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Working Paper · July 2016

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A Comparative Review of Various Energy Efficient DSR Routing Protocols in MANET

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ABSTRACT *- Mobile Ad-hoc Network (MANET) is a self-administering complex wireless network. It consists of several mobile devices. A routing protocol facilitates the movement of packet from source to destination via some intermediate nodes. Every node works as a router in the network. Whenever a node will work as a router it will spend some amount of its energy. Due to the limited battery energy of mobile devices, the energy consumption during routing is a challenging issue. A number of energy efficiency metrics has been reviewed in this paper to reduce energy consumption when transmitting and receiving packets during communication. The aim is to improve the network lifetime by considering battery power a major issue. This paper examined the variants of energy efficient DSR routing protocols for their benefits, functionality, and limitations. Finally the paper is concluded with the future scope for research.*

General Terms
MANET, Routing Protocol, Energy Efficient Routing Protocol

Keywords
DSR, Route request (RREQ), Route reply (RREP), Route error (RERR)

1. INTRODUCTION

An infrastructure less mobile Ad hoc network is a collection of multiple interconnected mobile nodes [1]. MANET is an example of peer to peer system where every node works as a router. Mobile Ad hoc network is autonomous, self-organizing and self-administering. MANET can 'hop' data packets from one host to another in a dynamic working environment. In mobile Ad hoc network, every node is independent to move randomly. Thus, at every movement there is an unpredictable change in topology [2, 3]. The communication routes update themselves very frequently. Applications of MANET are Public, Commercial, Sensor network, Home & enterprise, Entertainment, Emergency service, Battlefield and Decision making [4, 5]. The major challenges with MANETs are: dynamic topology, bandwidth, multi hop routing and limited battery resources. MANET has a limited battery power to transmit a packet from one node to another. Due to frequent topology change there is an extra effort done by the nodes so more battery power is consumed by them. This extra battery power consumption will reduce the network lifetime [6]. So to improve the efficiency and network lifetime of MANET, the big challenge is to manage the battery power of each node. Many researchers have done research on efficient battery power management. The network protocols can be categorized in two ways:

- Maximum network lifetime protocol - In maximum network lifetime protocol those networks are considered which will work for a long time [7].
- Minimum energy protocol - In minimum energy protocols a network which nodes consume less energy will be considered [8].

In MANET energy is consumed during data communication in four ways: Receiving, Sleeping, Idle and Residual energy. If a path is not found in the network than a newer path has to be discovered that will consume more energy. If a node is idle than there is still a power drain by overhearing [6]. As MANET is multi hop, where one node acts as an intermediary, it consumes energy. If MANET selects longer path than it will consume more energy. And the higher battery consumption will result lesser network lifetime. Multiple energy efficient routing protocols are being investigated where on demand routing protocols are found better in this scenario. In Energy efficient performance analysis, DSR routing protocol performs well as compared to the AODV routing protocol.

1.1 Routing and Routing Protocols

A process by which the routes between the nodes are established is called routing. A node selects a path through some intermediate nodes in the network and a message is routed through it to the node that is not directly in the range. Route establishment is a two stage process: Route discovery process where a route from source to destination is found. Route selection is the process of selecting an optimum route among the available alternatives. In MANET, every node is movable so there is a frequent change in topology and therefore a more dynamic mechanism is required.

In routing protocol, nodes communicate with each other. Each Routing protocol has its own significance and handling issues, high data error rate, security, bandwidth utilization, power consumption, packet loss during transmission, routing overhead, device discovery, internetworking etc. Many routing algorithms have been developed to deal with above mentioned criteria. Because of the mobility of nodes the protocols must adopt the frequent topology change. These routing algorithms should also follow certain minimum criteria:

- A selected route must be loop free.
- There should be a minimum number of nodes in route maintenance.
- It should be distributed.
- It should be adopted in frequent topology change. By limiting the number of broadcast number of packet collision must be kept to a minimum.

1.2 Categories of routing protocol

In Mobile Ad-hoc Network, routing protocols are categories as: Proactive routing protocol (Table driven Routing Protocol) and Reactive routing protocol (On Demand Routing Protocol).

