An Efficient Fuzzy C-Means with SAW and WPM Algorithms for the Cluster Head Selection

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Abstract*: *Wireless sensor network (WSN) is a type of ad hoc network self-configured and infrastructure less. This study provides the efficient approach for cluster heads (CHs) selection for achieving synchronous data sink operation. We have proposed FCM based clustering approach along with the simple additive weighting (SAW) and weighted product method (WPM) for the inner CHs selection based on the priority ranking. First the node weights were assigned based on the node operation. These values were considered for clustering. The cluster data provides the total coverage area and it shows the need of the nodes in the complete area. Then for the selection of CHs from the cluster, SAW and WPM methods have been applied. The results from the SAW and WPM provide an efficient way of inner cluster selection. The results comparison considered with the same parameters and the higher packet size. Despite of using the higher size the results from our approach is better than the traditional approaches in terms of packet delivery and energy consumption.

Index Terms*: *Wireless sensor network, FCM, Simple additive weighting, Weighted product method.

I. INTRODUCTION

Wireless sensor networks (WSNs) is the gathering of base stations and sensor nodes [1]. Different previous works suggested that the limited resources and unreliable communication are the main limitations of the WSNs [1−5]. In this regards there is the need of effective methods which is capable in efficient network node management. The next and important factor is the energy preservation [6]. So acquiring synchronization between source and sink is important. The changes in the data routine, variability in each iteration and lifetime are also important concern [7, 8]. In 2018, Rayenizadeh et al. [9] suggested the challenges like energy constraints, energy consumption in WSNs. They have suggested clustering to solve this issue. They have proposed a hesitant fuzzy method. The input parameters are remaining energy, distance to the BS, distance to the center of the cluster. In 2018, MU et al. [10] discussed the issues of low energy adaptive clustering hierarchy (LEACH). They have proposed LEACH partition topology (LEACH-PT) for the better lifetime. In this approach CH is chosen by the base station (BS). This approach is helpful in fixing the clusters in each round so the energy consumption burden can be minimized. In 2018, Darabkh and Zomot [11] proposed a modified centralized energy efficient distance (MODCEED) algorithm for CHs selection. They have suggested that this

approach provides the balancing the energy consumption between all sensor nodes. In 2018, Khandelwal and Jain [12] proposed a hybrid approach based on k-means. Their results show that these are efficient in CHs selection from the obtained clusters. In 2018, Darabkh, Al-Jdayeh [13] proposed an adaptive energy-aware fixed-clustering based data dissemination approach (AEFA) for WSNs. The fundamental focus of this work is to limit and equalization vitality utilization among all nodes. This methodology proposes another path for choosing the underlying group heads to assemble adjusted size and equally disseminated groups. In 2018, Juwaied, Jackowska-Strumitto [14] suggested the important parameter of WSN is the energy consumption by the sensor node. This is the important factor as it affects the lifetime. They have provided the analysis of stable election protocol (SEP) and LEACH. In 2018, Razzaq et al. [15] proposed an efficient k-means clustering-based routing protocol. They have considered the packet size according to the radio parameters and the channel conditions of the transceiver. This approach can limit the vitality utilization of nodes and increment the system lifetime. In 2018, Rubel et al. [16] suggested that the energy efficiency is important parameter in WSNs. They have proposed a clustering scheme that ready to oversee basic or deferral delicate applications with other best exertion applications and meets both delay and energy constraints. The main objective of this paper is to apply fuzzy c-mean (FCM) efficiently for the CHs selection.

II. METHODS

NETBEANS IDE environment is used with the Java code for the environment development. The entire execution and validation have been performed on this platform. Our proposed approach is helpful in CHs selection. It is helpful in the packet delivery rates and energy consumption. Read, write, update, send and receive have been symbolized as R, W, U, S, Re. These are the attributes of the data sink. The values are assigned based on the weight through the Java class for the reference priority. The range considered is {1, 10}. It is assigned automatically and set the value reduction based on the time. Then the pre-processed value is then input for the clustering phase. Fuzzy c-means(FCM) algorithm has been used in this study. It is helpful and efficient in feature analysis and clustering [17]. We have used FCM because it is also efficient in overlapped data. In our approach automatic weight based selection mechanism was applied. Higher strength group is selected first. The complete process was unbiased due to the randomness. Algorithm 1 shows the FCM algorithm used for the clustering. CHs selection within the cluster has been analyzed next.

