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Investigation on Aspects of Power Consumption in Routing Protocols of MANET using Energy Traffic Model

Dharam Vir[1], Dr. S.K.Agarwal[2], Dr. S.A.Imam[3]

Research Scholar, Department of Electronics Engineering, YMCA University of Science and Technology, Faridabad, India[1]

Professor, Department of Electronics Engineering, YMCA University of Science and Technology, Faridabad, India[2]

Assistant Professor, Department of Electronics & Comm. Engineering, Jamia Millia Islamia, New Delhi, India[3]

Abstract: In ad hoc mobile networks (MANET), the power of the nodes is a problematical factor that extensively affects the efficiency and performance of ad hoc routing protocols. The traffic and mobility patterns for each node such as end and intermediate nodes are restrained to extract features of each routing protocol. One of the main issues in MANET routing protocols is development of energy efficient protocols because of limited battery life and bandwidth of the nodes. This paper presents performance comparison of four popular mobile ad-hoc network routing protocols i.e. Ad hoc On-demand Distance Vector (AODV), Optimized Link State Routing Protocol (OLSR), Dynamic Source Routing (DSR) and Zone Routing Protocol (ZRP). The performance analysis is based on different network metrics such as Power Consumed in Transmit Mode, Power Consumed in Received, Ideal Modes and Residual Battery Capacity (in mAhr). We also present a performance comparison of the DSR, AODV, DYMO and ZRP routing protocols with respect to power consumption and evaluating how the impact on power consumption in the mobile nodes. Simulation and computation of power consumed, received and transmitted power were done with well known network simulator QualNet 5.0 from scalable networks to evaluate the performance of these protocols variations.

Keywords: MANET, CBR Traffic, Power-aware metrics, AODV, DSR, OLSR, ZRP, QualNet 5.0

I. INTRODUCTION

A Mobile Ad hoc Networks (MANET) represents a system of wireless mobile nodes that can freely and dynamically self-organize in to arbitrary and form temporary network topologies. One important aspect of ad-hoc networks is power efficiency since only a simple battery provides nodes independence. Thus, minimizing power consumption is a major challenge in these networks. Wireless Ad-hoc Networks operates without a fixed infrastructure. Mobility, multi-hop, large network size combined with device heterogeneity bandwidth and battery power limitations, all these factors make the design of routing protocols a major challenge [1][2]. Power consumption is also one of the most important performance metrics for wireless ad hoc networks, it directly relates to the operational lifetime of the networks. Mobile elements have to rely on finite source of power while battery technology is improving over time, the need for power consumption will not reduce. This point will have a harmful effect on the operation time as it will have on the connection quality and bandwidth [3].

Hence, network routing algorithms must be developed to consider power consumption of the nodes in the network as a primary objective. In MANETs, every node has to perform the functions of a router. So if some nodes die early due to lack of power so that the network becomes disjointed, then it may not be possible for other nodes in the network to communicate with each other. In the Wireless Ad-hoc Networks, battery replacement may not be possible. So as far as power consumption concerned, we should try to save power while maintaining high connectivity. Each node depends on small low-capacity batteries as power sources, and cannot expect replacement when operating in hostile and remote regions [3]. For Wireless Ad-hoc Networks, power depletion and reduction is the primary factor in connectivity degradation and length of operational lifetime. Overall performance becomes highly dependent on the energy efficiency of the algorithm. Energy consumption is one of the most important performance metrics for wireless ad hoc networks because it directly relates to the operational lifetime of the network.

The main factors of routing protocols consume maximum power are as following: [4]

- The topology of the network changed rapidly, which will lead to the lost of packets.
- Modification every node's routing table that within the communication distance of the rapid-passing node that will consumed a lot of the bandwidth and the overhead of the networks.

