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Literature Review and General Consideration of Energy Efficient Routing Protocols in MANETs

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Abstract*— A mobile wireless infrastructure-less network is a collection of wireless mobile nodes dynamically forming a temporary network without the use of any preexisting network infrastructure or centralized administration. However, the battery life of these nodes is very limited, if their battery power is depleted fully, then this result in network partition, so these nodes becomes a critical spot in the network. These critical nodes can deplete their battery power earlier because of excessive load and processing for data forwarding. These unbalanced loads turn to increase the chances of nodes failure, network partition and reduce the route lifetime and route reliability of the MANETs. Due to this, energy consumption issue becomes a vital research topic in wireless infrastructure-less networks. The energy efficient routing is a most important design criterion for MANETs. This paper focuses of the routing approaches are based on the minimization of energy consumption of individual nodes and many other ways. This paper surveys and classifies numerous energy-efficient routing mechanisms proposed for wireless infrastructure-less networks. Also presents detailed comparative study of lager number of energy efficient/power aware routing protocol in MANETs. Aim of this paper to helps the new researchers and application developers to explore an innovative idea for designing more efficient routing protocols.

***Keywords*— Ad hoc Network Routing, Load Distribution, Energy Efficient, Power Aware, Protocol Stack**

I. INTRODUCTION

Communication has become very important for people to exchange information anytime from and to anywhere. Wireless infrastructure-less network usually has a dynamic shape and a limited bandwidth. Routing is one of the key issues in infrastructure-less networks due to their highly dynamic and distributed nature. In particular, a very large number of recent studies focused on mobile infrastructure-less networks [1, 2]. The performance of a mobile infrastructure-less networks are depends on the routing scheme employed, and the traditional routing protocols do not work efficiently in a wireless infrastructure-less networks. Many proactive, reactive and hybrid protocols have been proposed from a variety of perspectives [2]. The energy efficient routing may be the most important design criteria for MANETs, since mobile nodes will be powered by batteries with limited capacity [3][4]. Power failure of a mobile node not only affects the node itself but also its ability to forward packets on behalf of others and thus the overall network lifetime. This paper surveys and classifies numerous energy-efficient routing mechanisms proposed for wireless infrastructure-less networks. A mobile node consumes its battery energy not only when it actively sends or receives packets, but also when it stays idle listening to the wireless medium for any possible communication requests from other nodes. Thus, energy-efficient routing protocols minimize either the active communication energy required to transmit and receive data packets or the energy during inactive periods. The transmission power control approach can be extended to determine the optimal routing path that minimizes the total transmission energy required to deliver data packets to the destination [5]. Another important approach to optimizing active communication energy is load distribution approach [6]. While the primary focus of the above two approaches is to minimize energy consumption of individual nodes, the main goal of the load distribution method is to balance the energy usage among the nodes and to maximize the network lifetime by avoiding over-utilized nodes when selecting a routing path.

The structure of this paper is as follows. Section 2 presents the overview of infrastructure-less networks. Section 3 presents the energy efficient routing protocols. In section 4 investigates research reviews on popular energy efficient/power aware routing protocols and tabulated limitations and techniques of wireless infrastructure-less networks. Finally, present the concluding remarks in Section 5.

II. OVERVIEW OF INFRASTRUCTURE-LESS NETWORKS

A simple wireless infrastructure-less network is represented in Fig.1. Some of the characteristics of these networks are fully distributed. Hosts in a wireless network can move around. Therefore, the network topology can be dynamic and unpredictable. Traditional routing protocols used for wired networks cannot be directly applied to most

wireless networks because some common assumptions are not valid in this kind of dynamic network. Therefore efficient routing protocols are key components of successful communications in mobile infrastructure-less network.

