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Modeling the Position Information Inaccuracy in MANET Position-Based Routing Protocols

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Abstract: This study aims to model the position information inaccuracy in position-based MANET routing protocol. The modeling aids on understanding the position information inaccuracy and assists the researchers to find suitable techniques and mechanisms to overcome the observed problems and improve the performance of the position-based routing protocols. 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 packets to the destination. Each node periodically sends its geographical position information to its neighbours using beacon packets. Nodes which receive the geographical position information of their neighbours store this information in their neighbours list. The data packet routing in position-based routing protocols uses neighbours' position information, which is stored in the node's neighbours list,and the destination'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 the position information in the node's neighbours list is accurate, while in reality, only a rough estimate of this position information is available for the nodes. Position information inaccuracy has a severe impact on degrading the performance of the position-based routing protocols in terms of average end-to-end delay, non-optimal route, false local maximum, and the routing loop.

Key words: MANET, position-based routing protocols, position information inaccuracy

INTRODUCTION

Position-based routing protocols (Mauve *et al*., 2001) have become more popular in MANET due to their advantages in using physical position information of the nodes to route the data packets towards the destination. These protocols have lower communication overhead to set up and maintain the routes.Also, thenodes only need to store position information about their neighbours on their neighbours list to make effective routing decision.

In position-based routing protocols, each node needs to determine its own position information using different mechanisms such as a Global Position System (GPS) receiver (Elliott, 2005).Then,it broadcasts its position information periodically to other nodes within its transmission range (neighbour nodes). Data packet routing in position-based routing protocols is carried out based on the neighbours' position information which is stored in the node's neighbours list and destination's position information stored in the routing packet header. However, current position-based routing protocols are shown to work correctly and efficiently with accurate position information of the nodes. Thus, the nodes in position-based routing protocols need to maintain up-to-date positions of their immediate neighbours in their neighbours list for making effective routing decision.

Most of the current work in position-basedrouting protocols (Sascha and Wolfgang, 2008; Takano *et al*., 2007; Chennikara-Varghese *et al*., 2006) assumed that position information in the node's neighbours list for its neighbours is accurate, while in reality only a rough estimate of this position information is available for the nodes which result in degrading the performance of position-based routing protocols.Therefore, the objective of this paper is to investigate carefully in the existing position-based routing protocols in order to handle the position information inaccuracy.

MATERIALS AND METHODS

This research was carried out during January 2008 to May 2011 at University Kebangsaan Malaysia. In this paper, to model the position information inaccuracy in position-based routing protocol, GPSR protocol is utilized

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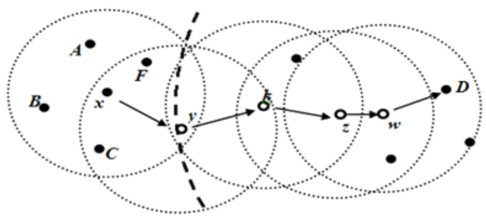

Fig. 1: Greedy routing strategy

Table 1: Node *x* neighbours list

Node ID	Neighbours (x, y Coordinates)
A	A (x_1, y_1)
B	B (x_2, y_2)
C	C (x_3, y_3)
F	F (x_4, y_4)
Y	y (x_5, y_5)

as the underlying routing protocol. The GPSR protocol (Karp and Kung, 2000; Takagi and Kleinrock, 1984) is an efficient, localized routing protocol in large-scale MANETs. Under GPSR protocol, a node makes routing decisions only based on the positions of its one-hop neighbours and the position of the destination node available by using position service protocols like flooding and grid position service (Boukerche, 2005). GPSR thereby avoids the overhead of maintaining global topology information. The GPSR protocol uses two forwarding strategies to route the data packet to the destination: greedy forwarding and perimeter forwarding.

