Design and Implementation of Topology Adaptive Distributed Clustering Protocol for MANET

Sahil, Naresh Kumar

Abstract: ***In this research work, 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. Neighbour Recognising Protocol (NRP) has been designed to help the nodes to probe their immediate neighbours. Topology adaptive distributed clustering protocol (TADCP) has been proposed, that uses the node mobility and its available battery power for calculating the node weights. A node having the highest weight among its immediate neighbours declares itself as the volunteer cluster head. As the current head consumes its battery power beyond a threshold, non-volunteer cluster heads are selected. The algorithm aims to utilise the battery power in a fairly distributed manner so that the total network life time is enhanced. Validation for the base protocol NRP and algorithm TADCP are made through simulation by using the MATLAB. Each of the proposed work is evaluated separately to analyze their performances and compared with the competent results.***

Keywords: (TADCP), MANET. Neighbour Recognising Protocol (NRP), Each

I. INTRODUCTION

A mobile ad hoc network (MANET) is a collection of mobile nodes that dynamically self organize into peer-to-peer wireless network without using any pre-existing infrastructure. The nodes of the MANET organize themselves to route the packets of the neighbour nodes by creating a multi-hop networking scenario while on-the-fly. Thus, the specially designed nodes should have the capability of a router to forward the packets in addition to its normal job of a transmitter or receiver. The term self-organize is also equally important when the topology control is taken into consideration. In this context, the nodes try to adjust their transmission ranges to remain connected to each other in the dynamic network.

II. CLUSTERING IN MOBILE AD HOC NETWORKS

Clustering in MANET can be defined as the virtual partitioning of the dynamic nodes into various groups. Groups of the nodes are made with respect to their nearness to other nodes. Clusters in MANET can be categorized as overlapping clusters or non-overlapping clusters as shown in figure.1. The small circles represent the wireless nodes in the network. The lines joining the nodes denote the connectivity among them. Cluster control structure forms the virtual backbone of communication where cluster heads are the communication hot spots. After clustering network divides into three types of nodes, these are:

- **Cluster Head:** Resembles base stations in cellular networks, but dynamic. It is responsible for resource allocation and act as router.
- **Gateway:** A node is called a gateway if it lies within the transmission range of two or more clusters. Distributed gateway is a pair of nodes that reside within different clusters, but they are within the transmission range of each other
- **Ordinary nodes:** All the nodes except cluster head and gateway works as ordinary nodes. These nodes become members of a cluster after clustering.

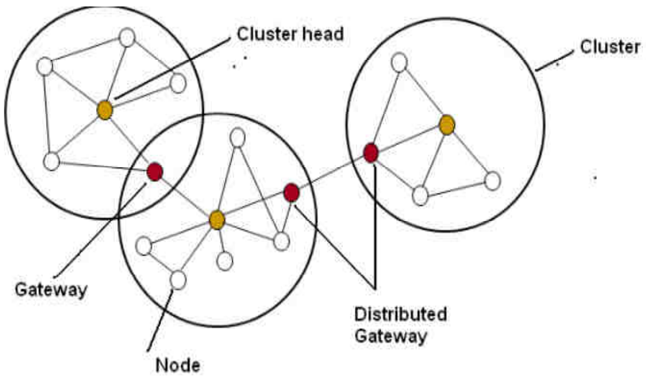

Figure 1: Overlapping and non-overlapping clusters

A. Phases of Clustering

The process of clustering can be visualized as a combination of two phases, i.e., **cluster formation** and **cluster maintenance.**

B. Cluster Formation:

The cluster formation phase deals with the logical partition of the mobile nodes into several groups and selection of a set of suitable nodes to act as heads in every group. In mobile ad hoc network, where the topology changes frequently, selection of optimum number of cluster heads is a NP-hard problem [1]. There exist some representative algorithms that use the parameters like node identity number, mobility, battery power, degree of connectivity etc. as the factors to decide its suitability for cluster head [2]. These selected nodes are responsible for routing as well as node management in the mobile network and collectively called as the dominant set in graph theory terminology [3].

C. Cluster Maintenance:

The objective of cluster maintenance is to preserve the existing clustering structure as much as possible. In one hop clustering, since every node is directly connected to a cluster head, the mobility of either the member node or the cluster head may drive them away from each other.

