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Reduction of Power Consumption at Mobile Nodes in MANETS

Abstract: With the advancement in cellular technologies many solutions were proposed for reducing the power consumption of the mobile devices to resolve the issues of low battery power and mobility management. An attempt has been made in the designed scenario for the same. Different routing algorithms, energy models, battery models and modulation schemes are proposed and compared to justify the title. The conventions of node types used are base, mobile and relay.CBR traffic and point to point links are used to connect the nodes. To increase the spectrum of the signal CDMA is used in between RN and BS and OFDMA in between BS and MS. The concept of relay is added to increase the transmission range, when the nodes are in mobility and is not reachable to the base station. The amount of energy utilized is measured for both relay and non relay node network. The configuration and .stat file are used to do the comparison. Dymo (Dynamic Manet on demand routing protocol) is a unicast advanced algorithm which is dynamic in nature and route discovery is explored in the direction of destination node, rather than flooding the packets in all directions as is the case in AODV. This could act as a reason for the consumption of less power in mobile nodes of Dymo when compared to other routing algorithms.

Keywords: CBR, MS, BS, RN, Energy, IEEE 802.16

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1 Introduction

With the gradual development of technologies like LTE, 4G and 5G models for efficient and smooth transition towards advanced leading edge technologies to increase the capacity, connectivity, and battery issues, there is still problem of making advanced technologies compatible with the existing technologies. There are many approaches and algorithm proposed by many researchers to reduce power consumption in MANETS but still the research is in progress. The intention of the experimentation is to reduce power consumption at the mobile station. The scenarios are designed by using 802.11, 802.16 with and without relay node and added with more features of battery model, energy model and different modulation technique to increase the signal capturing facility. The provision to enable OFDMA at the MAC layer is available in IEEE 802.16, thereby making it easier to analyze OFDMA burst received and forwarded to MAC. To model the PHY layer certain characteristics need to be incorporated at the source and the destination end like modulation, coding, noise, interference and antenna gains. In QualNet, a MAC Layer interface consists of Ranging type as normal or CDMA, normal type represent OFDMA modulation by default. The PHY component caters for signal transmission, reception and reflects the effects of the MAC, distortions and interference. As far as latest network scenarios and technological development are concerned, power optimization should be the first and foremost thing of concentration for NGN (Next Generation Networks) as Battery discharge, when experiencing highly mobile environments is more. The scenario is designed with fewer nodes so as to make analysis easier. The network consist of three mobile station, one base station and one relay station connected with a subnet and data transmitted through CBR and point to point link. Dymo is an advanced version of AODV, which is purely reactive protocol with routes computed on demand.

The rest of the paper is organized as follows: section II provides a brief description of related work; section III describes about topologies or architectures designed and analyzed, section IV discusses the result analysis of power consumption, energy models and its statistical analysis. Section V portrays conclusion and future research scope.

2 Related Work

The related work surveyed is summarized as follows

Paper [1] proposes power-efficient, cost efficient and power-cost efficient routing algorithms. Conditional Max Min Battery Capacity Routing (CMMBCR) is demonstrated to calculate the minimum and maximum battery consumption and residual energy. [2] Suggested considering both the total transmission energy consumption of routes and the residual power of the nodes for designing the system with a path to transmit data route with minimum total transmission power above some threshold among the chosen routes. Since less total power is required to forward packets for each connection, the load for most of the nodes must be reduced, thereby extending lifetime. The nodes with lowest battery capacity must be avoided to extend the lifetime of these nodes. Realistic consumption model [3] is used for calculation of energy cost, using channel quality as parameter for ensuring successful delivery of packet. Power-aware routing metrics are proposed in [4] for selecting the routes around congested areas, extend time for network partition and reduce the variance of host's power levels and adjust the cost function. Energy Based Routing algorithm (EBRA) [5] was developed to integrate Dynamic Source Routing (DSR) protocol for ensuring minimum energy consumption rate. The proposed scheme consist of three phases: nodes energy consumption is limited with high mobility; the effect of malicious behavior is reduced to avoid the replaying of packets and the unauthenticated node is identified using the digital signature verification. Efficiency of protocols is evaluated [6] for energy consumption indicating their energy usage of node's, taking into consideration nodes density and mobility. A new approach for optimizing power consumption in MANETs has been proposed and implemented [7] by introducing a threshold value on each node and transmitting the equal length of packet on the route. In [8] the upshot of power optimization in Mobile stations has been observed, optimized and simulated for no hop and multihop scenarios using 802.11 and 802.16 architectures. Different levels of power were taken as input using user defined energy model at the base station, mobile station and relay station with different modulation techniques from base to relay and relay to mobile station to reduce the energy level consumption at the mobile nodes during transmission.[9] specifies using the multi-hop relay networks to improvise the range of the existent cells and analyze the power saving obtained, but still none of the above have taken up the issue of highly mobile environments, such as those experienced while moving in high speed trains, and analyzed networks accordingly. Hence, this paper takes up this task and analyzes as well as compares the performance of the existent topologies with the multi-hop relay topologies. Also in [10] the power optimization based on the traffic load is one type of solution if the network is purely adaptive in nature. Power saving at NSP

