Schematic Modelling for Enhancing the Cumulative Network Lifetime of Mobile Adhoc Network using Power Efficient AODV

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Abstract – the planned scheme highlights one of the schematic modeling for enhancing the cumulative network lifetime of MANET using power efficient AODV. MANET system is always associated with the design constraint from unwanted power drainage during communication. The proposed system considers the intermediate mobile nodes as vital factor which estimates the current mean power of the cumulative network as comparison threshold in order to evaluate the response of route request message along with impact of the proposed system towards the routing performances. Experimented in NS2, the proposed system shows optimal throughputs which can be definitely used for optimizing the energy on overloaded nodes in MANET and enhance the cumulative network lifetime extensively.

Key Words – component; Mobile Adhoc Network, Energy, Routing protocol, AODV

I. Introduction

The area of mobile adhoc network or commonly termed as MANET [1] is currently under the scanner of extensive research due to the massive advantages it permits on its application. MANET can be termed as a system of wireless mobile nodes which dynamically self-organize in random and impermanent network topologies. Using this technology, various users can therefore be connected in networking areas without any presence of pre-existing networking infrastructure. The mobile nodes can directly communicate with each other within their transmission ranges. In this environment, dual condition can surface where all the mobile nodes which have participated in the transmission involuntarily generate a wireless network, consequently, such types of wireless adhoc network can be visualized as mobile adhoc network. For the purpose of introducing diversified power issues in MANET [2], various power effective routing strategies has already been seen in the review of literature. Any transitional node holds the request packet for an epoch of time previous to forwarding to next mobile node. The time period is set to be inversely proportional to its existing power so that nodes with lower level of power can be protected. The tradeoff between the cost of power utilization for distribution traffic and the enhanced spatial allocation of power overloads is discussed. Unwanted power utilization due to overhearing is considered, which involved not only the battery reservation of the mobile nodes in the routes, but also the amount of neighbors that these nodes may potentially interfere. The most favorable cardinality of the cooperation sets at each hop on a path to minimize the total power cost per transmitted bit, while a traffic-adaptive routing protocol was proposed to optimally combine the proactive and reactive strategies. The idea that each mobile node evaluates if the route request control message should be forwarded by comparing its residual power with a threshold, where the threshold is attuned incessantly as the network runs. Almost all mobile devices are supported by battery powers, so the power-efficient issue is one of the most important design issues in MANET. Solutions to the energy-efficient issue in MANET can generally be categorized as follows: 1) Low-Power Mode, in which mobile devices can support low-power sleeping mode. The main research challenges in low-power mode are that at what time mobile node can turn to sleeping mode, and at what time it should wake up. Corresponding issues are addressed in [3], [4], [5] and etc; 2) Transmission Power Control: In wireless communication, transmission power has strong impact on transmission range, bit error rate and inter-radio interference, which are typically contradicting factors. By adjusting its transmission power, mobile node can select its immediate neighbors from others, thus the network topology can be controlled in this way. How to determine transmission power of each node so as to determine the best network topology has been addressed in [6], [7], [8] and etc; 3) Power-Aware Routing: Other than the common shortest-hop routing protocols, such as DSDV [9], AODV [10], DSR [9], and etc, power-aware routing protocols take various power metrics or cost functions into account in route selection

The proposed system is designed on the backbone of frequently used AODV (Adhoc on demand distance vector) routing protocol for enhancing the cumulative lifetime of mobile adhoc network. In section 2, we give an overview of related work which identifies all the major research work being done in this area. Problem description is discussed in Section 3 followed by proposed system illustration in Section 4. Section 5 discusses about result analysis and finally in section 6, we make some concluding remarks.

