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SURVEY ARTICLE

A Survey on Energy Efficient AODV and DSR Routing Protocols

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Abstract— Mobile devices in ad-hoc network are operated with the help of battery power and have limited energy, so the energy optimization is vital for existence in the network and hence it is very important to maximize the network life. Due to asymmetric links and mobile nature of nodes, it is necessary to evenly distribute energy consumption. Advanced techniques are developed for optimizing the energy consumption of nodes. This paper reviews the previous researches that have been done for energy efficient AODV and DSR protocols.

Keywords—Routing, MANET, AODV, DSR, Energy-efficiency

I. INTRODUCTION

Routing is a process of establishing a route and then forwarding packets from source to the destination through intermediate nodes if the destination is not within the range of the source node. The route establishment process itself is a two-step process- route discovery and route maintenance. There are several protocols developed for routing in MANET. The two broad categories under which the protocols fall are:

- Table driven or Proactive Protocols
- On demand or Reactive Protocols
- Hybrid Routing Protocols

Table driven or Proactive Protocols: Under this type [1], each node maintains one or more routing tables to keep track of every node present in the network. These routing tables are periodically updated to maintain the current routing possibilities to all other nodes. It comes in use when a node requires a path to a destination. Examples of existing table driven protocols are DSDV, DBF, GSR, WRP, ZRP and many more. This paper does not discuss the table driven protocols as it focuses only on AODV and DSR protocols.

On Demand or Reactive Protocols: Here the protocols are on-demand routing protocols [2]. They lack the routing tables and hence the periodic updating is not done. Each node has route cache rather than routing table where it keeps all latest paths from source to destination. Route discovery is initiated only when a sender wants to communicate with the destination. Some of the example of on demand routing protocols are DSR, AODV, TORA, ABR etc.

Hybrid Routing: Hybrid protocols are the combinations of reactive and proactive protocols and takes advantages of these two protocols and as a result, routes are found quickly in the routing zone. E.g. ZRP (Zone Routing Protocol), Hazy Sighted Link State.

Wireless Networks have two types of topologies - **Infrastructured and Infrastructure-less (Ad-hoc)**. Routing Protocols are used for both Infrastructured and Infrastructure-less networks. An Infrastructure-less network (Mobile Ad-hoc Network or MANET) is a self-configuring network of mobile routers (and associated hosts) connected by wireless links. Ad-hoc Networks are simple to set up, inexpensive and fast but these networks also suffer from a lot of challenges. Some of the main challenges that affect the performance of ad-hoc networking are [3]:

Security: Security is a critical issue of ad hoc networks that is still a largely unexplored area. Since nodes use the open, shared radio medium in a potentially insecure environment, they are particularly prone to malicious attacks, such as denial of service (DoS). Cryptography and Secure routing are current approaches to the security problems is building a self-organized public-key infrastructure for ad hoc networks. Nevertheless, security is indeed one of the most difficult problems to be solved.

Power conservation: Without a fixed infrastructure, ad hoc networks have to rely on portable, limited power sources. A node in an ad hoc network has to relay messages for other nodes in the same network. The issue of energy-efficiency therefore becomes one of the most important problems in ad hoc networks. Most existing solutions for saving energy in ad-hoc networks revolve around the reduction of power used by the radio transceiver (the device's network interface), which is often the single largest consumer of power.

Scalability: Scalability can be broadly defined as whether the network is able to provide an acceptable level of service even in the presence of a large number of nodes in the network. It is one of the most important open issues of ad hoc networks. There is need of much work to be done to optimize the trade-off between capacity and scalability in different scenarios and applications separately for a general solution.

Quality of Service: QoS is a guarantee by the network to provide certain performance for a flow in terms of the quantities of bandwidth, delay, jitter, packet loss probability etc. Methods to detect and report changes in the connection quality need to be investigated in the future.

One of the major challenges of MANET is usage of power efficiently. 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 tradeoffs between frequencies 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 life time, network life time and causes network partition. Due to high network partition performance is affected due to increase in number of retransmission, packet loss, higher end to end delay and many more problems. Therefore energy efficient modifications are needed to be done in the existing protocols.

II. TERMINOLOGIES RELATED TO ENERGY EFFICIENCY

A. Types of communications

The communications in ad-hoc networks can be of one of the two types: active communication and inactive communication.

1) Active Communications: Active communication is when all the nodes of the route participate in receiving and forwarding of data. Minimizing the energy during active communication is possible through two different approaches which are transmission power control and load distribution.

2) Inactive Communications: In an inactive communication the nodes are idle i.e. neither forwarding any data packets nor receiving any data packets. In such situations, to minimize the energy consumption sleep/power-down approach is used.

B. Approaches for Minimizing Energy

1) Transmission Power Control Approach: We assume that a node's radio transmission power [5, 6] 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. It will not only save the energy of battery but also reduces the interference and congestion in the networks.

