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Energy Aware Quality of Service Based AODV (EAQoS-AODV) Protocol in MANETs

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Abstract

With the growing fame of multimedia applications, quality of service (QoS) support in MANETs has grown-up to be supplementary and more important. There are lot of research work has done by different authors on energy and stability based issues as these works have their pros and cons. This paper presents a framework to improve the route discovery, route maintenance and delay of packets by using link expiration time, residual energy and drain rate for the higher quality of service. To the best of our knowledge none of the existing protocol considers all these factors together for the establishment of route between source and destination. The overall goal of this paper is to enhance life time of network and quality of service for wireless ad hoc networks. Simulation results show that our proposed protocol performs better than the existing AODV and SQ-AODV protocols.

Keywords: MANET, Link Stability, Residual Energy, Delay of packets, and QoS Parameters.

INTRODUCTION

Mobile Ad-hoc Networks (MANETs) are self-configuring and self-healing wireless networks, where the mobile nodes communicate without the existence of infrastructure or centralized station. Such networks are suitable for scenarios requiring rapid deployment. With the increasing need of laptops and 802.11/Wi-Fi wireless networking have made MANETs a popular research topic since the mid-1990s. MANET is a dynamic, multi-hop, autonomous and complex distributed network composed of wireless mobile nodes usually having a dynamic networking environment. Mobile nodes in a Mobile Ad-hoc Network (MANET) communicate with each other directly located within its transmission range or indirectly with some intermediate node without the need of any infrastructure or any centralized node. All the hosts within the transmission range of a mobile host receives its transmission via broadcasting, and if two wireless hosts are out of their transmission ranges in the ad hoc networks, other mobile hosts located between them can forward their messages acting as routers [6], which effectively builds connected networks among the mobile hosts in the particular area. The mobile hosts can move arbitrarily and can be active or inactive depending on the energy drainage [30]. To provide Quality of Service (QoS) [1][24,25] in ad hoc networks is very challenging because to find a route for the preferred destination with high possibility to continue for the period of the session. There are lot of research work has done by different authors on energy and stability based issues where as these works have their pros and cons. This promise that when communication initiated will not concern as our simulation results show a key decisive factor that impacts successive QoS. We propose an approach to select a stable route on the basis of residual energy of node, link expiration time, drain-rate and delay.

Rest of paper is organize as section 2 presents performance issues and research challenges in MANET, section 3 presents literature review, section 4 introduces the proposed framework, its algorithm and functioning, section 5 provides performance of our protocol by comparing with AODV and SQ-AODV via wide simulations using NS2.34 and Finally, section 5 provides conclusion of the work.

Performance Issues and Research Challenges in MANET

In MANET, nodes have energy constraint as they are battery powered devices. Beside that nodes mobility is one of the key feature of MANET and also a key factor responsible for link breakage and route breakage. Quality of service in Mobile Ad-hoc network is important for sensitive applications like voice and video transmission. Most existing routing protocols for mobile Ad Hoc networks considers residual energy and link expiration time for the route discovery and route maintenance but they are not considered delay. There are basically three types of delay.

- Queuing Delay
- Contention Delay
- Transmission Delay

Queuing Delay- it is the time a job waits in a queue until it can be executed. As the rate at which the packets incoming in a node/router increases further than the processing time, they are queued up by the router (buffer) until it can transmit them.

Contention Delay-the promise of throughput in Mobile Ad hoc Networks is challenging because the disputation between nodes, collisions, and mobility. Due to nature of the shared channel in Mobile Ad hoc Networks results in inter-flow and the intra-flow contentions.

Transmission Delay- It is a function of the packet's length. The amount of time necessary to press on all of the packet's bits interested in the communication channel, i.e. this is the delay caused by the data-rate of the link.

In order to execute delay sensitive applications, it is necessary to consider these delays. Conventional algorithm for establishing a route between source and destination consider only shortest path or minimum hop count, residual energy and link expiration time but these do not provide the best performance algorithm. We should consider both, protocols and analytical frameworks, for efficient energy and quality of service routing.

