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Energy Aware Routing Protocols for Wireless Mobile Ad hoc Networks: A Review

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***Abstract*:** A wireless network is a multi-hop connection where each mobile node collaborates to form a network without using any infrastructure such as access points or base stations. It has important properties such as dynamic topology, restricted bandwidth and limited resources, which are major challenge to improve the use of energy resources which are the key aspects during the design of modern ad hoc network architecture. The nodes in the wireless ad hoc network have inadequate range of transport, and their processing and storage capacities in addition to their energy resources are inadequate. This resource constraint in ad hoc wireless networks creates significant challenges in effective routing to achieve better productivity in high-traffic network. This paper presents a review of the various issues and challenges in the power routing and optimization protocols during communication in the wireless network designed to improve the life span of the network for a longer period.

Keywords: Energy Efficient Routing, Energy aware routing, Wireless Mobile Ad hoc Network.

I. INTRODUCTION

Wireless mobile ad hoc network (MANET) is a group of self-adaptable wireless nodes where nodes communicate exclusively of any centralized management or coordination. Because there is no rigid substantial infrastructure, the nodes are proficient in generating a dynamic path to communicate. The nodes are used in such a network that sustains multiple paths and hops to the destination through the intermediate nodes. This network includes small devices such as cell phones, laptops, PDAs, etc. that are able to move regularly. This nature of network applies in an environment where it is hard or impractical to create a permanent infrastructure [1], [2]. The relevance area comprises information exchange on battlefields, search and rescue operations, and natural disasters, etc. The active behaviour and scattered environment create challenges to the existing approach for delivering data efficiently, which is a critical problem that needs to be explored further. Even, due to inadequate battery power and bandwidth, routing on this kind of network is a severe problem.

The mobile nodes in the MANET correspond through the intermediate nodes (INTM-Nodes) and the network structure is dynamically. Even the regular movement of the node changes the network topology irregularly. Since the nodes in this network have inadequate battery power, and the routing protocols (RT-Protocols) are liable for delivering packets effectively and efficiently the minimum utilization of mobile node power to achieve the much needed Energy efficiency (ENG-efficiency) routing [3],is taken into consideration.

The MANET mobile nodes run on their battery power and RT-Protocol functions, which should include a higher proportion of data delivery while maintaining a lower power consumption rate. The successful delivery rate depends mostly on the duration of the node with respect to the left over capacity of the node. To construct the network further suitably, the RT-Protocol must work in a proficient manner so that it is able to keep away from the early ending of the mobile nodes and greatly extend the life of the network.

There are several RT-Protocols for custom wireless networks. In common, these protocols are able to be classified as a paid, customized, and mixed table. In table-based RT-Protocols, every node requires to announcing routing data to preserve an updated vision of network topology periodically. Unlike table-based RT-Protocols, on-demand RT-Protocols only build a transport route, while requesting the source node. In general most of the ENG-saving schemes are proposed in the revised literature for on-demand RT-Protocols such as AODV [4] or DSR [5] to construct an energy-saving route, because the routing load is max in table-based RT-Protocols [6].
Route recognition in energy-saving RT-Protocols is quite different when compared to the normal routing. The middleware nodes cannot ignore duplicate routing request packets at present, because these packets might come from

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additional ENG-efficient routes. That is, the INTM-Nodes require to practice and to replay duplicate routing request packets, if the approach commencing an additional ENG-efficient route. Consequently, the nodes could require broadcasting the identical routing request packet several moments.

The mobile nodes in the MANET network continue through the intermediate nodes and the network structure is dynamic. Moving the node changes the network topology irregularly. Because the nodes of such a network have limited battery power, the RT-protocols are responsible for delivering packets effectively and efficiently taking into account the minimum use of mobile contract power. The successful delivery rate of packages is often dependent on the duration of the contract, in other words on the residual capacity of the contract. To make the network more convenient, the routing protocol must work in an efficient manner so that it can avoid early termination of the mobile contract and greatly extend the life of the network.

