PERFORMANCE ANALYSIS OF ENHANCED ADAPTIVE POSITION UPDATE IN MOBILE AD HOC NETWORKS

[1]V.Jeyasri, [2]Dr.P.Ramamoorthy

[1]PG Scholar, Department of Electronics and Communication Engineering & Anna University, India

[2]Dean, Department of Electronics and Communication Engineering & Anna University, India

[1]jeyasri.v7@gmail.com, [2]covairam33@ymail.com

Abstract: In MANET, the packet forwarding necessitates the location information of the neighbor nodes and the location update information is obtained by transmitting the beacon signals periodically. However in geographic routing, the periodic beacon scheme has two problems: (1) It wastes the packet delivery ratio if a node does not exhibit significant dynamism, (2) Energy saving is the most important issue due to power constraints on mobile nodes. We propose a replica allocation pattern over the adaptive beacon update to address these problems. The former case is conquered by making the occurrence of beacon updates in accordance with the mobility of the nodes and the latter case is handled by the replicated data. In this paper, we examine the impact of Enhanced Adaptive Position Update (EAPU) in a mobile ad hoc network from the perspective of energy conservation. In particular, we develop adaptive beacon update that considers the mobile nodes mobility and novel replica data to properly cope with incapacity of mobile nodes. The conducted simulations of Greedy Perimeter Stateless Routing Protocol (GPSR) protocol demonstrate the proposed approach outperforms traditional cooperative beacon update in terms of energy and average end to end delay.

Index terms: Mobile ad hoc networks, Geographic routing, Periodic beacons, GPSR, Replicated data.

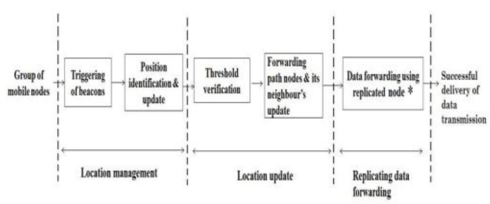
1. INTRODUCTION

In a mobile ad hoc network (MANETs), there is no fixed infrastructure such as base stations or mobile switching centers. Mobile nodes that are within each other's radio range communicate directly via wireless links, while those that are far apart rely on other nodes to relay messages as routers. In MANET, nodes move freely and so the topology of the nodes is highly dynamic. Due to the mobility of the nodes the topology of the network may change frequently and in unpredictable ways. Hence the process of routing data packets to the destination is a challenging task. In MANET the forwarding strategy requires the position of the final destination of the packet and the position of a node's neighbors. The final destination can be obtained by querying a location service such as the Grid Location System (GLS)[6] or Quorum[7]. To obtain the neighbor node's position, each node exchanges its own location information with its neighboring nodes. This allows each node to build a local map of the nodes within its vicinity, often referred to as the local topology. However, in situations where nodes are mobile or when nodes often switch off and on, the local topology rarely remains static. Hence in most geographic routing protocols, each node broadcasts its updated location information [3], [5] periodically.

The information obtained through beaconing scheme is further used to build the accurate network topology. However the periodic beaconing is wasteful if a node does not exhibit a significant dynamism. Further, the periodic beaconing has a direct impact on the routing performance in terms of packet delivery ratio and end to end delay and also leads to the high communication update cost. To overcome the above addressed problems the geographic routing is proposed with adaptive beacons. The adaptive beacon adjusts the beacon interval based on the mobility in the network. In MANET environment, energy conservation issues must be considered in developing periodic beacon strategies for mobile nodes since these issues impose limitations on data forwarding. A time taken by a data to reach its destination D entirely, from source S is referred as the route upholding time U_t. If the upholding time of a route is high then it leads to the poor route performance. Accordingly it makes sense to increase in average end to end delay along with high energy consumption.

In this paper, we propose a novel beaconing strategy for geographic routing protocols called

Enhanced Adaptive Position Updates strategy (EAPU) with replicated data forwarding. Our scheme eliminates the drawbacks of periodic beaconing strategy based on the mobility of the nodes which adapts the occurrence of beacon updates in accordance with the mobility of the nodes. On the contrary the EAPU addresses the energy saving issue through replicated data. We have illustrated the block diagram of our system in Fig.1. As shown in the figure, our method consists of three steps: location management, location update, replicating data forwarding. The location management achieved by using location update packets is usually referred to as beacons. Hence it is necessary that each node broadcasts its updated location information to all of its neighbors. In most geographic routing protocols (e.g., GPSR [3], [5]) beacons are broadcast periodically for maintaining an accurate neighbor list at each node. However our location update is based on both actual position verification as well as forwarding path nodes and its neighbors. The replicated data forwarding is established in case of forwarding path node's incapability situation to reduce the route upholding time U_t.



