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A Comprehensive Survey on Energy Efficient Routing Protocols for Wireless AD-HOC Networks

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Abstract - Increasing a lifetime of battery powered devices with reducing energy consumption is one of challenge in wireless communication. One of a major batter powered device is cell phone or mobile phone which is based on Mobile Adhoc network (MANE). In mobile ad hoc networks, all nodes are energy constrained so also cell phones. A mobile ad hoc network is nothing but a distributed system that consists of wireless nodes that can freely organize it into temporary ad hoc network topologies. It is a collection of nodes that is connected through a wireless medium forming dynamic topologies. The performance of the MANET scheme not only has a fairly significant end-result on the behavior of the routing approach employed, but also on the energy consumption of the wireless network interface card (NIC). We investigate the inadequacies of the MANET schemes designed for ad hoc wireless networks in the context of power awareness herein. There are uncontrollable factors such as node mobility, weather, interference, noise which causes topology changes. As well as on controllable parameters such as transmission power and antenna direction this causes significant amount of energy loss. Network coding is an effective method to improve the performance of wireless networks. If these rapid topology changes are controlled by minimizing the maximum transmission power used in ad hoc wireless networks and still maintaining networks connectivity can extent the battery life and hence network lifetime considerably. In addition, the potential energy consumption pitfalls of non–power-based and power-based routing schemes are explored in this paper. This paper presents a review on the energy efficient routing protocols in Mobile Ad-Hoc Network (MANET). We also present the statistical performance metrics measured by our simulations

Keywords - *Mobile Ad Hoc Network; Energy Efficient Routing; Transmission Power Control; Routing Protocols; Performance Metrics*

1. Introduction

Mobile ad hoc network (MANET) is basically a collection of mobile nodes which can move dynamically. The features of MANET topology are dynamic topology, unstable links, limited energy capacity and absence of fixed infrastructure when compared to wired networks. MANET does not have centralized controller like traditional wireless networks (cellular networks and wireless LAN). Due to these features the design of routing protocols for MANET becomes a challenge. Routing is one of the key issues in MANETs due to their highly dynamic and distributed nature. Energy efficient routing may be the most important design criteria for MANETs since mobile nodes is powered by batteries with limited capacity. In case of power failure the mobile node gets affected itself as well its ability to forward packets on behalf of others and thus affects the overall network lifetime. In MANET the cellular networks the centralized medium access by base stations should be administered in a distributed, and hence collaborative, fashion by mobile stations. The transmission of package from distinct mobile terminals results in packet collisions and energy losses which increases the chances of overlap may happen due to transmissions of packets from distinct mobile terminals. In addition, the performance of the MANET scheme is majorly based on the performance of the routing method employed and on the energy consumption of the wireless network interface card (NIC). So routing is one of the key issues in MANETs due to their highly dynamic and distributed nature. The on-demand routing or dynamic routing algorithms initiate to find out the suitable route when a route is requested. The routing algorithm in MANET exchanges routing information periodically and generates the routing table in advance of route request [2]. The routing protocols selects the routes based on the metrics. The mobile nodes in wireless ad-hoc networks are typically battery powered. The energy efficient routing is of paramount significance in the design of such networks. In case of power failure, the wireless node gets affected as well the capability of the node to forward packets on behalf of others also gets affected and in turn the overall network lifetime [3]. Researches have put many efforts

to extend the mobile node battery capacity which includes communication energy consumption and Non communication energy consumption. The energy consumption of active nodes is more significant than the others for high-traffic environment. Energy efficient active communications increases the network life time. The network life time is nothing but the time when a node runs out of its own battery power for the first time [4, 5]. The energy efficient routing protocols should consider the power consumption for the network and the node. Energy efficient routing protocols are designed to have effective active communications. The purposes of the MANET are proper utilization of network resources to gain maximum throughput, reduce packet delivery delay and prolonged network lifetime. The lifetime of cell phone depends upon the limited battery energy. Since the size of these mobile are becoming tiny day by day, it is required to ensure the highest degree of utilization of limited battery power. The best routing protocol should design and implement in such a way that, they are highly concerned about the energy constraints. Figure 1 shows a simple mobile ad hoc network. MANET is decentralized and self-organizing network where the functions from using appropriate network topology to delivering the correct message are carried out by the nodes themselves.

