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A Novel Application based Generic Cluster Creation Mechanism in Ad Hoc Networks

S. Thirumurugan
Ramakrishna Mission Vivekananda College, Chennai, India.
s.thiru.gan@gmail.com

Jasmine Beulah Gnanadurai
Dr.D.Y.Patil Institute of MCA, Savithri Bai Phule University, Pune, India.
jas.jebas@gmail.com

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Abstract – The wired mode of communication will no longer serve the purpose of our present scenario network where the expectations in communications system have been skyrocketed. Thus, wireless network with ad hoc nature will suit the present and forthcoming real world applications. This ad hoc wireless network will bind the entire globe and will reign the communication system tomorrow. But, ad hoc network has been limited by the growth factor. In order to address this issue, the clustering mechanism has been incorporated into this ad hoc network to get better results in terms of the network functionality. The ad hoc network efficiency has been improved when the clusters have been devised properly. There are various parameters which identify the efficacy level of clusters in networks. Existing cluster formation algorithms give more weight to any one of the parameters (degree, distance, energy, mobility) when selecting the cluster head of the cluster. This selection of parameters should be corresponding to the application to which the clusters are devised and cluster heads are selected. There is a desperate need for identifying the appropriate cluster head based on the importance given to parameters at various scenarios. Thus, this paper proposes NNPAC (Neural Network based Partitioning Around Cluster head), a generic method of cluster head election to fit for different applications. Implementation of this work has been carried out with the help of MATLAB simulator.

Index Terms – NNPAC, W-PAC, Feed-forward.

1. INTRODUCTION

The contemporary situation has been surrounded by the wire free mode of communication. There are various protocols to ensure secure communication in the network. The existing protocols are separated into two groups such as clustering and non-clustering protocols. The Non-clustering protocols DSR[1][2], TORA [3][4] and DSDV [5] show better performance till the network growth has been limited to a minimum number of nodes. When the number of nodes increases then it will increase the size of the network, thus data traffic increases. Apart from this, the non-cluster network treats all nodes as equal in behavior. This may put pressure on the nodes. In order to get rid of this setback which arises in the non-clustered network, the clustering concept has been incorporated into the network. This concept of clustering handles modular growth and reduces the burden of network nodes by fixing the nodes to play either the role as a member or cluster head. The burden of member nodes is reduced by cluster head and also has higher energy level than the member nodes. The cluster head changes when the energy level reduces below the threshold value. Further, cluster head may have single hop or multi hop neighbors. This research work considers single hop neighbors. Existing clustering algorithms PAC[6], Ex-PAC[7] and W-PAC[8] are static in nature by means they are specific for the scenario or applications. It is highly important to devise an algorithm which takes different scenarios into account. Thus, Artificial Neural Network based clustering algorithm has been proposed.

This research paper is structured as mentioned in the following manner. Section.1 describes the introductory part. Section.2 talks about the literature study. Section.3 briefs on the W-PAC mechanism. Section.4 deals with the performance analysis of existing clustering algorithms. Section.5 gives out the proposed NNPAC procedure. Section.6 comes out with the results of implementation. Section.7 states the future works. Section.8 concludes the research paper.

2. LITERATURE STUDY

The vital role of clustering has been understood when the protocols like AODV [9] have been combined with the clustering approach. The results are improved when this mechanism is added with the existing protocols. The performance of AODV decreases when an existing path has been disconnected and the packets are dropped before establishing new path from source to destination.

AODV algorithm [10] is combined with clustering mechanism to serve real world scenario. This ensures that clustering practice makes the ad hoc network to be appropriate for several real life applications. But, the single-hop approach leads to packet loss.

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PAC approach gives improved results than the existing k-means algorithm due the change of distance parameter. This lacks in implementation and creates many outlier nodes in ad hoc network.

