International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-5, June 2019

Multifactor Optimized Clustering with Improved Scheduling for Receiver-Initiated MAC

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Abstract: ***The WSN is a revolutionizing technology that uses the sensor to communicate the info to the base station(BS) from the field of observation. The sensor node is very important for the effectiveness of the WSN system. There were numerous protocols that were developed for achieving effective WSN. It was observed that the utmost issue was the sensor management as any issue in it affects the performance of WSN system completely. The effective management of sensor nodes involves the consideration of different factors like formation of cluster head, data flow and so on. Hence in the present work, the novel Multifactor optimized Clustering with Improved Scheduling (MoC-IS) is proposed to enhance the performance of the sensor node with effective intra node communication. The process of cluster head formation and clustering was carried out effectively through the MoC algorithm with Dual LEACH that considers the factors of battery, threshold and network stability. After the cluster formation, IS algorithm was employed to schedule the flow of data among the nodes. The data flow between the cluster heads was performed through the hop count. The proposed frame work was evaluated for its latency performance concerning the number of packets and nodes. The outcome exhibited the effectiveness of the proposed framework over the existing schemes.***

Index Terms: ***WSN, MoC-IS, intra node, Dual LEACH, hop count, latency.***

I. INTRODUCTION

The WSN is one among the encouraging technologies that provide the possibility of gathering information and can be used for creating global environment appropriate for distant observing, regulating and sensing an environmental or media state [1].The major sensor node components are microcontroller, external memory, sensors, battery, and transceiver [2]. WSNs have provided beneficial effects in numerous applications like surveillance, domestic automation, environmental health, agriculture and traffic monitoring, target tracking, fire and energy management, and industrial failure detection [3].Even though the WSN offer wide spectrum of application, the nodes of sensor are subjected to various resources constraints during its design like restriction incapacity of computing, condensed memory and storage size, weak communication range, low bandwidth, and an inadequate energy level[4].The transceiver radio [5-6] in the sensor node consumes majority of the battery power as it has dual activity for transmission/reception of control/data packets. A scalability between the resource constraints and energy restrictions of the sensor nodes are imperative for the performance of WSN. However, when the network density is high, the traditional direct routing exploits more energy and may considerably reduce the network lifetime [7].This limitation of power in WSN is the prime element for various research work for designing energy-aware protocols. Hence, better utilization of the sensor nodes by implementing appropriate clustering algorithm and proper selection of cluster heads can rapidly minimize energy that can lead to increase in network lifetime [8]. The WSN cluster formation is a Non deterministic Polynomial (NP) stiff optimization problematic that cannot be resourcefully resolved through the traditional approach. Therefore, a more precise solution for the NP optimization of the clustering is feasible by using methods built on recent research on Machine Learning (ML)and Computational Intelligence (CI) [9]. LEACH -Low Energy Adaptive Clustering Hierarchy [10] deliberated as unique among the utmost inspiring and standard hierarchal protocol for routings. The embedment of DUAL-LEACH algorithm espouses analytical research methodology gave enhanced dynamism reduction. Hence, the projected methodology gives source for minimization of the transmission energy in the selected CH [11]. In this research work, an algorithm for intra clustering with scheduling mechanism named Multifactor Optimized Clustering with Improved Scheduling(MoC-IS) protocol is proposed which includes battery, density of nodes and network stability as primary factors. The clustering of the nodes is performed through the MoC algorithm by adopting the DUAL-LEACH approach. Subsequently the scheduling algorithm of IS-MAC is implemented for reducing the packet latency and eliminating the conflict in schedules for each node. The NS-2 simulator was used for the construction and analysis of the proposed framework. The work was detailed with different sub section through the paper as monitors: segment 2 encloses the extensive survey on associated workings along with the problem statement for our work. In section 3, the detailed mechanism of the MoC-IS-MAC is deliberated, subsequently the algorithm for the proposed framework is provided in segment 4. The obtained outcomes from the evaluation of the projected framework and its contrast with the existing approaches are given in section 5. Lastly, the conclusion and the upcoming scope is reflected in section 6.

II. RELATED WORKS

HEED -Hybrid Energy Efficient Distributed Clustering [12] is unique among the furthermost prevalent power conformist protocols which embodies hierarchical communication with the descend through single hop and multi hop.

