Randomized Energy Adaptive Routing in MANET to Increase Network Lifetime and Minimize Energy Consumption

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ABSTRACT

Ad- hoc network is defined as the network in which the users communicate with each other by forming a network on-fly without any centralized node or base station. Here each node act as a host as well as a router and allow packet forwarding to neighbours. Ad hoc networks are highly dynamic in nature. They have highly deployable and self-configurable topologies. Due to self- organizing, self-configuring capability MANET is used in different areas like emergency search and rescue, military, etc. Various routing protocols are defined for these Mobile Ad-hoc networks.

One of main problem in Ad hoc network is energy issue in mobile nodes. As the Ad-hoc network node operates on battery power the routing algorithms must take account the node battery status while selecting the routing path between source and destination. The reason of packet drop in MANETs is link break which could be a result of mobility or node failure (due to battery exhaust or some hardware failure). Each drop packet is an energy wastage used in transmission and reception of the dropped packet. The existing routing protocols for MANETs do not support energy based routing path selection as they are not energy adaptive.

A new energy Adaptive routing mechanism based on AODV is proposed in this paper which selects the path based on node energy. It calculates the remaining energy levels of the nodes before they are selected for routing path. A threshold value is defined and nodes are considered for routing only if its energy level is above this threshold value. This enforces a fair energy consumption rule on all the nodes of the network between source and destination. Another threshold value is defined which decides when to search for alternate path. If during traffic forwarding a node energy level falls below this threshold value, then the node search for its neighbour with high energy and bypass the traffic to the selected neighbour. This will keep the node from complete battery drain condition and increase the network lifetime. The proposed algorithm also drops some of the unnecessary RREQ randomly based on neighbour count of a node, which further reduce energy consumption of nodes and also reduce congestion during Route Discovery process without affecting the Performance of the routing protocol.

The proposed IE-AODV (Improved Energy) is implemented in NS2 simulator. The simulation results have shown an increase in PDR, decrease in delay and throughput is maintained without inducing any significant overhead. The proposed IE-AODV provides more consistent and reliable data transfer compared to general AODV with less average energy consummation.
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Keyword: - *MANETs ROUTING, IE-AODV, ENERGY ADAPTIVE ROUTING, NS 2*

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1. INTRODUCTION

The wireless technology is a great tool in communication field which allows users to exchange information and services without concerning the geographic location. This technology gives freedom to users who can utilize and surf the Internet with computers (e.g., laptop, palmtop, smart phone and PDA) whenever and wherever possible. The wireless network can be categorized in two types based on the presence or absence of central coordinator (base-station) namely: Infrastructure network and Ad-hoc network. Ad-hoc network is defined as the collection of two or more wireless devices which have communication capability with each other without the help of any centralized administrator. These networks are generally referred to as MANETs (Mobile Ad-hoc Networks).MANET is an autonomous group of mobile users who communicate through relatively bandwidth constrained wireless links. Figure 1 show a typical MANET topology where each node acts as a terminal node as well as router. Mobile Ad hoc networks are easier to organize than wired networks and are used in many applications, such as in human or nature induced disasters, battlefields, meeting rooms where either a wired network is unavailable or deploying a wired network is inconvenient. Since the hosts are mobile, the network topology may changes rapidly and unpredictably over time.

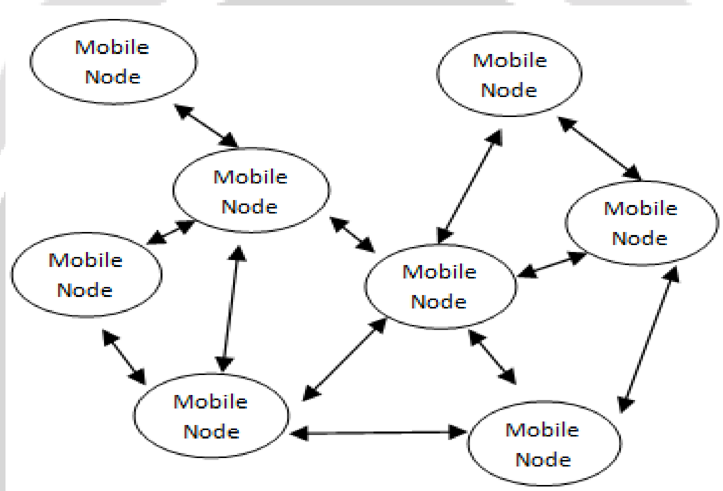

Figure 1 MANETS TOPOLOGY

This dynamic nature of MANET makes it enormously complicated to obtain accurate knowledge of the network state and that's why the consistency of data transmission in this network cannot be guaranteed. Due to the inherent properties of MANETs such as mobility and limited battery power, one of the key issues in MANETs is efficient routing considering these properties [1].

