Research Journal of Applied Sciences, Engineering and Technology 12(6): 658-667, 2016
DOI:10.19026/rjaset.12.2714
ISSN: 2040-7459; e-ISSN: 2040-7467

Submitted: July 19, 2015 Accepted: August 20, 2015 Published: March 15, 2016

Research Article

An Improved Load Balanced Connection Aware Clustering Hierarchy Protocol for Military Application in Mobile Ad Hoc Network

T. Kalaiselvi and T. Senthil Murugan
Vel Tech Dr. RR & Dr. SR Technical University, Chennai, India

Abstract: Mobile Ad-hoc Networks (MANETs) are expected to play an important role in military networks by providing infrastructure less communication. However, maintaining secure and instant information sharing is a difficult task especially for highly dynamic military MANETs. Different solution proposed for scaling own the large size of military ad hoc network, one of the most intrinsic approaches is clustering techniques which evolved an important role in military mobile ad hoc networks. Clustering can be used for load balancing to extend the lifetime of ad hoc network by reducing energy consumption and increase network scalability. And the cluster one node works as a cluster head and coordinates all the activities such as routing. In this study, an Improved Load Balanced Connection Aware (ILBCA) clustering hierarchy protocol is presented for MANET that leads to cluster formation in military application. The protocol launches two consecutive phases called setup and steady-state. In setup phase, cluster heads and relay nodes as well as the path between member node from cluster and cluster head are determined. In steady-state phase, network data is collected from member nodes and transmitted to cluster head according to the topology which is determined in the same round. Simulated tests indicate that the ILBCA clustering hierarchy protocol can build more balanceable clustering structure, enhance the network life cycle and energy efficiency.

Keywords: Cluster, distance and density, hierarchy protocol, military, mobility, Mobile Ad-hoc Networks (MANETs), position, random distribution

INTRODUCTION

With the widespread rapid development of computers and the wireless communication, the mobile computing has already become the field of computer communications in high-profile link. MANET is a completely wireless connectivity through the nodes constructed by the actions of the network, which usually has a dynamic shape and a limited bandwidth and other features, network members may be inside the laptop, Personal Digital Assistant (PDA), mobile phones, MP3 players and digital cameras and so on. On the Internet, the original Mobility (mobility) is the term used to denote actions hosts roaming in a different domain; they can retain their own fixed IP address, without the need to constantly changing, which is Mobile IP technology. Mobile IP nodes in the main action is to deal with IP address management, by Home Agent and Foreign Agent to the Mobile Node to packet Tunneling, the Routing and fixed networks are no different from the original; however, Ad Hoc Network to be provided by Mobility is a fully wireless, can be any mobile network infrastructure, without a base station, all the nodes can be any link, each node at the same time take Router work with the Mobile IP completely different levels of Mobility.

Early use of the military on the Mobile Packet Radio Networked in fact can be considered the predecessor of MANET, with the IC technology advances, when the high-tech communication equipment, the size, weight continuously decreases, power consumption is getting low, Personal Communication System (PCS) concept evolved, from the past few years the rapid popularization of mobile phones can be seen to communicate with others anytime, anywhere, get the latest information, or exchange the required information is no longer a dream. Military purposes Fig. 1, as is often considerable danger in field environment, some of the major basic communication facilities, such as base stations, may not be available, in this case, different units, or if you want to communicate between the forces, must rely on this cannot MANET network infrastructure limitations. In emergency relief, the mountain search and rescue operations at sea, or even have any infrastructure cannot be expected to comply with the topographical constraints and the pressure of time under the pressure, Ad Hoc Network completely wireless and can be any mobile feature is especially suited to disaster relief operations.

Corresponding Author: T. Kalaiselvi, Vel Tech Dr. RR & Dr. SR Technical University, Chennai, India

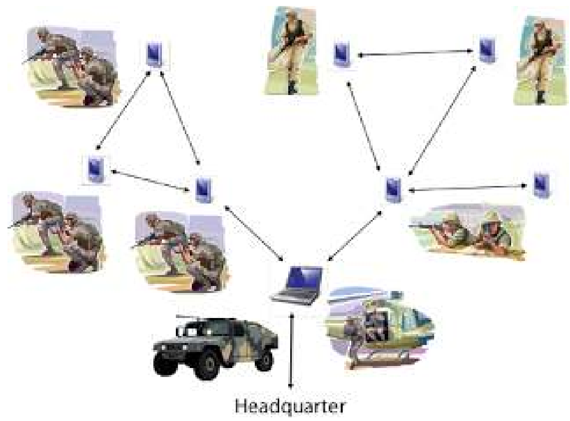

Fig. 1: MANET in military operation

Clustering is division of the network into different virtual groups based on rules in order to discriminate the nodes allocated to different sub-networks (Gavalas *et al*., 2006). The goal of clustering is to achieve scalability in presence of large networks and high mobility. Roles of nodes in clusters are grouped in four categories namely cluster-head, gateway nodes, member nodes and guest nodes:

- **Cluster-head:** A Cluster-head node is the local coordinator of a cluster. The transmission range of cluster head describes the limitations of a cluster.
- **Gateway nodes:** Gateway nodes are located at the boundary of the cluster. It can forward information between clusters.
- **Member nodes:** Member nodes are also called as ordinary node. Member nodes are members of a cluster and these nodes have neighbors belonging to their own cluster.
- **Guest node:** Guest node is a node associated to a cluster. Cluster-head maintains routing and topology information and passes it to other nodes. A member node does not maintain any routing and topology information or perform any routing functions, but can create a cluster heads bottleneck points in the network.

