An Effective Intra and Inter Cluster Formation with Scheduling Technique for a WSN System

P Rachelin Sujae, S Arulselvi

Abstract: ***The system of WSN is developing into a predominant technology in the field of remote sensing with the sensor node components. The sensor nodes are often clustered to the effective transmission of data pockets in the WSN system with the selected cluster head. Hence there were two major transmission models for data packets one was intra cluster communication and other inter cluster communication. The major concern for the WSN system is that there were many design constraints based on memory, energy, computing efficiency and so on. These issues lead to problem in clustering and most importantly the data flow among the intra and inter communication models. For addressing the issue, in the present work, the novel Intra and inter cluster modeling with scheduling (IICM-S) framework is proposed. The framework initially performs the clustering mechanism with the extensive multi-objective clustering algorithm with cluster head selection based on five different node parameters. The cluster obtained from the clustering mechanism is subjected to the scheduling algorithm that schedule the data flow among inter and intra cluster node corresponding to its buff size. The proposed framework was evaluated on the basis of the latency corresponding to the number of nodes. From the evaluated outcome it was exhibited that the proposed framework was efficient than the existing framework on the WSN system.***

Index Terms: ***Inter Cluster, Intra Cluster, IICM-S Framework, Latency, Node Parameters and Buff Size.***

I. INTRODUCTION

The growth of the field of Wireless Sensor Network (WSN) has potential significance for real-time observation of a physical phenomenon. The recent years have seen the increased interest in the potential utilization of WSNs in different fields such as agricultural, military, environment, medical, etc. Wireless sensors monitor the physical processes continuously and transfer data packets to the base station. A WSN has been developed to function high-level of data processing tasks like tracking, classification, and detection [1]. Clustering has been found to enhance the lifetime of network, a primary measure for assessing the performance of a sensor network. Network lifetime is defined as the time until the first or the last node present in the network drains its energy and the time until a node gets detached from the base station [2].

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Clustering is the architecture of choice as it maintains the traffic local; sensor nodes will communicate to the neighbor cluster-head that is found inside a boundary of a fixed radius, independent of size of the network. The problem in the gateway placement in WSNs is the requirement to access remote command centers. This considers in logically segmenting the WSN into a set of disjoint clusters, enclosing all the nodes present in the entire network. In each cluster, a node would serve as a gateway connected to the command center, serving the nodes inside the cluster and performing data fusion [3].Two clustering topologies are discussed in this research study, namely, intra cluster and inter cluster. When the cluster head does not have the capacity to communicate in a long haul, the connectivity of the cluster heads to the base-station has to be provisioned. In that case, topology of inter cluster is preferred. The clustering technique has to make sure of the feasibility of creating an inter-cluster head path from the cluster head till the base-station. Some of the formerly proposed works assume that the cluster head is capable of directly reaching the base-station. In the topology of Intra cluster, clustering algorithms are based on direct communication between a selected cluster head and the corresponding sensor. However, multi-hop sensor-to-cluster head connectivity is needed at times; especially when the communication range of the sensor is bounded to a shorter radius and the cluster head count is restricted [4].For one data set after clustering we get the number of clusters of which the objects in one cluster are similar to each other which is called as intra cluster similarity. If objects in one cluster are likely similar with the objects in the other cluster is termed as the inter-cluster similarity. If intra-cluster similarity of one cluster is lesser then we re-cluster it again to increase the intra-cluster similarity. For good clustering analysis there should be more intra-cluster similarity and less inter-cluster similarity. Hence the study combines both inter and intra clustering for establishing good clustering similarity metrics. The main contribution of this research work is energy minimization through enhanced inter and intra cluster scheduling.The organization of the remaining sections of the research paper are, Section 2 includes the literature review, Section 3 provides the methodology proposed, Section 4 presents the results and discussion, and Section 5 provides a conclusion of the work and a scope for proceeding it further.

