Energy Aware Routing Protocol for Network Performance Optimization in MANET

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ABSTRACT
In Mobile ad hoc network (MANET) all nodes are battery operated, as battery power or batter energy is limited resource therefore it requires special attention to minimize energy consumption in MANET. For MANETs, optimization of energy consumption has greater impact as it directly corresponds to lifetime of networks. The various factor related to of energy consumption include transmission power, receiving power, overhearing of nodes, packet size, random topology, idle state of nodes. In the present work has done to minimize energy consumption by making cluster head in network and provide medium access control (MAC) layer control approach to minimize energy consumption at idle/overhearing state of node. An algorithm is developed to achieve this goal which break ad hoc network into clusters and limit degree of node, uses energy efficient route to provide maximum throughput of network as compared to other protocols.

Keywords
MANET, energy consumption, idle state, MAC layer, cluster head**.**

1. INTRODUCTION
An Ad hoc network is capable of operating autonomously and is completely self-organizing and self-configuring. Therefore, it can be rapid and easily deployable. Another important property of an Ad hoc network is multi-hop capability. Unlike the cellular networks, which are single –hop wireless networks, an Ad hoc Hoc network does not guarantee that a mobile node can directly communicate with destination mobile node all the time. A mobile node, which lies outside the transmission of its specific destination node, would need to relay its information flow through other mobile nodes. This implies that mobile nodes in Ad hoc networks bear routing functionality so that they can act both as routers and hosts.

Since all nodes in ad hoc network are battery operated which is scare source of energy for communication, a power efficient routing protocol is required to minimize energy consumption of entire network and improve the lifetime of it.

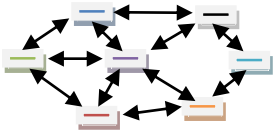


Fig.1. Mobile Ad hoc NETwork

A mobile ad hoc network is a dynamic distributed system of wireless mobile nodes in which node can move in any direction independent of each other. The mobile nodes in such network can communicate with each other through direct wireless link or multi-hop routing, which are different from wired network routing protocol. Ad hoc routing protocol broadly can be categorized into pro-active and on-demand routing protocol [3]. At one end are the table-driven or proactive routing protocols such as the Destination Sequenced Distance Vector (DSDV) routing protocol, Wireless Routing Protocol (WRP) which exchanges routing information periodically and generates the routing table in advance of route request [2], at the other end, on-demand or reactive protocols such as Dynamic Source Routing (DSR) protocol and the Ad hoc On-demand Distance Vector (AODV) routing protocols, which select route on demand.

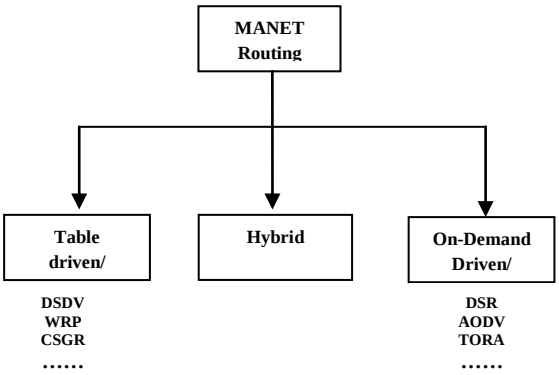
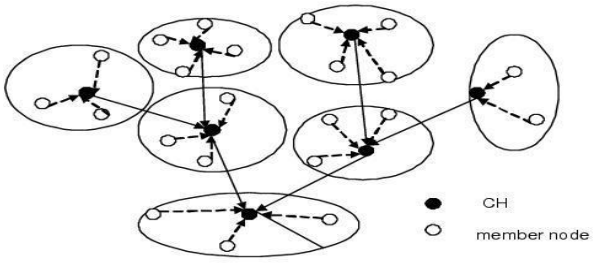