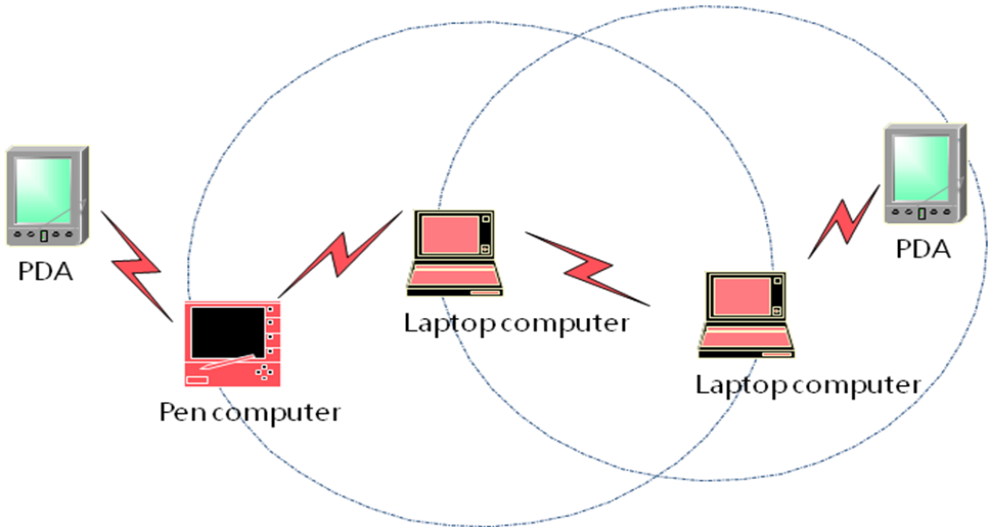

Fig. 1 Example of an Infrastructure-less Network

A. The Protocol Stack

In this section the protocol stack for mobile infrastructure-less networks is described. This gives a comprehensive picture of protocol stack of network layers, and helps to better understand, mobile infrastructure-less networks [7]. Fig. 2, shows the protocol stack which consists of five layers: physical layer, data link layer, network layer, transport layer and application layer. It has similarities to the TCP/IP protocol suite. As it can be seen that OSI layers for session, presentation and application are merged into one section called application layer. On the left of Fig. 2, the OSI model is shown. It is a layered framework designed for the purpose of network systems that allows for communication across all types of computer systems.

In the middle of the Fig. 2, the TCP/IP suite is shown. Because it was designed before the OSI model, the layers in the TCP/IP suite do not correspond exactly to the OSI layers. The lower four layers are the same but the fifth layer in the TCP/IP suite (the application layer) is equivalent to the combined session, presentation and application layers of the OSI model. On the right, the MANET protocol stack - which is similar to the TCP/IP suite, is illustrated. The main difference between these two protocols stacks lies in the network layer. Mobile nodes (which are both hosts and routers) use an ad hoc routing protocol to route packets.

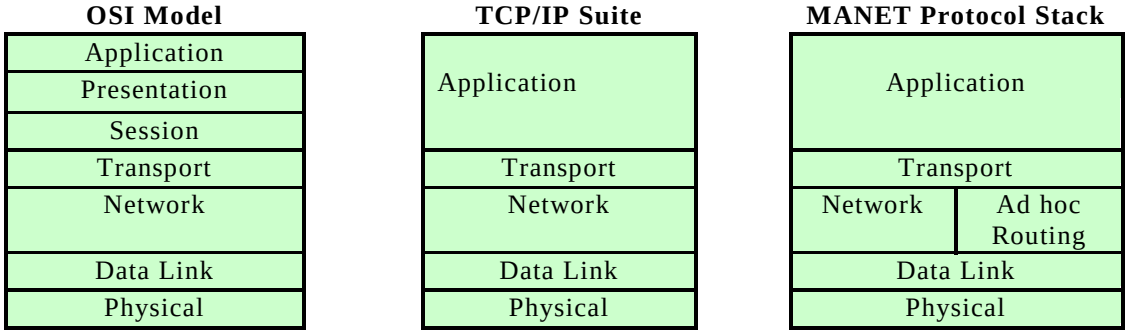

Fig. 2 Protocol Stack for Network Models

It is important to explain the developmental goals for an infrastructure-less network routing protocol so that the design choices of the protocols can be better understood. As already stated in previous chapter, the characteristics of infrastructure-less networks [8-10] include resource-poor policy, restricted bandwidth, high error rates, and a repetitively changing topology. Among the existing resources, battery power is usually the most constraining. Thus, the following are usual design goals for infrastructure-less network routing protocols as minimal control overhead, minimal processing overhead, multi-hop routing capability, dynamic topology maintenance, loop prevention etc.

