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An Energy and Priority Aware Routing Scheme for Mobile Ad Hoc Networks in Emergency Management

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Abstract

Objectives: The existing literature review is unable to prolong the energy of the battery power in disaster scenario based network. To overcome this issue the proposed priority based and energy-aware AODV prolongs the battery life of the mobile nodes in MANET. **Method/Analysis:** Proposed EPAODV protocol used to reduced traffic congestion with low-buffering route selection mechanism to prolong the battery life of the mobile nodes. **Findings:** NS2.35 simulator is used to perform the simulation results. Through EPAODV routing protocol, we have enhanced the PDR, minimized the E2E delay, and reduced the average energy consumption. The results of EPAODV protocol are benchmarked with traditional AODV. From simulation results EPAODV performance remained better than AODV. **Applications/Improvements:** EPAODV is specially used in disaster and emergency scenario based applications.

Keywords: Energy-efficiency, Natural-disaster, Priority, AODV, EPAODV, MANET

1. Introduction

MANET is a multi-hop and self-configured network. A MANET is group of nodes which form a network through wireless links without centralized administration[1]. Intermediate nodes of the network act as a router that participates in the network to send and receive the data and control packets[2]. The routing protocols play a major role to discover efficient routes from source to destination. The MANET routing protocols can be divided into three main types including reactive, proactive, and hybrid. All routes between source nodes to destination nodes are predefined in proactive routing that has been updated periodically, when a node changes its topological position by joining or leaving the network. However, routes between source and destination are discovered when desired in reactive routing.

MANET wireless network is used in various scenarios such as disaster rescue operations, battle field, conferences and environment control[3]. The lifetime of the MANET is as critical in such type of scenarios as the replacement and charging of the batteries of nodes during communication is difficult. The design of MANET routing protocol faces many challenges like topology control, limited bandwidth, average energy consumption, frequent link failure, network lifetime and packet loss[4]. Several MANET routing protocols consider less energy consumption of nodes to improve the energy efficiency.

During natural disasters, telecommunication infrastructure is badly collapsed due to massive destruction. The MANET is deployed at disaster affected areas to carry out rescue operations to save human lives and to minimize infrastructure losses[5]. The first responders are equipped with mobile devices to transmit

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emergency based information at the site of natural disaster. The responders apply real-time bi-directional person to person communication using voice and video services for coordinating rescue operations. The capabilities of data communication need to help the operational analysis in terms of disaster response. If the real-time information travels through low powered nodes or noise affected links, the information may be lost and may result in communication interruptions among rescue workers. Resultantly, this may cause into great loss of infrastructure and lives of the people.

This research study elaborates EPAODV routing protocol. EPAODV discovers the energy efficient and traffic aware routes to exchange emergency related information for undertaking efficient emergency management operations.

2. Literature Review

In[6] proposed Expanding Ring Search (ERS) mechanism to discover the efficient routes. The ERS prolongs the battery power of the nodes through minimizing overheads. The TTL mechanism is adapted by ERS. The Source node sets TTL value in RREQ packets and begins Route discovery process by broadcasting the RREQ packet to one hop neighbor for forming a first ring. If the nodes in the first ring do not contain any information regarding the destination node, then source node increments the TTL value then rebroadcast the RREQ packet to the nodes in the 2nd ring; the same process is continued until the route is discovered and information about destination is found.

In[7] Energy based AODV (EN-AODV) protocol is mentioned. Protocol introduces virtual energy concept. The external energy is provided to the source node on its depletion of energy level. In the route discovery phase unreliable nodes are identified by comparing the residual energy with energy threshold. Such inefficient nodes are not included in the energy efficient path. The protocol improves packet delivery ratio and minimizes delay.

Energy aware routing protocol related to the Route Energy Comprehensive Index (RECI) as defined in[8] calculates RECI value by adding Route Energy Fairness Index (REFI) and Route Energy Efficiency Index (REEI). The protocol protects source node and destination node from overloading when its energies are less to maximize the network lifetime. The protocol achieves two main objectives; first is to choose a shortest energy efficient path and second is to select a path having same number of hops with maximum RECI value. The protocol maximizes a network life time, reduces E2E delay, and also reduces average energy consumption.