The main challenge of clustering is to select proper nodes to act as cluster heads and gateways. Previous researches have proposed many cluster head election approaches for constructing cluster. In this study Improved Load Balanced Connection Aware (ILBCA) Clustering Hierarchy Protocol is proposed to determine an energy-efficient, reliable routing path, where balanced clustering structure is formed. The ILBCA clustering hierarchy protocol primarily considers mobility, position, density distribution and distance of the nodes and uses a novel clustering metric called the Predicted Transmission Count (PTX), to evaluate the qualification of nodes for cluster heads and gateways to construct clusters. Once the clusters are formed, the CH node uses the Improved Load Balanced Connection Aware Clustering Hierarchy Protocol. The CH collects and aggregates information from sensors in its own cluster and passes on information to the nodes.

LITERATURE REVIEW

A number of clustering algorithms for mobile ad hoc networks have been proposed in the literature. Smooth and Efficient Re-Clustering (SERC) protocol proposed as a new method to improve cluster stability (Al-kahtani and Mouftah, 2005). In SERC, every cluster-head is known as Primary Cluster-Head (PCH). Each PCH selects Secondary Cluster-Head (SCH). When PCH is no longer a cluster-head then SCH will act as the cluster-head. Since SCH is known to all cluster members, the cluster leadership will be transferred effectively. Each node has four battery power levels. W hen battery power of PCH is at critical threshold, it transfers its responsibilities to SCH. This approach improves cluster stability and reduces cluster communication overhead.

In Highest Connectivity Clustering algorithm (HCC) the degree of a node is computed based on its distance from others (Gerla and Tsai, 1995). The node with maximum number of neighbors (i.e., maximum degree) is chosen as a cluster head. This system has a low rate of cluster head change but the throughput is low. As the number of nodes in a cluster is increased, the throughput drops. K-CONID combines two clustering algorithms: the Lowest- ID and the Highest-degree heuristics. In order to select cluster heads connectivity is considered as a first criterion and lower ID as a secondary criterion (Chen *et al*., 2002). In HCC clustering scheme, one cluster head can be exhausted when it serves too many mobile hosts. It is not desirable and the CH becomes a bottleneck. So a new approach is given in which when a CH's Hello message shows its dominated nodes' number exceeds a threshold (the maximum number one CH can manage), no new node will participate in this cluster (Li *et al*., 2004). Adaptive multi hop clustering sets upper and lower bounds (U and L) on the number of cluster members within a cluster that a cluster head can handle (Ohta *et al*., 2003). When the number of cluster members in a cluster is less than the lower bound, the cluster needs to merge with one of the neighboring clusters. On the contrary, if the number of cluster members in a cluster is greater than the upper bound, the cluster is divided into two clusters.

Mobility-based d-hop clustering algorithm partitions an ad hoc network into d-hop clusters based on mobility metric (Er and Seah, 2004). The objective of forming d -hop clusters is to make the cluster diameter more flexible. Local stability is computed in order to select some nodes as cluster heads. A node may become a cluster head if it is found to be the most stable node among its neighborhood. In Mobility Based Metric for Clustering a timer is used to reduce the cluster head change rate by avoiding re -clustering for incidental contacts of two passing cluster heads (Basu *et al*., 2001). Mobility-based Frame Work for Adaptive Clustering partition a number of mobile nodes into multi- hop clusters based on (a, t) criteria (McDonald and Znati, 1999). The (a, t) criteria indicate that every mobile node in a cluster has a path to every other node that will be available over some time period 't' with a probability 'a' regardless of the hop distance between them.

In (LCC) the clustering algorithm is divided into two steps: cluster formation and cluster maintenance (Chiang *et al*., 1997). The cluster formation simply follows (LIC), i.e., initially mobile nodes with the lowest ID in their neighborhoods are chosen as cluster heads. Re-clustering is event -driven and invoked if two cluster heads move into the reach range of each other and when a mobile node cannot access any cluster head. Adaptive clustering for mobile wireless network ensures small communication overhead for building clusters because each mobile node broadcasts only one message for the cluster construction (Lin and Gerla, 1997).

3-hop Between Adjacent Cluster heads (3-hBAC) algorithm introduces a new node status, "cluster guest" (Yu and Chong, 2003). When a mobile node finds out that it cannot serve as a cluster head or join a cluster as a cluster member, but some neighbor is a cluster member of some cluster, it joins the corresponding cluster as a cluster guest.

A clustering protocol that does not use dedicated control packets or signals for clustering specific decision is Passive Clustering (Kwon *et al*., 2003). In this scheme, when a potential cluster head with "initial" state has something to send, such as a flood search, it declares itself as a cluster head by piggybacking its state in the packet. Load Balancing Clustering (LBC) provide a nearby balance of load on the elected cluster heads (Amis and Prakash, 2000). Once a node is elected a cluster head it is desirable for it to stay as a cluster head up to some maximum specified amount of time, or budget. Initially, mobile nodes with the highest IDs in their local area win the cluster head role. LBC limits the maximum time units that a node can serve as a cluster head continuously, so when a cluster head exhausts its duration budget, becomes a non-cluster head node. Power-aware connected dominant set is an energy-efficient clustering scheme which decreases the size of a Dominating Set (DS) without impairing its function (Wu *et al*., 2002). Clustering for energy conservation assumes two node types: Master and slave (Ryu *et al*., 2001). The purpose of this scheme is to minimize the transmission energy consumption summed by all master-slave pairs and to serve as many slaves as possible in order to operate the network with longer lifetime and better performance.

