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Overview of Energy Efficient Routing in MANET

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Abstract

Mobile ad hoc network (MANET) are infrastructure-less, self-organizing, rapidly deployable wireless network, they are highly suitable for applications involving special outdoor events, communications in regions with no wireless infrastructure, emergencies and natural disasters, and military operations. *Routing* is one of the key issues in MANETs due to their highly dynamic and distributed nature. In particular, *energy efficient routing* is the most important design criteria for MANETs since mobile nodes will be powered by batteries with limited capacity. Power failure of a mobile node not only affect the node itself but also its ability to forward packets on behalf of others and thus the overall network lifetime. The paper focuses on the review of work done in energy efficiency routing in MANET.

Keywords- MANET, Routing protocols, Energy efficiency, Power failure.

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Introduction

Ad-hoc wireless network is a collection of two or more devices equipped with wireless communication and networking capability. Mobile Ad Hoc Network (MANET) is communication network in which all nodes are mobile and communicate with each other via wireless connections. Nodes can join or leave the network at any time and they communicate with each other which are immediately within their radio range and communication beyond this range is established by employing intermediate nodes to set up a path in a hop-by-hop manner. There is no fixed infrastructure. There is no need for any fixed radio base stations, any wires or fixed routers. All nodes are equal and there is no centralized control or overview that is it is self-organizing and adaptive. This means that a formed network can be de-formed on-the-fly without need for any system administration. There are no designated routers: all nodes can serve as routers for each other, and data packets are forwarded from node to node in a multi-hop fashion. Due to presence of mobility, routing information will have to change to reflect changes in link connectivity. The diversity of ad hoc mobile devices also implies that the battery capacity of such devices will also vary. Since ad hoc networks rely on forwarding data packets sent by other nodes, power consumption becomes critical issue. The characteristics of the mobile ad hoc network are shown in fig1.

A. Routing Mechanism

Routing is the process of selecting paths in a network along which to send the important data. Routing is one of the most significant challenges in ad hoc networks as to develop support for routing is critical for the basic network operation. A Routing Mechanism specifies how routers communicate with each other, disseminating information that enables protocol to select routes between any two nodes in the network, the choice of the route being done by routing algorithms. The mobility in mobile ad hoc network that is nodes in an ad hoc network are allowed to move in an uncontrolled manner which results in a highly dynamic network with rapid topological changes causing frequent route failures.