Revised Version Manuscript Received on July 27, 2017.

Sahil, Research Scholar**,** HCTM Technical Campus, Kaithal (Haryana), India.

Er. Naresh Kumar, Assistant Professor, HCTM Technical Campus, Kaithal (Haryana), India.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.

There exists a bidirectional link between these two nodes till both of them are within their transmission range. When any of them moves away from the other, there occurs a link failure and the member node searches for another new head within its transmission range to get affiliated. This kind of situation is called as re-affiliation to a new head node. The requirement for the reelection of cluster heads arises when the current heads fail to cover all the nodes in the network. Sometimes a node may move away from the transmission range of all the current cluster heads and becomes an orphan node. This demands a reelection of cluster heads. Even at times any of the cluster heads may drain out of energy or may even fail to work due to any fault occurrence and needs a head reelection process. However, such an unavoidable reelection increases the computation cost and the message complexity.

Routing in MANET can take place either in a flat structure or in a hierarchical structure [4]. It has been proved that the packet delivery delay is reduced in a hierarchical structure than that of in the flat structure resulting in a better routing efficiency [5]. In large networks, the flat routing structure produces excessive information flow which can saturate the network.

III. PROPOSED WORK

A. Topology Adaptive Distributed Clustering Protocol:

In this research work, I have proposed a Topology Adaptive Distributed Clustering Protocol (TADCP) which targets to select minimum number of cluster heads so that there is minimum number of nodes in the virtual back bone. The algorithm uses the Neighbour Recognizing Protocol (NRP) to find its one-hop neighbours. .

B. Characteristics of TADCP:

The nodes in the ad hoc network have different transmission range. During the initial phase of the topology adaptive distributed clustering protocol TADCP, the range of all the nodes is different.

- Node mobility in MANET is considered to be a major and challenging parameter as 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. The battery power of the light weight nodes are another major constraint. Both of these parameters, Node Mobility and Battery Power, decide the stability of the cluster and the network. Hence, in my proposed algorithm these two factors are taken as the weight deciding factors for the nodes.
- Procedure of selecting cluster head takes place when the network is first activated. All selected cluster heads are called the volunteer cluster heads.
- A volunteer cluster head serves its one-hop members till it finishes its battery power beyond a threshold value. After that, the head selects another node within its cluster zone having the maximum weight to act as a new head. The newly selected cluster head by the volunteer cluster head is called the non-volunteer cluster head.
- When 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 get fair chances of serving as cluster heads, so that load on individual nodes could be avoided.

C. The Mechanism of the Neighbour Recognising Protocol (NRP) Is As Follows:

Step 1: Node *u* broadcasts the Neighbour Recognising Packet (NRPAK) to the network

Step 2: Let the packet is received by node *v* which is within the transmission range of *u*. Node *v* sends back a Neighbour Acknowledgement (NAC) Packet to *u* along with its own information like ID, transmission range, weight and status enclosed in the packet.

Step 3: After receiving the acknowledgement NAC packet from *v*, node *u* updates its neighbour table (NTAB) by adding *v* as its immediate neighbour along with its information.

Step 4: Finally, *u* sends back a Neighbour Confirmation (NC) message so that *v* updates its own neighbour table and a bidirectional link is established between the two nodes.

D. TADCP-Calculation of The Node Weight

The steps for calculating the weights are described below:

Step 1: Let the total distance covered by a node *v* during last *n* time units is

$$D_v = \sum_{i=t-n}^{i=t} dist_v ,$$

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

$$S_v = D_v / n$$

Step 2: Compute Mobility factor

$$\Delta M = \delta - S_v$$

This indicates the difference of the average speed of the node from maximum permissible network speed δ.

Step 3: Compute available battery power as

$$P_{av} = P_{av} - P_{cons}$$

where, P_{av} = Available battery power of the node.

P_{cons} = Battery power consumed by the node.

Step 4: Compute the weight of the node as

$$WT(v) = x_1 \Delta M + x_2 P_{av}$$

where x_1 and x_2 are the weight factors that are normalised so that $x_1 + x_2 = 1$. The weight factors indicate the major constraints of a network. For a highly mobile network, x_1 may be given a higher value where as for energy constrained network x_2 may be given a higher value.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.