Greedy routing: GPSR makes greedy routing decisions using only information about the position of immediate neighbours in the network topology as it appears in Fig. 1. In Fig. 1, *x* receives a data packet destined to destination *D*, *x*'s radio range is denoted by the dotted circle about *x*, and the arc with radius which is equal to the distance between *y* and *D* is shown as the dashed arc about *D*. *x* routes the data packet to*y* as *y* listed in *x* neighbours list as shown in Table 1 and as the distance between *y* and *D* is less than that between *D* and any off *x*'s other neighbours. This greedy routing process is repeated by nodes *y*, *k*, *z*, and *w* until the packet reaches the destination node *D*.

Algorithm 1 describes the greedy routing algorithm pseudo code. Where *p.a* contains the address of data packet's destination in the header of routing data packet *p*, and *p.l* is the position of the data packet destination. *N* is the node neighbours' list whose entries are a pair of neighbour node's address (*a*) with the neighbour's position (*l*). *Self.a* and *self.l* are the address and position of the node executing the algorithm and DISTANCE (*e*, *f*) is the computed Euclidean distance between nodes *e* and *f*, which can be calculated as:

DISTACE (Self .l,p.l) =

$$\sqrt{(xself.1 - xp.l)^2 + (ySelf.1 - yp.l)^2} \quad (1)$$

```
// Algorithm 1: GREEDY ROUTING (p)
n_best = self.a
d_best = DISTANCE (self.l, p.l)
foreach (a, l) in N
do d= DISTANCE (l, p.l)
if d <d_best or a == p.a
thenn_best = a
d_best = d
if a == p.a
then break
end
end
ifn_best = = self.a
 thenreturn greedy routing failure
else route p to n_best
return greedy routing success
```

Perimeter routing: The power of greedy routing strategy using only neighbour nodes' positions comes with one attendant drawback; there are topologies in which the only route to a destination requires the data packet move temporarily farther in geometric distance from the destination.

A simple example of such a topology is shown in Fig. 2. Here, *x* is closer to *D* than its neighbours *w* and *y*. Although two paths exist to *D*: *x*, *w*, *v* and *x*, *y*, *z*. node*x* will not chose to route the data packet to *w* or *y* using greedy routing. In this case, GPSR protocol terms *x* as local maximum in its proximity to *D* and terms shaded region without nodes as void region.

When the GPSR protocol fails to route the data packet using greedy routing strategy, the protocol uses perimeter routing strategy to route the data packet around void region. In perimeter routing, the protocol constructed planar graphfor the sender node's neighbours and applied the right-hand rule to route the packet around void region. Planar graph is a *graph* that can be drawn in the plane with no crossing edges. The right-hand rule states that when arriving at node *x* from *y*, the next traversed edge is the next one sequentially counter clockwise about *x* from edge (*x*, *y*).

Algorithm 2 describes the perimeter routing algorithm pseudo code. For a network node with a list of its neighbours' positions *N*, routing a data packet *p* that arrives from a neighbour n_{in} at bearing b_{in} by the right-hand rule amounts to choose the neighbour whose bearing b_a minimize the difference b_{in} - b_a, where bearings are defined on [0, 2π]. NORM normalizes its argument in radians into [0, 2π] by repeatedly adding 2π and ATAN2(*y*, *x*) computes the arc tangent of *y*/x. Network connectivity (Gomez and Campbell, 2004), in GPSR

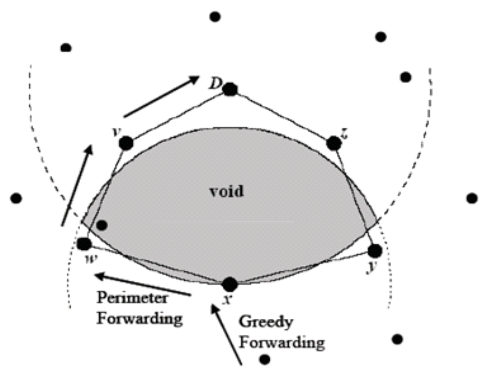

Fig. 2: Perimeter routing strategy

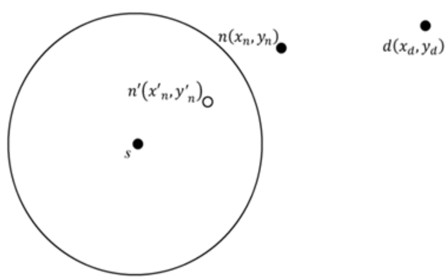

Fig. 3: Inaccuracy in node position information (INACC_NPI)

