PUBLICATION OF Little Lion Scientific R&D, Islamabad PAKISTAN
Journal of Theoretical and Applied Information Technology
30th June 2011. Vol. 28 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

ANALYSIS OF MOBILITY PARAMETERS EFFECT ON POSITION INFORMATION INACCURACY OF GPSR POSITION-BASED MANET ROUTING PROTOCOL

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ABSTRACT

Position-based routing protocols have become more popular in Mobile Ad hoc network (MANET) due to their advantages in using geographical position information of the nodes to route the data packet to the destination node. Each node periodically sends their geographical position information to its neighbors using beacon packets. Data packet routing in position-based routing protocol uses neighbors' position information, which is stored in the node's neighbors list and the destination node's position information stored in the routing data packet header field to route the data packet from source to destination. Most of the current work in position-based routing protocols assumes that position information in the node's neighbors list for its neighbors is accurate, while in reality, only a rough estimate of this position information is available for the nodes. This paper provides analysis study to realize the effect of position information inaccuracy caused by different mobility parameters on Greedy Perimeter Stateless Routing (GPSR) position-based routing protocol. In general, inaccuracy occurs when inexact position information is used. However, the results from the analysis work shown that the node beacon packet interval-time and node speed mobility parameters have a high impact on position information inaccuracy and have an intense effect in degrading the performance of GPSR protocol in terms of average end-to-end delay, non-optimal route, false local maximum, and routing loop.

Keywords: *Mobile Adhoc network (MANET), Greedy Perimeter Stateless Routing (GPSR), beacon packet interval-time, node speed.*

1. INTRODUCTION

Position-based routing protocols [1] route data packet from the source node to geographical direction forming the route toward the destination node. In order to use a position-based routing approach, each node making the network must be able to determine its own geographical position information (x, y Coordinate) using Global Position System (GPS) device [2]. In addition, the node needs to know the position of all neighbors within its transmission range using beacon packets, which each node sends out periodically to test and verify connectivity with its neighbors. In position-based routing protocols, each node selects the next hop for data packet routing through neighboring nodes determined from accessing its neighbors' list. The correctness and accuracy of position information in the node's neighbors list are crucial and fundamental in determining the performance of position-based routing protocols. Current position-based routing protocols assume implicitly or explicitly the availability of accurate neighbors' position information in the nodes' neighbors list when they make data packet routing decision.

Due to node mobility and time-interval of periodic beacon packets that cause regular network topology changes in MANET, neighbors' topology changes frequently and rarely remain static. Furthermore, the position information in the nodes' neighbors list is frequently inaccurate. In addition, position information in the nodes' neighbors list does not reveal the real positions of the neighboring nodes such that the retransmission and rerouting are required, which degrade the performance of

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

position-based routing protocols. For example, if the beacon interval-time of periodic beacon packets is small enough compared to the degree at which a node changes its present position through speed, nodes position information in nodes' neighbors list will be more accurate on the one hand but the network resources like the battery life will be highly exhausted on the other hand. Conversely, if the beacon interval-time of periodic beacon packets is not too long, then the network resources like battery life consume less power but the nodes position information in the nodes' neighbors list will be inaccurate.

In this paper, we provide analysis study to realize the effect of position information inaccuracy caused by different mobility parameters on GPSR position-based routing protocol. This paper examines the following two main mobility parameters which are the source of the position information inaccuracy in the nodes' neighbors list:

1. Node beacon packet interval-time: nodes send beacon packets periodically to update their position information into their neighbors' neighbors list. It is impossible to avoid the time gap between these position information updates since the time interval between position information updates is generally longer than the time when the information is actually looked up for routing decision in the nodes' neighbors list.
2. Node speed: Node's speed is one of the most effective parameters represents the degree of node mobility. The degree of node mobility is the most obvious challenge in MANET routing since the nodes can move in different speed and the maximum node speed is a critical factor in position information inaccuracy.

