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WIRELESS COMMUNICATION ADHOC ROUTING PROTOCOLS: A SURVEY

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Abstract—A **Wireless Ad hoc Network (WANET)**, it comprises of several flexible nodes that uses interfaces for transferring data packets. The flexible nodes are known as mobile nodes ,they arbitrarily moves in the network so the topology is highly dynamic in nature. Some of the challenging issues of wireless ad hoc networks are dynamic changing topology, channel bandwidth, limited energy constraints of mobile nodes, vulnerability to security attacks, maintaining QoS and the most important is routing by finding an optimal path. Routing, in a network without any structure and central coordinator is more challenging, so an efficient routing mechanism has to be adopted that is reliable, energy efficient, and assures QoS.

I. INTRODUCTION

In recent years there is rapid development in wireless ad hoc networks. A **Wireless Ad hoc Network (WANET)** or sometimes known as **Mobile Ad hoc Network (MANET)** or **Mobile Mesh Network**, is a network without any pre-existing structure. WANET is self-organizing, self-administrating, self-healing and infrastructure-less in nature [1][2]. WANET consists of several mobile nodes that use wireless interfaces to transfer the packet data. The mobile nodes are allowed to move arbitrarily, so the topology changes dynamically which is also a challenging factor in wireless ad hoc communication. The mobile nodes are equipped with transceivers, which allows direct transfer of data to another mobile node if it lies within the radio range [3] with wireless links while those nodes that far apart rely on other nodes to relay data.

Mobile nodes act as hosts (capable of sending and receiving) and routers, as they forward data to the specifically intended node. Data transmission through mobile nodes can be done through single or multiple hopping using an effective routing algorithm. With the increase in mobile devices and evolution of wireless communication, the wireless ad hoc networking technology is emerging with widespread applications such as Industry sector for e-commerce, Environmental monitoring, Vehicular networks, Bluetooth, Personal area network, Military usages, Disaster Management[4], classrooms, and conventions where participants could share their information dynamically using their mobile devices[5].

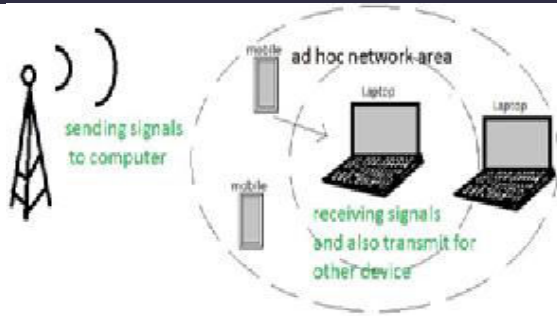


Fig 1: Wireless ad hoc Network

Some of the challenging issues of wireless ad hoc networks are dynamic changing topology, channel bandwidth, limited energy constraints of mobile nodes, vulnerability to security attacks, maintaining QoS and the most important is routing by finding an optimal path[6]. The high mobility of nodes makes rapid changes in the routes, thus focussing on an efficient mechanism for finding an optimal route for routing.

Routing, in a network without any structure and central coordinator is more challenging as the nodes are never constant, they can join or leave the network in an uncontrolled manner resulting in high dynamic network causing frequent route failures due to rapid topological changes. So an efficient routing mechanism has to be adopted that is reliable, energy efficient, and assures QoS. To achieve this purpose, the proposed paper surveys the various protocol designs for an energy efficient routing [7] assuring energy efficiency and QoS under various strategies.

II. STUDY ON MOBILE ADHOC ROUTING PROTOCOLS

The challenge of routing in WANET due to infrastructure-less behaviour leads to the research of many different routing protocols each based on different intuitions and assumptions. Mainly the routing protocols in ad hoc networks are divided into three types:

Table driven or Proactive protocols, On demand or Reactive protocols, Hybrid protocols. The example of Proactive protocol is Destination-Sequenced Distance-Vector Routing (DSDV), in this protocol every nodes maintains the entire information of its adjacent node, so it requires periodic updating for maintenance of table, leading to overhead. The examples of Reactive protocol are Ad hoc On-Demand Distance Vector (AODV), Dynamic Source Routing (DSR), and Temporally-Ordered Routing Algorithm (TORA), in this type of protocol, a route is formed only when required i.e. on demand. Most of the energy efficient routing schemes comes under reactive protocols as they have lesser overheads for Route discovery, because they doesn't need to maintain all possible paths, so the overhead is less. The hybrid protocols are combination of proactive and reactive protocol, enhances interior gateway routing protocols. The example of hybrid routing protocol is Zone routing protocols (ZRP). Based on route selection principles, MANET routing protocols can be classified as minimum-weight based and stability-based [8]. Minimum-weight based aims to minimise the number of hops in a path. Among various protocols some of the well-known minimum-hop based routing protocols are the Ad hoc On-demand Distance Vector (AODV) routing protocol, the Location-Aided Routing (LAR) and the Dynamic Source Routing (DSR) protocol. Stability-based protocols aim to reduce the number of route discoveries, maintaining routes with longer lifetime. Zhao et al[9] proposed Dynamic adjacent matrix routing protocol (DAMRP) which overcomes the shortcoming of traditional reactive, proactive and hybrid protocols that can't cope with

application of MANET. DAMRP uses adjacent matrix to describe network dynamic topology. The limitation of this protocol is it can be emphasised only to small scale MANET topology. Rajashekhar et al [10] proposed a mesh based multicast routing for group oriented service, this scheme assures better packet delivery ratio, reduced packet delay and reduced overheads but the author not concentrated on the energy efficiency. Dahai et al [11] proposed LEER (Location aided energy efficient routing) protocol which determines out all possible paths from source to destination and selects the path that requires minimum energy to route packets. Lambor et al [12] proposes that with the increase in network lifetime, the energy consumption decreases with increase in the number of hops and attains a minimum critical hops. After the critical hops, the energy consumption gradually increases due to increase in cumulative energy consumption of the intermediate nodes. Zhu Jinhua, and Xin Wang [13], 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. Dana et al [14] proposes a reliable routing algorithm based on fuzzy-logic (RRAF) for finding a reliable path in Mobile Ad Hoc Networks. In this scheme for every node two parameters are determined, one is trust value and another is energy value, to calculate the lifetime of routes. Siddesh et al [15] proposed a protocol for routing in ad hoc network using soft computing techniques like neural networks, fuzzy logic and genetic algorithm, this protocol establishes link between the nodes in

minimum time. Baisakh [16] 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 but has not concentrated on the mobility of the nodes in dynamic network. Sridhar et al [17] proposed an energy based EN-AODV protocol that identifies the nodes that drain out of energy level during data transmission. Energy value for each node is calculated to spot the unreliable nodes in the path during routing. A node which has sufficient energy level for the transmission is selected for routing but doesn't provide virtual energy for source nodes participating in the routing to enhance reliability in MANET and encryption scheme for secured transmission.

GuandZhu [18] proposed Route Energy Comprehensive Index (RECI) as the new routing metric, helpful in route discovery such as minimum hops and maximum energy comprehensive index. It also extends the lifetime of the nodes when their energy is low. Su and Sidda [19] present a fuzzy logic stable-backbone based multipath routing protocol (FLSBMRP) for MANET. It uses multiple correlated metrics including link stability parameters such as bandwidth, node energy, link quality and node mobility to select nodes. In FLSBMRP, the initial node selection is performed using a fuzzy logic technique, multiple paths are then established between the source and destination through these selected nodes, thus forming a routing backbone. If any node in the path fails due to a lack of bandwidth, residual energy or link quality, then an alternate path through another selected node is established. Wang et al [20]

proposed an Improved Ant colony-based Multi-constrained QoS Energy-saving Routing algorithm (IAMQER), aiming on the analysis of node information such as node residual energy, node queue length and node forwarding number of data packets. It also maintains the relationship between the network throughput and the energy consumption, thus improving the performance of network in multi-constrained QoS routing. Lou and Zhuang [21] proposed an Energy Efficient Opportunistic Routing (EEOR). In this routing, routing in network layer is assembled with sleep scheduling at the link layer. The foremost goal of applying scheduling is to increase energy efficiency and to identify an exchange between the transmitted energy at the sender level with more than one receiver level. Ravi and Kashwan [22] proposed an algorithm called Energy-Aware Span Routing Protocol (EASRP) for reactive protocol. This protocol used energy reduction schemes as Span and Adaptive Fidelity Energy Conservation Algorithm (AFECA). Remote Activated Switch (RAS) hardware circuit is used to optimize energy level to wake up sleeping nodes. Das and Tripathi [23] have proposed an energy efficient route using vague set measurement technique. Vague sets help in interval-based measurement system for energy and distance, selecting an energy efficient path. Das and Tripathi [24] have proposed Fuzzy based Intelligent Energy Efficient Routing (FIE2R) protocol for WANET, this method makes use of decision maker to take decision for inference engine. This routing protocol is implemented in two phases, one is initiation phase and the second one is reevaluation phase. Carvalho et al [25] proposed a fuzzy-based cross layer