E. TADCP-Selection of Volunteer Cluster Head

After the weight calculation of the nodes, 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.

```
1. Repeat for each node N in V
        a) If(Weight(N) > each Neighbour(N) Then
                Set head= v
                i) Repeat for each Neighbour(N) x
                        if STATUS(x) = 0 then
                                Set HEAD(x)= head
                        [ End of if]
                [End of Repeat for each neighbour]
        [End of If]
[End of repeat Loop]
2. End
```

F. Mechanism of Cluster Formation In TADCP

Following is the mechanism of cluster formation in TADCP:

- Each node broadcast its ID and weight.
- Each node receives the NRPAK Packet(node ID & Node weight) of its neighbours.
- Each node has to decide based on its weight and its neighbour’s weight.
    - If node N has highest weight among its neighbours, it has to receive notifications from its neighbours who want to become the members of its cluster. There may be zero or more members under its cluster.
    - If node N does not have highest weight, it will notify the node H having highest weight to become the cluster head. If node H accepts to become the cluster head, contract done. Otherwise, node N will notify the node having 2nd highest weight. This process continues until head finds or no neighbour willing to become head as all are already member in some other cluster.
- In this protocol, a node can become either cluster member or cluster head not both.

IV. PROPOSED NETWORK LIFETIME MODEL

According to IEEE 802.11, the wireless network interface can operate in either base station mode (BS) or ad hoc mode [2]. In base station mode, every mobile node remains in the transmission range of one or more base station, which are responsible for forwarding traffic between nodes. Nodes which want to transmit can send outgoing traffic to the base station anytime and can receive the incoming traffic from the base station by polling it periodically. The rest of the time the node can enter into a non-operating sleep state. The guaranteed availability of fixed infrastructure like base station for buffering and traffic management supports energy conserving functionality by allowing some nodes to enter into the sleep state.

In contrary, ad hoc mode of operation does not use any base station. So a node communicates directly with one-hop reachable nodes and indirectly with multi-hop unreachable nodes using dynamically computed routes. So nodes remain active all the time to receive and send traffic However, a node can enter into idle mode when it neither transmits nor receive. But it constantly listens to the wireless media and consumes energy which is almost same as the energy consumption in receiving traffic.. In the thesis the energy is assumed to be the battery power of the mobile node.

A simple linear model can be considered for the energy consumption cost of mobile nodes for sending or receiving packets. The authors of [6] have presented a linear model for the per-packet energy cost that consists of an incremental cost m associated with the size of the packet and a fixed cost c that is associated with the channel acquisition to represent broadcast communication as:

$$Energy = m_{send/receive} * size_{packet} + c_{broadcast}$$

V. RESULTS AND DISCUSSIONS

A. Graph on Cluster Head

Graphs on cluster head displays total number of head in the given transmission range. Figure 5.5 displays number of cluster heads of TADCP, LID and WBCA with variation in transmission range .As the transmission range increases average number of cluster head decreases. Figure 5.5(d) compares the head of all the three algorithms i.e. TADCP, LID and WBCA.

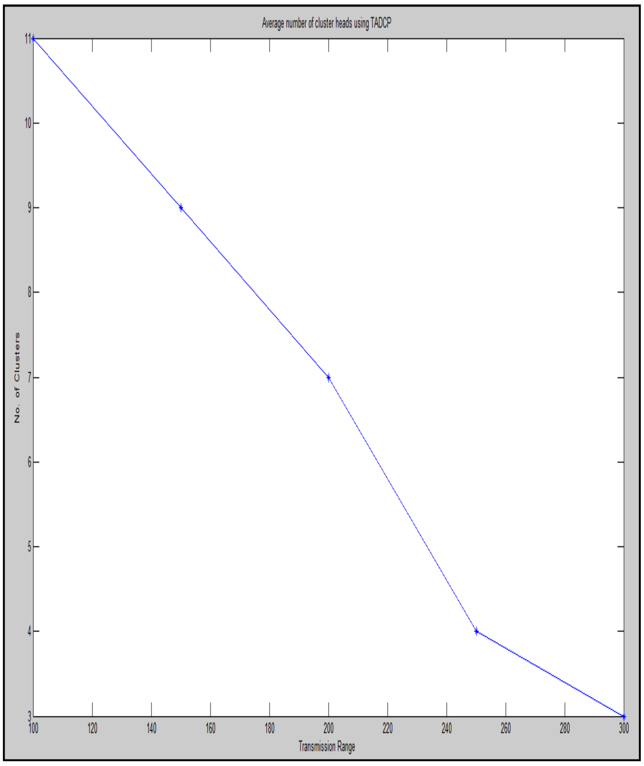

Figure 5.5 (a) Graph on cluster head (TADCP)

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.