2) Load Balancing Approach: The main objective of load distribution approach[7] 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 amongst the nodes, there is a high balance in energy usage of nodes. This approach does

not provide lowest energy route but certainly prevents some nodes from being overloaded and contributes towards longer network lifetime of a node.

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.

C. Energy Efficiency Parameters

1) Total Transmission Energy: This is the sum of energies of the all the nodes encountered in route from Source to Destination.

2) Remaining energy capacity: This parameter indicates the energy left in a node.

3) Energy consumed/packet: This metric is useful to provide the min-power path through which the overall energy consumption for delivering a packet is minimized.

4) Maximum node cost: With each path candidate is annotated with the maximum node cost among the intermediate nodes.

III. RELATED WORK

A. Protocols representing energy efficient modifications in AODV Protocol

ALMEL-AODV [8] Alternate Link Maximum Energy Level Ad-hoc on Demand Distance Vector Routing Protocol is an also an improvement of convention AODV routing protocol. In this protocol, the sum of remaining energy of nodes in a route works as a metric for route selection. The maximum energy route will be selected for longer transmission and to increase network lifetime. When source node broadcast Route Request to its neighbours, first it checks the remaining energy of the node, if remaining energy of the node is near to zero, disallowed the node from broadcasting Route Request packets. Otherwise it adds the energy information of the node to the accumulated energy field in the Route Request packet. When destination node receives first Route Request packet, the node will calculate and update accumulated energy field on the destination node route table. If there is a route with better energy sum received, the destination node will enter new information into its route table. After that destination node unicast Route Reply packet to the source node using reverse link. If the link is broken, Route Error packet will be sent to the source and source node will select alternate route from its route table if present, otherwise does route discovery. Simulation proves that ALMEL-AODV has better performance than AODV.

Xiangpeng Jing and Myung [9] present a comprehensive energy optimized (locally and globally) routing algorithm that investigates the combination of device runtime battery capacity and the real propagation power loss information obtained by sensing the received signal power, without the aid of location information. The functions and messages provided by routing protocols (such as HELLO message and route discovery message) are utilized to embed the energy information. In particular, an adaptive low-battery alert mechanism is introduced to prevent overuse of critical nodes. Simulation results show that in both static and mobile networks, algorithm can increase the network lifetime greatly based on first-dead time, average lifetime and most-dead time. Residual battery capacity deviation and range among nodes are also reduced. The paper also discusses a trade-off issue between the network lifetime and network throughput.

The algorithm proposed by Seema Verma, Pinki Nayak and Rekha Agarwal [10] takes care of crucial things, battery status of the path, and number of drained nodes in the path at the time of route selection. With these factors in consideration the proposed scheme always select more stable route for data delivery. Energy of the network is also reduced using variable transmission power when data transmission is done. The proposed work aims at discovering an efficient energy aware routing scheme in MANETs that not only uses the node energy effectively but also finds the best route and increases the lifetime of the network. For the chosen simulation parameter set, in low traffic scenario, the average residual energy of the network is increased by 30-40%. For high traffic scenarios this goes up by 45%.

The operation of the algorithm says that during route discovery from the source to the destination the energy values along the route are accumulated in the RREQ packets [11]. At the destination or intermediate node (which has a fresh enough route to the destination) these values are copied into the RREP packet which is sent back to the source. The source alternates between the maximum remaining energy capacity route and minimum transmission route every time it performs route discovery. The performance metrics used for evaluation are packet delivery ratio, throughput, network lifetime and average energy consumed. The objective of the proposed work is to develop an energy efficient AODV routing algorithm in a way which allows researchers to choose the most appropriate routing algorithm.

Jin-Man Kim and Jong-Wook Jang [12] proposed an energy aware AODV protocol which uses Mean Value Algorithm to maximize the networks lifetime. Each node has an important role in an ad-hoc network. Particularly, each node's energy state has a huge effect on the entire network lifetime. An attempted is made to extend the entire network lifetime by adjusting RREQ delay time according to the data acquired from comparison between node's energy state and the entire network's Energy Mean Value. The results show that by applying Energy Mean Value algorithm to AODV protocol has a positive result in extending the entire lifetime of the network.

Tripti Nema et al. [13] propose an Energy based Ad-hoc On-demand Routing algorithm that balances energy among nodes so that a minimum energy level is maintained among nodes and the life of network is increased. The focus of the algorithm is on increasing the extensive existence of node in the network. The energy is set at minimum threshold limit of a mobile node. When a node reaches up to the threshold limit the node goes to sleep mode, saves energy and joins in the event as long as possible, thus increases the network lifetime. Performance valuation of these strategies show a substantial reduction in power usage, with only a slightly decrease in performance but increasing the overall MANET efficiency.

