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Performance of Energy Efficient Routing Protocols in MANETS

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Abstract

A mobile ad hoc network (MANET) is a continuously self-configuring, infrastructure-less network of mobile devices connected without wires. Every device in a MANET is open to move separately in any route, and will therefore change its links to other devices frequently. Hence routing and power management becomes challenging issues in MANETS. However, due to the slow improvement in battery technology, battery power is considered to be a constrained resource. To increase the durability of the network, the existing battery power must be carefully used. Various energy efficient techniques have been proposed by different authors in this area to increase the network lifetime. In this paper the performance of various energy efficient routing protocols in MANETs are addressed.

Keywords: *MANET, power management, Energy efficient protocols*

1. Introduction

A MANET is a type of ad hoc network that can change locations and configure itself instantaneously. As MANETS are mobile, various networks are connected using wireless connections. The device must forward traffic unrelated for its own use, and therefore act as a router. Such networks operate in a individually, or may be connected to the Internet.

Power management in MANETS is needed as

- Wireless devices rely on battery power for all operations.
- scarcity of battery capacity
- Power breakdown of a mobile node not only affects that particular node but its ability to forward the packets and hence the overall network lifetime will be affected.
- A mobile node consumes battery power not only when it is active but also when it stays idle

2. Classification of routing protocols

MANETs Routing protocols can be categorized into three main types:

Proactive routing protocols: Each node in the network has one or more paths to any possible destination in its routing table at any specified time. Proactive protocols constantly learn the topology of the network by exchanging topological information among the nodes in a network. Hence, such route information is available instantly, when the route to a destination is needed. The cost of maintaining the network will be very high if the network topology changes too often. The details about actual topology will not even be used if the network activity is low. Proactive protocols constantly assess the routes within the network so that when the packet is to be forwarded, route is previously known and immediately available for use. Hence an optimized path can be found without any time delay. These protocols are not appropriate for very dense ad-hoc networks as there will be problem of high traffic. Many changes to proactive protocols have been proposed for overcoming its limitations. It upholds the unicast routes between all pair of nodes without taking into account whether all routes are actually used or not.

Reactive routing protocols: Each node in the network obtains a route to a destination on a demand basis. These protocols generally do not maintain routes to any destination in the network and do not exchange any periodic control information.

They are called on demand routing protocols. They are more efficient than proactive routing protocols. The most important characteristic behind this type of routing is to determine a route between a source and destination whenever that route is needed. In proactive protocols we maintain all routes without considering its use. In reactive protocols we don't

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consider the routes which are not currently being used. This is on demand routing. The cost of upholding the routes not being used is avoided by determining the route on demand. It also controls the traffic of the network as they don't send intense control messages. In reactive protocols time delay is comparatively greater than proactive protocols as routes are determined when it is required. e.g. Ad-hoc On Demand Distance Vector (AODV), Dynamic Source Routing (DSR) etc.

Hybrid routing protocols: All nodes acts reactively in the region close to their proximity and proactively outside of that region.

There are some advantages and disadvantages in both proactive and reactive routing protocols. There is a good combination of both proactive and reactive routing in hybrid routing. The routing is at first set up with some proactively prospected routes and then serves the demand from additionally activated nodes through reactive flooding. Hence these types of protocols can include the facility of other protocols without compromising with its own advantages. Example: Zone Routing Protocol (ZRP).

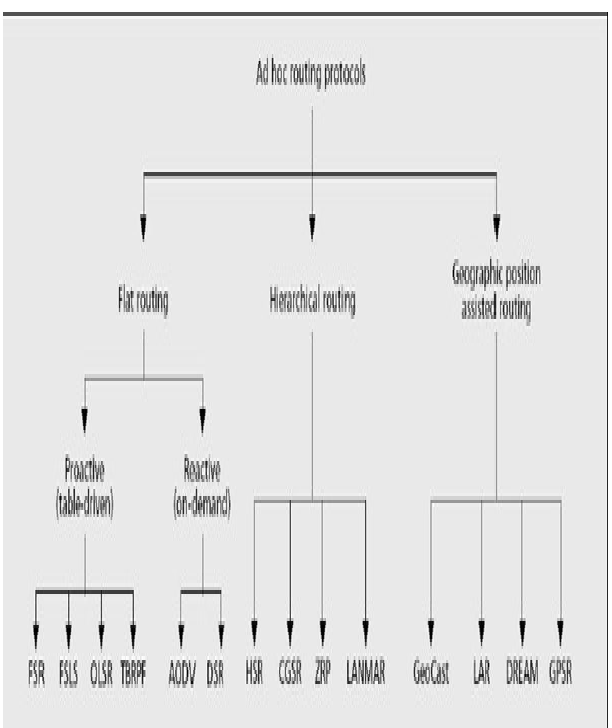

Figure 1. Classification of routing protocols

3. Energy Efficient Metrics

Some of the alternatives to save power from the devices:

- Energy utilization is the sum of power consumed on every hop in the path from a packet. The power consumption on a hop is a function of the distance between the neighbour and the load of this hop. Therefore it is better to choose a route where the distance between the nodes isn't too long and also take a shorter route so that there aren't too many hops on the route where the power level gets down.

