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DFA Based QoS-Aware Clustering Approach for Future Prediction and Performance Improvement in MANET

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Abstract: The tremendous usage of mobile nodes in wireless communication medium makes energy efficiency a fundamental requirement of Mobile Adhoc Network. Energy plays a vital role in prolonging the network life time. DFA based QOS Aware Clustering (DFA-QAC) for the Energy-aware Optimized Link State Routing protocol (E-OLSR) is used. This algorithm takes into account the mobility, residual energy of the nodes and gives major improvements regarding the number of elected cluster heads. The objective is to elect a reasonable number of cluster heads which regulates the network traffic and preserving bandwidth. The proposed scheme DFA-QAC uses modified weighted clustering technique which helps to decide the mode of each node. It can able to select the nodes having highest residual energy as a cluster head and able to switch between states. DFA based representation helps to determine the pattern of switching between various states and can able to predict average energy required for cluster formation. Reclustering mechanism helps in electing the new cluster head, when a node has entered or it has just left its cluster. The results of the proposed scheme E-OLSR perform better than the traditional AODV protocol. The performance metrics such as energy consumption. Packet delivery ratio and throughput has been analyzed in the proposed scheme.

Key words: MANETs, clustering, weighted clustering algorithm, reclustering, clustered, DFA, routing

INTRODUCTION

MANET enables users to communicate without any physical infrastructure, regardless of their geographical location. It is self-organizing and adaptive. The device should be able to detect the presence of other devices and perform necessary services. It is the collection of independent mobile nodes that can communicate with others through radio waves. The mobile nodes within radio range can directly communicate whereas others need the intermediate nodes to route their packets. Each node communicates with each other through wireless interface. These networks are fully distributed and can work at any place without help of any fixed infrastructure as base station.

Challenges of MANET:

- Low bandwidth
- Frequent change in topology
- Routing protocol complexity
- Packet losses
- Battery constraints
- Secure communication

Routing protocols: The routing protocols in MANET are commonly classified into three main classes; proactive, reactive and hybrid protocols as shown in Fig. 1.

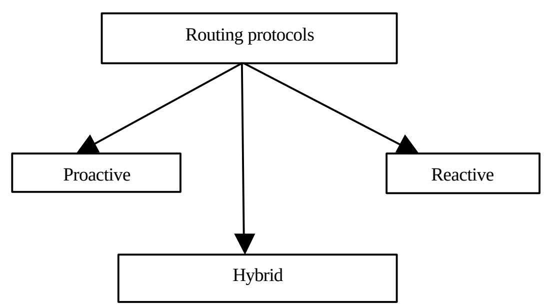

Fig. 1: Classification of MANET routing protocols

Proactive protocols: It is a table-driven routing protocols. Here, routing information are static and they are stored in different table. In this protocol, the topology information are updated frequently.

Reactive protocols: It is a on-demand routing protocol and routes are found when it is required. Currently, there exist many routing protocols for both proactive and reactive type. In this research, we focus on Optimized Link State Protocol (OLSR) (Johnson *et al*., 2007; Perkins *et al*., 2003), energy aware proactive routing protocol (E-OLSR) whose routes are available only when needed. It is a pure link state protocol, so the topological changes cause

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flooding to all available hosts in the network which consumes more power and drain the performance of the network.

The routing process can be improved by electing hierarchical routing which groups nodes as cluster. The clustering approach is employed to reduce the complexity of proactive protocols by partitioning networks into small and manageable areas. It overcomes the drawback of OLSR which generates the largest amount of control messages and preserves bandwidth and energy of mobile nodes.

Literature review: In (Mineno *et al*., 2011), the researchers proposed an integrated protocol for optimized link state routing and OLSR Based localization (ROULA). ROULA's localization is done by using OLSR overhead such as hello packets and routing tables. ROULA chooses the farthest 2-hop node by using a Multi-Point Relay (MPR) nodes. The objective of developing OLSR-L is to achieve parallel routing. The OLSR protocol maintains connectivity information by flooding hello packets. They generate a big amount of routing and control overhead which consumes bandwidth that should be employed by user data traffic (Ahmed *et al*., 2013) instead which leads to a scalability. Since, topology information must reach the whole network, the generated overhead can affect the network performance if more number of nodes are used in the network.

In (Ros and Ruiz, 2007), the researchers proposed a low overhead protocol called Clustered OLSR (C-OLSR). C-OLSR partition the network into clusters which restricts the propagation of topology control messages inside every cluster. The cluster head-based approach of C-OLSR provokes the lowest overhead which results in increased throughput. More bandwidth is available for user data traffic. In this cluster head-centered algorithm, even if the network is error free, chances that these messages reach all the destiny is lower. If the messages are more prone to be lost in the case of the cluster head-based and hybrid approaches, the throughput minimised with respect to the distributed algorithm.

In (Clausen *et al*., 2006), the researcher proposed the dynamic clustering with OLSR (tree clustering). The aim is too optimally to identify the root of trees (heads of the clusters). The network is viewed as a forest, i.e., a collection of logical trees. The OLSR nodes periodically exchange branch messages (in addition to usual OLSR messages) which introduce the routing and communication overhead.

In (Hajam *et al*., 2010), the authors proposed an enhanced solution for ad hoc clustering based on multi-hops and network density. This approach is modeled as framework to manage cryptographic keys in a distributed way. The objective is to elect a reduced and less mobile cluster heads that will serve for key exchange. The node which has more neighbors is selected as the cluster head. This scheme is based on the clustering technique and uses a (k, n) Threshold Secret Sharing Scheme. The criterion for electing cluster heads should focus on a system metric that will engage density, energy and the radio range of each node in the network.

