Survey on Energy-Based Geographic Routing Protocols and Position Update Strategies in Ad-Hoc Networks

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Abstract--Mobile Ad-hoc Network (MANET) is a wireless network with no infrastructure, used in vital places such as battle fields, disaster areas, remote areas etc. This emergency aiding network is formed on-demand by mobile nodes to accomplish communication and information sharing activities. Since there is no centralized control to oversee the ongoing activities, each node operates with the responsibility of acting as router to forward data. In MANETs, there are many challenges such as routing, security, bandwidth etc. are still under research. Among them routing with minimum energy is a predominant task because all the nodes operate with embedded batteries. In MANET routing protocols, Geographic Routing Protocols (GRPs) are the popular energy efficient, location-based routing protocols, which operate with the help of Global Positioning System (GPS) and Grid Location Systems (GLS). The mandatory requirement of GRPs, location information dissemination is the most energy consuming activity, as the beacon packets are exchanged among nodes. Greedy Perimeter Stateless Routing (GPSR) is a well-known GRP and its main goal is to reduce the number of hops in packet forwarding. The drawback of GPSR is the diffusion hole problem. This paper analyses GPSR, energy efficient geographic routing protocols which solve diffusion holes, other power management techniques and various position update schemes.

Key Terms-- diffusion hole; energy management; GPS; GPSR; position updates schemes

I. INTRODUCTION

Ad-hoc networks are wireless networks which do not rely on the infrastructure such as routers, access point etc., as in wired networks. The Latin word 'ad-hoc' means 'for this purpose'. That is, these are the special forms of networks aiming to work with a specific intention.

MANET is a form of ad-hoc network, consists of moving devices known as mobile nodes. They can be either highly, moderately or slowly moving dynamic nodes, which depend upon the nature of application. Moreover, each node has a transceiver to send and receive data which replaces the functionalities of base station of infrastructure-based networks. The mobile characteristics enable MANETs to be connected with outside world such as Wi-Fi and internet via wireless medium. While exchanging confidential and sensitive information, it’s necessary to be cautious due to frequent link disconnections, scarce resources, and mobility. Information is shared between two entities by means of packets transfer. It’s a two step process: (1) Packet framing, spend a significant amount of energy in construction of packets (2) Packet forwarding, spend some minimum energy to identify or recognize the destination node. The packet forwarding operations consume more energy than the packet reception. As mentioned earlier, battery power should be efficiently utilized to extend the lifetime of nodes. For this purpose applications use transmission power control mechanisms and energy management protocols. In some cases, nodes fluctuate between sleep and active modes when they are idle and busy respectively. Even though nodes are in sleep mode, they expel a small amount of energy for sensing the medium for possible connections and overhearing data transmissions.

Geographic Routing Protocols (GRPs) are on-demand and well-known protocols used widely due to the availability of Global Positioning Systems (GPS) and Grid Location Systems (GLS). With GPS information, each node knows its own location in the network at any point in time. The use of location information make the GRP's to be simple and scalable. The packets are forwarded directly to the location of the destination nodes, rather than finding the route to the destination. Thus, the prior route discovery is avoided.

Two main requirements of geographic routing protocols are location of the destination node and one-hop neighbor nodes. Suppose that a node 'A' (source) is ready to transmit data packets to node 'B' (destination). Now, as per geographic routing protocols node A has to do only two simple tasks: 1) To form the packet by stamping position of the destination 2) To forward the packet towards the location of the destination [1], [4]. Thus, each node needs to maintain the location tables to store the position information of the network nodes.

The main advantage of using GRPs, avoids poor routing technique "broadcasting". While many routing methods such as simple flooding, direction-based flooding are common for GRPs, unicasting outperform them as it reduces the number of packet duplications. But it needs proper packet back-up mechanisms for retransmission in case of packet loss.

Two location service points are GPS and GLS. GLS serve nodes with location information by splitting entire network into small squares known as grids. Determining the location of the destination is completely based on the grid unit, where it currently presents. Quorum [21] is a substitute for the GLS to provide location services [4], [21].