However, the analysis result introduced in this paper shows the long beacon packet interval-time and high node speed have a severe effect in leading to a higher percentage in the occurrence of position information inaccuracy in the nodes' neighbors' list position information. In addition, it shows the intense effect of these parameters in degrading the performance of position-based routing protocols in terms of average end-to-end delay, non-optimal route, false local maximum, and routing loop problems.

This paper is structured as the following: Section 2 explains the GPSR position-based routing protocol. Section 3 introduces the related works. Section 4 introduces mobility parameters represented by beacon packet interval-time and node speed on position information inaccuracy. And Section 5 concludes the paper and shows the future work.

2. GPSR PROTOCOL BACKGROUND

Greedy Perimeter Stateless Routing (GPSR) protocol [3] is an efficient and scalable [4] routing protocol in MANETs. In GPSR protocol, a node route the data packet using the locations of its one-hop neighbors. When the node needs to send a data packet to destination node, it transmits the data packet to the neighbor who has the shortest distance to the destination node among all its neighbors within its transmission range.

GPSR protocol uses two forwarding strategies to route the data packet to the destination: greedy forwarding and perimeter forwarding. In greedy forwarding, GPSR makes forwarding decisions using information about the position of immediate neighbors in the network topology. In Figure 1, *x* node wants to send a data packet destined to destination node *D*; *x* node sends a data packet to node *y* since node *y* is listed in *x*'s neighbors list as shown in Table 1, and the distance between *y* and *D* is less than that between *D* and any of *x*'s other neighbors. This greedy forwarding process is repeated by nodes *y*, *k*, *z*, and *w* until a data packet reaches the destination node *D*.

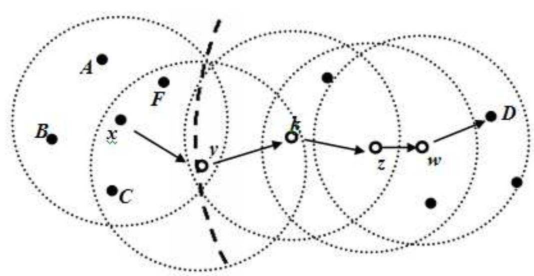

Figure 1. Greedy forwarding

Table 1. Node x neighbors list

Node-id	Neighbor (x, y coordinates)
A	A (x, y)
B	B (x, y)
C	C (x, y)
F	F (x, y)
Y	y (x, y)

Greedy forwarding strategy fails when the routing node does not find a closer neighbor within

Journal of Theoretical and Applied Information Technology
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ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

its range toward the destination node than itself. A simple example of such a topology is shown in Figure 2. Here, node *x* is closer to destination node *D* than its neighboring nodes *w* and *y*. Although two paths, *x-y-z-D* and *x-w-v-D* exist to node *D*, *x* will not choose to forward the data packet to node *w* or *y* using greedy forwarding. The protocol declares node *x* as the local maximum to node *D* and the shaded region without nodes as void region. In this case, GPSR protocol shifts from greedy forwarding strategy to the perimeter forwarding strategy to forward the data packet around the void region. In perimeter forwarding, the protocol constructs a planarized graph[1] for the nodes' neighbors and routes the data packet around void region by forwards the data packet to hop *w*, which sequentially counterclockwise around *x*, using right-hand rule.