LITERATURE REVIEW

This section presents detailed literature review of energy aware and quality of service related work in mobile ad-hoc networks. Mobile nodes establish dynamic, multi-hop network grid and set up communication links between devices that lie within their transmission range. The main issue in this network is the power-constrained nodes as they powered by battery. Thus, different routing protocols are being developed for efficient routing in MANET to improve quality of service and life time of the network. We discuss existing works one by one and show that each protocol has its own merits and de-merits.

Mohammad A. Mikki et al [8] has introduced a location based routing protocol based on energy efficient concept that confines the extent used for finding novel routes to a reduced region, hence reducing energy consumption**.** EELAR utilizes location information of mobile nodes to reduce the search area for the route; hence there is a huge decrease in energy consumption and number of routing messages. Beacon packets are used for updating the position table so as to maintain information of all the nodes in the MANET. While a source node needs to transmit data, then first asks to base station regarding the area identity of the destination node and after that data packets are moved into the specified area.

Tai Heing Tie et al [18, 21, 22] has proposes a modified and improved AODV protocol which is different than its traditional counterpart as it does not emphasize on shortest path but rather on higher energy path and a backup route. This modified protocol is named as Alternate Route Maximum Energy Level Ad Hoc Distance Vector (ALMEL-AODV). Highest energy routes are selected by merging energy of altogether connected nodes on a particular path here and new route is chosen in case of broken links. It is seen that ALMEL-AODV employs reduced rebroadcasting thereby putting a check on overall energy wastage. This results in the better performance of ALMEL-AODV. Additional, the increase the number of nodes in MANET increases network lifetime. In terms of data delivery ratio also the improved protocol is better.

A different approach is used to conserve energy in Mobile Ad Hoc Networks. Rather than employing the technique of shortest path to conserve energy, paths with highest energy and low costs nodes are employed. ALMEL-AODV, a modification of traditional AODV achieves better performance. System Lifetime is increased and there is also an increase in data delivery ratio besides significant improvement in making the network energy efficient. However, ALMEL-AODV fails to take link stability and delay into consideration while optimizing the traditional AODV protocol

S. K. Dhurandher et al [12] presents an Energy Efficient MANET Routing to balances energy load among nodes involved path selection in the network so that a minimum energy level is maintained among nodes and the network life is increased. Consider possible functions of optimization by which energy expenses in nodes is reduces. Transmission throughout is depends on packet sizes, destination node's distance from source, etc as well as energy-efficient transmission path selection. A node having lower energy level is not chosen even if it is the best time path. It's working is such that, when a node A wants to send packets to a destination node Z, it does so by initially checking a path in its routing table. If no such information exists, then it broadcasts a RREQ to all its neighbors. On receiving a RREQ request, the intermediate node replies with a RREP if its neighbor is the destination node Z, otherwise it checks in its routing table for a path to node Z and forwards the request to that path. If no information is found, then the intermediate node again sends a new RREQ to its neighbors. The destination node used optimization function to select best path on collected s RREQ messages.

Mallapur Veerayya et al [1,24,25] to provide QoS in ad hoc network the routing algorithms should computes minimum delay among nodes and used to find the path with the minimum delay. As the request packet is forwarded from node to node, it has a field for accumulated delay where the delay is added with every hop. Accumulated delay stores the sum forwarding delay and link delay for every node in the route. On reaching the destination, the path having the minimum accumulated delay can easily be determined. For every path that has value more than the required delay value can be discarded. The path with the minimum delay value can be selected to establish the route.

PROPOSED APPROACH

In this section, we present a framework to improve the route discovery, route maintenance by using link expiration time, residual energy, delay of packets and drain rate. As in Mobile Ad-hoc networks, it is quite difficult to guarantee better quality of service due to the formation of spontaneous network or dynamic nodes. First, we explain these factor then present flowchart and algorithms.

