed of the nodes is varied from 1-25 km/h in order to check the packet loss rate with varying speed. Weighting factors used in the simulation are wt_1 = 0.1, wt_2 = 0.2, wt_3 = 0.1, wt_4 = 0.2, wt_5 = 0.4. Different parameters considered during the simulation is given in TABLE 1. Different performance metrics considered in the simulation are:

Table 1: Simulation Parameters

Parameter	Value
Number of Nodes m	32,50,100 mobile nodes
Sink Node CB	one static sink
Network Size L_i x H_i	500 m x 500 m
Coverage Range C_{range}	30 m
Initial Energy Y_0	0.6
Mobility Model	Random way point
Simulated Rounds	100
Size of the Packets	128 bytes
Mobility Speed	1-25 km/h
Examined Protocol	MAWCA and MOFGSA
Propagation Model	Two-Ray ground model
Weights $(wt_1, wt_2, wt_3, wt_4, wt_5)$	(0.1, 0.2, 0.1, 0.2, 0.4)

1. Network Energy: Network energy plays an important role to prolong the IoT network life time and is considered in regard rounds simulated. Residual energy Y_{res} of all m nodes will determine the total energy of the network.

$$NetworkEnergy = \sum Y_{res} of \quad m \quad nodes$$

2. Packet delivery ratio (PDR): It is defined as ratio of total packets successfully received at destination to the total sent packets from source.

$$PDR = \frac{Totalpacketsreceived}{Totalpacketssent}$$

3. IoT Network Lifetime: Here total amount of rounds carried out will taken into account and it is calculated as time interval between death of first deployed node and the network.

4. Packet Loss: Packet loss is defined as the percentage of sent packets lost during receiving is known as packet loss. Packet loss is calculate for varying mobility speed.

B. Simulation results and performance analysis

In this section, we have examined and compared proposed MAWCA with MOFGSA. Different performance metrics compared here are network energy, PDR, network life time based on alive nodes and packet loss rate for different simulation rounds.

Fig. 2, 3 and 4 shows the network energy analysis against number of rounds. In MOFGSA, energy drains faster due to consideration of higher mobile and low signal level nodes as CH which results in rapid decrease of energy. In the initial stage of the proposed method energy dissipates at faster rate due to broadcasting of message to find neighbors and to elect cluster head. After selecting CH the energy depletion rate gradually decrease until next election of the CH. The results are compared for increasing nodes number and comparison provides better results for proposed method when compared with existing one.

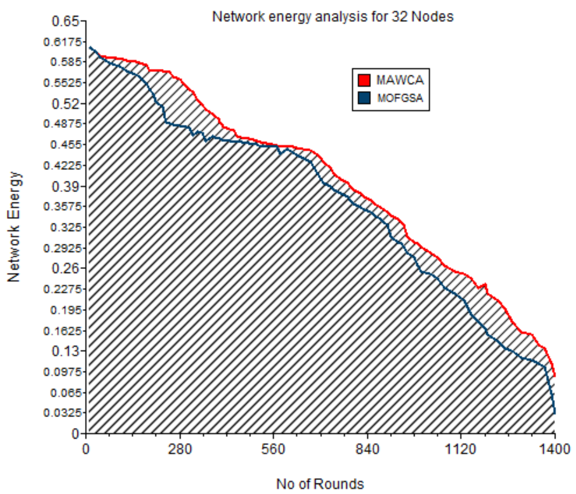

Fig. 2. Comparison of the network energy conservation for 32 nodes.

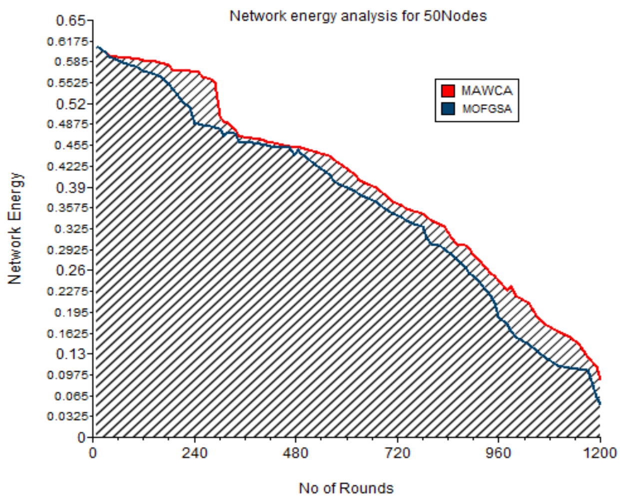

Fig. 3. Comparison of the network energy conservation for 50 nodes.