***** - In case of forwarding path incapability

Figure 1: Block diagram of our system

The remainder of the paper is organized as follows: In section II we summarize the related works and in section III we introduce our system model and the assumptions that to be consider. In section IV we explain Enhanced Adaptive Position Update and in section V we present our location management method. In section VI and VII we present our location update scheme and replica data forwarding respectively. Finally, we show experimental results in Section VIII, and conclude the paper in Section IX.

2. RELATED WORKS

In MANETs, by utilizing wireless networks the mobile nodes can change their locations while retaining network connections. The position update of the nodes are obtained through the location update packets called beacons which consists of the parameters such as signal strength, time stamp and available bandwidth resources. In geographic routing (such as GPSR) [3], the neighbor list of nodes and destination location is used for forwarding decision. In Greedy Perimeter Stateless Routing (GPSR) the local topology is maintained by periodically transmitting the beacons.

Heissen buttel etal [9] have shown that periodic beaconing leads to performance degradation due to high energy consumption in MANETs. They addressed several adaptive beaconing schemes based on the node mobility or traffic load to overcome the above drawback. In the distance-based beaconing, a node transmits a beacon when it has moved a particular distance d. A node is considered to be outdated if the node does not send any beacon to its neighbors even after the maximum time out. However this beaconing scheme can have many outdated neighbors in its neighbor list since the neighbor time-out interval at the slow node is longer. In addition a fast node may not able to detect the slow node due to the infrequent beaconing of the slow node when it passes a slow moved node which leads to the reduction in the perceived network connectivity.

In the speed-based beaconing, beacon interval is dependent on the node speed i.e. beacon interval is inversely proportional to its speed. Whenever a node's speed increases the beacon interval decreases and vice versa. If a node does not hear any beacon from a neighbor for a certain time interval, called neighbor time-out interval the node considers its neighbor as outdated. Nodes piggyback their neighbor time-out interval in the beacons to other nodes. A receiving node compares the piggybacked time-out interval with its own time-out interval, and selects the smaller one as the time-out interval for its neighbor nodes. In this way, a slow node can have short time-out interval, which eliminate first problem. However a fast node may not detect the slow node existences i.e. still second problem exists. Chen. Q et al [9] proposed APU (Adaptive position update) to dynamically adjust the beacon update intervals based on the mobility dynamics of the mobile nodes and the forwarding packets in the network. They used two rules: 1. MP (Mobility prediction) rule, 2. ODL(On-demand learning) rule. First rule makes a node to transmit its next beacon if the deviation in its predicted value with its actual location is more than the acceptable error range. Second rule is used to broadcast a beacon whenever a node overhears a data packet transmission in it neighbors. Accordingly high dynamic nodes update their positions very frequently and vice versa.

3. SYSTEM MODEL

In this paper, we assume that beacon updates include the current location and velocity of the nodes. We model a MANET in an undirected graph G = (Ń, Ĺ) that consists of a finite set of nodes (Ń), and a finite set of communication links (Ĺ). To focus on the energy saving issue, we consider the replica allocation in forwarding path nodes. We make the following assumptions, similar to those in [8], [10].

- Each node in a MANET has a unique identifier. Given a set of N encloses all nodes that are placed in a MANET and is given by N = {N_1, N_2, N_3,…., N_n}, where n is the total number of nodes.
- Each node moves freely below the maximum velocity.
- The access frequency does not change.
- All nodes are aware of their own geographical position and velocity.
- All links are bidirectional.
- Data packets can piggyback position and velocity updates to overhear the data packets in all one-hop neighbors

Upon initialization, each node broadcasts beacon to its neighbors about their presence, current location and velocity. Based on received information i.e. position updates each node continuously updates its local topology and builds a neighbor information base (NIB) which is used to determine the forwarding path nodes. In most geographic routing protocols (eg: GPSR), each node periodically broadcasts its current location information. Instead of periodic beaconing, the EAPU adapts the beacon interval, to update NIB. Whenever a forwarding path node N_i is not capable to forward entire data in a single data transmission i.e. if the data length exceeds the resource limitation, the data is transferred by multiple numbers of data transmissions. EAPU employs replicated data forwarding to improve the performance in terms of energy and end to end delay. According to EAPU, the replicated nodes (RN) replicate the original data and forwarded it to the destination D by guarantying the single data transmission. Note that the selection of replicated node is performed by means of NIB and access frequency of data items.