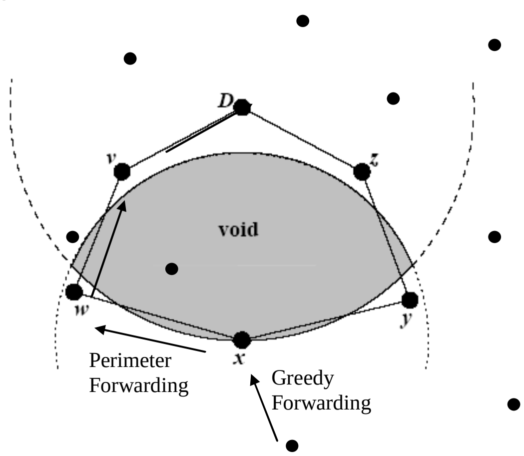

Figure 2. Perimeter forwarding

Network connectivity in GPSR protocol is determined by a simple beacon packet sub-protocol that provides all nodes with their neighbors' position information. Periodically, every node sends a beacon packet containing its unique individual identifier and its geographical position within the network topology. When any node receives a beacon packet from its neighbors, it creates or refreshes its neighbors list and uses beacon packet information for routing process when the node has a data packet to particular destination node.

3. RELATED WORKS

In [5], a preliminary work done by Seada et. al. to provide analyses study of face position-based routing protocol in the presence of position inaccuracy in static Wireless Sensor Networks (WSNs), WSNs is MANETs with static nodes. The authors showed that location errors in nodes' neighbors list could lead to incorrect behavior and noticeable degradation in protocol's data packet delivery rate. In [6], Son et. al. also investigated the effects of location errors in the WSNs, and their research concluded that the node mobility effects are significant in WSNs data packet-delivery performance.

In [7], Shah et. al. provided analysis and simulation study to understand the effect of GPS localization system error on GPSR protocol. The authors found degradation in GPSR protocol performance from data packet delivery ratio and nodes' power consumption perspective. Kwon and Shroff in [8] had investigated the location errors in greedy forwarding strategy. They found the different between real (accurate) and false (inaccurate) node position information in the nodes' neighbors list significantly degrade the success data packet-delivery rate. Peng et. al. in [9] founded the impacts of location errors yielded to data packet transmission failure and sub-optimal relay of the data packet to neighboring node. These impacts result on lost data packets and increased nodes' energy consumption. In [10], Yongjin et. al. observed the location errors degrades the performances of perimeter forwarding strategy in terms of data packet drop, optimal route and routing loop rate, especially in high network density.

On this paper, we extended the other works by doing analysis study on the effect of position information inaccuracy in the nodes' neighbors list. We identified the network performance metrics affected by position information inaccuracy in GPSR routing functionality such as: end-to-end delay, non-optimal route, false local maximum and routing loop. We also study and identify the node speed and node beacon packet interval-time as two main mobility parameters in making position information inaccuracy in a dynamic MANET topology.

4. MOBILITY PARAMETERS EFFECT ON POSITION INFORMATION INACCURACY

Tsumochi et. al. classified various mobility parameters that can affect the performance of routing protocols on MANET [11]. Among these parameters are the beacon packet interval-time and node speed. This section investigates the effect of

[1]Planar graph is a graph that can be drawn in the plane with no crossing edges.

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Journal of Theoretical and Applied Information Technology
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ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

these mobility parameters in introducing a position information inaccuracy in the GPSR position-based routing protocol.

4.1 *Effect of Beacon Packet Interval-Time (BPIT)*

One of the variables that control the determination of nodes connectivity in position-based routing protocols is a node Beacon Packet Interval-Time (BPIT) [12-13]. BPIT specifies the maximum time interval between the transmissions of beacon packets among the nodes. Each node in position-based routing protocols periodically broadcasts beacon packets to its neighbors to provide them with its presents (ID) and its (x, y) geographical coordinate position information. Receiving nodes, within the beacon packet sender transmission range, creates or refreshes their neighbors list and use beacon packets' information for later routing processing. Position information carried by these beacon packets becomes inaccurate as the BPIT increases. In addition, the position information that nodes associate to its neighbor in its neighbors list become less accurate between beacon packets as those neighbors move.