II. Related Work

K. Arulanandam and Dr. B. Parthasarathy [11] present Energy is the scarcest resource for the operation of the mobile ad hoc networks. Idle energy consumption is responsible for a large portion of the overall energy consumption in the wireless interfaces of the mobile nodes. Sunsook Jung et.al [12] considers energy constrained routing protocolsand workload balancing techniques for improving MANET routing protocols and energy efficiency. Also, they show new application of energy efficiency metrics to MANET routing protocols for energy efficiency evaluation of the protocols with limited power supply. Rekha Patil [13] proposes a cost based power aware cross layer design to AODV. The discovery mechanism in this algorithm uses Battery Capacity of a node as a routing metric this approach is based on intermediate nodes calculating cost based on Battery capacity. Rutvij H. Jhaveriand Ashish D. Patel [14] has discussed some basic routing protocols in MANET like Destination Sequenced Distance Vector, Dynamic Source Routing, Temporally-Ordered Routing Algorithm and Ad-hoc On Demand Distance Vector. Main objective of writing this paper is to address some basic security concerns in MANET, operation of wormhole attack and securing the well-known routing protocol Ad-hoc On Demand Distance Vector. Xiangpeng Jing and Myung J. Lee [15] presents a comprehensive energy optimized (locally and globally) routing algorithm and its implementation to AODV this algorithm investigates the combination of device runtime battery capacity and the real propagation power loss information, obtained by sensing the received signal power, without the aid of location information. Abdusy Syarif and Riri Fitri Sari [16] we present some improvement suggestion to AODV routing protocol. Our proposed protocol, called AODV-UI, improved AODV in gateway interconnection, reverse route and in energy consumption. They also measure performance indicators for some metrics, such as energy, routing overhead, end-to-end delay, and packet delivery ratio. And also they performed simulation scenarios with three mobility model with different maximum speed and sources in hybrid ad hoc network. Preeti Bhati et.al [17] in this paper has tried to remove the existence of misbehaving nodes that may paralyze or slows down the routing operation in MANET. This increases the efficiency of a network. Efficiency can be calculated by the parameters or factors such as transmission capacity, battery power and scalability. They are considering the most crucial factor named as transmission capacity of a node. Annapurna P Patil et.al [18] concentrated on emergency search and rescue operations which rely heavily on the availability of the network. Dr. Sanjay Sharma and Pushpinder Singh Patheja [19] present some improvement suggestion to AODV routing protocol. They proposed protocol, called AODV-PP, improved AODV in Priority models and in Power consumption. They also measure performance indicators for some metrics, such as energy, routing overhead, end-to-end delay, and packet delivery ratio, in WiMAX adhoc network. Nishant Gupta and Samir R. Das [20] develop a technique to make these protocols energy-aware in order to increase the operational lifetime of an ad hoc network where nodes are operating on battery power alone and batteries cannot be recharged. Jayesh Kataria et.al [21] present Reactive routing protocols like Ad-hoc On-Demand Distance Vector Routing (AODV) and Dynamic Source Routing in Ad-Hoc Wireless Networks (DSR) which are used in Mobile and Ad-hoc Networks (MANETs) work by flooding the network with control packets. P. Latha and R. Ramachandran [22] proposed protocol Energy Reduction Aware Multicast (ERAM) aimed to find a path which utilizes the minimum energy to transmit the packets between the source and the destination. Shivendu Dubey, Prof. Rajesh Shrivastava [23] present A mobile ad hoc network (MANET) is a collection of wireless mobile nodes dynamically forming a network Topology without the use of any existing network infrastructure or centralized administration. Sajjad Ali & Asad Ali [24] present the communication between these mobile nodes is carried out without any centralized control. M. Tamilarasi and T.G. Palanivelu [25] propose a mechanism which integrates the adaptive timeout approach, load balancing approach and transmit power control approach to improve the performance of on-demand routing. they applied this integrated mechanism on Ad hoc On- demand Distance Vector(AODV) routing protocol to make it as Energy Aware Adaptive AODV (EAA AODV) routing protocol. Lijuan Cao et.al [26] provides a survey and analysis of energy related metrics used for ad hoc routing. First, the most common energy efficient routing protocols are classified into four categories based on the energy cost metrics employed. Chansu Yu et.al [27] purpose of this paper is to facilitate the research efforts in combining the existing solutions to offer a more energy efficient routing mechanism. Tanu Preet Singh et.al [28] present in this paper an ad-hoc network is a local area network (LAN) that is built spontaneously as devices connect. Instead of relying on a base station to coordinate the flow of messages to each node in the network, the individual network nodes forward packets to and from each other. M. Tamilarasi and T.G. Palanivelu [29] present in this paper, a mechanism involving the integration of load balancing approach and transmission power control approach is introduced to maximize the life-span of MANETs. The mechanism is applied on Ad hoc On-demand Vector (AODV) protocol to make it as energy aware AODV (EA_AODV). Mahesh K. Marina and Samir R. Das [30] develop an on-demand, multipath distance vector routing protocol for mobile ad hoc networks. Specifically, they propose multipath extensions to a well-studied single path routing protocol known as ad hoc on-demand distance vector (AODV).

III. Problem Description

In the area of mobile adhoc network, routing is one of the prominent issue which surfaces because of highly dynamic and distributed environment in MANET. The power efficiency in mobile adhoc network has become one of the critical design factors as the mobile nodes will be supported by battery with limited capacity. The failure or degradation of energy in mobile nodes will not only influence the node itself but it will also have impact into its potential to forward the packets on behalf of others and therefore influence the cumulative network lifetime. Hence, majority of the researchers has attempted for designing power aware routing algorithms for specific mobile adhoc network scenario. Unfortunately, it is still in infancy stage as it is still not obvious that which one of the lists of routing protocols is best for majority of scenarios as every routing protocol is designed to work for only specific environment. But, it is also highly feasible to unite and incorporate the current solutions in order to facilitate maximum power efficient routing techniques. As power efficiency is also vital issue in many other network layers, considerable efforts has already been given for designing power aware MAC as well as transport protocols. Each layer is believed to function in remoteness in layered network architecture but, as some current research suggested, the cross-layer design is indispensable to exploit the highest power performance. In fact, many routing protocols analyzed in survey also deploy the similar concept, i.e. they utilize lesser layer techniques such as transmission energy control and sleep mode methods in their routing layer protocols.

