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Analysis Of Energy Efficient Routing Protocol For Mobilead-Hoc Network

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ABSTRACT

A Mobile Ad-Hoc Network (MANET) is a temporary, self configuring network of mobile routers without having any physical connections. These distributed network forms a dynamic topology due to the moving of nodes, multipath propagation and interference, path loss. MANET has limited bandwidth and battery power. Hence the energy efficiency is one of the primary metrics. This paper analysis the energy aware routing protocols proposed for MANET in order to improve the energy efficiency and increase lifetime of nodes. Different routing protocols have been proposed for MANET having several features and these protocols are analyzed based on their strength and weakness

Keywords: MANET, Routing Protocols, Review Analysis, Optimization, Performance Metrics.

I. Introduction

Ad - hoc networks are networks that are not connected to any static, i.e, wired infrastructure. A MANET is a type of ad-hoc network that can change locations and self configuring. Mobile ad-hoc network is a collection of independent mobile nodes communicated to each other directly or indirectly through radio waves.

Fig 1: Mobile Ad-hoc Network

These networks are fully distributed, and can work at anywhere without the need of any infrastructure. Mobile nodes in MANET frequently relay on batteries for energy and therefore have limited lifetime. Most of the ad - hoc networks works on battery. Battery energy is a rare resource in MANET and it often affects the communication activities in network. The energy efficiency can be achieved by effective selection of routes such as node energy, battery level and cost. Conserving energy is important to extend the lifetime of both individual node and network. It is difficult in ad-hoc networks since energy conserving action must be made in distributed manner.

The lifetime of network is based on the following:
1. The time interval until the first node burns its entire battery 2. The time until certain percentage of the node fail. 3. The time until network partitioning. In MANET nodes can perform the roles of both hosts and routers and there is a intrinsic mutual trust. These networks can be setup anywhere and also energy constraints with limited security. The inadequate battery lifetime causes a limitation on the network performance. Thus energy efficient routing is one of the prominent significance for MANET design. Hence many energy efficient protocols have been analyzed to prolong the mobile node battery capacity at different aspects. The main goal of this paper is to analyze and to understand the best energy efficient routing protocols.

2. Classification of Routing Protocols

Classification of routing protocols is done depending on routing strategy and network structure. MANET includes many routing protocols with features like distributed operations, security and QOS support. Based on the routing strategy and network structure the routing protocols are classified as flat routing, hierarchical routing and geographical position assisted routing. Flat routing protocol is further classified as proactive routing (Table-driven) and Reactive routing (on Demand).

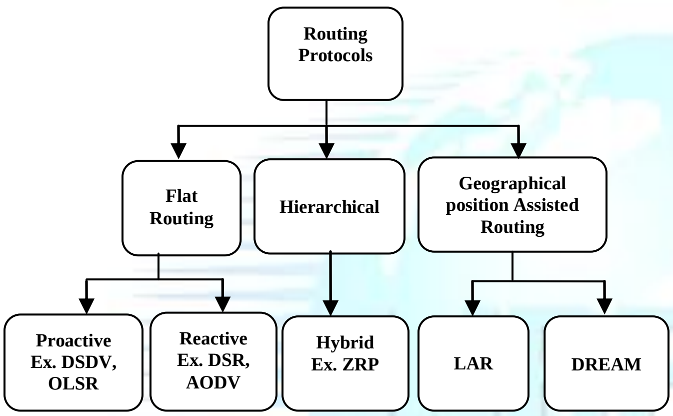

Fig 2: Classification of Routing Protocols

2.1 Proactive (Table Driven) Routing Protocols

Proactive protocols maintain the information about routing before it is needed. In proactive routing routes are computed automatically and independently of track arrivals. In proactive mode the portals will announce their presence by flooding Route Announcement (RANN) message in the network. Internal nodes will reply with a Path Registration (PREG) [13] [14] message. The result of the process will be routing trees with route in the portal. Each node in the network maintainsrouting information to every other node in the network. Routing information is kept in the routing tables and is updated periodically when the network topology. On the other hand routes will always be available on request. Most internet standard routing protocols and some ad-hoc protocols such as DSDV (Destination Sequenced Distance Vector) and OLSR (Optimized Link-State Routing) are examples of this style. Many of these routing protocols come from the conventional link-state routing. These routing protocols maintain different number of tables.The proactive protocols are notsuitable for larger networks, as they need to maintain node entries for each and everynode in the routing table. This causes more overhead in the routing tableleading to consumption of more bandwidth.

