A Survey of Energy Efficient Routing Protocols for Mobile Ad-hoc Networks

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***Abstract*— This paper presents a survey on energy efficient routing protocols for wireless Ad-Hoc networks. Survey focus on recent development and modifications in this widely used field. This discussion is centred on proposed power saving algorithms. Besides it we will discuss about the conventional protocols and also see how these are modified to make these protocols energy efficient and what the shortcomings that have been resolved.**

***Keywords*—** Mobile Ad-Hoc network, energy efficient routing, global positioning system.

I. Introduction

A Network is a collection of interconnected nodes. It can be wired, wireless or wired cum wireless. A wireless ad-hoc network[20] is a network where there is no fixed infrastructure. All wireless enabled devices within the range of each other can discover and communicate in a peer-to-peer fashion without involving central access points [21]. Wireless mobile networks and devices are becoming increasingly popular because they provide user access to information and communication anytime and anywhere. There is no need for router separately because each node can work as host as well as router accordingly. Each node or mobile device is equipped with a transmitter and receiver. The topology of mobile ad-hoc network is dynamic and depends upon the movement of the nodes so it can change rapidly and unexpectedly. Wireless mobile ad-hoc networks are useful in many areas which are as follows:

- Communication in battlefields
- Disaster recovery areas
- Institutions and Colleges
- Traffic Control areas
- Military areas
- Law and order maintenance
- Space and astronomy related projects
- Medical Field
- Conferences and Conventions

A. Challenges in Mobile Ad-hoc networks

Ad-hoc networks have to suffer many challenges at the time of routing. Dynamically changing topology (due to Brownian motion of the nodes of the network) and no centralized infrastructure are the biggest challenges in the designing of an Ad-hoc network. The position of the nodes in an Ad-hoc network continuously varies due to which we can't say that any particular protocol will give the best performance in each and every case topology varies very frequently so we have to select a protocol which dynamically adapts the situation. Another challenge in MANET [4] is limited bandwidth. If we compare it to the wired network then wireless network has less and more varying bandwidth. So, bandwidth efficiency is also a major concern in ad-hoc network routing protocol designing because sometimes data has to be transmitted within real time constraints. Limited power supply is the biggest challenge of an ad-hoc network so if we want to increase the network lifetime (duration of time when the first node of the network runs out of energy) as well the node lifetime then we must have an energy efficient protocol. So an ad-hoc routing protocol must meet all these challenges to give the average performance in every case. The main challenges in mobile ad-hoc networks are as follows:

- Limited Power Supply
- Dynamically Changing Topology
- Limited Bandwidth
- Security
- Mobility-induced route changes
- Mobility-induced packet losses
- Battery constraints

A. Routing

It is the process of establishing path and forwarding packets from source node to destination node. It consists of two steps, route selection for various source-sink pairs and delivery of data packets to the correct destination. Various protocols and data structures (routing tables) are used to meet these two steps. This survey paper is focussed on finding and selecting energy efficient routes. We are going to discuss the four approaches in the routing. These are proactive, reactive, hybrid and location based routing. Some proactive routing protocols are DSDV[1] , OLSR[2] etc. Some reactive routing protocols are DSR[6], AODV[12] etc. Some hybrid routing protocols are ZRP and HSLS. Some location based routing protocols are LAR[14], LEER[17], LEARN[16],DREAM[18] etc. Some others approaches are Flow oriented routing, Adaptive routing, Hierarchical routing etc. Some examples of flow oriented routing protocols are Link life Based Routing Protocol (LBR)[22], Lightweight Mobile Routing Protocol (LMR)[23], Lightweight Underlay Network Ad-hoc Routing Protocol (LUNER) [25], Link Quality Source Routing (LQR) [24] etc. Some examples of Adaptive routing protocols are TORA etc. Some examples of Hierarchical routing protocols are Cluster Based Routing Protocol (CBR) [27], Core Extraction Distributed Ad-hoc Routing (CEDAR)[26][29], Dynamic Address Routing(DART)[30], Fisheye State Routing Protocol(FSR)[27], Global State Routing Protocol (GSR)[31], Hybrid Ad-hoc Routing Protocol (HARP)[32] etc.