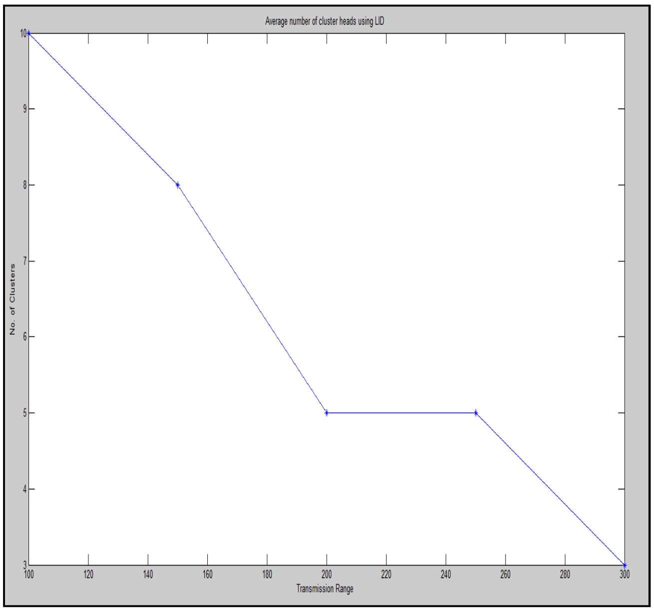

Figure 5.5 (b) Graph on cluster head (LID)

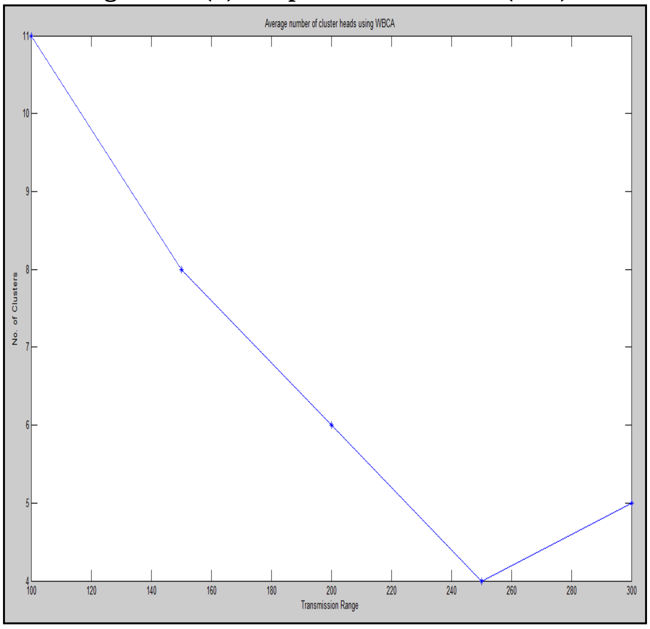

Figure 5.5 (c) Graph on cluster head (WBCA)

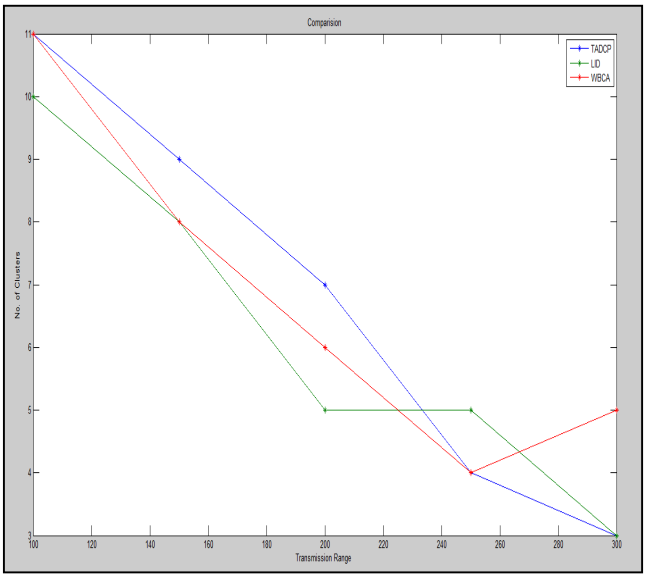

Figure 5.5 (d) Graph on cluster head (comparison of TADCP, LID and WBCA) Reaffiliation of TADCP

