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A Reactive Energy-Alert Algorithm for MANET and Its Impact on Node Energy Consumption

Shilpa Bade
Symbiosis Institute of Technology
Pune

Meeta Kumar
Symbiosis Institute of Technology
Pune

Pooja Kamat
Symbiosis Institute of Technology
Pune

ABSTRACT
Mobile Ad-hoc networks (MANETs) are self organized networks whose nodes are free to move randomly while being able to communicate with each other without the help of an existing network infrastructure. In MANET, the routing protocols have to route the packets depending on the MANET constraints such as battery power in addition to the shortest path. The limited battery supply to mobile node in MANET requires that the routing protocols utilize power efficiently and thus maximize the network life time. The energy aware deterioration in ad hoc networks is a very important aspect of the overall management of ad hoc networks. In this paper, the focus is on the reactive power-alert technique for communication between ad hoc network nodes by continuously alerting their energy status to neighbor nodes. Here the concentration is on reducing the energy consumption by proposing optimal path selection method. In this scheme a threshold value is set on the energy consumed by mobile nodes in ad-hoc network. If the energy level of any node/s in the network reaches a threshold level then such nodes are made inactive and inform other nodes not to establish connections with it in this sleep state. In this paper, experimental results and a comparative analysis are presented based on the use of this threshold. The result shows significant improvement in the throughput and routing load which in turn increases the lifetime of the network.

Keywords
MANETs, Routing, Energy Efficiency Metrics, AODV Protocol

1. INTRODUCTION
Ad hoc wireless networks are power constrained since nodes operate with limited battery energy. If some nodes die early due to lack of energy, they cannot communicate with each other. Therefore, inordinate consumption of nodes' energy should be prevented. In fact, nodes energy consumption should be balanced in order to increase the energy awareness of networks. In the next section an energy aware deterioration routing (EADR) algorithm is proposed to make an ad-hoc network aware about the energy of its nodes. The proposed scheme recognizes the unfaithful nodes and removes the problem of sudden loss of session. Further it can also be used to extend useful service life of the network if the proposed method is used in conjunction with AODV protocol [1]. Ad hoc On Demand Distance Vector (AODV) is simple, efficient reactive routing protocol [2] used for MANETs which do not have fixed topology. In order to address the energy efficiency issues in the communications within Ad hoc networks, it is important to understand the energy model which represents the power consumption behavior in the ad hoc network node wireless interfaces. Several studies have dealt with measuring energy consumption in the wireless interfaces [3] of mobile nodes, to determine the exact sources of energy consumed there. These studies examined the different modes of operation of the wireless interfaces. A mobile node's wireless interface consumes energy while communicating with other nodes and also during idle mode, i.e. when the node is listening to the medium but not handling packets. The ways of energy consumption that may exist are discussed below. Energy is consumed while sending a packet which forms the largest source of energy consumption of all modes. Energy is consumed while receiving a packet. An idle node which is not a part of communication still consumes a considerable amount of energy. Idle energy is a wasted energy that should be eliminated or reduced through energy-efficient schemes [4]. When the wireless interface of the mobile node is turned off even then energy is consumed. Routing a packet from a source to a destination in an ad hoc network involves a sufficient number of intermediate nodes. Hence, battery power of a node is a precious resource that should be used efficiently in order to avoid early termination of a node or a network. Thus, energy aware routing is an important issue in such networks.

This paper addresses the issue of energy-conserving routing protocols in ad hoc networks of mobile hosts. We suggest a power-aware routing algorithm that focuses on energy aware communications between ad hoc network nodes. The following metrics are utilized: received signal strength, link quality and the distance between the nodes to compute the energy required to transmit the data from a node to its neighboring node. The energy computed is involved in the selection of the optimal path which requires minimum energy to route the data from source to destination. In the experimental setup, to evaluate nodes' performance relative to each other, the following performance metrics have been used: PDR (Packet delivery ratio), Average packet latency, Routing load, Network size, Network area dimensions and Node energy parameters.

PDR: ratio of the data packets received at the destination nodes to the packets that were sent by the sources.

Average packet latency: includes all the delays encountered by the packet at the different hops from the time it was sent by the source until the time it was received at the destination.

Routing load: number of routing packets (and supporting protocol control packets) transmitted per data packet delivered at the destination.

Network size: Measured in the number of nodes.

Network area dimensions: This also includes the shape of the area.