Manuscript published on 30 June 2019.
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The prime elements utilized for the CH selection are nodes residual power and energy expenditure intricate in intra cluster communication.E-OEERP-Enhanced Optimized Energy-efficient Routing Protocol was considered, which narrowed its focus on the left behind nodes that considered as a cluster member. CH selection parameter was based on the distance among the CHs and the BS which resulted in non-uniform CH distribution. This method aided to improvise the stability of the network compared amongst the LEACH protocol; However, it resulted in an unbalance energy consumption [13].Later, Particle Swarm Optimization–based CH Selection Protocol (PSO-ECHS) was designed, where it used residual energy, distance between intra-cluster and sink of all the CHs as the key parameters of the fitness function. However, this method resulted in scattered CH distribution problem, that created deranged energy consumption in the network model [14].

ACH replacement based on threshold for aWSN (T-LEACH) was proposed to minimize the CH re-selection times by using residual energy[15]. A Stable Election Protocol (SEP) improvised the network lifetime established on 3categories of heterogeneous nodes: normal, super, and innovative nodes. This technique used the similar CH selection system as LEACH protocol, that aided to enhance the lifespan of the sensor network except that the elected CHs had to accomplish equal function equivalent to the normal nodes[16].As such, an adaptive fuzzy-clustering protocol, LEACH-SF,namely was projected. Here, the CH was elected with the assistance of Sugeno fuzzy inference system, which encompassed few parameters such as the node-to-sink distance, the residual energy, and the centroid distance of the cluster[17].Initially, all CH communicate openly with the BS without any techniques for relaying the data. Thus, CHs that are far away from BS deplete their energy faster [18-19].

Energy-efficient multilevel and distance-aware clustering (EEMDC) protocol considered the distance amongst the nodes to elect the CHs. Here, the whole network was partitioned into 3 layers based on heterogeneous node utilization. The immediate hop assortment in the 3 layers was fixed by including the average energy cunning method while electing the CH. This technique eased to enhance the extent of the cluster and nominated the nodes which were near to the BSas CHs[20].

In Distributed Fault Tolerance Clustering and Routing (DFCR) algorithm, TDMA constructed MAC arranging technique was implemented to circumvent packet collision. Cluster formation was conceded out in each Hyper Round (HR) and every HR encompassed with several rounds. The count of the HR rounds was determined by fuzzy interference system based on the distance among the BS and the node, and the remaining energy of the node. In order to prevent data collision, TDMA based MAC arrangement technique was incorporated in the CH. The frequent cluster formation and re-clustering increased the time payload as well as the energy ingesting. Whereas, in stagnant WSN, energy efficiency and load balancing together were concerted by the coverage unnatural node distribution technique. A unique clustering technique adopted unequal cluster members in every cluster. This required energy for communiqué on the beginning of node counts in each cluster. Though, the simulation results exhibited better energy saving characteristics, it could not be adopted for large scale node deployment.

1.1 Problem statement

In some research work, unequal clustering protocols may decrease the cluster radius or wide variety of CMs with heavier relay site visitors close to the sink node. As a result, CHs close to the sink node burden lighter local site visitors and continue to be extra strength to forward the relay visitors. The distances from the sink node or hop counts are used to form clusters. In a non-uniform distributed community, the node density influences intra-cluster strength consumption which need to be considered to restrict the cluster size.

The problem statement for our work is: “To develop a proper clustering scheme with multiple factors and an improved scheduling approach for efficient WSN system”.

III. PROPOSED METHODOLOGY

The proposed novel methodology consists up of two major algorithms: MoC algorithm for clustering through the DUAL-LEACH and Improved Scheduling (IS) technique for the data flow across the clusters. Fig 1: provides the proposed framework for effective WSN network.

a) Node modeling

The node modeling was the initial step in the construction of the proposed framework. The modeling of the nodes involves the creation of the candidate node, the cluster head, along with the active and passive RF transceiver. It was the fundamental step as the nodes generated will be processed with the novel algorithms and was scheduled for data transmission and aggregation.

b) MoC-LEACH mechanism for clustering

The DUAL-LEACH was one of the most common techniques that were implemented for maximizing the capabilities of clustering through the dual stage clustering process. The fuzzy based DUAL used the rules of fuzzy logic to develop the cluster over the dynamic WSN. However, the performance of the DUAL-LEACH greatly depends on the selection of the effective cluster head that provide more energy. Furthermore, the upcoming and present WSN based application requires the mobility that was lacking in it. Hence the proposed framework adopts the DUAL-LEACH for improving the clustering of the nodes with proper cluster head (CH) selection under the factors of density of nodes, network stability and battery. The mechanism encloses the communication model (CM) with clustering outcomes of the nodes along with its data forwarding and capturing.

i) Communication model:

The proposed framework consists up of the CM in which the communication occurs among the CH and the BS. The communication model for the proposed framework was given in fig 2. For providing more efficiency than the existing DUAL-LEACH method, the two novel models were incorporated in the form of data forwarding across the nodes and sink and information capturing time at each node. Fig 3 exhibits the distribution of the active and passive RF transceivers in the present work.