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For this process simple additive weighting (SAW) and weighted product method (WPM) have been used. SAW and WPM is helpful in the rank optimization. It is helpful in the individual CHs ranking.

The difference in the SAW and WPM are completely arithmetic in the calculation. One shows the additive performance and other uses the multiplication. The options utilized are additionally contrasted and the others. It is thought about by increasing various proportions.

This is relegated to the every model accessible in the node. The equivalent is relevant as what might as well be called the relative weight with the comparing criterion. The value of prioritization can be random or between {0-1}. In our approach it is 0.625, 0.125 and 0.25.

The SAW score was evaluated based on the below formula:

$$S_i = \sum_{j=1}^{n} w_j r_{ij} \quad (1)$$

S_i is the SAW score for the ith selection

W_j is the weight of jth criterion

The WPM score was evaluated based on the below formula:

$$R\left(\frac{A_k}{A_l}\right) = \prod_{j=1}^{n}\left(\frac{a_{kj}}{a_{ij}}\right)^{w_j} \quad (2)$$

Algorithm 1: Fuzzy c-means algorithm

Step 1: First the membership matrix has been created

$$U = \sum_{i=1}^{c} u_{ij} = 1, \forall j = 1,...,n$$

Step 2: Distance calculation according to the following:

$$J(U,c_1,c_2,...,c_c) = \sum_{i=1}^{c} J_i = \sum_{i=1}^{c}\sum_{j=1}^{n} u_{ij}{}^m d_{ij}{}^2$$

The range of u_{ij} is {0,1};

Centroid is denoted by c.

d_{ij} is the Euclidian distance between i^{th} centroid(c_i) and j^{th} data point;

$m \in [1,\infty]$ is a weighting exponent.

Step 3: Cluster membership based on the fuzzy membership has been created:

$$c_i = \frac{\sum_{j=1}^{n} u_{ij}{}^m x_j}{\sum_{j=1}^{n} u_{ij}{}^m}$$

$$u_{ij} = \frac{1}{\sum_{k=1}^{c}\left(\frac{d_{ij}}{d_{kj}}\right)^{2/(m-1)}}$$

Step 4: The process is stopped till the termination criteria satisfaction.

Step 5: Finish.

III. RESULTS AND DISCUSSION

This section discusses the results and the comparative study based on FCM algorithm for the CHs selection. It also includes the results of the SAW and WPM based comparative study. Different number of random combination of nodes has been considered for the experimentation. For the comparison 100-300 nodes are considered. First the nodes weight was assigned based on the operations and it fixes the values automatically according to the time interval. For clustering FCM has been used in this paper. It is beneficial for the group selection. So CHs are selected from the maximum weight sum cluster. In our approach we have also calculated the distance of CHs to BS for each node, sum distance (SD), average distance (AD) and the number of nodes (NON). CHs cluster 1 scaling with node distribution is shown in Figure 1. CHs cluster 2 scaling with node distribution is shown in Figure 2. The total distance to the BS has been represented in Figure 3. CHs average scaling to the BS (Considering all clusters) is shown in Figure 4. In the random node selection, it is deduced that the SD for cluster 1 is 259 and the AD is 19.92. SD for cluster 2 is 359 and AD is 27.61. For the cumulative procedure SD is 618 and AD is 23.76 and the NON is 26. So by our approach the total coverage area can be deduced and it shows the need of the nodes in the complete area. SAW and WPM methods have been applied for the rank arrangement in the procedural approach applied. Procedural ranking through decision matrix for cluster 1 is shown in Figure 5. Procedural ranking through decision matrix for cluster 2 is shown in Figure 6. It indicates clearly that the CHs are selected without any interruption and the energy consumed it in equilibrium with the process. Packet delivery time for the procedural ranking in the CHs of cluster 1 as shown in Figure 7. Packet delivery time for the procedural ranking in the CHs of cluster 2 as shown in Figure 8. It indicates that the time taken from the FCM based approach is minimum with different iterations and rounds. Figure 9 shows the total energy consumption in comparison to the traditional methods.

