

Overview of Energy Consumption and Propagation in MANET

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ABSTRACT: Ubiquitous smart devices with embedded sensors are paving the way for mobile ad hoc networks (MANETs) that enable users to communicate directly, thereby playing a key role in Smart City and Internet of Things applications. In such smart environments, people with smart devices (nodes) can freely self-organize and form self-configuring MANETs to send and forward data packets to a destination over multiple hops via intermediate nodes. However, the energy consumption during routing remains a challenge in such ensemble mobile environments due to the limited battery capacity of mobile devices. This challenging issue has received substantial research attention, necessitating an exhaustive literature search over the variety of academic fields addressing this topic. The main motivation of this paper is to review various power-efficient routing schemes in MANETs that have recently been proposed to reduce the energy consumed when transmitting and receiving packets during active communication. The review covers various state-of-the-art protocols for each category and highlights their operation concepts, design challenges and key features. In addition, the energy consumption modes are also discussed. Finally, we provide a conclusion and suggest potential directions for future research in the field..

KEYWORDS: MANET, Routing protocols, Propagation models, Energy Consumption Modes..

I. INTRODUCTION

The recent evolution of ad hoc wireless technologies has allowed mobile ad hoc networks (MANETs) to construct spontaneous connections among mobile devices without any infrastructure [1, 2]. Moreover, with the emergence of sensor-enabled smart mobile devices, MANETs have become an essential component in the infrastructure of Smart City and Internet of Things (IoT) scenarios because people with smart devices can freely and dynamically form a self-configuring MANET to send, receive and share data in a restricted zone [3]. In a such a smart environment, MANETs, Wireless Sensor Networks (WSNs) and Wireless Mesh Networks (WMNs) represent key technologies providing several IoT applications and services to users. Furthermore MANETs have found a variety of applications in health care, battlefield communications, disaster recovery, crisis management services education organizations, ad hoc collaborative computing, social activities and conference halls.

Despite the attractive applications of MANETs, these systems continue to face many challenges and constraints that require further investigation prior to the widespread commercial deployment of MANETs. The main constraints that can affect MANET design are as follows: (1) the limited energy and lifetime of the battery, quality of service (QoS), infrastructure-less and autonomous configuration, dynamic network topologies, the mobility of nodes, wireless link reliability, variation in node capabilities, multi-hop routing scalability, multicast support and security threats [4]. Therefore, routing protocol plays a significant role in such networks, and there remains a substantial need to consider the above constraints of MANETs in the development of new routing protocols to enable the efficient forwarding of

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packets over a wireless medium, mainly when the source and destination are non-neighboring nodes. The routing protocol must select the optimal route between pairs of source-destination nodes in terms of energy consumption and QoS metrics such as available link bandwidth, average end-to-end delay, packet losses and average jitter.

Wireless sensor network (WSN) is composed of thousands of sensor nodes. Sensor nodes continue to collect data, data fusion, transmission and exchange data, to realize the whole network status monitoring, data processing and other related functions. It integrates sensor technology, embedded computing technology, modern network and wireless communication technology and distributed information processing technology [5]. Sensor nodes are small volume and low power consumption, however, the accuracy of the data transmission is influenced by factors such as bandwidth, transmission delay and energy. Therefore, the main consideration is to reduce the node energy loss is design for wireless sensor networks

1.1 Routing Protocols in MANET

According to the underlying network, three types: data-centric, hierarchical and location based as shown in figure 1.

A. Routing protocols based on functions

Proactive: A routing table is generated at each node, so that routing information is kept for every node in the network. Routing information is periodically updated [6].

Reactive: No routing table is generated and route discovery is done as needed or on an on-demand basis. The route information is kept for future reference.

Hybrid: Combines the characteristics of proactive and reactive routing. Furthermore, hybrid routing protocol is powerful in reducing the cost of the network. It first computes all routes and then improves the routes at the time of routing [7].

