International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Research Article

Effective Cluster Head Selection Approach based on Topology Robust Clustering Algorithm TRCA for MANET

Zeba Khanam[†*] and Prateek Singh[†]

[†]Computer Science and Information Technology, SHIATS, Allahabad, India

Accepted 10 Aug 2015, Available online 14 Aug 2015, **Vol.5, No.4 (Aug 2015)**

Abstract

Communication in mobile ad hoc networks (MANET) without having any fixed infrastructure has drawn much attention for research. The infrastructure based cellular architecture sets up base stations to support the node mobility. Thus, mapping the concepts of base stations into MANET could meet its challenges like limited battery power, scalability, available bandwidth etc.. This leads to the design of logical clusters, where the cluster heads in every cluster play the role of the base station. The cluster heads also form the virtual back bone for routing the packets in the network. In our proposed research, simulation based survey has been made to study the strengths and weaknesses of existing algorithms that motivated for the design of energy efficient clustering in MANET. As the current head consumes its battery power beyond a threshold, non-volunteer cluster heads are selected locally. The algorithm we will propose shall aims to utilize the battery power in a fairly distributed manner so that the total network life time is enhanced with reduced cluster maintenance overhead. Therefore a new weight based clustering algorithm is developed using the remains energy, signal to noise ratio, mobility and connectivity for better performance in a cluster. The implementation and the comparative performance study are performed in CPN (Colored Petri nets).. The performance studies of the technique are given in terms of, Avg. No. of Cluster Heads, Frequency of node re-affiliations in the network. The obtained results demonstrate the proposed technique improves the reliability of clusters.

Keywords*: MANET, Base station, Cluster head, Non-volunteer cluster head, Cluster maintenance overhead.*

1. Introduction

The technology is growing at a faster rate. A day without the use of wireless technology is very rare. It is gaining immense popularity with the use of the most common portable devices like mobile phones, laptops etc. But the need for connectivity in situations where there is no base station available demanded the transition to a new system called Mobile ad hoc network. Mobile ad hoc network or MANET is a class of wireless network. In which the network devices utilize the wireless connectivity for communication. The mobile ad hoc network support the mobility and ad hoc network configuration. Due to the network's ad hoc nature, the new nodes can join the network and any node can leave the network at any time. The node's limited radio range affects the network scaling and the connectivity. Some of the important characteristics of MANET are:

1.1. Distributed Operation

Every mobile node has individual functionality. They are communicate as per own various configurationally setups. Every node must communicate with each other for information transmission. Each node may act as a relay for implementation of specific functions such as routing and security.

1.2. Multi-hop Routing

When a node tries to send information among other nodes which are out of its connectivity area, then packet must be forwarded via one or more existing intermediate nodes.

1.3. Autonomous

Every mobile node is an individual entity, which acts as host as well as router.

1.4. Dynamic Topology

The network topology may change randomly in MANET. Some of nodes are free to move throughout specified network having different speeds.

1.5. Neighbour Discovery

The neighbouring node is discovered by transmitting and receiving hello packets.

*Corresponding author **Zeba Khanam** is a M.Tech Scholars and **Prateek Singh** is working as Assistant Professor

1.6. Data Routing

Data packets can be routed from one source node to other destination node using a specific path.

1.7. Resource Constraints

Limited bandwidth is available for communication between intermediate mobile nodes.

1.8. Diversity in Nodes as well as Protocols

Various nodes are available like ipods, palm handheld computers, PCs, smart tablets, smart sensors. Nodes can use different protocols such as IrDA, Zigbee, 802.11, GSM ot TCP/IP etc.

1.9. Light-Weight Mobile Nodes

The nodes configuration is mobile with less CPU capability, low power storage and small memory size.