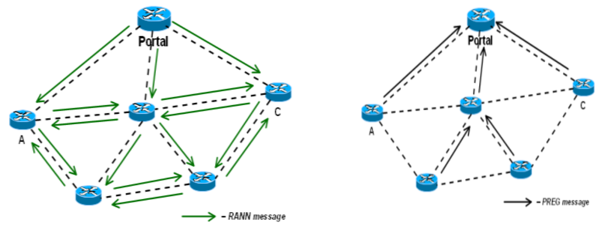

Fig 3: Proactive Routing protocol

2.2Reactive (On Demand) Routing Protocols

A reactive routing protocol does not make the nodes initiate a route discovery process until a route to a destination is required. This leads to higher latency than with the proactive protocols, but lower overhead. When a route is needed, the system floods the network with Route Request(RREQ) packets [13][14]. These are sent out to immediately connected routers that pass on the request for a path to a given destination. If a router with contact to the destination is reached, it messages back its availability. The first Route Reply received (RREP) determines the route to be used. Reactive routing can cause overhead on a network by clogging up channels with route requests. The system is appropriate for constantly changing networks such as ad-hoc mobile networks. In these networks, the

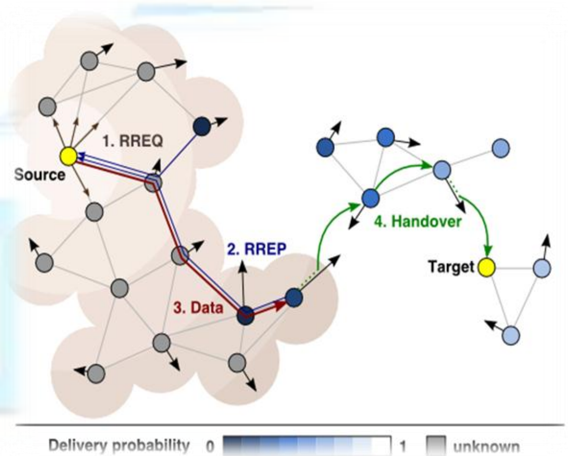

Fig 4: Reactive Routing Protocol

nodes creating links across which a route can cross are constantly changing and not working recording. Several reactive protocols have been proposed such as Dynamic

Source Routing protocol (DSR), Ad hoc On-demand Distance Vector (AODV).

2.3 Hybrid Routing Protocols

Hybrid routing protocols [13] seek to combine the proactive and reactive approaches. It takes the advantages of both distance vector and link state protocols and merges them into a new protocol. Typically, hybrid protocols are based on a distance vector protocol but contain many of the features and advantages of link state routing protocols. It is used for large number of nodes. An example of such a protocol is the Enhanced Interior Gateway Routing Protocol (EIGRP), Zone Routing Protocol (ZRP) and so on.

3. Analysis of Energy EfficientRouting Protocols

MANETs are infrastructure less and can be setup anytime, anywhere. We have conducted survey on routing protocols on MANETs and analyzed them. There is not a consistent approach to define the energy related cost metrics that are used to guide the routing protocol performance. The devices operating on battery try to involve in the energy efficiency heuristically by reducing the energy they consumed, and maintaining acceptable performance of certain task. Power consumption is not only a single criterion for deciding energy efficiency. Energy efficiency can be measured by the duration of the time over which the network performance level is maintained, which is usually called as the network lifetime. In recent years, it was mainly focused on the shortest path method to minimize the energy, which causes network failure since some nodes might exhaust fast, while some other nodes might not be used at all. This can lead to energy imbalance and to network life reduction. Research has been under taken not only to improve the Energy efficiency and also to increase the networks Lifetime.

3.1 Related Work

In this section, we analyse a brief description of energy efficient routing protocols related to MANET.

Energy Efficient Location Aided Routing (EELAR) Protocol:

Energy Efficient Location Aided Routing (EELAR) Protocol[1] for MANETs is a modification of the Location Aided Routing (LAR). It uses location information of the mobile nodes to limit the search for a new route to a smaller area of the ad-hoc network. This result in reduction in the number of routing messages and therefore the energy consumption of the mobile nodes batteries is decreased. Thus control packets overhead are significantly reduced. In EELAR a reference wireless base station is used and the network's circular area centered at the base station is divided into six equal sub-areas. At route discovery instead of flooding control packets to the whole network area, they are flooded to only the sub-area of the destination mobile node. The base station stores locations of the mobile nodes in a position table. EELAR protocol has the smallest control overhead among well known routing protocols such as LAR, AODV, and DSR.

