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Energy Efficient Routing Protocols in Mobile Ad hoc Network based on AODV Protocol

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ABSTRACT

A Mobile Ad-hoc Network (MANET) is a self-configuring network composed of mobile nodes without any fixed infrastructure. Energy is limited factor in case of Ad-hoc networks. The life of a node is directly proportional to the battery in the device operating at the node. Maximize the use of energy and maximize the life of network is still the key challenge of Mobile Ad hoc network. Different routing protocols for MANETs could be differing depending upon the network architecture and the application. This paper presents a survey on energy efficient protocols in MANETs based on AODV. These algorithms use energy consumption as routing metric. These algorithms use energy optimal routes to reduce the energy consumption of nodes.
Key words: Mobile Ad-hoc Network, On-demand Routing, Energy Efficient Routing, Routing Protocols.

1. INTRODUCTION

In recent years, wireless networks such as wireless LAN used in various places due to its simplicity and flexibility. The concept of wireless network is not new. The DARPA around early 70's establish the base of ad hoc network. This technology enables wireless networking environments where there is no fixed infrastructure. Mobile Ad-hoc network does not have fixed infrastructure, it is composed of mobile devices. Energy consumption is a crucial factor for the designing of energy efficient routing protocols. The basic objectives of MANET routing protocols are to maximize energy efficiency, maximize networkthroughput, maximize network lifetime and to minimize end-to-end delay in network.

Key challenges in Wireless Ad hoc networks are as follows:

- Limiting power supply
- Dynamically Changing Topology
- Limited Bandwidth
- Security
- Mobility-induced route change
- Battery constraints

Routing is the process of establishing path and forwarding packets from source node to destination node. It consists of two steps: first is route selection and second is delivery of packets to the correct destination. Energy is limited factor in case of Ad-hoc networks. Routing in wireless ad-hoc network has some unique characteristics:

1. Energy of nodes is crucial and depends upon battery which has limited power supply.
2. Nodes can move in an uncontrolled manner so frequent route failure are possible.
3. Wireless channels have lower and more variable bandwidth compare to wired network.

In this paper, we discuss different energy efficient routing algorithms (LEAR-AODV, PAAODV, EEAODR, OAODV and LPR-AODV) that reduce energy consumption and lead to a longer battery life at the terminals. They are based on one of the most important routing protocols, AODV (Ad hoc On-Demand Distance Vector). We focus on reactive routing schemes, since they are less expensive in terms of energy consumption than proactive schemes

2. ROUTING PROTOCOLS

Many protocols have been proposed for routing in MANET with the goal of achieving efficient routing [12]. These algorithms differ in the approach used for discovering a new route and maintaining a known route when node moves. The ad hoc routing protocols may be categorized as proactive (table driven), reactive (On-demand) and hybrid routing protocols.

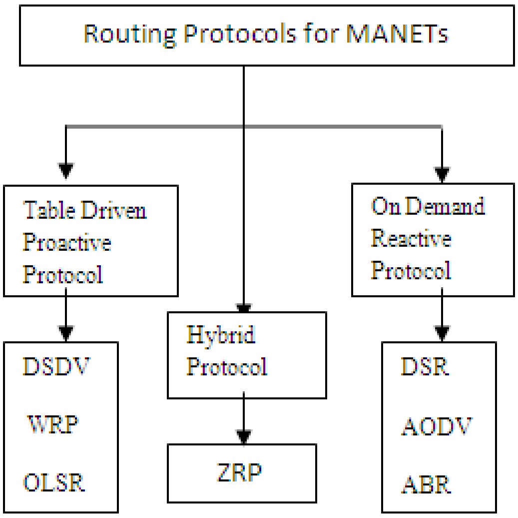

Figure 2.1. Different types Routing protocols in MANETs.

These algorithms are based on the some of the following criterion [5]:

- Keeping track of the residual battery power.
- Keeping track of the previously used paths.
- Keeping back-up paths.
- Keeping track of the message overhead.
- On-demand calculation/update of routing tables.
- Sending data packets at a lower energy compared with the RREP/RREQ.
- Moving the nodes to sleep mode when they are not being used.
- Requiring a node to send packets with energy proportional to the distance rather than with fixed energy.
- Using a hierarchical routing technique.
- Using directional antennas.
- Transmitting the data packets by taking into consideration the actual amount of energy required to transmit.