4. ENHANCED ADAPTIVE POSITION UPDATE

4.1 ADAPTIVE POSITION UPDATE

In MANET, at first each node broadcasts a beacon to its neighbors to inform its presence, stating its current location and velocity. Each node periodically broadcasts its current location information with respect to its transmission range and continuously updates its NIB. APU adapts the beacon update interval to the mobility of the nodes and the amount of data being forwarded in the neighborhood of the nodes. Further the neighbors which are outside the node's transmission range are not considered for data forwarding and the local topology is maintained by using the beacons. APU uses two principles: (1) Threshold verification, (2) Forwarding path nodes and its neighbor's update. In former case the beacon is triggered once a node moves beyond a particular distance. The constrained distance is calculated from the difference between the actual location and the prediction location. In latter case the nodes which are in and closer to forwarding path are updated.

4.2 REPLICA DATA FORWARDING

In MANETs, a mobile node may result poor performance if the route upholding time is large and it leads to a delayed data reception at receiver side. Fig.4. illustrates a network topology having six nodes as N_1, N_2,.., N_7. The dash lines in the figure denote the forwarding path between the source N_1 and the destination N_7. Assume that all forwarding nodes (N_1, N_2, N_5, N_7) maintains a successful data transmission to its one hop neighbor.

Let us consider that a data of 2560 bytes has to be delivered to the destination N_7 through the forwarding nodes. To transmit the data, it is divided into frames and each frame is assigned with unique frame-id. As per the frame-id the frames are transmitted and all the frames take the same route to the final destination. If node N_5 doesn't have the capacity to transmit 2560 bytes and its resource is limited to 1536 bytes, then the data to destination N6 is transferred in two phases. 1) First three frames are forwarded and their total length is 1536 bytes, 2) 4^{th} and 5^{th} frames are forwarded and their corresponding message length is 1024 bytes. The establishment of two phase data transmission consumes high energy of mobile nodes and the delay of data forwarding is high

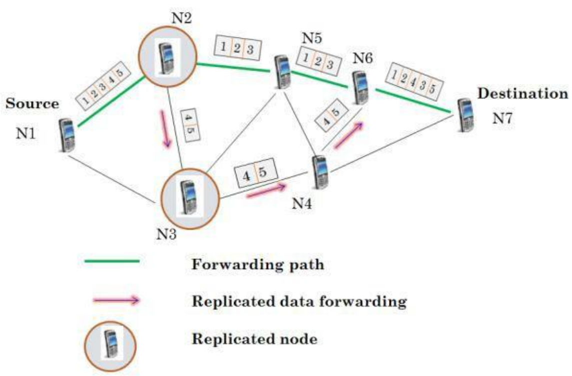


Figure 2: Replica data forwarding

To overcome this problem node N2 replicates the original data item and forwards it to both node N3 based on the NIB. As shown in Fig.4, node N2 forwards first phase data i.e. first three frames to node N5 and the second phase data i.e. 4^{th} and 5^{th} frames to node N3 (it reaches node N7 through node N4) thereby reducing the route establishment time between the source S and the destination D. Note that the replicated node N3 is selected based on the access frequency availability and the NIB.

5. LOCATION MANAGEMENT

In MANET the forwarding strategy requires the position of the final destination of the packet and the position of a node's neighbors. A location service such as the Grid Location System (GLS) or Quorum is used to obtain the final destination of a packet. Each node exchanges its own location information with its neighboring nodes in order to obtain the neighbor node's position. This allows each node to build NIB, which gives a local map of the nodes within its transmission range, often referred to as the local topology. In most geographic routing protocols, each node broadcasts its updated location information periodically. In MANET, each node has a unique identifier and they are denoted by N = {N1, N2, N3,…., Nn}, where n is the total number of nodes. The current position of node Ni at current time can be calculated from the following equations:

$$X_p^i = X_1^i + \; T_c - T_t \; * V_x^i \quad (1)$$

$$Y_p^i = Y_1^i + \; T_c - T_t \; * V_y^i \quad 2$$

We use a simple location prediction scheme based on the physics of motion to track a node's current location. When a node Ni receives a beacon update from its neighbors, it, records its current position, velocity and continue to track node Ni's location as shown in Fig.2. In equation (1) and (2), (X_p ,Y_p), (X_t ,Y_t) denotes the predicated position of the node Ni at current time and the coordinate of node Ni at time Ti respectively.

