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An Approach of Energy Efficiency in DSR Routing Protocol

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Abstract: ***Dynamic Source Routing protocol (DSR) has been accepted itself as one of the distinguished and dominant routing protocols for Mobile Ad Hoc Networks (MANETs). From various performance analysis and results, it is shown that DSR 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, DSR protocol does not 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 lie time o the network can be prolonged and performance can be enhanced. This paper presents a comprehensive summery of different energy efficient protocols that are based on the basic Mechanism of DSR and enlightens the effort and commitment that has been made since last 10 year to turn the traditional DSR as energy efficient routing protocol.***

General Terms: Mobile Ad hoc Networks, Routing Protocols, Energy-aware Routing Protocols
Keywords: DSR, Load, Residual Energy, Bandwidth, Hop Count

I. INTRODUCTION

Ad Hoc Network is a multi-hop wireless networks which is consist of autonomous mobile nodes interconnected by means of wireless medium without having any fixed infrastructure. It's quick and easy deployment in a situation where its highly impossible to set up any fixed infrastructure networks, has increased the potential used in different applications in different critical scenarios. Such as battle fields, emergency disaster relief, conference and etc. A mobile ad hoc network [MANET] [1, 2, 3, 4, 7] can be characterized by the mobile nodes which have freedom to move at any direction and has the ability of self-configuring, self-maintaining and self- organizing themselves within the network by means of radio links without any fixed infrastructure like based station, fixed link, routers, and centralized servers. As in the network there is no base station or central coordinator exists, so the
individual node plays the responsibility as a router during the communication has to be played by each and every node, participating in the network communication. Hence all the nodes are incorporated with a routing mechanism in order to transmit a data packet from source to destination. Nodes are operated by battery which is having limited capacity and they all suffer from severe battery consumption, especially when they participate for data communication for various sources and destinations. An uninterrupted data transmission from a particular source to destination requires a continual updating of path. If any moment path is not fond from source to destination, then Route Discovery Process has to be called. And multiple times route Discovery Process may introduce heavy power consumption. A number of routing approaches have been proposed to reduce various types of power consumption caused by various reasons in the wireless ad hoc network, which in result not only prolongs the life span of individual nodes but also reduces the network partition and enhances the performance of the network.

In fixed infrastructure wireless network [5] is a static network where its different components have to be set up permanently prior to the establishment of the communication. It takes not only huge time but also involves a huge cost for establishing the network.

The best example of a fixed infrastructure based network is Global system for mobile Communication (GSM) known as Second generation Mobile cellular System which is also a wireless network. In GSM, network architecture comprises several base transceiver stations (BTS) which are clustered and connected to a base station controller (BSC).Several BSC are connected to an Mobile Switching Center (MSC). The MSC has access to several data base, including Visiting Location Register (VLR), Home Location register (HLR).It is also responsible for establishing, managing and clearing connection as well as routing calls to proper radio cells. Here even if the nodes are mobile but they are limited with a fixed number of hops while communicating with other nodes.

But in case of MANET, it is completely different. The network is considered as a temporary network as it is meant for a specific purpose and for a certain period of time. And it is based on multi-hop technology where the data can be transmitted through number of intermediate nodes from source to destination.

With the rapid demands of MANET in the recent years,certainly have challenged the researchers to take up some of the crucial issues like bandwidth utilization, limited wireless transmission range, hidden terminal and exposed terminal

problem, packet loss due to transmission error, mobility, stimulated change of route, security problem and battery constraint.

One of the important challenges of MANET is power constraint. The mobile ad hoc networks are operated on battery power. And the power usually gets consumed in mainly two ways. First one is due to transmitting of data to a desired recipient. Secondly, mobile node might offer itself as an intermediate forwarding node in the networks. The power level of the node is also getting affected while any route is established between two end points. The tradeoff between frequency of route update dissemination and battery power utilization is one of the major design issues of ad hoc network protocols. Because high power consumption will increase the battery depletion rate which in turn reduces the node's lie time, network lie time and causes network partition. Due to high network partition performance et a affected due to increase in number of retransmission, packet loss, higher end to end delay and many more problems.