PAC technique functioned fine for less number of nodes. PAC approach could not able to produce better results when the growth of network happens continuously. Thus, Ex-PAC method has been devised to address the network which evolves continuously. This algorithm produces maximum number of clusters and leaves few outlier nodes. The results of Ex-PAC have revealed noteworthy enhancement over the k-k-means algorithm.

Single parametric algorithms PAC and Ex-PAC are lacking in identifying an efficient cluster head of the cluster. The swarm intelligence based multi-parametric clustering algorithm PSO-PAC [11] considers essential parameters such as distance and energy to recognize the cluster head. This parameter selection will make this algorithm fits for certain applications. This algorithm suits only for energy based applications since this has neglected other parameters.

The weight based multiple parameter depended procedure W-PAC has been developed to obtain the suitable cluster head for each cluster. This algorithm has an assumption on the importance level of the parameters. Thus, this approach can be considered as a generic approach.

The mobility analysis explains the situation of nodes communication while they are in movement [12]. Further, the author explains an integrated frame work which contains cluster formation and validation algorithms.

The stability of ad hoc network is shattered by the frequent changes happen in the network. This leads to re-clustering and re-election of cluster head. Thus, an index based cluster formation [13] explains the perfectness of clusters and time to do the re-clustering process to handle the mobility scenario concerning to ad hoc networks. This validation is limited to non-overlapping clusters.

Data forwarding happens after identifying the node as trustworthy based on the threshold value in the protocol CBTRP [14]. The trustworthy cluster head gains the trust to transmit the data. The member nodes can transfer the data with the help of cluster head since the trustworthy nature of the cluster head. This cluster formation approach does not include various parameters for creating the cluster.

Once the clusters are created then they should be maintained [15] till re-clustering situation is desperately induced. When dealing with the overlapping clusters, one of the cluster head nodes can leave its role and as a result of that the clusters can be merged. The re-election of cluster head is recommended when cluster head feels exhausted in energy level. An efficient cluster creation mechanism has not been addressed in this approach. The efficiency of cluster means the time for cluster creation in ad hoc network.

The resources can be efficiently utilized by keeping the nodes under critical section. The clustering algorithm [16] which makes use of token, ensures the proper resource utilization technique by exchanging token and sub token messages between the nodes and the cluster head. This algorithm leaves the implementation and energy efficiency.

The clustering scheme proposed by EWCA [17] combines two stages namely cluster creation and cluster preservation. The cluster head re-election and re-clustering time were not discussed in this study.

The cluster head gives away the role when the energy of the node descents below the threshold. This will request some other node to admit cluster head role for the same cluster. The turning of cluster head, without waiting for the cluster head to get drained of their energy, creates the network highly stable. This may reduce the burden happens in energy [18] consumption of the nodes. Recreation of clusters due to mobility nature of ad hoc network was not dealt in this study.

The author Jing An proposed a clustering mechanism to reduce the energy, prolonging the lifetime of the cluster and also to achieve the stable structure [19]. This approach couldn’t produce optimized results in cluster creation.

The nodes energy determines the withstanding capability of the cluster head role. The energy in data transmission alone is not enough to estimate the node’s weight. The uniform power distribution is achieved based on the power reward [20]. This algorithm gives better results seldom.

The signal strength [21] helps to identify the cluster head. The member nodes are considered for the selection of node to perform the part of cluster head. This approach focuses only one parameter and leaves other parameters with least priority.

The clustered network is constructed based on dominating test. The least self-determining set [22] can be made and the same can be represented in tree structure format. The dominating set procedure which is connected in nature and will be a procedure to devise clusters. The cluster head election is limited with single-hop neighbours.

SWCA [23] has been proposed to detect tampering the degree calculation with the help of malicious node which acts as a cluster head. This also safely does the data transfer towards the endpoint with the aid of an authentication procedure. This produces minimal security and restricted to one hop clustering.

NWCA [24] proposes parameter calculation method with help of an improved weight based algorithm. The degree calculation is altered to mean connectivity degree. This innovative method also decides the cluster head based on energy level of nodes.