Limitations:

Increasing number of areas results in more route loss. When there is a very large number of areas and due to moving of nodes, there is a higher probability that a node leaves its original area and enters a new area very quickly during a small time interval. Hence,in the case of larger number of areas, the possibility of routes loss is higher than in the smaller number of area when a source nodeinitiates a transmission to a destination node. This leads to increasedcontrol overhead. This increased control overhead becomesworse as the number of areas keeps increasing.

Power-aware Localized Routing (PLR) protocol:

A new power-cost metric[7] based on the combination of both nodes' lifetime and distance based power metrics. It defines power, cost, and power-cost GPS based fully distributed (i.e. localized) routing algorithms, where nodes make routing decisions solely on the basis of location of their neighbors and destination. Power-aware localized routing algorithm attempts to minimize the total power needed to route a message between a source and a destination. Cost-aware localized algorithm is aimed at extending battery's worst case lifetime. The combined power-cost localized routing algorithm attempts to minimize the total power needed and to avoid nodes with short battery's remaining lifetime.

Limitations:

These methods use control messages to update positions of all nodes to maintain efficiency of routing algorithms. However, these control messages also consume power, and the best trade-off for moving nodes is to be established.

A Minimum Transmission Energy Consumption (MTEC) Routing Protocol:

Minimum Transmission Energy Consumption (MTEC) routing protocol [4] prolongs network lifetime and reduces energy consumption in user-centric wireless networks. MTEC selects the minimum transmission power consumption path for data transmission based on the ratio of successful data transmissions, the number of channel events, the remaining node energy, and the traffic load of nodes (network). Distance between two nodes increases, the received signal strength decreases, which results in a decrease in the proportion of successful data transmissions. This routing protocol increases the better packet delivery rate and throughput than DSR and TSA and attempts lower average end to end delay. MTEC also consumes only less amount of energy during data transmission and thereby provides higher network lifetime than existing protocols. In addition, *MRE* denotes the minimum remaining energy of the nodes in a path after transmitting *N* data packets. And Filter *MRE* (*FMRE*) be the set of all paths where the value of *MRE* for each path is greater than zero. Thus, if a path belongs to *FMRE*, each node in the path is active after completely transmitting *N*data. As a result, we can find the path that consumes the minimum energy to transmit all data packets from *FMRE*.

Limitations:

Minimum Transmission energy consumption routing requires the discovery of fresh, optimum low power routes which come with a message overhead cost. Moving nodes and channel fluctuations adds problem of instability of low power routes.

Power-aware routing (PAR) protocol:

The Power-aware routing algorithm [6] minimizes the power consumption and maximizes the network lifetime during the route establishment from source to destination. PAR provides energy efficient and less congested path between a source and destination pair to transfer both real time and non real traffic. PAR focuses on 3 parameters:

- **Accumulated Energy of a path** - where total energy of a path from one node to other node is calculated
- **Status of Battery Lifetime**
- **Data transfer type**
  - Non Real Time (*NRT*)
  - Real time (*RT*).

PAR always selects less congested, more stable routes for data delivery and can provide different routes for different types of data transfer and increase the network lifetime.

Limitations:

In PAR nodes have wide varying energy consumptions provides which causes early death for some nodes. It also increases the latency during data transfer.

Geographic and Energy Aware Routing (GEAR) protocol:

Geographic and Energy Aware Routing (GEAR) protocol [2]usesenergy aware and geographically-informed neighbor selectionheuristics to route a packet towards the destination region. Thekey idea is to restrict the number of interests in directeddiffusion by only considering a certain region rather thansending the interests to the whole network. By doing this,GEAR can conserve more energy than directed diffusion.In GEAR, each node keeps an estimated cost and a learningcost of reaching the destination through its neighbors. A hole occurs when a node does not have any closerneighbor to the target region than itself. GEAR was compared to a similar non-energy-awarerouting protocol GPSR which is one of the earlier worksin geographic routing that uses planar graphs to solve theproblem of holes. GEAR not only reduces energy consumption forthe route setup, but also performs better than GPSR in terms ofpacket delivery.

Limitations:

As they operate on the basis of thegeographic or location information for routing, dataaggregation at any point is absent. Although GAF is highlyscalable, GEAR faces a problem of limited scalability.Another problem faced by both the protocols is that both themechanisms have moderately high overhead which affects theenergy efficiency.

Predictive Energy-efficient Multicast Algorithm(PEMA):

The Predictive Energy-efficient Multicast Algorithm (PEMA) [12] is to improve energy-efficiency in large-scale MANETs, since the complexity of PEMA does not depend on network size.The Predictive Energy-efficient Multicast Algorithm (PEMA) which exploits statistical properties of the network, as opposed to relying on route details or network topology.