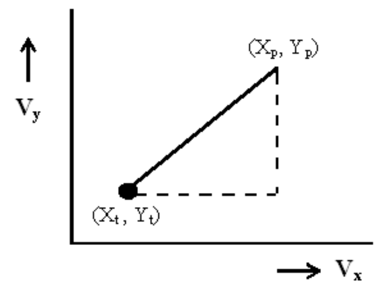


Figure 3: Location prediction scheme

Note that, in our discussion we assume that the nodes are located in a two-dimensional (2D) coordinate system with the location indicated by the x and y coordinates. However, this scheme can be easily extended to a three dimensional (3D) coordinate system.

6. LOCATION UPDATE

When a node receives beacon (starting its location update), it records the location of its one-hop neighbors. Nodes can use this information to update its NIB and to determine the route between source S and destination D. A node can include its current speed, energy level, signal strength over a recent time interval, with the location update packets, which is used to build the accurate network topology and could be used in future route discovery. The location update employs adaptive beacon interval scheme and for this we use two phases, namely threshold verification and forwarding path nodes & its neighbor node's update.

6.1 Threshold Verification

Based on position estimate N_i (as shown in fig.2.), the neighbors check whether a node is still within their transmission range and update their NIB accordingly. Whenever the predicted location of N_i is differed from its actual location than an acceptable value, node N_i sends its next beacon update. Thus this rule adapts the occurrence of beacon generation with respect to the difference between the actual location and the predicted location. Hence the high dynamic mobility nodes update their neighbors very frequently and vice versa. Node N_i computes the deviation as

Acceptable error range (AER):

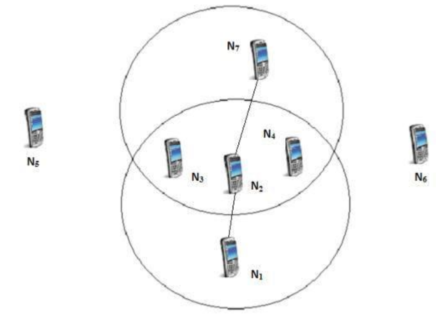
$$\mathrm{AER}^2 = (X_a^i - X_p^i)^2 + (Y_a^i - Y_p^i)^2 \quad (3)$$

In equation (3), (X_a^i, Y_a^i), (X_p ,Y_p) denotes the actual geographical location of node N_i and the predicted location of node N_i respectively. The actual location is obtained via GPS or other localization techniques. If AER is greater than a certain threshold, it acts as a trigger for node N_i to broadcast its current location and velocity as a new beacon. This rule, tries to maximize the effective duration of each beacon, by broadcasting a beacon only when the position information in the previous beacon becomes inaccurate. This extends the effective duration of the beacon for nodes with low mobility, thus reducing the number of beacons. Further, highly mobile nodes can broadcast frequent beacons to ensure that their neighbors are aware of the rapidly changing topology.

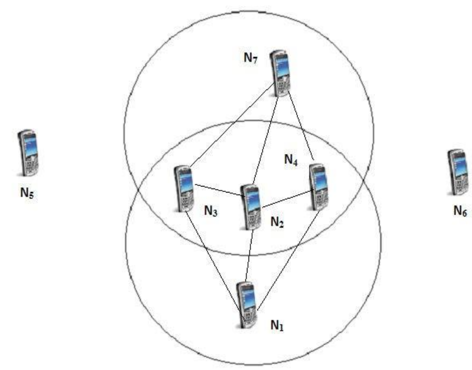
6.2 Forwarding path nodes & its neighbor node's Update

This rule devises a mechanism which maintains a more accurate local topology in those regions of the network where significant data forwarding activities are on-going. A node broadcasts beacons on-demand, i.e. in response to data forwarding activities of that node. According to this rule, whenever a node overhears a data transmission from a new neighbor, it broadcasts a beacon as a response. All active nodes that are involved in data forwarding enrich their local topology reactively in response to the network traffic whereas all inactive nodes maintain their basic NIB. From this alternate routes can be easily established without incurring additional delays.