Node energy parameters: This depends on whether an energy efficient algorithm is in use and generally includes parameters such as sleep times, frequency of the sleep state, number of sleeping nodes at a time, etc.

2. RELATED WORK

The problem of energy awareness in MANETs can be addressed at different layers. Many researchers [5, 7] have addressed the problem of optimizing the energy consumption in mobile nodes. Also presented below is a brief review of work carried out by some authors on energy awareness in MANETs.

Node Alarming Mechanism (NOAL) [6]-In this technique the authors suggest that an intermediate node having low energy, would alarm its status to the others. By notifying its energy status to others, it can prevent others from sending more data to itself, which stops consuming more energy by forwarding data packets.

Low energy Routing Protocols-Here the authors propose a new scheme that uses sub-optimal paths occasionally to provide substantial gains [5]. Multiple paths are found between source and destinations, and each path is assigned a probability of being chosen, depending on the energy metric. Every time data is to be sent, one of the paths is randomly chosen depending on the probabilities; hence none of the paths is used all the time, preventing energy depletion.

[7] suggests a GPS-based Routing Algorithm method that makes use of the location dependent position information to route packets with the minimum required transmit energy. The key requirement of this technique is that the relative positions of nodes are available to all nodes.

Minimum Energy Routing [8, 9,10] -This method proposes an on-demand routing algorithm[11] which trades off more routing overhead for lower total energy. It is based on minimizing the amount of energy per bit required to get a packet from source to destination.

Battery cost-aware routing- The author[12] proposes power-aware routing that maximizes the lifetime of ad-hoc mobile networks, by evenly distributing power consumption rate of each node and by minimizing overall transmission power for each connection request. He proposes a Minimum battery cost routing algorithm that minimizes the total cost of the route. It minimizes the summation of inverse of remaining battery capacity for all nodes on the routing path. Whereas Min-Max battery cost routing algorithm is a modification of minimum battery cost routing. This metric always tries to avoid the route with nodes having the least battery capacity among all nodes in all possible routes. The Conditional Max-Min battery capacity routing algorithm chooses the route with minimal total transmission power if all nodes in the route have remaining battery capacities higher than a threshold; otherwise routes including nodes with the lowest remaining battery capacities are avoided.

Lifetime Prediction Routing (LPR) [13, 14] is an on demand source routing protocol that maximizes the network lifetime by finding routing solutions that minimize the variance of the remaining energies of the nodes in the network. This uses battery lifetime prediction and favors the path whose lifetime is maximum. In Lifetime Prediction Each node tries to estimate its battery lifetime based on its past activity.

Localized Energy-Aware Routing (LEAR) [6, 15] achieves a trade-off between balanced energy consumption and shortest routing delay, and at the same time avoids the blocking and route cache problems. This algorithm grants each node in the network, permission to decide whether to participate in route searching, which thus spreads the decision making process among all nodes. When a routing path is searched for, each mobile node relies on local information of remaining battery level to decide whether to participate in the selection process of a routing path or not. Table 3 shows key techniques/ findings from some related papers.

It was observed that the previous work does not particularly address the issue of detecting unfaithful nodes (which run out of battery). In the paper, experimental results for a technique of EADR algorithm with AODV protocol have been put forward. This technique identifies the unfaithful nodes & stops other nodes from establishing connection with them, so that the routing load will be minimized.

3. PROPOSED METHOD

3.1 Energy Aware Deterioration Algorithm (EADR Algorithm)

In this energy aware deterioration algorithm [16], a threshold value is set on the energy consumed by mobile nodes in a network. This threshold value for experimental setup has been set to as 10% of total battery life. If the energy level of any node/s in the network reaches to threshold then such nodes are removed from any communication in the network and are set to inactive. Let the Threshold energy 'Q' be 10% of initial energy 'E'. Based on the Remaining Battery life and the radio range, a decision to establish a connection or not, is made. If, however, the energy of mobile node 'E' reaches the threshold 'Q' then that node stops its working & goes into a sleep mode.

In proposed algorithm the route establishment and data delivery procedure depends on the threshold value. EADR algorithm can be considered to have two main functional units [16] as shown diagrammatically in fig 1.

