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A Brief Survey on Energy Efficient Routing Protocols in Manet

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Abstract--- Mobile ad hoc network (MANET) is a group of mobile nodes which communicates with each other without any supporting infrastructure. Routing in MANET is extremely challenging because of MANETs dynamic features, its limited bandwidth and power energy. MANET nodes operating on battery try to pursue the energy efficiency heuristically by reducing the energy they consumed. In MANET, all nodes are mobile in nature and having limited battery charge. Continuous change in position and connection degrades the battery charge of the nodes therefore it is necessary to save battery of those nodes which are having low battery so that the network lifetime can be long lasting. It is really very significant to increase lifetime of MANET. In order to enhance the lifetime of MANET; energy efficient techniques are required. Ad hoc On-Demand Distance Vector (AODV) Routing protocol has been accepted itself as one of the distinguished and dominant routing protocol for Mobile Ad Hoc Networks (MANETs). From various performance analysis and results, it is shown that AODV has been an outstanding routing protocol that outperforms consistently than any other routing protocols. But it could not pervade the same place when the performance was considered in term of energy consumption at each node, energy consumption of the networks, energy consumption per successful packet transmission, and energy consumption of node due to different overhead. Because, AODV protocol doesnot take energy as a parameter into account at all. And as MANET is highly sensible towards the power related issues and energy consumption, as it is operated by the battery with the limited sources, needed to be used efficiently, so that the life time of the network can be prolonged and the performance can be enhanced. This paper presents a comprehensive summery of different energy efficient protocols that are based on the basic Mechanism of AODV.

Keywords--- Mobile Ad hoc networks; Routing protocols; AODV; energy-efficiency; lifetime prediction.

I. INTRODUCTION

Wireless communication is undergoing rapid advancements to meet the demands of current and future trends of communications. Unlike wired networks which require a fixed network infrastructure like a base station to communicate. Mobile ad-hoc networks are self configuring thus self organizing mobile nodes participate to form a wireless network without any existing network infrastructure. Each mobile node participating in this type of networks acts as a router by itself, there by discovering and maintaining the routes to other nodes to communicate over the network. MANETs are subject to rapid changes in their mobility and their performance is affected by topological changes. With limited band-width and power available to these nodes, the performance of these nodes hugely depend on the type of routing protocol used for communication. The nodes of MANETs have limited battery power and the routing protocols cannot efficiently serve the purpose of the MANETs' applications during communications once the onboard battery power of the constituent nodes get exhausted. Hence, it is required to sustain the MANETs' lifetime by properly utilizing the battery power of its nodes.

Energy efficiency has become one of the major design goals of any MANET routing protocols. Many routing protocols have been proposed which aim to make packet forwarding between nodes energy efficient. Different energy metrics have been used in each of them such as average energy consumption, network lifetime, energy drain rate, etc.

MANETs have several salient characteristics:

1) Dynamic topology
2) Bandwidth constrained , variable capacity links
3) Energy constrained operation
4) Limited physical security

II. CLASSIFICATION OF ROUTING PROTOCOLS

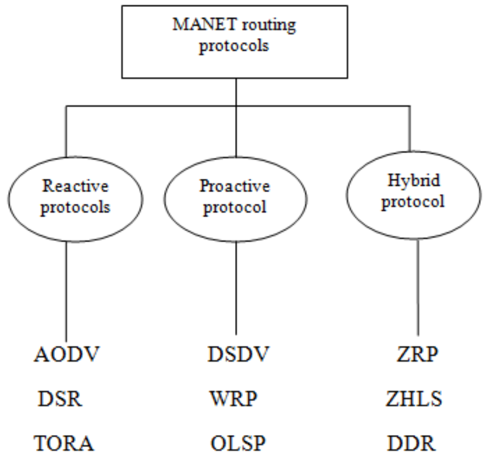

Figure.1: Routing protocols in MANET

The Routing Protocols for ad hoc wireless networks can be divided into three categories based on the routing information update mechanism. They could be Reactive (On-demand), Proactive (Table-driven) or Hybrid. Figure 1 shows the three categories of Ad hoc RPs and various proposed Protocols under each category.