(Network Service Provider) i.e at BS side but power saving at client side is still a challenge. Paper[11]is about the routing algorithms, energy models, battery model and propagation model. The different energy models discussed include user defined, Mica motes, Micaz and Generic collaborated with linear battery model and two ray propagation model. A comparative study was made for routing algorithms like AODV, DYMO and DSR for measuring throughput, Average Jitter, End to End Delay and energy consumption. Paper [12] discusses the comparison of Genetic Algorithm and Simulated Annealing meta-heuristics to obtain the minimum energy consumed in ad-hoc wireless networks. The signal power requirements are selected from this paper to compare the path loss and interference in designed scenario. Paper[13] portray the antenna models for measuring the QoS parameters like Average Throughput, Average End to End Delay, Average Jitter, and Packet Delivery Ratio were evaluated to check the performance and efficiency of the network in different scenarios. These performance metrics are used in the designed scenario for measuring the efficiency of the devices.

3 Architectures

Qualnet is used for designing the architectures with *.cpp, *.pcm, *.h, *.config, *.stat and *.h files to get the required functionality in collaboration with visual studio c++ version 2013. The parameters used for designing this continental network topologies with high mobility environment is depicted in table. An adhoc network with BS, SS, internet and point to point links are shown in fig. 1. to represent the designed scenario.

Node 7 is acting as a base node and the blue dotted line in fig. 1 show the random path via which the mobile nodes moves in mobility. A relay node is being added in between base and mobile stations connected by a subnet with an address 190.0.3.2 while the relay and base are connected with a subnet with address 190.0.3.1 as depicted in fig. 2. As node 2 is far apart from the base station it receives the least number of packets. The nodes 1, 2, 3, 7 and 8 are assigned address190.0.2.2, 190.0.2.1, 190.0.2.4 and 190.0.3.2 and 190.0.2.5 respectively. The routing protocols used are AODV and DYMO for devices and subnet connectivity. The Ricean fading model is used since the sight signal is dominant signal seen at the receiver and to apply it for line of sight communication. The unit of time, average interference used in the modeling is seconds and dBm respectively. The comparisons are made in between two AOVD and DYMO to check for low power consumption at the MS.