IV. Proposed System

The main aim of the project work is to introduce a novel scheme based on AODV, called Energy Saving Ad-hoc On-demand Distance Vector for routing in MANETs. It also achieves the energy information exchange among neighboring nodes through already-existed signaling packets in AODV and introduces a new network parameter as the comparison threshold, called current average energy of the network, which can fairly accurate estimate the mean power consumption of the cumulative mobile network.

Consider a MANET with n mobile nodes which are uniformly distributed in a field with a size of a*x*b square meters. The wireless transmission range of each node is set to r meters. In such scenario, the distance between two arbitrary nodes, denoted as d, has probability density function (PDF) as

$$f_d(x)\begin{cases} 2x\left[\frac{\pi}{ab}-\frac{2x}{ab^2}-\frac{2x}{ba^2}+\frac{x^2}{a^2b^2}\right] & 0\le x\le b \\ \frac{2x}{ab}\left[\frac{\pi}{2}-A\right]-\frac{2x}{a^2}-\frac{4x}{ab^2}\left[x-\sqrt{x^2-b^2}\right] & b\le x<a \\ \frac{2x}{ab}B-\frac{4x}{ab^2}\left[a-\sqrt{x^2-b^2}\right] & \\ \frac{2x}{a^2b^2}C+\frac{4x}{ba^2}\left[\sqrt{x^2-a^2}-b\right] & a\le x<\sqrt{a^2+b^2} \end{cases}$$

where

$$A=\left[\arcsin\left(x^2/2-b^2\right)/\left(x^2/2\right)\right],$$
$$B=\left[\arcsin\left(\left(a^2-x^2/2\right)/\left(x^2/2\right)-A\right)\right],$$
$$and\ C=a^2+b^2-x^2.$$

Given *d*, the average number of hops between these two nodes equals l = [d/r]

where [•] is the ceiling operator. Traffic load from each node is generated by a constant-bit-rate (CBR) source with transmission rate λ. Each node moves according to random waypoint model.

The method for determining the energy comparison threshold for each mobile node is also discussed. The main objective is to balance energy consumption among all nodes in the network.

A. Revised Control Packets

For exchanging energy information in the network, we modify the existed control packets in AODV to transmit the required energy information instead of adding new control packets.

HELLO packet: Neighboring nodes in proposed AODV utilize the HELLO packet in AODV to exchange the information of their remaining energy among each other. In order to store such information, a new field called Remaining Energy (RE) is added to the HELLO packet. With the support of the HELLO packet, every node maintains a Local Remaining Energy Table (LRET), which records the remaining energy of all one-hop neighbors.

RREQ packet: Proposed AODV also utilizes the RREQ in AODV which is forwarded in the route discovery process to cumulate the local average remaining energy information along the backward path. A new field denoted as E_{sum} is added to the RREQ packet and each intermediate node will update E_{sum} field by cumulating its own local average energy to it. As the RREQ packet being forwarded, the local energy information of all the intermediate nodes is spread through the backward path. Note that both R_E and E_{sum} fields only occupy 4 bytes in a 28 bytes HELLO packet and a 32 bytes RREQ packet, respectively. Therefore, the introduced traffic load due to energy information exchange is marginal.

B. Route Discovery

Route discovery process is initiated whenever a traffic source needs a route to the destination. Route discovery process includes the operations at source node, intermediate nodes and destination node.

Source Node: When a source node is going to communicate with a destination node and there is no available route, the source node will broadcast a RREQ packet. As the first node along the route, the source node initializes Esum with its local average energy, $\overline{E}^s{}_l$ which can be calculated as

$$\overline{E}^s{}_l = \left(E^s{}_r + \sum_{k=1} \Sigma^k{}_r \right) \Big/ (n_s + 1)$$

where E^s_r denotes the remaining energy of the source node, which can be measured from its physical layer. E^k_r , k =1… ns, denotes the remaining energy of its 1-hop neighboring nodes and ns denotes the number of neighbors. Notice that the availability of E^k_r at the source node results from the exchange of modified HELLO packets.