The results shown here indicate the capability of FCM along with the SAW and WPM methods. The results of SAW and WPM along with the FCM have the low variations which indicate the validated ranking in all the cases. The packet delivery time is also short, so it is energy efficient. For the comparison virtual grid based dynamic routes adjustment (VGDRA) [18] and energy efficient clustering and localization algorithms (EECLA) [18] have been considered. For comparison we have also considered the same parameters but the packet size in our case is higher. Despite of using the higher size the results from our approach is better than the traditional approaches. Our approach which is based on FCM and SAW/WPM provides run-time scaling and outperforms in the above parameters.
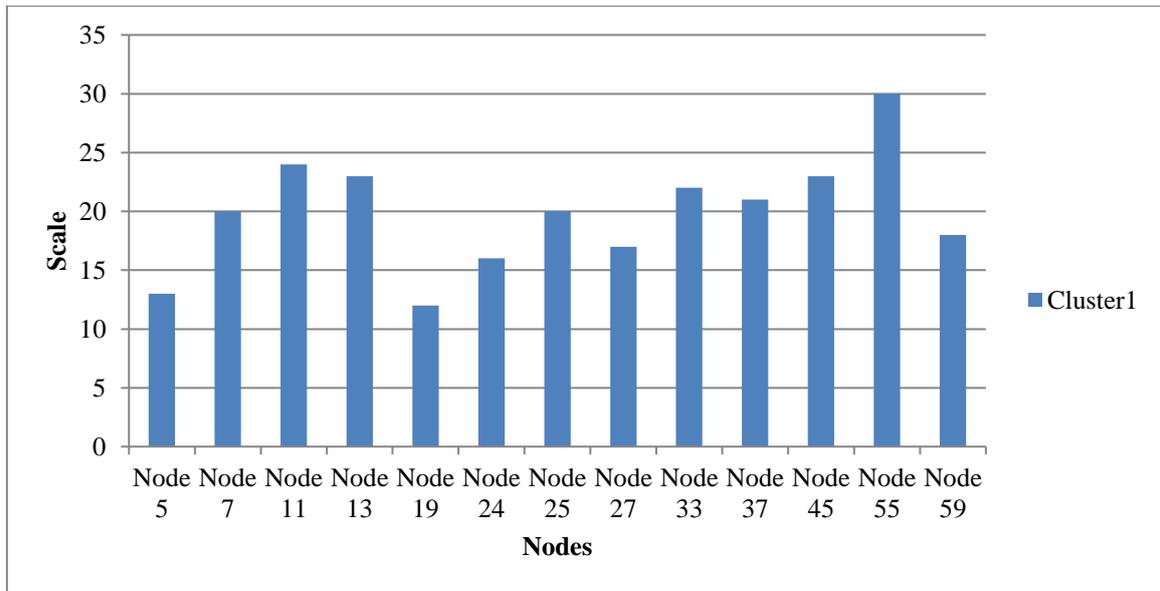
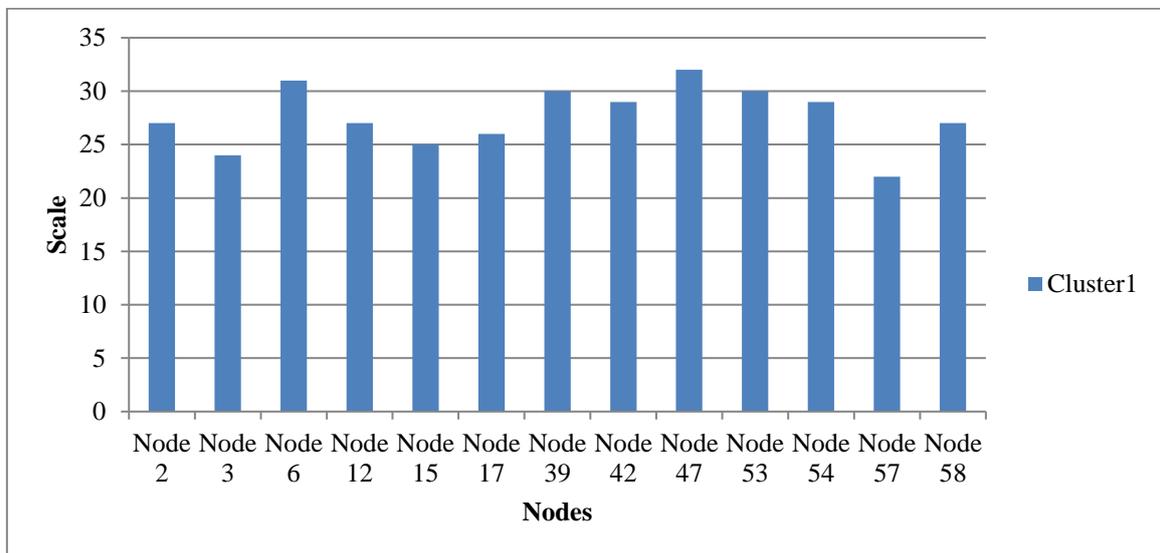**Figure 1: CHs cluster 1 scaling with node distribution**