C. Energy Efficient Routing

Energy is a limiting factor in case of Ad-hoc networks. Routing in ad-hoc networks has some unique characteristics.

First- Energy of nodes is crucial and depends upon battery which has limited power supply.

Second- Nodes can move in an uncontrolled manner so frequent route failures are possible.

Third-Wireless channels have lower and more variable bandwidth compare to wired network.

Energy efficient routing protocols are the only solution to above situation. Most of the work of making protocols energy efficient has been done on "on demand routing protocols" because these protocols are more energy efficient rather than proactive protocols but still these have some drawbacks which have been discussed in the next section. Energy efficiency can also be achieved by sensible flooding at the route discovery process in reactive protocols. And energy efficiency can also be achieved by using efficient metric for route selection such as cost function, node energy, battery level etc. Here energy efficiency doesn't mean only the less power consumption here it means increasing the time duration in which any network maintains certain performance level. We can achieve the state of energy efficient routing by increasing the network lifetime and performance and all the protocols discussed in this paper are based on this concept.

Rest of the paper is organized as: Section-II classification of routing techniques based on different approaches is addressed. Section-III desirable properties of various routing are discussed, Section-IV related work of energy efficient routing researches are surveyed. Section-V provides a brief discussion and analysis of energy efficient routing protocols, and finally Section-VI concludes the paper.

II. Classification

Routing protocols can be classified according to various approaches which are as follows:

A. Proactive Routing

Proactive protocols continuously evaluates the routes within the network so that when we are required to forward the packet route is already known and immediately ready for use. There is no time delay (time spend in route discovery process) takes place. So a shortest path can be find without any time delay however these protocols are not suitable for very dense ad-hoc networks because in that condition problem of high traffic may arise. Several modifications of proactive protocols have been proposed for removing its shortcomings and use in ad-hoc networks. It maintains the unicast routes between all pair of nodes without considering of whether all routes are actually used or not. It can be of two types depending upon the algorithms which have been shown in the next section. In link state proactive protocols each node maintains a view of the network topology and it stores the cost of each outgoing links and periodically broadcast its link costs via flooding. In distance vector proactive protocols each node maintains a routing table which contains the cost of every node of the network, next node to reach the destination and the total no of nodes to reach the destination and this routing information table is send to all neighbours to maintain the topology. Examples of the proactive protocols are – DSDV [1] (Destination-Sequenced Distance-Vector), Wireless Routing Protocol (WRP)[33], and Optimized Link State Routing, TBRPF[34].

B. Reactive routing

It is also called on demand routing.it is more efficient than proactive routing and most of the current work and modifications have been done in this type of routing for making it more and more better. The main idea behind this type of routing is to find a route between a source and destination whenever that route is needed whereas in proactive protocols we were maintaining all routes without regarding its state of use. So in reactive protocols we don't need to bother about the routes which are not being used currently. This type of routing is on demand. Discovering the route on demand avoids the cost of maintaining routes that are not being used and also controls the traffic of the network because it doesn't send excessive control messages which significantly create a large difference between proactive and reactive protocols. Time delay in reactive protocols is greater comparative to proactive types since routes are calculated when it is required. e.g. Ad-hoc On Demand Distance Vector (AODV)[12], Dynamic Source Routing (DSR)[6][7].

C. Hybrid Routing

Both of the proactive and reactive routing methods have some advantages and shortcomings. In hybrid routing a combination of proactive and reactive routing methods are used which are better than the both used in isolation. It includes the advantages of both protocols. As an example facilitate the reactive routing protocol such as AODV with some proactive features by refreshing routes of active destinations which would definitely reduce the delay and overhead so refresh interval can improve the performance of the network and node. These protocols can incorporate the facility of other protocols without compromising with its own advantages. Examples of hybrid protocols are Zone Routing Protocol, Hazy Sighted Link State.