- Delay of the data sending to the rapid-moving node.
- Transmission between two hosts over a wireless network does not necessarily work equally well in both directions. Thus, some routes determined by some routing protocols may not work in some environments.
- Decrease the routing updates as well as increase the whole networks overhead.
- Periodically sending routing tables will waste network bandwidth. When the topology changes slowly, sending routing messages will greatly waste the bandwidth of Wireless Ad-hoc Networks.
- Periodically sending routing tables also waste the battery power. Energy consumption is also a critical factor which prevents Wireless Ad-hoc Networks to be a non-flowed architecture.

This paper is organized as follow: Section I gives the introduction routing protocols of MANETs. Section II is helpful to understand the background about AODV, DSR, OLSR and ZRP routing protocols. Section III explains simulation environment, traffic models and energy evaluation models. Section IV shows the performance simulation and results are discussed and last section V conclude and future work than followed by references.

II. DESCRIPTION OF MANET ROUTING PROTOCOLS

A. *ROUTING PROTOCOLS:*

Routing protocols in MANET [22] based on their functionalities are classified to (i) Reactive (ii) Proactive and (iii) Hybrid.
Reactive protocols established path based on the present requirements for which they known as on-demand routing protocol. Proactive protocols in other hand obtain the path by the help of routing table information. Routing tables are periodically updated. Hybrid protocols carry some feature from both categories. Reactive protocols are considered the most suitable for network with higher mobility as compare to proactive protocols. Proactive protocols are best fit to the static network where node information does not change frequently. We have considered the four routing protocol of MANET for our study e.g. Ad hoc on demand distance vector (AODV), Destination sequence routing (DSR), Optimized Link State Routing Protocol (OLSR) Routing and Zone routing protocol (ZRP). AODV and DSR are reactive and OLSR is proactive routing protocols while ZRP belongs to hybrid routing protocol [5] [11].

1) *Ad hoc on demand distance vector (AODV):*

This protocol performs route discovery using control messages route request (RREQ) and route reply (RREP) whenever a node wishes to send packets source to destination [9]. When source node receives the route error (RERR) message, it can reinitiate route. Neighbourhood information is obtained from broadcasted hello packets. It is a flat routing protocol which does not need any middle administrative scheme to handle the routing process. AODV tends to reduce the control traffic messages operating cost at the cost of increased latency in finding new routes. The AODV protocol is a loop free and uses series numbers to avoid the time without end counting problem which is typical to the classical distance vector routing protocols [6][7][12].

2) *Dynamic Source Routing (DSR):*

In dynamic source routing (DSR) [6], source node floods a route request to all nodes which are in the (WSN) wireless transmission range. Source routing protocol is composed of two main mechanisms to allow the discovery and maintenance of source to destination routes in the ad hoc networks. To commence the route discovery mechanism, wireless node floods a route request to all nodes which are in the wireless transmission range. The originator (source) and objective (destination) of the route discovery is identified by each route request packet. The source node also provides a unique request identification number in its route request packet. For responding to the route request, the target node usually scans its own route cache for a route before sending the route reply toward the initiator node. However, if no suitable route is found, target will execute its own route breakthrough mechanism in order to reach toward the originator. A routing entry in DSR contains all the middle nodes of the route rather than just the next hop information [8] [9]. A source puts the entire routing path in the data packet and the packet is sent through the middle nodes specified in the path. If the source does not have a routing path to the destination, then it performs a route discovery by flooding the network with a route request (RREQ) packet. Any node that has a pathway to the destination in question can reply to the RREQ packet by sending a route reply (RREP) packet. The reply is sent using the route recorded in the RREQ packet. The advantages of this routing are to provide multiple routes and keep away from loop formation where as disadvantages are large end-to-end delay, scalability problems caused by flooding and source to destination routing mechanisms [13].

3) *Optimized Link State Routing (OLSR):*

It is a proactive routing protocol where the routes are always available when needed. OLSR [10] [11] is an optimization of the classical link state algorithm and an optimized version of a pure link state protocol. The topological changes cause the flooding of the topological information to all available hosts in the network. To reduce the possible overhead in the network protocol multipoint relays (MPR) are used. Reducing the time interval for the control messages transmission brings more reactivity to the topological changes. OLSR uses two kinds of the control messages namely hello and topology control. Hello messages are used for finding the information about the link status and the host's neighbours. Topology control messages are used for broadcasting information about its own advertised neighbours, which includes at least the MPR selector list.