2. Problem Description

Implementing the MANET is a difficult task. The absence of a static infrastructure, a boom in a way, increases the challenges to the research community for designing an ad hoc network with issues like resource allocation and routing strategies for the new topology of the ad hoc network. In order to solve these challenges, a clustering mechanism is used to organize the network topology in a hierarchical manner. Many clustering schemes have been developed to solve these issues in MANET. As we know that MANET is an infrastructure-less system, mobile nodes communicate with each other with the help of radio signals. During the movements of nodes energy is a very important issue and it should be handles carefully. Therefore, our main objective from the existing scenario is to make system energy efficient. To overcome this problem, we need to work over clustering of various nodes available in a MANET. Clustering means grouping of various nodes. Presently, clustering mechanisms are being used for MANET in various areas, such as building automation and home networks, and ubiquitous applications. Clustering strongly influences communication overhead, latency, congestion, inter-cluster and intra-cluster formation. Out of these formed clusters we choose one node. This one selected node is called cluster head (CH) node. These cluster head nodes are responsible to communicate over the network. The non-cluster head nodes selected the cluster head node using cluster head id by sending a confirmation packet to get in a particular cluster's vicinity. Then at a particular round, a node in a particular cluster sends its data to cluster head node. These cluster head nodes afterward forwards these collected information to the base station (BS). Then again cluster head is selection is done for another round. It goes on till nodes are shut down their battery life more than minimum nodes required for the communication in the network. Now we need to modify the existing system for making the system more energy efficient. We have used topology robust clustering algorithm (TRCA) to find the cluster head.

3. Related Work

A clustering technique for MANETs, which is weighted clustering algorithm is given in (S. Chinara *et al*, 2009). The performances of this algorithm are evaluated through simulation and the results are encouraging. A clustering technique is used to adapt the solution of energy consumption. Reviews of most clustering techniques that improves the power conservative in mobile ad hoc network and increase the battery usage in ad hoc wireless network devices and conserve the power energy consumption (Dhurandher *et al*, 2005). A distributed weighted clustering algorithm for MANETs (Chongdeuk Lee *et al*, 2005), this approach is based on combined weight metric that takes into account several system parameters like the node degree, transmission range, energy and mobility of the nodes. There are many clustering schemes available. But there is need to modify them according to the problem. As energy efficiency is one of the main constraints in MANET. Other is the heterogeneity in the network. These two major problems is to solve as much as possible. A practical approach is needed to analyze the existing routing protocols and modify using artificial neural network to get a better network communication and energy efficient. Ratish Agarwal *et al*. have surveyed on several clustering algorithms. After survey completed, it is observed that a cluster-based MANET consists many issues such as the control overhead of cluster, cluster structure stability, the energy consumption of mobile nodes, load distribution in clusters, and the fairness of serving as cluster heads for a mobile node.

4. TRCA Algorithm-for Effective Cluster Head Selection

The proposed topology robust clustering algorithm TRCA is designed for following purpose.

- The nodes in the ad hoc network will be capable of adjusting their transmission range that is they can increase or decrease their transmission range. However, the maximum permissible transmission range a node can posses is denoted as *RX*. The purpose of enabling the nodes to adjust their transmission range is to control the network topology even when the nodes move freely within it. However, during the initial phase of the topology robust clustering algorithm TRCA, the range of all the nodes are kept equal.
- There are several parameters of the nodes in the mobile ad hoc network, the node mobility is regarded to be a major issue. It changes the node connectivity very often. So a frequent topology change occurs in the network. The higher the rate of node movement, the greater is the frequency of

topology changes. Similarly, the battery power of the light weight nodes are another major constraint. The developments of techniques for energy resources are much slower than the network devices counterpart. Both of these parameters decide the stability of the cluster as well as the network. Hence, in the proposed algorithm these two factors are chosen as the weight deciding factors for the nodes.

- A cluster head selection procedure takes place when the network is first activated. The set of selected cluster heads are called the volunteer cluster heads.
- A volunteer cluster head serves its one-hop members till it exhausts its battery power beyond a threshold value. Then the head selects another node within its cluster zone to act as a new head. The newly selected cluster head by the volunteer cluster head is called the non-volunteer cluster head.
- As a node drains its battery power completely, it becomes dead and is removed from the network. As a result, the topology of the network is disturbed. Hence, in order to use the node battery power efficiently, the nodes g*et al*most fair chances of serving as cluster heads, because of that the load on individual nodes could be avoided.