Energy exhaustion of nodes has been one of the main problems to the connectivity of MANET. Since the mobile nodes in MANET have limited battery power, so it is required to efficiently use energy of every node in MANET. MANET is a multi-hop, in which node can freely move in any direction and have limited battery power. A reliable routing protocol for Mobile Ad hoc Networks (MANETs) keeps the energy consumption as low as possible.

The routing protocol in MANETS can be categorized in three different types based on the way in which routing update information is used: proactive, reactive (also called On Demand) and hybrid [2]. Proactive routing protocols, such as DSDV [3], attempt to maintain consistent and up-to-date routing information from each node to every other node in the network. In the on-demand routing protocols, such as AODV [4] and DSR [5] routes are discovered only when they are needed. The hybrid routing protocols [6] combines the features of both proactive and on-demand protocols. In the case of hybrid routing protocols, each node maintains routing information about its zone using the proactive approach. It uses on-demand routing approach outside the zone. The periodic routing information broadcast caused by broken links due to node mobility can lead to a large routing control overhead.

The current MANETs routing algorithms are not aware of node remaining energy, so when a new route is established, it will be used during the packet transfer from source to destination until node mobility or node failure (due to energy exhausted or some other cause) results in disconnection [9].

AODV [4] is based on both DSDV and DSR algorithm. It uses the route discovery and route maintenance practice of DSR. DSR packet carries the complete route information, while the packet of AODV only carries the destination

address, it has less routing overhead than DSR. At the same time, AODV makes use of routing messages and sequence numbering.
This paper presents an AODV based routing algorithm with some enhancements to save energy. AODV protocol is a reactive routing protocol which finds route to destination when required. AODV consists of routing table which helps to differentiate between expiry and fresh routes. The routing table at node contains the sequence number and next hop information. The working of protocol is consists of two phases: Route discovery and Route maintenance.
In route discovery process, the source node generate RREQ packet, if the path to destination is not stored in the routing table, and pass it to the neighboring nodes. The neighboring nodes will pass it to their neighbor and so on. When the packet reached to the destination node, then destination node generates RREP (Route Reply) packet and send it back to the source node. Thus the path is established between source and destination node. In route maintenance process, the source node is being informed by RERR (Route Error) message in case of link breakage. Also the connectivity between the nodes is maintaining using *Hello* messages [8]. The two factors that cause link failures are Battery life time and Mobility.
For achieving energy-efficiency in MANETs there are three approaches [9]: Power-Control, Power-Save and Maximum-Lifetime routing. The Power-Control approach is allowing nodes to decide the least amount of transmission power level which is sufficient to maintain network connectivity and to pass the traffic with least energy, the objectives is to increase network capacity and sinking energy consumption. The Power-Save approach deals with the energy loss during the idle mode and this can be minimized by increasing the amount of time a node spends in the sleep mode. Lastly, the Maximum-Lifetime routing approach looks for the nodes that have minimum energy so that they can be avoided from the path.
The paper is organized as follows. Section II show the literature survey of the related work to estimation of energy based Ad hoc routing protocols for MANET. Section III briefly describes the idea and mechanism of propose work which increase the life time of network and improve the energy efficiency of MANET. Section IV introduces the design of simulation network, the result of proposed work and compares it with AODV existing result. Section V draws the conclusion of the paper.

2. LITERATURE REVIEW

Vinay Rishiwal et al [10] proposed QoS based power aware routing protocol (Q-PAR). The route is selected with energy stability and bandwidth requirements. The protocol Q-PAR is divided in to two phases. In the first route discovery phase, the bandwidth and energy constraints are built in into the DSR route discovery mechanism. In the event of an impending link failure, the second phase, a repair mechanism is invoked to search for an energy stable alternate path locally. Moreover the local repair mechanism was able to find an alternate path in most of the cases, which enhanced the network lifetime.

Minimum Battery Cost Routing (MBCR) has been proposed in [11]. MBCR routing protocol calculates the sum of the residual power of all nodes in a path, which is used for selecting the route between the source and destination. But the method does not consider individual node residual power and may choose a path in which there may be mobile nodes with low power. The proposed mechanism enforces energy fairness on the network.