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This approach left re-clustering process under cluster maintenance phase.

DWCA [25] creates the clusters with the help of several parameters such as weight of node, mobility property and cluster maintenance. This protocol also deals with inclusion of node to the cluster through typical methodology. This algorithm considers the historical data for the mobility of the node and lacks in dynamically forming the clusters.

The threshold plays import role on reducing the load of cluster head [26]. This also confines the size of the cluster to guarantee the sustenance of cluster head. The determination of threshold has been a challenging phenomenon.

The wireless sensor networks are making use of the advantage of clustering mechanism to produce energy conservation and capable node as cluster head. The load balancing [27] among nodes of cluster greatly enhances the performance of the network.

In wireless sensor network the cluster head is selected based on Neural Network model. In this model, the residual energy [28] is considered for the selection of cluster head.

The author Bouchra Marzak proposed a novel clustering algorithm [29] based on mobility and reliability of vehicles for VANET, from which clusters use an artificial neural network system (ANN) in a distributed manner.

The cluster creation algorithms formulated so far has been based on the proper selection of cluster head. The selection of cluster head is totally depending on the value of the parameter which remains static. A novel dynamic and flexible approach is needed to choose the cluster head in accordance with the scenario where the network will be deputed for the specific application. Thus, NNPAC has been proposed in this study.

3. W-PAC

W-PAC (Weighted Partitioning Around Cluster head) obtains cluster that depends on the node's weight. There are three stages in the clustering method such as cluster creation, cluster head selection and maintenance stage. The cluster creation phase obtains cluster, cluster head selection phase to pick the cluster head and cluster maintenance to address the mobility of the cluster head.

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(1) Initialize M as Set contains Nodes, R= Radious.
(2) Find Degree of Nm Node.
(3) Degree (Nm) = 0.
(5) If (m < > n)
(4) n = 1.
  begin
    MD (Nm, Nn) = $MOD\{(X_2 - X_1) + (Y_2 - Y_1)\}$
    If (MD(Nm , Nn) < R)
      begin
        put (Nm , Cz) // add to cluster
        Deg(Nm) = Deg(Nm) + 1
        n = n + 1
      end
    else
      Add (Nm , NCk) // add to Non cluster
  end
(6) Repeat step 5 until n = M.

Algorithm 1 Cluster Creation

The Algorithm 1 cluster creation considers the formation of clusters using Manhattan distance (MD) as metric to decide the neighbour nodes. Further, the degree of each node is computed when making the node as a member of the cluster (Cz). In this phase, the clusters are formed within the short span of time for the given M set of nodes. The value of radius decides the boundary value of the cluster. The nodes which are moving outside value of radius known as outliers will be parked in non-cluster (Ck) for further analysis.

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(1) Create Clusters using algorithm 1 cluster creation.
(2) Cluster = Cm, Q = Number of nodes in Cm, R=Radious.
(3) n = 1; Nm = (U_t, V_t); Nn = (U_{t-1}, V_{t-1});
(4) If (m < > n)
  begin
    If (MD(Nm,Nn) < R)
      begin
  Calculate the Mobility speed of Node Nm belongs to Cm.

$$Mob(Nm) = \frac{1}{T}\sum_{t=1}^{T} MOD\{(U_t - U_{t-1}) + (V_t - V_{t-1})\}$$

  Calculate the Distance between Nm and Nn.

$$Dist(Nm) = \sum_{t=1}^{T} MOD\{(U_t - U_{t-1}) + (V_t - V_{t-1})\}$$

        n = n + 1
      end
  end
(5) Repeat step 4 until n = Q.
(6) Energy(Nm) = Energy consumption of nodes.
(7) The weight of node Nm computed as follows,
  Weight(Nm) = q1*Degree(Nm)
    + q2*Mob(Nm) + q3*Dist(Nm) + q4*Energy(Nm)
(8) Repeat the step 7 for all nodes belong to Cm.
(9) Find Min { Weight(N1),Weight(N2)…Weight(NM) }.
(10) Repeat step 2 through 9 for m = 1…..no of clusters.

