Analysis And relative study on CONGESTION-AWARE ROUTING PROTOCOL (CARM)

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Abstract

There are several routing protocols in MANETS. In this paper we propose comparative study on various routing protocols for MANET based on congestion, reliability, energy efficiency, throughput and security. On demand routing protocols deliver scalable and cost-effective solutions for packet routing in mobile wireless ad hoc networks, CRP (CONGESTION ADAPTIVE ROUTING PROTOCOL) for every node appearing on a route warns its preceding node when prone to be congested. The preceding node then uses a "bypass" route bypassing the potential congestion to the first non-congested node on the route and CARM (congestion-aware routing protocol for mobile ad hoc networks) which uses a metric including data-rate, channel delay, buffer delay, and retransmission count to combat congestion and improve network utilization. This metric is used, together with the escaping of unequal link data-rate routes, to make ad hoc networks robust and adaptive to congestion. Finally using these protocols we improve the congestion, reliability, energy efficiency, throughput and security.

Keywords: MANETS, congestion, data-rate, network, multicasting, Energy, CARM.

1. Introduction

MANET is one type of wireless networks offers a wide range of application deployment. The nodes in a mobile ad hoc network are mobile hosts. The MANETs [1] are characterized by mobility, error-prone shared broadcast radio channel, limited security, unseen and visible deadly Problems, and bandwidth and power constraint network.

The applications range from civilian request to domestic applications. Most of these requests demand for multicasting. Multicasting [2] is one type of transmission protects bandwidth when linked to a multiple unicast packet. Multicasting has emerged as an essential technology in many applications including group audio/video conferencing, collaborative and groupware applications, software distribution, etc. With multicast, a single stream of data can be distributed to a large number of recipients without congestion the networks since the data is communicated once and is duplicated only when necessary. Comparing this to multiple unicast [7] transmissions where the same data must be repetitively sent to each and every receivers independently, the benefit turns out to be tremendous.

Existing routing protocols in MANET are ODRP, CRP and CARM. On-demand routing protocols [13] are efficient for routing in large ad hoc networks because they maintain the routes that are currently required, starting a path discovery process every time a route is needed for message transfer[3]. CRP is on-demand and consists of the following components: Congestion monitoring, Primary route discovery, Bypass discovery, Traffic splitting and congestion adaptively, Multi-path minimization, and Failure recovery [4], [5]. CARM applies a link data rate classification method to avoid routes with unequal link data-rates. CARM is only discussed and simulated in relative IEEE 802.11b networks, however, it can be practical to any multi-rate [6], [8] ad hoc network.

2. LITERATURE REVIEW

We have recognized a few bits of key writing in the field of MANET steering conventions which highlight existing conventions and also the ebb and flow thinking inside the field and the headings specialists are moving later on. Reference [10] suggests that a viable MANET steering convention must be furnished to manage the dynamic and eccentric topology changes connected with versatile hubs, while additionally monitoring the restricted remote transfer speed and gadget power [25] contemplations which may prompt diminishments in transmission reach or throughput. This is developed by [13] who suggest that not with standing these center prerequisites; MANET directing conventions ought to likewise be decentralized, self-mending and self-sorting out and ready to misuse multi-jumping and load adjusting, these necessities guarantee MANET steering conventions capacity to work independently.

3. Related work

3.1 SELF-HEALING AND OPTIMIZING ROUTING TECHNIQUE

These conventions are likewise called responsive conventions since they don't keep up directing data or steering action at the system hubs if there is no correspondence. On the off chance that a hub needs to send a bundle to another hub then this convention hunt down the course in an on-interest way and sets up the association with a specific end goal to transmit and get the parcel .The course disclosure as a rule happens by flooding the course ask for parcels all through the system. In on interest conventions, question/reaction bundles are utilized to find (conceivable more than) one course to a given goal. These control parcels are generally littler than the control bundles utilized for steering table upgrades as a part of proactive plans, in this manner bringing about less overhead.

In the Self-Healing and Optimizing Routing Techniques for Mobile Ad Hoc Networks proposed a Self-Healing and Optimizing Routing Technique (SHORT) for ad hoc networks. Two broad classes of SHORT are proposed: Path Aware (PA) - SHORT and Energy Aware (EA)-SHORT. PA-SHORT is worried with enhancing and curing paths to reduce the number of hops, whereas the main goal of EA-SHORT is to conserve power in MANETs. [12] implemented both categories of the SHORT approaches and have evaluated the benefits in terms of performance and energy preservation. The outcomes show significant improvement compared to the underlying routing algorithms. The rest of the paper is organized as follows. The performance and energy concerns that distinguishes PA-SHORT and EA-SHORT are discussed [14]. Detailed descriptions on PA-SHORT and EA-SHORT are reported in respectively. The evaluation of the SHORT algorithms are detailed followed by the related work.