Intermediate Nodes: After receiving the RREQ packet, each intermediate node decides its own response to the received RREQ packet via comparing its remaining energy with an energy threshold which is derived as follows. Consider an intermediate node *i*. Following the same procedure as that in the source node, node *i* can calculate its local average energy as

$$\overline{E}^i{}_l = E^i{}_t / (n_i + 1)$$

where E^i_t is the total remaining energy of node i and its neighbors, the number of which is defined as ni. We introduce a new parameter, called the current average energy of the network, which can be calculated as

$$\overline{E}^i{}_c = \left(E_{sum} + \overline{E}^i{}_l \right) / i$$

where i is the number of nodes along the backward path. Obviously, since the accurate average energy of the network is ordinarily unavailable, such current average energy of the network is an estimation of it. Note that when initiating an RREQ packet, the source node has added its local average energy to the Esum field, and each intermediate node which forwards this RREQ packet has updated Esum by cumulating its own local average energy. Therefore, $\overline{E}^i{}_c$ is a good approximation of average remaining energy, which takes into account all nodes on the route and their neighbors?

Given current average energy of the network, the energy threshold is set as

$$E^i{}_{thres} = \alpha \overline{E}^i{}_c$$

where α is the system parameter, which satisfies 0 < α < 1. α represents different protection levels. The smaller α is, the more frequently intermediate nodes participate in the route discovery process. If the remaining energy of the intermediate node is larger than the threshold, we treat this node as a node with sufficient energy. Such node should cumulate its local average energy to Esum and forwards it to a next node immediately. Otherwise, the node should wait for a while, and determines whether to forward the RREQ packet based on the number of identical RREQ packets received during the delay period. If the number is larger than a threshold C, which is the effective RREQ packet number in a neighboring area, the node drops the RREQ packet to save energy. Otherwise, if there is not enough RREQ packets received during the delay period, the node should forward this RREQ packet to participate in the route discovery.

Destination Node: Finally, when the RREQ packet has reached the destination, the destination node responds by unicasting a RREP packet back to the source node as AODV does. And the route discovery is finished.

C. Route Maintenance

Route maintenance process is the same as that in AODV protocol. When a link breaks, route error (RERR) packet will be forwarded to erase all routes using the broken link.

V. Research Methodology

In this proposed system, a new architecture based on enhancement in AODV is proposed for conducting energy efficient routing in MANETs. The proposed scheme (Figure 1) achieves the energy information exchange among neighboring nodes through already-existed signaling packets in AODV and introduces a new network parameter as the comparison threshold, called current average energy of the network, which can estimated the mean power utilization of the network. In the proposed scheme, each intermediate node determines whether to forward RREQ packet by comparing its remaining energy with current mean power of network. If the energy of the node is larger than the threshold, it will forward the RREQ packet immediately. Otherwise, the node will wait for a while to decide whether the packet should be forwarded or dropped according to the number of the identical RREQ packets received during the waiting period. After that, effects of the proposed routing protocol on network performance are addressed. Both analytical

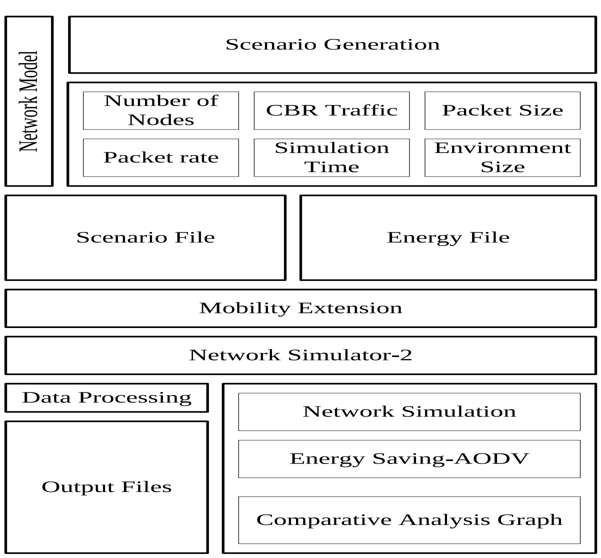

Fig. 1 Proposed architecture

and simulation results shows that the proposed routing scheme is comparatively easier for execution and can facilitate a maximized cumulative network lifetime.

The main objectives of the proposed system are as follows:

- To create a network model considering the probability density function with respect to the node and their distance.
- To design an enhanced control packet for exchanging energy information in the network using AODV routing protocol.
- To design an efficient and energy saving route discover scheme using average energy of the network.
- To simulate the proposed energy saving scheme on Network Simulator 2 in Linux OS
- To analyze the throughput with respect to packet delivery ratio, cumulative network lifetime, as well as mean end to end delay.

The routing protocols have multiple operations to be performed apart from instituting correct and resourceful routes among the twosome of mobile nodes. The most prominent aim of the routing protocol is to render the entire networking to operate for as long duration as possible. Such types of parameters are very essential to facilitate the minimum energy path through which the cumulative utilization of power for delivering a packet is reduced. In such experiments, the wireless link is interpreted with the cost of link in terms of transmission power over the link and minimum energy path is another factor which reduces the sum of the cost of link along the same path. But, unfortunately, if such types of routing parameters are selected than it may yield to unbalanced power utilization among the mobile nodes. It was also seen that when certain specific mobile nodes are incorrectly overloaded in order to support majority of packet-relaying operation, such nodes may utilize higher battery power and impede running earlier than other mobile nodes thereby disturbing the cumulative functionality of the mobile adhoc network.