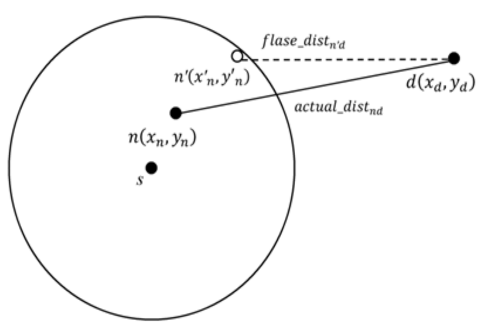

Fig. 4: Inaccuracy in node distance information (INACC_NDI)

protocol, is determined by simple beacon packet protocol which provides all nodes with their neighbours' position information. Periodically, each node transmits a beacon packet containing only its own identifier (e.g., IP address) and its position (x, y coordinates). When any node receives a beacon packet from its neighbours; it creates or refreshes its neighbours list and uses this beacon packet information for future routing process.

// Algorithm 2: PERIMETER ROUTING (p, n_{in})
b_{in} = NORM(ATAN2(self.l.*y*- n_{in}.*y*, self.l.*x*- n_{in}.*x*))
α_{min}= 3π
foreach (a, l) in N
do if a == n_{in}
then continue
b_a= NORM(ATAN2(self.l.*y*– a.l.*y*, self.l.*x*– a.l.*x*))
α_b = NORM (b_a - b_{in})
if $\alpha_b < \alpha_{min}$
then $\alpha_{min} = \alpha_b$
a_{min} = a
returna_{min}

RESULTS AND DISCUSSION

In this section, inaccuracy in node position information that may occurs in position-based routing protocols represented with four metrics: inaccuracy in node position information (INACC_NPI), inaccuracy in node distance information (INACC_NDI), inconsistency in node position information (INCON_NPI), and inconsistency in node distance information (INCON_NDI). In general, we said *inaccurate* for the thing if it is not has exact information according to the fact or truth. And we said two local views are *inconsistent* if they contain conflicting information about the same thing. Each of these inaccuracies has a negative impact on degrading the performance of position-based routing protocols in terms of end-to-end delay, non-optimal route, false local maximum, and routing loop.

Inaccuracy in node position information (INACC_NPI): INACC_NPI metric represents the inaccuracy in distance between the accurate (actual/real) position of the node and its inaccurate (false) position. Inaccurate or false node position refers to node wrong position information in its neighbours' neighbours list. Figure 3 shows the INACC_NPI, node *s* recognizes its neighbour node *n* in its neighbours list at the false position $n'(x'_n, y'_n)$ while the actual node *n* position is $n(x'_n, y'_n)$. Based on that, we can define the INACC_NPI metric as follows:

$$INACC\_NPI_{n,n} = \sqrt{(\Delta X_n)^2 + (\Delta Y_n)^2} \qquad (2)$$

where, $\Delta x_n = (x_n - x'_n)$ is the difference between actual and false node *n* position in *x*-coordinate and $\Delta y_n = (y_n - y'_n)$ is difference between actual and false node *n* position in *y*-coordinate.

One of the potential problems of INACC_NPI is the increasing on data packet end-to-end delay. End-to-end delay represents the total delays experienced by each data packet at each hop on the packet way from source node to the destination node. The problem can be explained by referring to Fig. 3. Here, node *s* may transmit the data packet to node *n* several times which is no longer within node *s* transmission range. If the routing protocol has a backup mechanism such as packet acknowledgment (Karp

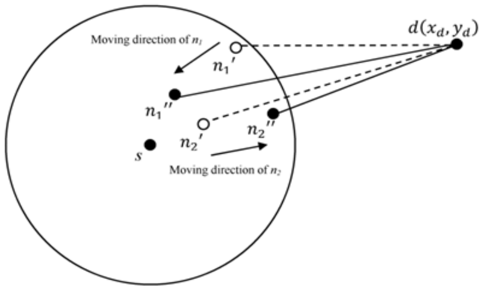

Fig. 5: Non-optimal route problem. n1, n_2 eal nodes' position.n_1',n_2' false nodes' position.