Link Expiration Time

We shall ensure that the route selected will be the stable one by calculating its link expiration time and then comparing it against the threshold value. Only if the LET is greater than the threshold value of LET_n then that node will take part in route discovery. The computation of LET is based upon the mobility of the nodes involved in a MANET. The link expiration time is calculated at each hop of the route, this further helps in the calculation of route expiration time. As the route expiration time is the minimum of LET of all links from which that route is made up.

Let us assume there are two nodes i and j having coordinates (x_i, y_i) and (xj, yj) respectively. The expiration time of the links connecting these two nodes can then be calculated by using the formula:

$$LET = [-(a+b) + sqrt (((a^2+b^2)^2) - (ad-bc))] / (a^2+c^2) \qquad (1)$$

Where, $a= vicos\beta_i-vjcos\beta_j$

$b= x_i-x_j$

$c= v_i sin\beta_i - v_j sin\beta_j$

$d= y_i - y_j$

β, I, v_i, v_j are the movement direction and speed of nodes.

Due to the dynamic structure of MANET, the nodes are not static and are on the move. Owing to this characteristic of MANET, often the nodes move out of each other's transmission range resulting in the link breakage. So, we plan to estimate the average amount of time till which a link will exist depending upon the mobility of nodes.

Residual Energy and Drain Rate

One of the limitations of MANETs is that the nodes are battery constrained. Energy is consumed by these nodes during transmission and reception activities. Therefore, energy is one of the actual significant constrained in ad hoc network. When less energy node is participated in route establishment may run off its power in later stages resulting in the breakdown of link. If more such nodes are selected during route establishment, network may get partitioned and route discovery process will be initiated repeatedly resulting in overhead and delay. So, a protocol is an energy aware reactive protocol which considers not only the nodes residual energy but also its average drain rate so that a path with maximum lifetime can be chosen, thus achieving considerable energy savings. As residual energy of each node is known at each instant of time along with the total initial energy of nodes. We can easily calculate the drain rate of these nodes. Drain rate is the measurement of the rate at which the energy dissipates. Drain rate, DR_i is computed for every t second's computing interval by taking the average of energy consumption amount and estimating the energy dissipated per second.

Well known exponential weighted moving average method can be used to calculate the actual value of DR_i.

$$DR_i=\alpha*DR_{old}+(1-\alpha) DR_{sample} \qquad (2)$$

DR_{old} represents previous calculated value of drain rate and DR_{sample} is the latest value. The current or latest sample drain rate is given the highest priority by taking α as 0.3; this in turn helps to better reflect the current energy consumption of node. This actual value of drain rate which is calculated by equation 1 will give us an estimate of the remaining life time of battery depending upon the current traffic. This can be found by dividing remaining battery power, RBP or the residual energy of nodes by its drain rate.

$$T_n = RBP/DR_i \qquad (3)$$

This gives us the time after which the route containing this node shall expire. Only those nodes whose Tn is greater than T_h will take part in route discovery process where T_h is the threshold value.

Delay

Existing AODV protocols do not consider delay for the data transmission in an ad-hoc network which is very important for sensitive applications like voice, video and military services. Here in **EAQoS-AODV**, we are considering delay both during finding path and path preservation for better quality of service.

Route Discovery in EAQoS

Whenever source node needs to send data to a target node, it forwards RREQ packets to all its neighboring nodes if it does not have a path to that destination node stored in its route table else it will follow that path to the destination if the sequence number of the path stored in the route table at that node is greater than the one stored in RREQ. Each node receiving the RREQ creates a reverse route to the source. Each node has its own routing table which contains destination IP address, destination sequence number, hop count, number of hops needed to reach the destination, next hop, list of precursors, life time etc. some of the important fields that each RREQ packets contain are source address, broadcast ID, destination address, latest sequence number for the destination, acc_d, max_d etc.