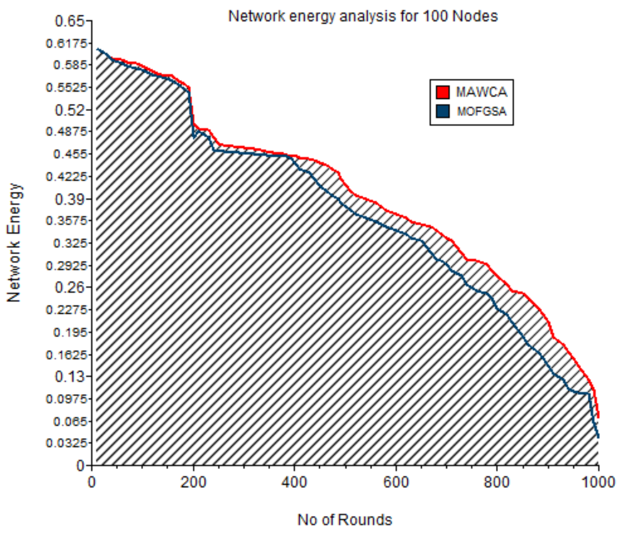

Fig. 4. Comparison of the network energy conservation for 100 nodes.

Fig. 5 provides PDR against number of nodes. If the number of nodes increases then the PDR increases relatively. If there is more number of nodes in the network then there is better change chance of electing CH having better weighting factor. This factor helps in minimizing packet loss rate due to optimal mobility among CHs. Proposed method has better PDR compared to existing method due to consideration of cumulative time and nodes mobility.

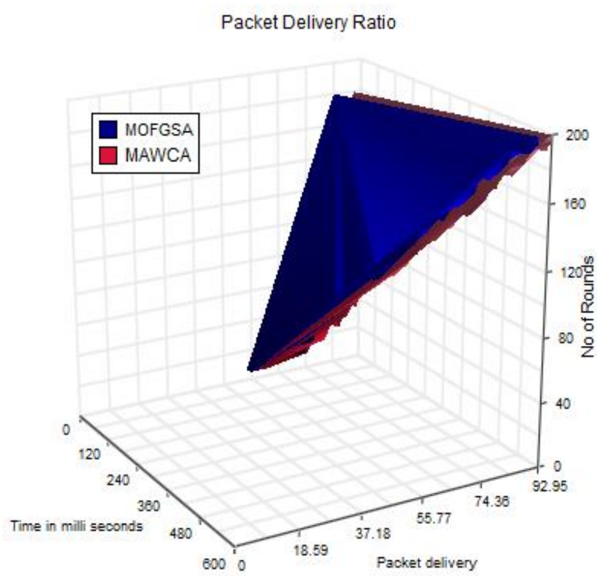

Fig. 5. Comparison of the PDR against number of nodes and time.

Fig. 6, 7 and 8 depicts IoT network lifetime in terms of number of alive nodes for different number of rounds. Death of the nodes happens due to faster rate of individual nodes energy consumption caused to the more number of member nodes in the cluster. Hence in the proposed method threshold has been set for maximum number of IoT member nodes in the cluster. Increase in cluster size increases energy consumption level of CHs. Hence, proposed method increase IoT network lifetime when compared to proposed method at any round due account of threshold factor during clustering and considering optimal node speed for CH.