In (Ge *et al*., 2005), the researchers proposed the optimizations to OLSR in order to limit the amount of control traffic generated in hierarchical wireless networks. The Hierarchical OLSR (HOLSR) reduces the protocol overhead and improves the protocol scalability in large size heterogeneous networks. HOLSR dynamically organizes nodes into cluster levels. The significant advantage is a reduction in routing cost and if any link between nodes is broken, only those nodes within that cluster need to recalculate the routing table maintaining other nodes unaffected. At each level, the cluster head searches for other nodes in the network to participate by sending Cluster ID Announcement messages. When a network is clustered, a new message called the cluster Id announcement is periodically sent by cluster heads to declare their leadership.

DFA based QoS aware routing clustering (DFA-QAC): The main objective of the proposed work is to formulate QOS aware clustering approach which elects a reasonable number of cluster heads, based on QoS criteria (energy factor). This approach (Loutfi and Elkoutbi, 2012) aims to regulate the network traffic, minimizing energy consumption and simplify the routing process. When the mobile nodes move out of radio range, links may be broken due of insufficient energy which leads to delays and dropping of information. Reclustering approach can be incorporated into this work to maintain link stability prolonging network lifetime. DFA based representation helps to depict the behavior of mobile nodes participating in cluster formation based on transition states and predicts minimum average energy required to form forthcoming clusters.

The proposed DFA based QOS aware clustering can be used to predict average energy required for upcoming cluster formation dynamically. The list of modules included in the proposed methodology are:

- Modified weighed clustering algorithm
- Selection of energy aware cluster head
- DFA based representation of mobile nodes
- Reclustering mechanism
- Mathematical model

MATERIALS AND METHODS

Procedure for modified weighted clustering formation: Event clustering mechanism is used where an equal number of nodes are taken for cluster formation. Cluster heads are selected based on energy parameter. Cluster Head (CH) is the node which maintains the cluster activities of route discovery and route maintenance. The nodes other than the cluster head inside the clustered architecture are called Cluster Members (CM). Nodes having inter-cluster links which can communicate with more than one cluster are called Gateway Nodes (GN). Nodes send their information only to the cluster head (Aissaa *et al*., 2013) if the destination nodes are within the same. This significantly reduces the routing overhead and also solves the scalability problem. The clustered structure for MANET includes the cluster head, member and gateway respectively.

Clustering is done for a better network lifetime, enhanced stability period, higher number of packet transmission and improved energy efficiency. The search space, bandwidth and power consumption can be reduced. Each node is assigned with weighted value and weights are determined based on given range (Ex = 0.5-1.0 range = cluster 1, 1.1-1.5 range = cluster 2, 1.6-2.0 range = cluster 3. etc).

Step 1: Finding the neighbors of each node 'v' which defines its degree, dv as.

Step 2: The degree-difference, $\Delta v = |dv - \delta|$ for every node v is computed.

Step 3: For every node, compute the sum of the distances, Dv with all its neighbors as.

Step 4: Compute the running average of the speed for every node till current time T. This gives a measure of mobility and is denoted by Sv as. Stability is one of the most important parameters that would change the network topology.

Step 5: Compute the cumulative time, P_v.

Step 6: Calculate the combined weight Wv for each node v, where $Wv = w1\Delta v + w2D_v + w3sv + w4P_v$ where w1, w2, w3 and w4 are the weighing factors. The value of weighting factors are taken in such a way that w1+w2+w3+w4 = 1.

'S_i' denotes is the measure of stability, which is computed by taking the running average speed of every node during a specified time T. 'Δv' is the degree difference which is obtained by calculating the number of neighbors of each node.

The above clustered network can be represented by a directed graph, G(t) = (V, E(t)) wherein V = {1, 2, ..., N} denoting the number of nodes and E(t) = {e1, e2, ..., em} denoting the number of wireless links. There exists a directed edge e(I, j) if node 'i' can receive messages from node j, i.e., node j is the neighbor of node i. Ei (tj) and Ei (tj+1) denote the wireless links situation of node iat two adjacent time points, tjand tj+1. Where θj is the included angle between the vector Ei (tj) and Ei (tj+1), Si denotes the similarity between node i's vicinity situations status.

Selections of cluster head: Each group of clusters consists of cluster head and cluster members and cluster head selection is based upon the QOS Metric such as battery level which increases the network lifetime.

The function of cluster head (Baolin *et al*., 2013) is to control the cluster members and to route the packets. Once the clusters are formed, each node communicates with its neighbor to elect the cluster head. The neighbor sensing mechanism takes place in which each node periodically sends a message to its neighbor within the transmission range. Initially, node energy is set to 100 joules, whenever a node transmits or receives data, its energy level decreases.

The selection of cluster head and cluster members are based on computing average residual energy of the mobile nodes (Loutfi *et al*., 2014). The mobile node which has greatest residual energy are elected as cluster head and others are selected as cluster member. In a Clustered OLSR network. Figure 2, represents that each node can be

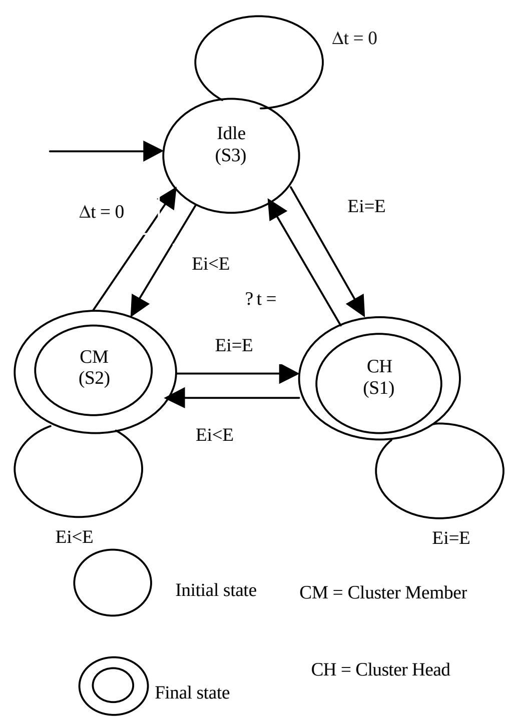

Fig. 2: Transition between modes

in any one of the three states (idle, cluster head and cluster member) and they are represented as Deterministic Finite Automata (DFA).

