# A Review on Power Saving Techniques in MANET

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***Abstract-*** Mobile Ad hoc Networks (MANETS) consists of distinct devices that communicate with the help of infrastructure created instantly. When these devices are used in the areas like battlefield, emergency and rescue operations, the battery power must be efficiently used to prolong the life of each device as human intervention is not possible in such areas. There are number of ways that are used to reduce the power consumed by the nodes in the network. In this paper, the three effective methods that reduce the power to considerable extent are seen. The three methods are given as: by using variable transmission power, by using power aware routing protocol and the power management technique. These methods deal with different layers like physical, network and MAC layers respectively.

***Index Terms***- Mobile Ad hoc Network (MANET), Power Management Techniques, Routing, Transmission power.

## I. INTRODUCTION

MANETs are the wireless sensor networks in which two different devices communicate without any base station or access points in between them. This is done with the help of instant infrastructure created between the nodes. The challenging fields of MANET include bandwidth constraint compared to networks with base stations or access points. Limited bandwidth in turn reduces the number of packets carried along the network and delivered to the destination. Also nodes are powered with the battery. Applications like battle field, emergency and rescue operations, the battery backup becomes very essential. The provided battery power is limited. Hence these devices become battery constrained devices. The power must be consumed efficiently by the devices in the network to prolong the life of the devices.

Topology changing is another major issue. In applications like collaborative works in business environment, this topology changes introduces unexpected route break which results in latency in message delivery. Here the power conservation is not a major issue but latency maintenance becomes important. The tradeoff between power and latency depends on the application where the devices are used. For MANETs, optimization of energy consumption has greater impact as it directly corresponds to lifetime of networks. The various factors that reduce the energy of the network is the transmission power as well as the reception power. Power consumption can be reduced at device level, at transmission level or by using power aware routing protocol or by using some power management technique.

In MANET, regarding the power constraint, there are several reasons behind it which limit the battery charge per node, limited transmission range per node and limited bandwidth. As MANET makes communication between two hops in multi hop manner. If the distance between the communicating nodes is larger than it increases the power consumed or it decreases the overall life time of the network. This means that the power consumption is directly proportional to the route length. As the nodes forward the packet to their neighbor the power consumption will be increased. This means the node consumes power at each time when it transmits or receives data. Thus the nodes are forced to expend their battery charge each time when it transmits or receives the data. These constraints have vital impact in node lifetime and network lifetime. The following techniques can be used to optimize the power in the MANET.

- Power conserving by controlling transmission power
- Power conserving by using minimized power aware routing protocol
- Power conserving by using power management Technique

## II. POWER SAVING BY VARYING TRANSMISSION POWER

The strength of the signal power transmitted from source to destination depends on the distance from the source node to the destination node which is mainly called as transmission range. Number of studies deals with the problem of power saving by varying transmission power or using variable transmission range method.

Jang Ping Sheu et al., in [1] discussed distributed transmission power control algorithm to vary the transmission power level that not only increases the life time of the devices but also increases the packet delivery ratio. This algorithm consists of two processes: initial phase and maintenance phase. Since the nodes are mobile the same transmission power level to all the nodes does not sound effective in terms of PDR and power consumption. Hence different power levels are selected. At various power levels the packets are initially broadcasted to all the nodes in the network. Each node depending on the Received Signal Strength Indicator (RSSI) acknowledges the source at the particular power level at which the received signal can be processed successfully without the need for retransmission. Hence the near nodes use the lowest power level and the far nodes use the highest power level. When the path chosen is multi hop, this algorithm saves power to greatest extent and gives better packet delivery ratio. This prolong the overall lifetime of the network.

Nagpal et al., in [2] compared two protocols: Multi Hop Routing (MHR) and Minimum Total power Routing (MTPR) in terms of power consumption under two scenarios: fixed and variable transmission ranges of the devices in the network. The shortest path is created using Djikstra algorithm. The results show that the power consumed by the devices is less in the

MTPR protocol with variable transmission range with better Packet delivery ratio.

Dhinesh et al in the work [3] proposed enhanced transmission power control mechanism (ETPM) by which the transmission power is varied according to the distance between the nodes and the received signal strength indicator (RSSI). The received signal is calculated as,

$$S_r = S_t * (1/D)^n$$

$S_r$ – Received signal power
$S_t$ – Transmitted signal power
D- Distance between source and the destination nodes
n- Transmission factor

The above relation shows that the power of the transmitted signal decays with the distance logarithmically. Hence transmitting the packets to the nodes that are far away from the source requires more power more transmission power. This drains the life of the battery provided to the network nodes. In this paper, four power levels are considered corresponding to the distance from the source. Thus ETPM prolongs the lifetime of the node as well as the network making the communication effective without affecting the packet delivery ratio.