Figure 3 depicts the effect of BPIT on position information inaccuracy in GPSR protocol. Here, node *s* recognizes its neighboring node *n* in its neighbors list at position n_1' from beacon packet information arrived at time t_1. If node n_1 broadcasts its beacon packet, using $BPIT_2$ at time t_3 rather than using $BPIT_1$ at time t_2, where $BPIT_2 > BPIT_1$ and $t_3 > t_1$, it is expected that the position information accuracy for node n_1 in node *s* neighbors list to be less accurate using $BPIT_2$ comparing with using $BPIT_1$. From this, we can conclude that as the BPIT increases, the position information accuracy for the neighboring nodes in the nodes' neighbors list decreases.

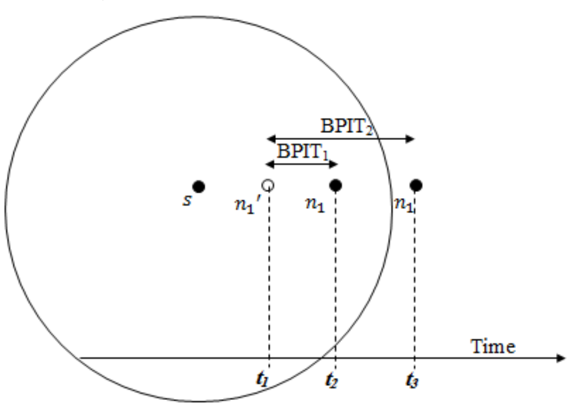

Figure. 3 The effect of BPIT on position information inaccuracy. t_1, t_2, t_3 are times for beacon packet sending. $BPIT_2 > BPIT_1$.

4.2 *The Effect of Node Speed (NS)*

The change on the Node Speed (NS) means a change in the level of node mobility [13-14]. This in turn affects the inaccuracy in node position information. Every node can move at a dissimilar speed and the node speed is one of the parameter deciding the level of position information accuracy.

Figure 4 shows the effect of NS on position information inaccuracy in GPSR protocol. The node *s* recognizes its neighbor node *n* in its neighbors list at position n_1 from beacon packet information arrived at time t_1. If node n_1 moves using NS_1 rather than NS_2 where $NS_2 > NS_1$ and $t_2 > t_1$, it is expected that node n_1 to travel longer distance and the position information accuracy for node n_1 in node *s* neighbors list to be less accurate. From this, we can find that as NS increases, the position information accuracy for the neighboring nodes in the node neighbors list decreases.

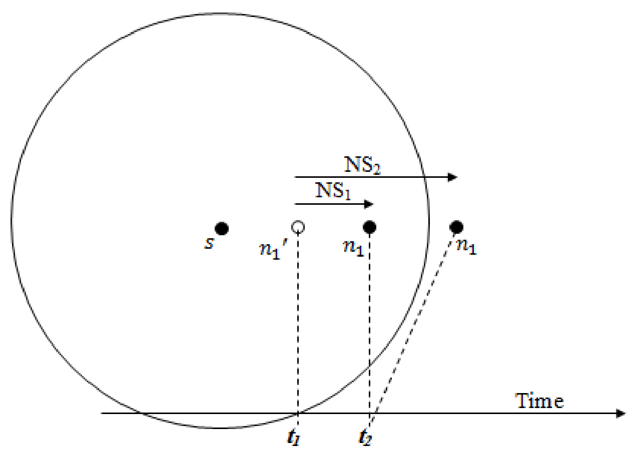

Figure. 4 The effect of NS on position information inaccuracy. t_1, t_2 are times for beacon packet sending. $NS_2 > NS_1$.

Figure 5 shows the average nodes' position information inaccuracy in nodes' neighbors list versus different BPITs and NSs values. When the NS and the BPIT increase, the inaccuracy in distance (meters) between the accurate (real) and inaccurate (false) node position in nodes' neighbors list increases.