Fig.2. Classification of MANET routing protocols

In large network flat routing schemes produces an excessive amount of information that can saturate the network [6], therefore breaking a large network into small groups (partitioning network) forms a cluster. This technique provides a hierarchical routing path between clusters instead of between nodes. This increases the routes lifetime, thus decreasing the amount of routing control overhead. Inside the cluster one node that coordinates the cluster activities is cluster head (CH). Inside the cluster, there are ordinary nodes also that have direct access only to this one cluster head, and

gateways. Gateways are nodes that can hear two or more cluster heads. [6]. Khalid Hussain et al [4] suggested Probability Based Adaptive Invoked Weighted Clustering algorithm (PAIWCA) for Cluster Head (CH) selection for enhance the stability of the network by taking battery power of the node into consideration for selecting cluster head and for forming clusters.[4] Ratish Agarwal et. al. [4] suggest Connectivity, energy, mobility driven clustering algorithm (CEMCA) which suggest that election of cluster head is based on the combination of several significant matrices such as: lowest node mobility, the highest node degree, the highest battery energy and best transmission range. This algorithm is completely distributed and all nodes have the same chance to act as cluster head.



As mobile nodes are connected to each other, so nodes are free to transmit and receive the data packet to or from other nodes and require energy to such activity. A node in wireless network can be in transmission, reception, idle and overhearing mode. In transmission and receiving mode node transmit and receive data packets, respectively. In idle/listen, overhearing mode nodes actually waste energy due to they still listen medium though data packets are not intended for them and they are in the range of other node transmission/receiving medium.

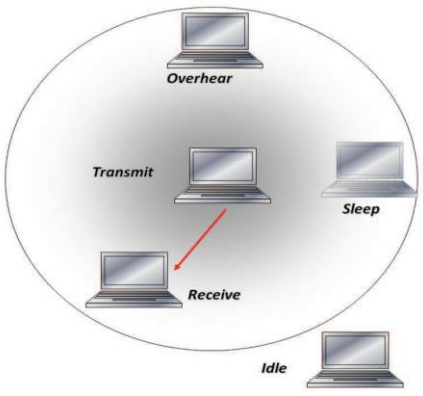


Fig.4. Energy consumption in a wireless network [5]

Typical values of consumption for a wireless interface measured for a Lucent Silver Wavelan PC Card are mentioned in Table 1. Where StatePower indicates state of mobile device, variable indicates states notation and value of energy in watt.

Table 1. Energy Consumption at various modes

StatePower	Variable	Value (in watt.)
Transmit	P_{tx}	1.3
Receive	P_{rx}	0.9
Idle	P_{idle}	0.74
Sleep	P_{sleep}	0.047

Equation to calculate energy cost [7] is

$$Cost_{tx}(i) = E_{tx} + n * E_{rx} \quad (1)$$

Where E_{tx} represent energy dissipated in transmission of one packet and E_{rx} represent energy dissipated in receiving of one packet and n represents the numbers of non sleeping nodes belonging to the interference zone of the transmitter i.

2. TECHNIQUE

In order to evaluate the energy cost of MANET we will design following matrices.

i. choose n number of clusters with n cluster head each associated with routing matrix of order n x 5 namely RM(,).

ii. Choose m number of slave nodes associated with each cluster head with residual energy matrix of order n x 2 namely REM(,)

iii. Choose n number of cluster head in with their residual energy nodes of order n x 2 namely CRM (,).

iv. Choose n cluster head each having degree of nodes Matrix of order n x 2 namely DM (,).

2.1 Algorithm

➢ **TO SETUP A NETWORK**

1) Selection of Cluster Head which has less mobility, max degree of nodes and max residual battery energy by broadcasting a message by all nodes. XU Li et al. proposed a Mobile balancing based clustering algorithm (MLCA) [8].

2) Select gateway node (nodes that connect all other cluster heads) using MLCA algorithm [3].

3) Send message to go in sleep mode by all cluster heads to their slave nodes using MAC layer mechanism using power-aware (MAC) protocols. The IEEE 802.11 standard for wireless LANs includes power control management[7]

```
For all nodes in cluster
    If mode of node = = ACTIVE
        Set mode = SLEEP
    End if
End for
```

➢ **TO DATA PACKETS TRANSMISSION**

1) If Source node has data to send to destination_ node, source_ node send signal message to its cluster head.