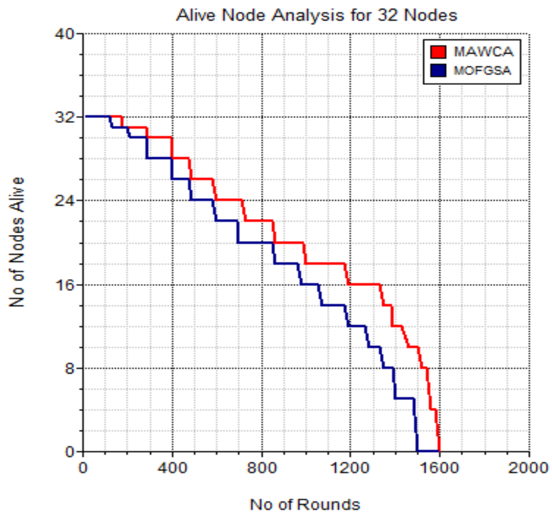

Fig. 6. Comparison of network lifetime v/s alive nodes number.

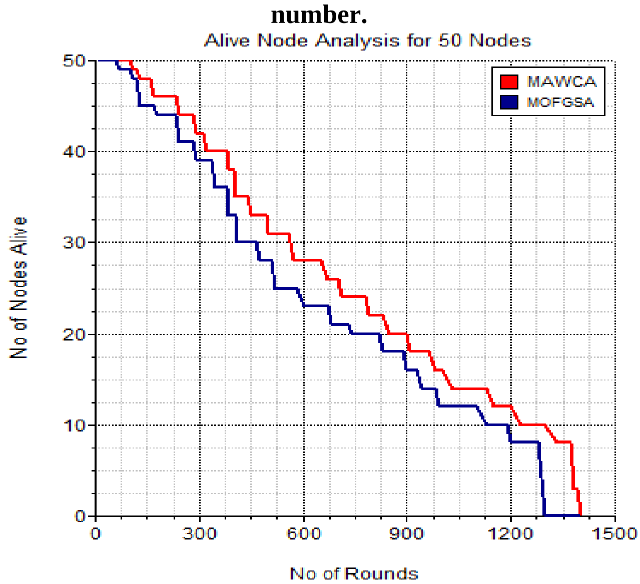

Fig. 7. Comparison of network lifetime v/s alive nodes number.

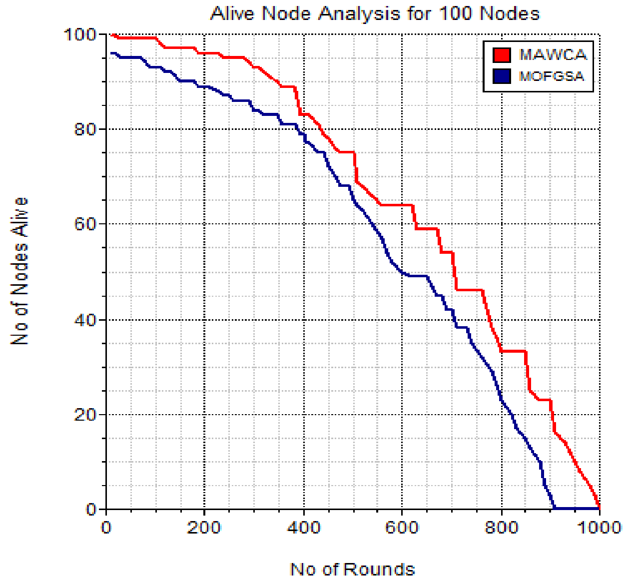

Fig. 8. Comparison of network lifetime v/s alive nodes number.

Fig. 9, 10 and 11 illustrates packet loss percentage for 32, 50 and 100 mobile nodes for varying mobile speeds from 1-25 km/h. Loss of sent packets happens due to the increasing in speed of the nodes. The percentage of packet loss is less until 10 km/h due to the lower mobility among node members and increases rapidly after this speed. Increase in number of nodes will increases percentage of packet loss. Packet loss percentage of MAWCA is minimum in par with existing method due to consideration of better signal quality and optimal mobile node during CH selection helps in minimizing loss rate in every round of the simulation.