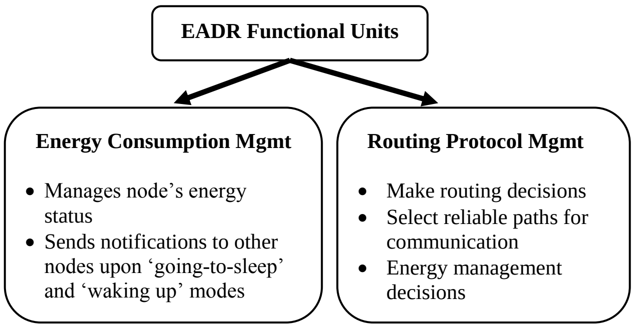
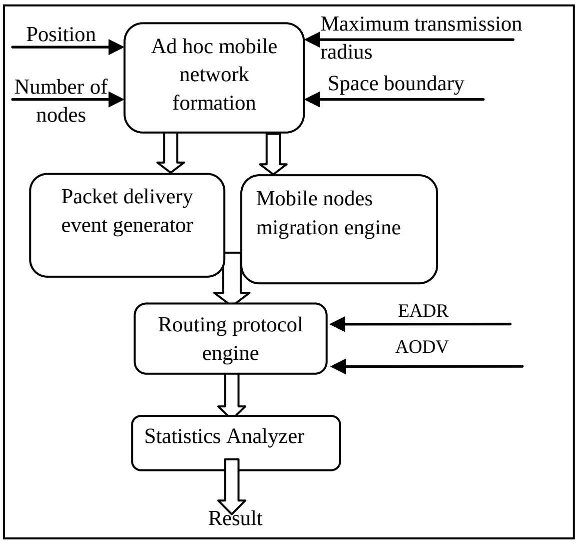


Fig 1: EADR Functional Units

Idle energy consumption constitutes a significant percentage of the overall energy consumed by the wireless interfaces of network nodes. EADR addresses this issue in a manner fair to all network nodes by giving equal opportunities to conserve idle energy. In addition to this, EADR manages other traffic routing issues as discussed in the prior work [16].

Fig 2: Simulation Model for Energy Aware Deterioration [16]



3.2 EADR with AODV

The second part of proposed method is EADR with AODV [16] which is a reactive routing protocol. The main objective is to extend the useful service life of an ad hoc network. The following formula is used to solve the problem of finding a route, at route discovery time t, such that the following cost function is minimized:

$$C(\pi,t) = \sum_{i\in\pi} Ci(t)$$

Where $C_i(t) = \rho_i \left(\frac{Fi}{Ri(t)}\right)^{\gamma}$

$\rho_{i=}$ Transmit power of node i.
Fi = Full charge capacity of node i
Ri= Remaining battery capacity of node i at time t.
γ= Transmit connection request to all reachable neighbour nodes.
In AODV, the nodes generate Route Request (RREQ), Route Reply (RREP) and Route Error (RERR) messages for uni-cast communication towards a destination. In order to process the messages correctly, certain state information has to be maintained in the route table entries for the destinations of interest.The route discovery for EADR with AODV is described below.

In AODV, activity begins with the source node flooding the network with RREQ packets when it has data to send. An intermediate node broadcasts the RREQ unless:

- It gets a path to the destination from its cache, or
- It has previously broadcast the same RREQ packet.

  (This fact is known from the sequence number of the RREQ and the sender ID.)

When the session expires, the source node selects the route with the energy greater than threshold value and replies. Subsequently, it will drop any received RREQs. The reply also contains the cost of the selected path appended to it. Every node that hears this route reply adds this route along with its cost to its route cache table. The node called unfaithful node having value less than threshold value has not participated in routing. Unfaithful nodes participate in network communication till they enter into a sleep mode state however they continually function in the network, in the sense that they continuously forward their energy status to neighbouring nodes. Although this scheme can somewhat increase the latency of the data transfer, it results in a significant energy saving as will be shown in results section.

4. RESULTS AND DISCUSSION

4.1 Simulation Setup

The simulator used to mirror an ad-hoc routing protocol is the Network Simulator 2 (NS-2). The experimental setup consists of the following major components: ad hoc mobile network formation, packet delivery event generator, mobile nodes migration engine, routing protocol engine and statistics analyzer, as depicted in the figure-2.

i. The ad hoc mobile network formation module takes as input the simulation area boundary, number of network nodes, their positions in space and their maximum transmission radius. This module is implemented using Tcl script.

ii. packet delivery event generator generates /varies communicating packets at regular time intervals .

iii. mobile nodes migration engine takes care of mobile nodes' migration speed and pause interval. Both (ii) and (iii) events are generated using Tcl script and are subsequently handled by the routing protocol engine.

iv. routing protocol engine employs EADR on top of AODV, in which EADR handles route selection, AODV manages route discovery, route maintenance, route refreshments and through cooperating with MAC and physical layers in the TCP/IP stack, it achieves reliable packet delivery.