2) Cluster head consult with its routing table

```
Initially SET FLAG =00
For all nodes in RT
    If NODE == destination_ node then
        SET FLAG =01
        If destination_ node mode = SLEEP then
            SET destination_node mode = ACTIVE
            Exit For
        End if
    End if
End for
```

3) If (FLAG ==01) AND (destination_node mode==ACTIVE) then

Send RREP message to source_node
Initiate data transfer between source_node and destination_node
Else
Goto step 4
End if

4) If FLAG ==00 then
Forward signal message with FLAG VALUE 10 to neighbor Cluster head
For all nodes in foreign cluster head RT
If NODE == destination_ node then
SET FLAG =11
If destination_ node mode = SLEEP then
SET destination_node mode = ACTIVE
Exit For
End if
End if
End for
End if

5) If (FLAG ==11) AND (destination_node==ACTIVE) then

Send RREP message to source_ cluster_head_ node
Initiate data transfer between source_node and destination_node using AODVEA [8].

End if

3. IMPLEMENTATION

Consider a wireless ad hoc network consisting a set C = c1, c2, c3, c4 of 4 cluster heads having a set of slave nodes. These Cluster heads and slave nodes combination has been stored in a squared node set matrix, NSM (,)

$$\text{NSM}(,) = \begin{array}{c} \\ C1 \\ C2 \\ C3 \\ C4 \end{array} \begin{array}{c} \begin{array}{cccc} n1 & n2 & n3 & n4 \end{array} \\ \begin{bmatrix} 1300 & 1200 & 1500 & 1400 \\ 1300 & 1200 & 1500 & - \\ 1400 & 1100 & 1500 & - \\ 1400 & 1100 & 1500 & 1500 \end{bmatrix} \end{array}$$

The graphical representation of combination of cluster head and slave nodes is shown in figure.

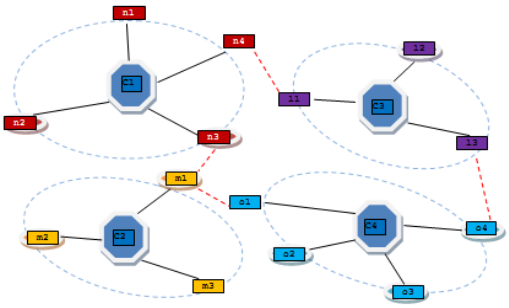


Fig 5. MANET with four Cluster Head

Cluster node's energy (in Jule), Hop count for different nodes, distance (in ft.) and sequence number is also known and mentioned in Routing Matrix RM (,) of order 4 x 5.

Cluster node	Energy (J)	Hop Count	Disance(ft.)	Seq#
C1	2000	0	0	S_1001
C2	2500	3	40	S_1002
C3	3000	4	50	S_1003
C4	2700	3	35	S_1004

In ad hoc Environment, some nodes of each cluster connected through Gateway nodes. In this paper 1 represents the connection with node of another cluster and 0 represent that node has no connection from one node to another node of different cluster. Connection values of each cluster and node is known and mentioned in squared connection value matrix CVM (,) of order 4.

$$\text{REM}(,) = \begin{array}{c} \\ c1 \\ c2 \\ c3 \\ c4 \end{array} \begin{bmatrix} 0 & 0 & 1 & 1 \\ 1 & 0 & 0 & - \\ 1 & 0 & 1 & - \\ 1 & 0 & 0 & 1 \end{bmatrix}$$

4. EVALUATION

Evaluation of Energy Consumption during transmission of one packet in MANET, this research paper will discuss two cases of packet transmission, one is communication between nodes within cluster i.e. Intra-Cluster Communication and another is communication between nodes having different cluster head i.e. Inter-Cluster communication.

4.1 Intra-Cluster Transmission

In order to evaluate the cost of energy consumption in MANET, this research paper has taken two scenario. In first case, the cluster head C2, in which slave node Source node m1 want to send data packet to destination node m2. This scenario is treated as Intra-Cluster transmission. node m2 is 2 hop count away from m1 and transmission will follow route $m1 \rightarrow C2 \rightarrow m2$. This route is having 4 interfering nodes, therefore total transmission cost 3.426mW and total receiving cost including overhearing of nodes 5.930mW therefore Total energy cost become 9.356mW.If same communication will occur using algorithm implemented then total energy cost of transmission become 5.789mW which show approx 61% of reduction in cost.