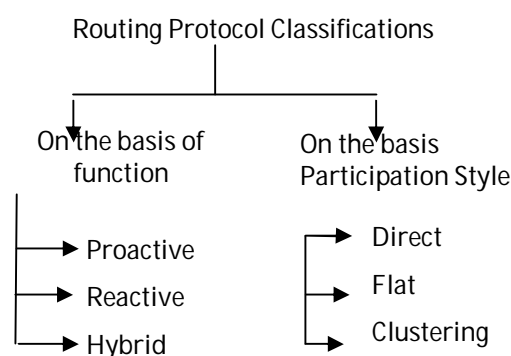


Fig- 1: Classification of Routing Protocol

B. Routing protocols based on participation style of nodes

Direct: Allows nodes to send information directly to base station/s[8-10].

Flat: If any node needs to send data, primarily it will find a valid route to the base station and then forward it [8].

Clustering: The whole area is divided into a number of small clusters then each cluster will have a cluster head (CH) and only this cluster head will directly communicate with the base station [10].

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On the basis of above three categories some important protocols are AODV, DSDV, DSR and AOMDV, each one of them have specific quality in different aspects of routing like load balancing, shortest path finding, and energy.

DSDV: It is a Destination Sequenced Distance Vector protocol, it comes under proactive category. This protocol is based on Bell-Man-Ford routing algorithm. In DSDV protocol each node maintain routing table which contains information of all possible destination node in network, each node entry has specific sequence number, if any new node is joined to network recently then that node has highest sequence number, also when any node left the network then this information is broadcast by transmitting packets to all node in network so that they can update their routing table, so the changes in routing table are extremely dynamic [11].

AODV: It is Ad-hoc on Demand Distance Vector Routing protocol [11] it comes under reactive protocol and based on distance vector algorithm. This algorithm uses different messages to discover and maintain links among nodes, means whenever any node want to communicate or send data packets to other specific node then it first find out all possible routes, it send route request to all neighbor route and all node will reply with specific message to source node. When any node send route request (RREQ) to all other nodes, the sender node will maintain all acknowledged messages from other requested nodes which helps to find route for the destination node as well as it indicate that all nodes are alive. If any other node not giving acknowledgment to the sender's request (request response: RREP) then sender node will remove that link as well as entry of that node from routing table.

DSR: It is Dynamic Source Routing protocol, it comes under reactive protocol. DSR protocol helps to discover desired destination root dynamically among the available roots. In DSR protocol when node sends root request (packet), then this packet stores all paths through which it has travelled to reach to the destination node. This concept reduce the periodic routing of messages which helps to reduce network bandwidth overhead, conserve battery power also avoid large routing updates through Ad-hoc networks.

AOMDV: The Ad-hoc On-demand Multi-path Distance Vector (AOMDV) routing protocol is multipath extension of the Ad-hoc On-demand Distance Vector (AODV) routing protocol. AOMDV [11] has three novel aspects compared to other on-demand multi-path routing protocols. Firstly, it does not have intermodal coordination overheads like some other protocols. Secondly, it ensures disjoint of alternate routes via distributed computation without the use of source routing. Thirdly, AOMDV computes alternate paths with minimal additional overhead over AODV. It does this by exploiting as much already available alternate path routing information as possible.

ZRP: Zone Routing Protocol [12] is suitable for big range of MANETs, significantly for the networks with large coverage and numerous mobility patterns. Within this protocol, every node pro-actively maintains routes with a neighborhood region, which is thought as routing zone. Route creation is performed by employing a query-reply mechanism. For creating completely different zones inside network, a node first has got to recognize who its neighbours are. A neighbour suggests that a node with whom direct communication is sometimes established, that is among one hop transmission array of a node. Neighbour discovery facts are used as being a basis for Intra-zone Routing Protocol (IARP), which might be described in more detail in [13]. As an alternative to blind broadcasting, ZRP runs on the query control mechanism to cut back route query traffic by guiding query messages outward from your query source and far from covered routing zones. A covered node is basically a node that belongs to the routing zone of any node that has received a route query. Throughout the forwarding with the query packet, a node identifies be it via its neighbour or not. If yes, then it marks most of its familiar neighbouring nodes within the same zone as covered. Thus query is relayed until it reaches its final destination. The destination successively sends back a response message through the reverse path and helps to create the path.

