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General Article

Study of Various Energy-Efficient Protocols in MANET's

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Abstract

Wireless networking has seen a wide area of interest from consumers in personal communication. As the demand of any media increases the demand of its efficiency rises. Due to limited battery life of mobile terminals the energy efficiency may be majorly taken into consideration. MANET's are generally battery powered device thus we need to figure out how to use the power of battery efficiently. In this paper we will discuss about few energy-efficient routing protocols which will help in reducing power consumption as MANET is typically based on battery power.

Keywords*: MANET, energy-efficiency, wireless networking, routing, AODV etc.*

1. Introduction

An ad-hoc network is a group of wireless mobile hosts forming a short-term network without the support of any stand-alone infrastructure or centralized administration. Mobile Ad-hoc networks are self-organizing and self-configuring multi-hop wireless networks where, the structure of the network changes dynamically. This is mainly due to the mobility of the nodes. Wireless hosts are generally motorized by batteries which provide a restricted amount of energy. There are many techniques available to diminish energy expenditure for Mobile Ad Hoc Networks (MANET's). The main inadequacy of ad-hoc systems is the Availability of power.

In addition to operating the onboard electronics, power utilization is governed by the number of processes and expenses required to sustain connectivity (K. Khamforoosh et al,2008). One way to save energy is to use power economic mechanisms. Power economic mechanism allows a node to enter a snooze status by powering off its wireless network interface when it seems reasonable. In addition to providing energy saving, power control can potentially be used to improve spatial reuse of the wireless channel. One of the main design constraints in mobile Ad Hoc networks (MANET's) is power. Therefore, every effort is to be channelled in the direction of reducing power. Network lifetime is a key design metric in MANET's. Main objective of this Paper is to discuses energy efficient routing mechanisms and protocols, satisfying less energy consumption. We will consider three typical MANET routing protocols (AODV, DSR and DSDV) using performance and energy aware metrics.

The shortcoming of ad hoc network is that the nodes should be in range of a foundation, so that these nodes can

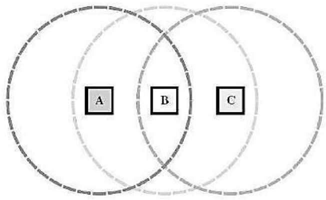

Fig. 1Simple ad hoc network

collect the information and broadcast it for further devices. If these nodes are not available, the whole network would fail (H. Idoudi, 2007). There is cooperation amid networks so that they should all be ready to accept and spread data. Also, a single node can receive data from several other nodes, exclusive of the other nodes knowing about each other. Ad hoc network is a multi-hop wireless network, which consists of number of mobile nodes (C. Perkins et al,2003). These nodes generate traffic to be forwarded to some other nodes or a group of nodes. Due to active nature of ad hoc networks, traditional fixed network routing protocols are not practical. Ad hoc radio networks have various operational areas. Some are like military, emergency, conferencing and sensor applications etc. Each of these areas has their explicit requirements for routing protocols. For example in military applications low likelihood of exposure and interception is a key factor such is routing effectiveness during declining and distressed radio channel conditions.

At sensor applications low or least amount of energy consumption is a precondition for an independent operation. In conference applications a definite quality of service for multimedia services is a needed characteristic. All application areas have some description and wants for protocols in common. The routing protocol transparency traffic is not allowed to drive the network to congestion

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nor is a local transform in link not allowed to cause a massive control traffic storm throughout the network. There are number of routing protocols for ad hoc networks, they are categorized into two: Proactive Routing and Reactive routing.

I.1 Proactive (Table- Driven) Routing Protocol:

In Proactive, nodes retain one or more routing tables about nodes in the network. These routing protocols renew the routing table information either cyclically or in comeback to change in the network topology. The benefit of these protocols is that a source node does not need route-discovery measures to find a route to a end node. On the other hand the negative aspect of these protocols is that maintaining a reliable and up-to-date routing table requires extensive messaging overhead, which consumes bandwidth and power, and decreases throughput, especially in the case of a large number of high node mobility.

There are various types of Table Driven Protocols: Destination Sequenced Distance Vector routing (DSDV), Wireless routing protocol (WRP), Fish eye State Routing protocol (FSR) etc.

I.2 Reactive (on-demand) routing protocol

Reactive routing is also well-known as on-demand routing protocol, these protocols have no routing information at the network nodes if there is no communiqué. These protocols take a sluggish approach to routing (S. Roy et al,2002). They do not maintain or regularly update their route tables with the latest route topology. If a node wants to send a packet to another node then this protocol searches for the route and establishes the link in order to transmit and receive the packet.

There are various types of On-demand protocols are the dynamic source Routing (DSR), ad hoc on-demand distance vector routing (AODV).