III. ENERGY EFFICIENT ROUTING PROTOCOLS

Energy is a limiting factor in case of infrastructure-less networks. Routing in infrastructure-less networks has some unique characteristics [11][16]. First- energy of nodes is crucial and depends upon battery which has limited power supply. Second-nodes can move in an uncontrolled manner so frequent route failures are possible. Third-wireless

channels have lower and more variable bandwidth compare to wired network. Energy efficient routing protocols are the only solution to above situation. Most of the work of making protocols energy efficient has been done on "on demand routing protocols" because these protocols are more energy efficient rather than proactive protocols but still these have some drawbacks. Energy efficiency can also be achieved by sensible flooding at the route discovery process in reactive protocols. Energy efficiency can also be achieved by using efficient metric for route selection such as cost function, node energy, battery level etc. Here energy efficiency doesn't mean only the less power consumption here energy efficiency means increasing the time duration in which any network maintains certain performance level. As discussed in the introduction, this goal can be accomplished by minimizing mobile nodes' energy not only during active communication but also when they are inactive. Transmission power control and load distribution are two approaches to minimize the active communication energy [11-15], and sleep/power-down mode is used to minimize energy during inactivity [16].

A. Power Aware Routing

A lot of effort is currently going on to reduce the power consumed in a mobile device within the ad hoc network and power aware routing strategy[18-20] can ensure optimal usage of battery power of each node. To enhance the efficiency of data communication, shortest path algorithms are usually used. But, if only shortest path algorithm is used, then it will be observed that the intermediate nodes in that shortest path will deplete their power much more early then their neighbors. Just as its name implies, power aware routing is to choose appropriate transmission range and routes to save energy for multi-hop packet delivery [18]. We first discuss the five metrics for power aware routing:

- Minimize Energy consumed per packet: the most intuitive metric, however not optimal for maximum lifetime;
- Maximize Time to Network Partition: important for mission critical applications, hard to maintain low delay and high throughput simultaneously;
- Minimize Variance in node power levels: balance the power consumption for all the node in the network, i.e., all nodes in the network have the same importance;
- Minimize Cost per packets: try to maximize the life of all the nodes;
- Minimize Maximum Node Cost: try to delay the node failures.

To improve the efficiency of data communication, shortest path algorithms are usually used. But, if only shortest path algorithm is used, then it will be observed that the intermediate nodes in that shortest path will deplete their power much more early then their neighbors.

IV. **RESEARCH REVIEW**

Energy efficient communication in wireless infrastructure-lee networks has received more and more attention, because one significant characteristic of such networks is that nodes are energy-constrained. Nodes are battery-operated and frequent recharging or replacement of batteries may be undesirable or even impossible. In [45,49], many protocols have developed such that it selects the nearest hop to minimize the transmission power, according to this simple observation, some routing algorithm for discovering an energy-efficient route with transmission power control (TPC) devices. Scheme presented in request that a node chooses a next hop, which reduces transmission power and exposed nodes along the route from sources to destinations to achieve better throughput.

PAMAS- power-saving medium access protocol [15, 50] turns off a node's radio when it is overhearing a packet not addressed to it. This approach is suitable for radios in which processing a received packet is expensive compared to listening to an idle radio channel. Chang J.H. [51] proposed the flow augmentation routing (FAR) to obtain the optimal routing path in favor of a given source–destination couple that reduces the total of link costs along the route. Result to maximize the network lifetime when data-generation rate is known. Li Q [52] proposed the OMM protocol to achieve the same goal as in FAR without knowledge of the data-generation speed in advance. It optimizes two dissimilar metrics of the nodes in the wireless network: Reducing power consumption (min-power) and enhancing the minimal residual power (max-min). Banerjee S [53] proposed minimum energy paths for reliable communication by utilizing intermediate nodes to save energy between two distant nodes using transmission power control. Narayanaswamy S [54] presents a Smallest Common Power (COMPOW) protocol [54] it is a straightforward solution to maintain bi-directionality between every pair of communicating nodes in a mobile infrastructure-less network. It is understood that the transmission power levels can't be arbitrarily used to but instead it should be chosen along with a small number of discrete power categories (P_1, P_2, . . . , P_{max}). Diverse power levels result in dissimilar node connectivity because they cover dissimilar radio transmission ranges. Alvin Valera [55] produces Caching and Multi-Path (CHAMP) protocol that enables the discovery of the shortest multipath, uses a straightforward load-balancing technique to distribute routing load, and uses data caching and multiple path routing to improve packet delivery and energy-efficiency. Rajgopal Kannan [56] proposed a method surrounded through duty cycle of the node (i.e. wake and sleep cycles) are based on their circumstances. A distributed method is used to discover sets of winners and losers, who are afterward assigned suitable slots in our TDMA, based MAC procedure. It used the model of sensor node based on criticality of the energy as a purpose of energies and traffic rates. Song Guo [57] presents a constraint formulation for the minimum-energy multicast problem in terms of MILP (mixed integer linear programming) for wireless infrastructure-less networks. Additionally, it is important to develop the distributed algorithms of MEM to cope with the dynamic topologies. Bor-rong Chen [58] presents the performance of AODV, DSR, TORA and DSDV under different mobility models. These protocols differ in their energy conservation under different mobility model. Thus proving that mobility models play significant role in determining the