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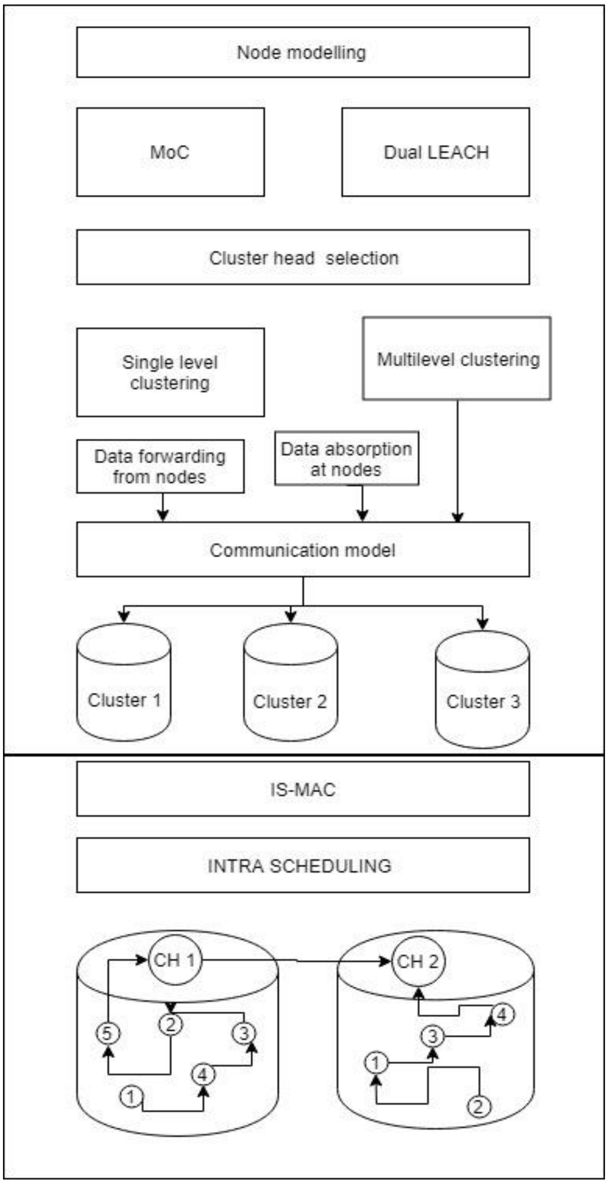

Fig.1 Architecture of proposed framework

- Data forwarding from nodes to nodes: The proposed MoC algorithm performs the practice of forwarding the data from one set of nodes to the others for performing the operation of data aggregation. The nodes that perform this process were termed as secondary data forwarding points.
- Data forwarding from nodes to BS: The primary data forwarding occurs among the nodes and the BS in the projected algorithm. The active RF transceivers gather the combined data from the CH and transmit it to the BS. The nodes that perform this process were called as the primary data forwarding points. The passive RF transceivers provide the support to the dying nodes and provide operational data aggregation in long run.
- Data capturing time: when the data was transmitted from the CH, it was only captured by the few nodes in the cluster; it leads to inconsistent capturing time at each node. This results in the variation of aggregated data size among the nodes in the cluster and there was a possibility of data loss in the network. Thus the stage taken by each node to capture the data from its cluster head is known as the Data capturing time.