Reactive v/s proactive

Table I: Comparison of Proactive and Reactive routing protocols

Reactive protocols	Proactive Protocols
A route is built only when required.	Attempt to maintain consistent, up-to-date Routing information from each node to every other node in the network.
No periodic updates. Control information is not propagated unless there is a change in the topology.	Constant propagation of routing information periodically even when topology change does not occur.
First-packet latency is more when compared with table-driven protocols because a route need to be built.	First packet latency is less when compared with on-demand protocols.
Not available	A route to every other node in ad-hoc network is always available.

2. Manet challenges

Some of the challenges in MANET include:
1) Unicast routing
2) Multicast routing
3) Speed
4) Dynamic network topology
5) Frequency of updates or Network overhead
6) Mobile agent based routing
7) Quality of Service
8) Scalability
9) Energy efficient/Power aware routing
10) Secure routing

The key challenges faced at different layers of MANET Challenges are shown in Fig. 2.

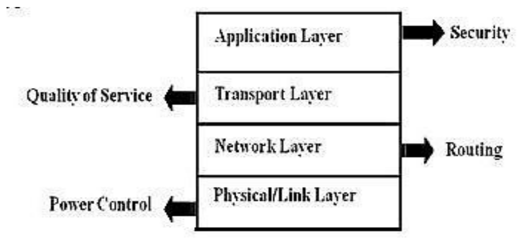

Fig 2: Manet challenges

3. Manet's protocols

Now a day mainly the MANET's routing protocol can be classified into

- Dynamic Source Routing (DSR)
- Ad Hoc on Demand Distance Vector (AODV)
- Destination-Sequenced Distance-Vector Routing (DSDV)

3.1 Ad Hoc on Demand Distance Vector (AODV)

The Ad hoc On Demand Distance Vector (AODV) routing algorithm is a routing protocol intended for mobile ad hoc networks. AODV is capable of both unicast and multicast routing. It is an on-demand algorithm, meaning that it links routes between nodes only as desired by source nodes. It maintains these routes as long as they are required by the sources. Additionally, AODV forms trees which connect multicast group members. The trees are collection of the group members and the nodes needed to connect the members. AODV uses progression numbers to ensure the originality of routes. It is loop-free, self-starting, and scales to large numbers of mobile nodes.

The AODV protocol uses route request (RREQ) messages filled through the network in order to determine the paths required by a source node. An intermediate node that receives a RREQ replies to it using a route reply message only if it has a route to the target whose consequent destination sequence number is larger or equal to the one enclosed in the RREQ. The RREQ also contains the most recent sequence number for the destination of which the source node is alert. A node receiving the RREQ may send a route reply (RREP) if it is either the destination or if it has a route to the destination with corresponding sequence number greater than or equal to that enclosed in the RREQ. If this is the case, it unicast a RREP back to the foundation node Otherwise, it rebroadcasts the RREQ.

3.2 Dynamic Source Routing (DSR)

Dynamic Source Routing (DSR) is a routing protocol for wireless web (mesh) networks and is based on method known as source routing. It is analogous to AODV in that it forms a route on-demand when a transmitting node requests one. Apart from that each transitional node that broadcasts a route request packet adds its own address identifier to a list passed in the packet. The end node generates a route reply message that includes the list of addresses arriving in the route request and transmits it back along this path to the source. Route preservation in DSR is accomplished through the confirmations that nodes generate when they can verify that the next node successfully received a packet. These confirmations can be link-layer acknowledgements, passive acknowledgements or network-layer acknowledgements specified by the DSR protocol. However, it uses source routing instead of relying on the routing table at each intermediate device. When a node is not able to verify the successful reception of a packet it tries to retransmit it.

When a finite amount of retransmissions fails, the node generates a route error message that specifies the problematic link, transmitting it to the source node. When a node requires a route to a destination, which doesn't have in its route cache, it broadcasts a Route Request (RREQ) message, which is infested throughout the network. The first RREQ message is broadcast query on neighbours without flooding. Each RREQ packet is uniquely identified by the initiator's address and the request id. A node processes a route request packet only if it has not previously seen the packet and its address is not here in the route record of the packet. This minimizes the number of route requests propagated in the network.

RREQ is replied by the destination node or an intermediate node, which knows the route, using the Route Reply (RREP) message. The return route for the RREP message may be one of the routes that exist in the route cache (if it exists) or a list reversal of the nodes in the RREQ packet if balanced routing is supported. In other cases the node may start it owns route finding mechanism and piggyback the RREP packet onto it. Thus the route may be considered unidirectional or bidirectional. DSR doesn't impose any use of sporadic messages from the mobile hosts for preservation of routes. Instead it uses two types of packets for route maintenance.