Algorithm 2 Cluster Head Election

The Algorithm 2 cluster head selection phase takes some more parameters such as mobility Mob (Nm) and energy level Energy (Nm) of nodes into account to decide the cluster head

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of the each cluster. The Manhattan distance metric is used to compute mobility of the node. This method takes each node from the cluster (Cm) to compute the weight value Weight (Nm). After computing the weight value of each node, the node with smallest weight value will be selected as the cluster head of the clusters. This process is applied to all clusters in the network.

1. Create Cluster using W-PAC.
2. Elect Cluster Head using W-PAC.
3. CH = Cluster Head
4. If mobility of CH = True
    Call Cluster Head procedure in W-PAC
    Put mobile CH as 'ordinary node' to the
    Cluster where CH moves.
5. Repeat step 4 for all the clusters.

Algorithm 3 Mobility of Cluster head

The Algorithm 3 mobility of cluster head addresses cluster maintenance phase of W-PAC algorithm. The node which comes into the cluster will get affiliated under the cluster head as a member node. Similarly, when the cluster head makes a move, it will become a member of the neighbour cluster and re-election of cluster head happens from where the cluster head moves.

4. PERFORMANCE ANALYSIS OF CLUSTERING ALGORITHMS

Let us consider a scenario that takes three sample sets of nodes (100, 200 and 300 nodes) for implementation using C++ programming language. Table.1 reveals the simulation parameters and values.

Parameter	Values
N (Number of Nodes)	100, 200 and 300
Tr (Transmission range)	50 units
Threshold(Energy)	500 units
Weighing Factors (q1,q2,q3,q4)	.7, .2, .05, .05
Single Parameter	Distance
Multi Parameter	Distance, Degree, Mobility and Energy.

Table 1 Implementation of Single and Multi-Parametric based Cluster Formation algorithms: Simulation Parameters

The single-parametric algorithm uses distance metric to decide the cluster size. The multi-parametric algorithm uses distance metric to decide the cluster boundary and multiple parameters to select the cluster head. This implementation has considered 50 units as transmission range to decide the region coverage of the cluster. The weight coefficients q1, q2, q3 and q4 are assumed for the analysis.

Nodes	Cluster Formation time (sec)				
	Single-Parametric		Multi-Parametric		
	K-means	Ex-PAC	WCA	PSO-PAC	W-PAC
100	0.015	0.005	0.015	0.015	0.015
200	0.031	0.015	0.046	0.031	0.035
300	0.046	0.031	0.062	0.048	0.050

Table 2 Consolidated results of Cluster Creation Time

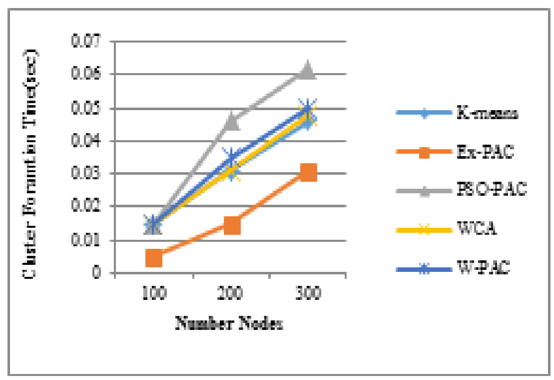

Figure 1 Comparison of Cluster Creation algorithms

These Algorithms (K-means, Ex-PAC, PSO-PAC, WCA, and W-PAC) are implemented using C++ programming language. The node coordinates are assumed in this analysis. Table 2 shows the consolidated results of the three sample sets of nodes (100, 200, 300). This consolidated result shows the cluster formation time obtained using time function in C++. Figure 1 shows graphical representation of comparison cluster creation algorithms.