Figure 2 highlights the total of 35 mobile nodes in the simulation environment (green circle). The 1st mobile node is shown by red circle, which is represented with its respective neighbor nodes (yellow circle). Figure 3 highlights the neighboring nodes (yellow circle) of node 2. Figure 4 highlights the progress in transmission as well as draining of energy from the source node 3 via intermediate node 25 to destination node 8.

An estimation algorithm to obtain the network average remaining energy is introduced (Figure 5).

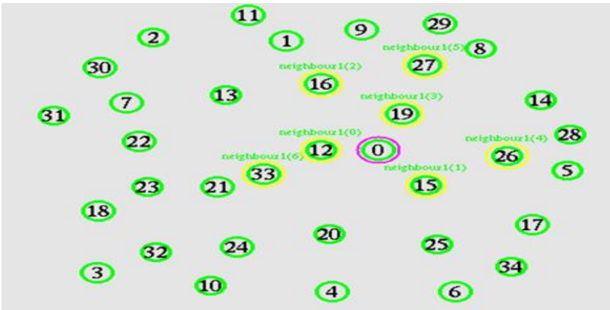

Fig. 2 Simulation Result-I

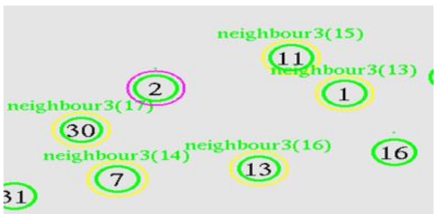

Fig. 3 Simulation Result-II

Fig. 4 Simulation Result-III

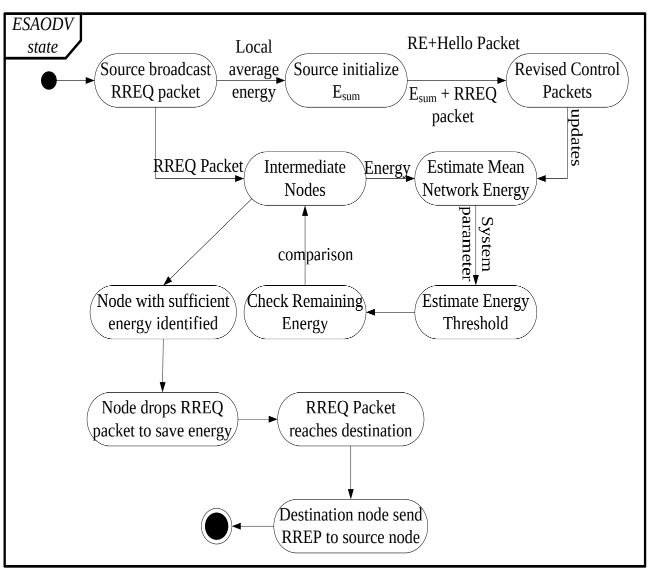

Fig. 5 Activity Diagram of the proposed system

With such assessment, intermediary mobile nodes can reasonably decide if their residual power is adequate or not. By preventing overused nodes from participating in route discovery processes, the proposed scheme using AODV effectively balances energy consumption around the network. Simulation results will show that the proposed energy saving schema can evidently increase the lifetime of the network

VI. Result Analysis

The proposed system is designed on Linux platform using network simulator (NS2), which is an object-oriented, discrete event driven network simulator developed at UC Berkeley. The performance analysis is checked with respect to delivery ratio, network overhead, delay, and cumulative network life time.