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II. LITERATURE REVIEW

This section discusses the formerly proposed works that are related to Inter and intra clustering methods. Nikhare, N. B., & Prasad, P. S. (2018) proposed K- SV Means clustering algorithm for Validity measure of cluster on the basis of intra-cluster and inter-cluster distance. They provide a simple measure of validity on the basis of the intra-cluster and inter-cluster distance measures that permit the count of clusters to be automatically determined [5]. However, for large datasets, this approach is computationally very expensive. A notable drawback of the k-means algorithm is that the cluster count, K, must be given as an input parameter. Wu, S., & Chow, T. W. (2004) proposed a new two-level Self Organizing Map (SOM)-based clustering algorithm using a clustering validity index based on inter-cluster and intra-cluster density through some preprocessing techniques for 4ltering out noises and outliers [6]. However, the method failed to estimate the number of non-trivial simulated clusters. Ali, A., & Khan, F. A. (2013) recommended a cluster-based hybrid security framework that supports both intra-WBAN and inter-WBAN communications. Energy-efficiency was ensured using multiple clusters [7]. This method was stated to be highly suitable for WBAN applications but it does not seem to provide promising solutions for cloud-assisted data privacy and integrity. Chen, Z. et al. (2016) considered a downlink beam forming (BF) for hybrid non-orthogonal multiple access (NOMA) systems, for the purpose of combating intra and inter cluster interferences [8]. The proposed beam forming algorithm was formulated by combining Projection Hybrid NOMA (PH-NOMA) and Projection Based Pairing Algorithm and Inversion Based Pairing Algorithm (PBPA/IBPA). The computational complexity resulted high for this method. Halkidi, M., &Vazirgiannis, M. (2002) introduced a new validity index, composite density between and within clusters (CDbw) [9]. CDbw determines the prototypes for clusters instead of indicating the clusters by their centroids, and computes the measure of validity on the basis of densities of inter- and intra-cluster, and segmentation of clusters. The densities are computed as the count of data packets within a standard deviation from the prototypes. However, it failed to indicate true inter- and intra-cluster densities when the density distribution of the clusters showed inhomogeneity. Amer, R. et al. (2018) developed a novel architecture for Device to Device (D2D) caching by the use of inter-cluster cooperation [10]. A cellular network in which consumers popular cache files was studied and was shared with the rest of the consumers either in their proximity through D2D communication or through remote users by employing cellular transmission. However, the problem is NP-hard and obtaining the optimal solution is computationally hard. Maulik, U., &Bandyopadhyay, S. (2002) evaluated the performance of three clustering methodologies namely, single linkage, hard K-Means, and a simulated annealing (SA) based algorithm, in combination with four cluster measures of validity, namely Dunn's index, Davies-Bouldin index, index T, and Calinski-Harabasz index [11]. Among these indices, Bouldin index and the generalized Dunn Index were most commonly used indices in researches. These two indices depend on a separation metric between clusters and a metric for compactness of clusters on distance basis. Although both the indices function satisfactorily for well-segmented clusters, they may fail for complex data structures with clusters of varied sizes or shapes or with overlapping clusters. Sert, S. A. et al. (2015) recommended a new clustering approach for WSNs, in which a multi objective fuzzy clustering algorithm (MOFCA) was introduced to address the hotspot and energy hole problems in stationary and evolving networks [12]. Three fuzzy input variables given to MOFCA are node density, residual energy, and distance from the sink. This scheme is dispersed, and thus, utilizes decisions made locally to find the node competition radius and choose tentative and final cluster heads. Bezdek, J.C. & Pal, N.R. (1998) discussed two clustering algorithms, c-means and single linkage. And three indices of cluster validity were also discussed namely, the modified Hubert Statistic, Davies–Bouldin, and Dunn's index. Inter-cluster distance measures are found to be larger using these techniques [13]. Inter-cluster measures of distances are the measurements of the distance between any two clusters. A larger inter-cluster value of distance infers a pair of more segmented clusters. Biradar, R. V. et al. (2011) developed a cluster based routing protocol Multihop-LEACH that follows intra and inter cluster multi-hoping. The protocol is evaluated using TinyOs and TOSSIM simulator [14]. However, energy consumption for this method needs to be reduced by improvising the clustering technique. Gharaei, N. et al. (2018) proposed a mobile sink (MS)-based inter- and intra-cluster routing algorithms, which is a routing strategy specially designed for the problem of energy hole and coverage hole [15]. The algorithm controls the sojourn position and stay time of mobile sink, effectively solving the problems of energy hole and coverage hole.

III. RESEARCH METHODOLOGY

The novel IICM-S involves the implementation of two algorithms namely: EMoC algorithm for generating the clusters and the cluster heads by Dual –LEACH and S-MAC was employed for the clustering heads to provide the inter cluster communication and over the nodes for achieving the intra cluster communication. The novel IICM-S framework was given in fig. 1.