1.2.1 Proactive routing protocol (Table driven protocol): In proactive routing protocols every node maintains multiple routing tables. Each node contains information of other nodes in the network. The routing information gets updated periodically. There are some proactive routing protocols e.g. OLSR (Optimal Link State Routing), DSDV (Destination Sequenced Distance Vector), DBF, GSR, WRP, ZRP etc.

1.2.2 Reactive routing protocol (On demand): In reactive routing protocol every node has route cache rather than routing table. The route cache keeps information of all the up-to-date paths from source to destination. So it reduces the routing overhead. They do not maintain and search the route when no data traffic is there. This is known as on demand routing. It also controls the network traffic by not sending the unnecessary control messages.

Reactive routing protocols have less overhead as compared to the proactive routing protocol. Delay in on demand is better than proactive because routes are calculated when it is required. When a node breakdown happen in the network it restructures the network [9]. Examples of on demand routing protocols are AODV (Ad-hoc on Demand Distance Vector) and DSR (Dynamic Source Routing).

1.2.2.1 Ad-hoc on Demand Distance Vector Protocol (AODV): To maintain a route to the destination node, AODV does not involve those nodes which are inactive [10]. Route messages RERR, RREQ and RREP are used to discover and maintain a route from source node to the destination node. AODV will select a route with maximum sequence number. Each active node will exchange information with each other by passing a Hello message periodically to its neighbour nodes.

1.2.2.2 Dynamic source routing protocol (DSR): DSR routing protocol consumes less bandwidth as compared to the table driven protocols by eliminating the periodic table update messages. In multi hop wireless routing, DSR is an efficient protocol [11]. In energy efficient routing approach it is an important routing protocol as compared to others [12]. It uses a source routing approach. The sender regulates the definite sequence of nodes through which it will transmit a packet. The packet header contains the list of various intermediate nodes for routing. Each node maintains a route cache in spite of routing table. The route cache will only store the information of predefined path selected by the source node. This protocol is self-organizing, self-healing and self-administering.

1.3 Benefits and limitations of DSR routing protocol: In DSR routing protocol, sending a packet does not need to keep route information in the routing table. The route information is stored in the packet header. Route cache reduces the control message that in turn reduces the routing overhead. Initially DSR was developed for small network up to 10 hops. It required more processing resources then other protocols. The other limitation of DSR was minimum hop count, so there was lesser number of nodes in the selected path. There may be more distance between intermediate nodes. More distance will require more transmission power for communication in between nodes, which will consume more energy.

The next section deals with related work of energy efficient DSR routing protocol, in detail. Section 3 covers literature review and a comparative table of DSR based routing protocols. Section 4 explores the Future Directions and Emerging Trends for DSR based routing protocols. Section 5 concludes all the discussion made earlier.

2. Related Work of Energy Efficient DSR Routing Protocol

In DSR routing protocol, the nodes can participate in routing data packets because they are dynamic in nature [13]. The major role of routing protocol is to establish an efficient, correct path as well as keep the network functioning for a long time [14]. MANET is infrastructure less and node energy is very essential for the appropriate functioning of the network. The efficient node energy can be achieved by limiting mobile node's energy during active and inactive mode. The consumption of energy can be minimized by the following energy efficient approaches:

- Transmission power control
- Load distribution
- Power down or sleep

a) Transmission power control approach

The transmission power control approach determines the best possible routing path that minimizes transmission energy required to deliver data packet from a source node to a destination node. To discover a route MANET broadcasts flooding of packets in the network. Flooding is done using minimum energy

Table 1. Energy Conservation approaches (redrawn from [18])

Approach	Type of communication	Node's Participation	Purpose
Transmission Power	Active	Forward or Receive packets	Minimize the total transmission energy. Control number of hops and End to End Delay between source and destination.
Load Distribution	Active	Forward or Receive packets	Distributed load to energy rich nodes.
Power Down/ Sleep	Inactive	Neither receive nor forward packets	Minimize energy consumption during inactivity.

The nodes have various transmitting power. The transmission range between any pair of node should be efficient. It should be according to the requirement in such a way that a node can only transmit to other node. It will save energy, interference and congestion in the network [15, 16].

b) Load distribution approach

The load distribution approach focuses on balancing energy usage among the nodes by avoiding over utilized nodes while selecting a routing path. In this approach we will optimize battery power. If we will select shortest path then some over utilized nodes may go out of network which will affect the network lifetime. So load is distributed according to the underutilized nodes rather than shortest path. It will prevent a node from overloading and result in longer network lifetime [17].

c) Power down/sleep approach

If a node is not in active communication then to save energy it is put into a sleep state.