A. On-demand Routing Protocols (Reactive)

The reactive or on-demand routing protocols are based on Query-Reply topology in which they do not attempt to continuously maintain the up-to-date topology of the network. When a route is desired, a procedure is invoked to find a route to the destination node. The major goal of on demand or reactive routing protocols is to minimize the network traffic overhead. These routing protocols are based on some type of "query-reply" dialog. They do not attempt to continuously maintain the up-to-date topology of the network

Some of the existing reactive protocols are Ad hoc On-Demand Distance Vector (AODV),Dynamic Source Routing (DSR),Associativity Based Routing (ABR) ,Signal stability based adaptive Routing (SSR).

B. Table-driven Routing Protocols (Proactive)

The table-driven ad hoc routing approach is similar to the connectionless approach of forwarding packets, with no regard to when and how frequently such routes are desired.The routing information is constantly propagated and maintained in table-driven routing protocols, a route to every other node in the ad hoc network is always available, regardless of whether or not it is needed.

There are various existing proactive routing protocols. The areas in which they differ are the number of necessary routing tables and the methods by which changes in the network topology are broadcast. Some of the existing proactive protocols are Destination-Sequenced Distance Vector (DSDV), Global State Routing (GSR),Fisheye State Routing (FSR).

C. Hybrid Routing

Hybrid protocols combine features from both reactive and proactive routing protocols, typically attempting to exploit the reduced control traffic overhead from proactive systems whilst reducing the route discovery delays of reactive systems by maintaining some form of routing table.

III. ENERGY CONSERVATION TECHNIQUES IN MANET

Energy conservation technique in MANET can be broadly classified into two types:

- Topology Control Approach
- Transmission Power Management Approach

There are many energy matrices used for calculating the power consumption caused by different reasons. The energy few energy related metrics are used. These metrics are helpful while determining energy efficient routing path instead of considering shortest path like in the traditional DSR protocol use. These metrics are:

1) Energy consumed per packet
2) Time to network partition
3) Variation in node power level
4) Cost per packet
5) Maximum node cost

A. Topology Control Approach

The topology control is an effective technique for power saving. The topology of MANET is considered as graph with its nodes as vertices and communication links between node pairs as edges. In dense network too many links leads to high energy consumption, network throughput, and quality of services. The primary target of topology control is to

replace long distance communication with small energy efficient hops. The dense network while ensures tight connectivity at the same time causes interference where in sparse network every node needs to be part in data communication as connectivity is being a question. So there is a tradeoff between network connectivity and sparseness [4]. For two nodes u and v the energy consumption of their communication grows quadratic ally with their distance.
By controlling network topology network throughput is enhanced because of two benefits. First the interference is reduced by varying transmission radii of nodes to near one, second more data transmission is carried out simultaneously in the neighborhood of a node. If a network has bad topology, there may be adverse effect such as low capacity, high end-to-end delay and weak robustness to node failure [5].

B. Transmission Power Management Approach

Power management approach basically decides when to switch off radio transceiver of the mobile terminal to save energy. This power management state can also be called as **sleep/power down mode** [6]. Turning the transceiver off make the node not to listen to the cannel and not take in active participation in packet transferring. So turning off the station should be done with a condition not to incorporate delays in packet transmission. The synchronization should be maintained in routing so that switching off one node does not affect the performances of overall network connectivity.
If the two nodes are coming in each other transmission range then the direct communication is possible, otherwise the communication is carried out by the intermediate nodes acts as routers. When the transmission range is controllable, their direct communication range as well as the number of its immediate neighbors is also adjustable for giving reliable communication. The stronger transmission range reduces the number of hops, whereas weaker transmission power makes the topology sparse resulting in network partitioning and high end-to-end delay due to large hop count [7]. The power of transmission range is directly proportional to node's battery energy. Increasing the transmission power make more energy consumption and vice versa. Also transmission power affects the interference and collision which may lead to retransmission causing unnecessary energy consumption. Power control is to utilize node's transmission power to reduce interference and to save energy. For energy efficient routing an appropriate transmission power of data packets at each node is decided [8]. The fixed transmit power approach may not be feasible as it won't give guaranty of finding neighbor within a node's fixed transmission power. So in some cases the maximum transmission power is used for control message and minimum required power for subsequent data reception.