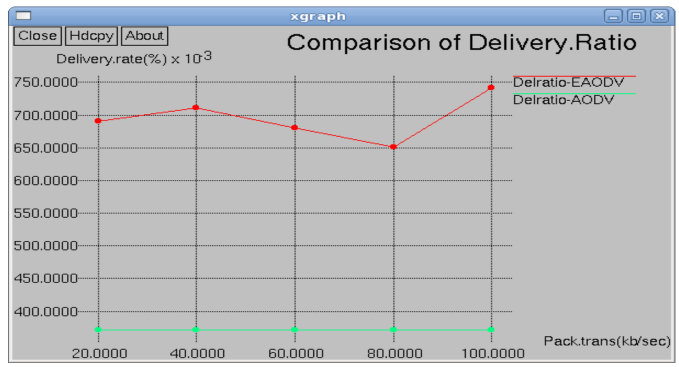

Fig. 6 Simulation Result-III

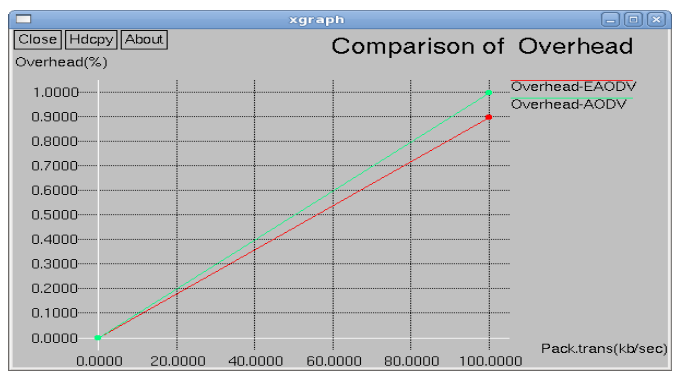

Fig. 7 Simulation Result-III

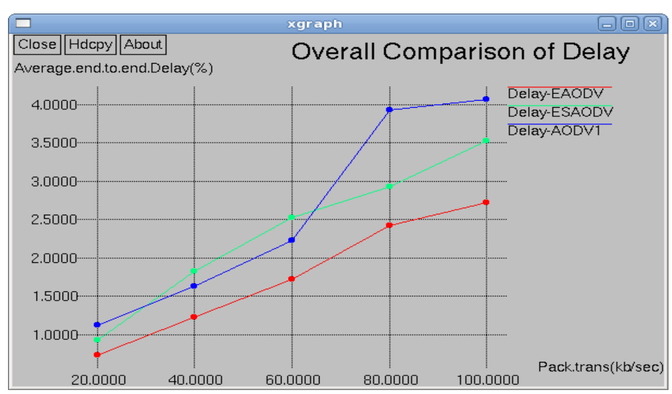

Fig. 8 Simulation Result-III

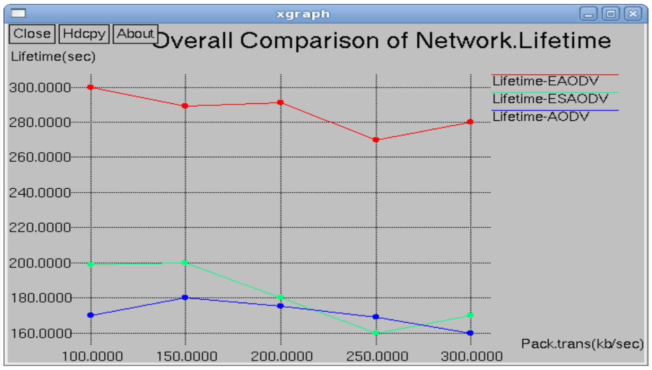

Fig. 9 Simulation Result-III

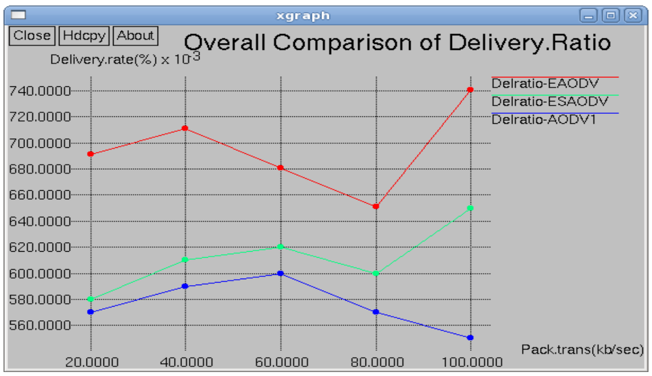

Fig. 10 Simulation Result-III

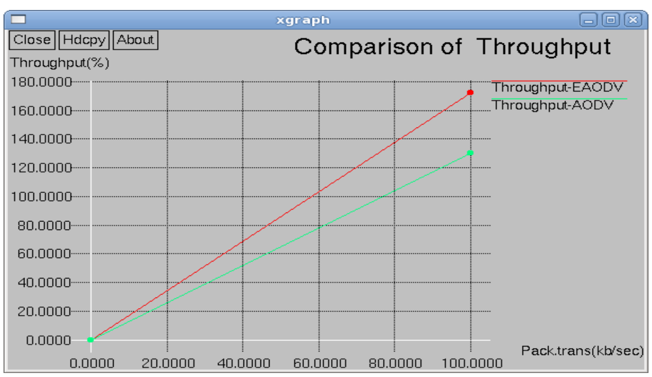

Fig. 11 Simulation Result-III

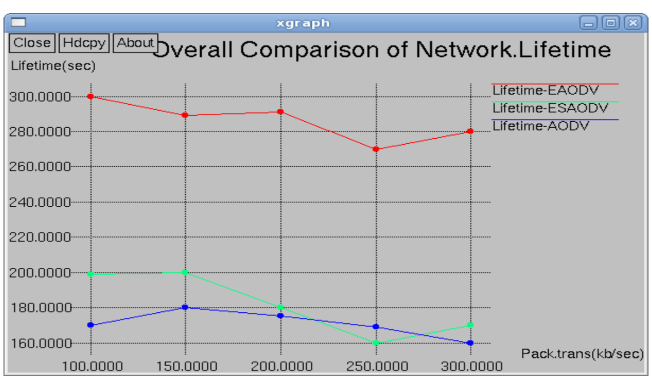

Fig. 12 Simulation Result-III

The above graph in Figure 6 shows the comparison of packet delivery ratio for proposed energy aware-AODV and AODV with x-axis of packet transmission (kb/sec) and y-axis of Delivery rate (10^3).