Route Error (RERR) packets and ACKs

Whenever a node encounters deadly transmission errors so that the route becomes invalid, the source receives a RERR message. ACK packets are used to confirm the correct operation of the route associates. This also serves as a passive acknowledgement for the mobile node. DSR enables multiple routes to be learnt for a particular destination. DSR does not require any intermittent update messages, thus avoiding wastage of bandwidth.

Now we give a format for RREQ packet:

Table 2: RREQ packet format

Type	J/R/G/D/U	Reserved	Hop-count
RREQ ID			
DESTINATION ID NO.			
DESTINATION SEQEUENCE NO.			
ORIGINAL ID NO.			
ORIGINAL SEQUENCE NO.			

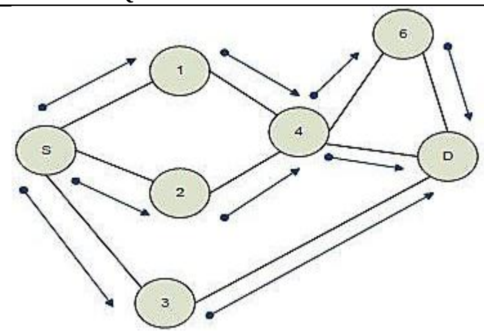

Fig 3: RREQ propagation

3.3Destination-Sequenced Distance-Vector Routing (DSDV)

Destination-Sequenced Distance-Vector Routing (DSDV) is a table-driven routing scheme for ad hoc mobile networks based on the Bellman-Ford algorithm. It eliminates route looping, increases convergence speed, and reduces control message overhead. In DSDV, each node maintains a next-hop table, which it exchanges with its neighbours. There are two types of next-hop table exchanges

Periodic full-table broadcast and event-driven incremental updating

The relative frequency of the full-table broadcast and the incremental updating is determined by the node mobility. In each data packet sent during a next-hop table broadcast or incremental updating, the source node appends a sequence number. This sequence number is propagated by all nodes receiving the resultant distance-vector updates, and is stored in the next-hop table entry of these nodes. A node, after receiving a new next-hop table from its neighbour, updates its route to a destination only if the new sequence number is larger than the recorded one, or if the new sequence number is the same as the recorded one, but the new route is shorter.

Table 3: A RREP packet format

TYPE	R/A	RESERVED	PREFIXED	HOP COUNT
DESTINATION IP ADDRESS				
DESTINATION SEQUENCE NUMBER				
ORIGINATOR IP ADDRESS				
LIFE TIME				

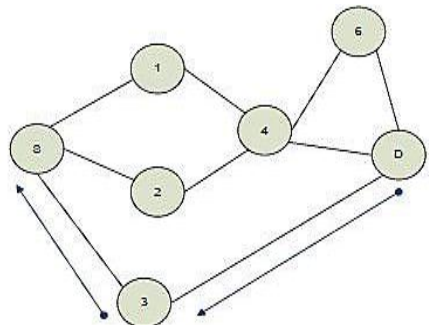

Fig 4: RREP propagation

4. Discussion of the modified protocols

A. Based on the routing techniques

In this section we will look at two modified AODV protocols viz. Reverse AODV (RAODV) and Modified Reverse AODV (MRAODV). In Reverse AODV (RAODV), destination node uses reverse RREQ to find source node. It reduces path breakdown, correction messages and can improve the robustness of performance. Therefore, success rate of route discovery may be increased even in high mobility situation.

When broadcasted *reverse request* packet arrives to intermediate node, it will check for redundancy. If it already received the same message, the message is dropped, otherwise forwards to next nodes and when the source node receives first *reverse request* message, then it starts packet transmission, and late inwards R-RREQs are saved for future use. Even if packet delivery ratio is enlarged there are other disadvantages.

Due to multicasting by destination there is considerable amount of energy wastage of nodes in the network and as well control packet operating cost increase. In Modified Reverse AODV (MRAODV) permanence estimation method is used for route choice and to increase performance. In the proposed routing algorithm, when a source node wants to communicate with a destination node, first it broadcasts a RREQ packet.

This stage is like that of AODV algorithm. When destination receives a RREQ message, it broadcasts R-RREQ message to find source node. Each midway node which receives the R-RREQ message, calculates its route firmness for each route using equation given below and this stability is used for selecting the path.

$RSr = \Pi \, nsi$ (1)

Where RSr is the route stability of the route r

Lr is the set of available routes and nsi is the stability of node i.

The stability of each node can be calculated by following equation,

$nsi = (t-t')/(Ln - Ln')$ (2)

Where Ln denotes the location of node ni at the time t.