2.1 Energy efficient matrices

- Total Transmission Energy: It is the amount of energy of all the intermediate nodes encountered in route from source node to destination node.
- Remaining Energy Capacity: It show the remaining energy left in a node.
- Maximum node cost: With each path node is remarked with the maximum node cost among the intermediate nodes.
- Energy Consumed/Packet: Provides the minimum energy consumption path through which the overall energy consumption for delivering a packet is minimized. DSR routing protocol has been found as the best choice for energy efficient routing protocols. For many years many routing protocols have been proposed to find the optimal solution for energy efficient routing. In DSR also multiple route request and broadcasts it to its neighbour nodes modifications and enhancements has been done to find best energy efficient protocols. After some modifications in DSR routing protocol, in the next session, there are some DSR based routing protocols.

3. Review of Literature

Y. Yu et al. [19] proposed a Geographical Energy Aware Routing (GEAR) protocol. GEAR sent back the remaining battery power and its identity along with the multiple route requests would reach to the destination, and then it would select the best route according to the remaining battery power among all received RREQ packet. One of the limitation of GEAR protocol was: If RREQ reaches after the specified time duration than it does not assure that it has chosen the best path. The other difficulty is to manipulate the waiting time of several RREQ from the same source. The source node would wait and receive all the RREQ along with all possible routes to select the best route. Another problem was that the route cache of a node does not have power related information. So it is incapable to utilize the route cache. While assigning time duration, short period may not select the best route while longer period may affect the response time.

Ivan S. et al. [20] and Kyungtae Woo et al. [21] in 2001 proposed, Localized power-aware routing algorithm (LEAR) protocol. They modified the route discovery procedure for balanced energy consumption. Parameters for LEAR protocol were willingness and remaining battery power. Only those nodes which were willing to participate were considered. If remaining battery power of a node was greater than the threshold value then the node might consider for the route path, and the route request was forwarded, otherwise the packet was dropped. So the shortest route was only possible for the first message arrived at the destination.

If the energy of a node in the path was lower than the threshold vale then a route request was not be considered. If this situation happened for all feasible paths then the source node would never receive a RREP even after a possible path in between source node and destination node. To prevent from this situation, the source node will again send the unchanged route with raised sequence number. When an intermediate node received the identical RREQ message again with larger sequence number, it adjusted (lowered) the threshold value to uphold transmission. In DSR some node may consume more power while some other nodes consumed less power. This led to the poor network life time. But in LEAR because of better balanced energy consumption the transmission time would be large. LEAR also removed the blocking property of GEAR.

The limitation of LEAR protocol was that in its basic form it did not avail the route cache and it might acquire RREQ messages due to falling of RREQ messages. The LEAR protocol perform 35% better in energy consumption and longer transmission time than DSR routing protocol.

The algorithm proposed by Xu Li Wu Zi-wen et al. [22] explained the Topology control based power aware and battery-life aware dynamic source routing (TPBDSR) protocol adjusted transmitted power reported to their adjoin node's position in the dynamic network topology. It could affect the traffic carrying capacity of the medium. It used distributed control where every node adjusted its transmitting power according to definite range of neighbours. The transmitting power field and lowest degree value field would be attached with the RREQ packet. Whenever a node received a RREQ packet an updated value of transmitting power value field would be updated. TPBDSR accepts multiple route requests and it would select one of them with several extra rules. As the first RREQ arrived at the destination; it set a timer and waited for more RREQ packet that would contain other route information. Then it would select the best path among them.

In this algorithm, it was studied how the period of adjusting power affected the performance of TPBDSR routing algorithm. The future work after that was how to extend the Quality of service of routing, broadcast and energy aware multicast in mobile ad-hoc network.

J.-E. Garcia et al. [23] introduced Energy efficient DSR (EEDSR) protocol same as LEAR protocol but the difference was that the eagerness parameter depended upon some other factors. According to these factors a node could decide to avoid nodes from a rapid sink of battery power, whether it should take part in forwarding the packets or not. This algorithm would compute residual battery power of each node periodically. A sufficient battery power node would participate in network activities. But if residual power became less than specified Threshold value, the node delayed broadcasting RREQ packet and the node would send a RREP packet to inform the source node. The source will find another route by route discovery process. Because the mechanism in LEAR is based on residual power, if a node has more battery power then the maximum load would be passed through it. That will cause high drain rate in such nodes. EEDSR saved more battery in a dense network. The limitation of EEDSR protocol was that it limited the number of nodes to 50.