2.1 Proactive Protocols (Table Driven Routing Protocols)

The proactive protocols are maintained the routing information even before it is needed. Each and every node in the network maintains routing information to every other node in the network. Routes information is generally kept in the routing tables and is periodically updated as the network topology changes. Many of these routing protocols come from the link-state routing. There exists some differences between the protocols that come under this category depending on the routing information being updated in each routing table. DSDV, WRP and OLSR comes under table driven protocols.

2.2 Reactive Protocols (On-Demand Routing Protocols)

The reactive protocols do not maintain routing information or routing activity at the network nodes if there is no communication. If a node wants to send a packet to another node then this protocol searches for route in an on-demand manner and establishes the connection in order to transmit and receive the packet. These protocols were designed to reduce the overhead encountered in proactive protocols by maintaining information for active routes only. This means that the routes are determined and maintained for the nodes that are required to send data to a particular destination. The route discovery usually occurs by flooding the route request packets throughout the network. DSR, AODV and ABR comes under reactives protocols.

2.3 Hybrid Routing Protocols

Both of the proactive and reactive routing methods have some pros and cons. In hybrid routing a well combination of proactive and reactive routing methods are used which are better than the both used in isolation. It includes the advantages of both protocols. As an example facilitate the reactive routing protocol such as AODV with some proactive features by refreshing routes of active destinations which would definitely reduce the delay and overhead so refresh interval can improve the performance of the network and node. So these types of protocols can incorporate the facility of other protocols without compromising with its own advantages. Examples of hybrid protocols are Zone Routing Protocol (ZRP).

3. RELATED WORK

Many research works has produced so much innovation and novel ideas in this field. We have discussed different reactive routing protocols based on AODV. Most of the work today is based on energy efficient routing because power is main concern in ad-hoc wireless networks. Each and every protocol has some advantages and shortcomings. None of them can perform better in every condition. It depends upon the network parameters which decide the protocol to be used.

3.1 Ad-hoc on demand Distance Vector Routing (AODV)

Ad-hoc on demand Distance Vector Routing (AODV) [3][9]is a reactive routing algorithm, improvement over DSDV routing protocol algorithm. It minimizes the number of broadcasts by creating routes on-demand as opposed to all possible routes as in DSDV. This protocol checks the route table when source needs to transmit data. AODV is a loop-free, single path, distance vector protocol based on hop-by-hop routing approach. There are two main procedures in AODV:

1. Route discovery
2. Route maintenance

- **Route discovery:** the route discovery process is begins when a source needs a route to a destination to send data. It checks its routing table to determine if it has a current route to the destination. If it has route, forwards the packet to next hop node otherwise it starts a route discovery process. Route discovery begins with the creation of a Route Request (RREQ) packet. Packet contains the following: Source node's IP address, Source node's current sequence number, Destination IP address, Destination sequence number, Broadcast ID number.

Broadcasting is done via flooding, and waits for a route reply (RREP). An intermediate node receiving a RREQ packet set a reverse route entry to the source in its rout table. Reverse route entry consists of: Source IP address, Source seq. number, number of hops to source node,IP address of node from which RREQ was received.When the destination node receives a RREQ, it also generates a RREP. The RREP is routed back to the source via the reverse path. As the RREP reaches to source, a forward route to the destination established.

- **Route maintenance:** route maintenance is done using route error (REER) packets. A route is "expired" if not used recently. A set of predecessor nodes is maintained for each routing table entry, indicating a set of adjacent nodes that use that entry to route data packets. These nodes are notified with route error (RERR) packets when the next hop link breaks. Each predecessor node, in turn, forwards the RERR to its own set of predecessors, therefore, effectively erasing all routes using the broken link. Then this RERR is propagated to each source routing traffic through the failed link, causing the route discovery process to be reinitiated if routes are still needed.

Advantages of AODV

- The benefits of AODV protocol are that it favors the least congested route instead of the shortest route and it also supports both unicast and multicast packet transmissions even for nodes in constant movement.
- It also responds very quickly to the topological changes that affects the active routes.
- AODV does not put any additional overheads on data packets as it does not make use of source routing.