Energy Level Based Routing Protocol (ELBRP) as proposed in[9] uses request-delay mechanism in route discovery process for finding efficient routes from source to destination. A mobile node having 'SATISFY' energy level holds RREQ packet for short time delay. After short delay, the intermediate node rebroadcasts RREQ packet to all its neighbors. This mechanism helps each node to accept only earlier request and discard the other duplicate packets. The proposed protocol reduces flooding of RREQ packets and balance energy among nodes which reduce energy consumption of whole network that is used to maximize the network lifetime.

In[10] proposed Modified AODV (MAODV) protocol; this protocol computes distance among all nodes. For finding the efficient route, MAODV selects a node having minimum distance and good energy level. A node having longer distance and low residual energy is dropped. The protocol reduces E2E delay that enhances network throughput and PDR.

In[11] an Energy Efficient AODV (EEAODV) routing protocol is mentioned. The protocol uses Receive Signal Strength (RSS) for maximizing the energy efficiency of the network. The closer node having good RSS value uses the less power for route selection to forward the data packets. This protocol maximizes network life time.

In[12] proposed an Energy Efficient Probabilistic Broadcasting (EEPB) routing protocol. The probability of broadcasting RREQ packet calculates the remaining energy of a node. RREQ packet is broadcast to the neighbor nodes by source node. The intermediate nodes compare their remaining energy with energy threshold. The remaining energy of a node is better than energy threshold; such nodes are considered dependable nodes DN. These DN nodes rebroadcast RREQ packet with high probability. After every rebroadcast, the probability of broadcasting is decreased as the value of the counter of DN increases. This discovery process continues still RREQ packet reaches to destination. EEPB reduces routing overhead by decreasing the rebroadcasting of RREQ packets. EEPB improves throughput of the network and increases the network lifetime by through those nodes which have more energy level.

In[13] proposed an Energy Aware and Load Balancing (EALB) routing protocol. The proposed protocol uses residual energy and load balance parameters for route selection. In the route setup phase; energy level of nodes is checked. A Danger node with low residual energy is dropped. The proposed protocol minimizes flooding of RREQ packets, which enhances PDR and NWLF.

According to[14], Priority based AODV (P-AODV) routing protocol is based on beaconing and overhearing mechanisms for route maintenance. The P-AODV enhances PDR.

In[15]proposed an Energy and Distance Aware AODV (EDA-AODV) routing protocol. The protocol uses two route metrics for route discovery process; node energy factor (NEF) and distance between two neighbor nodes. The protocol reduces the flooding of RREQ packets, which maximizes network lifetime by eliminating low energy nodes. EDA-AODV selects stable and efficient routes, which reduces routing overheads and maximizes network lifetime.

3. Proposed Scheme

In the proposed EPAODV routing protocol, network traffic is classified as time critical traffic (video/voice) and normal traffic (text/data). The control packets RREQ and RREP are modified by adding traffic priority in the reserved bits. The traffic with higher priority considers value 0 and lower valued with 1. When a source node plans to discover a path to the destination, it sets traffic priority in the reserved field in the RREQ packet and broadcasts it to its neighbor nodes. The detailed route setup process is given in the section 3.1.

3.1 Route Discovery Process:

Assume that node S is the source and node D is the destination as shown in Figure 1. The source node S starts the route discovery process broadcasting RREQ packets to nodes 1, 2, and 3. The intermediate nodes 1, 2 and 3 compare their residual energy with energy threshold Th_e. If the residual energy of node 1, 2 and 3 is greater than Th_e, nodes 1, 2 and 3 make reverse path entry and forward the RREQ packet to their neighbors. If any node among 1, 2 and 3 has low residual energy level than Th_e, it drops the RREQ packet. Assuming that all nodes have sufficient residual energy level, node 1 rebroadcasts RREQ packet to node 4 and node 5. Similarly, node 2 rebroadcast RREQ packet to node 4 and node 3 rebroadcast RREQ packet to node 4 and node 6. Node 4, 5 and 6 rebroadcast RREQ packet to destination node D as shown in Figure 1.