This paper provides an in-depth look at the problems of effective power management, awareness and optimization of the wireless network for mobile phones. It predominantly discusses the trends and mechanisms of wireless network protocols in Section-II. In Section-III, it illustrates the inadequacy affecting routing in MANET, Section-IV demonstrates the energy efficient routing and Section-V presents energy aware routing. In the section-VI, it provides existing energy routing protocols in wireless network, and Section VII provides the conclusion of the review.

II. WIRELESS ROUTING PROTOCOLS

In MANET mobile is a wireless node system that is dynamically organized into random and impermanent network topologies. In such a network, personnel and vehicles are able to be located in the fields, where there is no pre-existing telecommunications infrastructure or require the utilization of these wireless infrastructure accessories. In ad hoc mobile network, the contract can communicate directly with other nodes within their radio ranges; nodes that are not in direct contact range using the INTM-Nodes to communicate with each other. In these cases, the nodes involved in the connection usually structure a wireless network, so these types of wireless network are observed in ad hoc mobile network [7].

MANET RT-Protocols in general can be categorized into three main categories as follows:

1. *Pro-active RT-Protocols*: Pro-active protocols trained the network topology by sharing topological information along with network nodes. Therefore, while a path to a destination node (DEST-Node) is needed, path tracked data is instantaneously accessible. If the network structure is altered repeatedly, then the cost of network maintenance may also be exceptionally high.
   Pro-active protocols evaluate the paths inside the network continuously so that whiles it essential to reroute the packet path that is previously recognized and prepared to use immediately. So, there is no time delay and the shortest route able to be established, however these protocols are not suitable for highly intense and custom networks, since in this case, the difficulty may arise from high traffic. A number of amendments to pro-active protocols are being proposed to remove deficiencies and utilize them in MANET. It preserves the uncast paths among each couple of nodes with no believing whether every route is, in reality, being utilized or not.

2. *Reactive RT-Protocols*: The re-active RT-Protocols rely on a type of reply query dialog. It is as well termed as On-demand Routing. It is additionally resourceful than pro-active routing, and current amendments have been made in this kind of routing to make it better and effective. The foremost thought following this kind of routing is to locate a path among the source node (SRC-Node) and the DEST-Node, at any time the need arises for this path, while in pro-active protocols it maintains all paths regardless of their state. So in reactive protocols, it does not need to be concerned about paths that are not being utilized at present.
   Discovering the on-demand path leaves the outlay of sustaining and unmanaged paths, and also controls network traffic, because it does not transmit unnecessary control messages that cause a significant dissimilarity among pro-active and reactive protocols. This time delay in re-active protocols is superior in comparison to the pro-active, where methods are estimated as soon as they needed. Few popular protocols are, Ad hoc On Demand distance Vector (AODV), Dynamic Source Routing (DSR), and so forth.

3. *Hybrid RT-Protocol*: In together pro-active and re-active routing procedures have various pros and cons. In hybrid routing, a good mix of pro-active and re-active routing schemes is utilized that is improved than both. It comprises the improvements of equally in these protocols. For example, such reactive RT-Protocol is AODV which facilitates several pro-active characteristics by updating routes of active targets that will certainly reduce delay and overhead, so that the revive period can progress the network and node performance. Therefore, these kinds of protocols can be able to merge the provision of other protocols with no conciliation of their individual benefits. One of the existing hybrid protocols is Zone RT-Protocol (ZRP).

III. INADEQUACY AFFECTING ROUTING IN MANET

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In hop-based wireless networks, various types of power-aware RT-Protocols have been recommended in a multi-path to increase ENG-efficiency. Several geo-RT-Protocols are proposed locally using only the local information to make decisions more intelligently and to reduce overall overhead costs. However, ENG-efficiency cannot be guaranteed in the recommended local paths.

The inadequacy is caused mainly due to the **lack of any support in the physical infrastructure, physical security,** limited **Power** sources and mostly affected by the frequent varying network topology [8]. To overcome the disadvantages of the current method, it has studied the commonly used routing method with high power efficiency in MANET. These protocols are used in diverse methods to accomplish ENG-efficiency or battery utilization balancing. However, generally these protocols attempt to locate several network level mechanisms to let out flooding and redirect needless packets, but the most important shortcoming of most of these temporary RT-Protocols is that the data is not introduced to transmit routing congestion and routing path quality.