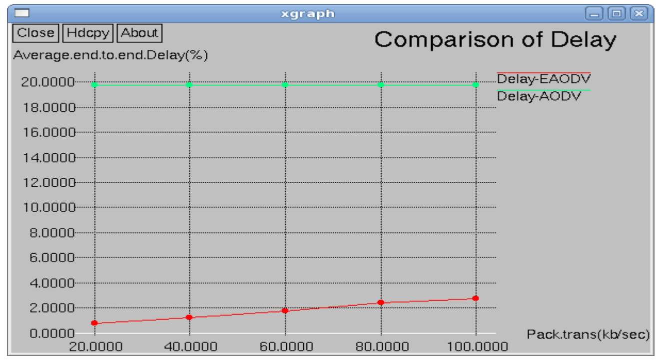

Fig. 13 Simulation Result-III

The above graph in Figure 7 shows the comparison of overhead for proposed energy aware-AODV and AODV with x-axis of packet transmission (kb/sec) and y-axis of Overhead (%).

The above graph in Figure 8 shows the comparison of delay for proposed scheme, energy aware AODV, and AODV with x-axis of packet transmission (kb/sec) and y-axis of average end-to-end Delay(%).

The above graph in Figure 9 shows the comparison of network lifetime for proposed scheme, energy aware AODV, and AODV with x-axis of packet transmission (kb/sec) and y-axis of network lifetime (sec).

The above graph in Figure 10 shows the comparison of overall packet delivery ratio for proposed scheme, energy aware AODV, and AODV with x-axis of packet transmission (kb/sec) and y-axis of delivery rate (10^3).

The above graph in Figure 11 shows the comparison of throughput for energy aware AODV, and AODV with x-axis of packet transmission (kb/sec) and y-axis of throughput (%).

The above graph in Figure 12 shows the comparison of overall network lifetime for proposed scheme, energy aware AODV, and AODV with x-axis of packet transmission (kb/sec) and y-axis of network lifetime (sec).

The above graph in Figure 13 shows the comparison of delay for energy aware AODV, and AODV with x-axis of packet transmission (kb/sec) and y-axis of average end-to-end delay (%).

VII. Conclusion

In this proposed system, a unique power-aware routing protocol using AODV is presented. In the route discovery process of the proposed scheme, transitional and intermediate nodes estimate the current mean power of the cumulative network as an evaluation threshold to establish how to retort to the received route request packets. An evaluation algorithm to accomplish the network mean residual power is highlighted. With such estimation, intermediate nodes can reasonably judge whether their residual power is adequate or not. By averting overused nodes from participating in route discovery processes, the proposed routing scheme using AODV efficiently stabilize the power expenditure around the cumulative network. For the analysis of the proposed system, with the assistance of graphical representation, the network lifetime of the proposed scheme and AODV with different levels of mobility and network loads is shown in result analysis. It is also shown that graph of data delivery rates with different levels of mobility and the network performance in term of mean end to end delay.

REFERENCES

[1] http://en.wikipedia.org/wiki/Mobile_ad_hoc_network. Accessed on 28th march, 2012

[2] Yu-Chee Tseng, Chih-Shun Hsu, Ten-Yueng Hsieh, Power-Saving Protocols for IEEE 802.11-Based Multi-Hop Ad Hoc Networks, INFOCOM 2002.

[3] S. Singh and C. S. Raghavendra, “Power Efficient MAC Protocol for Mul-tihop Radio Networks”, Proc. of IEEE International Personal, Indoor and Mobile Radio Communications Conference, July 1998, pp. 153–157.

[4] C. F. Chiasserini and R. R. Rao, “A Distributed Power Management Policy for Wireless Ad Hoc Networks”, IEEE Wireless Communication and Networking Conference, 2000, pp. 1209–1213.

[5] J. R. Lorch and A. J. Smith, “Software Strategies for Portable Computer Energy Management”, IEEE Personal Communications, Jun 1998, pp. 60–73.

[6] L. Hu, “Topology Control for Multihop Packet Radio Networks”, IEEE Transactions on Communications, Oct 1993, vol. 41, pp. 1474–1481.