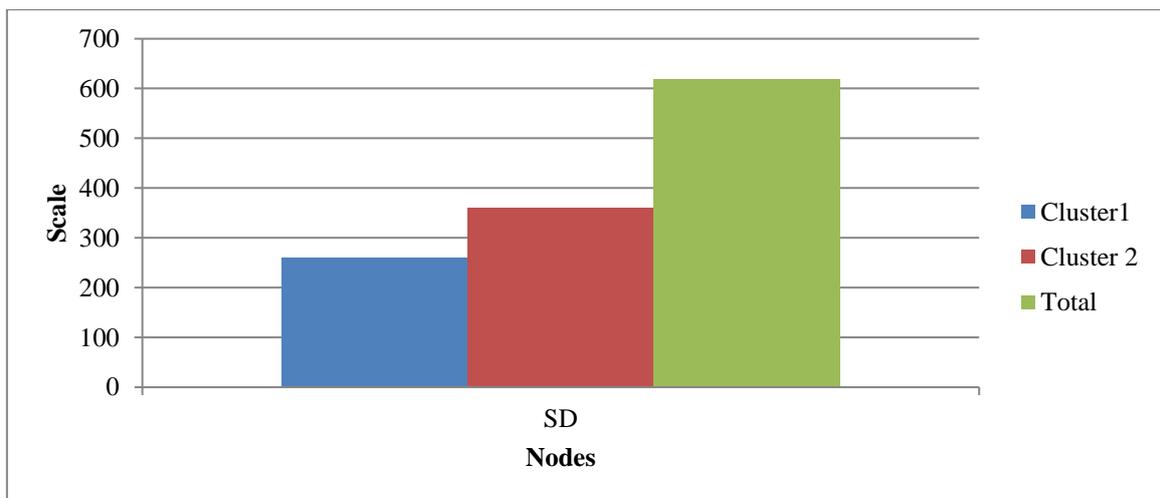**Figure 2: CHs cluster 2 scaling with node distribution**