Fig.3(a) illustrates the network topology before node N_1 starts sending data to node N_7. The solid lines in the figure denote that both ends of the link are aware of each other.



(a)



(b)

Figure 4: An example illustrating the ODL rule

The initial possible routing path from node N_1 to node N_7 is N_1 - N_2 - N_7. Now, when source node N_1 send a data packet to node N_2, both nodes N_3 and N_4 receive the data packet from node N_1. As node N_1 is a new neighbor of nodes N_3 and N_4 (according to this phase as shown in fig.3b.), both nodes N_3 and N_4 send back beacons to N_1. As a result, the links 1 - 3 and 1 - 4 is discovered. Further, based on the location of the destination and their current locations, nodes N_3 and N_4 discover that the destination N_7 is within their one-hop neighborhood. Similarly when node N_2 forward the data packet to node N_7, the links 2 - 3 and 2 - 4 are discovered. Fig.3(b) reflects the enriched topology along the routing path from node N_1 to node N_7.

7. REPLICA DATA FORWARDING

Some or all of the nodes in an ad hoc network may rely on batteries or other exhaustible means for their energy. For these nodes, the most important system design optimization criteria may be energy conservation. In MANET environment, route upholding time U_t has a direct impact on the network performance and it may result high energy consumption and increased average end to end delay. The replica data forwarding [13] is proposed to provide the data availability as soon as possible at receiver side with low delay. It consists of two phases:

- The replica allocation phase: In the replica allocation phase, the replicated nodes are selected based on the NIB and the access frequency of data items which are nearer to the forwarding path nodes.
- The replica manipulation phase: In this phase, the original data is replicated and it is transmitted along the replicated node (as shown in Fig.4.) to reduce the route upholding time U_t.

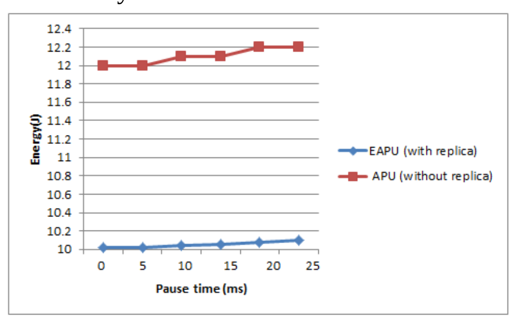
8. EXPERIMENTAL RESULTS

To evaluate our schemes, we performed simulations using NS2 (Network simulator – 2.34). NS2 is a discrete-event simulator used to build a flexible platform for the evaluation and comparison of network routing algorithms [15]. We compare the performance of EAPU with APU [9] in terms of energy and delay. For simulation, it is consider that all nodes have the same transmission range and all wireless links have the same bandwidth, 100 Kbytes per second. We have assumed that the nodes move according to the RDM model, to be consistent with our analytical results. We vary the average speed of the node from 5 m/s (18 km/hr, representing low dynamism) to 25 m/s (90 km/hr, representing high dynamism). This range is consistent with typical vehicular mobility scenarios. Table 1 list out the simulation parameters that are considered for experimental result analysis.

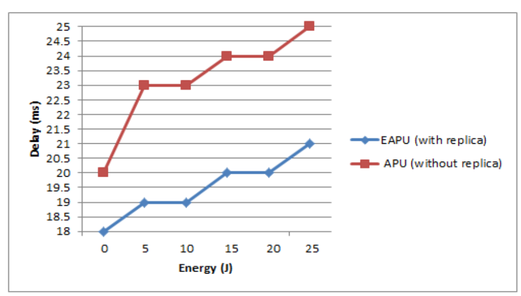
Table 1: Simulation Parameters

Tested Protocol	GPSR
Propagation Model	Drop Tail
Radio model	Two-way ground model
Type of Antenna	Omni directional
Area (m x m)	1600*1000
Number of Nodes	30
MAC type	Mac/802_11
Data rate	11 Mbps

Fig.5 (a) shows that the EAPU achieves the lowest energy consumption where as it is proportional to the dynamism of nodes. The energy consumption of mobile nodes depends on the beacon overhead and the total number of data packets transmitting. Delay is outlined as how long it takes for a packet to travel across the network from supply to destination. Since EAPU utilizes the optimal path rather than other beaconing schemes, it achieves lowest delay as shown in Fig.5(b). The figure shows that the EAPU has low end to end delay at lower average speed of nodes whereas in high average speed of nodes it has high end to end delay.