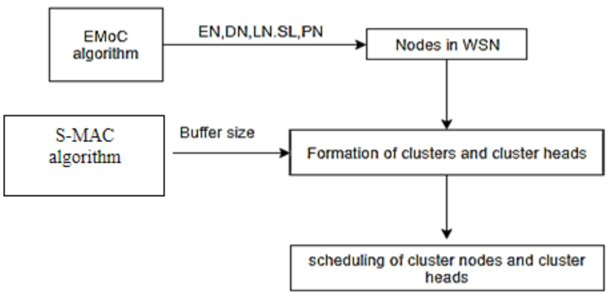

Fig.1 Framework for IICM-S

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a. Formation of Nodes

The initial set in the proposed framework was the formation of nodes in the WSN system. This phase involves the generation of general nodes that represent the sensor in the system along with the RF transceiver that were of active and passive in nature. The nodes that were generated contain the some parameters that are predominant in the effectiveness of the proposed framework that involves the energy, network stability and position etc. The generated nodes are clustered and the cluster head was determined along with the scheduled data flow for both the infra and intra communication in the subsequent phases of the proposed framework.

b. EMoC mechanism

The extended multi-objective clustering algorithm is implemented with the DUAL-LEACH approach that comprises the set of fuzzy rule and the clustering of the nodes is performed over the two stage process. The initial stage is the single objective level clustering and the second stage involves the multi objective level clustering. The other major objective of the algorithm is to select the effective cluster heads based on the multiple parameters as node energy EN, node density DN, node load LN, position of node PN and stability of link SL. The mechanism finally encloses the data forwarding and capturing model that provides the inter and intra communication model for the proposed framework. Fig 2 shows the mechanism of the EMoC algorithm over the generated nodes.

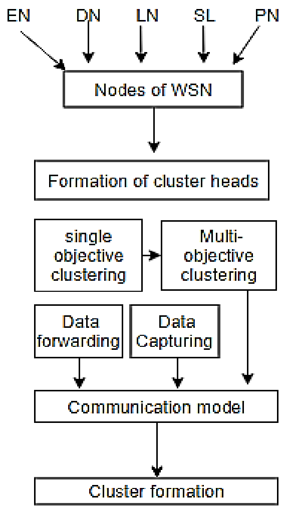

Fig.2 EMoC mechanism

i. Communication model

The communication model of eth proposed mechanism comprises of two major components one was the data forwarding from the nodes and the second was the time taken for the data capturing at each node. The communication model for proposed framework is shown in fig 3.

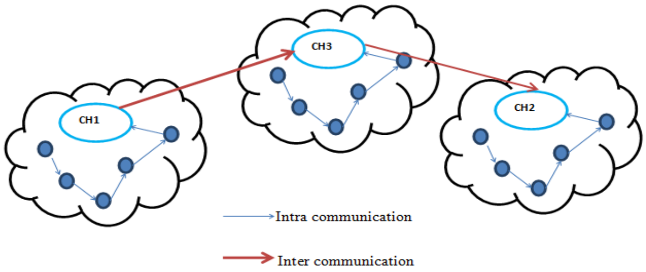

Fig.3 Communication model for proposed framework

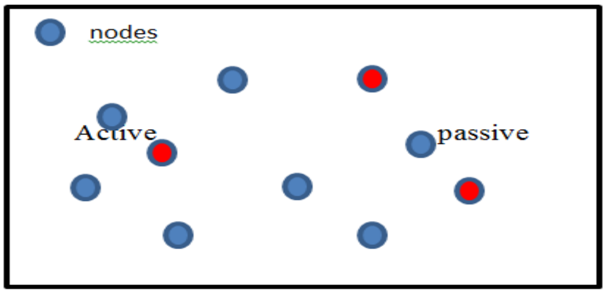

Fig 4: Active and passive RF transceivers

Data forwarding and capturing time: The data forwarding was one of the important aspects of the communication model in which the data packets are transmitted from one node to the other node and also to the cluster head and base station. The nodes that perform the intra communication was known as the secondary forwarding points and the nodes that perform the inter communication are the primary forwarding points. The active RF transceivers generally gather all CH data and transmit forward it to base station. The role of the passive RF transceivers was to provide transmission of data packet from dying node and to maintain the system without failure condition. During the transmission of data, all the nodes under the clusters do not capture the data instantaneously. Some nodes acquire the data packets while others remain inactive; these results in the variation in capturing time at each node. This may lead to the loss of data in the WSN system. Hence the proposed clustering model comprises this component as vital factor for cluster formation.

c. S-MAC scheduling mechanism for cluster head and nodes

In the proposed model the S-MAC scheduling scheme was implemented at the nodes and cluster heads in the WSN system. The S-MAC generally operates at the two states i.e., wake state and the sleep state. Each node can act as the transmitter or receiver node during its wake state based on the scheduling protocol policy. The scheduling mechanism was performed based on eth buff size of the cluster heads and the cluster nodes. The algorithm initially acquires the information of buff size of cluster heads and nodes. Based on the obtained values, initially the nodes and cluster heads are shuffled in the descending order and the data flow was obtained in the scheduled manner.in this method, the effectiveness of the nodes are ensured as maximum amount of data are held at each node.