K-means approach takes 0.015s to form clusters for the sample size of 100 nodes, whereas Ex-PAC takes 0.005s. In the case of 200 nodes as a sample, K-means takes 0.031s whereas the algorithm Ex-PAC takes 0.015s to create the clusters. Similarly, for the sample of 300 nodes, K-means takes 0.046s whereas Ex-PAC takes 0.031s to form the clusters. The cluster construction period of Ex-PAC is reduced due to distance metric and cluster formation logic.

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PSO-PAC takes less time than an existing WCA algorithm. Further, WCA approach takes 0.015s to form clusters for the sample size of 100 nodes, whereas W-PAC takes 0.015s. In the case of 200 nodes as a sample, WCA takes 0.046s whereas W-PAC takes 0.035s to build clusters. Similarly, for the sample of 300 nodes, WCA takes 0.062s whereas W-PAC takes 0.050s to form the clusters.

5. NNPAC

The Neural Network models are in the nature of parallel execution and distributed architecture. The proposed neural network based model takes multiple parameters at the input layer. The winning neuron (a row of the input weight matrix) weights are adjusted with the Kohonen learning rule. The Kohonen rule permits the weights of a neuron to absorb an input vector which is cooperative in recognition of applications. This model makes use of W-PAC for cluster creation and weight values are chosen based on applications.

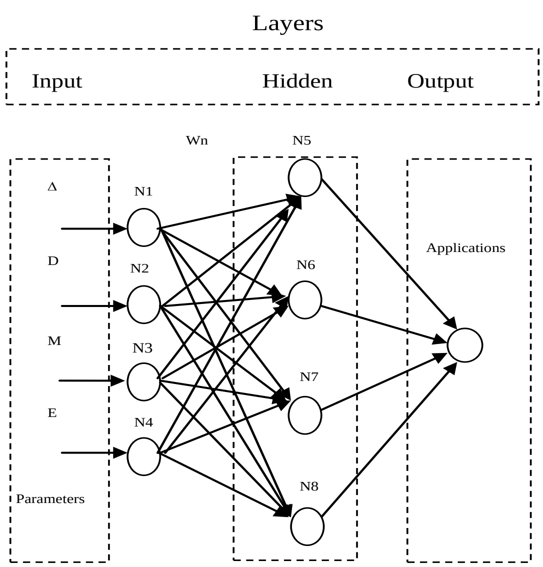

Figure 2 Application Selection based on feed-forward Neural Network

Figure 2 show the neural network model for deciding the type of application possible in accordance with the value of the input parameters at the input layer. The input layer carries 4 parameters namely degree(Δ), distance(D), Mobility(M) and Energy(E). The hidden layer considers maximum 4 neurons. The function of each neuron is to find the computed value which suits the application of the real world. The neuron function (1) is based on the weight assigned to each parameter to suit the application.

$$P_i * w_i + Error \tag{1}$$

The expression (2) tells the output of the neural network based on the input parameters and the respective weight value. This model is adaptive in nature which chooses the weight value in relation to the application.

$$\begin{cases} AP1 = \Delta * W1 + D * W2 + M * W3 + E * W4, & W1 \\ AP2 = \Delta * W1 + D * W2 + M * W3 + E * W4, & W2 \\ AP3 = \Delta * W1 + D * W2 + M * W3 + E * W4, & W3 \\ AP4 = \Delta * W1 + D * W2 + M * W3 + E * W4, & W4 \end{cases} \tag{2}$$

(1) Input weights { w1,w2,w3,w4}.
(2) If (prediction = AP1)
w1=1; w2=w3=w4=0;
$AP1 = \Delta * \mathbf{W1} + D * W2 + M * W3 + E * W4$
(3) If (prediction = AP2)
w2=1; w1=w3=w4=0;
$AP2 = \Delta * W1 + D * \mathbf{W2} + M * W3 + E * W4$
(4) If (prediction = AP3)
w3=1; w1=w2=w4=0;
$AP3 = \Delta * W1 + D * W2 + M * \mathbf{W3} + E * W4$
(5) If (prediction = AP4)
w4=1; w1=w2=w3=0;
$AP4 = \Delta * W1 + D * W2 + M * W3 + E * \mathbf{W4}$
(6) Call W-PAC : Cluster Creation.
(7) Call W-PAC : Cluster Head Election.