Weighted Clustering Algorithm (WCA) selects a cluster head according to the number of nodes it can handle, mobility, transmission power and battery power (Chatterjee *et al*., 2002). To avoid communications overhead, this algorithm is not periodic and the cluster head election procedure is only invoked based on node mobility and when the current dominant set is incapable to cover all the nodes. The cluster head election algorithm finishes once all the nodes become either a cluster head or a member of a cluster head. The distance between members of a cluster head, must be less or equal to the transmission range between them. No two cluster heads can be immediate neighbors. In WCA high mobility of nodes leads to high frequency of reaffiliation which increase the network overhead. Higher reaffiliation frequency leads to more recalculations of the cluster assignment resulting in increase in communication overhead.

Entropy-based weighted clustering algorithm in WCA high mobility of nodes leads to high frequency of reaffiliation which increases the network overhead (Wang and Bao, 2007). Higher reaffiliation frequency leads to more recalculations of the cluster assignment resulting in increase in communication overhead. Entropy based clustering overcomes the drawback of WCA and forms a more stable network. It uses an entropy-based model for evaluating the route stability in ad hoc networks and electing cluster head. Entropy presents uncertainty and is a measure of the disorder in a system. So it is a better indicator of the stability and mobility of the ad hoc network.

Vote-based clustering algorithm is based on two factors, neighbors' number and remaining battery time of every Mobile Host (MH) Each MH has a unique identifier (ID) number, which is a positive integer. The clustering approach presented in (WBACA) is based on the availability of position information via a Global Positioning System (GPS) (Dhurandher and Singh, 2005). The WBACA considers following parameters of a node for cluster head selection: transmission power, transmission rate, mobility, battery power and degree. In Connectivity, Energy and Mobility driven weighted Clustering Algorithm (CEMCA) the election of the cluster head is based on the combination of several significant metrics such as: the lowest node mobility, the highest node degree, the highest battery energy and the best transmission range (Tolba *et al*., 2007).

Dynamic energy-efficient clustering algorithm in DEECA that prolongs the network lifetime by electing cluster-heads taking into consideration, in addition to other parameters such as mobility, their residual energies and making them dynamically monitor their energy consumption to either diminish the number of their cluster-members or relinquish their roles (Safa and Mirza, 2010). DEECA for MANETs to prolong the network lifetime by balancing the load between neighboring cluster-heads and taking their energy consumption into consideration of presented network.

SYSTEM MODEL

In military application, ad hoc network can be modeled as a graph $G = (V, E)$. G is a unit disk graph. V is the set of nodes and $E \subseteq V2$ is the set of links among the nodes. There is a link between two nodes if they are within the transmission range of each other. The multi-hops MANETs with heterogeneous distribution and each node are assigned to a unique identifier. The node is not equipped with Global Positioning System (GPS) equipment and couldn't position solely. This study makes the following assumption. All nodes constitute network topology by self organizing and the nodes transmit data with the same signal intensity and with the same maximum distance L in the same frequency (shared channels are freely competitive and faultless). The refreshing time of algorithm is restrained by the switching of nodes state (such as node death). The position of each node is fixed in a certain period of time, which is commonly adopted in MANETs modeling. All the nodes are distributed according to a Poisson process with intensity λ. use the same radio model as stated, where to transmit an l-bit message over a distance d, the power consumption is:

$$E_{Fx}(l,d) = E_{Tx-elec}(l) + E_{Tx-amp}(l,d) \quad (1)$$

$$= \begin{cases} lE_{elec} + l\varepsilon_{fs}d^2, d < d_0 \\ lE_{elec} + l\varepsilon_{fs}d^4, d > d_0 \end{cases}$$

$$d_0 = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{fs}}}$$

And to receive the message, the power consumption is:

$$E_{Rx}(l) = E_{Rx-elec}(l) = lE_{elec} \quad (2)$$

The electronics energy E_{elec}-energy dissipation to depends on the digital coding, modulation, filtering and spreading of the signal, whereas the amplifier energy, $\varepsilon_{fs}d^2 or \varepsilon_{mp}d^4$, depend on the distance to the neighboring nodes and the l is the data length, d_0 distance threshold (Kadir *et al*., 2011).

PROPOSED METHOD

In this section, an Improved Load Balanced Connection Aware (ILBCA) clustering hierarchy protocol for MANET that leads to cluster formation in military application has been discussed. The improved load balanced connection aware clustering algorithms is used to form a hierarchical network topology which is a common method of implementing network management and data aggregation in military applications. In this method, the cluster head is selected on the basis of their distance, density distribution, position and mobility making it essentially different from the previous clustering algorithms.

Improved load balanced connection aware clustering hierarchy protocol: It is a clustering-based protocol that utilizes randomized rotation of the cluster-heads to evenly distribute the energy load among the nodes in the mobile network. In this protocol a dense network of homogeneous, energy constrained nodes. These nodes are responsible to send their data to a cluster head. In ILBCA clustering hierarchy protocol nodes are divided into clusters. Each cluster consists of a cluster-head which is responsible for creating and maintaining member nodes. The time schedule can be used to exchange data between member and the cluster-head. Member nodes within cluster send data to their CH and cluster-head broadcast this information or information collected from its member node to other cluster-head for routing purpose. ILBCA clustering hierarchy protocol is organized into rounds. Each round is sub-divided into two phases, set-up phase and steady state phase Fig. 2. The setup phase starts with the self-election of nodes to cluster-heads. In the following advertisement phase, the cluster-heads inform their neighborhood with an advertisement packet. The cluster-heads contend for the medium and no further provision against the hidden-terminal problem. The non-cluster-head nodes pick the advertisement packet with the strongest received signal strength.