Thus the parameters inputted to the simulation setup are: number of active communicating flows, mobile nodes' migration speed and pause interval.

4.2 Evaluation Parameters

The Evaluation Parameter like Number of nodes, Dimension, Routing protocol, transport layer protocol, application layer data and maximum speed of mobile nodes etc are obtained. The mobile ad-hoc network has been simulated according to table 1. The main performance parameters are Routing message overhead, average end to end delay, and throughput.

Table 1: Evaluation Parameters for MANET simulation

Simulator Used	NS-2.31
Number of nodes	50
Dimension of simulated area	800m×600m
Routing Protocol	AODV
Simulation time	100
Traffic type	CBR(3pkts/s)
Packet size	512 bytes
Number of traffic connections	4 / 25
Node movement at maximum Speed (m/s)	random
Transmission range	250m
Threshold value	10 J
Transmit power	1.5 mJ
Receiving power	1.0 mJ
Idle power	.17 mJ
Sleeping power	.047 mJ

4.3 Performance Analysis

In this section the performance metrics for remaining energy of a node are presented. A threshold value is fixed on the energy consumed by mobile nodes in a network .The network performance was tested in two scenarios i.e. one without applying threshold value and another by setting a threshold limit to 10% of total battery life of a node.

Table-2 summarizes the energy metrics for a scenario of 50 nodes .It was observed that in case a threshold was used, the results are better as compared to before applying a threshold. Here it was observed that the drop of packets and normal routing load decreases in threshold case. It means definitely the life of node increases, then life of network increases.

Table 2: Overall Performance Analysis of Fifty Nodes

Energy Metrics	Energy Before Setting Threshold	Energy After Setting Threshold
Send	6491	5830
Receive	4605	4924
Routing Packets	9234	2891
PDR	69.39	84.46
NRL	1.96	0.53
Average e-e delay(ms)	1269.72	1303.86
No. of dropped data (packets)	1886	906

4.3.1 Throughput Analysis

We plotted performance graphs using xgraph() function in NS-2 and observed improved results are after applying threshold. The graph in figure 3 shows Throughput analysis, having been plotted for the number of packets that successfully reached their destination nodes with respect to the allotted simulation time. An improvement is detected in throughput when EADR was employed and thus each node in the network efficiently uses their energy for communication. One important observation, however, is that the graph shows that throughput is affected between the interval 0-10 seconds since nodes take time to establish connection. Due to energy awareness, they establish reliable connections, after which the throughput slightly improves but in the time interval 55-100 sec the throughput continuously increases.

4.3.2 Routing Load Analysis

Routing Load is the total number of routing packet transmitted per node. It is calculated by dividing the total number of routing packets sent by the total number of data packets received.

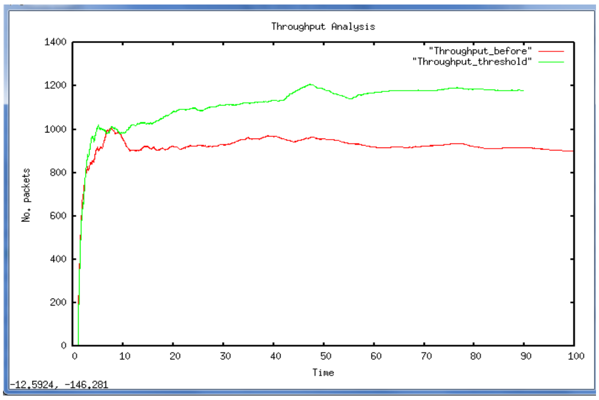


Fig 3: Throughput analysis of 50 nodes in case of before & after applying threshold

A graph was plotted for routing load (figure 4) which shows that before applying a threshold, the routing load continuously increases due to communication with unfaithful nodes. More and more number of packets are sent for connections establishment. But in case of threshold routing load is less, because only trusted nodes having a sufficient energy are participated in routing.