The nodes exchange location information either periodically or based on certain criteria. Each node determines its own position coordinates with the help of GPS [15] or other localization schemes [16]. It is not sure that GPS provided information is 100% correct because, some delay may be incorporated while receiving the information. Nodes exchange their locations by means of small packets known as "beacon packets". They are control packets, approved by IEEE802.11 based WLANs and capable to piggyback beacon interval, capability information, supported data rates and, traffic indication etc.

Although beacons are mandatory for geographic routing, they become a root cause for the major problems such as energy depletion, storage issues, and packet collisions in the medium access (MAC) layer. Beacon exchanges can be either periodic or adaptive to certain criteria. In periodic beaconing scheme, each node transmits beacon packet at regular interval to all the nodes. Generally, it is desired to opt 1 second as beacon interval. If there are 'n' nodes (e.g. 1000 nodes) in the network, then each of them will produce n(n-1) (1000x999) beacon packets at every 1 sec regardless of the change in their positions. This count is comparatively larger than actual data packets. Thus the control packets itself cause severe congestion and prevent data packets from reaching desired location. Hessenbuttel et al have experimented periodic beaconing scheme and have shown that it leads to the inaccurate local topology in highly dynamic networks. Thus it causes performance degradations namely packet delays and losses. To overcome these drawbacks distance-based, probability-based, and other adaptive beaconing schemes are proposed. As a result, a significant reduction in the energy spent for position updates is attained.

Apart from these improved beaconing schemes, MANETs implement various algorithms and protocols at different layers of internet protocol stack to conserve energy. For example, nodes go into sleep mode when they are not involved in any communication or data forwarding activity. Another important technique is to turn-off transceivers, when they are not in use as it's an important and most power consuming devices in ad-hoc network nodes. The reason for the extreme power consumption is that they are the only option for data reception and forwarding (act as relays). It is not only the task of making the devices to sleep but also necessary to wake them up so that they can involve in ongoing communications. Synchronous and asynchronous wake-ups are two different techniques used widely [11].

Some of the nodes split network nodes into high power and battery-based nodes. High power nodes are used as much as possible [12]. In distributed data transfer scheme, nodes work collaboratively to decide on the delivery, aggregation and compression of the data. Thus it reduces the amount of messages, nodes involved in communication [8]. Generally speaking, there are only two classifications in energy conservation techniques: active and passive techniques. Active methods reserve energy, while the passive methods employ network interface device scheduling to make the devices to oscillate between sleep and active modes [12].

GPSR is a farmer and famous geographic routing protocols, operate with the assistance of GPS.

According GPSR, a source node stamps the position coordinates of destination in the data packet and forwards it to one of its radio neighbor, which is geographically closer to the destination. Such neighbor is said to be "Greedy node" and the process is known as "Greedy Routing" [1], [21]. There may be situation of void i.e. no node is present in the $2\pi/3$ space in the direction of destination [1]. Perimeter routing solve void problem and it tries to forward the packets along the nodes situated in the perimeter. Once the perimeter routing succeeds, greedy routing come into play. The reason behind considering GPSR for geographic routing is that it's a simple and scalable routing protocol and can be applied to both dense and sparse networks. Hence the optimization methods are important for GPSR to achieve better performance.

The rest of the paper is organized as follows: Section II analyses various position update schemes. Survey on power management techniques of ad-hoc networks are discussed in section III. Section IV analyses the GPSR to explore its merits and demerits. Finally, section V concludes the paper.

II. POSITION UPDATE SCHEMES

A. Periodic position updates

Periodic beaconing means each node exchanges its position with every other node in the network at predetermined interval of time [19]. Marc Heissenbuttel et al. have analyzed periodic beaconing scheme thoroughly and found that it has many drawbacks [20]. Generally, they classify these impacts into direct and indirect impacts. Direct impacts include additional energy used to transmit/ receive, process the beacons and interference with the main data transfer activities. Thus they utilize the network resources unnecessarily and cause Quality of Service (QoS) degradation.