Algorithm 4 Prediction

The Algorithm 4 prediction clearly reveals that the applications are based on weight values which are assigned to the various parameters to identify the cluster head.

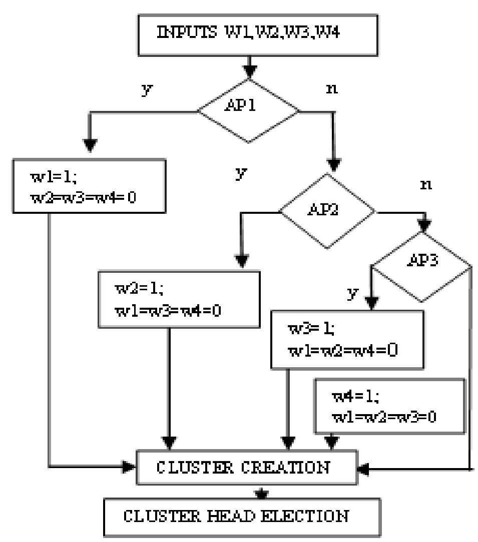

Figure 3 Flow chart of the Predictive Algorithm

The Figure 3 flow chart shows the cluster creation and cluster head selection steps in a pictorial manner. In this chart AP1, AP2, AP3 and AP4 are applications as a result of choosing the high state value for one of the input parameters. The cluster heads are selected for each application based on the neuron function. This shows a highly flexible and adaptive decision model to select the cluster head which suits the specific real life application.

Δ	D	M	E	APPLICATIONS SELECTED
1	0	0	0	CONFERENCE
0	1	0	0	DEFENSE NETWORK
0	0	1	0	VEHICULAR (CAR/AIRCRAFT) COMMUNICATION, AD HOC MEETING
0	0	0	1	FIELD STUDY RELATED

Table 3 Neural Network Results

Table 3 shows the importance of input parameters to suit the real world application. The weight value associated with the Δ must be maximum (value = 1) to suit the created cluster to set up an ad hoc wireless network to organize a conference of delegates. Similarly, the distance parameter plays a key role in defense networks. The mobility should be given high priority in case of vehicular networks. At last, the energy gets high focus in the field study of sensor networks.

6. EXPERIMENTAL RESULTS

The purpose of this study is to implement neural network model proposed in this paper. This implementation takes 4 input parameters such as Δ, D, M and E. These parameters are deciding factors in this model and will be linked with the real world applications. This simulation focuses on keeping one input parameter at a high value to make the output as high decisive. The following Table 4 shows the simulation parameters used in MATLAB Tool.

Parameter	Value
Epoch	1000
Layers	Input, Hidden, Output
Input Layer	4 parameters
Hidden Layer	4 Neurons

Table 4 Simulation Parameters

The results are good for the epoch of value 1000. The hidden layer carries 4 neurons for the effective results. Each neuron in the hidden layer is performing Pi * Wi for each input line comes from input layer.

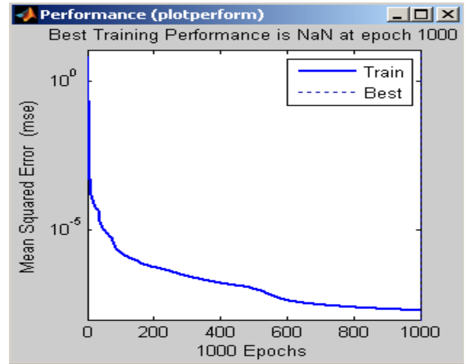

Figure 4 Performance of the Training

In this study, the error value must be reduced as much as possible. In this perception, the training set size 1000 has been chosen to reduce the error to the maximum. The Figure 4 shows that error reduction value while the number of iterations has been in the increasing order. The best case is visible only when the result is completely error free.