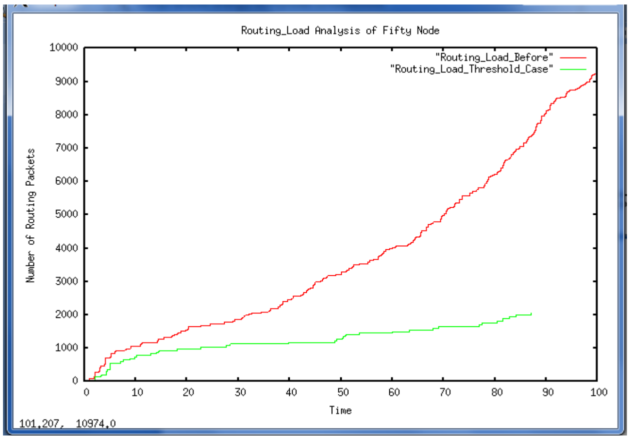


Fig 4: Routing Load analysis of 50 nodes in case of before & after applying threshold

5. CONCLUSION AND FUTURE SCOPE

In spite of developments in the battery technologies and diminishing power requirements for displays and other similar power intensive tasks, the energy aware deterioration in ad hoc networks remains a challenge. Since the majority of the devices for personal mobile communication are powered by batteries, the issue of energy efficiency in MANET wireless networks is an important study. Current work tries to suggest methods to conserve and increase the battery life by suggesting an energy efficient routing approach for reactive MANETs. The work is aimed at suggesting architecture for achieving effective energy awareness across different levels in mobile ad-hoc network. The proposed EADR algorithm effectively utilizes the energy consumption of nodes and minimizes total energy consumption in the network. Such a network lives longer than the others. With proposed algorithm, the life of route nodes increases with higher energy efficiency. The algorithm keeps a watch on the energy status of each mobile node and then selects only the reliable paths. This method can be incorporated into any ad hoc on-demand routing protocol to improve reliable packet delivery in the face of node movements and minimize the route breaks. Alternate routes are utilized only when data packets cannot be delivered through the primary route. Simulation results for EADR applied to AODV protocol were explored.

The results indicate that the technique provides robustness to mobility and enhances protocol performance. Its performance has been found much better than other existing protocols in dense medium as probability of finding active routes increases.

In the discussed algorithm, the end to end delay is slightly increasing. Further improvement may be made to minimize this. The work includes simulation on only reactive AODV routing protocol. The work can be extended to see performances with DSR, DSDV, OLSR, hybrid routing protocol and their characteristics be compared.

6. REFERENCES

[1] Jie Xiang, Samba Sesay, Yiming Wang and Jianhua He, " Ad Hoc State Aware Routing Protocols", IEEE Communication Society Proc. WCNC, pp. 3749-3753, 2007.

[2] Rahul C. Shah and Jan M. Rabaey,"Energy Aware Routing for Low Energy Ad Hoc Sensor Networks", Wireless Communications and Networking Conference, 2002. WCNC2002. IEEE

[3] Hussein Elattar, Hussen Abdelety, and Mohamed About-Dahab, "Improving the Life Time of Wireless Ad Hoc Networks Using Power Aware Routing", 18 Telecommunications forum TEFOR, pp. 416-419, 2010.

[4] L. Cao, T. Dahlberg, & Y. Wang, "Performance Evaluation of Energy Efficient Ad hoc Routing Protocols", Proc. IPCCC, IEEE, pp. 306-313, 2007.

[5] R. Lent, "Simulating the power consumption of computer networks," in the 15th IEEE International Workshop on Computer Aided Modeling, Analysis and Design of Communication Links and Networks (CAMAD'10), pp. 96-100, 2010.

[6] Eunkyu Lee, Minsoo Kim, ChansuYu and Myungchul Kim "Node Alarm Mechanism for Energy Balancing in Mobile Ad hoc Network", Proc. of Mobile Computing and Networking (Mobicom), 6th World Multiconference on Systemics, Cybernetics and Informatics, July 14-18, 2002,Orlando, pp. 85-96, 2002.

[7] Stojmenovic and X. Lin, "Power-aware localized routing in wireless networks." Proc. IEEE IPDPS, Cancun, Mexico volume-12, page no.-10, oct- 2001.

[8] F. De Rango, F. Guerriero and P. Fazio, "Link-Stability and Energy aware Routing Protocol in Distributed Wireless Networks," IEEE Transaction on Parallel and Distributed Systems, pp. 148-153, 2008.

[9] Jhade Srinivas and Dr. P. Chenna Reddy, "Enhancement Study of Power-Aware Routing Protocols in Ad hoc Networks", International Journal of Advanced Research In Technology, Vol. 1, No. 1, pp. 66-70, 2010.