[7] R. Ramanathan and R. Rosales-Hain, “Topology Control of Multihop Wireless Networks using Transmit Power Adjustment”, Proc. of IEEE Infocom, Tel Aviv, Israel, March 2000, pp. 404–413.

[8] R. Wattenhofer, L. Li, P. Bahl, and Y. M. Wang, “Distributed Topology Control for Power Efficient Operation in Multihop Wireless Ad Hoc Net-works”, Proc. of IEEE Infocom, Anchorage, Alaska, April 2001, pp. 1388–1397.

[9] C.E. Perkins and P. Bhagwat, “Highly Dynamic Destination- Sequenced Distance-Vector Routing (DSDV) for Mobile Computers”, Proc. of ACM SIGCOMM, London, U.K., 1994, pp. 234-244.

[10] C. E. Perkins and E. M. Royer, “Ad-hoc On-Demand Distance Vector Routing”, Proc. of 2nd IEEE Workshop on Mobile Computing Systems and Applications, New Orleans, LA, 1999, pp. 90-100.

[11] K. ARULANANDAM and Dr. B. PARTHASARATHY “A NEW ENERGY LEVEL EFFICIENCY ISSUES IN MANET” International Journal of Reviews in Computing 2009 IJRIC. All rights reserved

[12] Sunsook Jung, Nisar Hundewale, Alex Zelikovsky “Energy Efficiency of Load Balancing in MANET Routing Protocols”

[13] Rekha Patil , DrA.Damodaram “Cost Based Power Aware Cross Layer Routing Protocol For Manet” IJCSNS International Journal of Computer Science and Network Security, VOL.8 No.12, December 2008

[14] Rutvij H. Jhaveri Ashish D. Patel Ashish D. Patel “MANET Routing Protocols and Wormhole Attack against AODV” IJCSNS International Journal of Computer Science and Network Security, VOL.10 No.4, April 2010.

[15] Xiangpeng Jing and Myung J. Lee “Energy-Aware Algorithms for AODV in Ad Hoc Networks”

[16] Abdusy Syarif and Riri Fitri Sari “Performance Analysis of AODV-UI Routing Protocol With Energy Consumption Improvement Under Mobility Models in Hybrid Ad hoc Network” Vol. 3 No. 7 July 2011

[17] Preeti Bhati “An Efficient Agent-Based AODV Routing Protocol in MANET” Vol. 3 No. 7 July 2011

[18] Annapurna P Patil “Design of an Energy Efficient Routing Protocol for MANETs based on AODV” IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 4, No 1, July 2011 ISSN (Online): 1694-0814

[19] Dr. Sanjay Sharma, Pushpinder Singh Patheja “ Improving AODV Routing Protocol with Priority and Power Efficiency in Mobile Ad hoc WiMAX Network” International Journal of Computer Technology and Electronics Engineering (IJCTEE) Volume 2, Issue 1

[20] Nishant Gupta “Energy-Aware On-Demand Routing for Mobile Ad Hoc Networks”

[21] Jayesh Kataria “ACRR: Ad-hoc On-Demand Distance Vector Routing with Controlled Route Requests”

[22] P. Latha and R. Ramachandran “Energy reduction aware multicast routing for mobile ad hoc networks” Vol. 3 No. 3 (Mar 2010)

[23] Shivendu Dubey, Prof. Rajesh Shrivastava “Energy Consumption using Traffic Models for MANET Routing Protocols” International Journal of Smart Sensors and Ad Hoc Networks (IJSSAN) Volume-1, Issue-1, 2011

[24] Sajjad Ali & Asad Ali “Performance Analysis of AODV, DSR and OLSR in MANET” Department of Electrical Engineering with emphasis on Telecommunication Blekinge Institute of Technology, Sweden 2009

[25] M. Tamilarasi1, T.G. Palanivelu, “ADAPTIVE LINK TIMEOUT WITH ENERGY AWARE MECHANISM FOR ON-DEMAND ROUTING IN MANETS” Volume 4 Number 4

[26] Lijuan Cao Teresa Dahlberg Yu Wang “Performance Evaluation of Energy Efficient Ad Hoc Routing Protocols”

[27] Chansu Yu, Ben Lee “Energy Efficient Routing Protocols for Mobile Ad Hoc Networks” This research was supported in part by the Cleveland State University, EFFRD Grant No. 0210-0630-10.

[28] Tanu Preet Singh Energy-Efficient Routing Protocols In Mobile Ad-Hoc Networks" Volume 2, Issue 1, January 2012.

[29] M. Tamilarasi, T.G. Palanivelu "Integrated Energy-Aware Mechanism for MANETs using On-demand Routing" World Academy of Science, Engineering and Technology 38 2008.

[30] Mahesh K. Marina and Samir R. Das "Ad hoc on-demand multipath distance vector routing" Published online in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/wcm.432, 2006