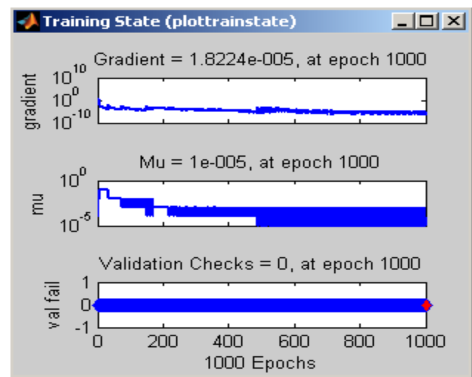

Figure 5 Train State Plot

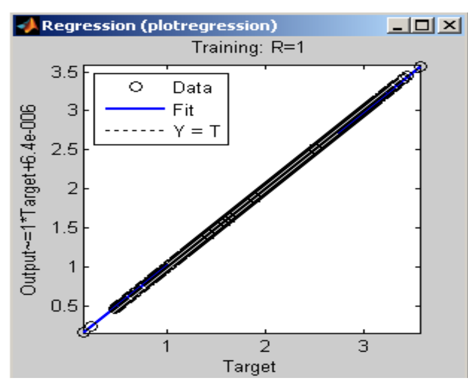

Figure 6 Regression Analysis

Figure 5 shows the state of the training set for the implementation. The regression analysis as shown in Figure 6 obviously shows the high regression value by means the

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expected output gets closer to the target with the least residual error. This confirms that output remains high as long as one the input parameter value remains at the high state. This analysis shows the target and output get almost equal while the numbers of iterations are high. The high output will be noted down with the corresponding input parameters value. In this generic model, the input parameter and the respective weight value have been decided based on the application that we have in our mind. This implementation showed the high output for randomly selecting one input parameter and the respective weight value. This model doesn't give fixed results like any other conventional model. As the input parameter and weight value selection is highly based on the application thus the name generic has been justified. All the existing works literally assume high importance for one of the parameters. But, the proposed model shows as an improvement by keeping out of assumption. The high input parameter value along with the function of the neuron will decide the application for which the cluster head selection happens.

7. CONCLUSION

This study describes the purpose of clustering in ad hoc network. In clustering approach, the existing various clustering methods are discussed. The cluster head selection for the clusters based on parameters is dealt clearly. The need of multi-parameter based clusters is pointed out. The cluster formation and cluster head selection time of various clusters are compared. Further, the advent of Neural Network on multi-parametric (W-PAC) cluster has been discussed with the help of a neural network model and MATLAB Tool. Eventually, a flexible and applications specific generic model has been proposed in this study.

8. FUTURE DIRECTIONS

This work has considered the feed-forward nature of the neural network. It is also needed to consider the bias value for the analysis of the results which suit the specific applications.

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Authors

S.Thirumurugan, received his B.Sc (Elect.), MCA from Bharathidasan University and M.Phil in Computer science from Madurai Kamaraj University and awaiting Ph.D Viva-Voce. He has around 14 years of experience in teaching which includes his association with the research. He has presented 13 papers at the international level. His area of research work is on wireless network and its application towards real world scenario.

Jasmine Beulah Gnanadurai, received her MCA from Bharathidasan University, M.Phil in Computer science from Bharathidasan University and awaiting Ph.D Viva-Voce. She has around 13 years of experience in teaching, 3 years of experience in industry and research experience of more than 5 years in wireless sensor network. She has published and presented many research papers at the international level to her credit.