A Brief Review of Energy Efficient Protocols in Mobile Ad hoc Networks

Kirandeep Kaur*, Satinder Kaur

Department of Computer Engineering & Technology, Guru Nanak Dev University, Amritsar, India

*Corresponding author

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Abstract

Mobile Ad Hoc Networks (MANETs) is an assemblage of multi-hop wireless mobile nodes that communicate with each other without centralized control and established infrastructure. Energy efficient routing is not merely concerned about less power consumption, it also deals with increasing the time duration in which any network maintains certain performance level. Therefore, power management becomes an essential issue. Considering this, various authors have designed and developed different techniques to enhance the energy efficiency of mobile networks. This paper focuses on the comparative study of different developments and modifications that have been carried out in this field in past decades. It also highlights how these modifications have helped to enhance the network lifetime.

Keywords: MANETs, Energy Efficiency, AODV, Routing Protocols, Network Lifetime

1 Introduction

Wireless network has gained huge popularity in the past few years. It has been contributing on a large scale in the advancement of various fields. Now a days, Wireless connection is the most prevalent mode of transmission utilized by networking devices. MANET is one such kind of wireless networks. It is a self-configuring and infrastructure-less network which contains the collection of various nodes. These nodes are free to move independently and hence can change their links with other devices in any direction frequently. This leads to the continuous maintenance of the required information to route the traffic in the creation of MANET environment which further becomes a challenge.

Mobile Ad-hoc networks face various issues which may affect the reliability of Ad-hoc networks and limit their feasibility in different scenarios. For example, lack of centralized structure within MANET requires that each individual node must act as a router and is also responsible for performing packet routing tasks. This can be done by using one or more common routing protocols across the MANET [7, 10]. Routing tasks also require a lot of memory and computational power. In order to maintain accurate routing, ad-hoc networks that contain huge number of nodes need greater processing power, memory and bandwidth which leads to traffic overhead within the network [7]. Another major concern is the security of MANETs. The security of nodes and the data transmitted needs to be well preserved as malicious nodes can enter any time into the network due to its wireless nature [7].

The most challenging issue in mobile ad hoc network is the efficient battery management. Due to the dynamic nature of nodes, these networks rapidly change their topologies, so energy efficiency must be maintained. Various researchers have carried out work in energy aware protocols that helped to enhance the energy efficiency and lifetime of network [12]. These protocols are basically categorized into two types; Minimum Energy Routing Protocols and Maximum Network Lifetime Routing Protocols. Both the protocols work for energy efficiency. The first protocols mainly focuses on finding the most efficient

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routing path from source to destination whereas second protocol emphasizes on balancing the remaining battery power [5]. The energy is also consumed in sleep mode, when the mobile nodes are not in use [5].
This study focuses on various routing protocols used in MANETs. The rest of the paper is structured as follows: Section 2 describes the related work based on energy efficient routing protocols and the improvements made by them in increasing the lifetime of network. Section 3 illustrates the comparative study of major algorithms and protocols. Section 4 summarizes with conclusion and provides recommendations for future work.