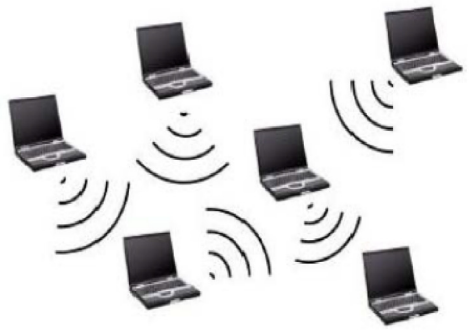

Figure 1: Simple mobile ad hoc network

1.1 Characteristics of a MANET:

MANET is characterized by some specific features as follows:

- Wireless: The nodes are connected by wireless links. Also the communication among nodes is wireless communication [3].
- Dynamic Topologies: Due to arbitrary (dynamic) movement of nodes at varying speed, the topology of network gets change is random and unpredictable.
- Multi hop Routing: In MANET there is no dedicated router as such. Every node in this case acts as router.
- Energy Constraint: Energy conservation becomes the major design issue as nodes in the MANET rely on batteries or some other exhaustible source of energy.
- Autonomous and infrastructure less: Network is self-organizing and is independent of any fixed infrastructure or centralized control.
- Ad hoc based: A MANET is temporary and dynamic network formed by the union of nodes and the connecting links in an arbitrary fashion.

2. Energy Efficient Routing

In wireless networks, many devices are operating on battery backup. These devices operating on battery try to pursue the energy efficiency heuristically by reducing the energy they consumed. Actually, energy efficiency can be measured by the network lifetime which is actually the duration of the time over which the network can maintain a certain performance level. Lesser energy will affect the working of the whole network because the underline nodes may exhaust their energy very soon. The energy consumed is balanced consumed among nodes in the networks.

The network maintains certain performance level for a longer time based on balance between all nodes and routes also increases the lifetime hence, energy efficiency is measured by the power consumption. The performance of any energy routing protocol is measured by the duration of time over which the network can maintain a certain performance level. Energy saving is done when broadcasting is done in order to recover from the node failure or re-routing around the failed nodes is essential. By the same token, multicast has the same challenge to achieve the energy efficiency. For unicast, it is highly related to the node and link status, which require a wise way to do routing as well. Sometimes, shortest path routing is possibly not the best choice from the energy efficiency point of view. An ideal network is the one that can function as long as possible.

On the other hand, optimal routing requires future knowledge and thus, it is not practically viable to have optimized routing in energy constrained environment. Therefore, instead of having energy optimal scheme, we have a statistically optimal energy efficient scheme that considers only past and present and not future knowledge.[10] In order to avoid coverage gap in many

surveillance / monitoring applications, lifetime of network is defined. Instead of average time or overall scenarios, the worst case (when a first node dies out) is maximized. Establishing correct and energy efficient routes, in mobile ad hoc networks, is not only an important design issue but also a challenging task. It is because operation time of mobile nodes is the most critical limiting factor. Mobile nodes derive their power from batteries with limited capacity.

2.1 Proactive Protocols

Protocol is also known as table driven a protocol which maintains the route of the nodes using routing table. [3] These tables contain a list of all the destinations, the next hop, and the number of hops to each destination. Each node keeps updating the table in response to change in network and also makes neighbouring nodes aware about the same. The table is created using link-state or distance vector algorithmic approach. Packets follow the predefined route specified in the routing table. In this scheme, the forwarding packets are faster but the routing overhead is high. All the routes have to be defined before transferring the packets.

Proactive protocols have lower latency because all the routes are maintained at all the times. DSR (Dynamic Source Routing), AODV (Ad Hoc On Demand Distance Vector Routing), ABR (Associativity Based Routing) are the examples of this type.

2.2 The other type of protocol is reactive protocols:

These are also called as On Demand Routing Protocols where the routes are not predefined for routing. In this type of protocol Route discovery and route maintenance are two main procedures: The route discovery process is nothing but sending route-request packets from a source to its neighbor nodes and then forward the request to their neighbors, and so on. Once the route-request reaches the destination node, it responds by neighbor from which an intermediate node that has a sufficiently sending a route-reply packet back to the source node via the up-to-date route. Once the route is established, some form of route maintenance process maintains it in each node's internal data structure. This is called a route-cache. Note that each node learns the routing paths as time passes not only as a source but also as an overhearing neighbor node. DSDV (Destination – Sequenced Distance Vector routing), OLSR (Optimized Link State Routing), Wireless Routing Protocol (WRP) are the examples of reactive protocols.

2.3 Hybrid protocols are the combinations of reactive and proactive protocols.

It takes advantages of these two protocols and as a result, routes are found quickly in the routing zone [3]. The route established with proactive routes and uses reactive flooding for new mobile nodes. ZRP (Zone Routing Protocol), Temporally Ordered Routing Algorithm (TORA), Orderone Routing protocol (OOPR) are the examples of hybrid protocol.