performance of infrastructure-less routing protocol which runs over it. Petra Berenbrink [59] studies random algorithms of gossiping and broadcasting in infrastructure-less networks. The objective is not only to minimize energy consumption but also gossiping and broadcasting time, it is calculated in terms of the total number of packets sent by nodes. Sanjay Kumar Dhurandher [60] presents an energy efficient mobile ad-hoc on-demand routing protocol that balances energy load along with nodes so, a minimum energy level is maintained in the middle of nodes and the network life is increased. Mainly focused on increasing the network permanence by distributing energy consumption in the network. Tai Hieng Tie[61] proposed algorithms improve performance in terms of energy conservation in comparison with existing AODV protocol , in this author provides changed route selection method. V. Rishiwa [62] recommend a very good algorithm, that can maximizes the network lifetime by reducing the power consumption throughout the source to destination path establishment, but author have not provided enough detail. In this paper [47] describes improvement over of the conventional routing protocol by utilizing higher energy path and backup route. Sofian Hamad [63] shows that signal strength based routing protocol (if signal strength is above threshold then the quality of link is high) and route lifetime is calculated using the link expiration time. Dure to this the overhead increases when mobility becomes high in AODV while stay in same level with LSEA. Radhika D. Joshi [64] has tried variable range transmission power control by means of DSR protocol. Using transmission range is adjusted dynamically as per node distance. Work is also described analytical modeling of the protocol performance to predict correct network behavior for future instances. This technique helps in proficiently estimating the performance of network with modified protocol.

This section presents the comparative performance analysis of existing well known routing protocols of wireless infrastructure-less networks in Table 1. This compression is important mainly new researchers they know about different techniques used as well as their limitations in energy efficient routing approach.

TABLE 1 LIMITATIONS OF POPULAR ENERGY EFFICIENT/ POWER SAVING WIRELESS INFRASTRUCTURE-LESS NETWORKS

Sl. No.	**Papers on Energy Efficient Model**	**Author/ Proposed by**	**Year of Pub.**	**Technique Used/ Available Information**	**Future Work(s)/ Limitation(s)**	**Remarks (if any)**
1	PAMAS (Power aware multi access protocol) Improved PAMAS	S Singh et al. [49] C. S. Raghwendra et al. [50]	1998 1999	In this multi-access protocol for infrastructure-less networks that conserves power by turning off a node's radio when it is overhearing a packet not addressed. To avoid the prying, a node must switch off the boundary for data channel, while not for the organize channel (which carries RTS/CTS packets). Every inactive node forever knows how long to sleep through the control channel to it.	Not separate control channel for users, so that nodes have to be able to receive on the control channel while they are transmitting on data and control channels simultaneously It may not be helpful when hardware is common for the data and control channels. It can't be feasible turn off a lot hardware due to the sharing.	Intelligently powering off nodes that are not actively transmitting and receiving packets. Control Channel (RTS/CTS packets) doesn't switch off.
2	Energy conserve-ng routing	Jae-Hwan Chang et al. [51]	2000	Author proposed algorithms are local and agreeable to distributed implementation.	The algorithms are not supported globally, these algorithms local and	Maximum flow problem

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Table 1 (continued)