- Idle state; when nodes just arrived or it has just left its cluster and has no neighbor in its neighborhood
- Cluster Head (CH); node with highest residual energy
- Cluster Member (CM); node with less value of residual energy, when compared to its neighbor. The energy value for each node is calculated based upon the equations E = Max (Ei) where Ei indicates the residual energy of each node
- Parameters; E-Maximum energy, Ei- Residual energy, ∆t-clustering interval (represents the time at which each node restarts the process of criteria calculation)

DFA approach: In every cluster, nodes which take part in routing process may be available in any one of the states and they are represented as DFA.

- Idle (State S3): Node does not have neighbors
- Cluster Member (State S2): Nodes whose residual energy are less compared to neighboring nodes
- Cluster Head (State S1): Nodes whose residual energy is maximum.

The behavior of each state and its transitions from one state to another state is shown in state diagram (Fig. 2). These three states are denoted graphically by circles. It has a finite sequence of input states (Ei<E, Ei = E and ∆t = 0) and produces desired output state. Upon reading the input state, DFA jumps from one state to another. DFA pattern could be used to identify the behavior of the nodes and whose transition of states can be clearly depicted.

During the routing process, if any, of the nodes' energy level changes, then following rules can be used to change from one state to another.

- Rule: 1 if any of the nodes residual energy is greater than 'E'(Ei>E), then the node moves from its original state to cluster head-Pattern 1
- Rule 2: if any of the nodes residual energy is less than 'E' (Ei<E), then the node moves from its original state to cluster member-Pattern 2

Table 1 and 2 reclustered transition table. The transition table shown in Table 1 has three possible states in every cluster. The event clustering mechanism is adopted where an equal number of nodes are taken into account for cluster formation. In this research, 10 clusters are used and in every cluster, nodes with high residual energy is selected as cluster head. The various possible states of each node in every cluster are clearly shown. The input states of the system are Ei<E, Ei = E and ∆t = 0. The output states are S1, S2 and S3 where 'S1' denotes the cluster head, 'S2' denotes cluster member and 'S3' denotes Idle state.

Table 1: Reclustered transition table

Clusters	Nodes	Residual energy (Ei)	Input states Ei<E	Ei = E	∆t = 0
1	0	37.4715	S2	-	-
	1	38.5482	S2	-	-
	2	38.9363	-	S1	-
	3	37.312	S2	-	-
	4	36.6176	S2	-	-
2	5	39.7236	S2	-	-
	6	39.2216	S2	-	-
	7	39.9894	-	S1	-
	8	38.3985	S2	-	-
	9	38.7387	S2		-
10	45	35.9453	S2	-	-
	46	36.1965	S2	-	-
	47	37.2674	-	S1	-
	48	36.0039	S2	-	-
	49	34.0435	S2	-	-
	50	-	-	-	S3

Table 2: Reclustered transition table

Clusters Ei≥E	Nodes	Residual energy (Ei)	Input states Ei<E	Ei≥E
1	0	37.4715	S2	-
	2	38.9363	-	S1
	3	37.312	S2	-
	4	36.6176	S2	-
2	5	39.7236	S2	-
	6	39.2216	S2	-
	7	39.9894	-	S1
	8	38.3985	S2	-
	9	38.7387	S2	-
	1	38.5482	S2	-

Recluster mechanism: During inter clustering mechanism, when a node moves out from the cluster or cluster head changes, they may join in the nearby cluster which alters the states of every node in the cluster. When a new node arrives or leaves the cluster, reclustering takes place at both arrival and departure clusters in order to elect the new cluster head based on the residual energy. Figure 3 shows flow of re-clustered mechanism when a node moves from cluster 'i' or cluster 'j'.

Table 2 shows the reclustered transition table which was occurred when a node in a particular cluster moves and joins in neighboring cluster. Both intra and inter clustering mechanism can be used. From the Table 2, during intra-clustering between cluster 1 and 2, when a node 1 moves from cluster 1-2, its state gets modified by

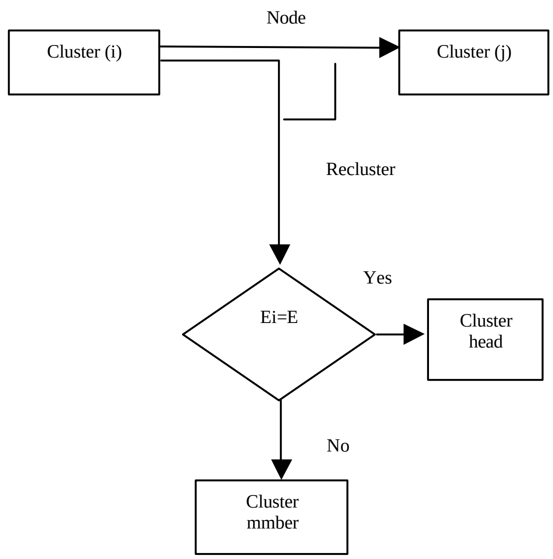

Fig. 3: Reclustered architecture

the cluster head to a cluster member since the residual energy of node 7 in cluster 2 is higher than that of node 1. The modified transition table of cluster 1 and 2 is shown in Table 2.