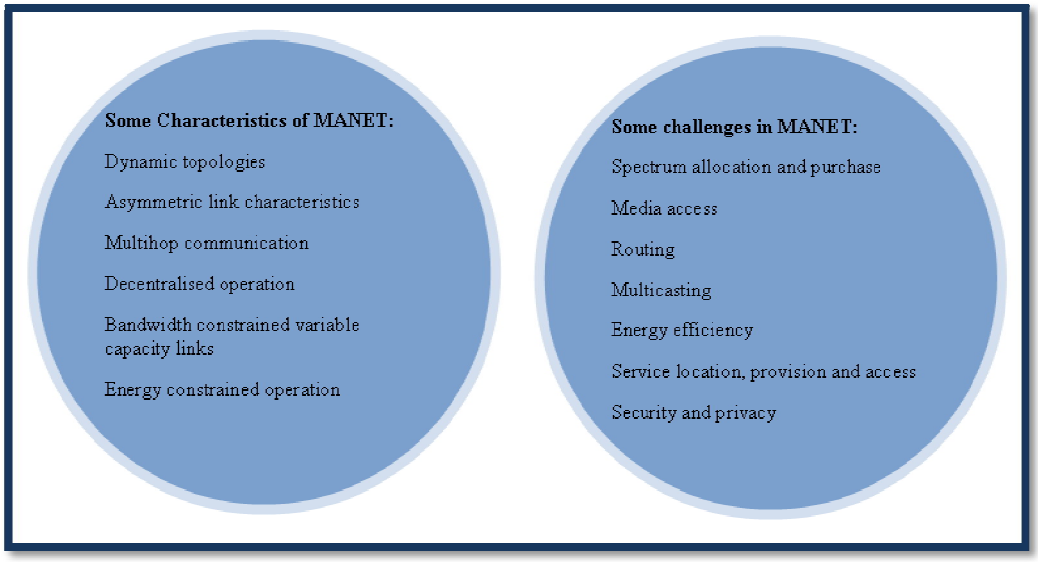

Fig.1. MANET Characteristics and Challenges

So a perfect Routing Mechanism for the mobile ad hoc network environment has to dynamically adapt to the changing network topology. The channels in wireless network provide much lower and more variable bandwidth as compare to wired networks. The wireless channels are working as a shared medium in wireless network. This channel makes available bandwidth per mobile node even lower. So a perfect Routing Mechanism should be bandwidth efficient by expending a minimal overhead for computing routes so that much of the remaining bandwidth is available for the actual data communication. The nodes in the mobile ad hoc network run on batteries which have limited energy supply. In order for nodes to stay and communicate for longer periods, it is desirable that a Routing Mechanism should be energy-efficient as well. Routing in MANET is a dynamic optimizing task aiming at providing paths that are:

- Optimum in terms of some criterion (e.g. minimum distance, maximum bandwidth, shortest delay)
- Satisfying some constraints (e.g. limited power of mobile nodes, limited capacity of wireless links)

Routing Mechanisms use several metrics to calculate the best path for routing the packets to its destination. These metrics are a standard measurement that could be number of hops, which is used by the routing algorithm to determine the optimal path for the packet to its destination. The different delivery semantics for the routing in MANET are as follows:

- Unicast: delivers a message to a single specific node within the transmission range
- Broadcast: delivers a message to all nodes in the network within the transmission range

- Multicast: delivers a message to a group of nodes that have expressed interest in receiving the message within the transmission range
- Any cast: delivers a message to any one out of a group of nodes, typically the one nearest to the source within the transmission range
- Geocast: delivers a message to a geographic area within the transmission range.

B. Energy efficiency in MANET

Energy efficiency is a major issue of concern in wireless an ad hoc networks as mobile nodes rely on batteries, which are limited sources of energy, and, in many environments, it is quite a cumbersome task to replace or recharge them. Despite the progress made in battery technology, the lifetime of battery powered devices continues to be key challenge and requires additional research on efficient design of platforms, protocols, and systems. Nodes within an ad hoc network generally rely on batteries (or exhaustive energy sources) for power. Since these energy sources have a limited lifetime, power availability is one of the most important constraints for the operation of the ad hoc network. There are different sources of power consumption in a mobile node. Communication is one of the main sources of energy consumption. Since the rate of battery performance improvement is rather slow currently, and in the absence of breakthroughs in this field, other measured have to be taken to achieve the goal of getting more performance out of the currently available battery resources. The types of energy consumption that have been identified:

- Energy consumed while sending a packet
- Energy consumed while receiving a packet
- Energy consumed while in idle mode
- Energy consumed while in sleep mode which occurs when the wireless interface of the mobile node is turned off.[16,17,18]

Devices used in the mobile ad hoc networks require portability and as they are mobile they also have size and weight constraints along with the restrictions on the power source. If the battery power is increased, it may make the nodes bulky and less portable. So the energy efficiency remains an important design consideration for these types of networks. A major challenge that a Routing Mechanism designed for mobile ad hoc wireless network faces is resource constraints. Therefore mobile ad hoc Routing Mechanism must optimally balance these conflicting aspects.

C. Power Optimization Techniques

As the mobile ad hoc network is infrastructure less, it follows individual mobile node that rely on the limited power sources. So energy conservation is an important issue in the mobile ad hoc network. Some of the schemes to optimize energy conservation in MANET[18] are listed below:

- Power conservation by controlling transmission power: The main aim of energy conservation is to reduce the total power consumed in packet transmission and increase network lifetime by increasing the residual power of battery.
- Power conservation by using power management techniques: The power management techniques are used to minimize the power consumption of battery powered based mobile devices. The main idea behind this scheme is to trigger mobile devices to the low power mode that is sleep mode from high power node, when they are not in use that is either in inactive mode or in idle mode.
- Power conservation by using minimized power aware Routing Mechanism: The main objective of Routing Mechanism in MANET is to maximize energy efficiency, network throughput, energy efficiency, network lifetime and minimize delay. The main distinguishing feature for the power aware Routing Mechanisms is its use of energy for each route entry. There is given more than one route to a specific destination, a requesting node is required to select one with best energy status and more active that is optimization with energy constraint. So, power aware routing becomes the most useful issue in MANET because it has been proved with best energy saving techniques.
- Power conserving at mobile node: The mobile nodes in MANET are all hardware devices. As they are hardware devices, they consume power in sleep mode also because trans-receivers is hearing signals for it constantly. Lot of efforts is needed for reducing the energy consumption in each and every aspect of mobile nodes.