The algorithm proposed by M. Tarique et al. [24] examined Energy saving DSR (ESDSR) protocol improved the network life time. For improved network lifetime, this protocol integrates the advantages of transmission power control and load sharing. First of all it decided the route based on load balancing approach and then it dynamically adjusted the transmitting power at each node before it transmitted the packet. In the path selection, it used minimum hop count before transmitting the packet. It introduced two new parameters, Current energy level of a node and Current transmitting power level of each node. Each node maintained a power table where there would be transmitting power of that node and the packet would be transmitted at that power thereby saving the power for the packet. To implement ESDSR various parameters are considered: number of dead nodes, energy consumption per packet, and total number of packets reached at the destination. It saved 40% energy per packet than DSR routing protocol. It could send 20% more packets to destination by consuming the same battery power as DSR protocol.

The limitation of ESDSR protocol was that the packets are sent via minimum hops, so the number of hops might increase. The delay might be higher in ESDSR protocol as compared to the DSR. Another limitation was when the network area gets large, the transmit power in ESDSR was almost equal to the DSR protocol. Hence the numbers of dead nodes are almost same in DSR and ESDSR protocols.

Zupeng Li et al. [25] presented a Peer Computing based Dynamic Source Routing protocol (PDSR) protocol as a multi-path protocol. For successful data packet transmission, the multi path provided a redundant and alternative route. They integrated advantages of peer to peer network by keeping highly dynamic network and holding network scalability into the design of MANET routing protocol. PDSR had reinforced the packet delivery and node discovery performance by taking advantages peer-to-peer network. PDSR had enhanced the routing performance as compared to the DSR routing protocol.

In the algorithm proposed by Mohammad Tariq et al. [26] presented the Minimum Energy Dynamic Source Routing (MEDSR) protocol. To upgrade the network lifetime in MANET, transmit power should be adjusted to the minimum level. But minimum transmit power could cause network partition. To determine correct transmit power, mobile node used control messages like "Hello" messages to collect information of its neighbours. But these control messages could cause huge overload. MEDSR ensured connectivity of the network. MEDSR resulted in less network partition and highly maintained network connectivity. The network lifetime was improved and more important data packets could be delivered to the destination. Energy saving per data was 55% higher in MEDSR protocol as compared to the DSR protocol.

The limitations of MEDSR protocol were that the data packet might traverse the large number of hops as compared to DSR. So the delay per data packet could increase.

Benamar Kadri et al. [27] proposed a protocol in which Weight Based DSR was the rectification of dynamic source routing protocol. In this algorithm, the weight of each route was advised a metric for route selection. Weight of each route could be calculated by calculating the weight of each node. Weight of a node was the sum of battery level of this node and Stability of this node.

The idea was to select the main route with maximum weight. If two or more routes had the same route-weights then select the route with minimum hops. Thus WBDSR gave the longest network life time.

In the algorithm proposed by Floriano De Rango et al. [28] presented Data packet scheduling among the energy efficient path and a mechanism for rising the traffic and energy load balancing. An energy aware multipath routing protocol has been proposed. This protocol resulted in reduced end to end delay and increased the data packet delivery ratio.

Vahid Nazari Talooki et al. [29] proposed a novel structure for control packets to replace the activity of nodes. E2DSR protocol created an algorithm for route selection and route cache and implemented an energy table. By applying data structure an array, an energy field is added in RREQ packet. The remaining battery power of a node was stored in this field that is forwarded with this RREQ packet. Some bits represented the energy. By route priority function source node will select the best route. This protocol will choose the route with high energy level. Best route will be chosen according to these parameters Delay, Length, Jitter, Packet delivery ratio, Energy of path, Freshness.