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The entire system of nodes and cluster head maintain the sleep and wake up state at a ratio of 70:30.

Illustration: Let us consider the system of four clusters with cluster heads CH1, CH2, CH3 and CH4. Each cluster consists of four nodes N1 to N4 and the buff size for each node and the cluster heads were given in table 1. After the implementation of the S-MAC the nodes scheduling was done initially for each clusters and then the cluster heads were schedules as shown in table 2.

Table 1: Nodes and cluster head with buff size

N1	N2	N3	N4	CH 1
3	6	4	5	20
N1	N2	N3	N4	CH 2
2	4	3	5	15
N1	N2	N3	N4	CH 3
5	3	6	2	18
N1	N2	N3	N4	CH 4
6	4	5	3	21

Table 2: scheduled nodes and cluster heads with S-MAC

Node scheduling					
N1	N3	N2	N4	CH 4	
6	5	4	5	21	
N2	N4	N3	N1	CH 1	Cluster head scheduling
6	5	4	3	20	
N3	N1	N2	N4	CH 3	
6	5	3	2	18	
N4	N2	N3	N1	CH 2	
5	4	3	2	15	

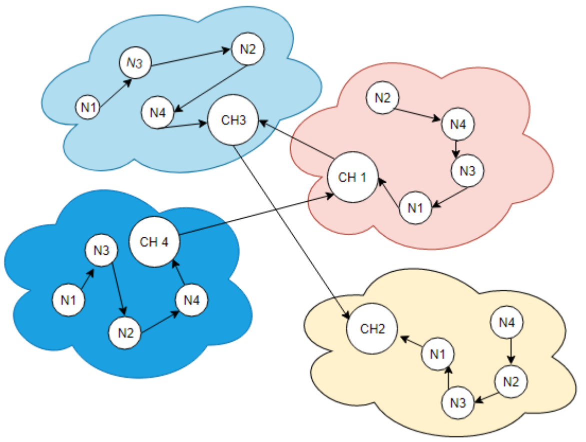

Fig.5 Illustration of IICM-S

IV. ALGORITHM

Input: node N, cluster threshold of DN_c, node energy EN_i, node network stability SL_i, node in cluster i, cluster head CH, stationary point of base station S_b, position of sensor S_s, packets P, data capturing time d_t, Objective function OF, node buff size of BN, data-time TD, wait time TW, event e, neighbor database DBN,

Output: clustering and scheduling of nodes

Begin

Initialize

$EN_i, DN_c, SL_i, LN_i, PN_i \leftarrow (battery, density, stability, load, position)$

If i not equal to CH Then N $\leftarrow 0$

Threshold $\leftarrow DN_{cn}$ *,Battery* $\leftarrow EN_{in}$ *,Network* $\leftarrow SL_{in}$*,load* $\leftarrow LN_{in}$*,position* $\leftarrow PN_{in}$

threshold

Increase n

If $DN_{cn} > DN_c$*,thenget* EN_{in}

else

go to threshold

If $EN_{in} > EN_i$*, then get* SL_{in}

else

go to threshold

If $SL_{in} > SL_i$*, then get* LN_{in}

else

go to threshold

If $LN_{in} > LN_i$*, then get* PN_{in}

else

go to threshold

If $PN_{in} \neq PN_{ed}$*; then in = CH*

else

check threshold

end

Begin

Initialize Sb, Ss, P, dt, N

Compute cumulative data capturing time.

$$d_t = \int_{z=1}^{N_{Dt}} d_t^z \, dz$$

Objective function

$$OF = \operatorname{argmin} \int_{z=1}^{n_{DT}} d_t^z \, dz$$

Objective function condition

$$Pin = \begin{Bmatrix} P & i = n \\ 0 & otherwise \end{Bmatrix}$$

end

Begin

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

$$Accumulation\ of\ nodes\ N_n = \sum_{n=1}^{N} N_n$$

If TW<TDn , then

varynodes (N1……Ni)

elseif

$e_n \leftarrow dataframe$

If $control\ frame = e_n$

ConstructDBNn

$DBNi = Tn + ST/NTn * \Delta ST$

Update DNBn with P,H,S

$$BDN_n = \sum_{n=1}^{N} BDN_n * ST/NT_n * \Delta ST$$

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elseif
ifTDn 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
Let CHn, be the total cluster heads and ST, be the total slot time then

$$Accumulation\ of\ cluster\ head\ CH_n = \sum_{n=1}^{N} CH_n$$

If TW< TDn , then
Vary clusterhead (CH1……CHi)
elseif
$e_n \leftarrow dataframe$
If $control\ frame = e_n$
Construct DBCHn
$DBCHi = Tn + T/CHTn * \Delta T$
Update DBCHn with P,H,S

$$BDCH_n = \sum_{n=1}^{N} BDCH_n * T/CHT_n * \Delta T$$

elseif
ifTDn expires , then
entersleep_state till next frame
end if
end if
Initialize Buff size for each cluster head in cluster CHb
Compare the buff size of each node $CH_{bi} \geq CH_{bj}$
Schedule nodes with descending order
End
End