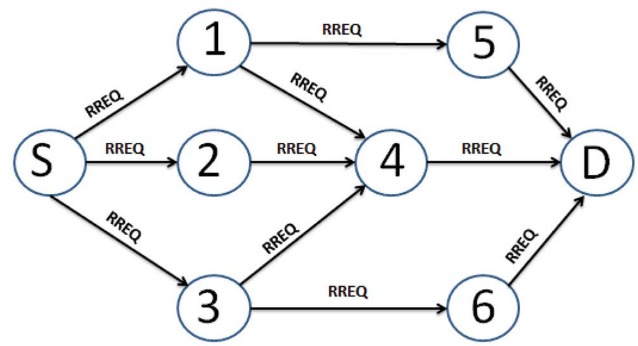

Figure 1. Broadcasting of RREQ control packet.

When the RREQ packets reach to destination node D, it updates the traffic priority field in the RREP packets and unicasts the RREP packets to node 4, 5 and 6. The traffic priority field in the RREP packet is updated from the received RREQ packet. When nodes 4, 5 and 6 receive the RREP packets, they check for the traffic priority field value. If the RREP packet contains priority value of 0, the nodes assume that the route is going to be established for high priority traffic. If so, node 4, 5 and 6 check the number of packets saved in their buffers P_c. If the number of packets stored in the buffers of the nodes receiving RREP packet is above the buffer occupancy threshold Th_b, they drop the RREP packet by assuming that they are already overloaded. If the buffer occupancy level of those nodes is less than Th_b, they forward the RREP packet to their neighbors on the reverse route. Assume that nodes 5 and 6 are not overloaded and node 4 is overloaded. Therefore, node 4 drops the RREP packet and nodes 5 and 6 forward the RREP packets to their neighbors 1 and 3. Node 1 assumes itself as overloaded and drops the RREP packet. Node 3 receives the RREP packet and assumes itself as not overloaded. Finally, node 3 forwards RREP packet to the source node S and the route S-3-6-D is established as shown in Figure 2.

If the priority value in RREP packet is 1, each node in the route assumes that the route is established for low priority traffic and simply forwards the RREP packet to its predecessor node until it reaches to the source node. Once, the route is established, the data transmission from source to destination starts.

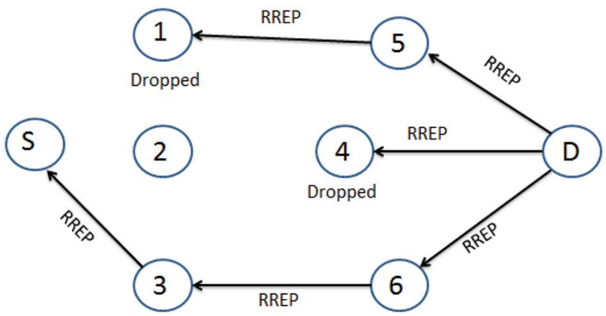

Figure 2. Unicasting of RREP control Packet.

3.2 The EPAODV Algorithm

Algorithm 1, describes the Route discovery process of the EPAODV Protocol.

Algorithm 1: Route discovery process of EPAODV

L.No	*Description*
Notations	
1.	Let S *denotes* the source node and D *denotes* the destination node
2.	Let N represents the set of intermediate nodes between S and D, where $N=\{n_0, n_1, n_2, \ldots\ldots, n_m\}$ and n_i represents the current node.
3.	Let Res_e represents the residual energy level of the current node and P_c represents the number of packets stored in the buffer of the current node.
4.	Node S sets the traffic priority value in the reserved field in the RREQ packet and broadcasts to its neighbors.
5.	Node n_i receives the RREQ packet, where $n_i \in N$.
Procedure	