Mathematical calculation: In this research, we consider the Energy Aware Clustered OLSR networks (E-OLSR) which can enhance the routing performance by grouping nodes as cluster. In this simulation model, 50 nodes are taken into account for performing cluster formation (Node N0 to N49). Event clustering mechanism is adopted where an equal number of nodes are used for cluster formation. Clusters are formed using modified Weighted Clustering procedure. Out of 50 nodes, 10 clusters are formed with each clustering having 5 nodes. The average residual energy of each of the clusters are calculated (Y). The Energy value calculation is based upon the equations E = Max (Ei) where Ei indicates the calculated residual energy of each node (Y). This model elects the cluster head based on greatest residual energy value of the nodes which can regulate the network traffic and minimize the energy consumption (Fig. 4 and 5).

The average energy prediction table is shown in Table 3 which gives average residual energy of each cluster used with node transition state along with DFA pattern. The nodes transition states are represented by 'Node-State'. The DFA pattern is represented by $State^{Node\ Number}$.

For example, in Table 3, the node transition state of Cluster 1 (C1) is N2-S1 N0, N1, N3, N4-S2 where node 2 is elected as Cluster Head (CH) and node N0, N1, N3, N4 are Cluster Members (CM). The DFA pattern of the corresponding cluster 1 is $S1^{N2}S2^{N0}S2^{N1}S2^{N3}S2^{N4}$.

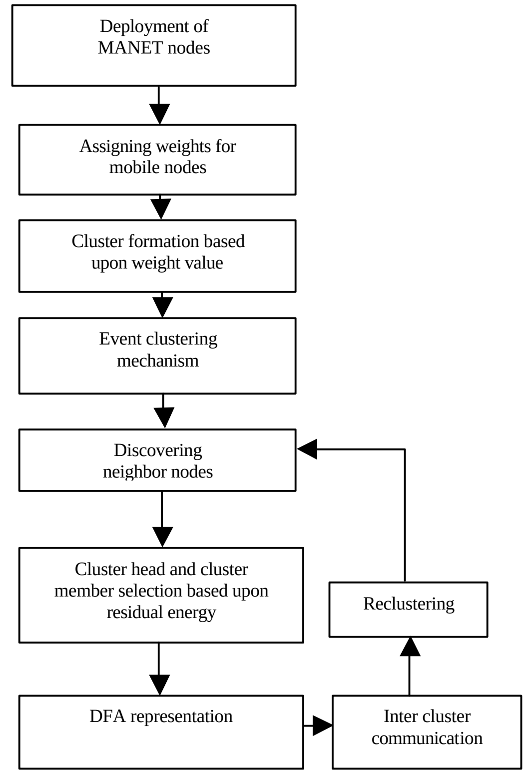

Fig. 4: Procedure for DFA based cluster

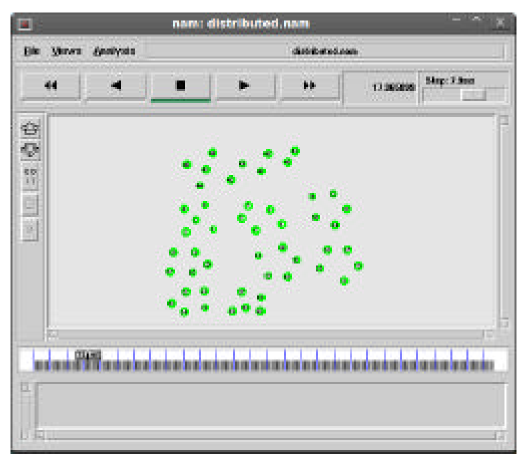

Fig. 5: Node creation

During intra/inter clustering process, when a node moves out from home cluster and joins in neighboring cluster, reclustering approach is used to re-elect the cluster head and members which maintain link stability prolonging network life time. When the mobile nodes move out and attach to the nearby cluster, the DFA

Table 3: Average energy prediction

Clusters	Average residual energy (Y)	X = X-5	XY	X^2	Node transition state	Pattern ($State^{NodeNumber}$)
C1	37.77712	-4	-151.10848	16	N2-S1 N0, N1, N3, N4-S2	$S1^{N2}S2^{N0}S2^{N1}S2^{N3}S2^{N4}$
C2	39.21336	-3	-117.64008	9	N7-S1 N5, N6, N8, N9-S2	$S1^{N7}S2^{N5}S2^{N6}S2^{N8}S2^{N9}$
C3	37.65818	-2	-75.31636	4	N12-S1 N10, N11, N13, N14-S2	$S1^{N12}S2^{N10}S2^{N11}S2^{N13}S2^{N14}$
C4	36.62832	-1	-36.62832	1	N19-S1 N15, N16, N17, N18-S2	$S1^{N19}S2^{N15}S2^{N16}S2^{N17}S2^{N18}$
C5	35.60664	0	0	0	N22-S1 N20, N21, N23, N24-S2	$S1^{N22}S2^{N20}S2^{N21}S2^{N23}S2^{N24}$
C6	36.6548	1	36.6548	1	N25-S1 N26, N27, N28, N29-S2	$S1^{N25}S2^{N26}S2^{N27}S2^{N28}S2^{N29}$
C7	35.4216	2	70.8432	4	N31-S1 N30, N32, N33, N34-S2	$S1^{N31}S2^{N30}S2^{N32}S2^{N33}S2^{N34}$
C8	34.0654	3	102.1962	9	N36-S1 N35, N37, N38, N39-S2	$S1^{N36}S2^{N35}S2^{N37}S2^{N38}S2^{N39}$
C9	35.44744	4	141.78976	16	N43-S1 N40, N41, N42, N44-S2	$S1^{N43}S2^{N40}S2^{N41}S2^{N42}S2^{N44}$
C10	35.89132	5	179.4566	25	N47-S1 N45, N46, N48, N49-S2	$S1^{N47}S2^{N45}S2^{N46}S2^{N48}S2^{N49}$
Sum	364.36418	5	150.24732	85	-	-

pattern of the corresponding cluster is embedded along with the node. This helps for the neighboring cluster to infer the information about the cluster and quickly perform the re-election process. The used parameters in average energy prediction table are”