Indirect impacts include presence of inaccurate position information in the location tables. Inaccurate information incorporate (a) incorrect location coordinates due to mobility (b) Presence of information of a node which is already moved out of the transmission range [false neighbor] (c) No information for a new node presently entered in the transmission range [unknown neighbor] [4].

B. Distance-based beaconing

Distance-based beaconing was discovered as a substitute for the periodic beaconing and it solved the majority of the problems of periodic beaconing system. In distance-based beaconing, nodes send beacon updates to other nodes only when they cross a given distance (d). False neighbors are discovered and removed, if there is no beacon update from nodes, for their k-fold movement of the distance d. Usually, nodes remove such outdated neighbors after a maximum timeout interval of 5s. It is clear that this approach is completely based on the mobility characteristics of nodes. Hence, nodes which move faster update frequently, than the nodes which move slowly. There are two main drawbacks in this approach. First, fast node may not be aware of the slow nodes because of their infrequent updates. Second, number of outdated neighbors is high for slow nodes because of their longer timeout intervals. As a conclusion, local topology is not clear in certain cases [23], [4].

C. Speed-based beaconing

In speed-based beaconing, the interval for beacon update depends on the nodes speed. This interval [a, b] is inversely proportional to the speed of the node. When a node has not transmitted updates for a time period, k-times the beacon interval, it's removed from the neighbor list. This duration is said to be neighbor timeout interval and the same is piggybacked by beacons. On receiving, nodes compare their own timeout interval with the piggybacked ones and choose smaller interval as timeout interval for that particular neighbor. One of the problems of distance-based beaconing is solved, since smaller timeout intervals are set for fast neighbors at slow nodes. However the slow nodes are not recognized by the fast nodes [23], [4].

D. Reactive beaconing

Reactive beaconing is an on-demand position update system, triggered by a request for beacon update packet (REQ). REQ packet is transmitted by a node only when the data packets await forwarding. For each data packet forwarding, REQ and beacon packets are exchanged. As a result it causes certain delay in every hop of the transmission path. But the accurate local topology is built [23], [4].

E. Adaptive position updates

As the name implies, APU adapts to the dynamic nature of the network. That is, beacon interval is determined from the mobility dynamics of the nodes. Beacon messages carry two components, namely speed and current position of the nodes. Linear kinematic equations help nodes to calculate their own positions whenever required. If this predicted location differs from the actual location obtained via GPS, then a beacon is transmitted to their radio neighbors. That is, whenever nodes change mobility characteristics only, beacon transmission is triggered [24], [4]. Moreover, these activities are executed during a node overhears the data traffic. A node can follow two different rules, namely Mobility Prediction (MP) and On-Demand Learning (ODL) rule to obtain the accurate local topology. False and unknown neighbor ratios are minimized significantly by MP and ODL rules respectively [4].

III. POWER MANAGEMENT TECHNIQUES

A. Distributed power control

Distributed power control is one the MAC layer based power conservation technique proposed by Sharad Agarwal and Srikanth V. Krishnamurthy. The approach tries to reduce the cost of communication between a pair of nodes and suitable for the delay tolerant but energy efficient networks. The key idea is to control the power consumption at MAC layer (MAC layer specifications are based on the IEEE 802.11 standard). Since the traditional MAC layer power control mechanisms do not have a centralized arbiter to inform the nodes about the required transmit power, it happened to handle the problem in distributed manner. The proposed power control loops allow nodes to choose different transmit power to communicate with different neighbors. Consequently, packet losses due to less transmit power and forwarding packets with high power are avoided.

Ready to Send (RTS) and Clear to Receive (CTS) control packets enable a node to capture the power level needed for communication. Always, maximum power is chosen for initial communication. Advantage of this algorithm is twofold: (1) reduction in energy consumption (2) average interferences.