4) Zone Routing Protocol (ZRP):

Proactive routing uses excess bandwidth to maintain routing information [14], while reactive routing involves long route request delays. Reactive routing also inefficiently floods the entire network for route determination. The zone routing protocol (ZRP) aims to address the problems by combining the best properties of both the proactive and reactive approaches. In ad-hoc network, it can be assumed that the largest part of the traffic is directed to nearby nodes. Therefore, ZRP reduces the proactive scope to a zone cantered on each node. In a limited zone, the maintenance of routing information is easier. Further, the amount of routing information never used is minimized. In ZRP each node is assumed to maintain routing information only for those nodes that are within its routing zone. Because the updates are only propagated locally, the amount of update traffic required to maintain a routing zone does not depend on the total number of network nodes [11]. A node learns its zone through a proactive scheme Intra zone Routing Protocol (IARP). For nodes outside the routing zone, Inter zone Routing Protocol (IERP) is responsible for reactively discovering routes to destinations located beyond a node's routing zone. The IERP is distinguished from standard flooding-based query/response protocols by exploiting the structure of the routing zone. The routing zones increase the probability that a node can respond positively to a route query. This is beneficial for traffic that is destined for geographically close nodes [16] [22] [24].

III. SIMULATION DETAIL AND ENERGY MODEL PARAMETERS

A. QualNet Simulator 5.0:

QualNet Simulator is a set of implementing tool for modelling wireless networks [22]. QualNet provides comprehensive graphical environment allows one to create and visualize network scenarios, and to analyze the simulation results in one single GUI. QualNet is a commercial program of GloMoSim) which is developed by Scalable Network Technologies. It consists of three layers [23]:

- Simulation kernel
- Model libraries
- QualNet Developer GUI.

It has three different tools such as:

- Scenario Designer: Create and design visualizes network scenarios taking different parameters.
- Animator : The simulation run is visualized in the tool 'Animator' During the simulation run, several outputs can be activated or deactivated in Animator such as throughput, energy consumed in transmit mode, end to end delay, broadcast messages, successfully received packets etc.
- Analyzer: Output of the simulation runs are different output files containing different information. The primary output file (.stat) contains statistical information.

1) Simulation Models:

A simulation model consists of four models such as Traffic Model, Mobility Model, Battery Model, and Energy Model. The specifications which we used for our simulation discussed as below [17] [23];

2) Traffic Model:

Constant Bit Rate (CBR) sources represent influence sources and FTP sources are the ones used for file transfer applications. We focus on Constant Bit Rate (CBR).The packet size is limited to 512 bytes. The source-destination pairs are chosen randomly over the network [18].

3) Mobility Model:

We use random way point mobility model where nodes in network moves randomly in any direction with given speed.

4) Battery Model/ Linear Battery Model*:*

Nodes in the mobile ad-hoc network are battery operated. Hence, battery models are useful tools for such types of system design approach; because they enable analysis of the discharge behaviour of the battery under different design choices for example power management policies. We used Linear Battery Model for the experimentation [18] [24].

5) Energy Model:

The User-defined energy model [20] is a configurable model that allows the user to specify the energy consumption parameters of the radio in different power modes. The total power required for transmission, reception, idle and sleep (nodes are not capable to detect signals so communication is not possible) we use different modes for our simulation is given in Table 1.