- ‘Y’; indicates the average residual energy of each cluster N0-N49 represents the naming of mobile nodes used
- S1; denotes the state of mobile node acting as cluster head
- S2; denotes the state of mobile node acting as cluster member
- $State^{Node\ Number}$; indicates the DFA pattern

From the Table 3, the value of:

$$\bar{X} = \frac{\text{Sum of X}}{\text{Total number of clusters}} = 0.5,$$

$$\bar{Y} = \frac{\text{Sum of average residual energy}}{\text{Total number of clusters}} = 36.436418$$

$$b = \frac{\sum XY - n(\bar{X})(\bar{Y})}{\sum X^2 - n(\bar{X})^2} = -0.3870877,$$

$$a = (\bar{Y}) - b\bar{X} = 37.429962$$

$$y = a + bX = 35.1074358$$

From Table 3, future prediction is done for the given network. From the inference of past values taken from cluster 1-10, the future average residual energy can be predicted in advance for the forthcoming cluster formation. The above formula can be used for calculating average residual energy required for forthcoming cluster formation. The Minimum energy required for cluster 11 (C11) is 35.1074358. Similarly to predict cluster 12 (C12) residual energy:

$$\bar{X} = \frac{\text{Sum of X}}{\text{Total number of clusters}} = 0,$$

$$\bar{Y} = \frac{\text{Sum of average residual energy}}{\text{Total number of clusters}} = 36.31560$$

$$b = \frac{\sum XY - n(\bar{X})(\bar{Y})}{\sum X^2 - n(\bar{X})^2} = -0.350724,$$

$$a = (\bar{Y}) - b\bar{X} = 36.31560$$

$$y = a + bX = 34.211256$$

The minimum energy required for cluster 11 (C11) is 35.1074358.

RESULTS AND DISCUSSION

Simulation environment: The evaluations of the protocols are carried out with the network simulator NS-2. The random way point network model is used in the simulation. The simulation parameters have been reported in Table 4. The event clustering mechanism is adopted where equal number of clusters are taken for consideration. The initial energy of the nodes are set to 100 Joules and nodes are distributed in random for routing process to take place. Initially, when number of nodes are

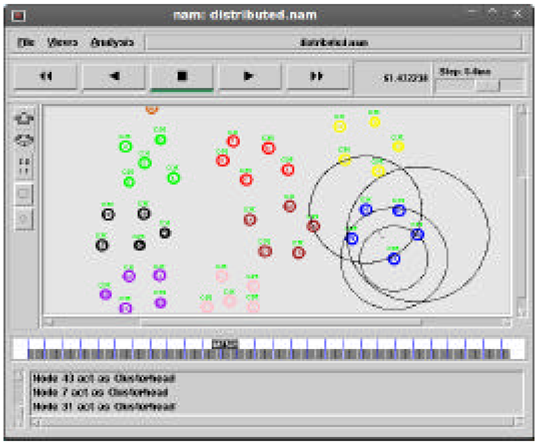

Fig. 6: Cluster head selection

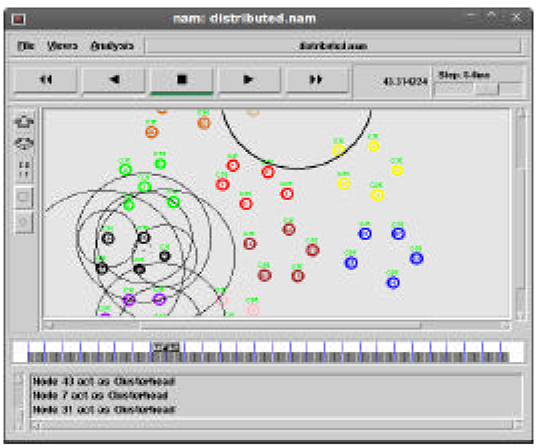

Fig. 7: Intraclustering

Table 4: Parameter value

Parameters	Values
Number of nodes	50
Maximum speed	30 m sec^{-1}
Minimum speed	0 m sec^{-1}
Simulation time	150 s
Traffic type	CBR
Dimension of space	1,250×900 m
Pause time	0 m sec^{-1}
Initial node energy (W)	100 J
Sleep Power	0.1 W
Transition Time	0.003 s
Max Sensing Range	20
Max Transmission Range	40
Power consumption Pr	0.5 W
Power consumption Pt	1.0 W
Power consumption	
Piddle	0.2W
Packet size	512

limited, energy taken by nodes for transmission of packet to destination is maximum. When number of nodes increases, distance between nodes are decreased and energy taken for transmission is minimum.