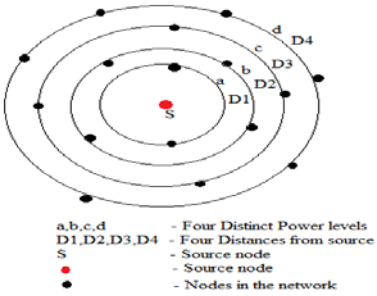


**Fig. 1. Four Transmission power level MANET**

In order to establish path and power level to the respective destination node, the source node first broadcasts the message at all the four power levels. The destination node in turn acknowledges the source node via shortest available path at corresponding power level that no needs retransmission. For example, the node S broadcasts all the nodes in the network. Let the destination node be at power ring "b", then destination node acknowledges to the source node at power level "b". It eliminates the messages received at power level "a" as it is insufficient to reproduce the message at the receiver side and also eliminates the message received at power level "c" and "d" as it demotes the battery power. Thus this system is more efficient in prolonging the battery power of the devices.

## III. Power Saving By Using Power Aware Routing Protocol

Routing in MANET can be unicasting, multicasting or broadcasting. The path from source to destination consists of number of nodes. Thus the routing in MANET is always referred to as multi hop routing. If the destination is immediate neighbor, then there is no need of multi hopping in the route. But this is not always possible in all the cases. Every packet, in order to reach the destination, needs defined path. In MANET, this path is given using three types of protocols: table driven, on demand and hybrid protocols. In table driven protocols, each node in the network maintains one or more tables regarding the active nodes in the route to reach the corresponding destination. An example for table driven protocols is: DSDV. In contrast to table driven protocols, in on demand protocols, the path or the route to the particular destination is created only when there is need to send packets to that particular destination by the source node. Some of the on demand protocols are: Ad hoc On demand Distance Vector (AODV), Dynamic Source Routing (DSR). Hybrid routing protocol inherits both the features of table driven and on demand protocols. One of the known protocols is Zone Routing Protocol (ZRP). On comparing the above types of protocols, On demand protocols best serves the purpose of power managing.

Sridhar et al., in [4] proposed Sensor Bee routing protocol based on swarm intelligence to reduce the power consumed by the nodes. Sensor Bee protocol reduces the routing loop which the packets takes to reach the source from destination in the reverse path. Hence the power consumed due to complex routing loop is reduced. Each node maintains a forward table entry for the packets that are passed through that particular node. If the same packet reaches the node which was previously visited during forward path, then the particular revisited packet is dropped and the entry against the particular packet is flushed out from the table. Thus the node selects the next hop with less distance and also the nodes which is not visited previously. Thus the power consumed by this sensor bee protocol less compared to the ad hoc routing protocols discussed above.

Dongkyun Kim et al., in [5] introduced a parameter called as Minimum Drain Rate (MDR) that is used to measure the rate at which the power is consumed in the network. This MDR mechanism is based on the metric drain rate and remaining battery capacity. Hence this mechanism efficiently uses the critical battery power in such a way that prolongs the lifetime of the devices. Also its performance is compared with the MTPR protocol and Min-max battery cost routing protocols. The comparative studies between these protocols conveys that the MDR protocol reduces the over dissipation of the power due to heavy traffic. This protocol efficiently operates even in the case of continuous heavy traffic flow and prolongs the life time of the battery.

In the work [6] of Morteze et al., proposed Power aware Source Routing (PSR) protocol for MANET. This is one of the on demand protocols. Like other on demand protocol, it also consists of two processes: Route discovery and route maintenance. Its performance is tested against all the well known on demand routing protocol which conveys that PSR performs better in terms of limited power consumption by the devices in the network. The PSR is efficient than DSR protocol in following manner. In DSR, when the node has packets to be sent it broadcasts the RREQ packets. If the node receiving this RREQ packet is not destination node it again broadcasts the RREQ packets or if it is destination node it sends ACK packet or if the node is aware of the destination node it sends the route information to the source node. In case of PSR, the each node in the network creates link cost and adds it to the route cost. The total cost is stored as Min-cost in the packet header. Only if the forthcoming packet has this Min-cost less than the previous

packet, then it is permitted to be forwarded or broadcasted. Thus PSR protocol saves more amount of power by decreasing the number of packets to be broadcasted in the network.

## IV. Power Saving By Using Power Management Technique

MANET is a mesh wireless network in which each node in the network is connected to every other node in the network. Hence failure of any node does not affect the communication of the entire network rather the communication to that particular node is affected. In MANET, every node performs transmission of packets, forwarding the packets, receiving and processing the packets. Thus it experiences three types of states: transmitting state, receiving state and sleeping state. Each state consumes different amount of energy. Transmitting state consumes the most energy assigned to the node as most of its energy is wasted in transmitting the packets and this can be minimized according to the methods discussed in the section.3. Receiving state also consumes energy but less compared to that of the transmitting state. Sleeping state can also be called as dozing state or listening state. During this state it listen the channel but cannot transmit or receive any signal from other node. In some networks, a wakeup is sent in order to wake up the node from the sleeping state.