TABLE 1. POWER REQUIREMENT FOR DIFFERENT MODES

POWER REQUIREMENT FOR DIFFERENT MODES (SUPPLY	POWER VALUES
Transmission Power	0.84 Watts
Reception Power	0.612 Watts
Idle Power	0.534 Watts
Sleep Power	0.042 Watts

TABLE 2. SIMULATOR PARAMETERS FOR DESIGN OF SCERRIO FIXED PARAMETERS

PARAMETERS	VALUES
Protocols under studied	AODV, DSR,OLSR, ZRP
Network Interface	Wireless Phy
Antenna	Omni directional
Propagation model	Two Ray Ground
Channel	Wireless Channel

TABLE 3. SIMULATOR PARAMETERS FOR DESIGN OF SCERRIO USING VARIABLE PARAMETERS

PARAMETERS	VALUES
Number of nodes	10 to 100
Topology area	1500m*1500m
Packet Size	512
Item to send	100
Simulation time	30 second

TABLE 4. SIMULATOR PARAMETERS FOR DESIGN OF SCERRIO USING ENERGY MODEL PARAMETERS

PARAMETERS	VALUES
Battery Charge Monitoring Interval	60 Sec.
Full Battery Capacity	1200 (mA,h)
Energy Model	Mica motes
Energy Supply Voltage	6.5 Volt
Transmit Circuitry Power Consumption	100.0 mW
Receive Circuitry Power Consumption	130.0 mW
Idle Circuitry Power Consumption	120.0 mW
Sleep Circuitry Power Consumption	0.0 mW

6) Power Consumption Model:

According to the specification of the Energy model, the energy consumption varies from 130mW in receiving mode to 100mW in transmitting mode, using a 6.5V energy supply [21]. In this work we have are assuming an energy supply of 6.5Volt. These values correspond to a 2,5MHz Wave LAN implementation of IEEE 802.11. The following equations represent the power used (in watts) when a packet is transmitted (Equation. 1) or received (Equation. 2); packet size is represented in bits:

$Power_{tx} = (100*6.5*Packet\ Size)/2*10^6$ (1)

$Power_{rx} = (130*6.5*Packet\ Size)/2*10^6$ (2)

Although actual equipment consume power not only when sending and receiving but also while listening, we assume in our model that the listen operation is power free, since all the evaluated ad hoc routing protocols will have similar power consumption due to the node idle time.

In this work QualNet 5.0 network simulator [22] has been used to evaluate the performance of Ad hoc On-demand distance vector (AODV), Dynamic Source Routing (DSR), Optimized Link State Routing Protocol (OLSR) and Zone Routing Protocol (ZRP) routing protocols of mobile ad-hoc networks. The physical medium used is 802.11 PHY with a data rate of 2 Mbps and the MAC protocol used is the 802.11 MAC protocol, configured for MANET mode. The other parameters using for simulation are given in table1, 2, 3 and 4 respectively. The scenario design procedure flow chart is shown in Fig.1 and snapshot of simulation is shown in Fig.2 [22].

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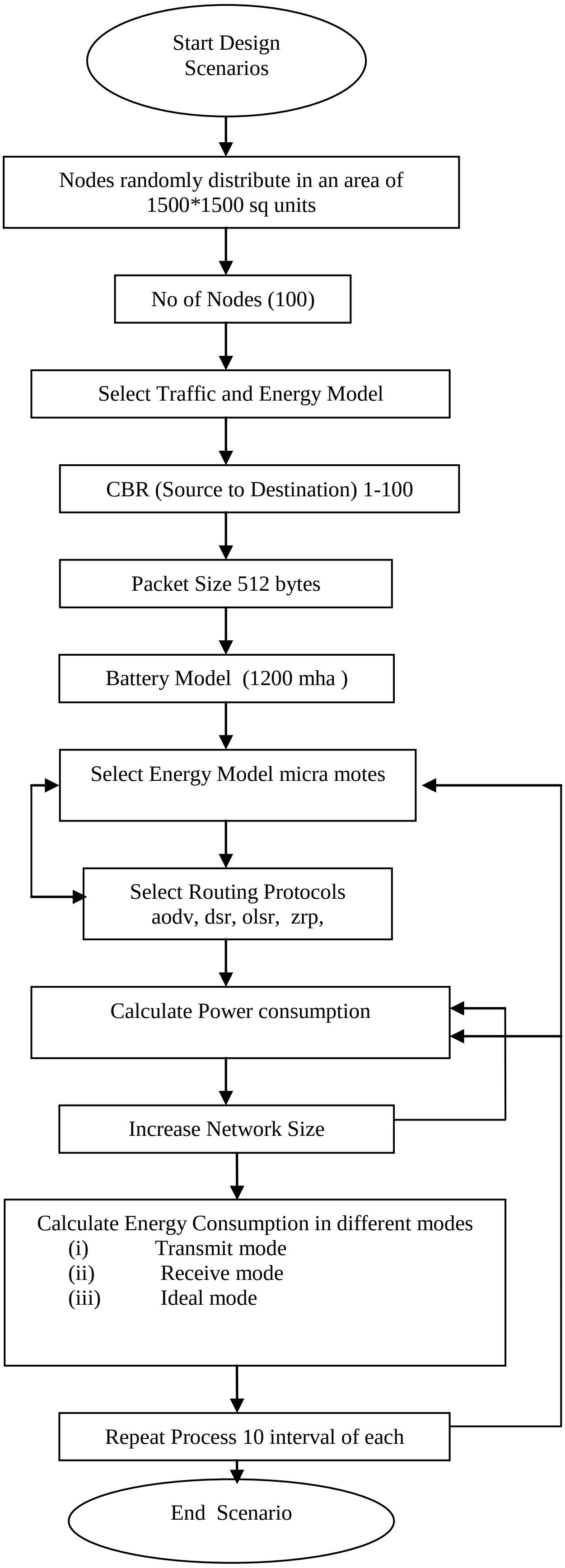