6.	*for* every node n_i in the forward route, where $n_i \in N$ {
	if (n_i!= D) then {
	n_i checks its Res_e
	if ($Res_e < Th_e$) then {
	n_i drops the RREQ packet
	else
	n_i makes reverse route entry for S and forwards RREQ to its neighbors
	}
	}
	}

7.	*if* (n_i= D) then {
	n_i replicates the traffic priority value from the RREQ packet into the reserved field in the RREP packet and forwards RREP to its neighbors
	}

8.	*for* every node n_i in the reverse route, where $n_i \in N$ {
	if ((n_i!= S) && (priority = 0)) then {
	n_i checks its P_c
	if ($P_c > Th_b$) then {
	n_i drops the RREP packet
	else
	n_i makes forward route entry for D and forwards RREP to its neighbors
	}
	}
	if ((n_i!= S) && (priority = 1)) then {
	n_i makes forward route entry for D and forwards RREP to its neighbors
	}
	}

9.	*if* (n_i= S) then {
	n_i makes forward route entry for D and starts sending data packets to D.
	}

4. Simulation Results

The performance of EPAODV has been evaluated using network simulator NS2[16]. The EPAODV routing protocol has been compared with traditional AODV.

The results of the EPAODV are simulated for emergency scenarios with node mobility and simulation time are evaluated and analyzed through PDR, E2E, and average energy consumption. The parameters are set in the NS2.35 has been mentioned in Table 1.

Table 1. Simulation parameters for NS2.35

Parameters	Values
MAC Layer	IEEE 802.11
Coverage Area	1000x1000 Meters
Antenna Type	Omni Directional
Routing Protocol	AODV,EPAODV
No. of Nodes	50
Packet Size	512 bytes
Mobility Models	Random way point
Traffic Type	CBR
Initial Energy	30 Joule
Buffer Size	50
Topology	Flat-grid
Simulation Time	1000 Seconds

In Figure 3, the PDR for time critical and normal traffic for EPAODV and AODV is shown. The comparative results in terms of PDR for EPAODV seems higher than AODV.

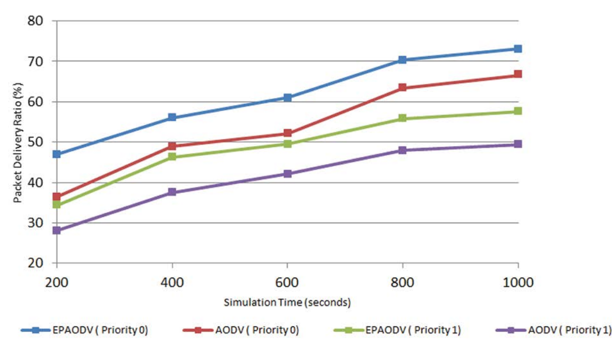

Figure 3. Packet delivery ratio vs. Simulation time.

The Consumed Energy of network for EPAODV and AODV as presented in Figure 4. It is observed that as the simulation time increases, consumed energy of entire network also increases due to generation of several control and data packets. EPAODV consumes the less energy by reducing the flooding of control packets.

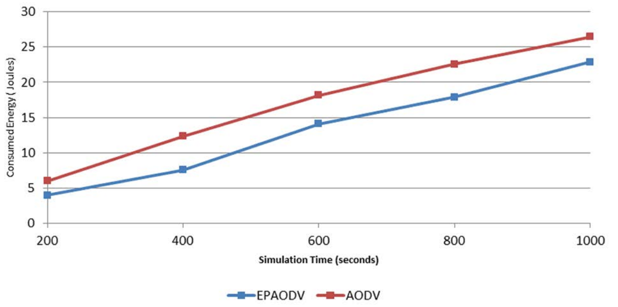

Figure 4. Consumed energy vs. Simulation time

Figure 5 focuses the E2E delay for time critical and normal traffic. EPAODV refers the avoidance of congested nodes for higher priority traffic, which reduces the E2E delay as compare to AODV.