Whenever a new RREQ packet is issued by a source, the broadcast ID is incremented. Upon the receipt of the RREQ packet on an intermediate node, the link lifetime of the node with the previous connecting node is calculated and checked against the threshold value. If it is smaller than the threshold value, then this RREQ packet will be discarded else this node will further have considered for further evaluation. Then depending upon the residual energy of the same node as well as the calculated remaining lifetime of that node, which is checked against a threshold value, we shall decide whether to consider this node for route discovery or not. If the required criteria are not met, RREQ packet shall be discarded else this node will be considered for further evaluation. After this the acc_d, max_d entries of both the RREQ packet and the route table are considered for calculating the delay of nodes as explained earlier. If this value is greater than the threshold value then this intermediate node shall further broadcast RREQ packet to all its neighboring nodes and update its route table accordingly else it shall discard the RREQ packet. This entire procedure is repeated until the RREQ reaches to the desired destination. After receiving several RREQs within a specified interval the destination selects the route with minimum acc_d and sends RREP to the same neighboring node in this stable route. This RREP message from the destination consists of the number of hops travelled as well as the aware source node to latest sequence number used for the target node. Each node receiving the RREP message creates a forward route to the destination. An intermediate node updates the acc_d field of its route table to the acc_d value contained in the RREP packet upon the receipt of the same and finally reaches to its originator. Thus, an energy efficient stable route from source to destination having minimum delay is established.

Route Maintenance in EAQoS

Once a route is established, data packets can be transferred along the same route. The node's delay which is computed by considering all the delays is added to the piggybacked acc_d field of every data packet. A new better route is selected from the buffered list of active routes, if the acc_d of the entire path is greater than the maximum allowed delay. In case of absence of any such buffered route, RERR packets are generated and subsequently the source node initiates a new route discovery. RERR packets are also generated if any node finds that it's neighboring nodes, which is also the next hop for a route is not working properly. This RERR is sent to the source node containing both the address of the non-working node and its own address. Intermediate nodes upon receiving RERR update their routing table by modifying the distance of the destination to an infinite value. When RERR message reaches the source node, it will check for an alternate path in the buffered list of active routes. On failure of finding any such routes, it shall initiate a new route discovery process.

Algorithm for EAQoS-AODV Protocol

Initially the value for accumulated delay(acc_d) is zero.

1. When node desires to communicate it start route discovery process to find path to destination.
2. Determine the link expiration time LET_n of all the neighboring nodes using

   $$LET = [-(a+b) + sqrt(((a^2+b^2)^2) - (ad-bc))] / (a^2+c^2)$$

   where, $a= v_i\cos\beta_i - v_j\cos\beta_j$, $b= x_i-x_j$, $c= v_i\sin\beta_i - v_j\sin\beta_j$, $d= y_i-y_j$ and β, I, v_i, v_j are the movement direction and speed of nodes

   2.1 If LET_n>LET threshold value then consider this node for further evaluation

   Else discard the RREQ packet.
3. Calculate the drain rate of the node based on residual energy of node using

   $$DR_i = \alpha * Dr_{old} + (1-\alpha) DR_{sample}$$

   3.1 Calculate the remaining lifetime of the node using T_n= RBP/DR_i

   where RBP= Remaining Battery Power.

   3.1.1 If T_n is greater than the threshold value then further consider these nodes

   else discard the RREQ packet.
4. Calculate the forwarding delay(fwd_d) of the node

   4.1. If fwd_d<max_d-acc_d then broadcast RREQ to the neighboring nodes and update routing table of all intermediate nodes (acc_d=acc_d+fwd_d),

   Else the RREQ packet is discarded and that route is rejected.
5. When the RREQ finally reaches the destination, the destination waits for a timeout period and then generate a RREP to the neighboring node which is the route having minimum value of acc_d.
6. Each intermediate receives route reply and process a forward path to the target and updates acc_d field its route table and pass it on to the previous node on the same route from source to destination.
7. Step 6 is repeated till the RREP finally reaches the source node which initiated the route discovery process
8. Thus, the most energy efficient stable route with minimum delay is established.
9. Start transmission of data packets along the previously established route.