4.1 Node Weight Calculation

The node weights are calculated by considering the node mobility and its available battery power as the key values. Available battery power is the energy associated with the node at the instant of weight calculation. These steps for calculating the weights are described below:

First Step: The total distance covered by a node v during last tn time units is

$$TDv = \sum_{i=t-tn}^{i=t} distance(v)$$

where t is the current time. So, average speed of a node is computed as

Avg.S = TDv/tn

Second Step: Mobility factor is computed as$\Delta Mob = \delta -$ Avg.S. This indicates the difference of the average speed of the node from maximum permissible network speed δ.

Third Step: Available battery power is computes as $Pav = Pav - Pcons$ where, Pav= Available battery power of the node.$Pcons$= Battery power consumed by the node.

Fourth Step: The weight of the node is computed as$WgT(v) = x_1 \Delta Mob + x_2 Pav$ where x_1 and $x_2$are the weight factors that are normalized so that $x_1 + x_2 = 1$.

4.2 Volunteer Cluster Head Selection

After the weight calculation of the nodes, in the initial clustering algorithm is called upon to select the set of volunteer cluster heads. A pseudo-code segment of the algorithm is presented below.

Begin
...
While(*every v* ∈*V*)
{
if*Wv*> *Wi* where *i*∈Γ(*v*)
Then SH= *v*
While(*every x* ∈Γ(*v*))
{
if STATUS(x) = 0 then
SH(x)=H
}
}
...
End

The example of volunteer cluster head setup phase of the proposed algorithm is demonstrated with the help of the figures. In figure 1 every node is identified with a unique ID and its associated weight in parenthesis.

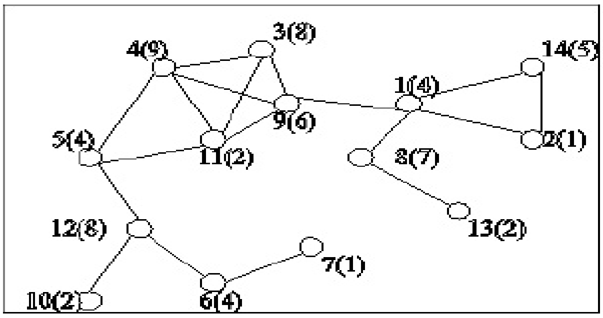

Figure 1 Initial topology of nodes after weight calculation

It is assumed that the weights are already computed for every node. The link between every pair of nodes denotes that they are within the transmission range of each other and establish a bidirectional link among them (i.e. one-hop neighbors).Figure 2 shows the network as the volunteer cluster heads are identified as the solid circles after the exchange of their weights within the local topology.

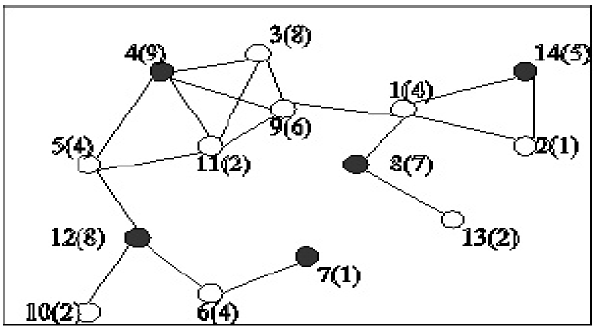

Figure 2 Initial cluster heads are identified as solid circles

A node having the highest weight among its 1-hop neighbors become the head and its immediate uncovered neighbors become its members. Figure3 shows the network after the initial clusters are formed.

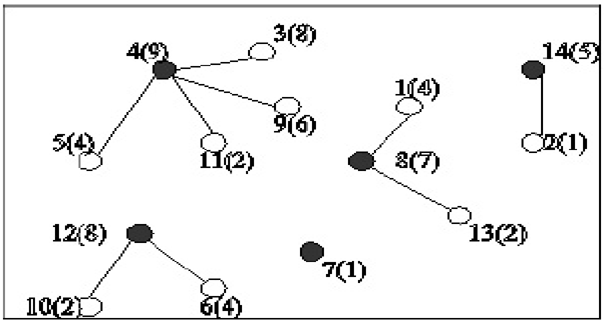

Figure 3 Clusters are formed

4.3 Non-Volunteer Cluster Head Selection

The cluster heads drain their battery power faster than the cluster members for energy consumption model of the ad hoc nodes. Thus in order to have fair distribution of energy drainage among the nodes in the network, local selection for non- volunteer cluster heads takes place. The pseudo-code segment of the algorithm for finding the non-volunteer head may be written as:

Begin
...
Set *i*= currt-head //volunteer or non-volunteer
Set max-wt= maximum (*WgTv*) where *v* ∈ *cluster i*
Set next-head= *vmax−wt*
H (*i*) = next-h
While (every *member* ∈ *cluster i* other than next-head)
{
ifdist (*next − h,member*) ≤ *next − ht range* then
{
H (*member*) = next-h //hand off
else if
Reaffiliate *member* to other head within range
// Reaffiliation
else
Select *member* as volunteer head //Reelection
}
}
...
End

5. Simulation, Result, and Analysis

We deals with the validation of the Topology Robust Clustering Algorithm (TRCA) using CPN tools. Figure 4.1. The simulation of the proposed algorithm is carried out in 100 X 100grid area. The mobility model under consideration is the Random Walk mobility model. This mobility model represents the most erratic and unpredictable movement of a node . Here, a mobile node (entity) moves from its current location by choosing a random speed between (*speedmin*, *speedmax*) and a random direction between (0, 2π) respectively.

The validation through simulation is carried out with six nodes in the network. For the purpose of validation, the nodes are considered to be non-mobile during the execution of the protocol. The top level of the CPN model for the TRCA is shown in figure 4

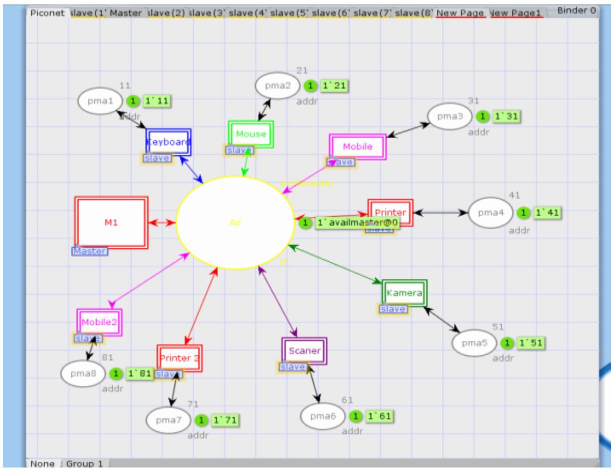

Figure 4: Top level of the model

The swapping transitions *NODE*1 to*NODE*6 have their own subpages linked with it two places are kept universal for all the nodes in the model. The message store place *MSGSTORE* and the acknowledgement store place *ACKSTORE*. The *MSGSTORE* contains the messages transmitted by all the nodes linked to it. Like wise, all the acknowledgements transmitted by the nodes are stored in the place *MSGSTORE*.

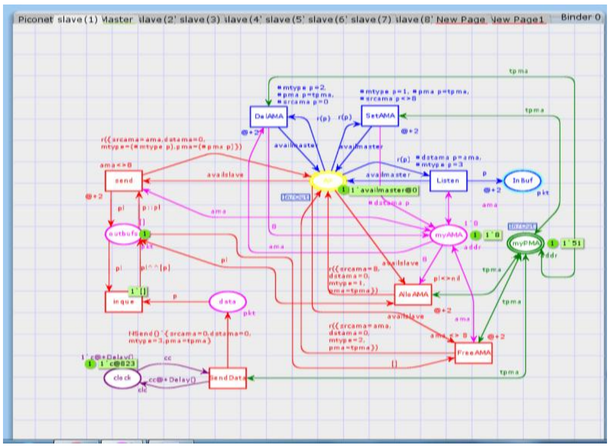

Figure 5: represents the detail model of the ad hoc nodes in their current marking state *M*0.