In reaffiliation Node changes its role i.e. member can become head or a head can become member. Number of nodes that experience reaffiliation is calculated and then the process is repeated a number of time to calculate original reaffiliation. Average of reaffiliation is used to find to calculate actual reaffiliation for more accuracy. Graph compares reaffiliation with transmission range.

Figure 5.6(a) Reaffiliation of TADCP

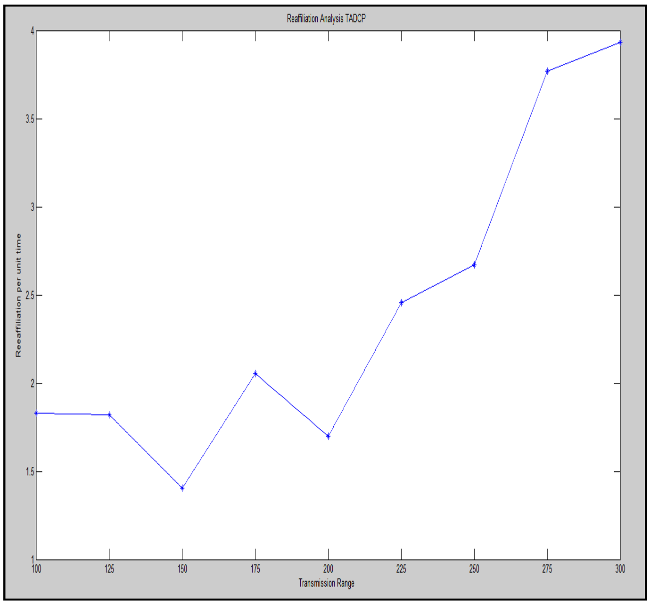

Figure 5.6(b) Reaffiliation of TADCP

B. Reaffiliation of LID

In reaffiliation node changes its role i.e. member can become head or a head can become member. Number of nodes that experience reaffiliation is calculated and then the process is repeated a number of time to calculate original reaffiliation. Average of reaffiliation is used to find to calculate actual reaffiliation for more accuracy. Graph compares reaffiliation with transmission range.

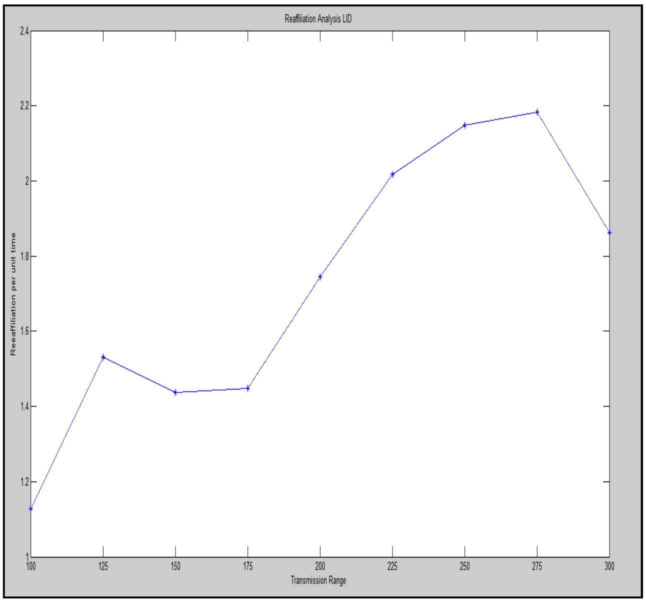

Figure 5.7(b) Reaffiliation of LID

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.

C. Reaffiliation of WBCA

In reaffiliation node changes its role i.e. member can become head or a head can become member. Number of nodes that experience reaffiliation is calculated and then the process is repeated a number of time to calculate original reaffiliation .Average of reaffiliation is used to find to calculate actual reaffiliation for more accuracy. Graph compares reaffiliation with transmission range.