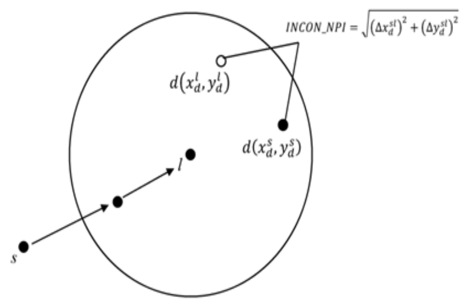

Fig. 6: Inconsistency in node position information (INCON_NPI)

and Kung, 2000), the backup mechanism reports that node *n* is unreachable and the data packet lost. Transmitting the data packet several times before it is announced that it cannot be delivered leads in a significant end-to-end delay.

INACC_NDI metric represents the inaccuracy in distance between the actual distance and the false distance between the routing node and the destination node. Figure 4 shows the INACC_NDI metric, the false and the real position of routing neighbour node *n* is $n'(x'_n, y'_n)$ and $n(x_n,y_n)$, respectively while the actual position of destination node *d* iss(x_d,y_d). From that, we can define the actual and false distance between node *n* and *d* as follows:

$$actual\_distnd = \sqrt{(xd - x'_n)^2 + (yd - y'_n)^2} \qquad (3)$$

$$flase\_dist_{n,d} = \sqrt{x_d = x'_n)^2 + (y_d - y'_n)^2} \qquad (4)$$

Then, from Eq. (3) and (4) we can define the INACC_NDI metric as follows:

$$INACC\_NDI_d^{n,n} = |actual\_dist_{nd} - flase\_dist_{n,d}| \qquad (5)$$

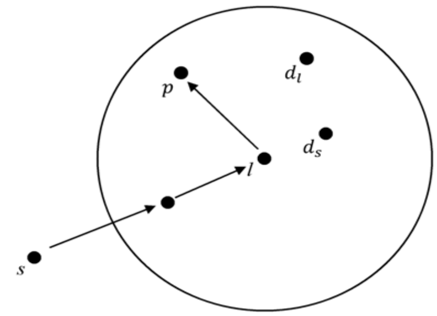

Fig. 7: False local maximum problem in INCON_NPI. Node *d* moes from location *ds* to location d_i while the data packet routs from *s* to *l*

One of the potential problems of INACC_NDI is non-optimal route problem, which represents the non-shortest route (hop) experienced from each data packet through its route from node *i* to node *j*. Figure 5 depicts this problem. The false position of routing neighbour nodes $n_1$and n_2 is n_1' and n_2' respectively while the actual position of n_1 and n_2 is n_1" and n_2" respectively. The actual position of destination node *d* is $d\ (x_d, y_d)$. In this instance, node *s* recognizes node n_1 in its neighbours list at the false position n_1' as a closest neighbour to destination *d* even though in reality node n_2 is the closest neighbour to destination *d*. Using node n_1 as a routing node in place of n_2 increases the number of routing hops toward the destination and directs the data packet along a non-optimal route.

Inconsistency in node position information (INCON_NPI): INCON_NPI metric represents the inaccuracy in distance between the actual and false positions of the destination node recognized by two nodes. Figure 6 shows the INCON_NPI metric, the source node *s* includes the destination position $d(x_d^s, y_d^s)$ in the header of its routing data packet to destination node *d*. When the data packet arrives to node *l* at the last hop to destination *d*, node *l* recognizes the destination node *d* at different position $d(x_d^l y_d^l)$ due to destination node *d* movement during the data packet routing process from *s* until it reaches *l*.
From that, we can define the INCON_NPI as follows:

$$INCON\_NPI_d^{sl} = \sqrt{(\Delta x_d^{sl})^2 + (\mathrm{X} y_d^{sl})^2} \qquad (6)$$

where, is the $\Delta x_d^{sl} = (x_d^s - x_d^l)$ difference between actual positions of node *d* asrecognized by node *s* and *l* in x-coordinate and $\Delta y_d^{sl} = (y_d^s - y_d^l)$ is difference between actual positions of node *d* asrecognized by node *s* and *l* in y-coordinate. One of the potential problems of