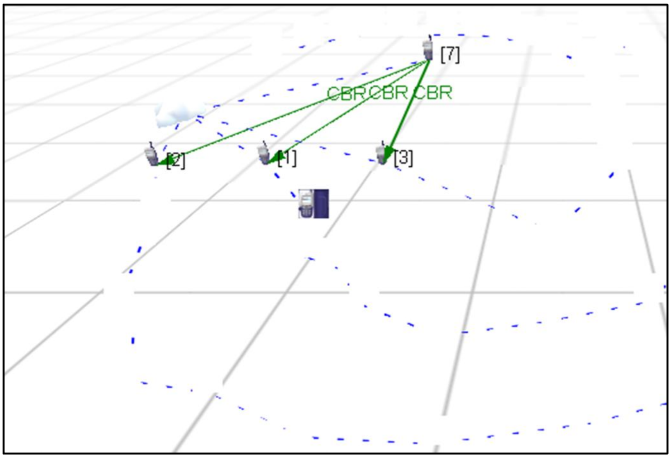

Fig 1. 3D view of BS, SS, Subnet and CBR

Table 1. Network parameters used in the scenario

Parameter	Value
Qualnet version	7.4
Terrain Size	1500*1500 meters
Physical Layer	802.16 Radio
Mobility model	Random waypoint
Fading Model	Ricean
Traffic Type	CBR
Network Layer	IPv4
Routing Protocol	AODV and DYMO
Simulation Time	60 seconds
Frequencies	2.4 GHz
No of Channels	2 or 1(one or no relay)
Gaussian component file	default.SR10000.fading
Battery model	Service life Estimator
Max transmission power at PHY layer	50 dBm
Energy model	User-specified
MAC interface Ranging type	CDMA or normal

The following scenarios are designed

1. IEEE 802.11 with and without relay
2. IEEEE 802.16 with and without relay
3. IEEEE 802.16 with relay and Service energy model
4. IEEE 802.16 with relay, Energy and battery model
5. IEEE 802.16 with and without relay, Energy and battery model.

This Section specifies the battery and Energy models that have been considered for the simulation Process. The input parameter must be configured initially for a given battery type from a battery manufacturer. The types of available battery model in qualnet are Duracell (AA, AAA, MX and MN), itsy and Panasonic (AA and AAA). For the designed model the selection of the battery types and the values of .pcm file used are listed in table 2 and table 3. Both AA and AAA use 1.5 voltages. In between BS and relay AA is used whereas for relay and mobile AAA is used.

Table 2. Battery types used in MS, SS, BS and relay node

Battery Model	Service Life Estimator
Battery charge monitoring interval	60 seconds
Battery type	MS-AAA,RN-AA, BS-AA

PCM file contain each entry in time interval of one sec to represent a unit load applied when the battery will be drained by X. It can be observed from table 3 that the amount of battery drained is more in AAA, as AA has more power, it stores more energy i-e ten times longer lasting power and is three times more in capacity.

Table 3. Duracell .PCM values used

Duracell PCM analysis	
AA	AAA
20.87559400	20.87892700
20.46963400	20.48361800
20.07778700	20.10169000
19.69947000	19.73260500

The scenario values columns of table 4 depicts the assumption made for implementing user defined energy model used for current and voltage values set at BS, SS and relay node while transmitting, receiving signals along with the current consumed in sleep and idle mode. The battery model captures the characteristics of real life batteries and can be used to predict their behavior under various conditions of charge /discharge. The User-defined energy model is a configurable model that allows the user to specify the energy consumption parameters of the radio in different power modes. The configurable parameters include the power supply voltage of the radio's hardware, electrical current load consumed in *Transmit*, *Receive*, *Idle*, and *Sleep* modes.

Table 4. Energy model used-User defined

GUI PARAMETER (Current load)	Parameter	Description	Default Value	Scenario values set for AODV	Scenario values set for DYMO
Transmit	ENERGY-TX-CURRENT-LOAD	The amount of current consumed by the network interface when transmitting a signal	280mA	BS=250mA SS=220mA RN=230mA	Transmit current=250mA Reception current=220mA Sleep current=0mA Idle current=14mA Voltage=3volts
Reception	ENERGY-RX-CURRENT-LOAD	The amount of current consumed by the network interface when receiving a signal	204mA	BS=220mA SS=200mA RN=210mA	
Idle	ENERGY-IDLE-CURRENT-LOAD	The amount of current consumed by the network interface when it's in	174mA	BS=180mA SS=150mA RN=160mA	

		IDLE mode			
Sleep	ENERGY-SLEEP-CURRENT-LOAD	The amount of current consumed by the network interface when it's in SLEEP mode	14mA	SS=0mA	
Supply voltage of the interface	ENERGY-OPERATIONAL-VOLTAGE	This parameter specifies the power supply voltage required for the operation of the radio interface	3Volts	BS=5volt SS=3Volt RN=3.5 Volts	

The architectures with relay nodes designed are shown in figure 2 and figure 3.The packets being transmitted in between node 1,3 and 8 are shown in fig. 3.The shaded circles shows the region of transmission and the thick green colour bidirectional arrows shows the route discovery and packet transmission process. CBR is represented by uni directional link connecting source and destination nodes and red flag gives the path of mobility.

