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Analysis of Energy Efficiency and Throughput for IEEE 802.11 based Mobile Adhoc Networks

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Abstract: ***In Mobile Adhoc Network (MANET) there is no central infrastructure and the mobile devices are moving randomly, they may give rise to various kinds of problems, such as energy efficiency and power consumption within a network. Our aim is to make energy efficient. Lot of research work has been done on energy efficiency in MANET with different constraints and with different protocols. One critical issue in MANETs is how to conserve energy of devices in the network. In this paper Energy model is used in GPSR protocol and various threshold are implemented at the MAC Layer to conserve energy.. Finally performance of entire network using different parameters like Total Energy Consumed, Throughput has been analyzed.***

Keywords: MANET, GPSR, Energy Efficiency, Throughput, Energy Model

1. Introduction

A mobile adhoc network (MANET) is a collection of wireless mobile nodes which have the ability to communicate with each other without having fixed network infrastructure or any central base station. Mobile nodes are not controlled by controlling entity, they have connectivity to others unrestricted mobility. Network management and Routing are done cooperatively by each other nodes. Because to its dynamic nature MANET has larger security issues than conventional networks. A MANET(Mobile Adhoc networks) is a type of adhoc network that change there locations and configure itself on the fly. Because MANETS are mobile, they connect to various networks with the use of wireless connections. This can be a Wi-Fi connection, or other medium, such as a cellular transmission.

A mobile ad hoc network [1,2] is a dynamic distributed system of wireless mobile nodes in which the nodes can move in any direction, independent of each other. In MANET there is no central infrastructure and the mobile devices are moving randomly, they may give rise to various kinds of problems, such as energy efficiency and power consumption within a network. Adhoc wireless networks have received widespread attention in recent years. Figure 1 shows a general structure of MANET. In most cases the devices which is used in adhoc networks requires portability and hence they also have size and weight constraints along with the restrictions on the power source. Mobile nodes are more bulky and less portable if battery power is increases. For these networks the energy efficiency remains an important design consideration.

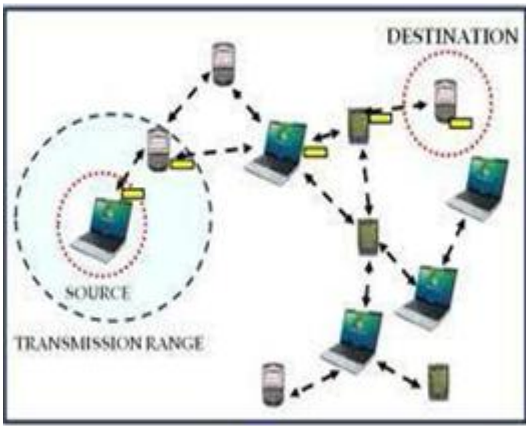

Figure 1: Mobile Adhoc Networks

To maximize energy efficiency is one of the most important objectives of MANET, since nodes in MANET depend on limited energy resources. Adhoc networks have no fixed networking infrastructure unlike wired networks or cellular network, applications of adhoc wireless networks are in those areas where it is not economically practical or physically possible to provide wired networking infrastructure. For example it is not possible in a battlefield situation to install a conventional network in hostile territory. adhoc wireless network in such a situation offers a promising solution. An adhoc wireless network can be modelled as a graph in which each vertex represents a communication node, and each link indicates that the corresponding vertices can communicate with each other directly.

1.2 Need for Power Management in MANET

The main reasons for power management in MANET are the following:

- **Limited Energy Reserve:** Adhoc networks have very limited power resources. If gap between the power consumption requirements and power availability increases, this adds to the importance of energy management.