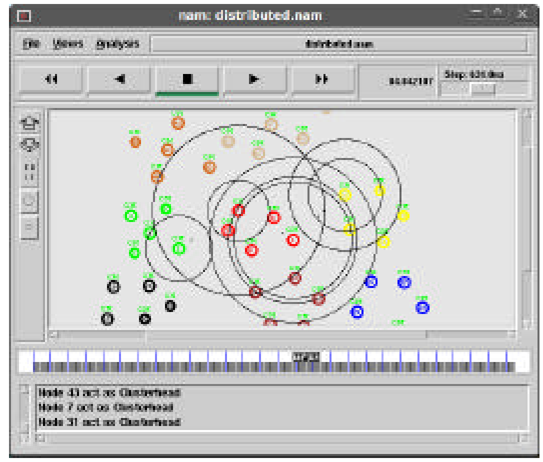

Fig. 8: Interclustering

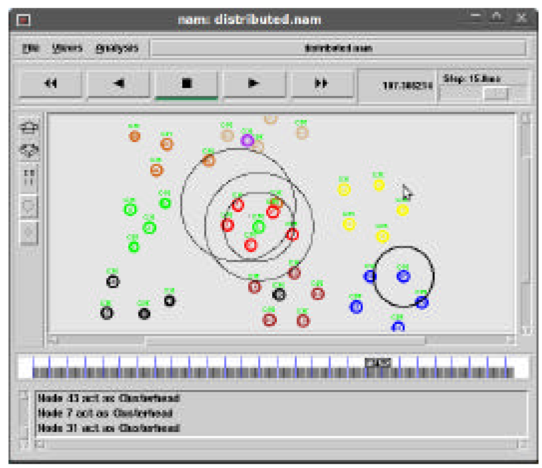

Fig. 9: Reclustering

Cluster formation: Figure 5, represents the group formation based on the weighted value of each node.

Cluster head selection: Figure 6, represents the different group of clusters with cluster head and cluster members. The cluster head is elected based on the residual energy level of the nodes.

Clustering: Figure 7, represents the intraclustering process where data communication takes place within the cluster. Figure 8, represents the interclustering mechanism where data communication takes place with other clusters.

Figure 9, represents the reclustering, mechanism which occurs, when the new node arrives or old node leaves from home cluster and joins in other cluster. Figure 10, represents the change of mode or states of every node in the cluster group. Figure 11, represents the final clusters after re-clustering process.

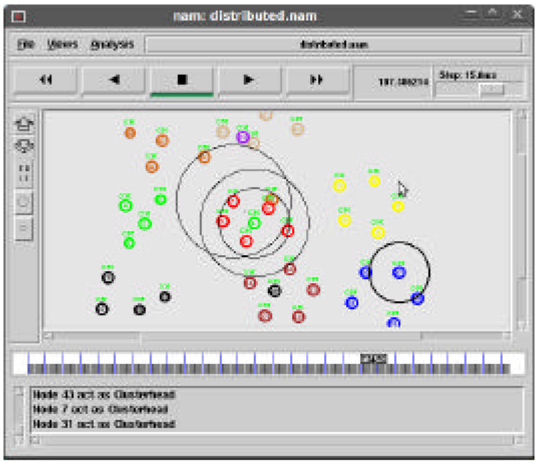

Fig. 10: Change of mode

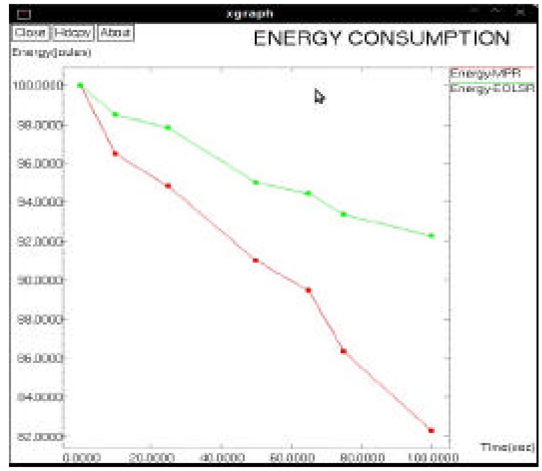

Fig. 12: Energy consumption

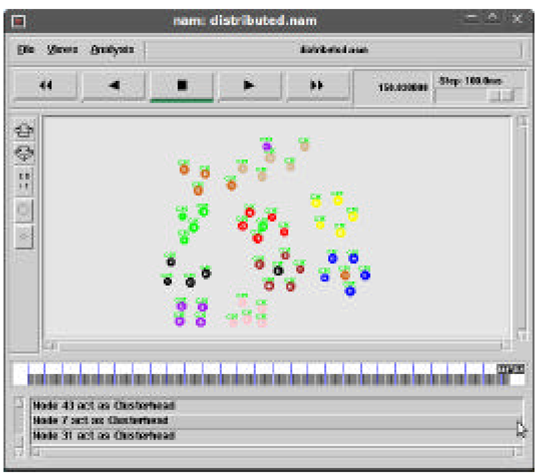

Fig. 11: Final clusters

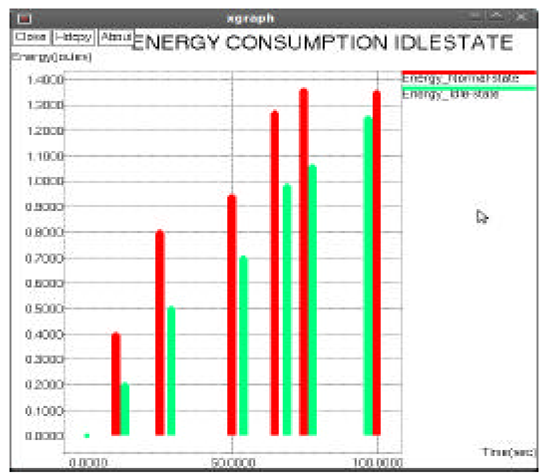

Fig. 13: Energy consumption on idle state

Performance analysis: The Quality of Service (QOS) denotes the level of a service offered by the network to the user. The QoS parameters considered in this work are

- Energy
- Packet delivery ratio
- Throughput

Energy consumption: Energy plays vital role in improving the network lifetime. In this research, energy is the main factor which is considered and the objective is to minimize energy consumption. Hence, the variations are found by considering this energy parameter by using the energy awk script. Initially, the energy for each node is fixed. Each node energy decreases during the transmission of packets. Finally, the residual energy of each node is calculated. The residual energy results in remaining energy of each node after the transmission of packets based on the request and reply.