FIG. 1 FLOW CHART FOR POWER CONSUMPTION APPROACH

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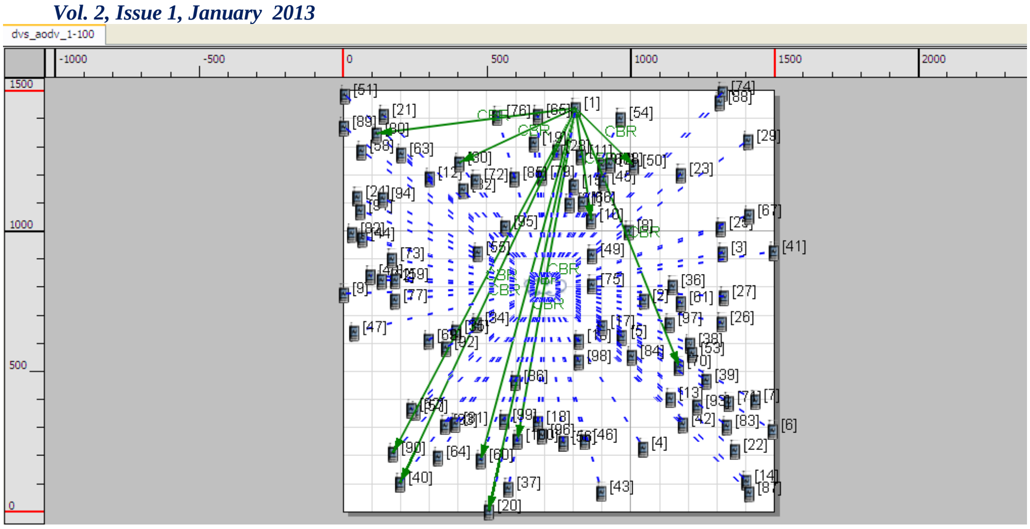

Fig.2 Snapshot of Nodes placement Scenarios

IV. SIMULATION RESULTS AND PERFORMANCE ANALYSIS

A. *Impact of Variation in Number of Nodes with Power Consumption in Transmit mode:*

The efficiency, mobility, scalability, effective sampling frequency, lifetime and response time of nodes, all these parameters of the MANET depend upon the power. In case of power failure the network goes down break therefore, power is required for maintaining the individual physical condition of the nodes in the network, during receiving the packets and transmitting the data as well