- **Difficulties in Replacing Batteries:** In some battlefield situations, it is very difficult to replace or recharge batteries. Power conservation is essential in such type of situations situations.
- **Selection of Optimal Transmission Power**: The battery charge will increase with the increase in transmision power. An optimum transmission power to be selected for effectively utilize the battery power.
- **Constraints on the Battery Source:** The size of the mobile nodes increases if the batteries will increase. If we reduce the size of the battery, it will results in less capacity. Energy management techniques are necessary to reduce the size of the battery,
- **Channel Utilization:** Transmission power will reduces as the frequency reuse will increase. To maintain the required SIR at receiver power control is required and to increase the channel reusability
- **Lack of Central Coordination:** Some of the intermediate node act as relay nodes due to lack of central coordination. Depletion of power source is faster if the proportion of relay traffic is more and as a result the corresponding vertices can directly communicate with each other.

1.3 Power Aware Routing Protocols in MANET

Activity-based protocols address the issue of power consumption as it relates to network activity, i.e. the actual transmission of data between nodes in the network. These protocols focus on making intelligent, power-aware routing decisions that govern the actual transmission of data. We further divide activity-based protocols into two classifications based on different routing tasks: unicasting and multicasting/broadcasting. Unicasting is further divided into Active energy saving and Maximizing network lifetime. In Unicasting context, existing protocols focus on two separate issues: maximal energy saving during delivery of single packet(active energy saving) and maximizing overall network lifetime.

Active energy saving: Active energy saving protocols focus on minimizing the total consumed power per packet. Main goal is to choose a routing path for the delivery of an individual packet that consumes the minimal amount of energy.

Maximizing Network: Protocols that maximize overall network lifetime focuses is to distribute the energy consumption among all nodes in balanced manner. If the route with the maximal energy saving is chosen for delivery, the subset of nodes along this route will be overutilized and therefore drained in a short period of time, which may lead to network partitioning. Multicasting protocols deal with power efficiency when a single message is sent to multiple destinations.

Connectivity based protocols look beyond the issues of transmission. Maintaining effective connectivity for a wireless network is essential to almost any operation. If the connectivity of a wireless network is too dense, it causes frequent interference among nodes. If the connectivity id too sparse, the network is sensitive to node or link failure. Connectivity based protocols can be categorised into two parts: topology control and passive energy saving.

Topology control: Topology control protocols adjust nodes's transmitting power to save energy while maintaining effective network connectivity.

Passive energy saving: Passive energy saving protocols save energy by simply turning off some idle nodes, since energy consumption when nodes's ratio is idle is not negligible

1.4 Position Based Routing Protocol

Greedy Perimeter Stateless Routing Protocol (GPSR)
Greedy Perimeter Stateless Routing (GPSR) is a well-known and most commonly used position-based routing protocol for MANETs [3]. GPSR works as, the source periodically uses a location service scheme to learn about the latest location information of the destination and includes it in the header of every data packet. If the destination is not directly reachable, the source node forwards the data packet to the neighbor node that lies closest to the destination. Such a greedy procedure of forwarding the data packets is also repeated at the intermediate nodes. Sometimes if forwarding node could not find a neighbor that lies closer to the destination than itself, the node switches to perimeter forwarding. In perimeter forwarding, the data packet is forwarded to the first neighbor node, when the line connecting the forwarding node and the destination of the data packet is rotated in the anti-clockwise direction. The location of the forwarding node in which greedy forwarding failed (and perimeter forwarding began to be used) is recorded in the data packet. After sometime switch back to greedy forwarding when the data packet reaches a forwarding node which can find a neighbor node that is away from the destination node by a distance smaller than the distance between the destination node and the node at which perimeter forwarding began. During both greedy forwarding and perimeter forwarding, the energy available at the chosen neighbor node to forward the data packet is not considered. In networks of moderate and high density, greedy forwarding happens to be used more than 98% of the time and the need for perimeter forwarding is highly unlikely. This motivated us to optimize the greedy forwarding phase of GPSR by considering the energy available at the neighbor nodes of a forwarding node before deciding the next hop node for transmitting the data packet.

1.5 Energy Consumption at Different Layers in MANET

Physical Layer: There are several factors which effect the power consumption on the physical layer including modulation scheme, data rate, transmit power, and different modes of operation.