An Energy Mean Value algorithm is introduced in [12] to enhance AODV routing protocol and to improve the network lifetime of MANET.

Krishna, Cheong Lau and Joseph H. Kang [13] propose the idea to increase energy efficiency by introducing sleep mode. A node in the network goes into a sleep mode and wake up at predetermined time slot(s) to snoop for transmissions from its instant neighbours. The knowledge of awakening slots for neighbouring nodes is used to arrange the transmissions within the neighbourhood. Finally, nodes adapt their sleeping cycles based on neighbour topology and remaining battery life in order to maximize the network lifetime also satisfying the latency requirements of sensor applications.

P.K. Suri et al [14] proposed a bandwidth-efficient power aware routing protocol “QEPAR”. The routing protocol minimizes the bandwidth consumption and delay of the network. QEPAR will help in increasing the throughput by decreasing the packet loss due to non availability of node having enough battery power to retransmit the data packet to next node. The proposed protocol is also helpful in finding out an optimal path without any loop.

A new routing protocol called energy-aware grid multipath routing (EAGMR) protocol is proposed [15]. The proposed protocol can conserve energy and provide the best path to route according to probability. Simulation results indicate that this new energy-aware protocol can save energy of mobile hosts and improve data packet delivery ratio.

3. PROPOSED WORK:

Many energy aware Routing mechanisms have been proposed in MANETs. Nodes mobility makes the routing difficult, and this dynamic nature is both an advantage and disadvantage for MANETs. Nodes communicate with each other and exchange data within the available nodes on the network. The proposed algorithm does routing decision based on residual node power as well as attempts to reduce energy consumption by controlling the broadcast flood in the network. The proposed algorithm requires following changes.

3.1 MODIFY RREQ: The traditional AODV RREQ does not have any field to convey the battery status to the neighbours. The battery status field is added in the proposed IE-AODV RREQ so that node can propagate energy information in the RREQ whenever a new route is required. Many other field are also initialized in the modified IE-AODV related with energy like initial energy (100J), consumed Energy, threshold1 (20% of initial energy) for RREQ drop and threshold2 (10% of initial energy) for alternate path selection. If the node battery status goes below threshold1(20% in initial energy) then node do not allow any new connection through itself by dropping all received RREQ, thus act like a malicious node for all new connections RREQ. But this will prevent any low energy node to be a part of route between source and destination. This will Increase network life time and fair energy consumption from each node by not including low energy nodes into routing path. Similarly if the node battery status fall below threshold2 (10% in initial energy) then the node will search for its neighbours list to select an alternate path. The neighbour is selected based on its battery status (highest battery status node gets selected) and routing table is updated to bypass the packets through selected neighbour. If no such node is available then current node continue forwarding packets. One drawback of such energy adaptive algorithm is that it does not consider the battery level of source and destination nodes. Here it is assumed that both the source and destination nodes are supported by auxiliary power source and never run out of power supply as long as there are some packets which need to be forwarded.

3.2 RREQ DROP: The flooding method, which is used by traditional AODV protocols, is a process in which a route request packet (RREQ) is broadcasted from a source node to other nodes in the network. This often results in unnecessary re-transmissions, causing packet collisions and congestion in the network, a phenomenon called broadcast storm. This also causes in energy loss in transmission and reception of such unnecessary RREQ. This energy can be saved by selectively dropping RREQs based on some probability like Bayesian probability [16] or hop count based probability [17]. For each received RREQ by a node, it calculates a forward probability for RREQ. During the route discovery process, every intermediary node between the source and the destination makes a decision to either forward the RREQ packet further towards the destination or drop it. Before forwarding a RREQ packet, every node computes the forward probability which increases with number of hop counts traversed by the RREQ packet. This forward probability lies in the range of 0 to 1. A random number is also generated and if the random number is lower than forward probability, the node forwards the RREQ packet. Otherwise, the RREQ packet is discarded and dropped. Here the aim is to minimize these unnecessary RREQ packets. The forward policy is conservative and its value becomes higher with higher number of hops. As RREQ packets get near the destination node, the chances of survival of RREQ packets are higher. Because of this conservative nature only a small number of RREQ packets are dropped. This will reduce the RREQ flood and thus save energy in transmission and reception of RREQs. It also reduce load on network during connection setup and avoid congestion in network.