5.1. Comparison with different pre exiting algorithms.

5.1.2. Highest Connectivity Algorithm (HC)

Parekh proposed Highest Connectivity Algorithm. With the help of this algorithm we aim to reduce the number of clusters in the network. In each cluster there exists a cluster head that belongs to the dominating set. If *Xi* represents the set of adjacent nodes of a particular node *i*, then the degree of connectivity of *i*is represented as *Di = |Xi|*, where *|Xi|* is the cardinality of *i*.

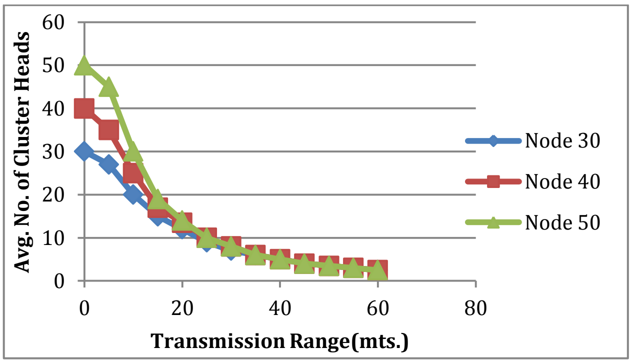

Figure 6: Avg. No. of Cluster Heads for HC

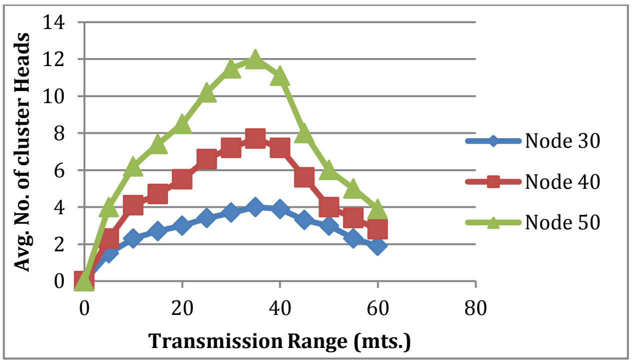

Figure 7: Frequency of Cluster Head Re-elections for HC

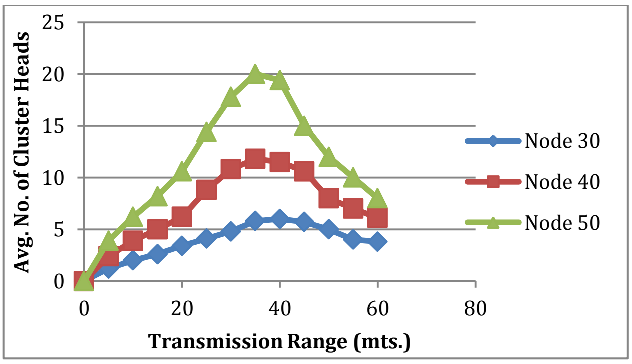

Figure 8: Frequency of node re-affiliations for HC.

5.1.2 Mobility Metric Based Algorithm (MOBIC)

A mobility metric based version of lowest ID algorithm MOBIC was proposed by Basu *et al.* in . The algorithm uses mobility based metric as cluster formation basic and calculation of weights of the nodes in the network. Thus the relative mobility metric which is denoted as:

$$M_Y^{rel}(X) = 10\log_{10}\frac{R_x P_r^{new} X \to Y}{R_x P_r^{old} X \to Y}$$