D. Location based routing

All of the above approaches share a common feature of discovering topology information with the help of routing messages and the further discovery of any other route uses this information with the help of routing tables. Location based routing is completely different from above these methods. It acquires a completely different approach that utilizes the global information of the nodes. This type of routing assumes that each node of the network is having a GPS installed in it. So, each node knows its own global position by using this GPS system or any other localization technology. It doesn't need any type of route discovery or route maintenance algorithms. This gathers the knowledge of other node's locations without transferring request messages. This only sends hello messages to its neighbours to know their global position. It is efficient when topology of the network changes frequently. e.g. Location Aided Routing, Distance Routing Effect Algorithm for Mobility (DREAM)[20].

TABLE I
Comparison among different routing approaches

Proactive	Reactive	Hybrid	Location
Unicast routes between all pairs of nodes are maintained regardless of whether all routes are actually used or not	Routes are established only when need arises.	Combination of proactive and reactive	It uses global positioning system(GPS)

III. Desirable Properties of Ad-hoc Routing Protocols

There are various protocols designed for ad-hoc routing which fulfils various properties of ad-hoc routing. It is impossible to design such a protocol which meets all the desirable properties of an Ad-hoc network. The main objective of designing energy efficient routing protocols to incorporate maximum of these properties in our protocols these desirable properties are

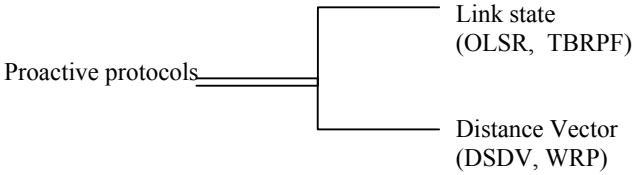
- Energy efficient
- Loop free routes.
- Demand based operation
- Security
- Power saving facility
- Quality of service

IV. Related Work

Recent past energy efficient dynamic routing was addressed by many research works which has produced so much innovation and novel ideas in this field. We have discussed reactive, proactive, hybrid and location based routing approaches. Most of the work today is based on energy efficient routing because power is main concern in ad-hoc wireless networks. Each and every protocol has some advantages and shortcomings. None of them can perform better in every condition. It depends upon the network parameters which decide the protocol to be used. Several protocols have been given regarding energy efficient routing and their modifications have also been proposed for use in ad-hoc networks.

A. *Proactive energy aware routing protocols and algorithms*

First of all we will discuss about proactive routing protocols which are categorized further in a following way on the basis of the algorithms used.



Destination-sequenced distance vector (DSDV)

DSDV [1] (destination sequenced distance vector) is the most obvious proactive protocol which was given by Perkins and bhagvat.it is based on bellman ford algorithm.it removed the shortcomings (loops, count to infinity problem) of contemporary distance vector protocol which was not suited for ad-hoc networks.it is a destination based distance vector routing protocol in which every node maintains a routing table. This routing table contains all available destinations, the next node to reach to destination, and the no of hops between it. Whenever any node changes its position it broadcast the routing updates to the other nodes. Sequence number is used to avoid loop problems. Keeping the simplicity of distance vector protocol it guarantees loop freeness it reacts immediately on topology changes. Since the route for destination is always available at the routing table of each node so there is no latency caused by route discovery. But broadcasting of routing updates may cause high traffic load between the nodes if the density of the nodes are high. So this protocol is best suited if the density of the ad-hoc network is low. However if the mobility of the node is too high broadcasting updates may cause time delay.

Optimized Link state routing (OLSR)

OLSR [2] is another link state proactive protocol which routes to all reachable nodes in the network with minimal delay. It was developed by IETF (Internet Engineering Task Force) which is an open standard organization. In this very protocol we use the concept of selective flooding which reduces the network traffic and power consumption for highly dense network since it allows only to the set of nodes (MPR's) to broadcast the control messages whenever the topology changes.it removed the problem of unnecessary duplication of control messages. The main advantage of OLSR protocol was that it was good for dense network which was not supported by AODV protocol. In OLSR each node periodically broadcast hello messages to learn topology up to 2 hops. Based on this hello messages each node select its set of MPR's. The problem in this type of protocol is to select a minimal set of MPR each time the topology changes which is a NP hard problem. However in this paper we are concerning on the energy efficient protocols the traditional OLSR protocol was not suitable for the viewpoint of energy efficiency which is a critical issue in case of mobile Ad-hoc