IV. ADHOC ON-DEMAND DISTANCE VECTOR ROUTING PROTOCOL OVERVIEW

In 2001, C. E. Perkins, E. M. Royer and S. Das [8] proposed Ad hoc On-Demand Distance Vector (AODV) routing protocol which functions similar to DSR protocol. But, instead of carrying out source routes in each packet as in DSR, AODV maintains route table entries at intermediate nodes. AODV also maintains destination sequence number to avoid loop problem. AODV works efficiently for large number of nodes which is not the case for DSDV
AODV routing protocol is a reactive routing algorithm. It maintains the established routes as long as they are needed by the sources. AODV uses sequence numbers to ensure the freshness of routes. Route discovery and route maintenance for AODV are described below.

A. Route Discovery

The route discovery process is initiated whenever source node wants to communicate with destination and if path is not available to destination then source floods or broadcasts RREQ i.e. request packet to all its neighbours in the network. On receiving RREQ packets, an intermediate node either rebroadcasts the RREQ packet when it has no routes, or sends RREP containing the route back to the source. The intermediate node also creates the backward path on receiving the RREQ. The destination on receiving the first RREQ, sends RREP or Route Reply down the path from which it received the RREQ. While traversing its way up the source, the forward path is built up, and on reaching the source, the entire forward path gets built. The source only knows about the next hop, and sends packet to next hop which using its next hop information forwards the packet down the route. The process goes on for every intermediate node till the destination is reached.

B. Route Maintenance

Route maintenance is done using route error (RERR) packets. When a link failure is detected, a RERR is sent back via separately maintained predecessor links to all sources using that failed link. Routes are erased by the RERR along its way. When a traffic source receives a RERR, it initiates a new route discovery if the route is still needed. Unused routesin the routing table are expired using a timer-based technique.

- **Advantages And Disadvantages Of Aodv**

The advantage of AODV is that it creates no extra traffic for communication along existing links. Also, distance vector routing is simple, and doesn't require much memory or calculation. The main advantage of AODV protocol is that routes are established on demand and destination sequence numbers are used to find the latest route to the destination. The connection setup delay is less. The HELLO messages supporting the routes maintenance are range limited, so they do not cause unnecessary overhead in the network.
One of the disadvantages of this protocol is that intermediate nodes can lead to inconsistent routes if the source sequence number is very old and the intermediate nodes have a higher but not the latest destination sequence number, thereby having stale entries. Also multiple RouteReply packets in response to a single RouteRequest packet can lead to heavy

control overhead . Another disadvantage of AODV is that the periodic beaconing leads to unnecessary bandwidth consumption. It requires more time to establish a connection, and the initial communication to establish a route is heavier than some other approaches.

V. AN ENERGY SAVING AD HOC ROUTING ALGORITHM FOR MOBILE ADHOC NETWORKS (ESAR)

In Energy saving adhoc routing algorithm for MANET (ESAR) [6], the authors have proposed a multi-path energy efficient modification to the AODV routing protocol. They consider the actual distance between source and destination nodes through each of the path taken and the minimum energy remaining in the node of the path as metrics. This information is collected while RREQs visit each node and aggregated in the destination node. The metrics are used to compute a cost function using network administrator set weights. The weights are set to give relative weightage to either the energy efficiency or the delay metrics depending on which factor we wish to optimize. All RREQs are collected for a certain time period. At the end of this time, the best path depending on the path having least cost is selected. Routing proceeds through the best path, till this path goes down and at that point backup paths are used. Backup paths are the next best path. When all backup paths have gone down, the cost is recomputed and paths are chosen afresh. It is basically a bi-criteria decision making problem solved using weighted sum approach to find a cost function as given below:

$Cost_i$ = α * DE_i + β * $Dist_i$

where,

DE_i is the difference between minimum available battery power of the node and the threshold.