energy aware (CLEA) approach. This approach ensures QoS and QoE and mobility adapting fuzzy decision making in network. This approach reduces energy failure and enhances energy efficiency during transmission. But the limitation is it does not consider optimization technique and no enhancement in network lifetime. Sarkar and Datta [26] proposed an energy-efficient routing protocol for MANET. It is based on stochastic Markov chain process. It determines efficient route stochastically among multiple paths from source to destination, this protocol also secures data flow on random paths from source to destination. Das et al [27] proposed a mesh based energy-efficient multicast routing protocol for ad hoc network. It is based on on-demand multicast routing protocol. To acquire multicast routing protocol, fuzzy logic is combined in on-demand routing protocol. It reduced interference among nodes and routes. It helps to enhance packet delivery ratio and reduces end-to-end delay of the network. Das and Tripathi [28] proposed an Energy-aware Efficient Routing protocol for MANET (IE2R). It is based on combining features of intuitionistic fuzzy soft set and multi-criteria decision making. Decision making is used to select energy aware route based on ranking method and soft set helps to reduce mutual interference among routes and nodes. This technique provides better network lifetime in several network metrics. Yadav et al [29] proposed an Efficient Fuzzy based Multi-constraint Multicast Routing Protocol (EFMMRP) for WANET, in this multicast paths are selected on minimum fuzzy cost, the path with minimum fuzzy cost is considered as optimal path to improve network performance. This protocol also controls the

uncertainties (bandwidth, delay, energy) which changes frequently due to dynamic topology, in order to conserve energy resources. Das and Tripathi [30] proposed a novel routing algorithm called Geometric programming based Energy Efficient Routing protocol (GEER) for hybrid ad-hoc network with fusion of multi objective optimization, geometric programming and intuitionistic fuzzy set. This algorithm evaluates an optimal solution based on all objectives and estimates non-linear parameters of the network.

III. COMPARISON TABLE

Following are the different MANET techniques implemented and their respective benefits:

Authors	Year	Proposed/Techniques	Benefits
N.Meghanathan	2009	Survey and Taxonomy of Unicast Routing Protocols for MANET	Routing in ad hoc network and classification of protocols- proactive, reactive and hybrid protocol
Zhao Min, Zhou Jilu	2009	Dynamic Adjacent Matrix Routing Protocol (DAMRP)	Emphasizes on fast, efficient and reliable dynamic routing protocol in MANET. Increasing the lifetime of network and reducing the number of route discoveries.
RajashakarBiradar , SumilkumarManviMylara Reddy	2009	Link Stability Based Multicast Routing scheme in MANET (LSMRM)	Ensures stability based multicast routing scheme, maintaining high stability of link connectivity.
Du,Dahai, and HuagangXiong	2010	Location aided Energy-Efficient Routing protocol (LEER)	Reduces energy consumption and prolongs network lifetime.
SMLambor, SM Joshi	2011	Network Lifetime and Energy Consumption in a Multi-Hop Wireless Sensor Network	Decreasing energy consumption with increase in network lifetime, attaining a critical hop.
Zhu, Jinhua, Xin Wang	2011	Progressive Energy-Efficient Routing (PEER) protocol for MANET	Proposes an analytical model to track the energy consumptions due to various factors, energy-efficient routing scheme to