Therefore, various energy efficient routing protocols have been proposed to increase the lifetime of the nodes as well as lifetime of the networks, so that communication can be carried out without any interruption. This article provides as well as analyzes different energy efficient routing protocols designed for ad hoc wireless networks which are only based on the mechanism of traditional DSR routing protocol.

The remaining of the session is organized as follow. The next section-2 presents two subdivision of Ad Hoc routing Protocols and their basic routing mechanism. We have basically emphasized the basic working principle o DSR routing protocol as it we have explained all energy efficient routing protocol which is based on DSR only. In section-3 we have shade some lights on the requirement of energy aware routing protocol for MANET and its different approaches to achieve that goal. The next section-4 highlights all related work that has been done to make DSR as an efficient energy aware routing Protocol. And finally the last section-5 concludes the article.

III. ROUTING PROCESS IN AD HOC NETWORKS

In MANET [1, 2, 3, 4, 6,7], routing is a process of establishing a route and then forwarding packets from source to destination through some inter mediate nodes if the destination node is not directly within the range of sender node. The route establishment itself is a two steps process. First one is the Route Discovery where it finds the different routes from same source to destination. Second, the Route Selection, where it selects a particular route among all routes found for the same source to destination. Traditional protocols and data structure are available to maintain the routes and to execute it by selecting the path that is having minimum distance from source to destination where the minimum distance is in term of minimum hop count.

2.1 Existing ad hoc routing protocols

Ever Since Defense Advance research Project (DARPA) sponsored packet radio networks in the early 1970, multifarious protocols have been developed for mobile ad hoc networks. And every protocol is having its own significance and meant for handling some of the issues like high data error rate, bandwidth utilization, security and high power consumption. As many routing algorithm were designed for dealing with these issues mentioned above, were expected to have certain characteristics fulfilling the minimum criteria that is needed for any mobile ad hoc networks. These characteristics are given below.

- It must be fully distribute, as centralized routing is less fault tolerant than the distributed routing which involves less risk single point of failure.
- It must be adopted to frequent topology change caused by the mobility of the node.
- Route maintenance must involve a minimum number of nodes.
- It must be loop free and stale route.
- It must converge the optimal route once the network topology becomes stable.
- Number of packet collision must be kept to a minimum by limiting the number of broadcast made by each node.
- It must use the scare resource such as bandwidth, computing power as demanded by the applications.

Considering all the above characteristics, the protocols have been divided into different classes where one protocol may fall under more than one classes. Depending upon the mechanisms, they have been classified. And so based on the routing information update mechanism the protocols are divided into two types.

- Table driven or Proactive Protocols
- On Demand or Reactive Protocols

2.1.1 Table driven or proactive protocols

Proactive Protocol as the name signifies, each node keeps all routing information to every other nodes in the network by maintaining one or more routing tables. These routing formations get updated periodically in the table to maintain the latest view of the networks. It comes in use when a node requires a path to a destination. Some of the existing table driven protocols are DSDV, DBF, GSR, WRP, ZRP and many more. This article does not cover all these table driven protocols as it is focused on DSR and different modification made on DSR protocols.

2.1.2 Reactive or on demand routing protocols

The protocols which fall under this category is completely different from the previous one. Here the protocols are On – Demand routing protocols [8, 12] do not update the routing information periodically as there is no routing table present for keeping routing information. Each node has route cache

rather than routing table where it keeps all latest paths from source to destination. Rather a path is obtained when it is to establish a communication path between a source to a destination. Some of the example of on demand routing protocols are DSR, AODV, TORA, ABR etc.

The emphasis in this research paper is concentrated on survey of different energy efficient routing protocols based on the basic Mechanism of DSR only. The next subsection describes the basic features of DSR protocols.