The possible applications of clustering algorithms, proposed previously, are in uniformly distributed

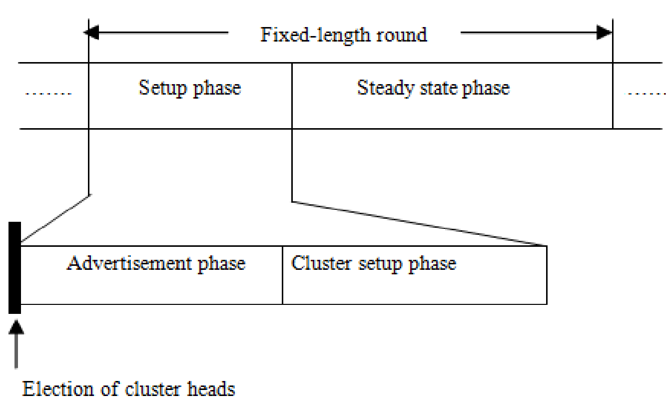

Fig. 2: Organization of ILBCA clustering hierarchy protocol rounds

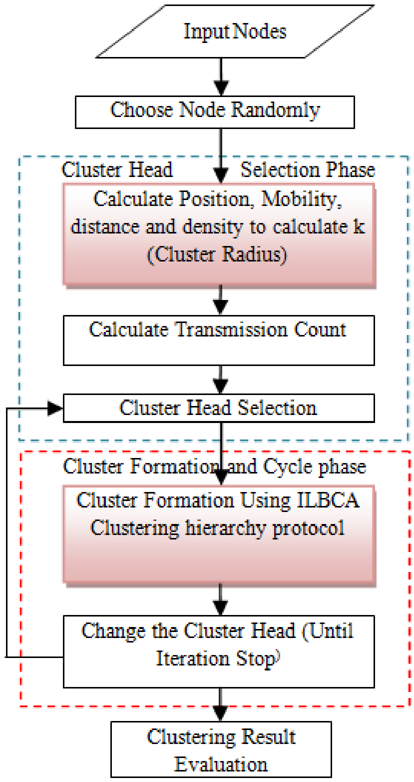

Fig. 3: ILBCA clustering hierarchy protocol based cluster formation

MANETs without considering the distance of the nodes. However, in the practical application of MANETs, the nodes are usually randomly arranged. In this case, if the clustering algorithm doesn't take the distribution of nodes into account, using uniform clustering strategy may lead to unbalanced topological structure and some nodes die rapidly because of excessive energy decline. The purpose of ILBCA clustering hierarchy protocol is to generate clusters with more balanced energy and avoid creating excessive clusters with many nodes. Figure 3 shows the process involved in ILBCA clustering hierarchy protocol. The protocol launches two consecutive phases called setup and steady-state. In setup phase, cluster heads and relay nodes as well as the path between member node from cluster and cluster head are determined. In steady-state phase, network data is collected from member nodes and transmitted to cluster head according to the topology which is determined in the same round. The basic idea of ILBCA clustering hierarchy protocol is based on the connectivity position, mobility, density and the distance from the neighboring nodes to calculate k (clustering radius) and predicted transmission count. The clustering radius is determined by density and distance: if two clusters have the same connectivity density, the cluster much farther from the nodes has larger cluster radius; if two clusters have the same distance from the neighboring nodes, the cluster with the higher density has smaller cluster radius. The protocol is to make sure as much as possible that the cluster heads are from the group of mobile nodes having minimum node mobility or they are in a group motion with the other cluster members. Mobility measure should have a linear relationship with link change rate. Predicted Transmission Count (PTX), to access the suitability of CH or Gateway candidates. The PTX represents the capability of a candidate for persistent transmission to a specific neighboring node. ILBCA clustering hierarchy protocol can be divided into three stages: cluster head selecting phase, clusters building phase and cycle phase.

Cluster head selecting phase: Based on the previous discussion the propose algorithm called ILBCA clustering hierarchy protocol that count the node id, mobility and the position of every node. The position can be efficiently used within certain transmission range that is, it will take less power for a node to communicate with other nodes if they are within close distance to each other. A cluster head consumes more battery power than an ordinary node. Here mobility is an important factor in deciding the clusters heads. In order to avoid frequent cluster head changes, it is desirable to elect a cluster head that does not move very quickly. This algorithm elect those cluster head that does not move very quickly or does not move. Here choose random value for mobility of every node. The cluster formation phase deals with the logical partition of the mobile nodes in to 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 difficult. Hence there exists some representative algorithm that used the parameters like node identify number, mobility, transmission power, battery power, degree of connectivity etc to decided how well suited a node is for being a cluster heads. The process of cluster head selection through this algorithm is described below. The values of mobility are chosen randomly.

Let $n_i(t), i = 0, 1, 2, 3, \ldots N-1$, where N is the number of nodes, represents the position vector of node i at time t and $d_{ij}(t) = | n_j(t) - n_i(t) |$, the distance from node i to j at time t.