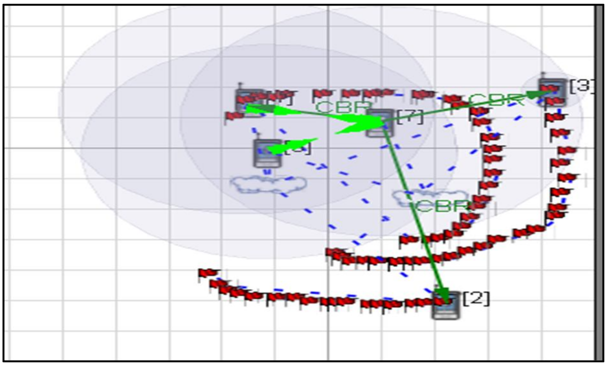

Fig 2. Network with 802.16 relay node

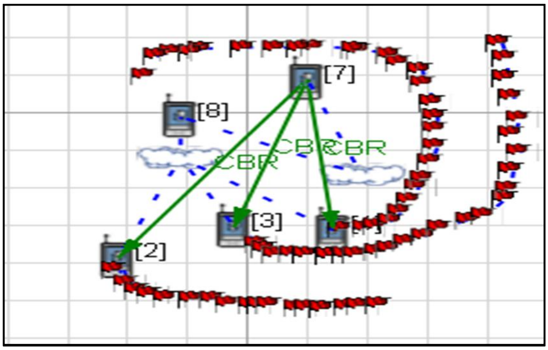

Fig 3. Data Transmission in mobility

The formulas used in the energy.cpp files for calculating different energies are listed below

Transmission Energy Consumed (E_{tx}) = Transmitting Current * Voltage * Time ------------ Equation 1

Receiving Energy Consumed (E_{rx})= Receiving Current * Voltage * Time ------------ Equation 2

Idle Energy Consumed (E_{idle})= Idle Current (mA) * Voltage * Time ------------ Equation 3

Sleep Energy Consumed (E_{sleep}) (if there is a period of inactivity) = Sleep Current *Voltage * Time ------------ Equation 4

Total energy consumed = E_{tx} + E_{rx} + E_{idle} + E_{sleep} ------------ Equation 5

Power consumption at Mobile station=$(sum(average(Tranmitting\ current, Idle, Sleep, Transmit)))$ ------------ Equation 6

Power consumption at Base station=$(sum(average(Tranmitting\ current, Idle, Sleep, Transmit)))$ ------------ Equation 7

Power consumption at Relay station=$(sum(average(Tranmitting\ current, Idle, Sleep, Transmit)))$ ------------ Equation 8

The energy consumed by transmitting (Etx) id the length of the packet with the preamble times the packet rates (i-e Energy = Power * Time).

The units of power is mW, voltage is volts , time, current , battery life is mAh, charge is mAs .The power consumption of mobile stations in table 5 is calculated by using equation 6 to equation 8.An average value is calculated for mobile stations using equation 6 get 1:1ratio for base and mobile station for power consumption.

4 Results generated and analysis

The analysis of the scenarios designed using AODV and DYMO proves that in DYMO the power consumption of the mobile nodes is reduced as shown in table 5.It can be observed form table 5 that the performance of AODV without relay is saving more energy when compared to relay. The addition of relay node increases the range of reach ability of transmission.

Table 5. Power consumption of AODV and DYMO

Routing Scenario	Base station	Relay station	Mobile station
AODV without relay	9.60E-01	Not available	5.760047
AODV with relay	1.19E+00	7.36E+00	6.20E+00
DYMO with relay	6.19E-01	5.94E-01	4.81E-01