Power management is a method of saving power in which the node switches between active state and sleeping state to reduce the power consumed and prolong the life of the network. Power management technique is simple if all the nodes are in same clock. In MANET, the nodes enter and leave the network at any time and hence maintaining synchronization between the all the nodes is impossible. MANETS are asynchronous networks. In asynchronous networks the power management is difficult task. The studies related to power management techniques used in the MANETs are seen below.

The first power saving protocol that uses power management technique concentrates on the simple quorum [7] in which all the nodes maintains the same quorum with the same Scheduled Repetition Interval (SRI). Even though this works on asynchronous network, it is not so much effective when the SRI of the nodes varies. Next is the Cyclic Quorum systems proposed by the Jiang *et al.*, in [8] where the nodes have the same SRI with different quorums of their own. Consider a network with the SRI =5 then there are five different quorum subsets possible. The quorum table for this case is given in the Table. 1.

**TABLE. 1**
**Quorum table for SRI =5**

| Subsets | Position of Beacon period | |
|---|---|---|
| q0 | 0 | 1 |
| q1 | 1 | 2 |
| q2 | 2 | 3 |
| q3 | 3 | 4 |
| q4 | 4 | 0 |

The slot number given in the table acts as the beacon period and the rest are the normal data period. The node which enters the sleeping selects one of the quorums from the above table. There is constraint present in this is that the two communicating nodes must select the same quorum or else the communication between them fails.

In the work of Shan-Hung Wu et al., [9], asynchronous cyclic quorum is proposed for clustered MANETs which is the first asymmetric quorum systems. Here the network is divided into clusters and each cluster is assigned a cluster head on its residual power basis. Each network consists of gateway or relay that connects various clusters. Two types of quorums are used: s-quorums, a- quorums. Basic cyclic quorum requires overlapping of awake periods of all nodes for effective communication where as the overlapping awake periods of cluster heads of different clusters is enough for effective inter cluster communication. Even though the cluster head consumes more power this protocol enhances the overall lifetime of the cluster. It prolongs the lifetime of the network as a whole of about 52% when compared to the cyclic quorum protocol.

The neighbor maintenance procedure is grid system instead of the table used in the above methods. Consider the SRI= 9 then the grid is filled row-wise starting from left to right and top to bottom s shown in the Fig.2

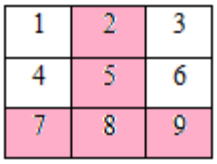


**Fig.2 Grid pattern for SRI=9**

The shaded portion in the above grid forms the beacon period and the rest forms the normal data period. Here the two nodes communicating have their own repetition pattern interval and different quorum. The transmitting node sends its beacon frame in any one of the above interval that is shaded such that it intersects with the shaded portion of the receiving node which is the beacon period of the receiving node. This in turn increases the probability that transmitting node sends the messages to receiving node when it is awake. This is effective compared to the previous method in the sense that all the nodes need not maintain the same table to communicate with each other. But this also possess a drawback where the SRI must be of the square number or prime number where in most it is preferably to be square to form the grid easier. This limits that a node which has SRI which is not a square cannot communicate efficiently with the other nodes in the network.

Shan Hung Wu et al.,[10] proposed Hyper Quorum Systems (HQS) in which the neighbor maintenance procedure supports any quorum of arbitrary length. Here when the neighbor is discovered, an imaginary plane is constructed. This imaginary plane is of length mod (a, b) where a and b are the SRI length of the two communicating nodes respectively. HQS protocol not only increases the residual power of the network it also increases the probability of neighbor discovery. Thus throughput, packet delivery ratio is also improved. With this protocol, a node entering the network can easily communicate with the rest of the nodes without any change in its quorum structure. Another advantage of using this protocol is controllable delay. This

provides 41% improvement in the power saving compared to the ACQ protocol.

Zi-Tsan Chou et al., [11] proposed OFAA protocol that uses power management technique to save the power. Compared to the previous methods the structure of the beacon interval is changed. This new structure decreases the active time of the node which means decreased duty cycle to reduce the power. The neighbor maintenance procedure is cyclic quorum table. The duty cycle of OFAA protocol is only 50% of the existing protocol. The quorum table is constructed such that it supports SRI of arbitrary length between 3 and 13. However, the nodes with SRI greater than 13 are not possible to communicate with other nodes. Since node with SRI above 13 is a rare case this is effective in terms of reducing the power consumption.

## V. Conclusion

MANET is the network of devices that communicate with the help of instant infrastructure. Each node is provided with a battery backup. Efficient use of this battery power is essential in order to establish a long term communication between any two nodes in the network. In this paper, number of methods which are used in each category like power saving by using variable transmission power, power saving by using power aware routing protocol and power saving by using power management techniques are seen. This gives a better view on which method can be used depending on the scenario where the MANET is used. One of the methods discussed above can be used depends on the factors such as distance between the two nodes, its delay tolerance, data traffic rate, criticl usage of battery power etc, using suitable algorithm not only enhances the life time of the network it makes the communication more effective in terms of throughput, PDR and delay.

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