The running time of PEMA depends on the multicast group size, not network size; this makes PEMA fast enough even for MANETs consisting of 1000 or more nodes.PEMA is very scalable. As such, PEMA can run easily on top of any unicast routing protocol to improve the energy savings, by serving as either a multicast extension at network layer or an application-layer multicast.

Minimum Energy Routing (MER):

Minimum energy routing [5] can be defined as the routingof a data-packet on a route which consumes minimumamount of energy to reach the destination. Minimumenergy routing requires the knowledge of the cost ofa link in terms of energy to transfer the packet successfully, the discovery of existing minimumenergy routes and the frequent maintenance of theenergy cost information of these routes.

Limitations:

Minimum energy routes translate to multi-hop routeswhich add an overhead per hop.Frequent updatesrequire a higher routing overhead and thus there exists atradeoff between the freshness/optimality of the routes inthe cache and the routing packet overhead.

3.2 Optimization of Energy Efficiency in MANET

An important goal of arouting protocol is to keep the network functioning aslong as possible.Thus, maximizing the networklifetimeis done by selecting the route which will result in the longest network operation. Various energy efficient protocols have been analyzed and each has unique attributes with different recovery mechanism.Energy-related metrics that have beenused to determineefficient routing path is discussed below.

Routing Protocols	Metrics	Analysis
EELAR	Control packet overhead, Delivery ratio	Improvement control packet Overhead, Increased delivery ratio.
PLR	Cost, Power-cost efficient Routing algorithms	It uses control messages to updatepositions of all nodes to maintain efficiency of routing algorithms.However, these control messages also Consume power
MTEC	Average end-to-end delay Data Generation Rate per flow Throughput Energy Consumption	-MTEC can select the path withthe minimum queue delay, hence lower average end-to-end delay -MT EC has higher packet delivery ratios - MTEC shows better throughput because of lower average end-to-end delay and a higher delivery ratio packets -MTEC has to find all the routing pathsduring Path discoveryand then selects the desired routing path.
PAR	Total Energy Consumption Node Termination Rate Network Lifetime	-Consumes less energy -Energy distribution is best -Node termination rate is less
PEMA	Low Complexity High Energy Efficiency	-PEMA is extremely fast becauseits running time is independent of the network size. -Routing decision does not rely on the route details
MER	Routing packet based power data-packet control Minimum Energy routing Cache replies off	-Enables the control of the transmission power -The minimum energy route is chosenfrom the cache. - The routes in the cache need to be fresh to achieve optimality

Table 1: Optimization of Routing Protocols

4. Performance Metrics to Calculate Energy Efficiency

We calculate energy efficiency performance according to the following metrics [15]:

Delay of time: The delay of time how much time taken to receive packet.

Retransmission attempts of packet: It will count the retransmission of packet again after failure.

$$\textbf{Delay of Time} = R_T - S_T$$

Where, R_T – Receiving Packet Time
S_T – Sending Packet Time

Average end-to-end delay: The end-to-end delay is averaged over all surveying data packets from the sources to the destinations.

$$\textbf{Average end-to-end delay} = \sum_{p=1}^{n} (RT_{pd} - ST_{pd})$$

Where, RT_{pd} – Delay of Packet at Receiver end
ST_{pd} – Delay of Packet at Sender side

Average Packet Delivery Ratio: It is the ratio of the number of packets received successfully and the total number of packets sent.

$$\textbf{Average Packet Delivery Ratio} = \sum_{p=1}^{n} (R_{np} / S_{np})$$

Where, R_{np} – Number of packet received
S_{np} – Number of packet sent.

Data Drop: It is the number of packets dropped.

$$\textbf{Data Drop} = S_{np} - R_{np}$$

Where, S_{np} – Number of Packetssent.
R_{np} – Number of packets received

Average Energy: It is the average energy consumption of all nodes in sending, receiving and forward operations.

$$\textbf{Average Energy} = \sum_{p=1}^{n} (E_{ps} + E_{pr} + E_{pf})$$

Where, E_{ps} – Energy Consumption of Packet Sending
E_{pr} – Energy Consumption of Packet Receiving

5. Conclusion

A Mobile Ad-Hoc Network (MANET) is a self configuring network which does not have fixed type infrastructure. Because of that routing becomes a challenging task. The nodes in the MANETs are typically powered by batteries which have limited energy reservoir.This becomes one of the main problems in MANET, especially in designing a routing protocol. In thispaper, we analyzed and classified a number ofEnergy-aware routing schemes each has individual strengths and weakness. In some cases, it isdifficult to compare them directly since each methodhas a different goal withdifferent assumptions and provides different means to achieve the goal.

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