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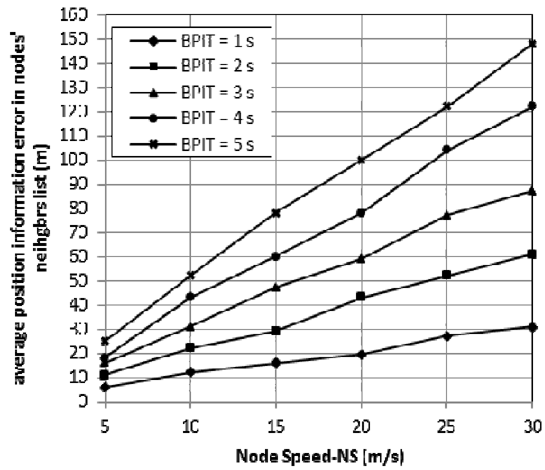

Figure. 5 Average nodes' position information inaccuracy in nodes' neighbors list. BPIT versus NS.

4.3 *Analysing Position Information Inaccuracy*

In this section, we analyse the potential problems that may occur due to inaccuracy in node position information in GPSR protocol. One of the problems of inaccuracy in node position information is increasing end-to-end delay in GPSR protocol. Figure 6 depicts this problem. Node *s* recognizes its neighboring node *n* in its neighbors list at the false position $n'(x'_n, y'_n)$ while the real node *n* position is $n(x_n, y_n)$. Here, node *s* may transmit the data packet to node *n* several times, which is not within the node *s* transmission range. If the routing protocol has a backup mechanism such as the data packet acknowledgment scheme [3], the backup mechanism will report that node *n* is unreachable and that the data packet loss has occurred. Transmitting the data packet several times before it cannot be delivered yields in a significant data packet end-to-end delay.

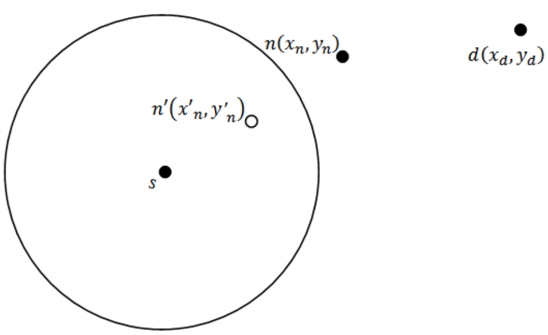

Figure. 6 End-to-end delay problem. $n'(x'_n, y'_n)$ false position, $n(x_n, y_n)$ real position.

The second problem of inaccuracy in GPSR protocol is the non-optimal route problem. Figure 7 depicts this problem. The false and the real position of neighboring node n_1 is n_1' and n_1 while for node n_2 is n_2' and n_2 respectively. The real position of destination node *d* is $d(x_d, y_d)$. In this instance, node *s* recognizes node n_1 in its neighbors list to be at a false position n_1' as a closest neighbor to destination node *d* even though in reality node n_2, at real position n_2, is the closest neighbor to destination node *d*. Using node n_1 as a routing node in place of n_2 will increase the number of routing hops toward the destination and route the data packet along a non-optimal route.

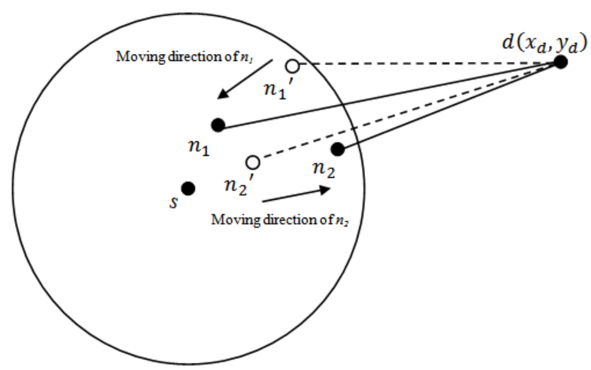

Figure. 7 Non-optimal route problem. n_1, n_2 real position. n_1',n_2' false position.