				It turns out that in order to maximize the lifetime, the traffic should be routed such that the energy consumption is balanced among the nodes.	amenable to distributed implementation. In global scenario it may not be amendable to distributed implementation system.	with node capacities Maximum flow problem with node capacities
3	Online	Li Q. et	2001	OMM protocol maximizes	OMM protocol requires	Preventin

	power-aware routing	al.[52]		the network lifetime even though data-generation rate is not known in advance. It optimizes two dissimilar metrics of the devices in the network: reducing power consumption (min-power) and enhancing the minimal residual power (max-min).	information concerning the power levels of all mobile nodes. In big networks, this requirement is not trivial.	-g the occurren-ce of overloade d nodes
4	CHAMP: A highly resilient and energy-efficient routing protocol for MANETs	Alvin Valera et	2002	Designed a new routing protocol that enables the discovery of the shortest multipath, uses a straightforward Load-balancing technique to distribute routing load, and uses data caching and multiple path routing to improve packet delivery and energy-efficiency.	More studies are still needed to determine the protocol's scalability and performance in scenarios with low mobility rates.	Every node maintaini ng two buffers, send buffer and data cache.
5	Energy and rate based MAC protocol for wireless sensor networks	Rajgopal Kannan et al. [56]	2003	Propose an method in which node task cycles (i.e sleep and wake schedules) are related to their complexity. A distributed algorithm is used to discover sets of losers and winners, who assigned suitable slots in our TDMA related MAC protocol. They utilize the idea of energy-criticality of a wireless sensor device as a role of energies and traffic rates.	This makes the problem of conserving energy at individual sensor nodes challenging. S-MAC and PAMAS are two MAC protocols which periodically put nodes (selected at random) to sleep in order to achieve energy savings.	Using critical value for sleep and wake period
6	Minimu m Energy Multicast Routing for Wireless Ad-hoc Networks with Adaptive Antennas	Song Guo et Al. [57]	2004	The technique of adaptive antennas is used. There is source initiated multicast traffic. MILP- Mixed Integer Linear Programming is used and hence tries to give an enhance solution to obtained in a timely manner for moderate networks typically with 50 nodes.	The technique works well with 50 nodes, requires to extent the model to large-scale Networks. Need to develop the distributed algorithms to cope with the dynamic topologies	It assumes global knowledg e of pair-wise distances between the nodes
7	Mobility contact on Energy conservat ion of ad hoc routing protocol	Bor-rong Cheng et al[58]	2005	Presents the performance of AODV, DSR, TORA and DSDV under different mobility models. These protocols differ in their energy conservation under different mobility model Thus proving that mobility models play significant role in determining the performance of ad hoc routing protocol which runs over it.	The fact that battery will have finite power and they will get drained is not taken under consideration. So there exists a need to take this fact into account while doing future work. There also exists a need to take different traffic patterns under consideration as well.	NS-2 network simulator has been used

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Table 1 (continued)

8	Energy Efficient Randomised Communication in Unknown AdHoc Networks	Petra Berenbrink et al.[59]	2007	As the energy consumption is measured by the no. of messages sent, this paper aims to reduce the broadcasting and gossiping time along with reducing energy consumed.	The lack of practical application of this model is a drawback, and hence other methods for random graphs, like geometric graphs should be considered.	Assumption is made that the nodes, unaware of the network, cannot adjust the area size that their messages can cover.
9	An Energy-Efficient On-Demand Routing Algorithm	Sanjay Kumar Dhurandher et al.[60]	2008	EEAODR: Energy Efficient Ad Hoc On-Demand Routing algorithm to increase the network life and to minimize energy consumption by distributing load to all mobile nodes and selecting the path with remaining maximum power level in nodes.	For the first time algorithm waits for dt time which is useless because all the nodes are fully charged and have equal energy thus initially this algorithm does not perform well in comparison to AODV protocol	Cost = [σ * Time + μ* (1/minimum battery power of node in route) + τ *(1/number of hops)]
10	Max. Energy Level Ad Hoc Distance Vector Scheme for Energy Efficient Ad Hoc Network Routing	Tai Hieng Tie et al.[61] Tai Hieng Tie et al.[61]	2009	MEL-AODV routing-The protocol is based on path detection by calculating the remaining energy of the nodes and there after selecting the path with maximum energy and minimum cost.	It uses transmission power and transmission time to calculate energy in transmit mode and receive mode however, there can be other factors like time management, no. of Hops, shortest distance etc.	Energy in transmit mode Etx) = txPower × txtime Energy Remaining (Enode)= current energy - Etx Energy in receive mode (Ercv) = rcvPower × rcvtime
11	Power Aware Routing in Ad Hoc Wireless Networks	Vinay Rishiwal et al.[62]	2009	The author proposed PAR (Power Aware Routing) protocol. The algorithm focuses on three different parameters for route discovery i.e. Accumulated energy of a path, status of lifetime of a battery and the type of data to be transfer i.e. NRT(Non Real Time) and RT (Real Time)	Though the algorithm best discovered the path for packet transfer but, it does not provide any solution to save the battery power of the nodes.	Route selection criteria based on energy consumption
12	Alternate Link Maximu	Tai Hieng Tie et al.	2010	The author proposed ALMEL-AODV (Alternate Link Maximum Energy	However it is an improved version of it MEL-AODV but here	Energy in forwarding mode,