[10] Volkan Rodoplu, Teresa H. Meng, "Minimum Energy Mobile Wireless Networks", IEEE journal on selected areas in communications, vol. 17, no. 8, august 1999

[11] Sheetalkumar Doshi, Timothy X Brown,"Minimum Energy Routing Schemes for a Wireless Ad Hoc Network", IEEE INFOCOM 2002

[12] C.K. Toh, "Maximum Battery Life Routing to Support Ubiquitous Mobile Computing in Wireless Ad hoc Networks", IEEE Communication Magazine, Vol. 39, PP. 6, June 2001.

[13] Morteza Maleki, Kartik Dantu And Massoud Pedram "Life Time Prediction Routing in MANET", Wireless Communications and Networking (WCNC), IEEE, pp. 1185-1190, 2005.

[14] Maleki M., Dantu K. ; Pedram M. ,"Lifetime prediction routing in mobile ad hoc networks", Wireless Communications and Networking, 2003, IEEE (Vol: 2), 20-20 Mar 03, pp: 1185 - 1190 vol.2

[15] Kyungtae Woo, Chansu Yu; Dongman Lee; Hee Yong Youn ; Lee, B," Non-Blocking, Localized Routing Algorithm for Balanced Energy Consumption in Mobile Ad Hoc Networks", IEEE MASCOTS 2001, Proceedings 9th International Symposium on Modeling, Analysis and Simulation of Computer and Telecommunication Systems,, 15-18 Aug. 2001, pp: 117 – 124.

[16] Shilpa Bade and H.K.Sawant," Uncertain Deterioration on Node Energy in MANET through Trust Based Solution", IJAERS, Vol. 1, Issue 3, pp. 319-324, 2012.

[17] Suresh Singh, C.S.Raghuvendra, "PAMAS—power aware multi-access protocol with signaling for ad hoc networks", ACM SIGCOMM Computer Communication Volume 28 Issue 3, July 1998 pp: 5 - 26 ACM USA. doi>10.1145/293927.293928

[18] Noorani, Razia Nisar. "Comparative analysis of Reactive MANET Routing protocols under the traffic of TCP VEGAS with mobility considerations." Emerging Technologies, 2009. ICET 2009. International Conference on. IEEE, 2009.

[19] Mangrulkar, R.S.,"Trust based secured ad-hoc on-demand Distance Vector Routing protocol for mobile ad hoc networks", IEEE Explore, WCSN Conf.15-19 Dec 2010, pp: 1-4.

[20] Charalampos Konstantopoulos, Damianos Gavalas, Grammati Pantziou, "A mobility aware technique for clustering on mobile ad-hoc networks", ICDCN'06 Proceedings of the 8th international conference on Distributed Computing and Networking,2006, pp: 397-408

[21] Vidhyapriya, R., and P. T. Vanathi. "Energy efficient adaptive multipath routing for wireless sensor networks." IAENG International Journal of Computer Science 34.1 (2007), pp: 56-64.

[22] F.Xie, L Du, Y Bai, L.chen, "Energy Aware Reliable Routing Protocol for Mobile Ad hoc Network," Proc. Wireless Communication and Networking Conference (WCNC),IEEE,pp.4316-4320,2007

Table 3: Related Work

Ref Id	Year	Test Method /Technique	Key Findings
[17]	1998	PAMAS Protocol	Power aware Multiple Access Protocol was proposed using radio interface of a node
[18]	2009	Analysis of AODV & DSR protocols	Here selected MANET Reactive Routing protocols i.e. Ad-hoc On-demand Distance-vector (AODV) and Dynamic Source Routing (DSR) Protocol were analyzed in accordance with their finest performance of packets delivery rate, average end-to-end delay, and packet dropping.
[19]	2010	Ad-hoc on demand distance vector routing with path accumulation	This paper proposes the source route accumulation feature. In addition a routing algorithm is proposed which adds a field in request packet which stores trust value indicating node trust on neighbor.
[20]	2006	Energy & mobility aware clustering technique	Passive clustering or GRIDS algorithm (Geographically Repulsive Insomnious Distributed Sensors) was used.
[21]	2009	AODV-PA :AODV with Path Accumulation	Modify AODV to improve the source route accumulation feature of DSR.
[22]	2007	Energy Aware for low energy Ad hoc sensor networks.	Proposed a new routing protocol that is suitable for low energy & low bit rate networks. Idea is to use the lowest energy path & utilize resources equitably.