The third problem of inaccuracy in node position information in GPSR protocol is a false local maximum problem within the range reachable to the destination node. False local maximum (as explained in Figure 2) problem occurs when the routing node does not find a closer neighbor to the destination node among its neighbors other than itself even though in reality there is a closer neighbor to the destination node. Figure 8 depicts this problem. Where, node *l* recognizes the destination node *d* into its neighbors list at position d_l while the source node recognizes the destination node *d* at position d_s. When the data packet arrives at node *l* carrying the destination position from source node *s* at d_s, node *l* will not find any of its neighbors closer to destination node than itself even though in reality the destination is the neighbor to node *l* at position d_l. This situation causes the false local maximum problem by allowing node *l* to route the packet to node *p* using perimeter routing strategy. Hence, false local maximum occurs when the distance between d_l and d_s is greater than distance between *l* and d_s.

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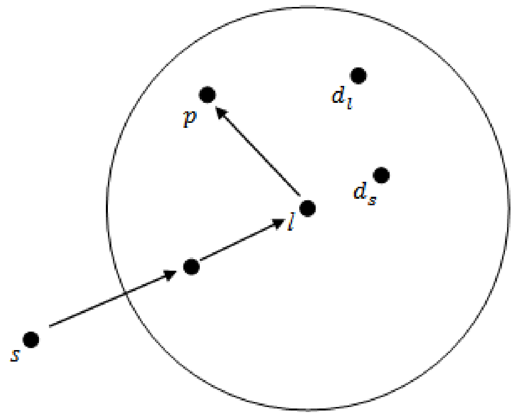

Figure. 8 False local maximum problem. d_l position of d recognized by l. d_s position of d recongnized by s.

The fourth problem of inaccuracy in node position information in GPSR protocol is the routing loop problem. Figure 9 depicts this problem. Here, nodes recognize each other on their neighbors' list at false positions n_1', n_2', n_3' while the real positions of these nodes are n_1, n_2, n_3. Node *s* thinks that node n_1 is the closest neighbor among its neighbors to destination node *d* and it routes the data packet to it at position n_1. Node n_1 thinks that node n_2 is the closest neighbor among its neighbors to destination node *d* and it routes the data packet to n_2 at position n_2. Then, node n_2 thinks that node n_3 is the closest neighbor among its neighbors to destination node *d* and it routes the data packet to n_3 at position n_3. In return, node n_3 thinks that node n_2 is the closest neighbor to destination and routes the packet again to n_2, which in turn causes node n_2 to thinks that node n_1 is the closest neighbor to destination node *d* and routes the data packet again to n_2. This situation causes the data packet to loop between routing nodes n_1, n_2, and n_3 infinitely.

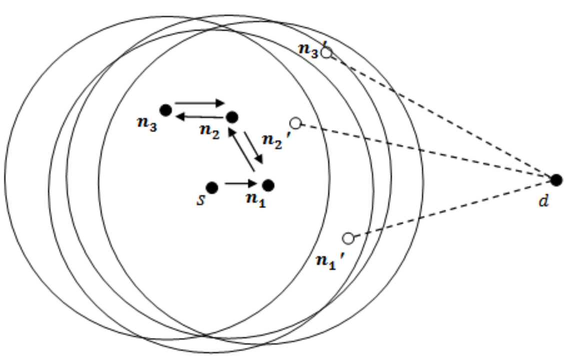

Figure 9. Routing loop problem. n_1, n_2, n_3 nodes' real positions. n_1', n_2', n_3' nodes' false positions.

5. CONCLUSION AND FUTURE WORK

In this paper, we introduced the functionality of position-based routing protocol represented by GPSR protocol and discussed the problems associated with position information inaccuracy in the nodes' neighbors list. We reviewed related works to show what research work has been carried out in studying the inaccuracy in position information inaccuracy on position-based routing protocols as well as indicated some the shortcomings. This was followed by analyzing the problems and discussing the effect of beacon packet interval-time and node speed mobility parameters that occur due to inaccuracy in node position information on position-based routing protocols.