2.2 Dynamic source routing protocol

Dynamic Source Routing (DSR) [9, 10] is a simple and efficient routing protocol designed specification for use in multi-hop wireless ad hoc mobile networks. DSR is one of the important routing protocols that are used for mobile ad hoc networks as much energy efficient routing protocols are designed based on its mechanism. It finds the route from source to destination only when the source initiates route discovery process. All aspects of protocol operate entirely on demand. This protocol also makes the network self-organizing and self configuring. Basically the protocol is composed of two mechanisms, Rote Discover and Route Maintenance and these two mechanisms work together to allow nodes to discover and maintain the source route to any destination node in the a hoc networks.

- Route Discovery
- Route Maintenance

2.2.1 Route discovery

Route discovery is done with two sub steps that is Route request and Route Reply.

2.2.1.1 Route request

The route discovery comes in play when a mobile node has some data/packet to send to any destination and it does not have any route to the destination in its route cache. Then it initiates route discovery by broadcasting a **route request (RREQ) packet.** This route request contains address of the destination, address of the source and a unique identification number that is generated by the source node only. Each node receives the packet and checks whether the packet is meant for it or not. If it is not the destination node then it simply forwards the packet to the outgoing links adding its own address in the packet. To avoid duplicate route request which is generated from the same source, a node only forwards the route request that has not yet been seen appear in the route request with the same identification number.

2.2.1.2 Route reply

As soon as the packet arrives at the destination node or arrives at a node that contains in its route cache an unexpired route to the destination, then a route reply is generated. Not only the packet contains all the address of the intermediate node it has come across but the sequences of hops are also stored in it. The Route reply is generated by the destination placing the route record contained in the route request into route reply.

During the route reply if the destination node has the route to the initiator in its route cache, It may use that route for route reply. Otherwise destination node may reverse the route in the route record if the link is symmetric. If the symmetric links are not supported then the node may initiate its own route discovery piggybacking the route reply on the new route request. When any intermediate node receives any route reply from destination node or any other node then they append their route record and forwards it to its neighbor nodes.

2.2.2 Route maintenance

Route maintenance is a process of identifying link whether it is reliable and capable of carrying packet on it or not. This process is executed by the use of route error packets and acknowledgements. When the data link layer encounters a **fatal transmission problem** then a route error message is generated. Suppose a packet is retransmitted (up to a maximum number of attempts) by some hop the maximum number of times and number of receipt conformation in received, then this node returns a packet error message to the original sender of the packet, identifying the link over which the packet could not be forwarded.

2.3 Benefits and Limitation

As the entire route is contained in the packet header, there is no need of having routing table to keep route for a given packets. The caching of any initiated or overheard routing data can significantly reduced the number of control message being sent, reducing overhead.

But DSR is not scalable to large networks. The internet draft acknowledges that the protocol assumes that the diameter of the network is not greater than10 hops. Additionally DSR requires significantly more processing resources than most of other protocols. The other drawback of DSR is selecting the path for routing on the basis of minimum hop counts from the source to the destination. As it selects the path of having minimum hops count, lesser will be the number of intermediate nodes, more will be the distance between each pair of nodes. As the distance is more we need to have more transmission power to communicate between any pair of nodes and hence it consumes more battery power as it is one of the limited resources.

III. ENERGY EFFICIENT ROUTING PROTOCOLS

The energy efficient routing protocols [6, 11] play a significant role in mobile ad hoc networks as the nodes are dynamic in nature and each node can participate in routing the data packets. In such scenario, efficient routing protocols are needed for Ad Hoc networks, especially when there are no routers, no base stations and no fixed infrastructure. So establishing the correct and efficient routes between the a source and destination is not the ultimate

aim of any routing protocols, rather to keep the networks functioning as much as possible with less battery consumption at each node, should also be the objective of any routing protocols.