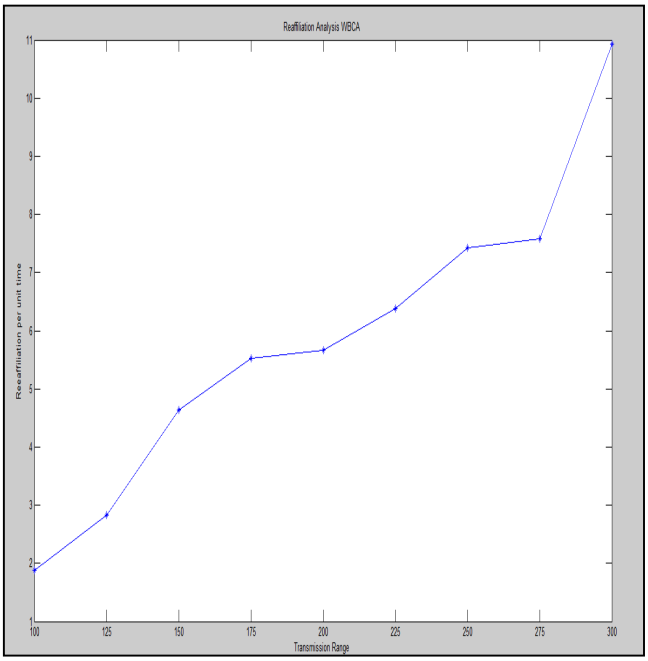

Figure 5.8(b) Reaffiliation of WBCA

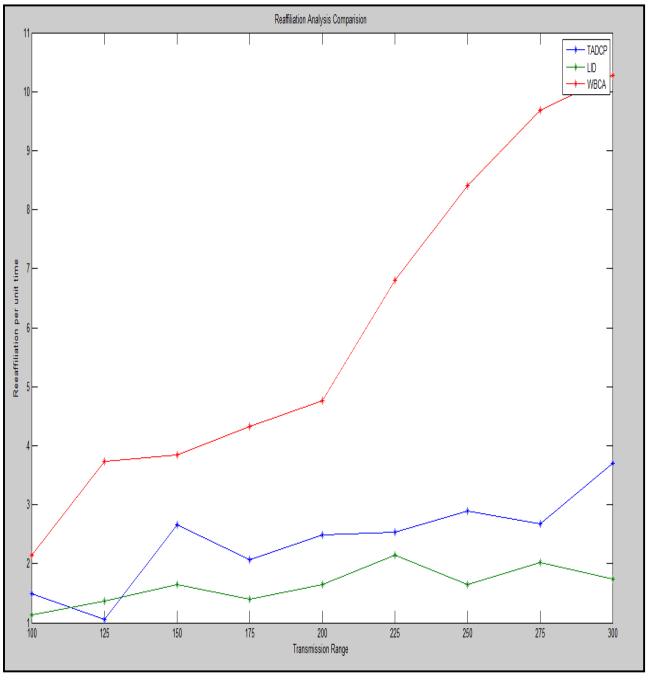

Figure 5.9 Reaffiliation comparison of TADCP, LID and WBCA

D. Network Life Time Analysis

Life time of a network defines the time (in ms) between the initiation of network and dying of first node (when the energy exhausts completely or energy reaches at threshold value) .Figure 5.10 compares the life of LID, WBCA and TADCP.