Figure 12, represents the energy consumption of node at particular time interval. X-axis = time (sec), Y-axis = Energy (Joules). It is calculated by using the equation $Ei(t) = Ei(t-\Delta t)-eitotal(\Delta t)$. The energy consumption is computed for Multi Point Relay (MPR) and Energy OLSR (E-OLSR). Since, the transmission of data packets is carried out through the cluster head, Energy OLSR results in less energy usage when compared to MPR as shown in Fig. 12. In E-OLSR, the node with the highest residual energy iselected as cluster head which takes part in the propagation of routing update or control messages. This decreases the routing overhead and solves the scalability problem. Figure 13, represents the energy consumption of node on idle state at particular

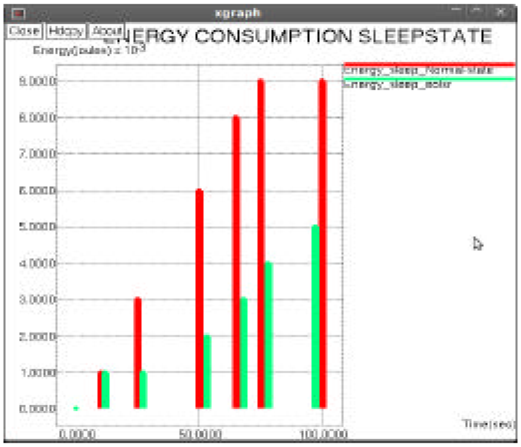

Fig. 14: Energy consumption on sleep state

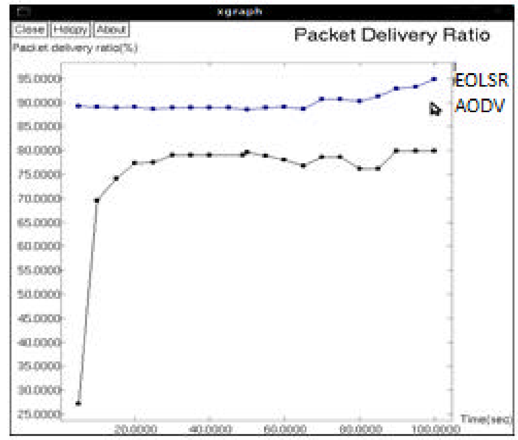

Fig. 16: Packet delivery ratio

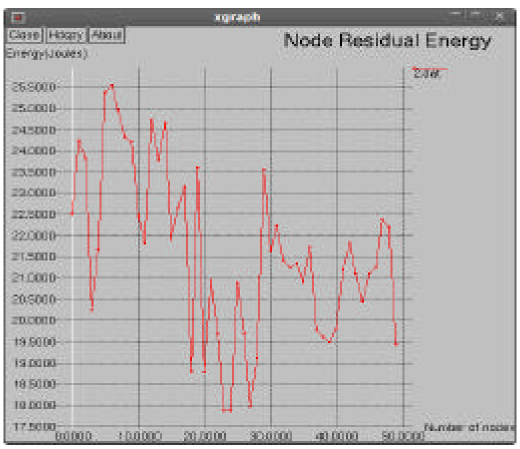

Fig. 15: Energy consumption sleep state

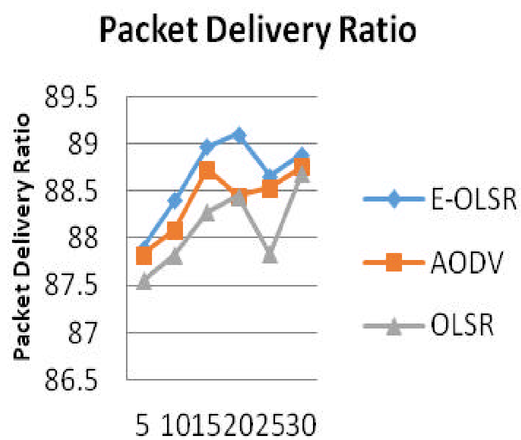

Fig. 17: PDR between AODV and E-OLSR

time interval. X-axis = Time (Sec), Y-axis = Energy (joules). Figure 14, represents the energy consumption of node during sleep state at particular time interval. X-axis = Time (sec), Y-axis = Energy (Joules).

Figure 15 shows the node residual energy which is obtained by varying the initial energy. The initial energy is set to 100 joules and 50 nodes are taken. From the Figure 15, the variation of residual energy of the nodes is shown.

Packet delivery ratio: It is calculated as the ratio between numbers of data packets successfully received by the number of data packets sent by the source nodes. The higher the packet delivery ratio is the more data packets are being delivered to the higher layers. In Fig. 16, X-axis represents time in sec and Y-axis represents the packet delivery ratio. Under the same network conditions, E-OLSR provides better packet delivery ratio compared to MPR.

From the Fig. 16, Energy-aware Optimized Link State Routing (E-OLSR) outperforms AODV (Perkins *et al*., 2003) in terms of PDR by maintaining its high values for all possible pause time. It is been observed from the result that the packet delivery ratio of optimized link state routing improves by some margin when the number of nodes is increased to 50.