3.2 CONGESTION ADAPTIVE ROUTING (CRP)

a. Congestion Monitoring

A variability of metrics can be used for a node to monitor congestion status. Chief among these are the proportion of all packets rejected for lack of buffer space, the average queue length, the number of packets timed out and retransmitted, the average packet delay, and the standard deviation of packet delay. In all cases, rising numbers indicate growing congestion [15]. Any of these methods can work with CRP in practice. We further classify the congestion position at a node into 3 levels: “green”, “yellow”, and “red”. A node is said to be “green” if it is far from congested, “yellow” if likely congested, or “red” if most likely or already congested. As later discussed, a bypass is a path from a node to its *next green node*. The next green node is the first green node as a minimum two steps away downstream on the primary route.

b. Primary Route Discovery green

To find a route to the receiver, the sender broadcasts a REQ packet toward the receiver. The receiver responds to the first copy of REQ by sending toward the sender a REP packet. The REP will traverse back the path that the REQ formerly followed. This pathway becomes the *primary route* between the sender and the receiver. Nodes along this route are called *primary nodes*. To reduce traffic due to route discovery and better deal with congestion in the network, we hire two strategies: (1) the REQ is throw down if received at a node already having a route to the destination, and (2) the REQ is throw down if received at a node with a ”red” congestion status.

c. Bypass Discovery

A node periodically broadcasts to neighbors a UDT (update) packet. This packet contains this node’s congestion status and a set of tuples fdestination R, next green node G, distance to green node mg, each for a destination R that the node has a route to. The purpose is that when a node N receives a UDT packet from its next primary node Nnext regarding destination R, N will be aware of the congestion status of Nnext and learn that the next green node is G which is m hops away on the primary route. If Nnext is yellow or red, a congestion is likely ahead if data packets continue to be forwarded on link N ! Nnext. Since CRP tries to avoid congestion from occurring in the first place, N starts to discover a bypass route toward node G - the next green node of *N* known from the UDT packet. This bypass search is similar to primary route search, except that: (1) the bypass request packet's TTL is set to 2 £ *m*, and (2) the bypass request is dropped if arriving at a node (neither *N* nor *G*) already present on the primary route. Thus, it is not costly to find a bypass and the bypass is disjoint with the primary route, except that they join at the end nodes *N* and *G*. It is possible that no bypass is found due to the way the bypass request approaches *G*. In which case, we continue using the primary route. However, [1] finds that the chance for a "short-cut" to exist from a node to another on a route is significant.

d. Traffic Splitting and Congestion Adaptability

At each node that has a bypass, the probability *p* to forward data on the primary link is initially set to 1 (i.e., no data is sent along the bypass). It is then modified periodically based on the congestion status of the next primary node and the bypass route. The congestion status of the bypass is the accumulative status of every bypass nodes. The key is that we should increase the amount of traffic [16] on the primary link if the primary link leads to a less congested node and reduce otherwise

3.3. congestion-aware routing protocol

CARM is an on-demand routing protocol that aims to create congestion-free routes by making use of information gathered from the MAC and physical layer. The CARM [16], route discovery packet is similar to that in DSR where every packet carries the entire route node sequence. CARM employs the WCD metric in to account for the congestion level. In addition, CARM adopts a route effective data-rate category scheme to combat the MDRR problem discussed [17]. The combination of these two mechanisms enables CARM to ameliorate the effects of congestion in multi-rate networks. CARM uses the same route maintenance approach as that in DSR.