MAC Layer: There are different sources of energy consumption in MAC Layer comprising collision, overhearing, control packet overhead, and idle listening.

Network Layer: Main functionality of network layer is routing of information. More energy is consumed in retransmission of the information.

Transport Layer: Transport layer functionalities include end-to-end data delivery, acknowledged and unacknowledged services and flow control. Energy is consumed at this layer when there is no flow control i.e no buffer available while receiving the packets from the nodes.

In this paper work is done on MAC layer with Implementation of various thresholds with energy model to enhance the GPSR.

2. Related Work

In [4], The recent years have seen a tremendous increase in the number of Wi-Fi enabled mobile devices. All Devices which have wireless networking capabilities are such as PDAs, high-end cell phones, tablets, gaming devices etc.. In mobile ad-hoc networks, these devices participation may extend their capabilities, e.g., when no Wi-Fi base stations are within range, they provide internet accessability and to communicate with each other when no other networking infrastructure is available over multiple hops. With continuous participation in a MANET one of the problem that occur is energy consumption Various types of power saving routing protocols are required to overcome the problem that allow the devices to preserve as much energy as possible to keep network connectivity.

In **[5]**, authors proposed a location-aided power-aware routing protocol , protocol is fully distributed such that only location information of neighboring nodes are exploited in each routing node. In LAPAR, a forwarding node constructs its relay regions based on the position of its neighbors, and forwards a data packet to the specific neighboring node whose relay region covers the destination. If there are more than one neighbours that are able to cover the destination, the algorithm makes greedy choices to determine the next hop to forward the packet.

In [6], authors proposed that in a MANET, nodes are free to move and organize themselves in an arbitrary fashion. Energy-efficient design is a significant challenge due to the characteristics of MANETs such as distributed control, constantly changing network topology, and mobile users with limited power supply. The IEEE 802.11 MAC protocol includes a power saving mechanism, but it has many limitations. A new energy-efficient MAC protocol (EE-MAC) was proposed. The key idea of EE-MAC is to elect some nodes to form a connected dominating set and use this as a virtual backbone to route packets, while other network nodes, called slaves, stay in power-saving mode. EE-MAC i is a cross-layer design which spans the network layer and the MAC layer.

In **[7]**, Authors proposed that Power conservation in wireless ad hoc networks is a critical issue as energy resources are limited at the electronic devices used. Power-aware routing protocols are essentially route selection strategies built on existing ad hoc routing protocols. Conditional Maximum Residual Packet Capacity (CMRPC) Protocol most comprehensively captures tradeoffs of network lifetime, energy efficiency and reliability in packet delivery. The ones we have listed include Minimum Total Transmission Power Routing (MTPR) and Conditional Min-Max Battery Cost Routing (CMMBCR) with the latest being Conditional Maximum Residual Packet Capacity (CMRPC). The simulation suggests the threshold value of CMRPC protocol to be set approximately in range of 20-40%. With such values the protocol shows its best performance because of the combination of MRPC and minimum total energy routing.

In [8], authors proposed two simple protocols, the Basic Energy-Conserving Algorithm (BECA) and the Adaptive Fidelity Energy-Conserving Algorithm (AFECA), an AFECA is an extension of BECA. These algorithms attempt to improve power consumption with turn off node radios as often as possible . With BECA, each node can be in one of three states: sleeping, listening, or active.. AFECA is an extension of BECA that takes advantage of node density to allow nodes in dense are as to sleep for longer periods of time. AFECA uses an additional timer, Te, to determine how long to keep neighbors in the neighbor set from the time that the node last overheard them. The observation that leads to AFECA's design was that the denser the local area of nodes, the more nodes there are to handle routing.