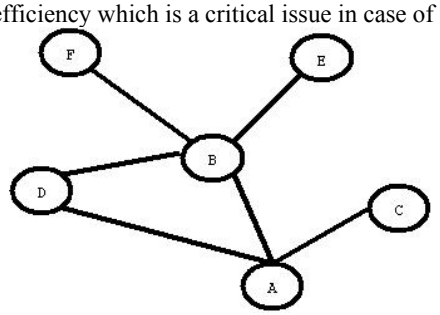


Fig. 1. MPR node A is B

network. Several enhancements have been done by the professionals for making it energy efficient which are as follows OLSR protocol does not take energy saving techniques into account proposed a new energy efficient unicast routing protocol EOLSR [3] which made it energy efficient. EOLSR increases the network lifetime by selecting the path having minimum cost where the cost is calculated on the basis of residual energy of each traversed node and the energy conserved on this path.

Energy-efficient broadcast OLSR

A new protocol EBOLSR [4] is proposed in 2010 which adapts the OLSR protocol in order to maximize the network lifetime for broadcast communications. In EBOLSR energy efficient MPR [3] selection is done by the residual energy of nodes, in this protocol we considers the weighted residual energy of energy efficient MPR candidate and its 1 hop neighbours. The basic phenomenon about this EBOLSR protocol was to select the energy efficient multipoint relays [MPR's].

Energy-Efficient OLSR

EEOLSR [5] is another enhancement of OLSR [2] for increasing the network lifetime without loss of performance. Two mechanisms are used in this protocol.

- EA-Willingness Setting mechanism
- Overhearing Exclusion

TABLE II

Comparison between DSDV and OLSR

Parameters	DSDV	OLSR
Algorithms used	Distance vector	Link state
Unidirectional link support	No	Yes
Qos Support	No	Yes
Multicasting	No	Yes
Frequency of updates	Periodic and as required	periodic
Characteristic feature	Loop free	Reduces control overhead using MPR

In EA-Willingness setting mechanism we consider the energy state of the node in MPR selection. Every node shows the willingness for being an MPR heuristic value of the node (default, high, low) is used to determine which node can work as an MPR. The heuristic value is calculated with the help of battery capacity and predicted lifetime of a node. If the battery charge is low that node will have LOW heuristic value whereas if the battery is highly charged and there exist a low traffic in that node then the node will have HIGH heuristic value. In the overhearing Exclusion device is turned off when neighbourhood nodes exchanges message with each other. This method saves significant amount of energy. In this way EEOLSR solved the problem of energy efficiency of conventional OLSR protocol.

B. Reactive energy aware routing protocols and algorithms

In reactive routing, the routes are discovered only when need of that route arises. There are two types of reactive routing.

Source Routing: In source routing, data packets carry the complete addresses from source to destination and no routing table in intermediate nodes. Some source routing protocols are: Dynamic Source Routing, Associatively Based Routing, and Signal Stability-based Adaptive Routing

Dynamic Source Routing

DSR [6] is a source routing protocol it means the sender node knows the complete route to the destination. These routes are stored in the route cache. If a node has data to send and no route is present then route discovery process will go on. Route discovery is basically based on flooding mechanism in which route request (RREQ) packets is sent to all its neighbours. Each intermediate node rebroadcasts it unless it is the destination or it has a route to the destination. This type of node replies to the request with a route reply packet that is routed back to the source node. If the node has already treated this route request it rejects the new received request. Route maintenance will go on if a link of route is broken then it deletes each route having this link from its cache, then it generates a route error packet to inform the source node and all intermediate nodes about this link failure until this route error packet reaches to the destination. After that a new route request launched by source to find a new route or check in its route cache. Due to caching DSR is more effective at low mobility and at low loads. But, it has many limitations such as it doesn't take into consideration the capacity of each node as power computing and no security mechanism is defined for DSR.