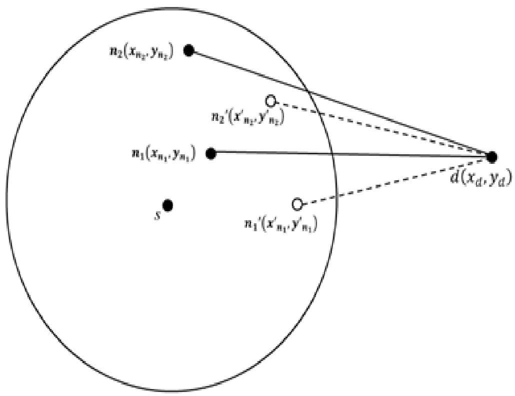

Fig. 8: Inconsistency in node distance information (INCON_NDI)

INCON_NPI is false local maximum problem within the range reachable to the destination node. False local maximum is the problem occurs when the routing node could not find closer neighbour to the destination node than itself even though in reality there is closer neighbour to the destination node. Figure 7 depicts this problem. Here, node *l* recognizes the destination node *d* into its neighbours list at position d_l while the source node recognizes the destination node *d* at position d_s. When the packet arrives to node *l* carrying the destination position from source node *s* at d_s, node *l* will not find any of its neighbours closer to destination than itself even though in reality the destination is the neighbour to node *l* at position d_l. This situation leads the false local maximum problem and let node *l* to route the data packet to node *p* using perimeter routing strategy. Hence that, false local maximum occurs when the distance between d_l and d_s is greater than distance between *l* and.d_s

Inconsistency in node distance information (INCON_NDI): INCON_NDI metric represents the difference in distance between the actual distance and the false distance between the routing nodes and the destination node. Figure 8 shows the INCON_NDI metric, the false and the actual position of routing node $n_1$is $n_1'(x'n_1, y'n_1)$ and $n_1(x_{n1}, y'_2)$, respectively while the false and the actual position of routing node n_2 is $n_2'(x'_{n2}, y'_{n2})$ and $n_2(x_{n2}, y_{n2})$, respectively. The actual position of destination node *d* is $d(X_d, Y_d)$. From that, we can calculate the actual and false distance between node n_1, n_2 and *d* as follows:

$$actual\_{}_{n1d} = \sqrt{(x_d - x_{n1})^2 + (y_d - y_{n1})^2} \qquad (7)$$

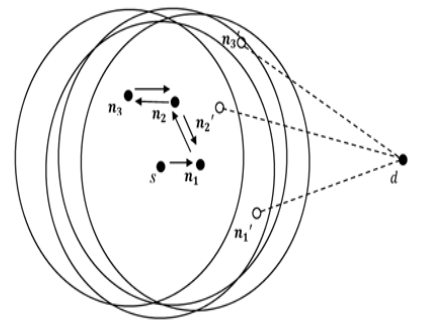

Fig. 9: Routing loop problem in INCON_NDI

$$flase\_dist_{n1,d} = \sqrt{(x_d - x'_{n1})^2 + (y_d - y'_{n1})^2} \qquad (8)$$

$$actual\_dist_{n2d} = \sqrt{(x_d - x_{n2})^2 + (y_d - y_{n2})^2} \qquad (9)$$

$$flase\_dist_{n,2} = \sqrt{(x_d - x'_{n2}) + (y_d - y'_{n2})^2} \qquad (10)$$

Then, from Eq. (7), (8), (9) and (10) we can define the INACC_NDI metric between node n_1 and *d* and between node n_2 and *d* as follows:

$$INACC\_NDI_d^{n1,n1'} = |actual\_distn_{1d} - flase\_dist_{n1'd}| \qquad (11)$$

$$INACC\_NDI_d^{n2,n2'} = |actual\_dist_{n2d} - flase\_dist_{n2,d}| \qquad (12)$$