B. Energy Aware Greedy Routing (EAGR)

Raiza Haider et al. proposed EAGR works based on both energy level and distance [8]. Initially, before transmission of data the algorithm blacklists the nodes which are low power weak nodes. Among the remaining high power nodes, the node that optimizes the distance to the destination is chosen as greedy node. Such high power nodes are very much reliable and aid in successful packet delivery. Packet loss due to the dead destination can't be achieved but can be minimized in the intermediate levels. The energy model being used is equal initial energy in all nodes and forwarding a packet consumes 1 unit [joules] of energy.

C. Hybrid, Energy-Efficient clustering Approach (HEED)

Ossama Younis and Sonia Fahmy have proposed the scheme HEED, suitable for the cluster-based ad-hoc networks. HEED increases the network lifetime in terms of energy based selection of cluster head [3]. Since all communications happen via cluster head, they are more prone to energy depletion. Hence, the algorithm discards the current cluster head after a specific amount of time and selects a new one completely based on the residual energy and cost of transmission. Eventually, network lifetime is prolonged, rapid cluster head changes trigger frequent announcement of the same.

D. Span: Energy-Efficient Coordination Algorithm

Benjie Chen et al. proposed Span works by electing "coordinators" among the network nodes [7]. Coordinator nodes are meant to stay awake and responsible for all multi-hop packets forwarding, while other nodes are in power-saving mode. The power-saving nodes periodically wake-up and check whether they have a chance to be the coordinator. Span ensures the global connectivity by electing enough number of coordinators and also, increases the network lifetime as it applies decentralized methods for coordinators election. Moreover, Span is a proactive technique and each node transmits HELLO messages periodically.

E. Cross-Layer Design

Cross-layer design has been proposed to meet the energy constraints and interface issues in ad-hoc networks. Many energy conservation techniques such as multiple antennas, power control, MAC layer scheduling and network layer optimizations such as energy and delay-constrained routing are unique to that particular layer only. It results in reduction of interdependency and lack of flexibility among the layers of protocol stack and it's not desirable for the ad-hoc networks. Cross-layer design allows information to be exchanged throughout all the layers and clearly specifies what information to be exchanged [6].

F. On-Demand Power Management

Rong Zheng and Robin Kravets designed on-demand power management scheme is based on the network traffic patterns [5]. Nodes are dispensed from consuming minimal energy, when they do not involve in data transmission. Soft-state timer is used to assist nodes to fluctuate between power-save and active modes. Soft-state keep-alive timer sets the active mode duration of the node based on the type of packet received. Once the keep-alive timer expires nodes switch to power saving mode. However, neighbor's current mode is obtained either by explicit HELLO messages or snooping to the air for possible communications. HELLO message exchanges poor performance than the passive interference in energy conservation perspective.

G. Energy - aware Greedy Routing (EGR)

Gang Wang and Guodong Wang enhance existing GPSR in their EGR protocol. Basic mode of GPSR is greedy routing and void problem due to local maxima is solved by perimeter routing. For both the phases EGR elects greedy nodes based on residual energy and distance as mentioned in EAGR. Perimeter routing utilize the perimeter nodes most of the packet forwarding activities, they are very much prone to energy depletion and make the hole still larger. EGR utilize the energetic nodes as much as possible during perimeter routing by choosing only maximum residual energy nodes in every hop. Moreover, it increases the angle of flooding compared to Location Aided Routing (LAR) [18] and Distance Routing Effect Algorithm for Mobility (DREAM) [17], [21]. The performance degradation of EGR is due to the periodic HELLO messages for location and residual energy disseminations [2].

H. Geographical and Energy Aware Routing (GEAR)

Yan Yu et al. proposed GEAR resembles geographical routing protocol GPSR and it aims to forward the packet to the target region based on the method known as learned cost [9]. On packet reception, a node checks whether a closer neighbor node (i.e. a greedy node which minimizes the learned cost) exists, if so that node is chosen as next-hop node. Learned cost is the combination of distance and energy spent. On the other hand, during a hole combination of update rule and learned cost is used to select the next-hop. Neighbor Hello Protocol is used for location and energy level disseminations.