	m Energy Level Ad Hoc Distance Vector Scheme for	[47]		Level AODV) routing protocol. The protocol is an improved version of MEL-AODV. It works similar to MEL-AODV except its nature of selecting the alternate path for routing if the current path exhausts.	also It lacks other factors like time management, no. of Hops, shortest distance etc. in. calculating the energy in transmit mode and receive mode	*Ef = Etx + Ercv*

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Table 1 (continued)

	Energy Efficient Routing					
13	Link Stability and Energy Aware for Reactive Routing Protocol in Mobile Ad Hoc Network	Sofian Hamad et al.[63]	2010	Signal strength based routing protocol(if signal strength is above threshold then the quality of link is high) and route lifetime is calculated using the link expiration time	The overhead increases when mobility becomes high in AODV while stay in same level with LSEA.	Lifetime of the network can be reduced
14	Energy Aware Variable range DSR	Radhika D. Joshi et al.[64]	2011	Transmission range is tuned dynamically depending on node's distance in VRDSR. Power control affects the physical layer performance. Reducing the transmission range demands more number of forwarding nodes but energy utilization is less. The comparison of different parameters for both the protocols is done.	For modified VRDSR protocol, the improvement in number of alive nodes , network lifetime is due to transmitter power adjustment done at each node before transferring the data. Required to know the actual distance between nodes is difficult.	MAC layer protocol is defined by IEEE802. 11 standard.

As it has been shown in table 1 that the comparison of main energy efficient routing protocols based on their limitations and techniques used. There exists a huge variety of energy efficient routing protocols designed exclusively for wireless infrastructure-less mobile networks. The comparison shows that every routing protocol has their limitations and advantages. This comparison shows that new researches can find lot of information at one place means this paper helps the new researchers and application developers to explore an innovative idea for designing more efficient routing protocols.

V. CONCLUSION

There is not a single protocol which can give the best performance in ad-hoc network. Performance of the routing protocols varies according to the variation in the network parameters as the position of the nodes in an mobile infrastructure-less network continuously varies due to which we can't say that any particular protocol will give the best performance in each and every case topology varies very frequently so we have to select a protocol which dynamically adapts the ever-changing topology very easily.

Limited power supply is the biggest challenge of a mobile infrastructure-fewer networks so if we want to increase the network lifetime (time duration when the first node of the network runs out of energy) as well the node lifetime, an efficient energy protocols which can perform better in all cases of mobility. The mobility of the node in infrastructure-fewer networks varies with time so sometimes it becomes the prime concern while the other times energy of the node may be the prime concern. So, we will choose the protocol in such a way that which perform best for that particular type of network.

REFERENCES

[1] Charles E. Perkins and Pravin Bhagwat, 1994.Highly Dynamic Distance Destination-Sequenced-Vector Routing. *In Proceedings of the ACM SIGCOMM,* Vol. 24, No. 4, October, 1994, pp.234-244.

[2] Samba Essay, Zongkai Vang, Jianhua He, 2004. A survey on mobile ad hoc wireless network. *Asian Network for Scientific Information, White Paper* [Online] Available at: http://whitepapers.zdnet.com/whitepaper.aspx?&docid=148894& promo =100511, [Accessed July, 2004].

[3] Goldsmith AJ, and Wicker SB, 2002. Design challenges for energy-constrained ad hoc wireless networks. *IEEE Wireless Communications*; vol. 9, No. 4, 2002, pp. 8–27.

[4] C.K. Toh, 2001. Maximum battery life routing to support ubiquitous mobile computing in wireless ad hoc networks. *IEEE Communication Mag*., vol.39, no.6, June 2001, pp. 138-147.