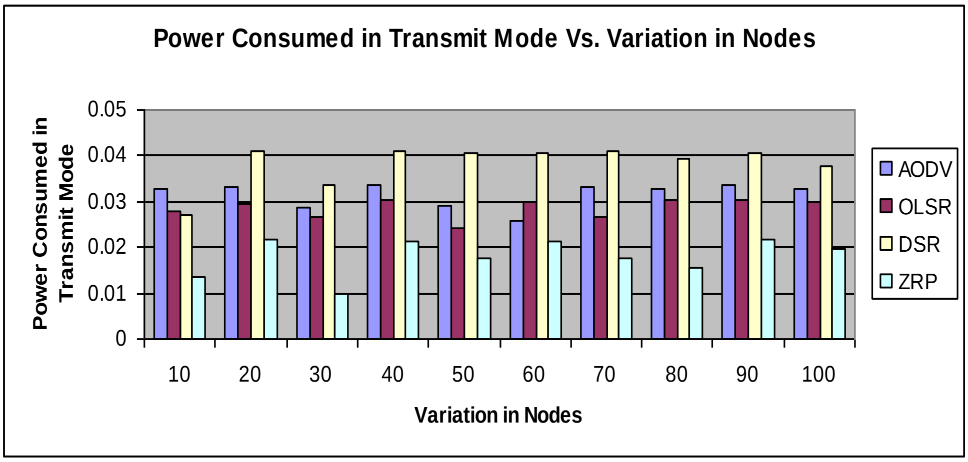

Fig.3 Impact on variation of number of nodes with power consumption in transmit mode of protocols.

Fig. shows effect on AODV, DYMO, DSR and ZRP routing protocol when node variation on power consumption. In case of
DSR consumes maximum power followed by AODV, DYMO than ZRP. It is seen that for four protocols there is increasing trend of power consumption when we increase the number of nodes.

B. *Impact of Variation in Number of Nodes with Power Consumption in Received mode:*

Fig. 4 shows the impact of variation of nodes on the power consumed in received mode taking routing protocol as parameter. Following interference can be made:

- The ZRP presents highest power consumed in received mode in when increase no of nodes.
- The DSR and AODV consume moderate power for over all simulation when varying no of nodes 10 to 100.
- The OLSR consumes least power when we increase the number of nodes, but initially OLSR consumes more power as compare to other routing protocols.

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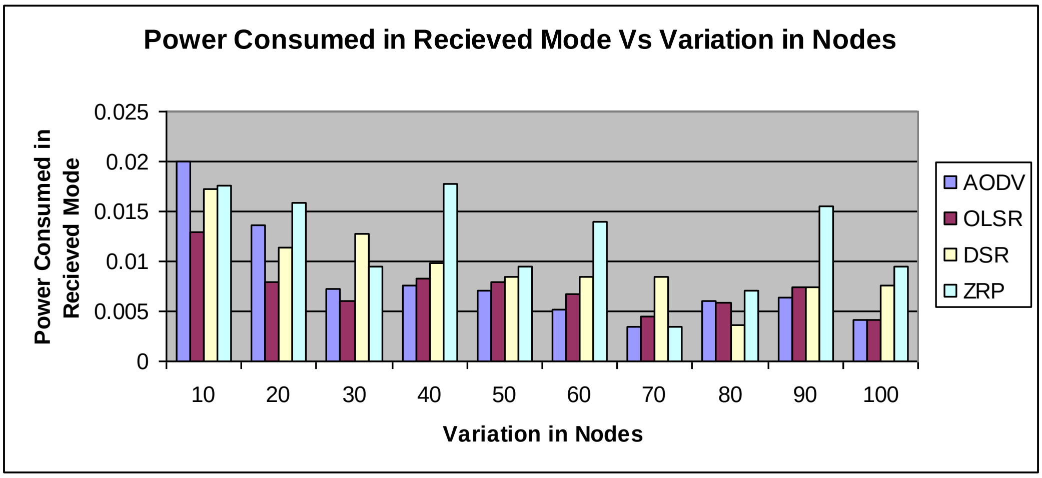

Fig.4 Impact on variation of number of nodes with power consumption in received mode of protocols.

On analyzing the results for power consumption in transmit and receive mode it has been concluded that ZRP consumes maximum power while power consumption for the rest three protocols.