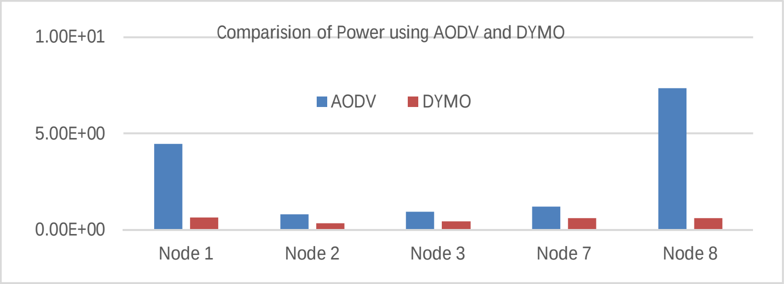

Fig 4. Power consumption using relay node

The path accumulation function of DYMO includes source routing characteristics helps to acquire knowledge about routes to other nodes without initiating route request discoveries themselves, thereby reducing the routing overhead. CBR source flows from base to three mobile stations with 50 packets/second and a packet size of 512 bytes.

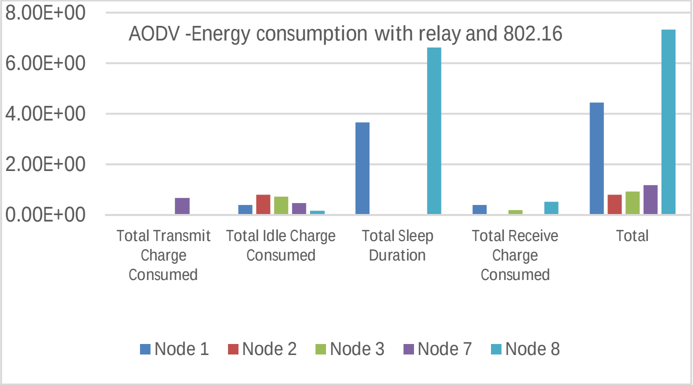

Fig 5. Power consumption using AODV with relay node

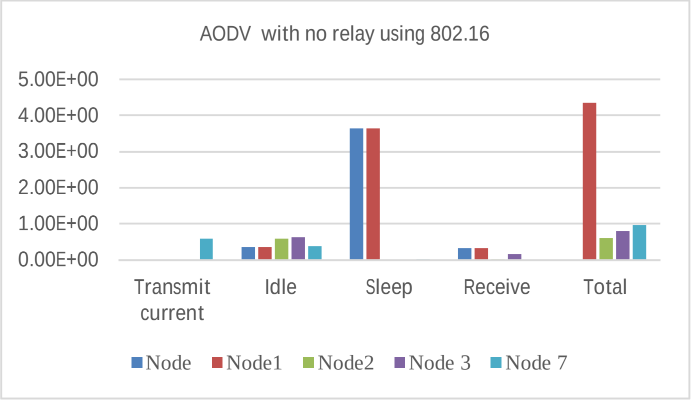

Fig 6. Power consumption using AODV without relay node

The power consumption at all the nodes in sleep mode is explicitly set to zero, because sleep mode allows much of the electronics to be turned off and can be activated again by host in a small amount of time. The node stays idle but listen to the ongoing traffic through the wireless medium for any possible communication from other nodes for which it requires power consumption.

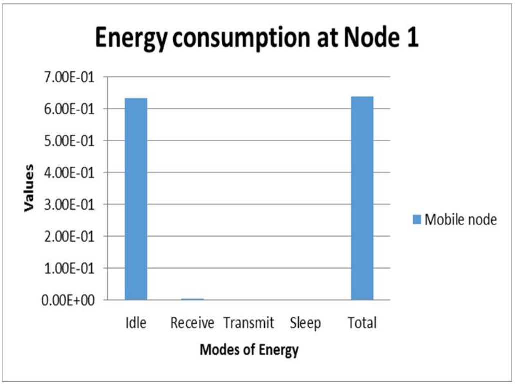

Fig 7. Mobile node 1 using DYMO

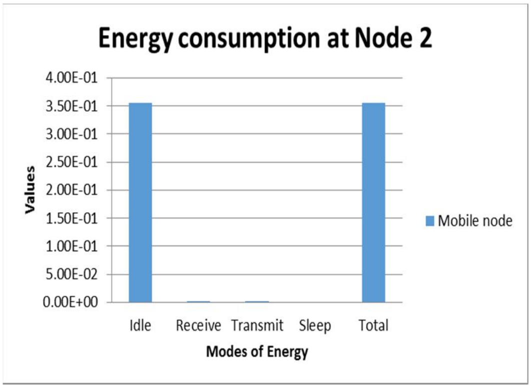

Fig 8. Mobile node 2 using DYMO

Figure 7 to figure 9 shows that the mobile nodes are consuming negligible amount of energy for transmit and the energy utilization is for idle and receive mode only. The total power consumption is calculated using equation 5 and is depicted in figure 12.