I. Energy Conservation – Prioritized Pheromone Aided Routing Algorithm (EC-PPRA)

Rongsheng Dong et al. have improved already existing PPRA, proposed by P. Jeon et al. PPRA uses ant colony based routing and divides the data packets into latency-sensitive and latency-insensitive packets. EC-PPRA uses source routing algorithm for route initialization. None of the Forward Ants (FANT) of route discovery is discarded and hence multiple paths are discovered. But the Backward Ants (BANT) are never flooded and forwarded to only one neighbor. EC-PPRA turns off nodes when they are not in use and its operations resemble state machine [10].

K. Fair Energy Aware Geographical Routing (FEAR)

FEAR proposed by Wang et al. solves the unfairness problems. Energy level and on-going traffic based next-hop selection is employed. The main intension is to drop the packet during congestion and giving equal chance for forwarding to the packets of all the flows. Probabilistic factor calculated using remaining energy in nodes and aggregate flow rate is used for better utilization of neighbors. Thus it spreads traffic across all the neighbors. The overhead of the protocol is the use of many tables such as FlowTables and periodic HELLO message exchanges [13].

L. Geographical Adaptive Fidelity (GAF)

Xu et al. proposed GAF uses load balancing strategies to ensure fairness among the nodes. According to GAF, nodes oscillate between discovery, active and sleeping states to conserve energy. A node set sleeping mode if and only if there is an equivalent node capable of handling routing and packet receiving activities [14]. To choose equivalent nodes, the algorithm splits the network into virtual grids. But identifying such a node is a complex process and it requires estimation of energy level and storage capacity etc. The main goal of GAF is to turn on only one node per grid area.

IV. ANALYSIS OF GPSR

Merits

As stated in the previous sections, GPSR uses the geographic information aggressively in order to reduce the number of hops and, there by both number of nodes utilized for packet forwarding and network resource wear and tear are reduced [1]. One of the ultimate goals of any routing protocol of any kind of network (wired, wireless, or ad-hoc) is that it should be scalable. Scalability can be measured against the two factors: 1) rate of topology change and 2) number of routers in the routing area. Since GPSR insensitive to the number of nodes in the network, it is a scalable routing protocol.

GPSR packets piggyback [1], [22] the local forwarding node's position throughout its path and copy of the same is given to all neighbors of that forwarding node. All nodes' promiscuous mode of operation makes this scenario possible. Thus the secondary position update is also achieved to obtain the accurate local topology. Another important feature of GPSR is that inter-beacon timer can be reset in the packet forwarding areas to avoid number of packet collisions, drops and retransmissions [1].

Demerits

Greedy forwarding approach blindly selects the greedy node without considering its residual energy, mobility rate, reliability etc [1], [21]. If a selected node does not have power to move the packet one hop farther, simply it will drop the packet. So, unnecessary retransmission is triggered to decay the network resources. Sometimes hot-spot nodes deplete their energy completely, forming a hole, due to the blind greedy node selection phenomena. We term it as G-Diffusion hole to differentiate it from the diffusion hole caused by perimeter routing.

Fig. 1 depicts a typical working scenario of GPSR. There are two data flows that take place simultaneously namely from sender1 to destination 1 (i.e. S1 to D1) and sender2 to destination2 (i.e. S2 to D2). Both S1 and S2 choose greedy nodes A and B [1], since they have less mobility. They are often termed as hot-spot nodes. The hot-spot nodes A and B deplete their energy soon than other nodes and become dead nodes in the forwarding path. These dead nodes increase the chance of using less effective perimeter routing and reduce the network lifetime. Sometimes in dense networks, there may be more than one greedy node. The node A has two greedy nodes B and E to reach the next hop as shown in fig. 1. Node E has high energy and less traffic compared to node B but both are greedy nodes for the flow S2 to D2. In this case, GPSR choose any one the greedy node randomly without considering QoS criteria.