1.2 Energy Consumption Modes

Energy is very important part in Ad-hoc network because in this network all nodes communicate with each other by consuming power. The only source for power is battery of mobile node. The node consumes energy in Sending mode, Receiving mode, idle mode or sleep mode. In idle mode and sleep mode there is a constant power drain because transceiver is constantly hearing signal for itself. When node sends packet or data at that time many Ad-hoc routing protocols and mobility models are available, each having different characteristics and

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scenario so each may consume different amount of energy, so the best one is who sends packets at successful rate with consuming minimum energy[14].

A. Transmission Mode

In transmission mode energy consumed by the node to transfer the packets or data, in this the amount of energy is depend upon the number of packets being send by that node, large the number of packets so large amount of energy is consumed. It also depends upon which Ad-hoc routing protocol and mobility model is used. Generally the transmitted power is represented by Tx.

$$P_t = T_x / T_t \text{ Watts}$$

Where P_t is power consumed in transmission mode T_x is energy consumed in transmission, T_t is time to consume that energy.

B. Receiving Mode

In this energy is consumed in receiving mode, because in this mode nodes are receiving packets from sender. The power in receiving mode can be given as:

$$P_r = R_x / T_x \text{ Watts}$$

Where P_r is the power at receiver node in Watt, R_x is the energy in receiving mode.

C. Idle Mode

In this node neither sends nor receives packets so it is called as idle mode. Still it consumes energy the reason is that the node has to continuously check and update their status table to intimate that any new node added in network. The amount of energy consumed by node in idle mode is less than the energy consumed in sending or receiving mode because in idle mode the actual communication among node is not going on. So power in idle mode is nearly equal to power in receiving mode.

$$P_i = P_r.$$

D. Overhearing Mode

When node receive packets that are not destined to it then it is a overhearing node and it may consume energy in receiving those packets, it is undesirable energy consumption, the power consumption in overhearing mode is given as

$$P_{\text{over}} = P_r$$

Where P_{over} is power consumed in overhearing mode and P_r is power consumption in receiving mode.

The main target of adding Energy model is to calculate energy in transmission, receiving, idle and overhearing mode. If consumed energy is minimum then the lifetime of network is longer because all nodes get energy from battery.

1.3 Propagation Models

The propagation model is the model which helps to predict and analyze the power of received signal of each packet on each node. In Network Simulator there are three main propagation models which are Two-ray model, free space model and Shadowing model [15]. At physical layer of each node there is one specific threshold value which indicates that if the received signal power of received packet on each node is below than that specific value then that packets are dropped by that node.

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A. Two Ray Model

In this model direct path ray and ground reflected ray are used. The accuracy of this model is much greater than other models. This model is preferred for nodes which are separated by long distance. In this type of model the power of received signal is given by:

$$P_r = [P_t \times G_r \times G_t \times h_t^2 \times h_r^2] / d^4 \times L$$

Where P_r is power of received signal, P_t power of transmitted signal, G_r and G_t are gain of antenna in transmitted and receiving mode, d represent distance between two antennas, L is system loss which has specific value.

B. Free Space Model

The Free Space Model assumes ideal assumption that the sending and receiving of packets are done by line of site action. Basically in this model the Transmitting antenna send signals in circular form around it so the receiving antenna which is in the range, it will receive packets otherwise loose the packets. The power in free space model is given by following equation:

$$P_r(d) = [P_t \times G_t \times G_r \times \lambda^2 / [(4\pi)^2 \times d^2 \times L]$$

Where P_t and P_r are the power of transmitter and receiver Antenna, G_r , G_t are gain of transmitter and receiver Antenna, d is distance between transmitter and receiver, λ is wavelength.

C. Shadowing Model

As both the free space model and Two-ray model are using distinct function of distance to predict the strength of received signal although the power at different location on each node is varying. Both models are predicting the mean received power, so to get more accuracy in received signal power use Shadowing model. The Shadowing model has two parts, first part is Path loss Exponent and second is Log normal random variable.