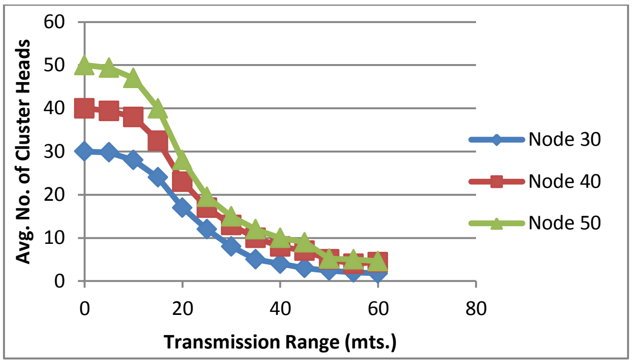

Figure a: Avg. No. of Cluster Heads for MOBIC

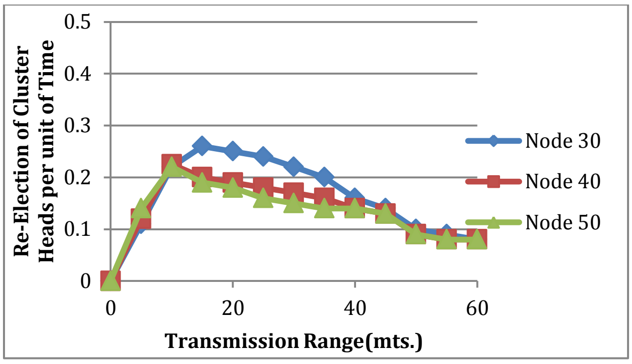

Figure b: Frequency of Cluster Head Re-elections for MOBIC

5.2. Simulation Results and Discussion of Proposed Algorithm

The simulation parameters can be summarized as:

The battery power consumption by the mobile nodes for different operating modes are considered as per the IEEE 802.11 LUCENT WAVELAN cards as Figure d shows the comparison of results of proposed algorithm with that of LID and MOBIC algorithms for the frequency of node re-affiliations.

Area	100 X 100 m
Mobility Model	Random Walk
Packet Size	1024 bytes
Max. Nodes	70
Trans. Range	5-40
$Speed_{min}$	0 m/sec
$Speed_{max}$	5 m/sec
δ	5
n	5

$$Broadcast_{send} = 1.9\mu W.s/byte * size_{packet} + 250\mu W.s$$

$$Broadcast_{recv} = 0.5\mu W.s/byte * size_{packet} + 56\mu W.s$$

$$idle = 808mW.$$

The results show that, the frequency of re-affiliation of node for proposed algorithm is lower than that of the other algorithms. As MOBIC depends on the mean connectivity of the nodes for weight calculation, the change in the transmission range changes the connectivity of the nodes and so as the weights. This may lead to the frequent cluster head changes as well frequent re-affiliations to the heads. But proposed algorithm does not depend on the degree of node connectivity for selecting its cluster heads. So the re-affiliation overhead is lesser in comparison to the other algorithms. Here, it is seen that the frequency of re-election of cluster heads for proposed algorithm is much lesser than that of LID, but it remains almost similar to that of MOBIC Figure e shows the results for the average number of cluster heads for the three algorithms.

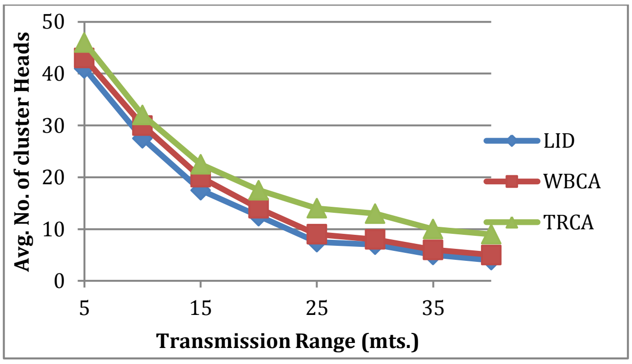

Figure e: Avg. No. of Cluster Heads

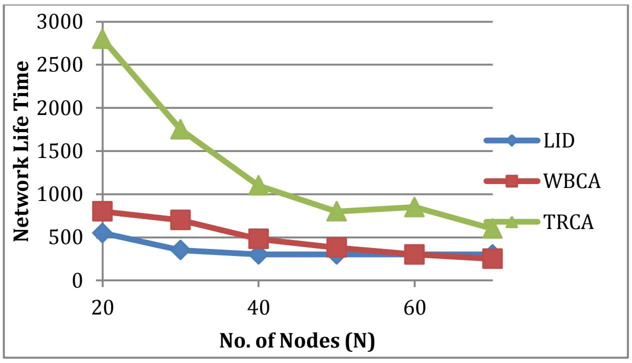

Figure f: Network Life Time (in ms)