Limitations of AODV

- This approach is shortest-path specific and static, i.e. these algorithms keep on using the same path, without taking into consideration its energy impact on the network.
- It could be possible that the path taken by them might put the system into imbalance of energy levels in the network and might affect the connectivity of the network
- There is also a lot of wastage of energy, as RREQs and RREPs are sent a lot of unnecessary times.
- Potentially, very high overhead
- Data packets may be delivered to too many nodes who do not need to receive them
- Potentially lower reliability of data delivery
- Flooding uses broadcasting -- hard to implement reliable broadcast delivery without significantly increasing overhead

3.2 Local Energy-Aware Routing based on AODV (LEAR-AODV)

The main objective of LEARAODV (Local Energy-Aware Routing based on AODV) [2] is to balance energy consumption among all participating nodes. In their approach, each mobile node relies on local information about the remaining battery level to decide whether to participate in the selection process of a routing path or not. An energy-hungry node can conserve its battery power by not forwarding data packets on behalf of others. The decision-making process in LEAR-AODV is distributed to all relevant nodes.

--*In route discovery*, each node determines whether or notto accept and forward the RREQ message depending on its remainingbattery power *(E_r)*. When it is lower than a threshold value $\theta(E_r \leq \theta)$, theRREQ is dropped; otherwise, the message is forwarded. The destination will receive a route request message only when all intermediate nodes along the route have enough battery levels.

--*Route maintenance* is needed in two cases:

(i)When connect ion between some nodes are lost on the path due to mobility of nodes.

(ii) When the energy of some nodes on the path depleting quickly.
In first case, a new RREQ is sent out and entry in the route table corresponding to the node that has moved out of range is done. In second case node sends a route error RERR message back to the source node to initiate route discovery again.

3.3 An Energy Efficient Ad-hoc on demand Routing Protocol for Mobile Ad-hoc Network (EEAODR)

Energy Efficient Ad-hoc on demand Routing Protocol for Mobile Ad-hoc Network (EEAODR) [3]is an improvement over Ad hoc on-demand destination vector protocol that considers power level of each node in the network while calculating the route in order to increase lifetime of the network. The optimization function is used to select the energy efficient path among the all discovered by considering different factors such as nature of packets, their size and distance between nodes.
Cost = σ × time + μ × 1/minimum battery power of node in route + τ× 1/ number of hops

The path that has minimum of the communication cost among all the possible paths between a source and destination node pair is chosen as the best path. In this case, every time we uses different path for sending packet which is not possible in the case of AODV which uses same path every time.

Advantages of EEAODR
- The advantage of EEAODR over AODV is that EEAODR increases the network life as it considers the alternate paths rather than just considering the minimum hop path. It takes into account the energy of every node for selecting the best route.
- EEAODR is flexible in its approach as it allows the network administrator to vary the priority of optimality functions: time, number of hops and power consumption in path, based on network requirement.
- EEAODR is quite simple and it does not contain any significant overhead, which can degrade the system.
- This approach keeps track of backup path and allows the nodes to sleep and wake up on need, thereby avoiding the path rediscovery saving energy.

Limitations of EEAODR
- It takes more time to determine the optimum path as the destination nodes need to wait for δt time before calculating the best route, the network delay increases.
- EEAODR gives a more optimized path, but at the cost of large control packet size even though the packet size is not very large.
- Deciding δ*t* needs computing the density, that slightly increases the complexity.
- Setting up the values of parameters such as μ, σ and τ in the cost equation requires expertise to analyze the demand of network.

3.4 Lifetime Prediction Routing based on AODV(LPR-AODV)

LPR-AODV (Lifetime Prediction Routing based on AODV) [1][2] 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 S atroute discovery time W, such that the following cost function ismaximized:

$$Max_{\pi}(T_{\pi}(t))=Max_{\pi}(\underset{i\,\varepsilon\,\pi}{Min}(T_i(t))$$

Where$T_{\pi}(t)$ is the lifetime of path π and $T_i(t)$ is 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.
--*In route discovery*, all nodes except the destination and the source node calculate their lifetime and in each RREQ request there is another field representing the minimum lifetime *(Min-lifetime)* of the route. When an intermediate node receives the first RREQ packet, it keeps the *Min-lifetime* in the header of that packet as *Min-lifetime*. If other RREQs come with the same destination and sequence number, the Min-lifetime of the newly arrived RREQ packet compared to the Min-lifetime:

- If new packet has greater *Min-lifetime* and if the intermediate node has a route to the destination then node forwards *Compute lifetime* message to calculate the lifetime of this route.