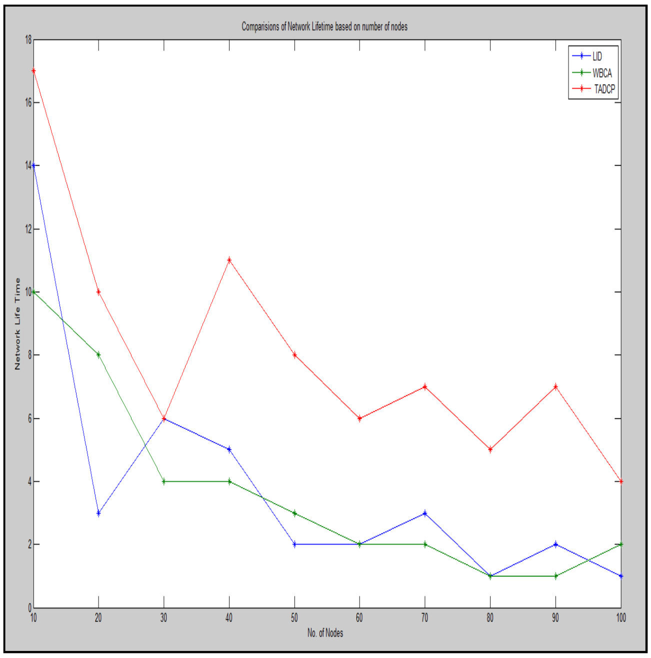

Figure 5.10 Network life time comparisons (LID, WBCA, and TADCP)

VI. CONCLUSION

In cellular networks, the mobile nodes directly communicate with the fixed base station, reducing the wireless part of communication to the single hop problem. This concept of cellular networks can be mapped into the infrastructure-less network, so that selected number of nodes perform the job of base stations and form the virtual backbone of communication. This process of selecting few nodes as the virtual base stations, where their one hop neighbors directly communicate with them, can be visualized as the formation of logical clusters in the network. Thus, every cluster consists of a cluster head representing the virtual base station and its one hop members within it.

In this research work, Topology Adaptive Distributed Clustering Protocol (TADCP) is proposed for the efficient design of clustering in MANET. The existing clustering schemes are thoroughly investigated by simulation. To start with a clustering algorithm, it is required that the nodes in the MANET must be aware of the network topology. So as to enable the nodes to probe their one-hop neighbours in the network, a neighbour recognising protocol is proposed. The protocol uses neighbour recognising packets by the sender nodes and corresponding acknowledgements by the receivers. This protocol also enables the nodes to receive the detail information about the neighbours. The working principle of the protocol is analysed through simulation by using the MATLAB.

FURTHER SCOPE

The proposed protocols that mostly deal with the cluster formation, cluster maintenance and network life time, can be extended to some other areas of clustering like load balancing among the cluster head,

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.

fault tolerant clustering or privacy and security in clustered MANET. Deriving the actual speed of the node with respect to its node position is a challenging task. A further study will be helpful to find the accurate mobility of the node and its subsequent analysis.

REFERENCES

1. M. R. Garey and D. S. Johnson. Computers and Intractability: A guide to the theory of NP-completeness. Freeman, San Francisco, CA, 1979.
2. S Basagni, M Mastrogiovanni, and A Panconesi. Localized protocols for ad hoc clustering and backbone formation: A performance comparison. IEEE Transactions on Parallel and Distributed System, 17(4):292–306, 2006.
3. B. Bollbas. Random Graphs. Academic Press, 1985.
4. E. Perkins. Ad Hoc Networking. Addison Wesley, 2000.
5. C. C. Chiang, H.K. Wu, W.Liu, and M. Gerla. Routing in clustered multihop, mobile wireless networks with fading channel. In Proceedings of IEEE Singapore International Conference on Networks SICON' 97, pages 197–212, 1997.
6. L. M. Feeney. An energy consumption model for performance analysis of routing protocols for mobile ad hoc networks. Journal of Mobile Networks and Applications, 6(3):239–249, 2001.
7. S. Raguvaran, "Improving QoS in MANET by estimating the available bandwidth," in
8. Sixth International Conference on Advanced Computing (ICoAC),DOI:10.1109/ICoAC.2014.7229723, 2014
9. J. Anju;C. N. Sminesh, "An Improved Clustering-Based Approach for Wormhole Attack Detection in MANET," in 3rd International Conference on Eco-friendly Computing and Communication Systems,DOI:10.1109/Eco-friendly.2014.105, 2014
10. Anju Shukla; A. K. Vatsa, "Optimized and secure address allocation scheme in MANET," in Fourth International Conference on Advances in Recent Technologies in Communication and Computing (ARTCom2012),DOI:10.1049/cp.2012.2485, 2012
11. Shabana Habib;Somaila Saleem;Khawaja Muhammad Saqib, "Review on MANET routing protocols and challenges," in IEEE Student Conference on Research and Development, DOI:10.1109/SCOReD.2013.7002647, 2013

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.