As in the past decade, many energy-saving RT-Protocols have been proposed and the search for the best solutions out of them. Because it is extremely difficult to restrict technology, optimized search, and drilling, many important modifications have been made to modify the DSR as an effective RT-Protocol and to act as effective RT-Protocols such as other protocols. So the following sections discussed some important RT-Protocols that are made after some changes to the traditional DSR protocol.

Routing at all times was one of MANET's main challenges and became difficult as the network grew. Different MANET RT-Protocols were proposed in [9], [10] and [11]. These protocols are to be categorized in a dissimilar type in similar to diverse condition. RT-Protocols are able to be grouped into proactive and interactive protocols if they are categorized in a manner consistent with network structure changes.

The reactive RT-Protocol works well on small networks with hundreds of nodes. However, due to the development of the network given the overhead guidance and high power consumption, their performance is rapidly deteriorating. The Cluster head Gateway Switch Routing (CGSR) [12] is a pro-active RT-Protocol that separates the network into sections in round areas with a predetermined number of hops. Later, the network is divided into sections, local path maintenance works without the adjacent part, but other parts are not affected. Therefore, scalability is achieved.

However, as the network evolves the route along with the SRC-Node and DEST-Node occurs is intended for a longer period. When the path is interrupted due to the node navigation or node malfunctioning, interactive RT-Protocols such as DSR and AODV usually reject the path and begin to discover another path to create a new route from the SRC-Node to the DEST-Node. In the case of a broken route, there is only damage in some hops, but previous hops are not damaged. Therefore, this methodology insulates the knowledge of the unique path and can lead to a significant loss of energy and energy in discovering the new path.

IV. ENERGY EFFICIENT ROUTING

Many research works have produced a lot of improvement and innovative schemes in this area. Many proposals in the reactive, proactive and hybrid approaches are being made to provide the ENG-efficient routing. Much of today's work relies on energy-saving routing as energy is the foremost concern in MANET. Every protocol has various benefits and drawbacks. No one is able to carry out enhancement in each case. This depends on the network constraints that determine which protocol has to be used. A lot of protocols for effective energy routing have been introduced and variations have been suggested for utilizing in MANET.

A. Proactive Energy Efficient Routing

1. DSDV - Destination Sequenced Distance Vector

DSDV [6] is the primarily noticeable pro-active protocol. It depends on the Bellman-Ford algorithm. It eliminated the defects of loops and counting perpetuity problem of the contemporary distance vector protocol, which is not suitable for the MANET. It is the DSDV which is depend on the DEST-Node, where every node remains an RT-TAB. This RT-TAB encloses all existing DEST-Node, the subsequent node to achieve the DEST-Node, and the number of hops among them. At any time a node alters its location, it transmits routing information to the nearby nodes. The series of numeral is utilized to keep it away from the loop difficulties.

While maintaining the easiness of the distance vector protocol it ensures the freeness from iteration that instantaneously responds to the topology transforms. Because the path of the destination is forever obtainable in the RT-TAB for every node, there is no transition time resulting from the path discovery. But broadcasting updates might be the reason for traffic among nodes to increase if the node compactness is high. Therefore, this protocol is most appropriate if the compactness of the allocated network is minimum and in case of high broadcast might be the reason for the delay.

2. OLSR - Optimized Link State RT-Protocol

The OLSR [13] includes two enhancements to the traditional link state routing (LSR) in custom networks. Every node specifies a group of adjacent nodes termed as multipoint relays (MPRs). Additionally, as soon as it exchanges LSR

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information, the node lists only associations with those adjacent devices that it specified as MPR, which specifies the specific relay points. Dramatically it reduces the rebroadcasting. The MPRs of the node is essentially the least group of the nearby nodes, which are able to actually achieve all double-hop nodes in the range of node. The MPRs for the node are changed by means of node mobility and are updated by means of a HELLO periodic communication. The SRC-Node to DEST-Node path is essentially a series of hops across a multi-point relay node. The specific routes are shorter hop as in the traditional LSR algorithm. The protocol specifies a two-way link for routing.