Weight based DSR (WBDSR)

WBDSR [7] Weight Based DSR is an improvement of conventional DSR. In this protocol, the weight of each route is considered as metric for route selection.

Weight of each route can be calculated as:

- Compute the node weight of each node weight i= battery level of this node + Stability of this node
- Compute the route-weight as the minimum of all node weights included in this route.
- To select the main route the one having the maximum route-weight.
- If two or more routes have the same route-weights then choose the route which has minimum hops.

Thus WBDSR gives always the longest network life time in both high mobile networks and static networks because it timely change the used route with another one which maintains the use of the nodes which enhances the network life time.

Energy Dependent DSR (EDDSR)

EDDSR [8] is energy dependent DSR algorithm which helps node from sharp and sudden drop of battery power. EDDSR provides better power utilization compare to LEAR (least energy aware routing) and MDR (minimum drain rate). EDDSR avoids use of node with less power supply and residual energy information of node is useful in discovery of route. Residual battery power of each node is computed by itself and if it 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. With help of ns-2 simulator author performed simulation which shows MDR and EDDSR is better than DSR in terms of node lifetime. EDDSR has further advantage over MDR because it can use route cache used by DSR.

Dynamic Source Routing-Cache (DSR-C)

DSR-Cache(DSR-C)[9] is the variant of existing DSR protocol which is based on energy efficient modification to this protocol .DSR works in two phase-first is route discovery and second is route maintenance. It is essential to reduce the cost of route discovery therefore each node maintains cache of source routes it has obtained through route discovery.

Associatively-Based Routing (ABR)

ABR [10] Associatively-Based Routing Protocol is another protocol in which selecting the longer lived route is the main concern because it will help in reducing cost of reconstructing routes.

TABLE III
Comparison between Source routing and hop by hop routing:

Source Routing	Hop by Hop Routing
Data packets carry the complete address from source to destination.	Data packets carry the destination address and next hop address.
No routing table in intermediate nodes	All nodes maintain localized routing table
Not scalable	Scalable

The metric used instead of the shortest hop count is the Location Stability or the Associativity between nodes. Moving nodes tend to break the associativity with their neighbours and hence they are not good candidates to carry routes. Nodes periodically broadcast beacons to signify their existence with their neighbours; Location Stability is determined by counting the periodic beacons that a node receives from its neighbours. Links between nodes are classified into Stable and Unstable links based on the count of beacons.
When source node broadcasts route request packets, each neighbour will check if it received this request before or if its ID is in the list. If yes it will drop the packet. If not it will append its ID and the status of the link weather it is stable or not to the packet and rebroadcast the packet again. Destination node will select the route one with less unstable links while it is not shortest one.

Signal Stability-based adaptive routing (SSA)

SSA [11] Signal Stability-based adaptive routing protocol is a derivative of ABR. In this protocol signal strength works as a prime metric for route selection. When source node broadcasts route request, route requests are forwarded through stable links only. Route requests received through unstable links are dropped. Destination node once get the first route request over a stable links it will send a route reply to the source.

Hop by Hop Routing

In hop- by- hop routing data packets do not carry complete route from source to destination while it carries only the address of destination and the next hop. Some hop-by-hop routing protocols are: Ad-hoc on demand Distance Vector routing, Temporarily Ordered Routing Algorithm.

Ad-hoc On demand Distance Vector Routing)

AODV [12] Ad-hoc On Demand Distance Vector Routing is a protocol which combines some properties of DSR and DSDV routing protocols. This protocol when a source needs to send data packets, it checks the route table. If there exist a route to the destination, the data packets will be transmitted to the next node following the route in the route table. Else if the route is not present in the route table, source node starts the route discovery process. The source node broadcasts a route request [RREQ] message.
A RREQ message contains following important fields:

- Source address
- Source sequence number
- Broadcast ID
- Destination address
- Destination sequence number
- Hop counter

Source address and broadcast ID uniquely identifies a RREQ packet.