Now from above discussion it is clear that the energy can be consumed at different levels in MANET. Power saving at Routing Mechanism is much easier as compared to power saving at transmission level or at mobile nodes level. The energy aware Routing Mechanisms are compared with following energy efficiency metrics:

- The relative routing overhead: It is the ratio of the number of control packets over the number of delivered data packets.
- The delivery ratio: It is the Ratio of number of packets delivered over the total number of packets sent.
- The end-to-end delay: It is the average of delays between each pair of a communication session.
- The normalized hops: It is the ratio of average number of hops over optimal hops.

Energy consumed per packet: the selecting the minimal power path depends which minimizes the sum of link cost along with path.

LITERATURE SURVEY

The major routing protocols in MANET are divided in three categories namely Table driven or proactive protocols, on demand or reactive protocols, Hybrid protocols[17] Table driven or proactive protocols: In these protocols all nodes maintain the information about next node. All nodes of any protocol have to relay its entire information to its adjacent nodes. The mechanism of manual agreement is used so entire node constantly update their position. The example of proactive protocol is Destination-Sequenced Distance-Vector Routing (DSDV).On demand or reactive protocols: These protocols depend upon some sort of query-reply dialog. The information is provided on demand by the specific node. There is no need of continuous update. The example of reactive protocol is Dynamic Source Routing (DSR), Ad hoc On-Demand Distance Vector (AODV), and Temporally-Ordered Routing Algorithm (TORA). Hybrid protocols: It is the combination of both proactive and reactive protocols. The hybrid protocols enhances interior gateway routing protocols. The example of hybrid routing protocol is Zone routing protocols (ZRP).

The routing protocols for ad hoc networks must deal with limitations such as high power consumption, low bandwidth, high error rates and arbitrary movements of nodes. Most of the working routing has been focusing on energy-aware routing protocols and applications. For conserving energy, many energy-efficient routing protocols have been proposed. Several protocols have been given regarding energy efficient routing and their modifications have also been proposed. Each and every protocol has some advantages and disadvantages. The work on the developing more efficient minimum energy routing protocols if focus of many researchers.

Stojmenovic, Ivan, and Xu Lin.[1] have proposed LEAR (Local Energy Aware Routing) protocol which is based on DSR routing mechanism and its basic idea is to consider only those nodes for the communication which are willing to participate in the routing path. It achieves balanced energy consumption based only on local information. Maleki, Morteza, Karthik Dantu, and Massoud Pedram[2] have proposed PSR (Power aware source routing) uses greedy policy to fetched paths from cache and has taken care of both the node mobility and the node energy depletion that may cause a path to become invalid.Chao, Chih-Min, Jang-Ping Sheu, and Cheng-Ta Hu[3] have proposed ECGRID (Energy Conserving GRID routing protocol) conserves the energy by turning the not gateway hosts trans-recievers off when the hosts are idle. Also lod balance of the mobile host's battery energy scheme is applied to prolong the lifetime of all mobile hosts. Li, Xu, Wu Zi-wen, and ZhengBao-yu[4] have proposed TPBDSR(Topology Control Based Power-aware and Battery Life-aware) protocol uses simple pure distributed control that is the transmitting power gets adjusted according to their neighbor node's position in the network topology which may change dynamically.Tarique, Mohammed, Kemal E. Tepe, and Mohammad Naserian[5] have proposed ESDSR (Energy