In [9], authors proposed that A Mobile Adhoc Network is a collection of mobile nodes that dynamically forms networks temporarily, one of the main issue in MANETs is the development of energy efficient protocols due to limited bandwidth and battery life. The conventional MANET routing protocols are DSR and AODV use common transmission range for transfer of data and does not consider energy status of nodes. Authors discussed a new energy aware routing (EAR) scheme which uses variable transmission range. The protocol has been incorporated along with the route discovery procedure of AODV and analyze their performance based on energy consumption, network lifetime and number of alive nodes metrics for different network scenarios.

3. Proposed Work

Since the transmission power required between two nodes increases with the distance between the sender and the receiver. The power level defines the communication range of the node and the topology of the network. Due to the impact on network topology, artificially limiting the power level to a maximum transmit power level at individual nodes is called topology control. MAC layer coordinate all nodes within transmission range of both the sender and the receiver. In the MAC layer, the channel is reserved through the transmission of RTS and CTS messages. Node other than the destination node that hears these messages backs off, allowing the reserving nodes to communicate undisturbed. The power level which defines the area in which other nodes are silenced, and so defines the spatial reuse in the network . Once the communication range of a node has been defined by the specific topology control protocol, the power level for data communication can be determined on a per-link or even per-packet basis.

Using carrier sense threshold CSThresh and receive sense threshold RSThresh to determine whether frame is received correctly. If Pr < CSThresh the station will discard the frame. If Pr >= RSTresh frame can be received successfully provided no collision occurs otherwise station will mark the frame as received.If the other frames arrived at the receiver simultaneously, it compares the ratio of Pr and Pi(interfering Power) to the third threshold, CPThesh(capture threshold). If Pr/Pi >= CPTresh, the frame will receive correctly. Otherwise all frames are discarded because of collision.

3.1 Energy Model

Initial Energy: It is the initial energy of single node in the network.

Idle Power: Even when no messages are being transmitted over the medium, the nodes stay idle and keep listening the medium.

Transmission Power: A node is transmitting a frame with some transmission power.

Receive Power: A node is receiving a frame with some reception power . That energy is consumed even if the frame is discarded by the node because it was intended for another destination, or it was not correctly decoded

Sleep Power: when the radio is turned off and the node is not capable of detecting signals, no communication is possible. The node uses the power that is largely smaller than any other power.

Table 1: Energy Model

Initial Energy	2.5
Transmission Power	31.32E-3
Receive Power	25.28E-5
Idle Power	712E-6
Sleep Power	144E-9

4. Results

Table 2: Comparision between Consumed Energy at different simulation times

Simulation Time	*Energy(P)*	*Energy(E)*
80	17.401	40.655
100	21.221	55.792
150	46.625	95.716
200	55.128	117.529
250	64.413	139.333
300	73.318	161.159

Energy (P) are the Consumed Energy in proposed work and Energy(E) are the Consumed Energy