B. Re-Active Energy Efficient Routing

1. DSR - Dynamic Source RT-Protocol

DSR [5] is an iteration-free, source driven protocol, which are designed according the application RT-Protocol. This protocol originates from the source instead of hops. This is specifically created for utilizing the multi-channel wireless networks that are dedicated to mobile nodes. Essentially, the DSR protocol does not require several networks or management infrastructure and its agreement to the network to be fully self-regulating and configuring.

This protocol consists of two main divisions namely, path discovery and path maintenance. Each node stores a temporary buffer to accumulate newly discovered routes. As soon as, it wants a node to transmit a packet to another node, it foremost ensures that it is entered in the storage. If is stored, it utilizes this route to move the packet as well as connect its SRC-Node address to the packet. If there is no storage or the storage entry has perished, then the transmitter broadcasts an RT-REQ packet to every one of its neighbours requesting a route to the DEST-Node. The transmitter has to wait until the new route is re-discovered.

At this stage of the waiting period, the transmitter can execute other assignments such as transmitting previous packets. When the RT-REQ packet reaches any nodes, it checks its neighbour or its temporary memory if the requested destination is recognized or unidentified. If path information is identified, it sends a response packet on the route to the destination or else it broadcasts the RT-REQ packet itself. When the path is detected, the packets requested by the sender will be sent on the detected path. An entry will also enter the cache for future use.

2. AODV - Ad hoc On-Demand Distance Vector Protocol

The AODV [4] is a variation in the DSDV, which cooperatively relies on DSDV and DSR. It intends to decrease the requirements of system-extensive transmits. Paths commencing for every node are not kept to each other node in the network; they are discovered when required and preserved only as long as they are necessitated. The main actions of AODV are used to make unicast methods for the Route discovery and Route maintenance.

3. Energy-Aware Algorithm for AODV

The latest energy-aware algorithm [9] can be useful for the existing custom RT-Protocols such as AODV. The cost of power saving can be derived in support for the transmission, which is to be reduce power wastage and lifetime of battery of a node, and the methods were efficient according to the functioning price of the nodes, A warning method for the low battery power is commenced to advance the routing information changes, which prevents the excessive use of significant nodes. Network throughput is not influenced to a large extent, a problem of replacing the warning of the low battery power stages. Energy utilization is stabilized between the network and the restricted power storage reserves make utilization of these resourcefully.

4. PAAODV - Power Aware AODV Protocol

The PAAODV [14] protocol is an improvement of the AODV RT-Protocol, which performs energy managing data for the period of path discovery. The PAAODV includes two methods such as, (1) the discovery of the power path of multiple power (2) control of link through a link capacity.

During path discovery, RT-REQ packets are utilized to locate a power-saving path and the path response packets are utilized to control the power transmission. It uses several energy levels for the period of path discovery. The nodes try to locate a way to the DEST-Node with minimum energy levels at first. If it does not work, the power level will be enhanced to continue until the discovery of the path is successful. It considers only two power levels as, low or high.

C. Hybrid Routing Energy Efficient Routing Protocol

1. ZRP - Zone RT-Protocol

ZRP [15] is considered as a hybrid protocol that utilizes pro-active routing scheme inside the local node available nearby, and a re-active RT-protocol for interconnection. Each node identifies a zone area roughly, and the radius of the region is the count of hops around the zone area. The re-active global search is done proficiently by querying merely an opted collection of nodes in the network. The various nodes that were queried are in the area and they were queried by means of a network-wide flood procedure.

If the range of the region area is chosen watchfully, the node is able to be in several overlapping regions. Therefore, effectiveness decreases in path discovery. In addition, the movement of the node, the radius of the region could very rapidly and also influence node functions within the perimeter of the region. The intro region RT-Protocol utilized within the sector is not an RT-Protocol specified. It is a group of active RT-Protocols in a limited-strength. Similarly, the zone is a set of re-active RT-Protocols that can give improved discovery and preservation provisions by means of IARP's local nodes information. Accordingly, it is

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not able to categorize ZRP into either category or its view as a structure for pro-active and re-active RT-Protocols.