Figure 3: Total distance to the BS

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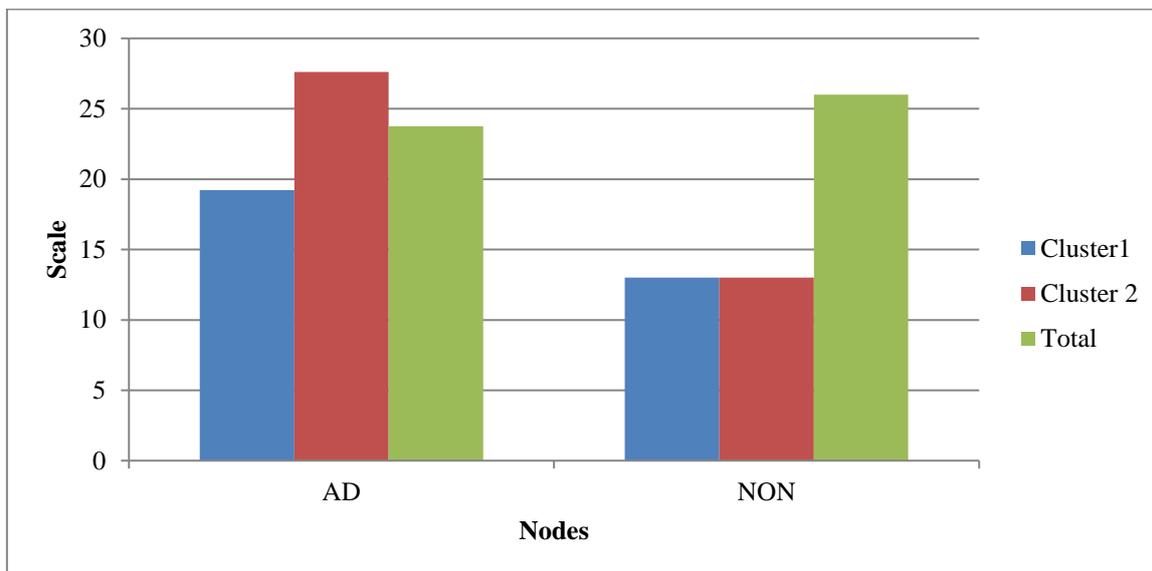

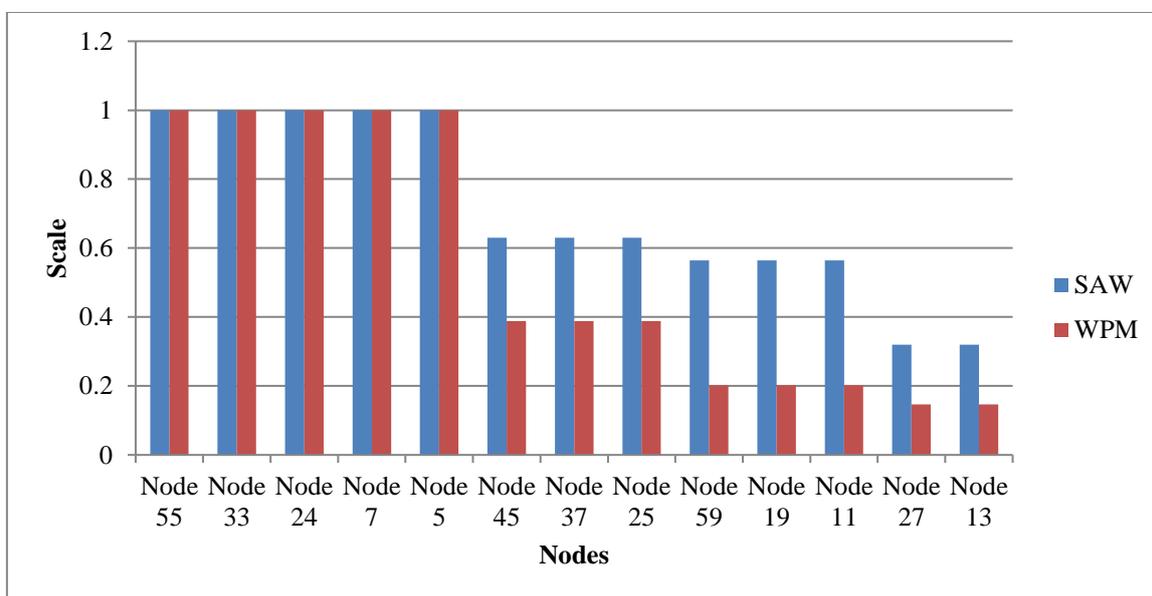**Figure 4: CHs average scaling to the BS (Considering all clusters)**