Addressing Mismatched Data-Rate Routes Because the effective bandwidth of a link can be dramatically degraded by congestion, regardless of its specified physical bit rate, we introduce the effective link data-rate for `i,j as Defined.

$$\mathcal{D}_{i,j}^{\text{eff}} = \frac{L_{\text{data}}}{\tau_{i,j}}$$

Next the effective link data-rate category (ELDC) scheme, where each link is marked by its ELDC type which is determined by its effective link data rate range. For example, in an IEEE 802.11b network with data-rates ranging from 1Mbps to 11Mbps, we might choose the following two categories:

ELBC I: $D^{eff}_{i,j}$ <6Mbps; ELBC II: $D^{eff}_{i,j}$ ≥6Mbps

For a given route, the route ELDC is taken as that for the link directly connected to the source and is included in the route request (RREQ) packet. During route discovery, an intermediate node only forwards a RREQ if the ELDC type of the link preceding the current node is higher than or equal to that of the route. That is, for two ELDCs, if the route ELDC is I then all paths are possible. However, if the route ELDC is II, only links with ELDC II may be chosen, eliminating low data-rate links and lessening the chances of congestion [18]. This lessens the occurrence of very slow initial links being teamed with very fast links in the same route. While using the ELDC scheme helps to solve the MDRR problem, in extreme cases, the limiting of choice of links in a route could lead to route discovery failure. To counter this situation, we include a field, ELDCF, in the RREQ packet to flag whether or not the ELDC scheme is in operation. It is utilized in the following way. On an initial route discovery attempt, the ELDCF field is set to 1, indicating that the ELDC [20] scheme is in use, such that nodes should only forward the RREQ under the ELDC rules given above. If this route discovery process is unsuccessful, another is initiated, this time with the ELDCF field set to 0. In this way, all RREQs are forwarded as in DSR.

Route Discover, Now we describe the route discovery process in CARM. 1) RREQ Initiation: A source node i wishing to transmit data to a given destination node, generates a RREQ which it transmits to the neighbours. The RREQ packet to neighbor j contains the following fields: <source ID, source sequence number, destination ID, transmission start-time at i, Qi, ni,j , ELDC, ELDCF, record of route hop sequence>. The ELDC field is assigned appropriately at the first intermediate node. For the first route search cycle the ELDCF field is set to 1, indicating that the ELDC scheme is in use. If this route discovery is unsuccessful, ELDCF is set to 0 and a second cycle is initiated. 2) Processing a RREQ: Each intermediate node maintains a local forwarding list of the triples <source ID, source sequence number, ELDC> to record and keep track of the RREQs that it has received. Upon receiving a RREQ packet, an intermediate node compares the appropriate fields in the RREQ and its local list to avoid propagating duplicate RREQs. The ELDCF field is also checked. If ELDCF = 1, the ELDC of the preceding link is determined and compared with that in the RREQ. If the link ELDC is lower than the route ELDC, the RREQ is discarded. Note that in DSR intermediate nodes drop any RREQ with the same source ID and lower or identical source sequence number to those in any RREQs they have already seen. So, in DSR [19] each node only forwards a RREQ, during a given route discovery process, once. In CARM, as the ELDC is also taken into account, any node may forward a RREQ during a route discovery up to the number of ELDC types. This means that more routing information is required to establish feasible routes [21] because more copies of the same RREQ are propagated around the network. This causes a slight increase in overhead during the route discovery phase of CARM over DSR [15]. *3)* Prioritizing *RREQ with WCD [23]:* In the interface queue routing packets have higher priority over data packets [25], such that they are forwarded immediately, without queuing. Because of this, the congestion level information inherent in queuing delays is lost in DSR [27]. This is addressed in CARM via the WCD described.

4. Results and Discussion

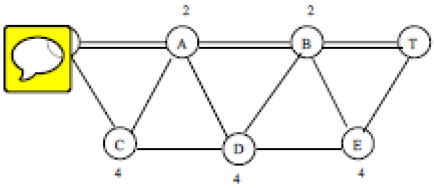
In ad hoc network routing, two issues are of prime concern: performance and power conservation. Our goal is to optimize both of these issues without incurring any significant overheads. The role of SHORT in enhancing performance and power conservation of MANETs.

When implementing SHORT-DV algorithm, we find a need to control the aggressiveness of the algorithm. Without this curbing, short-cut messages interfere with the routing tables, causing much more route updates than the original protocols. This problem is caused by ephemeral short-cuts and multiple short-cuts. Ephemeral short-cut happens when a fast-moving node finds out itself in a position to form a short-cut and informs the involved on-route nodes, but actually it only can stay in the effective short-cut position range for a short time. Multiple short-cuts means that more than one node stays within the position range of one certain shortcut. So they all report to the same involved on-route nodes, which causes the informed node to change the relevant routing table entry too frequently. However, responding only one short-cut report is enough. For a node to identify ephemeral short-cut, it needs to know its position and moving speed.