2. *Optimizing power-Aware Routing using Zone RT-Protocol in MANET*

The routing path is different from the way energy is controlled. A guidance structure for improving the usage of power through advance awareness was developed in a Power-Aware Routing Optimization (PARO) and ZRP [16] for efficient energy control and communication. These routing algorithm attempts to reduce the power utilized by sending a packet of network life through letting out nodes that have a smaller life span.

V. ENERGY AWARE ROUTING

The purpose of ENG-efficient RT-Protocols is to decrease energy utilization in packet communication among SRC-Node and DEST-Node, to avoid routing packets over low-power nodes, to improve the flow of routing details above the network, and to exclude interference and intermediary confliction.

The failure of a particular node in WSN is typically insignificant since it not able to result in failure of sensor and message exposure, while MANET are auto-adjusted in the direction of individual communication and failure of connection to several large node.

The wireless network edge is present in one of the subsequent 4 situations as: Transmit Receive, Idle or Sleep. Every situation corresponds to a dissimilar stage of power utilization.

- *Transmit* → The node sends a structure with a little transmission of energy influence.
- *Receive* → The node receives a structure with numerous reception power. This power is utilized still if the window is ignored by the node since it was anticipated for an added DEST-Node, or it is incorrectly decrypted.
- *Idle (hearing)* → Yet, if the messages are not sent across the network, the nodes remain dead and continues to listen to the transmitters.
- *Sleep* → While the radio is turned-off and the node is unable to identify the signals, a connection cannot be made. The power node uses much smaller power than any other power.

Most of MANET's ENG-efficient RT-Protocols attempt to cut power consumption using a power-saving routing metric, which is utilized to calculate the routing metric as a substitute of the least-hop metric.

There are four categories for energy saving devices are:

1. *Nominal Energy Consumption per Packet*: Power utilization is the addition of energy utilized per hop in the route of the packet transmission. Energy utilization in the hop is the utility of the distance among neighbour and carries this hop. So, it's appealing to decide a route, where the length among the nodes is not too extensive, and it's exciting to acquire a smaller path, so that there are not many hopes on the path where the energy level is low.
2. *Improvising the Network Connectivity*: This measure attempts to overhead balancing on every node in the network. This assumption is important in the situations, where the network connection is guaranteed.
3. *Lowest inconsistency in Node power Levels*: This measure suggests a load distribution between every node so that energy utilization is left-out consistently for every node. This difficulty is extremely composite when the rate and packet data fluctuate. When each node has an identical stage of power, it can make sure that the network is working extensively.
4. *Lowering the Maximum Node Cost*: This computation factors reduce the highest price per nodes intended for a packet beyond the routing of a many packets or later than a specified phase. The node, therefore, is obstructed for routing to accumulate battery storage energy. These computation factors will accumulate, the connection commencing each node. As soon as a node is utilized multiple times for the path, it prevents self for saving power.

VI. EXISTING ENERGY ROUTING PROTOCOLS IN WIRELESS NETWORK

Energy is usually an insufficient resource for portable devices that operate on batteries with limited capacity. In addition, battery technology development is expected to be slow and will not improve in the near future [17]. The optimal design of ENG-efficiency under these critical conditions is an urgent requirement for MANET and focuses on the most economical ways to use mobile power while ensuring proper operation of the network. In previous literature, improving ENG-efficiency for mobile communications systems has attracted much attention [18], [19].

Lots of research has been done in previous years, and the authors have attempted to extend an energy-saving path based on load balancing [20], [21] and [22]. To enhance network life, the DSR (CLB-DSR) cross-load balancing algorithm was suggested to install the load among the Data Link Layer and the Network Layer. The CLB-DSR can exchange information between these layers to properly handle the load, thereby reducing network power consumption [23].

The author [24] designed the original DSR protocol and suggests a Dynamic Power Source Directive approach. If the node power level exceeds a predefined limit, the node broadcasts an individual packet. These packets notify adjacent nodes that the indent node is not competent to send

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several fresh request messages because of the outstanding power shortage. Therefore, the adjacent node does not forward the message to this node. The difficulty in this protocol is that the transmission of this specific control packet gets a large amount of energy from the mobile node. In addition, the overhead of the network is improved as more nodes attempt to deliver these control packets over time.