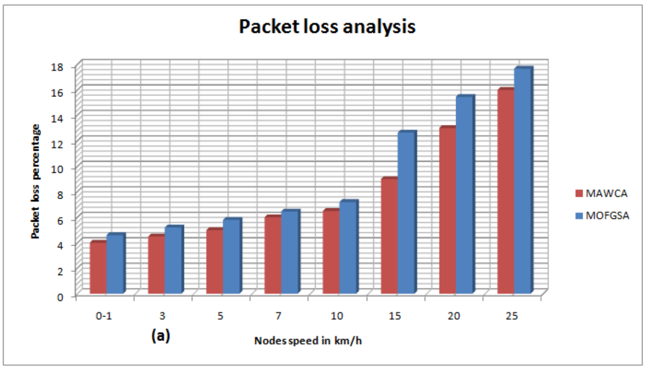

Fig. 9. Comparison of packet loss in terms of varying speed for 32 nodes.

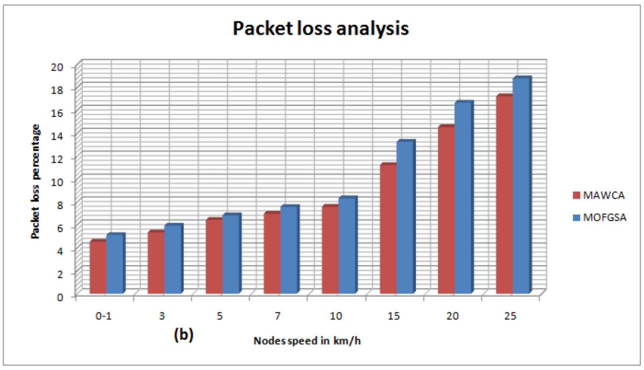

Fig. 10. Comparison of packet loss in terms of varying speed for 50 nodes.

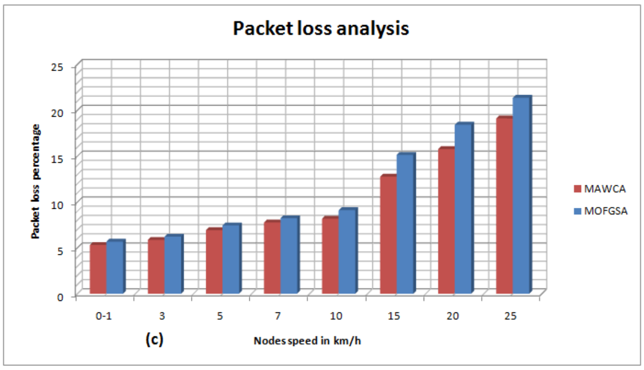

Fig. 11. Comparison of packet loss in terms of varying speed for 100 nodes.

VII. CONCLUSIONS AND FUTURE WORK

Large scale network based on IoT comprises of many events that requires transmitting/ re-transmitting of data packets during the process of communication which drains large amount of energy from battery powered energy aware IoT devices. Most of the solutions provided to enhance network energy of the IoT lack mobility of the nodes which is a major requirement of the IoT applications. Large amount of energy is consumed due to mobility of nodes during clustering and communication. Due to the growth of the communication volume and the IoT application usage, the IoT network lifetime should be maximized in order to fulfill application objectives. In this paper mobility aware weighted clustering algorithm (MAWCA) is proposed with objectives to prolong network lifetime and to deliver data using energy aware routing mechanism in IoT. MAWCA present five main contributions: (1) Considering different mobility level among nodes and signal quality between nodes as threshold while selecting CH; (2) Reliable routing of packets with higher PDR ratio in highly varying network due to mobility of the nodes; (3) Clustering of nodes in dense network without overlapping of clusters; (4) Maximizing percentage of alive nodes in the network, due to reduced energy consumption of the nodes; (5) Improving overall network lifetime by reducing packet loss rate. Proposed method is delineated on weighted clustering algorithm and this method considers different weighting factors such as degree difference of the node, sum of differences between neighbors, cumulative time, nodes mobility and delay in choosing CH. Proposed method is simulated by considering these weighting factors and results outperforms when compared to MOFGSA in terms of network energy, PDR, prolonging lifetime on basis of alive nodes and packet loss percentage for varying mobile speed. Through experimental study and results proved that proposed algorithm conserves nodes energy and prolongs the network lifetime by increasing number of alive nodes. This work can be further improvised by reducing redundant data in order to increase network life time and considering sleep and wakeup concept to conserve nodes energy along with mobility in the sink node.

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