Presently, we are performing simulation experiments to show the severe consequences of long beacon packet interval-time and high node speed parameters on the effect of position information inaccuracy on the network performance in terms of end-to-end delay, non-optimal route, false local maximum and routing loop. In addition, we aim to investigate on mechanisms and models to overcome the position information inaccuracy in the node's neighbors list.

REFRENCES:

[1] Mauve, M., Widmer, J., and Hartenstein, H. (2001). "A Survey on Position-Based Routing in Mobile Ad Hoc networks," IEEE Network, vol 1, issue 6, pp. 30-39.
[2] Elliott, D.K. (2005). "Understanding GPS: Principles and Applications," Second Edition. Artech House Publishers.
[3] Karp, B., and Kung, H. T. (2000). "GPSR: Greedy Perimeter Stateless Routing for Wireless Networks," Proceedings of the sixth annual international conference on Mobile computing and networking (MOBICOM 2000). Boston, Massachusetts, United States, pp. 243-254.
[4] Jain, R., Puri, A., and Sengupta, R. (2001). "Geographical routing using partial information for wireless ad hoc networks," IEEE Personal Communication, vol 8, issue 1, pp. 48-57.
[5] Seada, K., Helmy, A., and Govindan, R. (2007). "Modeling and analyzing the correctness of geographic face routing under realistic conditions". Journal of ad hoc networks, vol 5, issue 6, pp. 855-871.
[6] Son, D., Helmy, A., and Krishnamachari, B. (2004). "The effect of mobility-induced

PUBLICATION OF Little Lion Scientific R&D, Islamabad PAKISTAN
Journal of Theoretical and Applied Information Technology
30th June 2011. Vol. 28 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

location errors on geographic routing in mobile ad hoc sensor networks: analysis and improvement using mobility prediction," IEEE Transactions on Mobile Computing, vol 3, issue 3, pp. 233-245.

[7] Shah, R.C., Wolisz, A., and Rabaey, J.M. (2005). "On the performance of geographical routing in the presence of localization errors," 2005 IEEE International Conference on Communications. ICC 2005, vol 5, pp. 2979-2985.

[8] Kwon, S., Shroff, N.B. (2006). "Geographic routing in the presence of location errors," The international journal of computer and telecommunications networking, vol 50, issue 15, pp. 2902-2917.

[9] Peng, B., Kemp, A.H., and Maheshwari, H.K. (2009). "Impact of location errors on energy-efficient geographic routing in wireless sensor networks," 15th AsiaPacific Conference on Communications. APCC 2009, pp. 830-833.

[10] Yongjin, K., Jae-Joon, L., and Ahmed, H. (2004). "Modeling and Analyzing the Impact of Location Inconsistencies on Geographic Routing in Wireless Networks," ACM SIGMOBILE Mobile Computing and Communications Review, vol. 8, no. 1, pp. 48-60.

[11] Tsumochi, J., Masayama, K., Uehara, H., and Yokoyama, M. (2003). "Impact of mobility Metric on Routing Protocols for Mobile Ad Hoc Networks," IEEE Pacific Rim Conference on Communication, Computers and Signal Processing, (PACRIM 2003), vol 1, pp. 322-325.

[12] Chakeres, I.D., and Belding-Royer, E.M. (2002). "The utility of hello messages for determining link connectivity," The 5th International Symposium on Wireless Personal Multimedia Communications, vol 2, pp. 504-508.

[13] Shanudin, M., Ismail, M., and Saqour, R. (2005). "Impact of Mobility Metrics on Geographical Greedy Ad Hoc Network Routing Protocol and Improvement using Angular Prediction Model," Proceeding of The IEEE Malaysia International Conference on Communications (MICC) and the IEEE International Conference on Networks (ICON), Vol.1, pp.262-267.

[14] Saqour, R., Shanudin, M., and Ismail, M. (2007). "Prediction schemes to enhance the routing process in geographical GPSR ad hoc Protocol", Mobile Information Systems, vol. 3, pp. 203-220.

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