When an intermediate node gets a RREQ message, it first checks that the RREQ has been received already according to the source address and broadcast ID. If this RREQ message has been already received, discards the RREQ message. Else it records the information in RREQ, increases the hop counter and broadcast the RREQ to its neighbours. This process continues until the RREQ message reaches to the destination or the value of Time to Live (TTL) exceeds the maximum allowed. When a RREQ message is received by an intermediate node from a node, a reverse link is formed between these nodes. When the destination node gets the RREQ , a reply message RREP will transmitted back to the original source along the established reverse route path and after receiving the reply message, the source node gets a path from source to destination and source is ready to send the data packets. AODV broadcasts a HELLO message with regular intervals to check the connectivity of the active route. When neighbouring nodes receives HELLO message, they update corresponding routes. If HELLO message is not received in the definite time interval, the link is considered to be break. When a link is broken, a route error message RERR is transmitted to inform the source node that a link has been broken. Then route discovery process restarts. AODV performs well in high mobility and high loads.

Alternate Link Maximum Energy Level Ad-hoc On demand Distance Vector Routing (ALMEL-AODV)

ALMEL-AODV [13] Alternate Link Maximum Energy Level Ad-hoc on Demand Distance Vector Routing Protocol is an also an improvement of conventional AODV routing protocol. In this protocol, the sum of remaining energy of nodes in a route works as a metric for route selection. The maximum energy route will be selected for longer transmission and to increase network lifetime. When source node broadcast Route Request to its neighbours, first it checks the remaining energy of the node, if remaining energy of the node is near to zero, disallowed the node from broadcasting Route Request packets. Otherwise it adds the energy information of the node to the accumulated energy field in the Route Request packet. When destination node receives first Route Request packet, the node will calculate

and update accumulated energy field on the destination node route table. If there is a route with better energy sum received, the destination node will enter new information into its route table. After that, destination node unicast Route Reply packet to the source node using reverse link. If the link is broken, Route Error packet will be sent to the source and source node will select alternate route from its route table if present, otherwise does route discovery.
Simulation proves that ALMEL-AODV has better performance than AODV.

TABLE IV
Comparison among AODV, ALMEL-AODV and ECAO

Protocol	Energy Efficient	Route Selection metric
AODV	No	Shortest path
ALMEL-AODV	Yes	Maximum energy of route
ECAODV	Yes	Stability and residual energy into the route path.

ECAODV

ECAODV[20] is also an energy efficient routing protocol which taking into account the density of nodes which impact the energy consumption and effective flooding mechanism associated with node stability and residual energy of nodes. The following definitions are convenience to illustrate this approach.
Node density: the number of neighbours in the transmission range of node i is denoted by D_i
Set of neighbour nodes based on energy: The set of neighbour nodes based on energy is denoted by Sn_i.
Neighbour nodes change rate based on energy:

$$NCr_i=\sum|Sn_{t2}-Sn_{t1}|/k$$

Quality of route path: If there are k paths from source node to destination, considering the hops of each path denoted by m and the residual energy of the node denoted by rp, then the quality of route path

$$C_i=\ln(\sum D_j)*\alpha+\{\sum rp_l/m\}*\beta$$

The value of C_i is bigger; the better quality of route path is achieved. When source node initiates route discovery process and when the intermediate node gets the RREQ message at the first time , the node checks that it has been already received or not, if note transmit it otherwise discard it. The node compares its rate of change it's rate of change of neighbours NCr_v with the predetermined threshold NCT. If NCr_v < NCT so it discards the RREQ otherwise transmit RREQ packet.When destination node gets first RREQ message, it starts a timer and waits for other RREQ messages.after that destination sets up the reverse path with the best quality which is calculated by previous formula of quality of route.