1.4 Radio Energy Models

The Radio Energy Models [16] reads the energy consumption specifications of the radio where the specifications are defined by the configuration parameters which are the power supply voltage of the radio, electrical current load consumed in Transmit, Receive, Idle, and Sleep modes. Each state represents a different level of energy consumption such as in transmit mode, receive mode, idle mode and sleep mode.

A. MicaZ Radio Energy Model

The MicaZ radio energy model is a radio-specific energy model which is pre-configured with the specification of power consumption of MicaZ motes (embedded sensor nodes).

B. Mica Motes Radio Energy Model

The Mica Motes radio energy model is a radio-specific energy model which is pre-configured with the specification of power consumption of Mica motes (embedded sensor nodes).

C. Generic Radio Energy Model

The main feature of the generic model is estimation of energy consumption for the radios with common modulation schemes (analog and digital) and common classes of amplifiers (class-A,B,C,D). Further, the model can estimate energy consumption in transmitter for the case of continuous transmits power level.

II. RELATED WORK

- 1) **Sonika Kandari Manoj Kumar Pandey, Springer 2015**, Author analyzed the comparison of three routing protocols namely AODV, DSR and DYMO under Residual Life Estimator Battery Model. The nodes of designed scenario communicate all the way through constant bit rate (CBR) application traffic.

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- 2) **Ray, N. K., & Turuk, A. K, 2014**, Authors have proposed a routing technique which considers a cost metric being function of battery residual power and energy consumption rate of participating nodes for path computation, along with minimization of over-utilization of participating nodes.
- 3) **Rohit Sangwan et al. 2013**, Author presents performance comparison of proactive, reactive and hybrid algorithms. The performance analysis is based on different metrics of Physical Layer such as Power Consumed in Transmit Mode, Power Consumed in Receive and Idle Modes, and metrics of application layer like Average End to End Delay, Average Jitter, Throughput and Packet Delivery Ratio based on the simulation analysis.
- 4) **Anshul Shrotriya, Dhiraj Nitnawwre 2012**, Author gave analysis of energy consumption in Wireless Sensor Network based upon different modulation techniques. There are two main energy models, MICA MOTES and MICA Z. This research investigated the more energy efficient energy model under different modulation schemes. It has been found that, based upon the modulation schemes; mica z performs better than mica mote energy model.
- 5) **Maryam Sabet, 2016**, In this paper, a new distributed energy efficient multi- level route-aware clustering algorithm for WSNs called MLRC is proposed MLRC applies a route conscious manner in which nodes could gain desired information about possible routes to the destination Cluster heads are elected based on effective parameters. The algorithm could moderate energy consumption of relays close to the base station with assigning probability to adjacent cluster head and avoiding the insistence on the nearest cluster head selection.

III. EXPERIMENTAL RESULTS

A. Simulation Setup

Aim of this study is to analyze the energy consumption by the AODV, DSR and DYMO routing protocols using different radio energy models namely generic, micamotes, and micaZ. The simulations have been performed on QualNet 5.0.2 simulator.

The simulation has been carried out in terrain size of 1500Mx1500m with 100 nodes placed randomly. The performance of AODV, DSR and DYMO routing protocols have been evaluated on basis of average jitter rate, average end-to-end delay, throughput, energy consumed in transmit mode, energy consumed in receive mode, and energy consumed in idle mode performance metrics.

In the study generic, mica-motes and micaZ radio energy models with fixed parameters values have been used as mentioned in Table I.