saving Dynamic Source Routing) protocol which first decides the route based on the load balancing approach and then it dynamically adjusts the transmitting power at every node before it transmits packet. Tanque, Mohammed, and Rumana Islam[6] have proposed MEDSR (Minimum Energy Dynamic Source Routing) protocol which is present on mechanisms of route discovery and link power adjustment. De Rango, Floriano, Paola Lonetti, and Salvatore Marano[7] have proposed MEADSR (Multi-path energy aware DSR routing) protocol is to have the best path for routing by computing multipath node disjoint where the best path is with the high energy efficient. It proves that there is evenly distribution of energy consumption among nodes by using their residual batterycapacity. Rishiwal, Vinay, Mano Yadav, S. K. Bajapai, and S. Verma[8] have proposed PAR (Power aware routing) protocol that maximizes the network lifetime and minimizes power consumption by selecting less congested and more stable route,during the source to respective destination route establishment process.Du, Dahai, and Huagang Xiong[9] have proposed LEER (Location aided energy efficient routing) protocol which finds out the all possible paths from source to destination and selects minimum energy pathto route packets. Here the selection of next hop depends on whether the node situated near to destination than to source as well as transmit power of that node.Talooki, V., Hugo Marques, Jonathan Rodriguez, Hugo Água, Nelson Blanco, and Luís Campos[10] have proposed E2DSR (Energy Efficient DSR) protocol with some new structure for the control packets to change the behaviour of the nodes which implements a new energy table and creates a new algorithm for route cache and rute selection.Liu, Wei, Chi Zhang, Guoliang Yao, and Yuguang Fang[11] have proposed DELAR (A Device-Energy-Load aware relaying Framework) which utilizes the device heterogeneity inherent in ad hoc networks and features the cross layer protocol design methodology. The transmission power control and power aware routing can be integrated to jointly achieve better energy conservation.Tavli, Bulent, and Wendi Heinzelman[12] have proposed Energy Efficient Real Time Multicast Routing In Mobile Ad Hoc networks 4which uses MC-TRACE which is a cross layer functionality where the medium access control layer functionality and the network layer functionality are performed by a single integrated layer and it provides superior energy efficiency. Zhu, Jinhua, and Xin Wang[13] have given the Model and protocol for energy efficient routing over mobile ad hoc networks. This model is used to track the energy consumption due to various factors and progressive routing protocol is used to improve the performance during path discovery and in mobility scenarios. Baisakh and Nileshkumar R. Patel[14] have proposed ESSDSR (Energy saving and Survival DSR routing) protocol in which the DSR has been modified in such a way that if an energy of a node which is forwarding the data packet within a multi hop path reaches a level less than or equal to certain threshold percentage of its initial battery energy the node will ask the neighbour nodes to look for another location for such data. Patel Nileshkumar R. and ShishirKumar[15] have designed ECDSR (Energy

Conscious DSR) which imposed two important characteristics as energy saving and energy survival in basic DSR through which it not only enhances the lifetime of network but also increases performance of the network.

A major challenge that a routing protocol designed for ad hoc wireless networks faces is resource constraints. Devices used in the ad hoc wireless networks in most cases require portability and hence they also have size and weight constraints along with the restrictions on the power source. Increasing the battery power may make the nodes bulky and less portable. The energy efficiency remains an important design consideration for these networks. Therefore ad hoc routing protocol must optimally balance these conflicting aspects. To achieve the desired behaviour, so many energy efficiency mechanisms have been proposed. None of them can perform better in every condition. It depends upon the network parameters which decide the protocol to be used. Some proposals make use of clustering or maintain multiple paths to destinations (in order to share the routing load among different nodes). The majority of energy efficient routing protocols for MANET try to reduce energy consumption by means of an energy efficient routing metric, used in routing table computation instead of the minimum-hop metric. This way, a routing protocol can easily introduce energy efficiency in its packet forwarding. These protocols try either to route data through the path with maximum energy bottleneck, or to minimize the end-to-end transmission energy for packets, or a weighted combination of both. The energy optimization of a routing protocol, however, can exploit also other network layer mechanisms, like control information forwarding. For the above proposed algorithms so many schemes for the energy efficient routing were proposed. But the protocols only tell us about some network parameters for the MANET like the simulation results, throughput, packet delivery fraction, average energy consumption, end to end delay. Some results are for only small number of nodes that is if the network size increases then the above protocols failed. There is a strong to focus on the need to have a secure multicasting after more analysis on key management schemes. The protocol does not seem to behave effectively at higher energy of nodes. The aim to reduce the transmission redundancy and overall network overhead, and thus achieve the minimum energy is not achieved by proposed algorithms. The mechanism based on link failure frequency has been adopted to make the protocol robust to mobility; so better methods that allow the protocol to react to mobility more appropriately is the part of study. The more work on the development of power-efficient multicasting or broadcasting protocols should be done, especially.

CONCLUSION

The energy efficient routing an important issue in MANET. It is the need of hour for the effective communication in MANET. The various characteristics and issues in MANET are discussed in the paper. The

shortcoming of several protocols is main focus of this paper. There is need efficient protocol for addressing the issue of mobility with efficient energy utilisation.

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