Comparative simulation between E-OLSR and AODV: The performances of ad-hoc on demand distance vector, energy-aware optimized link state routing are analyzed on the basis metrics like throughput and packet delivery ratio. This analysis was made while varying the value of pause time parameter.

Packet delivery ratio: It is the ratio of actual packet delivered to total packets sent. Table 5 shows the PDR for AODV and E-OLSR protocols.

Table 5: PDR between AODV and E-OLSR

Pause time	E-OLSR	AODV	OLSR
5	87.9	87.83	87.55
10	88.4	88.09	87.83
15	88.97	88.73	88.28
20	89.1	88.45	88.45
25	88.66	88.54	87.84
30	88.89	87.56	89.23

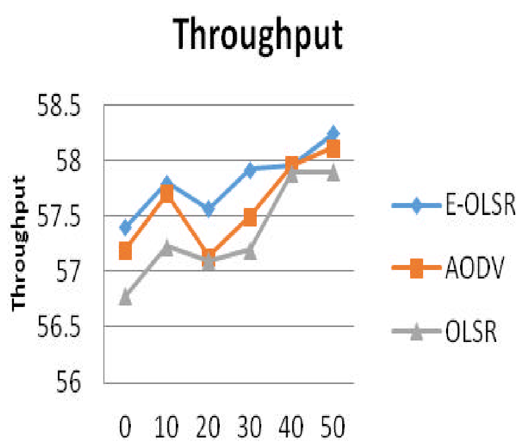

Fig. 18: Throughput between AODV and OLSR

Throughput: It is the ratio of a total number of packets received to the number of packet transmitted per unit time. From the Fig. 18, the throughput for Energy aware Optimized Link State Routing (E-OLSR) was the best even when the number of nodes increases. It increases gradually and linearly when compared to AODV. Hence, they outperform better than reactive protocols in these respects. These protocols show consistency in their throughput values, especially Optimized Link State Routing which was rarely effected by changes in pause time or number of nodes.

CONCLUSION

Clustering results in dividing an ad hoc network into several areas for performance and scalability issues. The solution proposed in this research which enables the clustering for OLSR networks without causing any change in the structure of control messages. Energy-aware clustering approach is used for improving the performance of ad-hoc network. DFA representation is used where the behavior of each node and the transition of states in different clusters with different simulation time is shown. Reclustering mechanism helps in electing new cluster head when a node moves from one cluster to another cluster during routing process. Finally, based on the past inferred value, future prediction can be done where average residual energy required is calculated for forthcoming cluster formation. In order to ensure security, secure aware clustering algorithm can be incorporated into this work to provide the secure transmission of data. The work can be extended by including optimization technique for efficient routing. This will improve the overall efficiency of wireless networks.

REFERENCES

Ahmed, L., E. Mohammed, B. Jalel and A. Kobbane, 2013. An Energy Aware Algorithm for OLSR Clustering. Springer, Berlin, Germany, pp: 201-207.

Aissa, M., A. Belghith and K. Drira, 2013. New strategies and extensions in weighted clustering algorithms for mobile ad hoc networks. Procedia Comput. Sci., 19: 297-304.

Baolin, S., C. Gui, Y. Song and C. Hu, 2013. Stable clusterhead selection algorithm for Ad Hoc Networks. Int. J. Future Gener. Commun. Networking, Vol. 6,

Clausen, T., C. Dearlove and P. Jacquet, 2006. The Optimized Link State Routing Protocol. Ver. 2, Academic Press, USA..

Ge, Y., L. Lamont and L. Villasenor, 2005. Hierarchical OLSR-a scalable proactive routing protocol for heterogeneous ad hoc networks. Proceeding of the IEEE International Conference on Wireless and Mobile Computing, Networking and Communications WiMob-2005, August 22-24, 2005, IEEE, Ottawa,Canada, ISBN:0-7803-9181-0, pp: 17-23.

Hajam, A., K. Oudidi and M. Elkoutbi, 2010. A distributed key management scheme based on multi hop clustering algorithm for MANETs. Int. J. Comput. Sci. Network Secur., 10: 39-49.

Johnson, D., Y. Hu and D. Maltz, 2007. The dynamic source routing protocol (DSR) for mobile ad hoc networks. IPv4, rfc4728. http://tools.ietf.org/html/rfc4728.

Loutfi, A. and M. Elkoutbi, 2012. Optimizing the process of OLSR clustering based on mobility and density in Ad hoc networks. Proceeding of the 2012 International Conference on Multimedia Computing and Systems (ICMCS), May 10-12, 2012, IEEE, Rabat, Morocco, ISBN:978-1-4673-1520-3, pp: 522-526.

Loutfi, A., M. Elkoutbi, J. BenOthman and A. Kobbane, 2014. An energy aware algorithm for OLSR clustering. Ann. Telecommun., 69: 201-207.

Mineno, H., K. Soga, T. Takenaka, Y. Terashima and T. Mizuno, 2011. Integrated protocol for optimized link state routing and localization: OLSR-L. Simul. Modell. Pract. Theor, 19: 1711-1722.

Perkins, C.E., E. Belding-Royer and S. Das, 2003. Ad hoc on-demand distance vector (AODV) routing. IETF Internet Draft.

Ros, F.J. and P.M. Ruiz, 2007. Cluster-based OLSR extensions to reduce control overhead in mobile ad hoc networks. Proceedings of the 2007 International Conference on Wireless Communications and Mobile Computing, August 12-16, 2007, ACM, New York, USA, ISBN:978-1-59593-695-0, pp: 202-207.