These goals can be accomplished by minimizing mobile node's energy during both the active as well as inactive communications. Active communication is when all the nodes of the route are participating in receiving and forwarding of data. Minimizing the energy during active communication is possible through two different approaches:

- Transmission power Control
- Load distribution

In an inactive communication the nodes are idle i.e. neither forwarding any data packets nor receiving any data packets. In such situation, to minimize the energy consumption Sleep/Power-down approach is used. We will not discuss about the power consumption during inactive communication in the network. 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:

- Energy consumed per packet
- Time to network partition
- Variation in node power level
- Cost per packet
- Maximum node cost

By using these metrics we can determine the overall energy consumption for delivering a packet, which is known as Link cost. In other word, link cost is the transmission energy over the link. Basically the efficient energy protocol selects the minimal power path depends which minimizes the sum of the link cost along the path.

3.1 Transmission Power Control Approach

We assume that a node's radio transmission power [13, 14] is controllable, if its direct communication range as well as the number of its intermediate neighbors is also adjustable. As the transmission power increases, the transmission range also increases and it reduces the number of hop count to the destination. Weaker transmission makes topology sparse and it may result more network partition and high end to end delay.

So it is desirable to have perfect transmission range between any pairs of nodes, so that less power consumption will occur. And it is possible when the transmission power can be adjustable according to the requirement of the receiver. So, instead of having high or low transmission power between the pair of nodes let the transmission power be set in such a way that any pair of nodes just reachable to each other. It will not only save the energy of battery but also reduces the interference and congestion in the networks.

3.2 Load Distribution Approach

The main objective of load distribution approach [16] is to select a route in such a way that the underutilized nodes will come in play rather than the shortest route. Due to the proper load distribution among the node, there is high balance in energy usage of all nodes. This approach certainly do not provide lowest energy route but surely prevent certain nodes from being overloaded and contributes towards longer network life time of the node.

3.3 Sleep/Power-down Approach

This approach is used during inactive communication. When any node is not receiving or transmitting any packets to other node, then it is desirable to put the subsystem/hardware into the sleep state or simply turn it off to save energy.

3.4 Power Consumption Modes

The mobile nodes in wireless mobile ad hoc network are connected to other mobile nodes. These nodes are free to transmit and receive the data packet to or from other nodes and require energy to such activity. The sources of power consumption are communication and computation with communication often being the chief power consumer. An ad hoc (or "spontaneous") network is a local area network or other small network, especially one with wireless or temporary plug-in connections in which some of the network devices are part of the network only for the duration of a communications session or in the case of mobile or portable devices, while in some close proximity to the rest of the network. Although significant in terms of reducing the power consumption in the wireless transmitter of a sender, it does little to conserve power among the other nodes receivers, forwarders and nodes not involved in this communication. The total energy [12, 13] of nodes is spent in following modes: Transmission Mode, Reception Mode, Idle Mode and Overhearing Mode. These modes of power consumption are described as:-

a. Transmission Mode: A node is said in transmission mode when it sends data packet to other nodes in network. These nodes require energy to transmit data packet, such energy is called Transmission Energy of that nodes. Transmission energy is depended on size of data packet (in Bits), means when the size of a data packet is increased the required transmission energy is also increased.

b. Reception Mode: When a node receives a data packet from other nodes then it said to be in Reception Mode and the energy taken to receive packet is called Reception Energy.

c. Idle Mode: In this mode generally the node is neither transmitting nor receiving any data packets. But this mode

consumes power because the nodes have to listen to the wireless medium continuously in order to detect a packet that it should receive so that the node can then switch into receive mode from idle mode. Despite the fact that while in idle mode the node does not actually handle data communication operations it was found that the wireless interface consumes a considerable amount of energy nevertheless. This amount approaches the amount that is consumed in the receive operation. Idle energy is a wasted energy that should be eliminated or reduced.

d. Overhearing Mode: When a node receives data packets that are not destined for it, then it said to be in overhearing mode and it may consume the energy used in receiving mode. Unnecessarily receiving such packets will cause energy consumption.