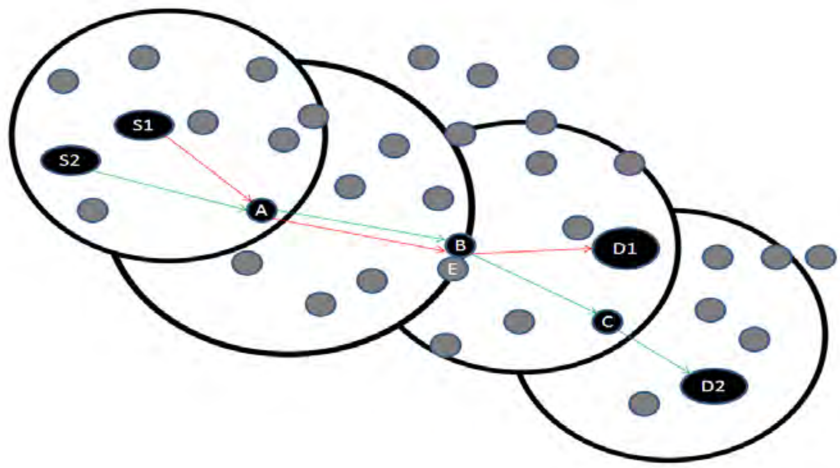

Fig.1. G- Diffusion hole

Perimeter mode suffers from permanent loop and incorrect planarization, if RNG and GG graphs do not remove a crossing edge and if an edge is left without removing respectively. Use right hand rule ignore some of the efficient routes and cause performance degradation. And also, as discussed by various authors, perimeter nodes suffer from diffusion hole problem.

V. CONCLUSION

Many energy based optimizations suggested by various GRPs discussed in this paper, compromise the main aim of GPSR (reducing the number of hops) and choose nodes with maximum residual energy in every hop in order to prolong the network lifetime. Thus the actual greedy nodes are underutilized. Using energetic nodes saves energy but underutilizing greedy nodes indirectly depletes energy. Both these process are more or less compensated, when it's viewed from the energy efficiency perspective. When there are more greedy nodes, high energy node can be opted for forwarding.

As far analyzed in this paper, position update schemes trigger beacon packets periodically, based on certain mobility criteria such as speed and distance. Reactive beaconing explicitly sends REQ packet itself, for added energy depletion. APU is appropriate and efficient compared to other position update schemes as it solves both false neighbor ratio and unknown neighbor ratio effectively.

REFERENCES

[1] B.Karp and H. T. Kung, "GPSR: Greedy perimeter stateless routing for wireless networks", in MOBICOM'00, Boston, USA, pp. 243-254, Aug. 2000.

[2] Gang Wang and Guodong Wang, "An Energy-Aware Geographic Routing Protocol for Mobile Ad Hoc networks" in I J Software Informatics, vol. 4, No. 2, pp. 183-196, June 2010.

[3] Ossama Younis and Sonia Fahmy, "HEED: A Hybrid, Energy-Efficient, Distributed Clustering Approach for Ad Hoc Sensor Networks", in IEEE TRANSACTIONS ON MOBILE COMPUTING, Vol. 3, No. 4, pp. 366-379, Oct 2004.

[4] Quanjun Chen, Salil S. Kanhere and Mahbub Hassan, "Adaptive Position Update for Geographic Routing in Mobile Ad Hoc Networks", in IEEE TRANSACTIONS ON MOBILE COMPUTING, Vol.12, No.3, pp. 489-501, Mar 2013.

[5] Rong Zheng and Robin Kravets, "On-Demand Power Management for Ad Hoc Networks", in Ad-Hoc Networks, pp. 51-68, Nov 2003.

[6] Macro Conti, Gaia Maselli, Giovanni Turi and Silvia Giordano, "Cross-Layering in Mobile Ad Hoc Network Design", in Ad-Hoc Networks, pp. 48-51, Feb 2004.