Table I. Parameters Considered for Simulation

S.No	Parameters	Values
1	Simulator	Qualnet 5.0.2
2	Terrain	1500*1500m
3	Antenna Model	Omni Directional
4	No. of Nodes	100
5	Radio Type	802.11b
6	Data Size	512 bytes
7	Data Rate	2 mbps

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8	Mobility Model	Random Way Point
9	Propagation Model	Two Ray Model
10	Traffic Source	CBR
11	Node Speed	Min=1m/s, Max=10m/s
12	Pause Time	10m/s
13	Battery Model	Linear
14	Energy Model	Generic, Mica-motes, Micaz
15	Routing Protocols	AODV, DSR, DYMO
16	Performance Matrix in Application Layer	Throughput, Average Jitter, End to End Delay
17	Performance Matrix in Physical Layer	Energy Consumption in Transmit mode, Receive Mode and Idle Mode

B. Results and Discussion

In this paper, the performance comparison of AODV, DSR and DYMO routing protocols have been conducted in Wireless Ad hoc Networks by using different radio energy models.

Average Jitter Rate Analysis

From the Fig. 2, the DSR routing protocol performed better than DYMO and AODV routing protocols in terms of average jitter rate.

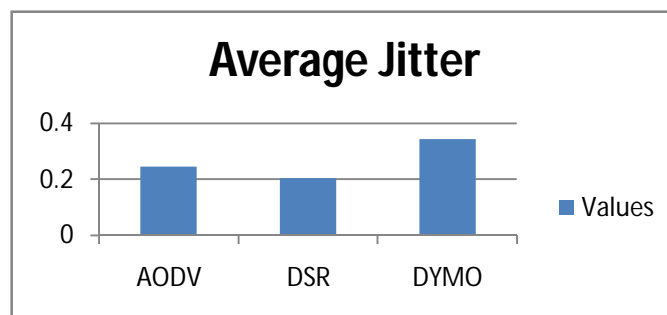


Figure 2: Routing Protocol vs Average Jitter

Average End-to-End Delay Analysis

According the results shown in the Fig. 3, the DSR routing protocol outperform than DYMO and AODV routing protocols.

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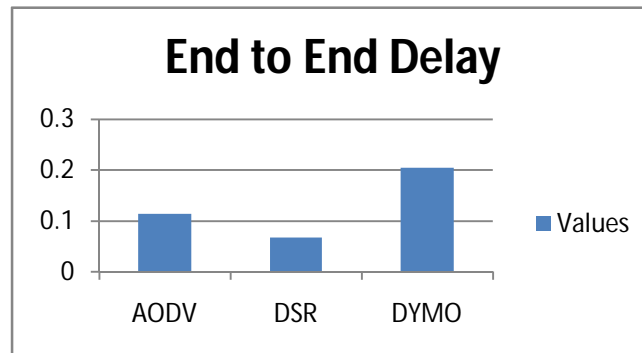


Figure 3: Routing Protocol vs End-to-End Delay

Throughput Analysis

As per the results shown in Fig. 4, the throughput is better of DSR routing protocol in comparison to DYMO and AODV routing protocols.

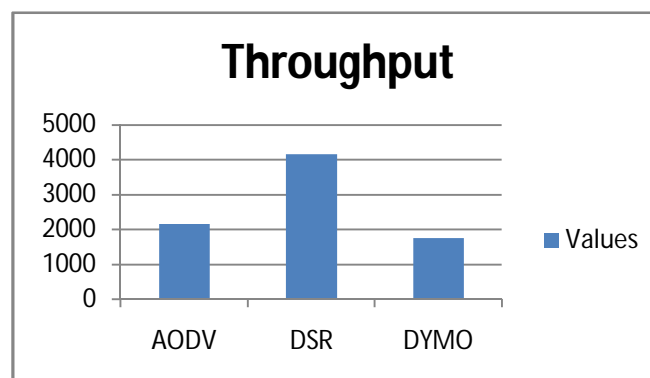


Figure 4: Routing Protocol vs Throughput

Energy Consumption in Transmit mode Analysis

From Fig. 5, it has been observed that wireless nodes consumed less energy in Mica-motes radio energy model to transmit the data using AODV, DSR and DYMO routing protocol in comparison to Generic and MicaZ energy models.