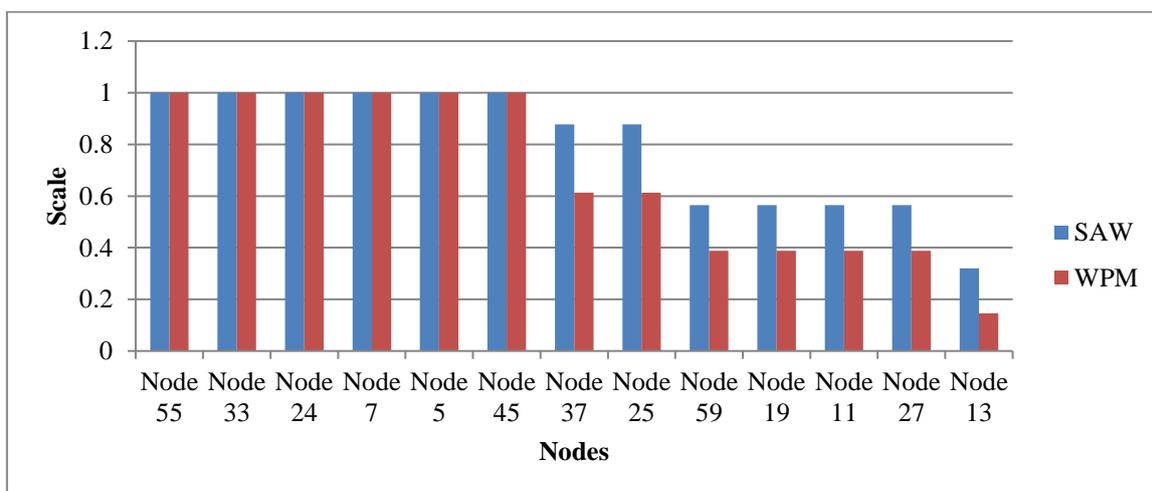**Figure 5: Procedural ranking through decision matrix for cluster 1**

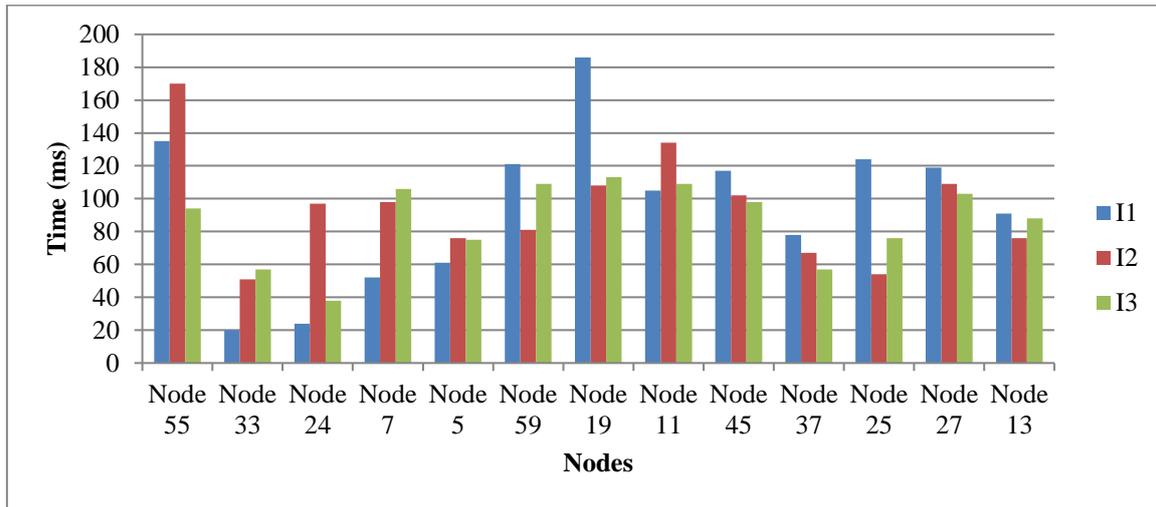**Figure 6: Procedural ranking through decision matrix for cluster 2**