C. *Impact of Variation in Number of Nodes with Power Consumption in Ideal mode:*

Fig. 5 shows the impact of variation of nodes on the power consumed in ideal mode taking routing protocol as parameter. Following graphical representation effect shown below and interference can be made:

- The ZRP presents highest power consumed in ideal mode when nodes varied.
- The OLSR consumes moderate power.
- The AODV and DSR consume least power as shown in simulated graphs.

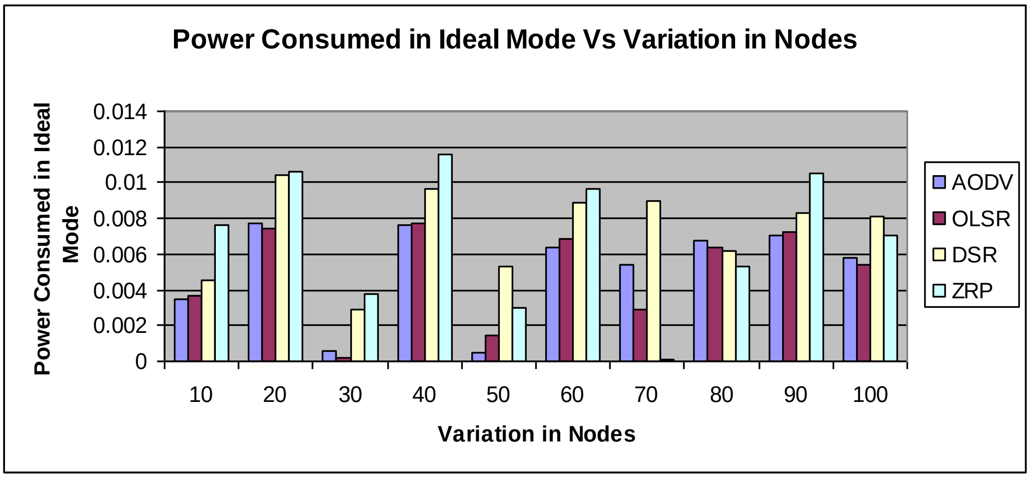

Fig.5 Impact on variation in number of nodes with power consumption in ideal modes of protocols.

D. *Impact of Variation in Number of Nodes with Residual battery capacity:*

Fig.6. The impact of variation of nodes with residual battery capacity in nodes taking routing protocol as parameter. Following graphical representation effect shown below and interference can be made:
Hence wireless devices are becoming ubiquitous; batteries are used to power these devices. However, batteries are not durable and have to be replaced periodically obtained by QualNet shown in the fig. 6. Batteries such as Duracell AAA(MN-2400), Duracell AAA(MX-2400), Duracell C-MN(MN-1400) standard using Qualnet as a Simulation tool for residual battery capacity. Since Energy conservation is main focus area now days. Hence performance of the protocols with various battery models along with FIFO and residual battery parameters counts and helps to make a right selection of battery model. If we need more efficiently for power conservation residual battery capacity constant.

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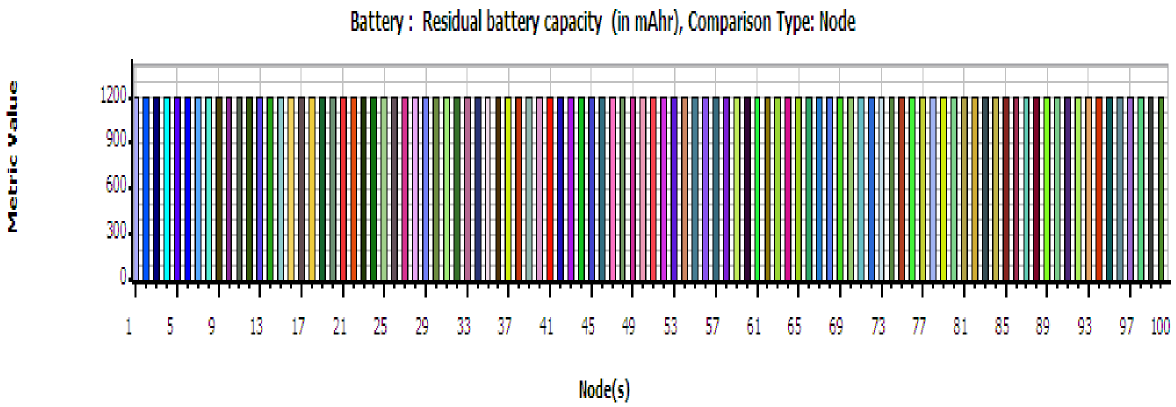