5.3. Summary

CPN model of TRCA provides new insights and thoughts into the design of the system. The study of the existing work on MANET using CPN tools has provided the motivation to propose the required protocol for the current work and verify its operation using the CPN tools to ensure its correctness before implementation. The purpose of designing TRCA is to enable every node to identify its one hop neighbour node. The protocol creates a neighbour table for every node in the network and keeps track of the neighbours. The validation of TRCA starts from the initial marking of the model *M*0 to its final marking where every node is updated with its one-hop neighbours in the NTAB. Every state of the simulation is marked with a marking *Mx* indicating the flow of control through the different CPN components. The result of the simulation ensures that a node in the network is able to detect its one hop neighbours and establishes a bidirectional link with them by the exchange of neighbour request and acknowledgement messages. However, it can be observed that the neighbours of a node are detected for a instance when the node is static. As the nodes move in the network, the connectivity among them changes requiring the NTAB to get updated. Thus, TRCA can be called upon periodically or on-demand basis whenever the NTAB has to be updated. The objective of topology control is to enable most of the nodes to remain connected in the network while consuming optimum energy. In this a transmission range adjustment protocol is proposed to allow the isolated cluster heads to increase their transmission ranges, so that they could affiliate to the existing cluster heads. This reduces the number of hops in the virtual backbone reducing the delay in communication. Further, the increase in transmission range of some nodes enables the other nodes to remain connected even on the move resulting in reduced frequency of re-affiliation and cluster head re-election. Thus, it can be concluded that, the proposed protocol reduces the maintenance overhead as well as the delay in communication meeting the requirements of an efficient cluster design.

References

S. Chinara and S. K. Rath (2009), A survey on one- hop clustering algorithms in mobile ad hoc networks, *Journal of Network and Systems Management*, vol. 17, no. 1-2, pp. 183–207.

K. Hussain, A. H. Abdullah, K. M. Awan, F. Ahsan, and A.Hussain (2013), Cluster head election schemes for WSN and MANET: a survey, *World Applied Sciences Journal*, vol. 23, no. 5, pp. 611–620.

Dhurandher, S.K.; Singh (January 2005), G.V. Weighted-based adaptive clustering algorithm in mobile ad hoc networks. In Proceedings of ICPWC'2005, New Delhi, India; pp. 96-100.

Chongdeuk Lee and Taegwon Jeong (2011), FRCA: A Fuzzy Relevance-Based Cluster Head Selection Algorithm for Wireless Mobile Ad-Hoc Sensor Networks International Journal sensors, ISSN: 1424-8220.

Krishan Kumar, V.P.Singh (Jan 2011), Neural Network Model Based Cluster Head Selection for Power Control in Mobile Ad-hoc Networks, International Journal on Computer Science and Engineering (IJCSE),Vol. 3 No.1, pp. 28-33

Shengxiang Yang, Hui Cheng, and Fang Wang (Jan 2010), Member, Genetic Algorithms With Immigrants and Memory Schemes for Dynamic Shortest Path Routing Problems in Mobile Ad Hoc Networks, IEEE transactions on systems, man, and cybernetics—part c: applications and reviews, vol. 40, no. 1, pp. 52-63.

A. Abbasi and M. F. Younis. (2007), A Survey on Clustering Algorithms for Wireless Sensor Networks, *Computer Communications*, Vol. 30, No. 14-15, 2007, pp. 2826– 2841. doi:10.1016/j.comcom.2007.05.024

R. Agarwal and M. Motwani (2009), Survey of Clustering Algorithms for MANET, *International Journal on Computer Science and Engineering* ,Vol. 1, No. 2.

N. Gupta, M. Shrivastava, A. Singh (2012), Cluster Based on Demand Routing Protocol for Mobile Ad Hoc Network, *IJERT*, Vol. 1, No. 3.

H. Wu, Z. Zhong and L. Hanzo (2010) A Cluster-head Selection and Update Algorithm for Ad Hoc, *In IEEE Globe-com.*

J. J.Yin Leu, M.H. Tsai, T. C. Chiang and Y. M. Huang (2006)Adaptive Power-Aware Clustering and Multicasting Protocol for Mobile Ad Hoc Networks,.