Figure 7: Packet delivery time for the procedural ranking in the CHs of cluster 1
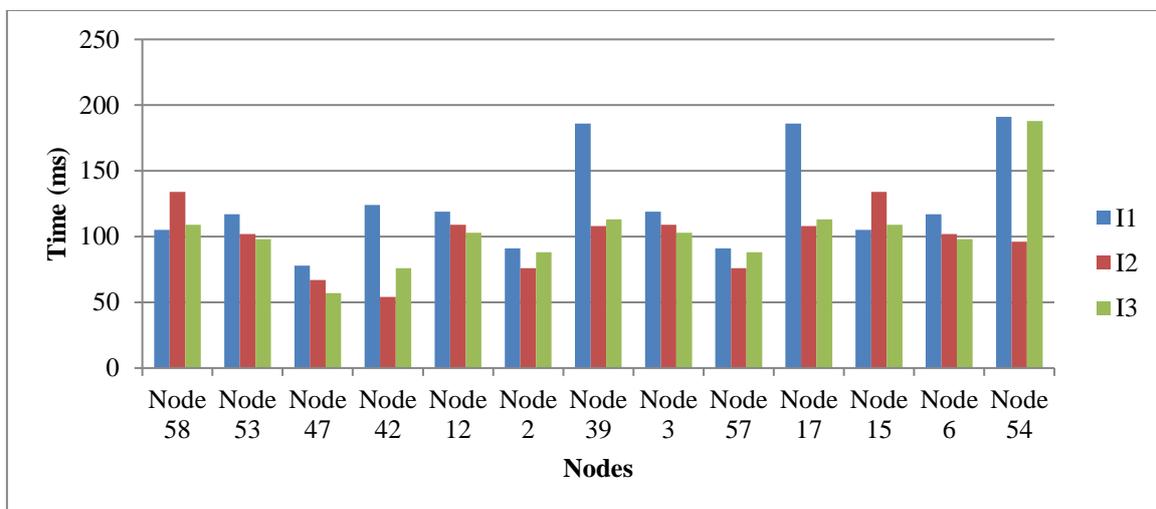

Figure 8: Packet delivery time for the procedural ranking in the CHs of cluster 2
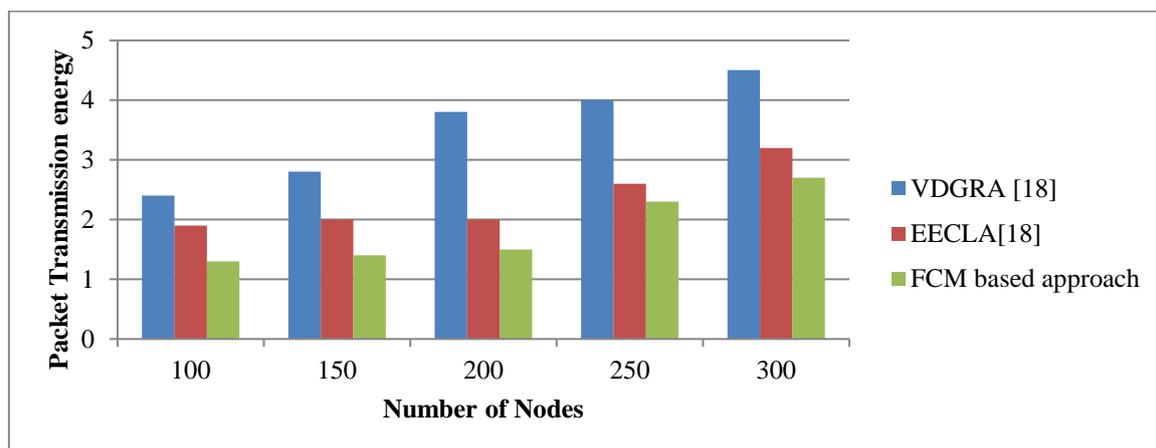

Figure 9: Total energy consumption

IV. CONCLUSION

This study provides the data clustering mechanism along with the SAW and WPM for the decision ranking. Our approach is efficient in cluster selection and CHs selection within the cluster. Clustering is done through FCM algorithm. The ability of grouping the nodes have been considered through the qualities weight and afterward the positioning technique. The experimentation is completely unbiased because of the random selection and participation of the nodes. The same comparison parameters have been used or the comparison and analysis. Our approach which provides run-time scaling and outperforms in the performance parameters.

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