As a node moves relative to the other nodes, remoteness remains proportionate to its previous values. But as the node moves in a manner, in which its speed and angular deviation from the current state are not predictable, remoteness changes in time. Thus the definition of relative mobility measure in terms of remoteness of a node as a function of time with respect to its immediate neighbors is:

$$M_i(t) = \frac{1}{N-1}\sum_{j=0}^{N-1}\left|d'_{ij}(t)\right| \quad (3)$$

In order to calculate $d'_{ij}(t)$, from ith node to all its jth neighboring nodes, the broadcast medium may be used. In ILBCA clustering hierarchy protocol all nodes in a cluster are time synchronized with the cluster head. ILBCA clustering hierarchy protocol follows a distributed approach to establish hierarchical structure in self-organizing mode without central control. It selects the random nodes to trigger clustering process first. Then the trigger node A calculates its connected density and distance of the neighboring nodes to determine cluster radius r by Eq. (4) and becomes the temporary cluster head:

$$r = \text{floor}[\beta d(A)/dk(A)] \quad (4)$$

where, $d(A)$ is the distance from the neighboring nodes of A, $dk(A)$ is the connectivity density of nodeA, β is the sensor parameters determined by specific applications of MANETs and floor is the calculation of rounding. $d(A)$can be calculated as follows. node s_i, receives report messages form sj, it can use Eq. (6) to derive the PTX is the residual energy of s_i, d_{ij} is the distance between s_i and s_j and $E_{tx}(k, d_{ij})$ is the energy consumption for s_i to transmit a k-bit message where RSSI is received signal strength indicator and S is the signal strength with 1 m distance from the neighboring nodes. $Nk(A)$ is k-hop neighbors of node u. use hops to indicate distance approximately. Node connection density is calculated by Eq. (5) and $|Nk(A)|$ is the number of k-hop neighbors of node a:

$$dk(a) = \frac{\left|(t,v) \in \frac{E}{t}, v \in Nk(u) \cup \{u\}\right|}{|Nk(u)|} \quad (5)$$

In this phase, the node with the highest weight in k-hop neighbors of Ut is elected as cluster head. The weight of the node is calculated by (6), which takes the residual energy, connection density and times of being elected as cluster head of nodes into account. Thus, generate clusters more balanced in energy and position:

$$W(a) = \varphi \times P[dk(a)] + \phi \times P\left[\frac{Re(a)}{E(a)}\right] - \gamma \times P[H(a)], 0 \le \varphi, \phi, \gamma \le 1, \gamma < \varphi + \phi < 1 \quad (6)$$

where, φ, ϕ, γ as the effect factors are defined by specific application, $Re(a)$ is the residual energy of node a, $E(a)$ is the initial energy of node a, $H(a)$ is the times of the node a being elected as cluster head.

The proposed ILBCA clustering hierarchy protocol also considers node status and link condition and Predicted Transmission Count (PTX), to evaluate the suitability of CH or GW candidates. The PTX represents the capability of a candidate for persistent transmission to a specific neighboring node. This study considers the transmit power, residual energy and link quality to derive the PTX of CH or GW candidate. Each node in the network periodically broadcasts a message to obtain the distance, forward delivery ratio and reverse delivery ratio of its neighbors, thereby making it possible to determine the ETX when over a distance d_{ij}. A large PTX value and weight indicates a high possibility of becoming a Cluster head.

In the initial stage, the node A triggers the clustering process and sends Hello messages to its k-hop neighbors. The neighbors in k-hop utilize to calculate the respective weight and then the node with the highest weight will become the cluster head. From then on, cluster head node broadcasts (Head_message) in its k-hop neighbors to declare itself as cluster head and asks them to join the cluster. Head_message includes the ID of Cluster Head node (IDCH), the ID of the sending node (IDS) and the number of hops from the Cluster Head (HD). When a node receives Head_message, IDS can be used to maintain a path to reach the cluster head. The algorithm discards broadcast package when HD is over k to ensure that the cluster is no more than k-hop. When a neighbor node receives Head_message, even if it is already in a cluster, it sends Join_message to the cluster head to request joining the new cluster as long as its weight is lower. Head_message is limited to transmission within k-hop, so it may happen that some nodes couldn't receive any Head_message.

Cluster forming phase: ILBCA clustering hierarchy protocol sets the threshold of cluster size. The number of cluster nodes cannot exceed the threshold to avoid forming large clusters, which will cause extra overhead and thus reduce network lifetime. When the cluster head node receives Join_message sent by the ordinary node, it will compare the size of cluster with threshold to accept new member and update the count of cluster nodes if the size is smaller than threshold, or reject the request. If the rejected node has cluster head already, the clustering process ceases. Otherwise, it finds another appropriate cluster to join. Each member node of cluster maintains a cluster information table, which saves the IDCH, HD, IDS and other information. If a node receives transmitting packet in work, it will update its cluster information table correspondingly. For example, the node checks HD in a newly received packet, if HD is smaller, then it updates the value of HD in table, with IDS updated. That is to say, it has found a shorter path to cluster head and sets the new IDS as its forwarding node. There is only a single IDCH entry in the ordinary node because it belongs to one cluster head, but the overlapping cluster node has multiple IDCH information entries for different clusters.

Cycle phase: ILBCA clustering hierarchy protocol avoids the fixed cluster head scheme, with periodic replacement to balance the node energy consumption.

The cluster is stable for a while until the process of reelecting cluster head is triggered in T (k). The cluster head gathers the weight of all member nodes and then selects the node with highest weight as the next head node. In this way, the communication costs are decreased. The reelecting of cluster head occurs in the old cluster, so the broadcast of temporary head and the corresponding responses of all the k-hops neighbors are unnecessary.

RESULTS AND DISCUSSION

In this section, the performance of the proposed ILBCA clustering hierarchy protocol scheme is evaluated through simulations and compares it with that of a Weighted Clustering Algorithm (WCA) (Chatterjee *et al*., 2002) and Dynamic Energy Efficient Clustering Algorithm (DEECA) (Safa and Mirza, 2010). of the existing models. Performance of the proposed model is evaluated from energy efficiency perspective while making sure that it provides an acceptable level of load balancing among adjacent cluster-heads. Performance of the network can be evaluated through a number of nodes changes in the network.