Fig.6 Impact on variation in number of nodes with Residual battery capacity (in mAhr)

V. CONCLUSION

We presented the results after simulation and analyzing the power consumption behavior of four routing protocols respectively the Ad-hoc On Demand Distance Vector (AODV), the Dynamic Source Routing (DSR), and the Optimized Link State Routing Protocol (OLSR) and Zone Routing Protocol (ZRP). We selected the most representative parameters for a MANET is power consumption in nodes. We then defined and simulated power consumption scenarios and finally, by varying the selected parameters, generated and simulated more scenarios. The results obtained from the simulations allow us to conclude the following as far as power consumption refers. Generally pure on-demand protocols such as DSR and AODV perform better than OLSR and clearly better than ZRP. For all scenarios explored, ZRP has the worst performance index. Besides, increasing the number of nodes while maintaining the number of traffic sources makes ZRP not scalable, increasing the power consumption by a 39% extra while nodes move from 25 to 50. DSR offers a quite constant behavior for all tested scenarios, mainly due to his table-driven philosophy. The DSR normally performs better than AODV except in static networks in which they show a similar behavior. Comparing AODV and OLSR, there are several scenarios in which AODV perform worse than OLSR, typically when longer routes are allowed. Finally, referred to DSR and AODV, outcome in general power consumption favorable to OLSR in all simulated execution.

CONCLUSION

The work can be extended to more than 200 nodes and higher packet rate and different network area by keeping other network parameters constant. Finally, the best scenario can be obtained by which we perform power consumption in large networks keeping all above routing protocol same. Suggested also where all network QoS parameters gives best results.

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Biography

Dharam Vir received the M.Tech Degree from MDU Rothak (Haryana) and B.E Degree in Electronics and Communication Engg. From Jamia Millia Islamia, Central University, New Delhi 2004, 2008 respectively. He started his carrier as R&D Engineer in the field of computers and networking, Since 1992, he is the part of YMCA University of Science & Technology as Head of Section (Electronics & Inst. Control) in the Department of Electronics Engineering. He is pursuing his PhD in the field of Mobile Ad hoc Networks. Presently he is working in the field performance improvement in MANET routing (Power aware routing protocol). His current interest in power control in wireless network system, wireless communication, computer networks

Dr. S.K. Agarwal received the M.Tech Degree from Delhi Technical University. New Delhi and PhD degree in Electronics Engg. from Jamia Millia Islamia Central University. New Delhi in 1998 and 2008, respectively, Since 1990. He has been part of YMCA University of Science & Technology Faridabad (Haryana), where he is Dean & Chairman in Department of Electronics and Communication Engineering. He has more than 20 publications in journals and conf. of repute. His current research interests are in the field of Control System, electronics and biosensors, Analog Electronics, wireless communication and digital circuits.

Dr. Syed A Imam received the B.E Engg. degree (Electrical Engg) from Jamia Millia Islamia, M. Tech (Instrumentation & Control System) from AMU, Aligarh and PhD degree in Electronics & Comm. Engg from Jamia Millia Islamia (a Central University), New Delhi, in 1990, 1998, and 2008, respectively. Since 1990, he has been part of Jamia Millia Islamia University, where he is Assistant Professor in the Department of Electronics and Communication Engineering. He has more than 70 publications in journals and national/international conferences of repute. His current research interests are in the field of sensing technologies, electronic and bioinstrumentation, signal processing and digital circuits.