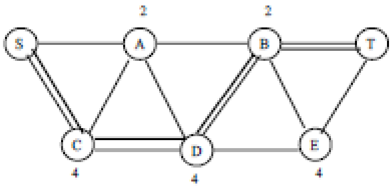
Such support may not be available for the ad hoc network. Multiple short-cut problem cannot be prevented without introducing extra overhead of message exchanging. We can resort to the receiver side to solve this problem, by making each node conservative in accepting short-cuts. We introduce the concept of a *stable period* for any newly entered or updated entry in routing table, so that each node ignores any update to it within the *stable period*. In this way, we can protect the consistency of routing tables.

Energy Aware Load Balancing

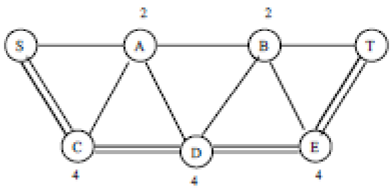
The goal of energy aware load balancing is to fairly distribute the traffic load among all the participating nodes in the network. For example, consider a part of an MANET shown in Figure the path S-A-B-T is the optimal path for a connection from S to T. The metric for optimality can be hop count for shortest path routing. Thus, nodes A and B will continuously be used in forwarding the traffic, leaving the other nodes free from the traffic load. As a result, the residual energy level of the nodes becomes widely varied. If the routing is not energy-aware, it will keep using the path for S-T connection. Nodes A and B will eventually be drained out of battery supply and die early. However, an energy-aware routing scheme will try to divert the traffic to other nodes. Here we propose the EA-SHORT scheme based on route redirection. With successive local redirection operations, the route will gradually converge to an alternative node disjoint path.



a) Initial path that drains the residual energy at nodes A and B.

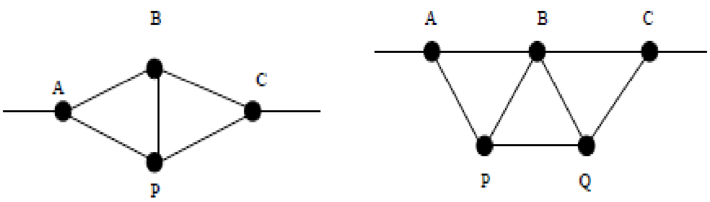


b) After route redirection, node A is circumvented. Figure



c) After route redirection, node B is circumvented.

Example of successive local route redirection operations. (The links shown in the figure are wireless links.)



Case 1: 2−step alternate sub−path, A−P−C Case 2: 3−step alternate sub−path, A−P−Q−C Figure 8: Basic cases of alternative sub-paths. It shows two basic redirections. In case 1, nodes A, B, and C are three consecutive nodes on the path for S-T connection. Node P is a nearby node which is a common neighbor of all three nodes. In a network that is dense enough to maintain continuous network connectivity, this scenario could occur frequently. As the data packets are successively forwarded by the three nodes (A, B and C), node P can overhear the same packet three times. With careful bookkeeping, node P can identify this scenario and realize that it can replace node B for the connection, namely, the sub-path A-B-C can be redirected to A-P-C. If node P sees the current energy level of node B, and find out that the difference of energy level at node B and itself is significant enough (power level of P is more than that of B), node P will do the redirection

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In case 2 shown in Figure, we suppose that the energy level difference between B and P is significant enough. The same is true between node Q and B. As a data packet travels along nodes A, B and C, node P will find out that node B needs to be circumvented. Node P also knows that it is a neighbor of both node B and its up-stream on-route neighbor, namely, node A. Similarly, node Q will find out that node B needs to be circumvented and node Q is adjacent with the down-stream on-route neighbor of node B, namely node C. We see that even from the locally overheard information, nodes P and Q can distinguish their different roles. It is up to node Q to find the existence of node P. To facilitate this process, Q broadcasts a message saying that "Node B needs help, and I am its down-stream helper, who is its up-stream helper?" If the up-stream helper, node P, gets this message, it replies with an acknowledgement. The wireless link between P and Q is thus identified. The two helper nodes will do the redirection to replace the A-B-C sub-path by the new A-P-Q-C path. Consider the example shown in Figure 7(a), nodes A and B both have relatively low energy level. After one redirection of case 2, node A is circumvented and the S-A-B-T path becomes S-C-D-B-T, shown in Figure. Then, after a case 1 redirection takes effect, the new S-C-D-E-T path will replace the original one, as shown in Figure.