- Maximized Network Connectivity tries to balance the load on all the nodes in the network. This is required where the network connectivity is to be ensured.

- Minimum Variance in Node Power Levels helps to distribute the load among all nodes so that the power consumption remains uniform to all nodes. This problem is very complex when the rate and size of data packets vary. When every node has the same power level, we can be certain that the network operates for long duration. When a node has to switch off because of the power level, there is possibility that whole network can break down the connectivity between the nodes.

- Minimizing maximum node cost reduces the maximum cost per nodes for a packet after routing certain number of packets or after a specific period. Hence to save battery power a node can be blocked for routing. This will save the connectivity from every node. Whenever a node is used many times for a route, it blocks itself to save the power.

4. Energy Efficient Routing Protocols

The purpose of Energy-Efficient routing protocols is

- to reduce energy consumption in transmission of packets between source and a destination
- to avoid routing of packets through nodes with low residual energy
- to minimize loss of routing information over the network
- to avoid interference and medium collisions.

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EE-OLSR (Energy Efficient OLSR Routing Protocol): EE-OLSR [22] (Energy-Efficient OLSR) is a routing protocol obtained by modifying OLSR[21] in order to improve its energy behaviour, without losing performance. We have two mechanisms for this protocol: i) the EA Willingness Setting and ii) the Overhearing Exclusion.

i) EA-Willingness Setting mechanism: The Energy Aware Willingness Setting is a technique to involve energetic considerations in multi-point relay (MPR) selection. The OLSR specification has a variable, the "willingness" of a node, representing the availability of that node that act as a MPR for its neighbouring nodes. Each node declares a default willingness value. In EE-OLSR, each node, calculates its own energetic status, and can declare an appropriate willingness. The metrics battery capacity and the predicted lifetime is based on the willingness selection decision.

ii) Overhearing Exclusion is a technique which allows to save energy in OLSR protocol. A large amount of energy can be saved by turning off the device when a unicast message exchange happens in our neighbourhood,. This is achieved using the signalling mechanisms at the lower layers and thereby do not affect the protocol performance. OLSR does not take any benefit from unicast network information directed to other nodes. After the MPR election it is important to select the next hop for forwarding the data packet.

Localized Energy-aware Routing (LEAR) Protocol

Local Energy-Aware Routing (LEAR) aims to balance energy consumption with shortest routing delays. It takes into account a node's willingness to participate in the routing path which is based on its remaining battery power. The destination node does not wait to reply and it makes Efficient use of route cache. It simultaneously optimizes trade-off between balanced energy consumption and minimum routing delay and also avoids the problems of blocking and route cache. LEAR achieves balanced energy utilization based only on local information. Due to the simplicity of LEAR, it can be easily integrated into existing ad hoc routing algorithms without affecting other layers of communication protocols. LEAR is the first protocol to determine balanced energy utilization in a practical situation where routing algorithms are all considered [10] and [15] and [16].

Energy Dependent DSR: EDDSR is energy dependent DSR algorithm which assists a node from sharp and unexpected fall of battery power. This protocol provides better power consumption compare to LEAR This algorithm avoids the use of node with less power. The residual energy information of node is useful in discovery of route and residual battery power of each node is computed. If the value 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. EDDSR has further benefit as it can use route cache used by DSR.

Energy-Aware Algorithm for AODV in Ad Hoc Networks: This energy optimized protocol can be applied to ad hoc routing protocols such as AODV. Based on the propagation power loss and node battery capacity information a cost function has been deduced and routes are optimized based on the cost functions of links and nodes. To improve the routing update behaviour, and preventing overuse of critical nodes a low-battery alert mechanism is introduced. With the low-battery alert level network throughput is not affected. Energy utilization is balanced among the network and the limited battery resources are utilized efficiently.

Power Aware AODV (PAAODV) Protocol: This protocol is an improvement of AODV routing protocol, which employs power control information during route discovery. It has two mechanisms: (i) multiple power level route discovery (ii) link-by-link power control. To discover a route, 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. This protocol uses several power levels during discovering a route. Nodes try to find a route to the destination initially with low power levels. The power level is increased if it does not succeed. This process continues until route discovery succeeds. Two power levels low and high are used.

Power-Aware Routing using Zone Routing Protocol in MANET:

ZRP is a hybrid protocol which takes benefit of a proactive routing strategy within a node's local neighbourhood and a reactive routing protocol for communication between the neighbourhoods. Every node defines a zone and the zone radius is carefully chosen so that a node can be in multiple zones and zones overlap. Therefore the efficiency in route discovery decreases. The zone radius may fluctuate quickly in the presence of node mobility, and it also affects the functionality of nodes within and at the periphery of the zone. This Power-Aware Routing using Zone Routing Protocol has been developed for effective power control and transmission. It tries to minimize the power utilized in transmitting a packet from the lifetime of the network by avoiding nodes that have a shorter lifetime remaining.