Unlike other routing protocols, our protocol uses no periodic routing overhead messages, so by reducing bandwidth of network; it uses dynamic source routing to route packets in an adhoc network. According to source routing technique the source node determines the entire sequence of nodes through which a packet has to pass from source to destination. The source node puts the list of addresses of all the intermediate nodes in the header of the packet, so that the packet is reached at destination through those specified nodes. Source routing is done using a technique called route discovery. Whenever a node want to send a packet to some other node, the sending node initiates the route discovery. Each node maintains a cache called route cache to store the information about all routes it has gathered to different destinations. To support efficient routing in energy constrained ad hoc networks, power aware routing policies can be integrated and evaluated with existing features of routing protocol [3]. The routing mechanism basically involves two activities first, to find optimal routing routes and secondly, transferring data packets through network.

There are various Energy-Efficient routing protocols which deal with this technique but in this paper DSR is used as base protocol. The DSR protocol is a type of reactive routing protocol for MANET. It uses source routing which means that the sender must know the complete hop-by hop route sequence to the destination node. These all routes are stored in a route cache. DSR is composed of two passes that work together to perform the route discovery and route maintenance of source routes in the ad hoc network. When a node in an adhoc network attempts to send a data packet to a destination for which it does not already know the route, it uses a route discovery mechanism to dynamically find such a route. Route discovery works by flooding the network with route request RREQ packets. Each node that receive a request rebroadcasts it, unless it is the destination or it has a route to the destination in its route cache. Such a node replies to the request with a route reply RREP packet that is routed back to the original source. Route request and reply packets are also source routed. The request builds up the path traversed so far. The reply routes itself back to the source by traversing this path backward. The route carried back by the reply packet is cached at the source for future use. If any link on a source route is broken detected by the failure of an attempted data transmission over a link, route error RERR packet is generated. Route error packet is sent back toward the sender which erases all entries in the route caches along the path that contains the broken link. A new route discovery must be initiated by the source, if this route is still needed and no alternate route is found in the cache. But sometimes an alternative path is selected from already available routes if source still want to interact with destination and another path should not have that error causing node. Route Maintenance is performed by each node that originates or forwards a data packet along a source route. Each such node is responsible for confirming that the packet has been received by the next hop along the source route given in the packet; the packet is retransmitted until this confirmation of receipt is received [4].

IV. ENERGY EFFICIENT POSITION BASED ROUTING PROTOCOL

This approach selects a route that contains nodes having maximum available residual energy so that the energy usage among all nodes can be balanced because underutilized nodes usually have more energy than utilized nodes. The approach compares not only energy but all the parameters such as bandwidth, load and hop Count for the route selection so this may result in small, best and energy-rich routes for routing packets. Thus, ensures long network lifetime.

In this protocol the method of broadcasting the RREQ packet for Route Discovery is same as the DSR, only the difference is in the RREQ packet format. The intermediate node which receives the RREQ packet performs the following task[5]:

1) It checks in its Route Cache for the availability of a route for the destination node, if it found then it attach that route in a RREP packet and sends back to the source node.
2) If the node finds its own address as actual destination, then the packet reached the final target.
3) Otherwise, that node appends its own address in that Route Record and its available residual energy in RREQ and rebroadcasts it to all its neighbour nodes.

All the routes are defined along with number of intermediate nodes from source to destination called hop count. Then minimum value of all parameters like hop count, bandwidth, residual energy and load is calculated. Then position count is calculated in final position table on the basis of next mentioned four rules.

A specific route is selected having minimum value of position count. That specific route will be best suitable from all aspects like having maximum available residual energy and bandwidth etc.

The best route is selected on the basis of following rule set on the basis of minimum value of all parameters:

Rule 1: If the routes are of equivalent Energy (routes have same energy value) then Route with maximum available Bandwidth will be considered.

Rule 2: If the routes are of equivalent Energy and equivalent Bandwidth (same value for energy and bandwidth): then Route with minimum Load will be considered.

Rule 3: If the routes are of equivalent Energy, equivalent Bandwidth and equivalent Load (same value for energy, bandwidth, load) also then Route with minimum Hop Count will be considered.

Rule 4: If all the routes are not of equivalent Energy: Then Route with maximum Energy should be given preference. One best route having minimum value of position count is considered and all other remaining routes are taken as backup and used later on in case of failure of transmission of data packets in first best route.

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