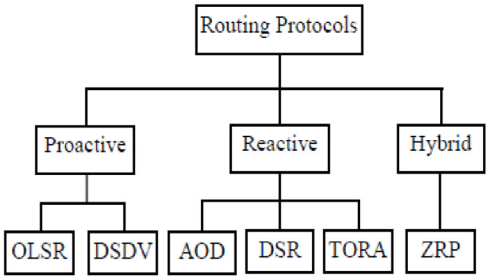

Figure2: Categorization of Routing Protocols

Table1:

Characteristics	**Reactive**	**Proactive**	**Hybrid**
Topology	On Demand	Periodical	Both
Mobility Handling	Route maintenances	Periodical updates	Both
Network Organization	Flat	Flat Hierarchical	Flat
Route Latency	Available when needed	Always	Both
Communication Overhead	Low	High	Medium

2.4 Efficiency of Energy of Proactive and Reative Protocols.

Table-driven protocols or proactive protocols have the overhead of route updates. It never considers the frequency of forwarding packets that take place in the Ad-Hoc network. The routing information is constantly updating within the network. Whereas on-demand protocols or Reactive protocols, routing information is exchanged only when the source wishes to send some information to the destination. It has no information about the destination in its route cache. On the other hand, since routing information is constantly propagated and updated in Proactive protocols, information about a particular source-destination route is always available. This feature leads to significant signaling overhead and

power consumption. As in AdHoc networks the battery and bandwidth are scarce resources in Ad-Hoc networks, this becomes a serious limitation.

3. Overview Of Different Routing Protocols

In this section, the overview of routing operations performed by the routing protocols like AODV, DSR, ABR, DSDV, TORA, CGSR are discussed.

3.1 Ad Hoc on-demand Distance Vector Routing (AODV) Protocol:

The Ad Hoc On-demand Distance Vector Routing (AODV) [3] protocol is a reactive unicast routing protocol for mobile ad hoc networks. AODV only needs to maintain the routing information about the active paths. The improvement is on minimizing the number of required broadcasts by creating routers on an on-demand basis.[15] The routing information in AODV is maintained in the routing tables at all the nodes. Every mobile node keeps a next hop routing table, which contains the destinations to which it currently has a route. A routing table expires if it is not used in stipulated time period or reactivated for a pre-specified expiration time. In AODV it initiates a route discovery operation when a source node wants to send packets to the destination but no route is available,. In the route discovery operation, the source node broadcasts route request (RREQ) packets which includes Destination Sequence Number. When the destination or a node that has a route to the destination node receives this RREQ, it checks the destination sequence numbers it currently knows and the one specified in the RREQ. To assure the freshness of the routing information, a route reply (RREP) packet is created and forwarded back to the source. [4] AODV uses only symmetric links and a RREP follows the reverse path of the respective RREQ. Upon receiving the RREP packet, each intermediate node along the route updates its next-hop table entries. The redundant RREP packets or RREP packets with lower destination sequence number will be dropped.

Advantage:

1. Low Connection setup delay.
2. Uses Bandwidth efficiently.

Disadvantage:

1. More number of control overheads.
2. Node uses the routing cache to reply to route queries.

3.2 Associativity Based Routing (ABR) Protocol:

Associativity Based Routing is free from loops, deadlock and packet duplicates. It defines a new routing metric for ad hoc networks. Each node generates periodic beacons to signify its existence to the neighbors'. Beacons are used to update the associativity table of each node with the temporary stability. ABR consists of 3 phases: a. Route Discovery b. Route Repair/Reconstruction c. Route Delete

3.3 Dynamic Source Routing (DSR) Protocol:

In DSR, the routing is based on the concept of source routing. Mobile nodes are supposed to maintain route caches that contain the source routes of which the mobile is aware. DSR consists of 2 major phases: a Route Discovery - Uses Route Request and Route Reply packets. B. Route Maintenance - Uses Route error packets and acknowledgements.

Advantages: Fast recovery cache can store multiple paths to a destination.

3.4 Destination-Sequenced Distance-Vector Routing (DSDV) Protocol:

The Proactive DSDV protocol is a modified version of the Distributed Bellman-Ford (DBF) Algorithm that was used successfully in many dynamic packet switched networks [12]. The Bellman-Ford method gives a means of calculating the shortest paths from source to destination node. The distance vector factors to each link are known. DSDV uses this idea, But overcomes the tendency to create routing loops by including a parameter called destination-sequence number [3]. In DSDV, each node is required to transmit a sequence number, which is periodically increased by 2. It is transmitted along with any other routing update messages nodes.

4. Conclusion

In this paper, discussion is done on the energy efficient routing protocols in mobile ad hoc networks and an overview of some of the routing protocols like DSDV, DSR, ABR, AODV, TORA. A brief idea is given for the function of energy efficient routing protocols.

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