3.3 ALGORITHM FOR PROPOSED WORK:

1. Initialize the parameters threshold1=20% of initial_energy, threshold2=10% of initial_energy, initial_energy = 100J.
2. **For** each intermediate node receive RREQ: check
   If remaining energy <= threshold1 drop RREQ.
   else If forward_probability < random number drop RREQ
   else process the packet normally as in AODV.
   End
3. **For** each intermediate node receiving data packet: check

If remaining energy <= threshold2
Search neighbour list and find common neighbours with remaining energy > threshold1.
(Only those node will replay for which remaining energy > threshold1, condition 2)
If neighbours found.
Select the neighbour with highest remaining power. Update the routing table to bypass the traffic through the selected neighbour.
else
Continue with the current routing path, until either flow stops or node battery drains.
else (remaining energy > threshold2) continue with normal procedure of AODV.
End

4. **Stop.**

4. SIMULATION AND RESULTS:

To simulate the behaviors of the nodes under proposed algorithm in a mobile ad hoc network we use NS-2.35[18]. The experiments are conducted with variable number of nodes and variable number of connections. Energy model is included with initial energy 100J, radio range of 250m. The traffic model used is CBR (Constant Bit Rate) with packet size of 512 bytes, rate 100 packets/sec. The mobility is 10m/sec with pause time 0. The parameter values of simulation are as shown in table1.

Table -1: Simulation parameters

Type	**Values**
Channel	Channel/Wireless Channel
Radio Propagation Model	Propagation/Tworayground
Network Interface	Physical/Wirlessphy
MAC	MAC/802_11
Interface Queue	Queue/DropTail/PriQueue
Antenna	Antenna/Omniantenna
Link Layer	LL
Interface Queue Length	50
Routing Protocol	AODV
Simulation Time	100s

4.1 VARIABLE NUMBER OF NODES: Nodes are increased from 20 to 50, which are randomly scattered in a region of 1000m X 1000m. The cbrgen.tcl and setdest utility is used for traffic and mobility model generation. The performance of the proposed algorithm is evaluated and compared with the traditional AODV.

The values obtained using traditional AODV and proposed modified IE - AODV at different node sizes are listed in table 2. The traditional AODV doesn't provide reliable routing since the nodes present in the network are not checked against its energy levels which may result in packet loss since node may drain out of energy. The simulation results are as shown in table 2, which shows the packet delivery ratio and delay for both the traditional AODV and Modified AODV for different number of nodes.

Table -2: Simulation Result Summery

No. Of Nodes	AODV (PDR)	AODV (DELAY)	IE-AODV (PDR)	IE-AODV (DELAY)
20	64.25	3.35s	84.33	1.95s
50	73.42	2.24s	93.22	1.09s

The QoS parameter values are showing better improvement when the routing takes place with the proposed AODV protocol which works using energy levels of each node that identifies nodes with low energy levels in the route and immediately take an alternate path to provide reliable routing.

The results shown in the following table clearly shows the PDR and delay of the proposed AODV protocol are superior compared to traditional AODV protocol at different node sizes. Chart 1 shows the result of packet delivery ratio for 20 nodes and 50 nodes for traditional AODV and Proposed AODV.

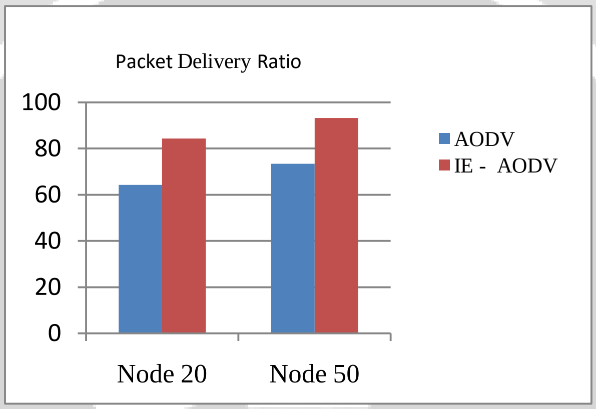

Chart -1: Packet delivery ration and No. of Nodes

4.2 VARIABLE NUMBER OF CONNECTIONS: Nodes are kept constant (50 nodes) that are randomly scattered in a region of 1000m X 1000m. The number of connections is increased from 10 to 40.The cbrgen.tcl and setdest utility is used for traffic and mobility model generation. Figure 3 shows that end to end delay is same for 10 connections but increase as the no of connections increases. But the proposed IE – AODV gives lower delays as compare to the traditional AODV because low energy nodes and avoided, alternate path is selected for energy drained nodes and some RREQ packets are dropped to reduce load on network.