J. Zhu et. al. [25] made an important proposal for the creation of a power-saving RT-Protocol for dedicated mobile networks known as PEER. However, without the intention of observing, energy-saving RT-Protocols can outperform conventional RT-Protocols. In particular, energy-saving RT-Protocols can lead to an advanced delay in load and path control as demonstrated by simulations and can obtain additional power from a typical RT-Protocol in a mobile environment. The new link cost model allows for more accurate energy consumption tracking, path maintenance issues related to route routing, and minimum power RT-Protocols. The PEER protocol with fast and small overhead search proficient path and maintenance plan to reduce power consumption, particularly in a mobile environment.

J. E. Garcia et. al. [26] proposed that ED-DSR is an energy-based DSR algorithm that prevents nodes from drastically reducing battery power consumption. ED-DSR provides better energy usage compared to LEAR and MDR [11]. The ED-DSR avoids the use of low power nodes and outstanding power information for nodes to find a useful path. The remaining battery power is calculated for each node alone, and if it is beyond an assured threshold, the node will not be capable of participating in the routing activity. Otherwise, the node retransmits the Request Routing message in a phase that is inversely proportional to the expected duration.

Y. Chen et. al. [27] proposed ECAODV that acquires interested in the relationship of the nodes that affect the energy consumption, the flood mechanisms value related to the node stability and the remaining energy of the node. The Alternate Link Maximum Energy Level of AODV (ALMEL-AODV) [28], is as well an enhancement of the current AODV RT-Protocol. In this protocol, the total remaining power of the nodes works in the path as a measure of route assortment. The highest energy route is selected for a longer connection and network duration. The Energy Saving Dynamic Source Routing (ESDSR) is another average DSR protocol to extend the life of the network using two basic methods of power consumption. In such, one of the control methods is the transmission power and the subsequent is the load assessment technique. The Minimum Energy DSR (MEDSR) is an unique and best attempt to make the DSR a power-saving RT-Protocol.

J. Kuruvilla et al. [29] proposed a new system familiar with routing the local energy path, which selects current node neighbours, to reduce power consumption and distance travelled to the DEST-Node. This is the initial traditional support scheme in the association involving the cost of development. The author also proposes several versions and performs large-scale simulations.

M. Khabbazian et al. [30] explore the potentiality of a Local Broadcast Algorithms (LBA) to reduce the entire count of communications, necessitated to accomplish complete deliverance. As, it can be seen, the fixed local broadcast algorithms cannot guarantee low consumption, if the direction is incorrect. It has been discovered that Relative Location Information can limit the number of abbreviated nodes much simpler through the static policy problem.

Many ENG-efficient RT-Protocols have been recommended in the past, while energy is an inappropriate resource that determines the existence of wireless networks [31], [32]. Different methods are designed to take the energy-related situation relative to traditional measures for instance, delay or hop distance. In general, the suggested Energy computation factor is described as the energy needed to connect via the link or the remaining lifetime function [33]. However, in order to reduce global energy utilization for the selected pathways, generally of the lowest energy routing algorithms [34], [35] are presented as central controlling algorithms.

The main insight of this review is to improve the node life span of the network by conserving energy and sharing the cost of carefully routing the packet. Therefore, our further research will present the novel ENG-efficient RT-Protocols utilizing the energy-aware metrics that can provide the enhancement to the energy-saving in the routing mechanism.

VII. CONCLUSION

In this paper, we have reviewed several papers related to the energy efficient routing protocols for wireless networks. This study, in particular, has investigated the design challenges for mobile ad hoc networks such as lack of infrastructure and dynamic communication between network nodes. It also suffers from many technical barriers such as limited power consumption, unreliable wireless connectivity, and dynamic network topology, which pose a difficult problem. These problems for the scalability and performance also arise in large networks due to the lack of energy and greatly increased the large networks with longer paths. Therefore, energy-saving systems in the MANET are exceptionally necessary.

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