Load Balancing Factor (LBF): LBF can be used to measure how well balanced the clusters are (Gavalas *et al*., 2006). For a network with N number of nodes, cluster-based structure is formed by k number of clusters and each cluster has x_k number of members. Average number of neighbors of each cluster head is μ and $\mu = (N - k) / k$. Load balancing factor is defined as:

$$LBF = \frac{k}{\sum_{i=1}^{k} |(x_i - \mu)|^2} \quad (7)$$

A higher value of LBF signifies a better load distribution and it tends to infinity for a perfectly balanced system. Existing methods of WCA and DEECA does not have any limit on the number of members of cluster heads and thus there is non-uniform distribution of the load on the cluster heads. Proposed work distributes the load uniformly and an improved load balancing factor is achieved as showed in Fig. 4.

Measuring Network Lifetime (NLT) with respect to cluster-heads' load: In this experiment, the impact of increasing the load of cluster-heads on the network lifetime is examined. Fifty nodes were used in this experiment. Initially started with 30% of the nodes sending packets to their corresponding cluster-heads and then increased this percentage gradually to 70%. Each node generated a packet every 3s. Figure 5 intuitively shows that the network lifetime decreases when the load on cluster-heads increases. Nevertheless, compared with WCA and DEECA, the proposed ILBCA clustering hierarchy protocol model maintains a much higher NLT.

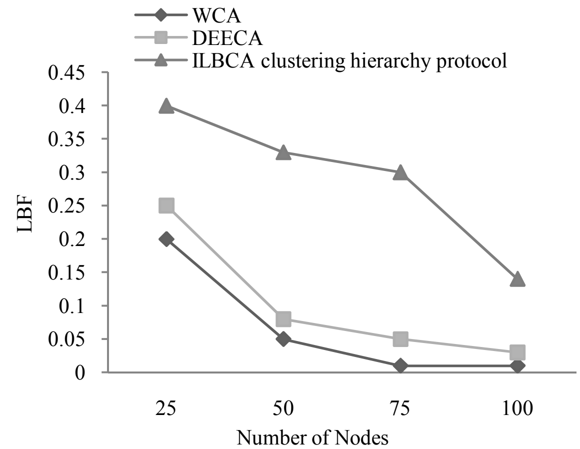

Fig. 4: Load balancing factor vs. number of nodes

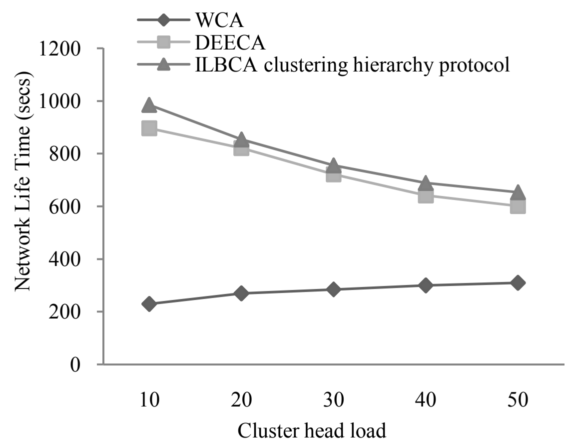

Fig. 5: NLT with respect to cluster head

Measuring Network Lifetime (NLT) with respect to traffic: In this experiment, the impact of increasing the load of cluster-heads on the network lifetime is examined. The number of nodes used in this experiment is 50, where 50% of them were transmitting packets. The rate of the transmitted packets was increased slowly, from 1 packet per node every 5s to 1 packet per node every 1s. Figure 6 shows that the network lifetime decreases when the traffic rate increases. Nevertheless, compared with WCA and DEECA' version, ILBCA clustering hierarchy protocol maintains a much higher NLT, for the same reasons discussed earlier.

Average Dissipated Energy (ADE) with respect to cluster-heads' load and traffic: In this experiment, the impact of increasing the load of cluster-heads on the network lifetime is examined. The number of nodes used in this experiment is 50 nodes, where initially 30%