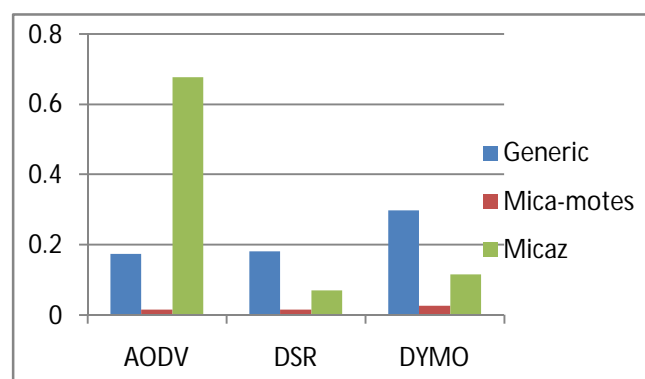


Figure 5: Energy Models Vs Energy consumed in Transmit mode

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Energy Consumption in Receive mode Analysis

Shown in Fig. 6, the wireless nodes consumed less energy in Mica-motes energy model in AODV, DSR and DYMO routing protocols in comparisons to Generic and micaZ radio energy models.

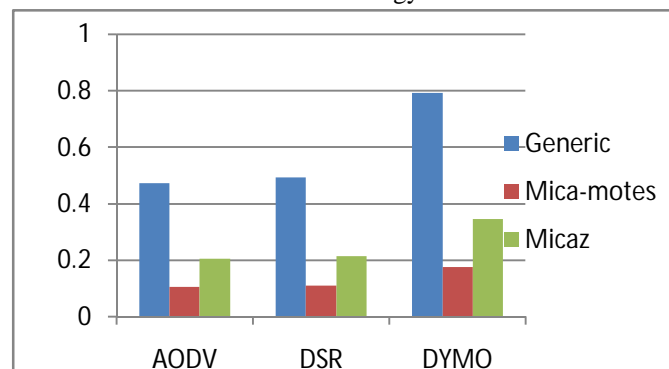


Figure 6: Energy Models Vs Energy consumed in Receive mode

Energy Consumption in Idle mode Analysis

The simulation results of energy consumption in idle mode have been depicted in Fig. 7. It has been observed that the wireless nodes consumes less energy in Mica-motes and micaZ radio energy models as compare to Generic radio energy model using AODV, DSR and DYMO routing protocols.

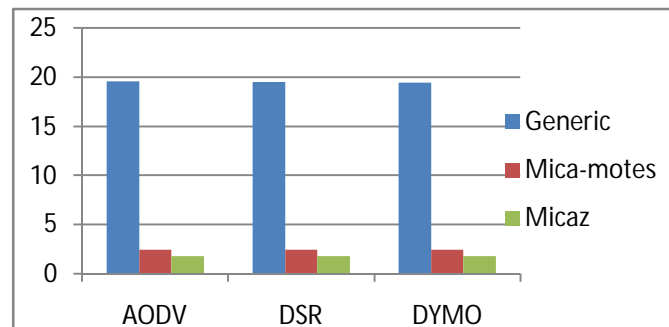


Figure 7: Energy Models Vs Energy consumed in Idle mode

IV. CONCLUSION

In conclusion, the evolution of sensor-enabled mobile devices toward smart environments has catalyzed the development of MANETs, which play a key role in providing users with a variety of IoT applications and services. The limited energy resources of nodes represent one of the critical issues facing efforts to apply MANETs, particularly with respect to the design of routing protocols. In this paper, we concentrated on the power-efficient routing protocols that have been developed for MANETs to obtain reliable paths for data packet routing that require less energy. In this paper the analysis of energy consumption in transmission mode, receiving mode and idle mode has been carried out. Consequently, further investigation on developing a routing scheme that can extend the network lifetime, reduce energy consumption, and ensure network connectivity while simultaneously improve the QoS remains in high demand. In this paper energy consumption by the wireless nodes using three routing protocols AODV, DSR and DYMO for communication has been compared with respect to generic, mica-motes and micaZ energy models for a particular simulation scenario. Results show that the Mica-motes energy model is best as compared to micaZ and Generic energy models and also observed that the DSR outperform AODV and DYMO routing protocols in energy radio models.

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