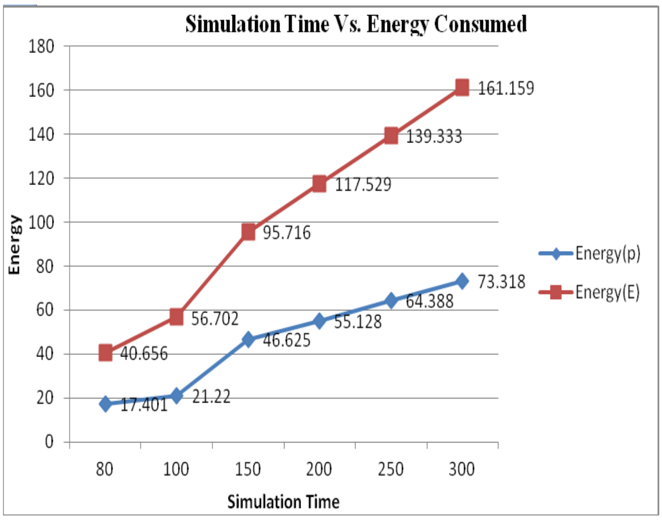

Figure 2: Graph plotted between Simulation Time and Energy Consumed

At simulation pause 80s, It is observed that consumed energy in existing work is 40.655 and consumed energy in proposed work is 17.401. So, 57% energy consumption is less at 80s. At simulation pause 100s, It is observed that consumed energy in existing work is 56.702 and consumed energy in proposed work is 21.221. So, 55% energy consumption is less at 100s. At simulation pause 150s, It is observed that consumed energy in existing work is 95.716 and consumed energy in proposed work is 46.625. So, 51% energy consumption is less at 150s. At simulation pause 200s, It is observed that consumed energy in existing work is 117.529 and consumed energy in proposed work is 55.519. So, 52% energy consumption is less at 200s. At simulation pause 250s, It is observed that consumed energy in existing work is 139.333 and consumed energy in proposed work is 64.413. So, 54% energy consumption is less at 250s. At simulation pause 300s, It is observed that consumed energy in existing work is 161.159 and consumed energy in proposed work is 73.318. So, 55% energy consumption is less at 300s. It is concluded that total 54% energy consumption is less in our work.

Table 3: Comparision between Throughput at different simulation times

Simualtion Time	*Throughput(P)*	*Throughput(E)*
80	352	351
100	1523	1486
150	3097	2999
200	3097	2999
250	3097	2999
300	3097	2999

Throughput(P) are the throughput in proposed work and Throughput(E) are the throughput in existing work.

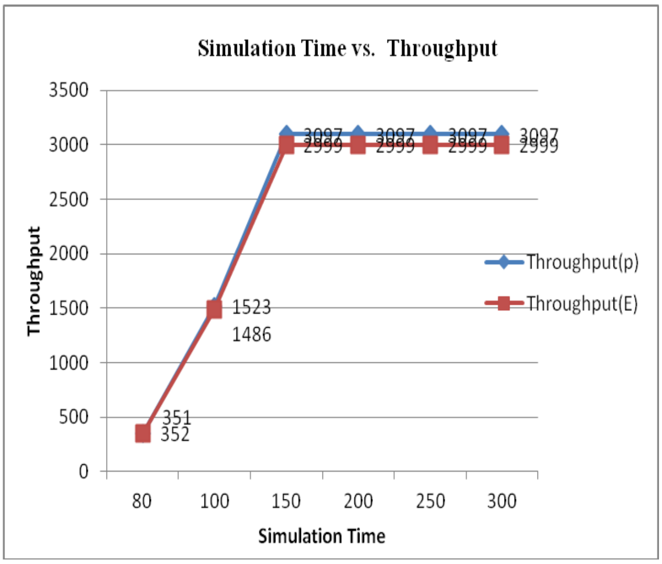

Figure 3: Graph plotted between Simulation Time and Throughput

At simulation pause 80s, It is observed that Avg throughput in existing work is 352 and in proposed work it is 351. So, 0.2% throughput increases at 80s. At simulation pause 100s, It is observed that Avg throughput in existing work is 1486 and in proposed work it is 1523. So, 2.4% throughput increases at 100s. At simulation pause 150s, 200s, 250s, 300s it is observed that Avg throughput in existing work is 2999 and in proposed work it is 3097. So, 3.2% throughput increases at 150s, 200s, 250s, 300s. It is concluded that total 3% throughput is increases in our work.

5. Conclusion

The Energy efficiency continues to be a key factor in limiting the deployability of Mobile adhoc networks. Deploying an energy efficient system exploiting the maximum lifetime of the network has remained a great challenge since years. The time period from the instant at which the network starts functioning to the time instant at which the first network node runs out of energy, i.e. the network lifetime is largely dependent on the system energy efficiency.Since nodes have limited energy in MANET they get out of energy results in interruption in communication link and decrease network lifetime. So the routing protocol must keep energy aspect in consideration. Various routing protocols are used in MANET to conserve the energy but still this is challenging task in MANET. In this paper, GPSR routing protocol is used with energy model and implementing Thresholds CPThresh, CSThresh, RXThresh at the MAC layer. As per result, energy consumption is 54% less and throughput is increased by 3%

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