V. EXPERIMENTAL RESULTS & DISCUSSION

It The IICM-S framework was proposed for clustering the nodes in the WSN system with cluster head and scheduling was performed at the nodes in each cluster and also for the cluster heads. The proposed frameworks had provided scheduling for data flow at both the intra and inter communication among the clusters. The latency-based performance analysis was carried out over the quantity of nodes and packet flow in the system of WSN. The results obtained were related to the existing R-MAC and REA-MAC models.From the assessment of the IICM-S framework it was obvious that there is an increase in latency and increase was minimal corresponding to the number of packet flows. The same trend was obtained concerning the latency/ hop as it increases with increase in number of nodes and the rise was observed to be minimal as shown in fig. 6.After the comparative study, it was realized that the IICM-S framework was more effective than the existing REA-MAC and R-Mac. From the graph in fig. 6, it was evident that latency conferring to the pocket flow quantity in the recommended method escalates steadily but existing method showed the inconsistency in increase. The value of latency/hop for IICM-S was compared to existing frameworks; it was deliberated that the differences among the values based on the number of nodes shows the benefit of the proposed framework over others as shown in fig 7.

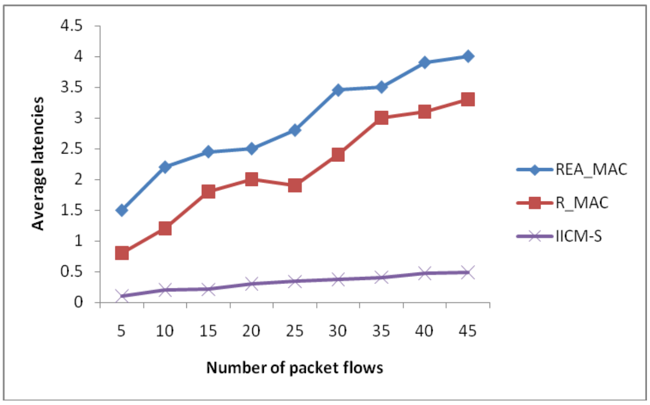

Fig.6 Comparison among the proposed and existing framework on average latencies

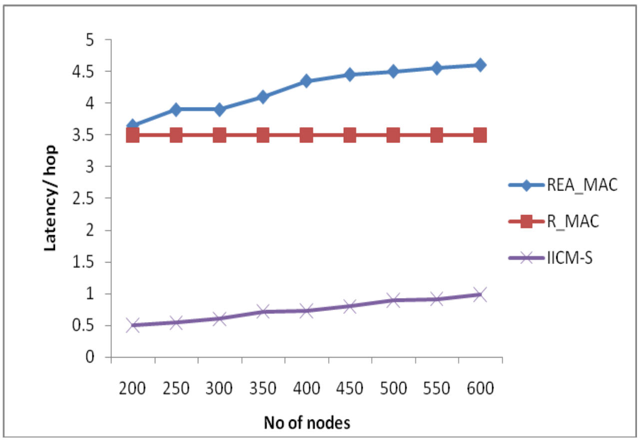

Fig.7 Comparison among the proposed and existing framework on latency/hop

VI. CONCLUSION

The novel framework of IICM-S was proposed for providing effective data flow among the nodes and clusters in the WSN system. The novel method had adopted the DUAL-LEACH set up for providing cluster head selection through the multiple node parameter viz: node density, node battery, network stability, node load, and position of node. The EMoC algorithm executes the process of clustering and cluster head selection. The cluster head was selected only after satisfying all the parameters conditions. Then the generated clusters were processed through the improved scheduling algorithm and it schedules the data flow across the nodes and the cluster heads corresponding to their buff size. It maintains the duration of the nodes under wake or sleep state corresponding to their efficiency in data management.

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The proposed model was illustrated and evaluated based on the latency measures corresponding to the number of nodes. From the comparison over the existing framework, the proposed IICM-S had performed better. The future scope for the present novel framework is to include the complex node parameters with more effective clustering techniques for enhancing the performance of the WSN system.

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