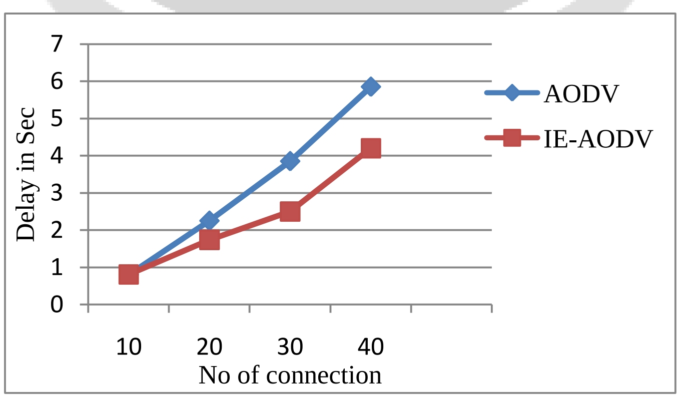

Chart -2: End to End delay and No. of connections

Chart 3 shows the achieved packet delivery ratio of both the protocol is similar when the offered load is 10 connections. This is because when the number of flows is less, the number of RREQ and data packet is less. When the no of flows increases from 20 to 40, as an outcome, more RREQ packets and data packets are generated and transmitted which lead to high load on network and decrease the PDR. But IE-AODV have higher throughput then AODV an alternate path is used in case of low energy node and also some RREQs are dropped to reduce load on the network.

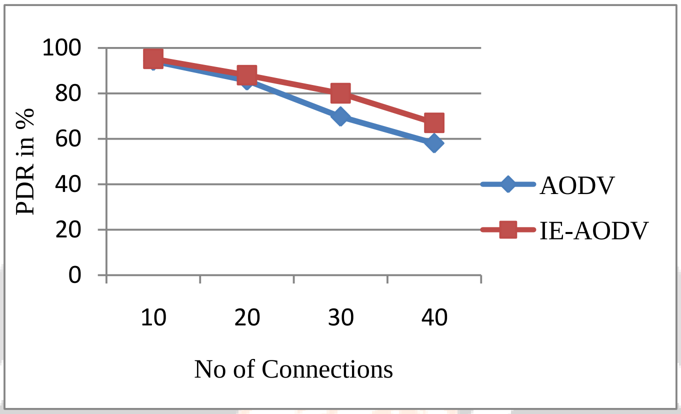

Chart -3: PDR vs No. of Nodes

Chart 4 shows the average energy consumed is almost same for both the protocol when the offered load is 10 connections. When the number of flows increases from 10 to 40, as an outcome, more nodes goes in lower energy state and power off state in case of AODV routing protocol compare to IE-AODV. IE-AODV prevents node form falling below a threshold value and select alternate path. One more reason of higher energy efficiency is that some RREQ are dropped in IE-AODV which saves energy in transmission and reception of such packets. IE-AODV chooses path such that average energy consumption remain fair for each node. This reduces the energy consumption and increase the network lifetime.

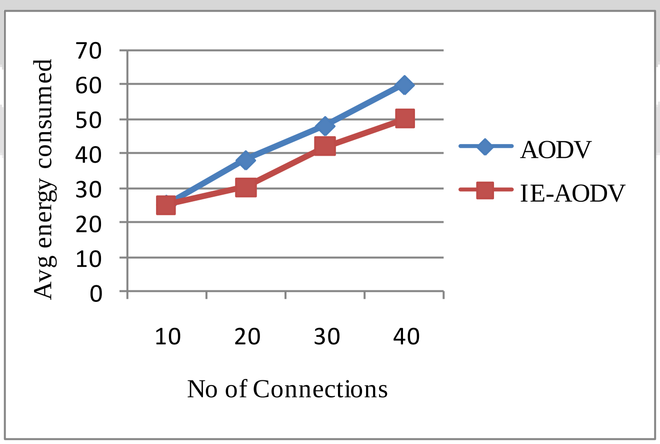

Chart -4: Average consumed Energy and No of Connections

5. CONCLUSIONS

The energy aware routing protocol (IE-AODV) is proposed in the paper. The results show an improvement in the Packet delivery ratio, End to End delay and at the same time saves power by fairly consuming power from all nodes. The effect of RREQ forward probability is also clearly visible in saving node energy. The nodes are prevented from participating in the routing if the energy level is low. Also an alternate path is used if the energy level falls below a threshold value. This stops the nodes from completely drains and save the packet drops in such scenario as wll as increase the network lifetime.

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