Study of Congestion Adaptive Routing in Ad hoc Networks

Using Ns-2, we implemented CRP and compared it to AODV and DSR. The network consisted of 50 nodes moving continuously but not faster than 6m/s within a 1800m £ 400m rectangular field. The radio model used was Lucent's WaveLAN and the MAC layer was based on IEEE 802.11 DCF. In each 300s simulation run, 20 connections were generated and remained open until the simulation ended. Each source generated 512-byte CBR data packets at a rate chosen among 20, or 60 packets/s to illustrate different traffic loads. We considered the following metrics: (1) data packet delivery ratio, (2) end-to-end delay, (3) normalized routing overhead, and (4) normalized energy efficiency. As shown in Table II, CRP outperformed both AODV and DSR in most performance metrics, especially in highly congested networks.

MAC overhead can dramatically decrease the capacity of the congested link. For example, if only the physical bit rate is applied, the link in scenario II (15Mbps) would be said to have a higher capacity than the link in scenario I (5.8Mbps). However, when the MAC delay is included, the links in the two scenarios turn out to have identical overall channel delays, giving them the same *trusted* channel capacities. Therefore, in the design of a congestion aware metric for multi-rate ad hoc networks, the data-rate and the MAC delay should be jointly considered to more accurately indicate channel capacity.

5. Conclusion

In this paper we have identified and reviewed a range of protocols on the MANET routing, our initial work discussed a pair of survey papers from which we identified early reactive and proactive MANET routing protocols. Our review focuses upon protocols, namely the Self-Healing and Optimizing Routing Technique (SHORT), CONGESTION ADAPTIVE ROUTING (CRP) and CONGESTION-AWARE ROUTING PROTOCOL (CARM) which researchers claim is the most popular MANET routing protocol. Due to the popularity of the CRP protocol a number of variations and improvements on the core protocol have been proposed by researchers to address specific issues with the protocol.

CARM utilizes two mechanisms to improve the routing protocol adaptability to congestion. Firstly, the weighted channel delay (WCD) metric is used to select high throughput routes with low congestion. The second mechanism that CARM employs is the avoidance of mismatched link data-rate routes via the use of effective link data rate categories.

CRP is unique in its adaptability to congestion. Although our preliminary evaluation study has shown the promising performance of CRP, our future work will expand this study to experience with different network scenarios

Finally using CRP we may improve the congestion, reliability, energy efficiency, throughput and security.

References:

[1]. C. Gui, and P. Mohapatra, "A Self-Healing andvOptimizing Routing Technique for Ad Hoc Networks," Computer Science Department, UC Davis, Technical Report CSE-2002-23.

[2]. S. J. Lee, "Routing and Multicasting Strategies in Wireless Mobile Ad Hoc Networks," Ph.D. Thesis,
2000, Computer Science Department, UCLA.

[3]. S. Singh, M. Woo, and C.S. Raghavendra, "Power-Aware Routing in Mobile Ad Hoc Networks," ACM International Conference on Mobile Computing and Networking (MOBICOM), 1999.

[4]. J. Broch, D. B. Johnson and D. A. Maltz, "The Dynamic Source Routing Protocol for Mobile Ad Hoc Networks," IETF Internet draft, draft-ietf-manet-dsr-01.txt, Dec. 1998.

[5]. H. Raghavandra and D. A. Tran. Improving routing performance in mobile ad hoc networks with congestion adaptivity. Technical Report, Computer Science Dept., University of Dayton, Summer 2004.

[6]. S. Zhao, Z. Wu, A. Acharya, and D. Raychaudhuri, “PARMA: a PHY /MAC aware routing metric for ad-hoc wireless networks with multi-rate radios,” *Proc. of WoWMoM 2005*, pp. 286–292, Jun. 2005.

[7]. C. E. Perkins, E. M. Royer, S. R. Das, and M. K. Marina, “Performance comparison of two on-demand routing protocols for ad hoc networks,” *IEEE Personal Communications*, vol. 8, pp. 16–28, Feb. 2001.

[8]. J. E. Wieselthier, G. D. Nguyen, and A. Ephremides, “ Energy-Aware Wireless Networking with Directional Antennas: The Case of Session-Based Broadcasting and Multicasting,” IEEE Trans. on Mobile Computing, Vol. 1, No. 3, pp. 176-191, July-Sept, 2002.