In the conventional AODV the intermediate node having less lifetime or energy, also forwards RREQ. As lifetime expires after some time i. e. node goes down; it could not forward RREP (Route Reply) on reverse path. So, source node restarts the RREQ rebroadcast to communicate with the destination, which results in unnecessary RREQ rebroadcast, less Packet Delivery Ratio (PDR) as well as throughput and more end to end delay. Optimized AODV (OAODV) [15] routing protocol is the solution to these problems in which the node does not forward RREQ unless there is sufficient energy (battery lifetime), and until the node density in its surrounding exceeds a particular threshold. By adding these two parameters the new protocol is much better than AODV in terms of battery lifetime and throughput.

A. Protocols representing energy efficient modifications in DSR Protocol

The Energy efficient DSR (E2DSR) [16] is one of the splendid efforts made so far in order to make DSR as an efficient routing protocol because it has introduced many significant parameters as performance matrices which help in calculating energy consumption in MANET. The parameters include length, freshness and energy parameters which are used to determine parameters like average end to end delay, inter arrival Jitter, normalized routing load (NRL), balancing of battery power consumption and nodes failure degree. The protocol has a broad scope for the research activities. E2DSR has proposed some new structure for the control packets RREQ and RREP to change the behavior of the nodes implements a new Energy table and creates a new algorithm for route cache and route selection. Thus the routing behavior of the source, intermediate and destination nodes is also changed. The simulation result shows that E2DSR has better performance than DSR.

The basic idea of LEAR Protocol [17] is to consider only those nodes for the communication which are willing to participate in the routing path. This "Willingness" is the special type of parameter used in the modified DSR to find the route from source to destination which can be determined by the Remaining Battery Power. If it is higher than a threshold Value, then the node will be considered for the route path and Route Request is forwarded, otherwise the packet is dropped. It means only when the intermediate nodes will have good battery levels then only the destination will receive route request message. So the first message that arrives at the destination will be considered to follow an energy efficient as well as reasonably shortest path.

There can be the situation that an intermediate node in the route has lower power than the threshold. In such situations the request is dropped. The same situation can be with every possible path between source and destination. To avoid this problem, intermediate nodes adjust the threshold value to continue the forwarding. The protocol has achieved the balanced energy consumption across all nodes successfully which is 35% more than that of DSR and LEAR provides longer transmission time compared to DSR.

Along with the route request, Global Energy Aware (GEAR) Protocol piggybacks the remaining battery power as well as its identity and broadcast it to its neighbor nodes. When the destination nodes receive these different route request (RREQ) from the same source, it selects the best route on the basis of high remaining/residual battery power out of the all received RREQ but it does not guarantee that the selected path is always the best path.

Utilizing the route cache, its blocking property and manipulating the waiting time are other major problems of GEAR. While specifying the time duration, it should be taken into consideration that too short time may not select the best path always. On the other hand too long time may affect the average response time. LEAR protocol acts as a remedy for these problems.

EDDSR [7] is energy dependent DSR algorithm which helps node from sharp and sudden drop of battery power. EDDSR provides better power utilization compare to least energy aware routing (LEAR)[17] and minimum drain rate(MDR). EDDSR avoids use of node with less power supply and residual energy

information of node is useful in discovery of route. Residual battery power of each node is computed by itself and if it is above the specific threshold value then node can participate in routing activities otherwise node delays the rebroadcasting of route request message by a time period which is inversely proportional to its predicted lifetime. With help of ns-2 simulator author performed simulation which shows MDR and EDDSR is better than DSR in terms of node lifetime. EDDSR has further advantage over MDR because it can use route cache used by DSR.

Weight Based DSR [18] is an improvement of conventional DSR. In this protocol, the weight of each route is considered as metric for route selection. Weight of each route can be calculated by computing the node weight of each node $w_i = \text{battery level of this node} + \text{Stability of this node}$. The route-weight is the minimum of all node weights included in this route. Select the main route which has the maximum route-weight. If two or more routes have the same route-weights then choose the route which has minimum hops. Thus WBDSR always gives the longest network life time in both high mobile networks and static networks because it timely change the used route with another one.

MEDSR protocol [19] has is one of the finest attempts that makes DSR an energy aware routing protocol. The whole approach is based on two mechanisms- Route Discovery and Link Power Adjustment. In MEDSR, the Route Discovery process itself is classified into two sub processes.

-Route Discovery mechanism using low power level,

-Route discovery mechanism using high power level.

MEDSR uses two levels of powers, the network connectivity is highly maintained and results less network partition. The result shows that when the network size is small the energy saving per data is maximum in MEDSR as compared to DSR, almost 55% high which indeed turning out to be an efficient routing protocol.

IV.CONCLUSION

The biggest issue for the establishment and persistence of MANET is the constraints on the consumption of battery power. Various protocols show various results as far as the energy consumption is concerned. As the network parameters and network parameters change, protocols show different behaviours.

Since every protocol has its unique features and deployment strategies, it is difficult to figure out one particular protocol to be the best energy efficient protocol. All the discussed protocols have proved that they outperform existing AODV and DSR protocols in one or more performance metrics. So it can be concluded that for different requirements and different metrics above discussed protocols can be used for reducing power consumption and improving network life time.

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