4.2 Inter-Cluster Transmission

Now, in second case Source node n1 in cluster head C1 want to send data packet to destination node l3 which is in cluster head C3.This scenario is treated as Inter-Cluster communication. Using minimum hop count, node n1 is 5 hop counts away from l3 node and transmission will follow route $n1 \rightarrow n4 \rightarrow l1 \rightarrow C3 \rightarrow l3$, this route is having 10 numbers of interference nodes include gateway node n4 and l1. Without using algorithm this transmission cost 6.852mW as total energy transmission cost and 11.860mW total energy receiving cost for all participating nodes. Total energy cost incur for inter-Cluster communication will be 18.712mW. If same communication will be performed by using algorithm then total energy cost will be 11.568mW which show approx 62% of reduction in energy cost.

Table 2.0 Intra-Cluster Communication

Hop Count	Source node	Destination node	Total transmission cost (mW)	Total interference nodes	Total receiving cost (mW)	Total energy cost(mW)	Remark
2	m1	m2	3.426	4	5.930	9.356	Without Algorithm
2	m1	m2	3.426	0	2.372	5.789	With Algorithm

Table 3.0 Inter-Cluster Communication

Hop Count	Source node	Destination node	Total transmission cost (mW)	Total interference nodes	Total receiving cost (mW)	Total energy cost(mW)	Remark
5	n1	l3	6.852	10	11.860	18.712	Without Algorithm
5	n1	l3	6.824	0	4.744	11.568	With Algorithm

5. CONCLUSION

Here we have taken the problem, in which the four cluster head are involved with their slave nodes which formed MANET. This model is implemented in pseudo code and test for two type of communication, one within cluster and another outside cluster; in both cases energy cost is lesser than without using algorithm.

6. REFERENCES

[1] A Review of Power Conservation in Wireless Mobile Adhoc Network (MANET), Neeraj Tantubay ET AL., IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 4, No 1, July 2011.

[2] P. Johansson, T. Larsson, N. Hedman, B. Mielczarek, and M. Degermark, Scenario-based performance analysis of routing protocols for mobile ad-hoc networks, In Proceedings of the ACM/IEEE International Conference on Mobile Computing and Networking, pages 195–206, August, 1999.

[3] J. Broch, D. Maltz, D. Johnson, Y. Hu, and J. Jetcheva, A performance comparison of multi-hop wireless ad hoc network routing protocols, In Proceedings of the ACM/IEEE International Conference on Mobile Computing and Networking, pages 85–97, October, 1998.

[4] Research Article, Efficient Cluster Head Selection Algorithm for MANET, Khalid Hussain et al, Hindawi Publishing Corporation Journal of Computer Networks and Communications Volume 2013, Article ID 723913, 7 pages.

[5] Energy Issues and Energy aware Routing in Wireless Ad-hoc Networks, Marco Fotino and Floriano De Rango, University of Calabria, Italy.

[6] Survey of clustering algorithms for MANET, International Journal on Computer Science and Engineering Vol.1 (2), 2009, 98-104.

[7] Evaluating the Energy-Consumption Reduction in a MANET by Dynamically Switching –off Network Interfaces, Juan-carlos Cano and Pietro Manzoni, Camino de vera, S/N – 46071 Valencia, SPAIN

[8] Energy Aware Routing in Ad Hoc Networks, Radhika D. Joshi, priti P. rege, 6th WSEAS International Conference on CIRCUITS, SYSTEMS, ELECTRONICS, CONTROL & SIGNAL PROCESSING, Cairo, Egypt, Dec 29-31, 2007.

[9] Evaluation of the Energy Consumption in MANET, Geraud Allard et. al., Feb 2006.

[10] http://www.secs.oakland.edu/~shu/research.htm [07 may 2014]