			improve the performance during path discovery in mobility scenarios.
Siddesh, G.K., Muralidhara,K.N., Manjula.N.Harihar.	2011	Implementation of Soft Computing techniques	Establishes link between nodes in less time, implementing neural networks, fuzzy logic and genetic algorithm.
Baisakh Patel Nilesh R. Shishir Kumar.	2012	Energy Conscious DSR (ECDSR) in MANET	Enhances the lifetime of network, performance improvement.
Sridhar, S., Baskaram, R., Chandrasekar, P	2013	Energy based AODV protocol (EN-AODV) in MANET	Identification of unreliable nodes basing on energy during transmission. Optimal selection of nodes for reliable routing.
Chao Gu, Zhu Qi	2014	Energy aware routing metric for MANET. Route Energy Comprehensive Index (RECI)	Helpful in route discovery such as minimum hops and maximum energy comprehensive index.
Sujata V. Mallapur, Siddarama R. Patil	2014	Fuzzy Logic Stable-Backbone based Multipath Routing Protocol (FLSBMRP) for MANET	Node selection is performed using fuzzy logic technique.as a result multipath are established forming a routing backbone.
WANG, Y., Mei, S. O. N.G., WEI, Y., WANG, Y., & WANG, X.	2014	Improved Ant colony-based Multi-constrained QoS Energy-saving Routing algorithm (IAMQER) for WANET	Implemented ant colony algorithm, a heuristic algorithm to find the optimal path between source and destination nodes.
Lou, C., Zhuang, W.	2015	Energy Efficient Opportunistic Routing (EEOR) for WANET	Increasing network wide energy efficiency and identifying the energy level between sender and multiple receivers.
Lou, C., Zhuang, W.	2015	Energy Efficient Opportunistic Routing (EEOR) for WANET	Increasing network wide energy efficiency and identifying the energy level between sender and multiple receivers.
Ravi, G., Kashwan K. R.	2015	Energy-Aware Span Routing Protocol (EASRP)for reactive protocol in Ad hoc Network	Optimizes energy levels to wake up sleeping nodes to make routing efficient. This protocol uses energy reduction schemes as Span and Adaptive Fidelity Energy Conservation Algorithm (AFECA). Remote Activated Switch (RAS) hardware circuit.
Das SK, Tripathi S	2015	Energy efficient routing protocol using vague set	Selecting an energy efficient path using interval based measurement for energy and distance.
Das SK, Tripathi S, Bumwala AP	2015	Fuzzy based Intelligent Energy Efficient Routing (FIEER) protocol for WANET	Fuzzy intelligent functions which use decision maker for energy efficient routing.
Carvalho T, Junior JJ, Frances R	2016	Fuzzy-based Cross Layer Energy Aware (CLEA) for MANET	Enables a new energy-aware decision-making process to provide QoS, QoE, maximize the lifetime of the network through a lower and realistic energy consumption model
Sarkar S, Datta R	2016	A Secure and Energy-Efficient Stochastic Multipath Routing for Self-organized MANET	Selecting energy efficient path stochastically among multipath from source to destination using stochastic Markov chain process and providing security
Das SK, Yadav AK, Tripathi S	2016	Intellectual Energy Efficient Multicast Routing(IE2M) Protocol	It is an on demand multicast routing protocol proposed for mesh network. Enhance packet delivery ratio and reduces end-to-end delay of the network using fuzzy inference model.

Das SK, Tripathi S	2016	Intelligent Energy-Aware Efficient Routing (IEER) for MANET	Emphasis on increasing the life time of network using multi criteria decision making, intuitionistic fuzzy sets.
Yadav AK, Das SK, Tripathi S	2017	Efficient fuzzy based multi-constraint multicast routing protocol (EFMMRP) for WANET	Selection of optimal path basing on fuzzy cost and preserving energy sources in multicast paths.
Das Sk Tripathi S	2018	Geometric programming based Energy Efficient Routing protocol (GEER) for HANET	Efficient routing in HANET, using multi objective optimization with geometric programming and intuitionistic fuzzy set.

Table 1: Prior research work (various research gaps summarized for different MANET algorithms)

IV. CONCLUSION

The improvement of the ad hoc routing protocols over the last 15 years is an example of one of the most organized surveys of a design space in the history of computer science. Although, clearly, newer protocols have built upon the earlier ones, we cannot identify a single “best” protocol. Almost all the protocols we discussed in this paper have their own deployment scenarios and performance metric combinations where they overtake their competitors. Towards this end, in this paper, we review the present state-of-the-art of MANET routing protocols, their merits and demerits in the context of different categories of MANET protocols based on their routing information maintenance.

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