2 Literature Review

Mobile ad hoc network has a dynamic topology where the nodes move frequently. It is necessary to maintain the energy efficiency. This paper enlightens the various key aspects of literature in research area of MANETs based on energy efficient protocols. Majority of researchers have carried out different studies in this discipline [3, 8, 11, 13]. Yang and Wu [21] utilized network coding and directional antennas in their proposed work. The intermediate nodes were united with packets before sending with the use of network coding. Directional Antennas added more advantage in efficient broadcasting due to their unique quality. These antennas helped to improve the channel capacity and interference. It helped to reduce the total number of transmissions which further reduced energy consumption.
Further, Bhatsangve and Chirchi [3] proposed an Optimized Ad-hoc On-demand Distance Vector (OAODV) routing protocol. In this protocol, the nodes did not forward Route Request (RREQ) without sufficient battery lifetime and required node density. Node density in the network was also compared with a particular threshold. Battery lifetime and node density uploaded in routing table of the proposed protocol. It was observed that OAODV is much better than conventional Ad-hoc On-demand Distance Vector routing with improved battery lifetime. Although, Kaliappan et al. [9] utilized Dynamic Genetic algorithm like Elitism- based Immigrants Genetic Algorithm (EIGA) and Memory Enhanced Genetic Algorithm (MEGA) to solve dynamic load-balanced clustering problem (DLBCP). Distance and energy parameters were measured for the formation of clusters by using EIGA and MEGA schemes. These two schemes selected the cluster heads with highest energy which further balanced the load and maintained cluster structure. This design technique resulted in enhancing the energy efficiency of the entire cluster structure so that the lifetime of network is increased.
Moreover, Gupta et al. [7] formulated Energy Conserving Medium Access Control (EC-MAC) protocol with centralized scheduler which focused on intensifying energy efficiency of a network. According to the proposed strategy, all the nodes in the network are needed to register with centralized scheduler. The transmission can only take place after this registration in an organized manner. It was found that with the use of centralized scheduler, number of data retransmits and the delay in delivery of data was considerably reduced. Therefore, it expanded the network lifetime and subsequently increased energy efficiency. The performance of new strategy was found to be more effective as compared to the existing techniques. Additionally, Mathurajkumar et al. [14] designed a routing algorithm called Cluster based energy efficient secure routing algorithm (CEESRA). The proposed algorithm is based on trust-based secure routing algorithm which works under three different phases namely Trust score evaluation, Threshold setting and routing using the trust values. It also focused on formation and maintenance of cluster. Cluster heads are selected by trust values and behavior patterns. Moreover, it avoided Dos attacks within the network. CEESRA found to be more effective as it provided secure routing and also enhanced energy efficiency.
Furthermore, Boddu et al. [4] framed a novel fault tolerant multipath routing protocol that assured the reliability of MANET. The primary objective of designed algorithm was to reduce the packet loss caused by link failure. Authors used another route to rebroadcast the data packets in case the intermediate nodes

fail to forward the packets. The proposed algorithm worked under three major steps namely Calculating Transmission energy, Selection criteria and Calculating residual battery energy. It was found that the new protocol achieved improved throughput and packet delivery ratio with reduced delay, packet drop and energy.

In addition, Kumar and Bhavani [10] introduced a scheme namely Residual Energy Based Reliable Multipath Routing scheme (RERMRS). It used remaining energy based reliable routing scheme that balanced fault tolerability and energy efficiency. All the neighbor nodes in the network were provided with remaining energy value of nodes using multipath routes. The result findings indicated the increase in network lifetime based on the fault tolerable routes. Further, Selvi and Ghanadas [18] presented an improved energy efficient zone based routing protocol. The main idea behind this protocol is to control the network topology. The proposed scheme functions in three different processes such as network setup, cluster head selection for every zone and packet routing. Experimental results of this study reduced the overhead and enhanced the energy efficiency of MANET on a large scale.

Although, Roy and Chauhan [15] proposed an algorithm named Relative Density Aware Routing (REDEAR). Relative density of neighbor nodes was considered to forward the RREQ (route request). Here, they selected the low density zone with high density zone for a gateway to forward the RREQ packets. The nodes that lie in same density zone acted as non-gateway nodes. The primary focus of this work was to lessen the redundant RREQ within the network. REDEAR resulted with a better performance when compared to AODV in terms of remaining energy. However, Anand and Sesikala [1] proposed Intelligent Routing Ad-hoc On-demand distance vector routing (IRAODV) protocol which is an advanced feature of AODV. All nodes in mobile ad hoc network used intelligent technique for broadcasting of data. The designed protocol followed a certain procedure such as finding distance between nodes, finding the nodes that fall under same region and were able to receive packets. Then, one specific node was selected to transmit the packet and others were deactivated. The results after implementation demonstrated that the proposed strategy works much better than the existing AODV protocol.

The authors [6] proposed DE-AODV protocol to minimize packet delay, maximum network lifetime and reduced energy consumption. The new model helped to identify the nodes which are energy efficient and trustworthy in order to select the shortest path. It also used the external battery in case of link failure during packet transmission. Performance evaluation of proposed protocol found to be more effective when compared with previous protocols. The researchers [2] proposed network Lifetime Extension Aware cooperative Medium Access Control (LEA-CMAC) protocol. This protocol focused on enhancing the network performance through cooperative transmission and attained multi-objective target orientation. Result findings revealed that proposed protocol improved the overall network performance, throughput and proved better than the existing CMAC protocols. Robinson et al. [16] proposed a routing scheme that worked during link failure condition. Fuzzy-enabled Particle Swarm Optimization- based energy efficient algorithm (FPSOEE) FOR multipath routing used to increase the Quality of service of the network. The concept of Fuzzy helped to optimize the multipath routing performance in MANETs. Further, Shivakumar et al. [19] formulated Cross-layer routing protocol that utilized Particle-Swarm optimization (PSO) algorithm. The proposed technique resulted in increased delivery ratio of packets, less consumption of energy and overhead as compared to existing techniques.