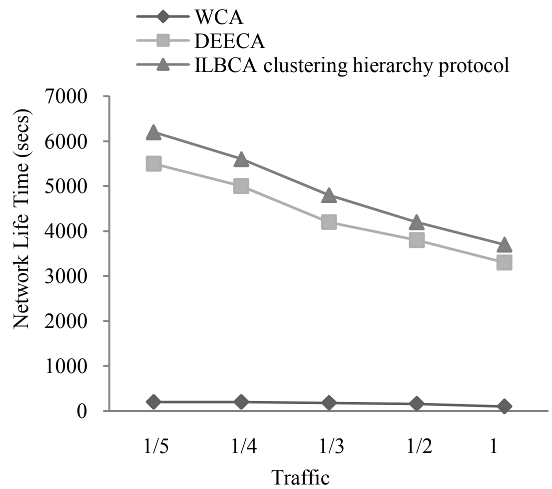

Fig. 6: NLT with respect to traffic

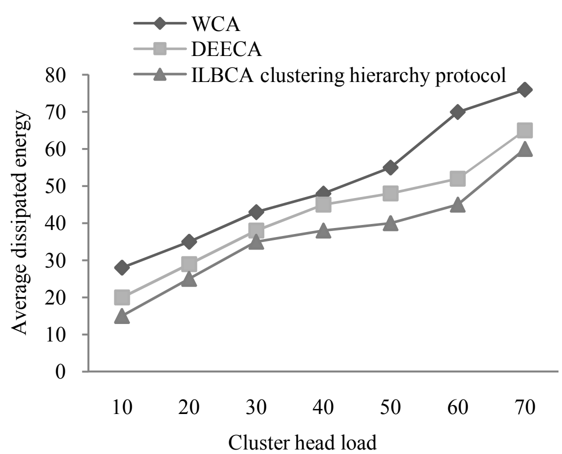

Fig. 7: Average dissipated energy with respect to cluster-heads' load

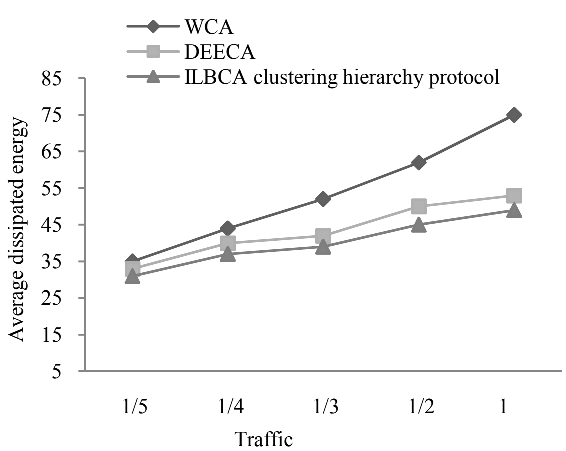

Fig. 8: Average dissipated energy with respect to traffic

of them were transmitting packets at a rate of 1 packet per node every 3 s. Then this rate was gradually increased to 70%. The energy consumed by each node

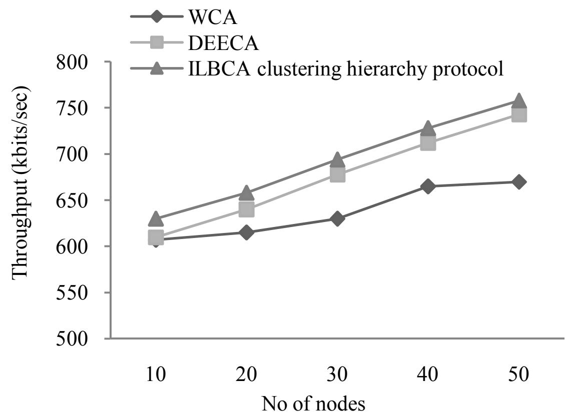

Fig. 9: Throughput comparison

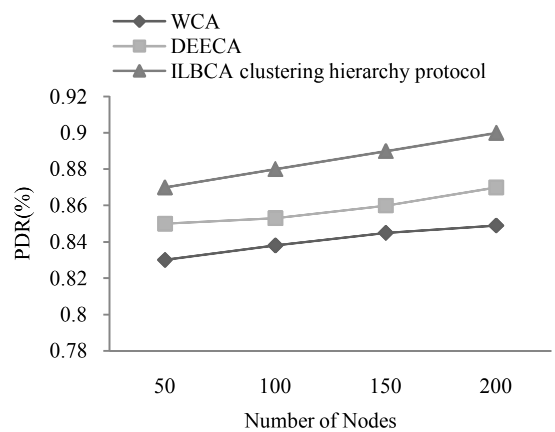

Fig. 10: Packet delivery ratio vs. number of nodes

was extracted after 1000 s of simulation time. The average of these consumed energies is considered as the average dissipated energy by each node. Figure 7 shows that as the load increases, the average dissipated energy increases as well. In fact, as the number of nodes sending packets to their cluster-heads increases, the cluster-heads consume more energy since they serve more nodes. ILBCA clustering hierarchy protocol outperforms both the WCA and DEECA models.

Figure 8 illustrates the impact of increasing the traffic on the energy consumed in the network. It shows the results of a network of 50 nodes, 50% of which were transmitting packets at a rate varied from 1 packet per node every 5s to 1 packet per node every 1s. It is clear that the average dissipated energy increases when the rate of packets transmitted increases. Nevertheless, compared with WCA and DEECA, ILBCA clustering hierarchy protocol maintains a much higher performance.

Throughput evaluation: Figure 9 shows the throughput comparison of the proposed ILBCA clustering hierarchy protocol approach and the existing WCA and DEECA. It is noted that the proposed ILBCA clustering hierarchy protocol attains higher throughput when compared with the existing WCA and DEECA algorithms. The reason is that, the probability to meet the desired event data in a short hop count is very high in such a way.

Packet delivery ratio: Figure 10 shows that the below graph is plotted across the number of nodes and the Packet Delivery Ratio (PDR). Normally the value of PDR will get increased when compared with the existing methods. In this graph, it shows that the packet delivery ratio increased for the proposed ILBCA clustering hierarchy protocol model since it stores, the best individuals in the memory when compared to the existing WCA and DEECA.

CONCLUSION

In this study, Improved Load Balanced Connection Aware (ILBCA) clustering hierarchy protocol is proposed to build clusters and choose cluster head in mobile ad hoc network for military application. The cluster head selection technique is based on position, mobility, distance and density of the nodes. And predicted transmission count is considered to elect the cluster head. The protocol has setup and steady-state phases. The path between member node from cluster and cluster head are determined by setup phase. The network data is collected from nodes and transmitted to cluster head according to the topology which is determined by steady-state phase. Compared with hierarchy protocol clustering algorithms, the proposed algorithm ILBCA clustering hierarchy protocol can form more stable and reasonable cluster structure and also improve the network life cycle significantly. Thus, with the new protocol suggested in this study could overcome the drawback of existing methods such as WCA and DEECA since the number of nodes forming the chain is smaller in new approach and could minimize the overhead while clustering. Thus the new approach improves the network life time. This algorithm can support scalability and energy efficient transmission and it also increase wireless MANET lifetime. In future research, alternate the clustering scheme with less power utilization and optimized location of cluster head selection.