Then, from Eq. (11) and (12) we can redefine the INCON-NDI between node n_1, n_2 and *d* as follows:

$$INCON\_NDI_d^{n1,n'1,n2,n'2} = |INACC\_NDI_d^{n1,n1'} - INACC\_NDI_d^{n2,n2'}| \qquad (13)$$

One of the potential problems of INCON_NDI is in making routing loop problem. Figure 9 depicts this problem. Here, nodes recognize each other at false positions $n_1' n_2' n_3'$, while the actual positions of them aren1,n_1,n_2,n_3. Node *s* thinks that noden$_1$ is the closest neighbour among its neighbours to destination *d* and its route the data packet to it at positionn$_1$. Then, noden$_1$ thinks that noden$_2$ is the closest neighbour among its neighbours to destination *d* and its forward the data packet to n_2 at position n_2. Then, node n_2 thinks that node n_3 is the closest neighbour among its neighbours to destination *d* and its forward the data packet to n_3 at position n_3 In return, node n_3 thinks that node n_3 is the closest neighbour to destination and routes the data packet again ton n_2, then, node n_2 thinks that node n_2 is the closest neighbour to destination and routes the data packet again to n_1 and so on. This situation makes thedata packet to go through looping routes between the nodes.

CONCLUSION

In this study, we discussed the position information inaccuracy on position-based routing protocols. We started by modeling the four types of metrics for position information inaccuracy that may observed in position-based routing protocols: inaccuracy in node position information (INACC_NPI), inaccuracy in node distance information (INACC_NDI), inconsistency in node position information (INCON_NPI), and inconsistency in node distance information (INCON_NDI). In addition, the paper showedThe effect of these metrics in degrading the performance of position-based routing protocols in terms of average end-to-end delay, non-optimal route, false local maximum problem, and routing loop problem.

As a conclusion, we can say that INACC_NPI metric, which represents the inaccuracy in distance between the actual position of the node and its false position into its neighbour node's neighbours list, is the main metric in inducing INACC_NDI, INCON_NPI and INCON_NDI metrics of position information inaccuracy. For that, mitigating the effect of INACC_NPI inaccuracy metric will lead to mitigate the other position information inaccuracy metrics.As a future work, we aims to study the techniques and mechanisms which can be used in order to overcome the effect of INACC_NPI metric and to overcome the perceived problems in order tobring better performance for position-based routing protocols.

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REFERENCES

Boukerche, A., 2005. Handbook of Algorithms for Wireless Networking and Mobile Computing. Chapman and Hall/CRC Publisher.

Chennikara-Varghese, J., W. Chen, O. Altintas and S. Cai, 2006. Survey of Routing Protocols for Inter-Vehicle Communications. 3rd Annual International Conference on Mobile and Ubiquitous Systems. pp: 1-5.

Elliott, D.K., 2005. Understanding GPS: Principles and Applications. 2nd Edn., Artech House Publishers, Norwood, MA, USA.

Gomez, J.and A.T. Campbell, 2004. A Case for Variable-Range Transmission Power Control in Wireless Multihop Networks. Proceeding of Twenty-third Annual Joint Conference of the IEEE Computer and Communications Societies (INFOCOM2004). 2: 1425-1436.

Karp, B. and H.T. Kung, 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, 6-11 August, pp: 243-25.

Mauve, M., J. Widmer and H. Hartenstein, 2001. A Survey on position-based routing in mobile Ad Hoc networks. IEEE Network, 1(6): 30-39.

Sascha, S. and E. Wolfgang, 2008. Position-Based Unicast Routing for City Scenarios. International Symposium on a World of Wireless, Mobile and Multimedia Networks (WoW MoM 2008), pp: 1-8.

Takagi, H. and L. Kleinrock, 1984. Optimal transmission ranges for randomly distributed packet radio terminals. IEEE Tran. Commun., 32(3): 246-257.

Takano, A., H. Okada and K. Mase, 2007. Performance Comparison of a Position-Based Routing Protocol for VANET. IEEE International Conference on Mobile Ad Hoc and Sensor Systems, pp: 1-6.