Khelifa et al. [20] focused on finding the path with lowest energy cost using genetic algorithms. Authors used new fitness function which was based on transmission and reception power, node connectivity index and remaining energy capacity. The proposed scheme was found to be more effective than the previous algorithms. In addition, Riasudheen et al. [17] formulated Energy Efficient Cloud-Assisted Routing Mechanism (EECRM) for Cloud assisted MANETs. The proposed scheme worked on link failure issue.

The result attained from proposed algorithm provided better performance in terms of energy consumption, residual energy and network lifetime when compared with existing protocols.

3 Comparative Study of Major Protocols

Energy Efficiency is the most prominent aspect that needs to be enhanced in Mobile Ad-hoc networks. This section aims at comparative study of major protocols that were reviewed in literature as well. Table 1 frames a brief overview of related studies to compare Energy Efficient Protocols in MANETs.

Study Reference	Year	Proposed Methodology	Improvement Factor	Parameters used	Number of nodes used	Research Gaps
Kaliappan et al. [2016]	2016	Enhancing energy efficiency using dynamic genetic algorithm	Network Lifetime, Energy Efficiency, Load balancing	Packet delivery ratio, Energy consumption, Throughput, Routing overhead	200	Does not provide secure network
Gupta et al. [2017]	2017	Energy Conserving Medium Access Control (EC-MAC) Protocol	Energy Efficiency using Centralized Scheduler	Throughput, Residual Energy, Delay packet loss	Not Specified	Performance evaluation could be done with State-of-art Protocols
Mathurajkumar et al. [2017]	2017	Cluster-based energy efficient secure routing algorithm	Security of network, Energy Consumption	Packet drop ratio, throughput, Energy consumption	500	Complex Structure of the Algorithm
Boddu et al. [2017]	2017	FTMPR- Fault Tolerant multipath routing protocol	Fault Tolerance, Energy Efficiency	Packet delivery ratio, Throughput, Energy consumption, Packet drop, Delay	50	Non-Scalable, Can become inefficient for larger number of nodes
Selvi and Ghanadas [2018]	2018	Improved Energy Efficient Zone-based Routing Protocol	Network Topology, Cluster Head, Energy efficiency	Throughput, Packet delivery ratio, Delay, Control Overhead, QoS	1000	Division of network into zones consume lot of energy and time, Overall network lifetime improvement is not considered

Roy and Chauhan [2018]	2018	REDEAR-Relative Density Aware Routing Algorithm	Low-High speed MANETs, lessening redundant broadcasting of RREQ.	Remaining energy, Throughput, Energy efficiency	1000	Limited number of parameters are used.
Anand and Sesikala [2018]	2018	IRAODV-Intelligent Routing Ad-hoc on Demand Distance Vector Routing	Battery power, Better quality Packet transmission	End to End throughput, Consumed energy, Residual energy, Packet delivery ratio	Not Specified	State-of-art protocols are not considered for performance evaluation, Minimum distance parameter is not used.
Deepa and Sutha [2019]	2019	DE-AODV Dynamic energy Ad-hoc On-demand Distance Vector Routing Protocols	Network Lifetime, Energy Consumption	Throughput, Packet delivery ratio, End to end delay, Packet loss ratio	50	Network size is too small. QoS is not considered along with energy efficiency.
Shivakumar et al. [2020]	2020	EECRP-PSO Energy Efficient Cross-Layer Routing Protocol using Particle Swarm Optimization	Energy consumption	End to end delay, Packet delivery ratio, Routing overhead, Energy consumption	150	Protocol structure is too complex. QoS and distance parameters are not considered.

4 Conclusion

Mobile Ad-hoc network has become one of the most emerging fields in present era. Due to its dynamic nature, energy efficiency turns out to be the primary issue. This paper aims to compare various energy efficient routing protocols and algorithms for Mobile Ad hoc network. The comparison has been carried out in terms of improvement factors, parameters used, number of nodes utilized and the limitations of related studies. It is observed that each protocol has its own pros and cons according to different situations. Future work can be extended on the security of network as it affects the overall performance of transmission. Furthermore, a hybrid protocol can be proposed to overcome the shortcomings of current protocols.

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