(a) Energy vs Pause



(b) Delay vs Energy

Figure 5: Simulation results

9. CONCLUSION

In contrast to the network viewpoint, we have addressed the energy conservation issue from the replica allocation perspective. Our work was motivated by the fact that a large route upholding time U_t could lead to poor network performance along with high energy consumption in MANET. Since traditional Adaptive beacon schemes are failed to consider this fact we proposed EAPU strategy to address these problems. The APU phase uses mobility prediction to increase the accuracy of the location estimation and adapts the beacon update interval accordingly, instead of using periodic beaconing. Further it allows nodes along the data forwarding path to maintain an accurate view of the local topology by exchanging beacons in response to data packets that are overheard from new neighbors. The replica data forwarding allows replicated node to cope up with the resource limitation of forwarding path nodes. In addition, we have simulated the performance of the proposed scheme and the extensive NS2 simulation shows that the proposed strategies outperforms existing representative cooperative position update schemes in terms of delay and energy. In future we plan to identify how mobility prediction along with replica allocation can be applied to other network tasks or services.

10. ACKNOWLEDGMENT

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REFERENCES

[1] C.E. Perkins, “Ad hoc Networking”, Addison Wesley, 2001.

[2] C. K. Toh, “Adhoc Mobile wireless networks: Protocols and Systems”, Prentice Hall, New Jersy, 2002.

[3] Karp and H.T. Kung, “GPSR: Greedy Perimeter Stateless Routing for Wireless Networks,” Proc. ACM MobiCom, pp. 243-254, Aug 2000.

[4] I. Stojmenovic, “Position based routing in ad hoc networks”, IEEE Communications Magazine 40 (7) (2002) 128–134.

[5] S. Lee, B. Bhattacharjee, and S. Banerjee, “Efficient Geographic Routing in Multihop Wireless Networks,” Proc. ACM MobiHoc, pp. 230-241, May 2005.

[6] Li, J. Jannotti, D.S.J.D. Couto, D.R. Karger, and R. Morris, “A Scalable Location Service for Geographic Ad Hoc Routing,” Proc. ACM Mobi Com, pp. 120-130, Aug. 2000.

[7] Z.J. Haas and B. Liang, “Ad Hoc Mobility Management with Uniform Quorum Systems,” IEEE/ACM Trans. Networking, vol. 7, no. 2, pp. 228-240, Apr. 1999.

[8] Q. Chen, S.S. Kanhere, and M. Hassan, “Adaptive Position Update for Geographic Routing in Mobile Ad Hoc Networks”, IEEE Transactions on Mobile Computing, vol. 12, no. 3, pp- 489-501, Mar 2013.

[9] M. Heissenbuttel, T. Braun, M. Walchli, and T. Bernoulli, “Evaluating of the Limitations and Alternatives in Beaconing,” Ad Hoc Networks, vol. 5, no. 5, pp. 558-578, 2007.

[10] Jae-Ho Choi, Kyu-Sun Shim, Sang Keun Lee, and Kun-Lung Wu, “Handling Selfishness in Replica Allocation over a Mobile Ad Hoc Network”, IEEE transactions on mobile computing, vol. 11, no. 2, Feb 2012.

[11] M. Mauve, J. Widmer, H. Hartenstein, “A survey on position based routing in mobile ad-hoc networks”, IEEE Network 15 (6) (2001) 30–39.

[12] I. Stojmenovic, B. Vukojevic, “A routing strategy and quorum based location update scheme for ad hoc wireless networks”, Tech. Rep. TR-99-09, SITE, University of Ottawa, Ottawa, Canada, Sep 1999.

[13] Takahiro Hara, “Effective Replica Allocation in Ad Hoc Networks for Improving Data Accessibility”, IEEE INFOCOM 2001,pp 1568 –1576

[14] S. Krco, M. Dupcinov, “Improved neighbor detection algorithm for AODV routing protocol”, IEEE Communications Letters (12) (2003) 584–586.

[15] Teerawat Issariyakul, Ekram Hossain, “Introduction to Network Simulator NS2”, 2009