REFERENCES

Al-kahtani, M.S. and H.T. Mouftah, 2005. Enhancements for clustering stability in mobile ad hoc networks. Proceeding of the 1st ACM International Workshop on Quality of Service and Security in Wireless and Mobile Networks, ACM, New York, pp: 112-121.

Amis, A.D. and R. Prakash, 2000. Load-balancing clusters in wireless ad hoc networks. Proceedings of 3rd IEEE Symposium on Application-Specific Systems and Software Engineering Technology, pp: 25-32.

Basu, P., N. Khan and T.D.C. Little, 2001. A mobility based metric for clustering in mobile ad hoc networks. Proceeding of the International Conference Distributed Computing Systems Workshop, pp: 413-418.

Chatterjee, M., S.K. Das and D. Turgut, 2002. WCA: A weighted clustering algorithm for mobile ad hoc networks. Cluster Comput., 5(2): 193-204.

Chen, G., F.G. Nocetti, J.S. Gonzalez and I. Stojmenovic, 2002. Connectivity based k-hop clustering in wireless networks. Proceeding of the 35th Annual Hawaii International Conference on System Sciences, pp: 2450-2459.

Chiang, C.C., H.K. Wu, W. Liu and M. Gerla, 1997. Routing in clustered multihop, mobile wireless networks with fading channel. Proceeding of IEEE SICON' 97, pp: 197-211.

Dhurandher, S.K. and G.V. Singh, 2005. Weight based adaptive clustering in wireless ad hoc networks. Proceeding of the IEEE International Conference on Personal Wireless Communications (ICPWC, 2005), pp: 95-100.

Er, I.I. and W.K.G. Seah, 2004. Mobility-based d-hop clustering algorithm for mobile ad hoc networks. Proceeding of the IEEE Wireless Communications and Networking Conference, 4: 2359-2364.

Gavalas, D., G. Pantziou, C. Konstantopoulos and B. Mamalis, 2006. Clustering of mobile ad hoc networks: An adaptive broadcast period approach. Proceeding of the IEEE International Conference on Communications (ICC'06), 9: 4034-4039.

Gerla, M. and J.T.C. Tsai, 1995. Multicluster, mobile, multimedia radio network. Wirel. Netw., 1: 255-265.

Kadir, J., O. Ghazali, M. Firdhous and S. Hassan, 2011. Node selection based on energy consumption in MANET. Internetworks Research Group, School of Computing, University Utara Malaysia, pp: 1-6.

Kwon, T.J., M. Gerla, V.K. Varma, M. Barton and T.R. Hsing, 2003. Efficient flooding with passive clustering-an overhead-free selective forward mechanism for ad hoc/sensor networks. P. IEEE, 91(8): 1210-1220.

Li, F., S. Zhang, X. Wang, X. Xue and H. Shen, 2004. Vote-based Clustering Algorithm in Mobile Ad Hoc Networks. In: Kahng, H.K. and S. Goto (Eds.), ICOIN, 2004. Lecture Notes in Computer Science, Springer-Verlag, Berlin, Heidelberg, 3090: 13-23.

Lin, C.R. and M. Gerla, 1997. Adaptive clustering for mobile wireless networks. IEEE J. Sel. Area. Comm., 15: 1265-1275.

McDonald, A.B. and T.F. Znati, 1999. A mobility-based framework for adaptive clustering in wireless ad hoc networks. IEEE J. Sel. Area. Comm., 17: 1466-1487.

Ohta, T., S. Inoue and Y. Kakuda, 2003. An adaptive multihop clustering scheme for highly mobile ad hoc networks. Proceeding of 6th International Symposium on Autonomous Decentralized Systems (ISADS, 2003), pp: 293-300.

Ryu, J.H., S. Song and D.H. Cho, 2001. New clustering schemes for energy conservation in two-tiered mobile ad-hoc networks. Proceeding of IEEE International Conference on Communications (ICC, 2001). Helsinki, Finland, 3: 862-866.

Safa, H. and O. Mirza, 2010. A load balancing energy efficient clustering algorithm for MANETs. Int. J. Commun. Syst., 23: 463-483.

Tolba, F.D., D. Magoni and P. Lorenz, 2007. Connectivity, energy & mobility driven weighted clustering algorithm. Proceeding of IEEE GLOBECOM, pp: 2786-2790.

Wang, Y.X. and F.S. Bao, 2007. An entropy-based weighted clustering algorithm and its optimization for ad hoc networks. Proceeding of the 3rd IEEE International Conference on Wireless and Mobile Computing, Networking and Communications, pp: 56.

Wu, J., F. Dai, M. Gao and I. Stojmenovic, 2002. On calculating power-aware connected dominating sets for efficient routing in ad hoc wireless networks. J. Commun. Netw., 4(1): 1-12.

Yu, J.Y. and P.H.J. Chong, 2003. 3hBAC (3-hop between Adjacent Clusterheads): A novel non-overlapping clustering algorithm for mobile ad hoc networks. Proceeding of IEEE Pacific Rim Conference on Communications, Computers and Signal Processing (PACRIM, 2003), 1: 318-321.