Comparison of AODV and DSR:

- DSR has access to significantly greater amount of routing information than AODV by virtue of source routing and promiscuous listening
- DSR replies to all requests reaching a destination from a single request cycle whereas AODV only replies once thereby learning only one route
- In DSR no particular mechanism to delete stale routes unlike AODV
- In AODV the route deletion causes all the nodes using that link to delete it, but in DSR only the nodes on that particular part are deleted

C. Location based energy aware routing protocols and algorithms:

Location Aided Routing (LAR)

LAR [14] (Location Aided Routing) protocol is one of the most important and popular geographical based routing protocol for wireless mobile Ad-hoc networks. LAR is based on sensible flooding. In flooding source node broadcasts the route request to its neighbours. These nodes check there identification with destination. If a match occurs destination is found otherwise they re-broadcast the message to their neighbours. Whenever any node gets the broadcast for first time it re-broadcast it. So broadcast moves outwards from source .This broadcast is terminated when every node has got the message and transmitted it once. Using unique identifier with each packet helps in avoiding loops. We don't have to maintain any topological information in case of flooding. Flooding sometimes becomes very inefficient because to transfer a single message from source to destination total number of transmissions is in the order of network size. LAR is used to reduce the flooding overhead with help of location information of nodes. Location information of node can be achieved with help of global positioning system [GPS]. There is some amount of error in location information obtained from GPS but with the advancement in this technology this error is reduced significantly. Now real co-ordinates and GPS computed coordinates are quite similar. In LAR it is assumed that nodes are moving in 2-Dimensional plane. LAR applies the concept of Expected Zone and Request Zone. The expected zone is the area where destination node can be found calculated with help of its location information and speed. Additional information like direction of movement can help in reducing the size and increasing the accuracy of expected zone. Request zone include expected zone as well as other regions around the expected zone. Route request can be forwarded by those nodes only which belong to this request zone. So a restriction on flooding is applied to increase the efficiency of protocol. There are two variations to decide the membership of request zone: -LAR scheme 1 and LAR scheme 2. First LAR scheme request zone is the smallest rectangle which includes source and expected zone. This rectangle is parallel to X and Y axis. Much variation regarding the area selection is also proposed by various researchers. We can also select the rectangle which is parallel to line connecting source and destination. In second LAR scheme source forwards the route requests to only those nodes that are nearer to destination by comparing the required destinations.

Many optimizations and improvements are proposed in LAR to make it energy efficient as energy is the prime concern in mobile ad-hoc networks. One such improvement is proposed by J. Lee, S. Yoo and S. Kim is improved LAR protocol [17]. Improved LAR is a more efficient routing protocol which restricts the spread of unnecessary control

messages. A function is given to select next hop which considers both distance as well as energy. In improved LAR network is divided by virtual grids and node with largest energy becomes grid header. Grid headers can communicate with each other and can get information of all nodes. This protocol suggests an equation to select next hop which contains sum of two factors. First factor deals with distance parameters. That hop will get preference which is nearer to the destination. While second parameter deals with energy and take decision according to neighbours initial energy, remaining energy and required transmitting power level. A weight value α is is given to control the equation. As α tends to 1 routing protocol become distance aware and as α tends to 0 routing protocol become energy aware. So by this procedure improved LAR selects the routing path so that network lifetime can be improved. Simulation results shows that improved LAR is 12% better than LAR in terms of lifetime of nodes.

.Localized Energy Aware Restricted Neighbourhood Routing (LEARN)

LEARN [16] is an energy efficient routing protocol proposed by Y. Wang, W. Song, X. Li, T. Dahlberg. This routing algorithm theoretically guarantees the power efficiency of its route asymptotically almost sure. If destination node is t, any intermediate node u will only choose a particular neighbouring node v if $\angle vut \leq \alpha$ for a parameter $\alpha < \pi/3$ in learn method. They theoretically show that for a network, formed by nodes that are produced by a Poisson distribution with rate n over a compact and convex region Ω with unit area, when the transmission range $rn = \{\beta \ln n/\pi n\}^{1/2}$ for some $\beta > \pi\alpha$, LEARN routing protocol will find the route for any pair of nodes asymptotically almost sure. When the transmission range $rn = \{\beta \ln n/\pi n\}^{1/2}$ for some $\beta < \pi\alpha$, the LEARN routing protocol will not be able to find the route for any pair of nodes asymptotically almost sure.