The analysis based on power consumption from base and relay stations using DYMO routing protocol and IEEE 802.11 physical layer standard is shown from figure10 to figure 12.It can be noted that the mobile stations or subscriber stations are consuming energy in receive mode as its function is to accept data from the base station, where as the base station is using it for transmit mode as it is meant to transmit data to subscriber stations.

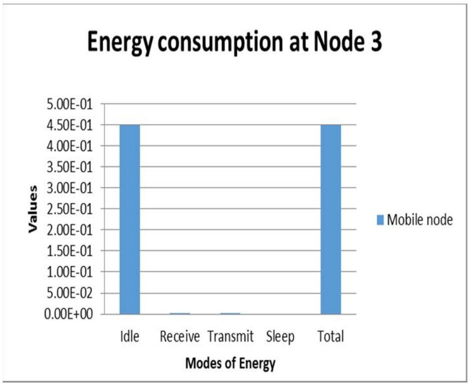

Fig 9. Mobile node 3 using DYMO

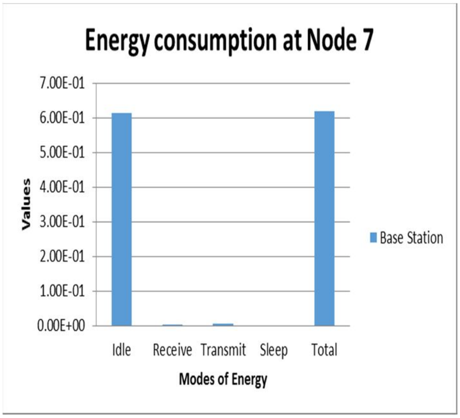

Fig 10. Power consumption at Base node 7

Conclusion

The statistics generated in the scenarios concludes that DYMO outperforms AODV in terms of power consumption and can be used to save power of mobile nodes in current scenarios. The ratio of average transmission delay of base: mobile: relay stations is equal to 0.757:2.596: 0.688 which indicates that the delay in base and relay node is quite less when compared to mobile nodes. Further the utilization in mobile and base station is almost same and relay is

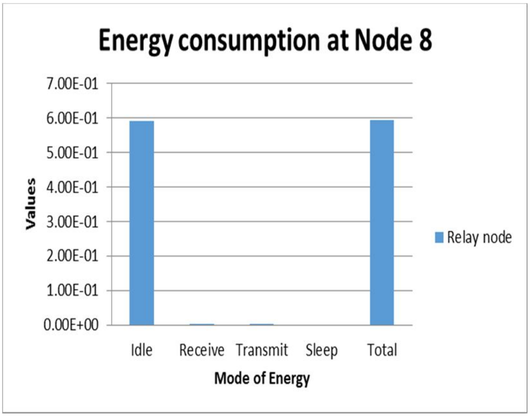

Fig 11. Power consumption at Relay node 8

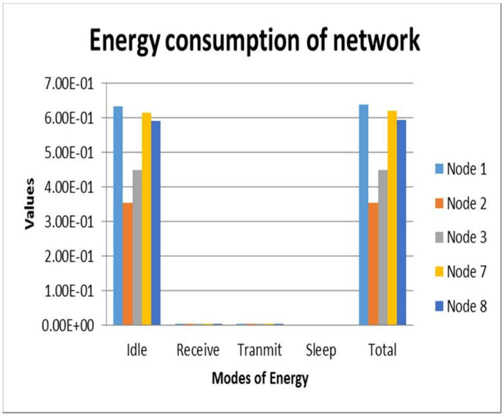

Fig 12. Power consumption of all nodes using DYMO

half of base nodes. The enhancement is to work on IEEE standard 802.16 and check for the utility with respect to other available models of energy and battery for an optimal solution.

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