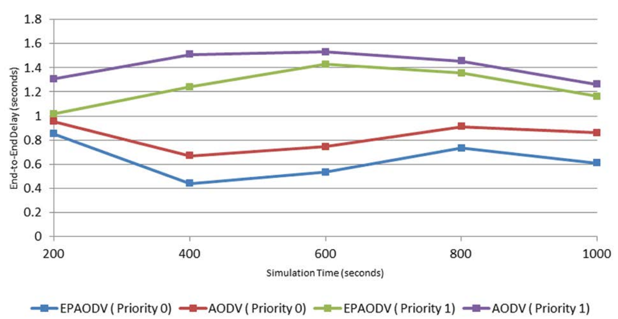

Figure 5. E2E delay for EPAODV and AODV.

In Figure 6 the PDR is shown for time critical and normal traffic. In Figure 6 the PDR becomes decreased for AODV due to link failure between nodes because AODV is unable to control the node mobility. On other hand PDR for EPAODV is higher than AODV because it controls the node mobility in efficient way.

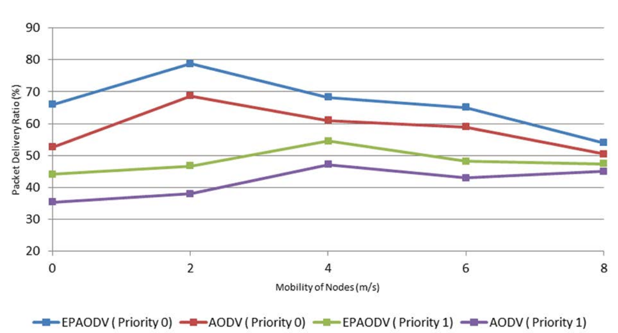

Figure 6. PDRfor EPAODV and AODV

Figure 7 focuses the average energy consumption for EPAODV and AODV through node mobility. EPAODV consumes the less energy as compare to AODV due to minimization of flooding control packet. The AODV consumes high energy due to uncontrolled node mobility.

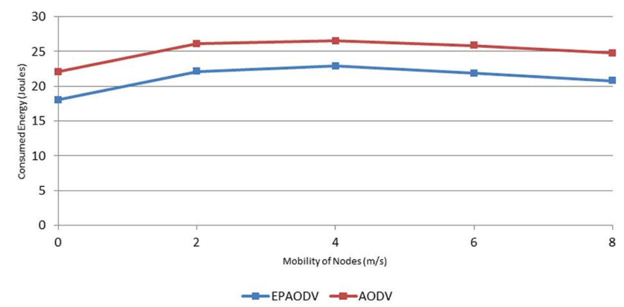

Figure 7. Energy consumption for EPAODV and AODV.

Figure 8 focuses the simulation results of EPAODV and AODV for E2E delay. The E2E delay for EPAODV is smaller than AODV because EPAODV controls the node mobility through establishing the smaller new routes between source and destination nodes. On other hand the E2E delay for AODV is higher than EPAODV because AODV is unable to control the mobile nodes.

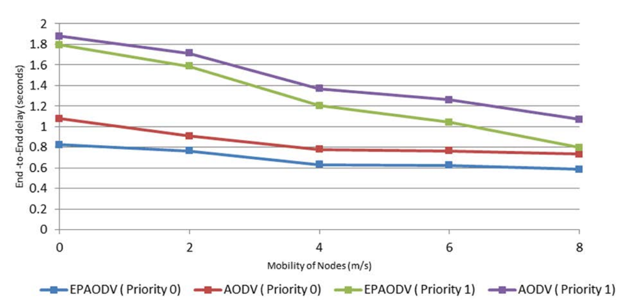

Figure 8. End-to-End delay vs. Mobility of nodes

5. Conclusion

EPAODV is the extension of AODV. From the simulation results, the performance analysis of EPAODV is considered better than traditional AODV because EPAODV controls the node mobility, traffic congestion, and routing overheads. On other hand, traditional AODV is unable to control the mobile nodes due re-transmission of control packets which exhaust the energy level of the nodes. AODV is unable to check the memory buffers during route setup process. Whereas, EPAODV develops the new routes based on node energy and controls the mobile nodes by avoidance of the congestion.

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