-if new packet has greater *Min-lifetime* and if the intermediate node does not hasany valid route to the destination, *Min-lifetime* is changed to this new value and the new RREQ packet is re-broadcast.

--otherwise, the new packet is dropped if new packet has a lower *Min-lifetime.*

When the destination receives either a RREQ or a *Compute lifetime* message, RREP message is routed back to the source node via reverse path and source select the route with the maximum lifetime.

--*In route maintenance*, if there is a change in node's predicted lifetime, the node sends RERR route error back to the source node even when the lifetime goes below a threshold level.

3.5 PAAOMDV

PAAODV protocol is an enhancement of AODV routing protocol, which implements power control information during route discovery. In PAAOMDV [5][6], each node should maintain an Energy Reservation Table (ERT) instead of the route cache in the common on-demand protocols. Each item in ERT is mapped to a route passing this node, and records the corresponding energy reserved. The entries of an item in ERT are Request ID, Source ID

Destination ID, Amount of Energy Reserved, Last Operation Time, Route, and their functions will be presented in detail below. PAAODV incorporates two mechanisms:
(i) multiple power level route discovery
(ii) Link-by-link power control.
During route discovery, route request packets are used to find a route that is power efficient and route reply packets are used for link-by-link power transmit control. PAAODV employs several power levels during route discovery. The nodes attempt to find a route to the destination initially with low power levels. If it does not succeed, then the power level is increased. It continues until route discovery succeeds. Two power levels are used, i.e. one low and one high, are used.

3.6 OAODV (Optimized AODV)

In the conventional AODV routing mechanism, a node broadcasts or floods RREQ message to its neighbors when it wants to communicate with a destination node. If intermediate nodes' lifetime is less, that node expires after some time. Thus, it may not be able to forward the RREP message on the reverse path. Hence, the source node would have to rebroadcast the RREQ message in order to find a path for communicating to the destination node. This may cause congestion in the network, decrease the packet delivery ratio; increase the end to end delay and unnecessary rebroadcasting of RREQ packets
Each node has a certain battery life and node density in its surrounding which is saved in the routing table of proposed OAODV [4] protocol. The intermediate node doesn't forward the RREQ message immediately if there is a route to destination. In fact, it will first check its lifetime and calculate the node density of its surrounding. Second parameter is taken into consideration because; there should be sufficient number of nodes to forward RREQ. Hello messages are used to determine neighbor connectivity or node density. Two thresholds are used, one for RREQ rebroadcasting and second for node density of the environment. If the battery life and node density of the intermediate node, who receives the RREQ is greater than Threshold for RREQ broadcast and density of environment, it can be concluded that, the broadcast of RREQ successfully reaches the destination node and so the intermediate node can rebroadcast RREQ message. If the ratio is less than both, the intermediate node buffers the packets pand repeats the above process iteratively until either the broadcast is successful or the number of attempts exceeds a threshold. This process helps to decrease unnecessary packet rebroadcasting and increase the throughput.

4. CONCLUSION& FUTURE WORK

In this Survey Paper we have discussed about reactive routing protocol AODV and its modification which includes energy efficiency with the importance of energy efficient routing protocols. These AODV extensions increase the network survivability and lead to a longer battery life of the terminals. They achieve balanced energy consumption with minimum overhead. We conclude, there is not a single protocol which can give the best performance in ad hoc network. Performance of the protocol varies according to the variation in the network parameters and ad hoc network properties continuously vary. So, the choice of the protocol is the basis to perform in a particular type of network. Sometimes the mobility of the node of the network is high and sometimes it is low but energy of the node is our prime concern.

In future work, we will introduce enhancement of energy efficient routing algorithm based on AODV by updating different parameters used in EEAODR according to the workload and the node requirements in the network.

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