10. Route maintenance is started.

10.1. If the route is broken then the upstream node at which the link is broken sends RERR message is propagated.

10.1.1 When the source receives the RERR

Message it checks the buffered list of active route for an alternate path from source to destination, if the route is present then Goto Step 9 else Goto Step1.

10.2. Calculate delay (contention delay, queuing delay and transmission) during route maintenance at each node using formulae

$$CW=\alpha*CW_{old} + (1-\alpha)*CW_{sample}$$

$$qlen= \beta*qlen_{old}+ (1-\beta)*qlen_{sample}$$

$$Li=\gamma*CW/CW_{max} + (1-\gamma)*qlen/qlen_{max}$$

10.2.1 Packet departure time – packet arrival time

These delays are added to the piggybacked acc_d and the node having minimum delay is selected.

11. A new better route is selected from the buffered list of active routes, if the acc_d of the entire path is greater than the maximum allowed delay.

12. If alternate better route is not found then generate RERR packets and propagate them and Go to Step1

SIMULATION RESULTS AND ANALYSIS

We have verified simulation result of our proposed protocol with existing AODV and SQ-AODV in NS 2 .34 [5]. The network testbed is created using TCL, the resource condition, establishment of root and setting up is simulated on TCL using C++. Simulation setup considers experiments; every transmission session begins at start of the simulation. After running fifty times of every experiment, then averaged the subsequent constraints of these 50 rounds. The simulation constraints of the network are used as detailed in table 1. The density of network is considered similar to existing authors setup [1]. The nodes are uniformly distributed on the specified area of their size 1000 m x 1000 m, as well as capability wise equal, but initialization performed by different energies. The medium access control of IEEE project 802.11 distributed coordination function is set and the data rate 1 Mbps in PHY-specific preamble header field. The two-ray ground reflection model considers both the direct path and a ground reflection path. We have conducted simulation for CBR traffic foundations to evaluate the total performance of EAQoS-AODV, SQ-AODV and AODV We considered flexible network load for evaluation of routing protocols of the MANET and focused the minimization of delay so that QoS should enhanced.

Table 1: Network parameter Values used in Simulation

Parameter	Value
Network area	1000x1000
Number of Nodes	50
Mobility model	Random Waypoint Motion Model
Data Traffic	CBR with 3 pkts/sec
Packet Size	512 Bytes
Buffer Length	50 Packets
Initial Energy	100 Joules
Packets/Session	Variable
Simulation Time	800 Seconds
Transmit power	0.3 W
Reception Power	0.15W

Figure 1 illustrates that in our network configuration, the x-axis specifies the expired number of connections, and it isn't the connection identifier whereas y axis specifies expiration time in seconds. AODV perform better than both SQ-AODV and EAQoS-AODV by about 400 seconds after that EAQoS-AODV perform better than both SQ-AODV and AODV