Xu Zhen et al. [30] introduced, the nodes had limited computing and energy resources in MANET. And in real time streaming application to find a shortest path was insufficient. This paper depicts the delay-aware and energy-aware dynamic source routing approach is put forth. In order to setoff traffic load in DSR_ED protocol efficiently utilized the network resources. It was a flexible DSR routing protocol. It selected routes according to different energy level. It avoided busy and low power intermediate node to ensure timeliness and energy efficiency. The nodes had sufficient energy level and it would select short hop route. The nodes that had less energy level would select route on the basis of node's residual energy and total transmission power consumption. DSR_ED protocol performed better on network lifetime and end to end delay. The restriction of DSR_ED protocol was that it worked for low traffic, up to eight packets/second, The packet end to end delay are almost equal.

Baisakh Nileshkumar et al. [31] proposed that the most important feature of a node in MANET was that in the absence of base station it could take its own action. Hence a node could take the routing decision. Routing decision navigate the packet from source to destination. Routing protocol was responsible for transmitting packet through several intermediate nodes between source and destination. But several routing protocols found it by using minimum hop count. It resulted in high battery consumption. If a node drains its battery then the network partition would break the communication that will result in poor performance of network. ECDSR protocol considered the basic concept of DSR protocol with residual power of a node. This protocol was designed so that in route discovery phase, it would select those nodes having higher amount of energy rather than minimum hop count. If a node's energy would reach to the minimum threshold value than it would be eliminated and the nodes would transmit an error message to the destination. To continue the communication the source will find a new path. Packet delivery, remaining residual, network lifetime, throughput of the network was better in ECDSR as compared to the DSR. Energy consumption per successful delivery of data, number of dropping nodes was less in ECDSR.

The limitations of ECDSR protocol were that if there was a single source and single destination, so the performance in case of multiple sources and multiple destinations could not be found. The limitation the mobility of node was not considered, so it has to observe the performance in dynamic network. The ECDSR protocol had overhearing and stale route problem, which leads to packet loss and over energy consumption.

Shiva Shankar et al. [32] argued that in MANET to evade deactivation of a network or a node, battery power should be used efficiently. For route discovery mechanism Energy power routing DSR selected the power constraints and the bandwidth. It utilized the status power of alternate paths and each mobile node. As compared with DSR routing protocol EPRDSR protocol enhanced 60-65% more lifetime and delays the reconstruction and repair of the route. It extended the lifetime of each connection. It performs well in high mobility and high traffic load. The limitation of EPRDSR protocol was that initially it caused a little overhead in the route selection.

Shivashankar et al. [33] proposed the network lifetime was improved by reducing the battery power consumption of nodes. The main objective of EPRDSR routing protocol was to select energy efficient paths.

Some intermediate nodes might act as a selfish node to save their own battery power. These selfish nodes might drop the packets. The EDSR protocol would find those selfish nodes and also deal with them. The network lifetime of EDSR performed better than DSR and protocol with different pause times. Packet delivery ratio was improved. EDSR protocol performed well than DSR in high mobility with less overhead. The average node lifetime of EDSR protocol was 45–60% more than DSR protocol. The limitations of EDSR protocol was, for total energy consumed for 100 pause time in the initial stage EDSR consumes more energy than DSR.

Uma Rathore Bhatt et al. [34] proposed an algorithm which could enhance the performance of ad-hoc network in terms of average end to end delay, average jitter, residual power and throughput. To enhance performance of the network DSR1 protocol reduced the flooding of route request packets. This approach reduced the energy consumption and congestion. A node checked its residual energy, speed and received signal strength when a node received RREQ packet. If