[9]. C. E. Perkins and P. Bhagwat, “Highly Dynamic Destination-Sequenced Distance-Vector Routing(DSDV) for Mobile Computers,” Comp. Commun. Rev., Oct. 1994, pp. 234-44.

[10]. Lima, M.N., da Silva, H.W., dos Santos, A.L., Pujolle, G.: ‘Requirements for survivable routing in MANETs’. Proc. Wireless Pervasive Computing, (ISWPC 2008), 2008, pp. 441–445

[11]. Hu, Y., Perrig, A., Johnson, D.B.: ‘Ariadne: a secure on-demand routing protocol for ad-hoc networks’. Proc. Mobicom 2002, National Science Foundation and the Polytechnic University, Atlanta, Georgia, USA, 23–26 September 2002.

[12]. C.E. Perkins, E.M. Royer and S.R. Das, “Ad hoc on-demand distance vector(AODV) routing protocol,” IETF Draft, RFC 3561, February 2003

[13]. M..K. Marina and S.R. Das, “On-demand multipath distance vector routing in ad hoc networks,” in Proc. Ninth IEEE International Conference on Network Protocols, pp.14- 23, November 2001.

[14]. X. Wu and B. Bhargava, “Ao2p: ad hoc on-demand position-based private routing protocol,” *IEEE Trans. Mobile Computing*, vol. 4, no. 4, pp. 335–348, July-Aug. 2005.

[15] Xiaoqin Chen, Haley M. Jones, A .D .S. Jayalath, "Congestion-Aware Routing Protocol for Mobile Ad Hoc Networks" in proceedings of IEEE conference on Vehicular Technology,pp.21-25, 2007, Doi. 10.1109/VETECF.2007.21.

[16] Yung Yi and Sanjay Shakkottai, "Hop-by-Hop Congestion Control Over a Wireless Multi-Hop Network", IEEE/ACM on Networking, vol.15, no.1, February 2007.

[17] Lei Chen and Wendi B. Heinzelman, "QoS-Aware Routing Based on Bandwidth Estimation for Mobile Ad Hoc Networks", IEEE on Selected Areas in Communications, vol.23, no. 3, march 2005.

[18] Shivashankar, Suresh H.N, and Varaprasad Golla, “Designing Energy Routing Protocol With Power Consumption Optimization in MANET”, IEEE Transactions on Emerging Topics in Computing, vol.2, no. 2, pp. 192-197, June 2014.

[19] Mandeep Kaur Gulati and Krishan Kumar, “A Review of QoS Routing Protocols in MANETs”, IEEE Conference Publications, International Conference on Computer Communication and Informatics (ICCCI -2013), Jan. 04 – 06, 2013.

[20] Uma Rathore Bhatt, Priyanka Jain, and Raksha Upadhyay, “Enhanced AODV- An Energy Efficient Routing Protocol for MANET”, IEEE Conference Publications, 2013 Nirma University International Conference on Engineering (NUiCONE), 28-30 Nov. 2013.

[21] Raj Kamal Kapur and Sunil Kumar Khatri, “Analysis of Attacks on Routing Protocols in MANETs”, IEEE Conference Publications, International Conference on Advances in Computer Engineering and Applications (ICACEA) 2015.

[22] N. Marchang and R. Datta, “Light-weight trust-based routing protocol for mobile ad hoc networks”, Information Security, IET Journals & Magazines, June 2012.

[23] Wang, N.-C , “Power-aware dual-tree-based multicast routing protocol for mobile ad hoc networks”, Communications, IET Journals & Magazines, May 2012.

[24] Loay Abusalah, Ashfaq Khokhar, and Mohsen Guizani, “A Survey of Secure Mobile Ad Hoc Routing Protocols”, IEEE Communications Surveys & Tutorials, Vol. 10, no. 4, Fourth Quarter 2008.

[25] G. Varaprasad and R.S.D. Wahidabanu, “New power-aware multicast algorithm for mobile ad hoc networks”, Potentials, IEEE Journals & Magazines, Vol. 32, Issue. 2, April 2013.

[26] Karim El Defrawy, and Gene Tsudik, “Privacy-Preserving Location-Based On-Demand Routing in MANETs”, IEEE Journal On Selected Areas in Communications, Vol. 29, No. 10, December 2011.

[27] Gilaberte, R.L. and Herrero, L.P, “A secure routing protocol for ad hoc networks based on trust ”, IEEE Conference Publications, ICNS. Third International Conference on Networking and Services, 2007.