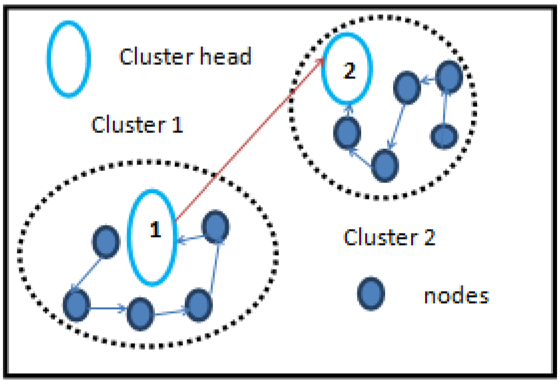

Fig.2 nodes scheduling -communication model

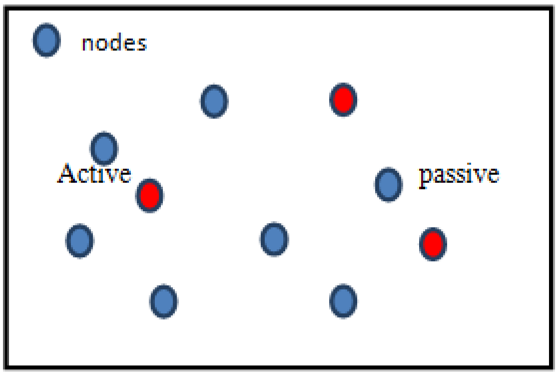

Fig.3 Data capturing point

C) IS for scheduling mechanism

The proposed IS operates in 70:30 ratio of sleep-state and wakeup-state, respectively, changes are only made in the 30% of the wake-state of the sensor node. Each sensor node has 2 states: wake-state and sleep-state. In the wake-state, the sensor node can operate either as a transmitter or a receiver node depending on the protocol scheduling policy.

During the duty operation cycle of the node, the relay node and the source node undergo beacon scheduling and forwarding mechanism to schedule the packet to the destination. The selection of peer is projected based on the highest available data from the peer with the shortest path towards the sink based on the cross-layer routing information. This enables the sender to schedule highly available data forwarded to the sink node to ensure the maximum data held by each node. Each node can act as a sender or a relay/intermediate node, which participates in the active topology network. This mechanism ensures the data transmission on the network to reach the sink based on highly available data payload from the sender or from the peer nod.

Illustration

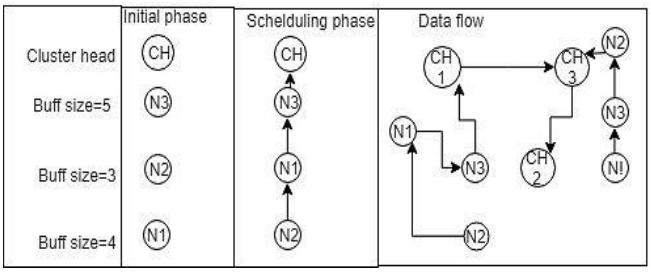

Fig.4 Illustration of the proposed MoC-IS

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Let us ruminate the simple system with three nodes N_1, N_2 and N_3 with each buffer size 4,3, and 5 respectively. The cluster was assumed to be formed after the application of theMoC algorithm over the group of nodes and results in the formation of the cluster heads namely CH1,CH2, and CH3. When the IS algorithm was implemented over the nodes in the nodes in the cluster 1, it schedules the data flow over the nodes based on the buffer size as shown in fig. 4. Similarly, the nodes at eth cluster 2 and 3 are also scheduled for its data flow. Once the cluster head reaches its threshold value it transmits the information from it to the other cluster. So in our model the flow of data from one cluster head to the other was based on the hop distance.

IV. ALGORITHMS

Input: node n, threshold of cluster $\boldsymbol{Th_c}$, energy of node battery $\boldsymbol{E_n}$, network stability at node $\boldsymbol{N_n}$, number of node in cluster j, cluster head CH, stationary point of base station Ss, position of sensor Sp, packets P, data capturing time dct , Objective function Fo, buff size of node nb, wait time Wt, datatime DT, event e, neighbor database NB,

Output: clustering and scheduling of nodes

Begin

Initialize

$Th_c, E_n, N_n \leftarrow (neigh-density, battery, network\ stability)$

If n not equal to CHThen j$\leftarrow 0$

Threshold$\leftarrow Th_{cj}$,Battery$\leftarrow E_{nj}$,Network $\leftarrow N_{nj}$

Check thresholdIncrease j

If $Th_{cj} > Th_c$,thenget E_{nj}

else

check threshold

If $E_{nj} > E_n$, then get N_{nj}

else

check threshold

If $N_{nj} > N_n$, thennj = CH

else

check threshold

end

Begin

Initialize Ss, Sp, P, dct, n

Compute cumulative data capturing time.