For t computation of stability for each node we need to obtain t-t' delay

Semi-Proactive AODV (SP-AODV) is a combination of pro-active and reactive dynamic routing protocol. It is node centric rather than based on zones or areas as in mixed approaches of routing protocol. The efficiency of this protocol lies in the fact that some nodes which are often used will dynamically update a few sections of their routing table like pro-active protocol and other nodes which are used less operate like reactive routing protocol. The results showed that the routing protocol has extra packet delivery ratio and less end-to-end delay compared to AODV. Furthermore, control packet overhead in SP-AODV is fewer than AODV in low and medium mobility of nodes; however, it is more than AODV in elevated mobility of nodes.

B. Based on the alternate back up route

In this section, we will discuss about two modified AODV protocols, Load Balancing AODV (LBAODV) and Robust AODV. In LBAODV protocol, all the exposed paths are concurrently used for transmitting data. Due to this, data packets are unbiased over exposed paths and energy expenditure is dispersed across many nodes. In route discovery the source broadcasts RREQs. When destination receives RREQs, it reverses the route record from the inward RREQs and uses this route to send RREPs to the basis node. When a node receives multiple RREPs from an another node, it increments the number of route answer back, *Count Reply*, received from this node in its *route table* field which means how many routes from this next hop to the destination exist.

Each node that receives data packets sends them to the next hops according to their *Count Reply* values. The More the count reply, greater the amount of data sent and vice-versa. This protocol helps to attain better packet delivery ratio and disseminated energy utilization. Due to synchronized transmission of data packets source to destination delay may be reduced. In Robust AODV with Local Update, the route is built on demand and maintained by locally updating route information.

Various back up routes are built around active route and the highest priority back up route will be switched to become new active route when the current active route is less favoured. The route detection process is almost same as in original AODV protocol apart from that all the routes are back up routes. Route entries are updated whenever a link breakage is detected and if backup route exists we switch to a new route. The broadcasted route update message which replaces the AODV hello message contains all the necessary route information.

This protocol works best in case of high mobility. It is preferred when the energy of node is not a matter of concern but a strong and reliable network is desired. Disadvantage of this protocol is the complexity in execution and high power consumption.

C. Based on Energy

In this section we will look at two modified AODV protocols viz. Energy Saving AODV (ES-AODV) and Energy Multipath AODV (EM-AODV). In Energy Saving AODV (ES-AODV) protocol, the power controlled mechanism is adopted to regulate the emanation power of node dynamically and to perk up the energy saving performance of AODV routing protocol in mobile Ad Hoc networks.

ES-AODV protocol focuses on the local patch up and minimizes the probability of using source node for the route rebuild. ES-AODV protocol methodically evaluates excess energy of nodes, each node in the link calculates its weight which is in converse proportion with its energy. The routing protocol always chooses the smallest cost link for data transmission. Energy utilization of nodes in the network could be successfully balanced and the average endurance time of nodes in the network can be enhanced.

The ES-AODV protocol makes full use of the backup route information which is cached during the stages of route optimization to repair the broken link. Even with suitable increase in node's speed, its lifetime is better as compared to AODV at same speed. Also increase in number of nodes' reduces the power of communiqué between nodes, which directly affects the rate of energy consumption and thus lengthen nodes' lifetime.

Energy Multipath AODV (EM-AODV) proposes a new adaptive approach which considers the metric residual energy of nodes instead of the number of hops in the process route selection. In this we define the rate of energy consumption for each node to estimate its lifetime and as well define a cost that fits this lifetime and the energy level. This information is used for calculating the cost of routes and the path with minimum cost is selected. EM-AODV improves the performance of AODV in most metrics, as the packet delivery ratio, end to end delay, and mostly energy consumption which is most important.

5. Comparison of DSDV AODV and DSR

In this section we will compare the three algorithms which were considered and discussed throughout the paper

Table 2: comparison of AODV, DSDV and DSR

Sr. No.	DSDV	AODV	DSR
1	It is Proactive protocol	Reactive protocol	Reactive protocol
2	It performs almost as DSR, but requires transmission overheads of many packets.	It delivers virtually all packets at low mobility	It is very good at all mobility rates.
3	It has high for pause time 0 but it starts decreasing as time increases.	Less delay	It has low end to end delay
4	It performs better for few number of nodes	It performs better for larger number of nodes	It performs better for larger number of nodes
5	Eliminates route looping	Save power consumption	Mesh routing/route on demand

Conclusion

There are numerous routing techniques proposed so far in MANET's, here in this paper we have gone through many algorithms which show their effectiveness in terms of back up route, routing mechanism or lower energy consumption. We can conclude that so-far the two algorithms ES-AODV and EM-AODV are the two algorithms which can be used for energy efficient routing mechanism as the spreads the load to every node resulting in lowering of energy consumption.

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