[5] V. Kawadia and P.R. Kumar, 2003. Power Control and Clustering in Ad hoc Networks. Wireless Communications, *IEEE INFOCOM,* Vol. 12, No.1, 2003, pp.3-11.

[6] Radhika D. Joshi and Priti P. rege, 2008. Distributed Energy Efficient Routing in Ad-hoc Networks. IEEE, Fourth International Conference on Wireless Communication and Sensor Networks (WCSN 2008), 27-29 Dec., 2008, pp.16-21.

[7] M. Frodigh, P. Johansson, and P. Larsson, 2000.Wireless ad hoc networking: the art of networking without a network, *Ericsson Review*, No.4, 2000, pp. 248-263.

[8] Chlamtac I., Conti M., and Liu, J. J.N, 2003. Mobile ad hoc networking: imperatives and challenges. *Ad Hoc Networks.* Vol. No.1, 2003, pp. 13–64.

[9] Elizabeth M. and Belding-Royer, 2004. Routing Approaches in Mobile Ad hoc Networks. *Proceedings of IEEE Workshop on Pervasive Computing Education (PerEd),* on *Mobile Ad Hoc Networking*, March 2004, *pp. 231-235*.

[10] R. Kravets and P. Krishnan, 2000. Application-Driven Power Management for Mobile Communication. *Wireless Networks, Vol. 6, No.* 4, 2000, pp. 263–277.

[11] Shiva Prakash, J.P. Saini, S.C. Gupta and Sandip Vijay, "Design and Implementation of Variable Range Energy Aware Dynamic Source Routing Protocol for Mobile Ad hoc Networks", published in International Journal of Computer Engineering &Technology (IJCET), ISSN 976 - 6367(Print), ISSN 0976 – 6375(Online), Volume 4 Issue 1, January- February, 2013.

[12] Yonghui chen, chunfeng zhang and zhiqin liu, 2010. Energy Efficient Routing Protocol Based on Energy of node and Stability of Topology. *3rd International conference on Information and computing*, 2010, pp. 262-265.

[13] Radhika D. Joshi and Priti P. rege, 2008. Distributed Energy Efficient Routing in Ad Hoc Networks. *in 978-1-4244-3328-5/08 in IEEE*, 2008.

[14] Lei Zhang, Deying Li and Alvin Lim. 2010. Energy-efficient Traffic-aware detour trees for Geographical Routing. *International Journal of Computer Networks & Communications (IJCNC)*, Vol.2, No.1, January, 2010.

[15] Suganya Senthil, Palaniammal Senniappan, 2011. A Detailed Study on Energy Efficient Techniques for Mobile Adhoc Networks. *IJCSI International Journal of Computer Science Issues*, Vol. 8, Issue 5, No 1, September 2011, pp. 383-387.

[16] Stojmenovic I, Lin X, 2001, Power-aware localized routing in wireless networks. *IEEE Transactions on Parallel and Distributed Systems*; Vol. 12, Issue 11, 2001, pp.1122–1133.

[17] Chansu Yu, Ben Lee, Hee Yong Youn, 2003. Energy Efficient Routing Protocols for Mobile Ad hoc Networks. *Wireless Communications and Mobile Computing, Wirel. Commun. Mob. Computing 2003*; Vol.3, November, 2003, pp. 959–973.

[18] Xiaoying Zhang, Thomas Kunz, Li Li and Oliver Yang, 2010. An Energy-efficient Broadcast Protocol in MANETs. 8th Annual Communications Networks and Services Research Conference, Proceedings of the 2010 ISBN: 978-0-7695-4041-2, 2010, pp.199-206.

[19] Tai Hieng Tie, Chong Eng Tan and Sei Ping Lau, 2010. Alternate Link Maximum Energy Level Ad-hoc Distance Vector Scheme for Energy Efficient Ad-hoc Networks Routing. International Conference on Computer and Communication Engineering (ICCCE 2010), Kuala Lumpur, Malaysia, May, 2010, pp.11-13.

[20] Dahai Du and Huagang Xiong, 2010. A Location aided Energy-Efficient Routing Protocol for Ad-hoc Networks. *in proceeding of 19th annual wireless and optical communications conference (WOCC)*, 2010.