TABLE II A comparison of various DSR based power-efficient routing protocols

Routing Protocol (Year)	Motivation	Disadvantage	Route metrics	Performance metrics	Variable parameters	Considered parameters		
						RE	TE	OH
GEAR (2001)	To route a packet from source to the destination it apply energy aware neighbour selection mechanism.	Difficulty in utilizing the route cache and the blocking property.	Balance EC and Network LT	Number of packets, Number of connected pairs.	Network size	Yes	No	No
LEAR (2001)	Avoids the blocking and route cache problems	Very less competent in low movability scene, Do not expect secondary path.	RE	PDR, Peak-to-mean ratio, SD, ratio of accepted RREQs	Pause time	Yes	No	No
EEDSR (2003)	Energy-efficient mechanism to prevent nodes from abrupt sink of battery power.	Limited for small size network.	RE	Node expiration time, ratio of received data, EC per packet type	Maximum speed, simulation time, pause time	Yes	Yes	Yes
ESDSR (2005)	The load balancing approach is responsible for routing decision. When a routing decision is made, link by link transmit power tune-up per packet is done based on a transmit power control approach.	Delay may be higher in ESDSR because packets are not sent via minimum hop. To judge the performance an examination of ESDSR with some other routing protocols are required.	Minimum node energy, Network LT	Capacity, EC per packet, Number of dead nodes	Distance, Network Area	Yes	Yes	No
WBDSR (2008)	Avoids links failure	Preferred in only large network. There is no mechanism by which we can measure the power of any intermediate node.	Node weight (energy and stability)	Delay, network LT route errors	pause time, number of nodes, time	Yes	Yes	No
MEA-DSR (2008)	Minimizes frequent route discovery, balances EC	in low mobility scenarios higher routing overhead and lower PDR	Hops count and RE	E2E delay, PDR, EC per packet, SD of node EC, normalized routing overhead	Pause time	Yes	Yes	Yes
E2DSR (2010)	Balancing EC amongst different nodes in the network,	In a larger scenario It required a complete analysis of protocol performance, using the protocol scalability and represented metrics.	Route reliability is improved. Early node failure is delayed.	Balancing of Battery, EC Average E2E Delay, Normalized Routing Load, Inter arrival Jitter, Node's failure degree,	Mobility	Yes	Yes	No
DSR_ED (2012)	It avoid engaged intermediate nodes and less powered node to ensure both EC and timeliness.	This protocol should be evaluated in dense network.	Packet loss rate, maximum bandwidth availability and minimum E2E delay	average E2E delay, network LT	Packet rate	Yes	Yes	No

RE Residual battery energy, TP transmission power, OH node overhearing, EC energy consumption, LT lifetime, PDR packet delivery ratio, TE transmission energy, E2E end-to-end, UDP user datagram protocol, SD standard deviation

Routing Protocol (Year)	Motivation	Disadvantage	Route metrics	Performance metrics	Variable parameters	Considered parameters		
						RE	TE	OH
ECDSR (2012)	Rather than minimum hop count, this protocol selects only that path whose nodes have high remaining battery power	This protocol has not considered mobility of nodes. Large number of nodes can be taken to judge the performance. We can take multiple destination node and source node.	Network life time, RE	Number of dropping nodes, throughput, EC per delivery of packet, RE of the node.	Packet delivery fraction	Yes	Yes	No
EPRDSR (2013)	Provides robustness to mobility and high traffic.	Longer average E2E delay	Bandwidth and total EC	PDR, E2E delay, EC	Pause time, nodes speed, No. of nodes	Yes	Yes	No
EDSR (2013)	Finds and addresses selfish intermediate nodes.	The overall time delay is high.	EC per packet and node LT	Total EC, network Lifetime, average RE	No. of sources, pause time	Yes	Yes	No
DSR1 (2014)	Reduces congestion and EC	Does not perform well in small networks.	RE, RSS and speed	Average RE, throughput, E2E delay, average jitter	No. of nodes	Yes	Yes	No
EEPDSR (2014)	It evaluates the conserved energy level. Reduces routing overhead	The performance should be analysed for more dense network with some other EE routing protocols	RE, EC per node.	PDR, E2E delay	Number of nodes	Yes	Yes	Yes
MDSR (2014)	It conserves the energy of nodes during route discovery and data transmission phase.	More improvement required in route maintenance and also in fastest and efficient route discovery process.	Optimal path for data transmission that consumes less energy	Average EC	No of Packets Send	Yes	Yes	Yes

RE Residual battery energy, TE transmission energy, OH node overhearing, TP transmission power, EC energy consumption, LT lifetime, PDR packet delivery ratio, E2E end-to-end, UDP user datagram protocol, EE energy efficient

the defined Threshold value of residual energy, speed and received signal strength was satisfactory then the route request packet would be forwarded in the network, otherwise the packet would be discarded.

To reduce network congestion and battery consumption, DSR1 did not consider those nodes having less battery power, greater distance and mobility than the Threshold value. As compared to DSR the DSR1 used better utilization of bandwidth, increased Throughput and average residual batter power. It reduced the jitter and end to end delay. DSR1 was suitable only for large size of network. The limitations of this protocol were that it could only be used where node density is very high. Another limitation was that it is not suitable for a network with fewer number of nodes in terms of delay.