Energy Efficient Multicast Routing Protocol (EEMRP):
Reactive protocols are generally better than proactive protocols in terms of packet delivery ratio, routing overhead, and efficient utilization of energy. DSR-MB protocol and MAODV protocol are two well-known multicast routing protocols. The adhoc network is energy-controlled system with the portable devices. Routing protocols like DSR-MB and MAODV take only shortest path to arrive at the destination. Shortest path consumes more energy due to repeated usage. This makes network partition and reduce the network lifetime [19] and [20]. The EEMRP not only makes the system energy utilization down but also extends the system lifetime and improves the delay features. Analysis shows that EEMRP has a better delay performance, lower energy utilization and longer network lifetime. In EEMRP, routing forward decisions should be based on each node's power level. The vital goal of our approach is a good energy balance among mobile nodes, which finally results in a longer lifetime of the network. Multicasting environment and threshold energy level is set for each node. If each node energy level has above than threshold level then it is used for packet forwarding. MRP algorithm is used to calculate the energy in each node and reduce the more energy consumption in a way of choosing the nodes, which has threshold level. The incoming packet is having the energy information of each node which will be analysed through energy measurement process. After the above process, the best node will be selected and also optimal path selected through routing process .

Minimum Energy Routing (MER) Protocol Minimum Energy Routing (MER) routes the data-packet on a route that consumes the minimum amount of energy to get the packet to the destination. This requires the knowledge of the cost of a link in terms of the energy extended to successfully transfer and receive data packet over the link, the energy to determine routes and the energy lost to retain the routes. MER incurs higher routing overhead, but lower total energy and can take down the energy utilized of the simulated network within range of the theoretical minimum the case of static and low mobility networks. Therefore as the mobility increases, the minimum energy routing protocol's efficiency degrades although it still yields impressive reductions in energy as compared performance of minimum hop routing protocol [8] and Lifetime-AwareMulticast Routing [10].

Lifetime-aware Tree (LMT) Protocol This algorithm [14] maximizes the network lifetime by discovering routes that decreases the variance of the remaining energies of the nodes in the network. It increases the lifetime of a source based tree, considering that the energy required to transmit a packet is directly proportional to the forwarding distance. Therefore, this protocol is said to be inclined towards the bottleneck node. Many simulation results were given to assess the performance of LMT with respect to a number of different metrics in comparison to a variety of existing routing algorithms. These results clearly show the effectiveness of LMT over a large range of simulated scenarios [15] and [16].

Lifetime-aware Refining Energy Efficiency of Trees (L-REMIT) In terms of energy Lifetime of a tree is the duration of the existence of the service until a node dies due to insufficient energy. This is a distributed protocol and is part of a group of protocols called REMIT (Refining Energy efficiency of Trees). Minimum-weight spanning tree (MST) is used as the initial tree and it improves its lifetime by switching children of a bottleneck node to another node in the tree. A tree is obtained from the "refined" MST (after all possible refinements have been done) by pruning the tree to reach only group nodes. LREMIT is a distributed algorithm where each node gets only a local view of the tree and each node can independently switch its parent as long as the tree remains connected that utilizes an energy consumption model for wireless communication. LREMIT takes into account the energy losses due to radio transmission as well as transceiver electronics. L-REMIT adapts a given tree to a wide range of wireless networks irrespective of whether they use long-range radios or short-range radios [5] and [16].

Conditional Max-Min Battery Capacity Routing (CMMBCR) Protocol This protocol uses the idea of a threshold to maximize the lifetime of each node and to fairly use the battery. If all the nodes in some possible routes between a source-destination pair have larger remaining battery energy than the threshold, the minimum power route among those routes is chosen [3]. If all possible routes have nodes with lower battery

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capacity than the threshold, the max-min route is chosen. It selects the shortest path if all nodes in all possible routes have adequate battery. Routes going through the nodes will be avoided if the battery capacity for these nodes goes below a determined threshold. Therefore the time until the first node failure is extended if the battery capacity is exhausted. We can maximize either the time when the first node powers down or the lifetime of most nodes in the network by adjusting the value of the threshold [10] and [18].

5. Conclusion

A mobile ad hoc network (MANET) consists of separate mobile nodes, which communicates directly with the nodes within its proximity. An efficient routing protocol is required to create routes between the nodes so as to make effective and reliable communication within a MANET. Energy efficiency is one of the challenge faced in MANETs. In this paper, we analysed a number of energy efficient routing protocols and we can conclude that there is no single protocol which can give the best performance. The efficiency of the protocol differs with respect to the variation in the network parameters. Hence one routing protocol cannot be a solution for all energy efficient issues that are seen in MANETs, instead each protocol should offer maximum possible requirements, in accordance with the required situations.

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