[21] V.Roduplu and T. Meng, 1999, Minimum energy mobile wireless networks. *IEEE J. Sel. Areas Communication*, vol.17, no.8, Aug. 1999, pp. 1333-1344.

[22] C. S. Raghavendra and S. Singh, 1999. Improved PAMAS—power aware multi-access protocol with signalling for ad hoc networks. *Published in ACM, Computer Communication Review*, Vol. 29, No. 2, 1999.

[23] Chang J.H., Tassiulas L., 2000. Energy conserving routing in wireless ad-hoc networks. *Proceedings of the Conference on Computer Communications (IEEE Infocom 2000);* vol.1, 2000, pp. 22-31.

[24] Li Q, Aslam J, Rus D., 2001. Online power-aware routing in wireless ad-hoc networks. *Proceedings of International Conference on Mobile Computing and Networking (MobiCom'2001)*, 2001, pp. 97–107.

[25] Banerjee S, Misra A., 2002. Minimum energy paths for reliable communication in multi-hop wireless networks, *Proceedings of Annual Workshop on Mobile Ad Hoc Networking & Computing (MobiHOC 2002)*, 2002, pp.146–156.

[26] Narayanaswamy S, Kawadia V, Sreenivas RS, Kumar PR, 2002, Power Control in Ad-hoc Networks: theory, architecture, algorithm and implementation of the COMPOW protocol. *Proceedings of European Wireless*, 2002, pp. 156-162.

[27] Alvin Valera, Winston K.G. Seah and SV Rao, 2002. CHAMP: A Highly-Resilient and Energy-Efficient Routing Protocol for Mobile Ad hoc Networks. *in proceedings of 4th International Workshop on Mobile and Wireless Communications Network, 2002.*

[28] Rajgopal Kannan, Ram Kalidindi, S. S. Iyengar and Vijay Kumar, *2003*. Energy and Rate based MAC Protocol for Wireless Sensor Networks. *Published in ACM Article. Bibliometrics Data Bibliometrics, 2003*.

[29] Song Guo and Oliver Yang, 2004, Minimum Energy Multicast Routing for Wireless Ad-hoc Networks with Adaptive Antennas" published in Proceedings of the 12th IEEE International Conference on Network Protocols (ICNP'04), 2004.

[30] Bor-rong Chen and C. Hwa Chang, "Mobility Impact on Energy Conservation of Ad Hoc Routing Protocols", MTC, 2005, pp.1-7.

[31] Petra Berenbrink, Colin Cooper, and Zengjian Hu, 2007. Energy Efficient Randomised Communication in Unknown Ad Hoc Networks. *SPAA'07, San Diego, California, USAACM 978-1-59593-667-7/07/0006*, June 9–11, 2007.

[32] Sanjay Kumar Dhurandher, Sudip Misra, Mohammad S. Obaidat , and Vikrant Bansal, Prithvi Singh, Vikas Punia. 2008. An Energy-Efficient On-Demand Routing Algorithm for Mobile Ad-Hoc Networks. *IEEE, 978-1-4244-2182-4/08*, 2008.

[33] Tai Hieng Tie, Chong Eng Tan, Sei Ping Lau, 2009. Maximum Energy Level Ad Hoc Distance Vector Scheme for Energy Efficient Ad Hoc Networks Routing. *Proceedings of the 2009 IEEE 9th Malaysia International Conference on Communications Kuala Lumpur Malaysia*, 15 -17 December, 2009.

[34] Rishiwal Vinay, Yadav, Mano, Verma S., Bajapai S. K., 2009. Power Aware Routing in Ad Hoc Wireless Networks. Journal of Computer Science & Technology (JCS&T), Vol. 9 Issue 2, 2009.

[35] Sofian Hamad, Hadi Noureddine, and Hamed Al-Raweshidy, 2011. Link Stability and Energy Aware for Reactive Routing Protocol in Mobile Ad Hoc Network. *MobiWac'11, Miami, Florida, USA, Copyright ACM 978-1-4503-0901-1/11/10*, October 31–November 4, 2011.

[36] Radhika D. Joshi and Priti P. Rege, 2011. Performance Evaluation and Simulation Based Modeling of Energy Aware Variable Range DSR (VRDSR) Protocol. *Published in International Journal of Computer Science and Communication,* Vol. 2, No. 2, July-December 2011, pp. 565-575.