Location aides Energy Efficient Routing (LEER)

LEER [17] (Location aided Energy Efficient Routing Protocol) is an energy efficient routing protocol proposed by D. Du and H. Xiong. It is better than both AODV and DSR in terms of energy consumption. Packet format contains MsgID, Destination Location, Source Location, Length and DATA. MsgID shows the identity of the packet. Destination Location tells about X and Y co-ordinates of the destination node. Similarly Source Location tells about co-ordinates of source node. Length of the whole packet is descripted by LENGTH. In route discovery phase only those node can relay the message which fulfils the criteria of locality, relay nodes must have their position within the rectangle whose diagonal is SD where S is source node and D is Destination node. It will restrict the unnecessary flooding. Route maintenance is done with help of cache. This protocol shows that sum of transmission power in case of multiple hop is lesser than transmission power by only single hop: -

$P_1 + P_2 + P_3 + P_4 \ldots\ldots\ldots\ldots\ldots\ldots + P_{n-1} + P_n \leq P_{one}$.

So better route can be selected with help of multiple hop routing rather than by using one hop. [LEER] present the proof of this theorem. Simulation shows energy consumption in LEER is less than AODV and DSR. So this protocol helps in prolonging the network life time.

Distance Routing Effect Algorithm for Mobility (DREAM)

DREAM [18] (Distance Routing Effect Algorithm for Mobility) is an example of routing protocol which is location based. DREAM uses location service with help of which every node proactively updates every other node about its location. DREAM geographically forwards data packets in the form of directional flood. S is source node and D is destination node. Here flooding is directional as it always select a path which will help the packet to move in direction of destination. Location information is helpful in deciding the path and direction of movement for routing.

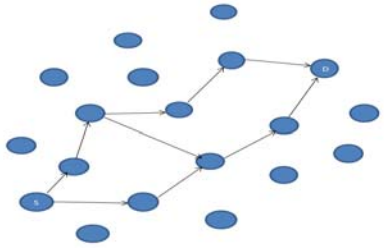


Fig.2. Restricted directional flooding in LAR and DREAM

Localized Energy Efficient Multicast Routing (LEMA)

LEMA [19] is localized energy efficient multicast routing proposed by J. Sanchez and P. Ruiz is an energy efficient multicast routing protocol based on geographic routing. The protocol is based on localized source routing scheme to reach next hop. This algorithm is adaptive to topology changes.

V. Analysis and Comparison

Comparison of routing protocols: Based upon the above discussion a comparison table can be made which is as follows:

TABLE V

Comparison of main routing protocols on the basis of route type and selection

Protocol	Route	Route Selection Criteria	Beacon
DSR	Multiple	Shortest path	No
ABR	Single	Link Stability	Yes
SSA	Single	Signal Strength	Yes
AODV	Single	Shortest path	Yes
LAR	Multiple	Shortest path	No

TABLE VI

Comparison of main routing protocols on the basis of route maintenance and discovery

Protocol	Maintenance	Special needs	Route discovery
DSR	Global, notify source		Global
ABR	Local, bypass broken link		Global
SSA	Global, notify source		Global
AODV	Global, notify source		Global
LAR	Global, notify source	GPS	Localized

DSR and LAR protocol has multiple routes available in its route table while ABR, SSA, AODV has single route. LAR, AODV and DSR uses Shortest path as metric for route selection, ABR uses Link Stability as metric for route selection and SSA uses Signal Strength for route selection.ABR, SSA and AODV uses beacons for monitoring the routes but DSR and LAR does not use beacons.

The route discovery process in DSR, ABR, SSA and AODV is global but in LAR it is localized.

VI. CONCLUSION

In this survey paper we discussed a lot of conventional protocols and their modification which includes energy efficiency with the importance of energy efficient routing protocols. We conclude that there is not a single protocol which can give the best performance in ad-hoc network. We have also discussed the factors that can be improved to increase the routing efficiency. Performance of the protocol varies according to the variation in the network parameters. Sometimes the mobility of the node of the network is high sometimes energy of the node is our prime concern, We have discussed that in which type of network environment these protocols will perform better and for which type of networks these are not suitable. The comparisons of these energy efficient protocols have been shown in this survey paper. We have tried to present almost all possible approaches of energy efficient protocols.

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