$d_{ct} = \int_{z=1}^{nDCT} d_{ct}^{z}\, dz$

Objective function

Fo= argmin$\int_{z=1}^{nDCT} d_{ct}^{z}\, dz$

Objective function condition

Pij = $\begin{cases} P & i = j \\ 0 & otherwise \end{cases}$

end

Begin

Let N, be the total nodes and T, be the total slot time then

$Accumulation\ of\ nodes\ N_i = \sum_{i=1}^{N} N_i$

If Wt<DTi , then

varynodes (n1……ni)

elseif

$e_i \leftarrow dataframe$

If $e_i = control\ frame$

Construct NBi

$NBi = Ti + T/NTi * \Delta T$

Update NBDi with P,H,S

$$NBDi = \sum_{i=1}^{N} NBD_i * T/NT_i * \Delta T$$

elseif

ifDTi expires , then

entersleep_state till next frame

end if

end if

Initialize Buff size for each node in cluster nb

Compare the buff size of each node $n_{bi} \geq n_{bj}$

Schedule nodes with descending order

Begin

Initialize hci, IDNi,DSi<hopcount ,node id, size of data

Compute Tuple any TP = {hci, IDNi,,DSi}

If(ni→hci<nj→hci) &&

(ni→dsi>nj→dsi) then

delay for Tx slot;

Transmit data frame fromni

End if

end.

V. RESULTS AND DISCUSSION

The proposed novel framework for clustering and scheduling of nodes was evaluated for its performance on latency based on the number of packet flow and nodes in the WSN. The observed results were compared with the existing REA-MAC and R-MAC models. From the evaluation of the proposed framework it was evident that the latency tends to increase with the rise in the amount of packet flows in which the steep increase was seen when the number of pockets increases more than 30. Similarly, there was increase in latency/hop as the amount of nodes rises and the increase was perceived to be minimal as shown in fig. 5.From the comparative observation, it was seen that the proposed framework was effective than both the R-MAC and REA-MAC. It was observed from the graph that the latency according to the quantity of pocket flow in the proposed method increases steadily but for other two methods there was inconsistency. Despite the fixed value of latency/hop for R-MAC compared to the increase in proposed framework, the differences between the values deliberate the advantage of the proposed framework over it as shown in fig 6.

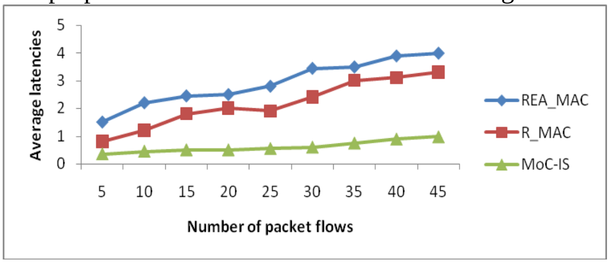

Fig.5 Comparison of Average latencies with number of packet flows

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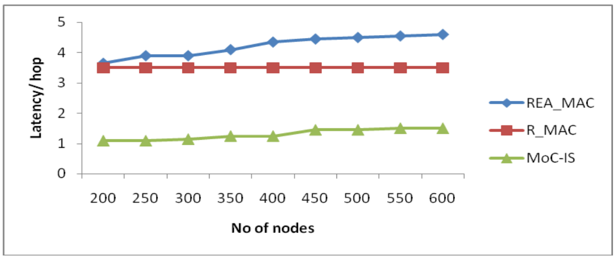

Fig.6 Comparison of latencies/hop with number of nodes

VI. CONCLUSION

The novel framework that provide the enhanced clustering and scheduling of nodes in the WSN was proposed and named as Multifactor optimized Clustering with Improved Scheduling (MoC-IS). The dual-LEACH set up was adopted by our novel MoC algorithm that select the cluster head for the nodes with three parameters viz: density of nodes, battery capacity of nodes and the available network stability at the node. If any of the parameter fails to meet the conditions, the scheme instantaneously picks the another node that satisfies the condition as the cluster head. The MoC terminates with the formation of different clusters with cluster heads that converse with the nodes and BS. Then the improved scheduling scheme was implemented over the nodes in the obtained clusters. After the completion of the network learning phase, the nodes are scheduled based on the buff size. The data was transmitted from the cluster head was achieved through the hop count approach.The proposed framework was evaluated for its performance on latency based on eth number of nodes and packet flow. From comparing the obtained results with the existing REA-MAC and R-MAC, it was evident that the proposed framework performed effectively than the two schemes.

The future scope of the present work is to embrace the inter node clustering and scheduling in an effective manner. Furthermore, other parameters nodes like network scalability can be employed for enhancing the WSN.

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