$Dist_i$ is the distance between source and destination.

α and β are weighing factors, assigned by network administrators. They denote the specific weight-age of each of the metrics.

VI. LIFETIME PREDICTION ROUTING IN MOBILE ADHOC NETWORKS (LPR-AODV)

LPR-AODV [7] uses the concept of lifetime prediction. This protocol favors the route with maximum lifetime, i.e. the route that does not contain nodes with a weak predicted lifetime. LPR-AODV solves the problem of finding a route π at route discovery time*t*, such that the following cost function is maximized.

Max_{π} *(Tπ(t))=* Max_{π} *(*$Min_{i\in\pi}$ *(Ti(t))*

where *Tπ(t)* is the lifetime of path π;

Ti(t) is the predicted lifetime of node *i* in path π.

LPR-AODV uses battery lifetime prediction. Each node tries to estimate its battery lifetime based on its past activity. This is achieved using a recent history of node activity. When node *i* sends a data packet, it keeps track of the residual energy value (*Ei*(*t*)) and the corresponding time instance (*t*). This information is recorded and stored in the node. After *N* packets sent/forwarded, node *i* gets the time instance when the *N*th packet is sent/forwarded (*t'*) and the corresponding residual energy value (*Ei*(*t'*)). This recent history, {(*t*, *Ei*(*t*)), (*t'*, *Ei*(*t'*))}, is a good indicator of the traffic crossing the node. Hence, we use it for lifetime prediction. Our approach is a dynamic distributed load balancing approach that avoids power-congested nodes and chooses paths that are lightly loaded.

Ti(t)=Ei(t)/discharge_ratei(t) - (1)

discharge_rate i(t) = Ei(t')-Ei(t)/t-t' – (2)

where,

t' is the recorded time instance corresponding to the moment when the Nth predecessor packet to the current packet was sent or forwarded.

t is the current time.

E(t), is the energy at the current time

E(t') is the time instance at the time Nth predecessor packet was sent or forwarded**.**

VII. LIFETIME PREDICTION BASED ENERGY SAVING ROUTING ALGORITHM FOR MANETS (LP-ESAR)

Lifetime prediction based energy saving routing algorithm for manets (LP-ESAR)[9] is an enhancement over energy saving ad hoc routing algorithm(ESAR) by utilizing the concept of lifetime prediction used in LPR-AODV.

The predicted lifetime of a node can be predicted using the formula (1) and (2) as mentioned above.

When each data packet is transmitted through the node, the present time instance and available battery power at that node are recorded. Such ten records are maintained, in the form of a circular queue known as energy queue. The old information is replaced by the new information.

The RREQ collects the minimum predicted lifetime of the node instead of minimum available battery power of the node in the path. At the destination, cost function is calculated based on the formula given below:

$Cost_i$ = α *1/ Min(Ti(t)) + β * $Dist_i$

Where Min(Ti(t)) is the minimum predicted lifetime of the node in the path.

.α and β are weighing factors, assigned by network administrators. They denote the specific weight-age of each of the metrics.

VIII. CONCLUSION AND FUTURE WORK

In this paper we have reviewed three energy efficient routing protocols based on AODV i.e ESAR, LPR-AODV and LPR-ESAR.In order to facilitate communication within MANET an efficient routing protocol is used to discover routes between two nodes. Performance of the protocol varies according to the variation in the network parameters, as we know that in ad-hoc network properties continuously vary. Sometimes the mobility of the node of the network is high while sometimes energy of the node is our prime concern. So, we will choose the protocol in such a way that performs best for that particular type of network.

In future work, we will introduce enhancement of energy efficient routing algorithm based on AODV by considering physical layer reliability of the communication link between two nodes involved in the path.

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