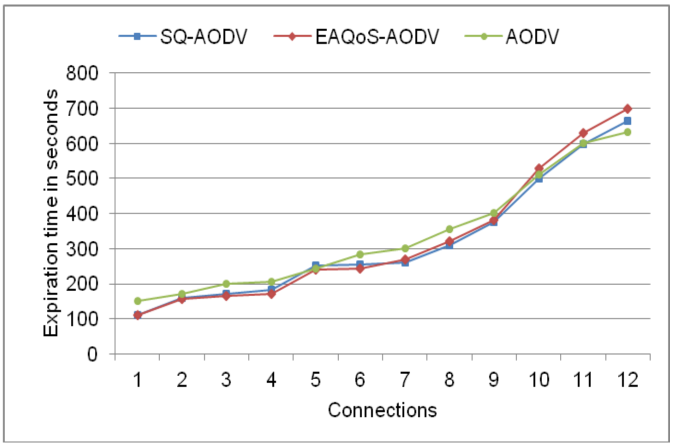

Figure 1: Expiration of connections

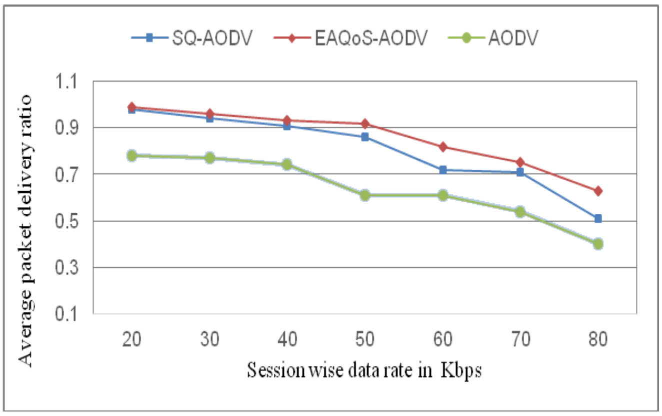

Figure 2: Average packet delivery ratio

In figure 2 we observe average Packet Delivery Ratio(PDR), x- axis consider session wise data rate in Kbps and y axis contains average PDR is the ratio of overall packets arriving at every destinations to overall packet send by each source in the entire network. The PDR is therefore numbers from 0 and 1. The packet delivery ratio of EAQoS-AODV is significantly improved than to AODV or SQ-AODV. In reality, the packet delivery ratio for EAQoS-AODV is enhanced by among 26%-12% as compare to AODV and via between 14%-6% as compare to SQ-AODV in excess of the network loads measured.

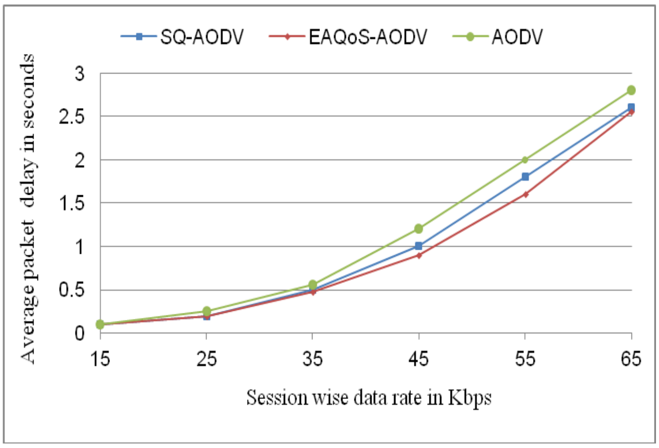

Figure 3: Average packet delay

Figure 3 shows that, EAQoS-AODV experiences better delay by packets than both SQ-AODV and AODV considering the entire loads under reflection. The interruption resulted in AODV is flanked by 200-400 ms upper side, or from 15%-40% upper side as compared by AODV and between 120-250 ms higher or from 10%-20% upper side than as in SQ-AODV since route updates are periodic results longer waiting time due to data packets have the higher loads.

CONCLUSION AND FUTURE WORK

The proposed Energy Aware Quality of Service Ad-hoc On-demand Distance Vector protocol with link stability for ad-hoc networks. We considered three factors link expiration time, residual battery power and drain rate and delay in our EAQoS-AODV routing protocol. EAQoS-AODV provides us the better energy aware, stable route having minimum delay results the enhancement in QoS and improved PDR. Thus, increases the quality of service the protocol making it energy conserving as well as satisfying delay parameter of QoS. The comparison results of our EAQoS-AODV protocol with AODV and SQ-AODV it's result shows that EAQoS-AODV protocol do improved than the existing SQ-AODV as well as AODV protocol in their expiration time, delay and PDR.

Further we can enhance the EAQoS-AODV by considering variable range transmission power instead of constant power model used in communications.

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