In the algorithm proposed by Dr.V.Ramesh et al. [35] the Energy Efficient Preemptive DSR protocol illustrated the energy conservative method to improve the efficiency of routing protocol. It reduced the routing overhead. It calculated the required energy and available energy of a node. It evaluated the conserved energy level. EE-PDSR had better packet delivery ratio and end to end delay. EE-PDSR showed a better energy efficient performance than the existing PDSR and DSR protocol.

Navin Mani Upadhyay et al. [36] proposed an algorithm in which the nodes act as an intermediate nodes which increases energy consumption. To increase the life time, energy consumption should be minimized. When the size of network increased overhead also increased. MDSR will reduce the overhead to conserve the power during route discovery (by reducing the RREP packets) and data transmission.

4. Future Directions and Emerging Trends

In the literature review it seems that most of the energy efficient routing protocols consider energy information to either ensure that to avoid nodes with low battery power or the route with the lowest energy consumption is selected. Therefore, these approaches enhance the network lifetime. Some approaches combined best aspects of multicasting information or energy information with location together to achieve better

performance. As per discussed various energy efficient protocols in the previous section many open issues and challenges are remain and are pertinent to energy constraint in MANET. Which motivate researchers to find more accurate and efficient protocols by considering these constraints. For future directions some open issues are summarized as follows.

1) According to the review, it is understood that the intermediate nodes consumes more battery power. It is stated that some over utilized nodes may go out of network while some nodes are having high energy level because some approaches are suffering from unequal load distribution among all nodes. The challenging area of research in MANET is to find most competent path that keep and balance the energy and load among multiple mobile nodes. A scheme is required to merge the multipath and power aware concepts to balance load among various path.

2) There may be some intermediate nodes which act as selfish node. In order to save their battery power they drop the packets for other nodes. Therefore an algorithm should be designed that can find those selfish nodes in order to enhance the lifetime of the network.

3) The routing solutions present in the literature are simulation based approaches. To study the routing trustworthiness a mathematical model should be developed, that can be assimilate with the simulation model to validate the performance of these protocols in high density networks.

4) To obtain correct information about the energy levels of nodes, the dynamic topology is a big challenge. That makes it difficult to find an energy efficient path between the source and destination nodes. So the research should be conducted during the selection of optimal path in terms of energy consumption.

So the research that considers mobility of nodes simultaneously with the energy related metrics during the selection of optimal path in terms of energy consumption should be conducted.

5) During route computation in conventional energy efficient routing protocols in MANET there is no optimal trade-off between energy efficiency and quality of services. In MANET to improve quality of service and network lifetime a combination of multiple energy and quality of service metrics are useful for route computation.

6) For network layer and medium access control layer a new energy efficient, cross layer design can be developed. In MANET, to find a cross layer approach instead of selecting the shortest path, we can select the optimal path to save energy is an open issue.

7) In heterogeneous networks (MANETs, WMNs and WSNs) to identify energy efficient routing protocol will give us a new area for research.

8) One of the future directions in designing application level routing algorithms used to provide certain automatic services required by mobile devices should combine automatic MANET formation, message routing, peer detection and peer to peer cooperative communication systems. When making routing decisions the algorithm must consider the congestion levels and resources of neighbouring nodes when making routing decisions.

Conclusion

In this paper, we concentrated on the variant of power-efficient DSR routing protocols in MANET to obtain reliable paths for routing with less energy consumption. To design a routing protocol in MANET, the limited energy resources of nodes represent a critical issue. Various routing protocols have been reviewed and compared in terms of their important features. These protocols are summarized in conjunction with their challenges and limitations. In MANET, each approach has its merits and limitations as depicted in the table 2 and literature review section. To obtain the best performance in terms of QoS and energy efficiency, the scenario and network topology plays a critical role in deciding which protocol should be used. It is found that not even a single protocol fits well in all the situations. Every protocol has different methodologies, different implementation environment, different performance metrics and different techniques. Each protocol has some enhancements over others. One protocol is performing well in some aspects while the same protocol is lacking in other performance issues. There is still much scope to find such an energy efficient protocol that extend the network lifetime, ensure network connectivity and reduce energy consumption by modifying the existing DSR based routing protocol.

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