[7] Benjie Chen, Kyle Jamieson, Hari Balakrishnan and Robert Morris, "SPAN: An Energy-Efficient Coordination Algorithm for Topology Maintenance in Ad Hoc Wireless Networks", in Wireless Networks, pp. 481-494, 2002.

[8] Razia Haider, Muhammad Younus Javed, and Naveed S. Khattak, "Design and Implementation of Energy Aware Algorithm using Greedy Routing for Sensor Networks",in I J of Security and its Applications, Vol. 2, No. 2, pp. 71-86, April 2008.

[9] Yan Yan Yu, Ramesh Govindan and Deborah Estrin, "Geographical and Energy Aware Routing: a recursive data dissemination protocol for wireless sensor networks", in 2001.

[10] Rongsheng Dong, Yuanchuang Hu, and Jiamming Liu, "EC-PPRA: An Energy Efficient Routing Protocol for Ad Hoc Networks", in

JOURNAL OF NETWORKS, Vol. 5, No. 6, pp. 748-755, June 2010.

[11] Rong Zheng, Jennifer C Hou and Lui Sha, “Asynchronous Wakeup for Ad Hoc Networks”, in ACM MobiHoc’03, pp. 35-45, June 2003.

[12] Vinay Rishiwal, Mano Yadav, S. Verma and S.K. Bajapai, ”Power Aware Routing in Ad Hoc Wireless Networks”, in JCS&T, Vol 9, No. 2, pp. 101-109, Oct 2009.

[13] Na Wang, Chorng Hwa Chang, “Proababilistic-Based Energy Aware Routing for Network Lifetime and Source Level Fairness in Wireless Sensor Networks”, in Systems and Networks Commnications, 2006.

[14] Ya Xu, John Heidemann and Deborah Estrin, “Geographyinfofrmed Energy Conservation for Ad Hoc Routing”, Proc. ACM Mobicom, july 2001.

[15] Jeffrey Hightower and Gaetano Borriello, “A Survey and Taxonomy of Location Systems for Ubiquitous Computing”, Computer, Aug 2001.

[16] Jacquelyne Ta, “Global Pisitioning System”, M.Science Thesis, State University Channel Islands, April 2011.

[17] Stefano Basagni, Irnrich Chalmtac, Violet R Syrotiuk and Barry A. Woodward, “A Distance Routing Effect Algorithm for Mobility”, Mobicom, pp. 76-84, 1998.

[18] Young-Bae Ko and Nitin H. Vaidya, ”Location Aided Routing (LAR) in mobile ad hoc networks”, Wireless Networks, Vol 6, no 4, pp. 307-321, 2000.

[19] Adrian Perrig, Robert Szewczyk, J.D. Tygar, Victorwen and, David E. Culler, “SPINS: Security Protocols for Sensor Networks”, Wireless Networks, Vol 8, pp. 521-534, 2002.

[20] Marc Heissenbuttel, Torsten Braun, Thomas Bernoulli and, Markus Walchli, “BLR: beacon-less routing algorithm for mobile ad hoc networks”, Computer Communications, Vol 27, pp 1076-1086, 2004.

[21] Martin mauve and Jorg Widmer, “A Survey on Position-Based Routing in Mobile Ad Hoc Networks”, IEEE Networks, pp. 30-39, Nov-Dec 2001.

[22] Xiaoyan Hong. Kaixin Xu and Mario Gerla. “Scalable Routing Protocols for Mobile Ad Hoc Networks”, Networks, IEEE, 2002.

[23] M. Heissenbuttel, T. Braun, M. Walchili and, T. Bernoulli, “Evaluating of the Limitations and alternatives on Beaconing”, Ad Hoc Networks, Vol.5, no.5, pp. 558-578,2007

[24] Q.Chen, S.S. Kanhere, M. Hassan and, K.C. Lan, “Adaptive Position Update in Geographic Routing”, Proc. Int’l Conf.Comm (ICC’06), pp. 4046-4051, June 2006.