

A Recovery Method for Greedy Routing Protocols in Web Communications

Sheetal Kaushik¹, Neeraj Raheja²

¹ M.Tech Computer Science, MMU Mullana,
Ambala, Haryana, India
Sheetal.kaushik618@gmail.com

² Professor, Computer Science, MMU Mullana,
Ambala, Haryana, India
Neeraj_raheja2003yahoo.co.in

Abstract

Greedy Perimeter Stateless Routing (GPSR) protocol is an appropriate and the most well-known routing protocol for high mobile vehicular ad-hoc networks. The protocol includes two routing modes, the greedy mode and the recovery mode, and utilizes a neighbor list to make a route decision. However, not only does the neighbor list in the protocol involve stale neighbor information, but also the stale nodes inherit a higher selection priority in the greedy mode according to the routing policy; besides, the useful redundant route information can be eliminated during planarization in the recovery mode. To overcome those problems, we propose a new recovery mode, named as Greedy Border Superiority Routing (GBSR), along with an Adaptive Neighbor list Management (ANM) scheme. A node generates a border superior graph instead of generating a planar graph when the node faces the local maximum. Packets in the recovery mode can escape from the recovery mode as fast as possible using the graph. Here, GBSR protocol has the same assumption as that of GPSR, and does not require any additional information. With a network simulator, GBSR and ANM are evaluated using two vehicle mobility scenarios. GBSR shows higher network performance in comparison with GPSR protocol. In addition, we accomplish a nearly stale-free neighbor list using the ANM scheme.

Keywords: *Greedy Border Superiority Routing, Greedy Forwarding, Adaptive Neighbor List Management, Vehicle Ad-hoc Networks*

1. Introduction

Wireless technologies play an important role in vehicular industry at the present time. The design points are inclined toward safety, usability, and fuel efficiency of cars. When a wireless communication technique is available between vehicles, various new services could be possible for the safety. Cars on a road can form a Vehicular Ad Hoc Network (VANET) with WAVE communication devices. VANET has some different features with Mobile Ad Hoc Networks

(MANET) highly dynamic network topology, some logical structures as LAN. Owing to the differences, the current MANET protocols such as AODV, OLSR, or DSR, are not appropriate for VANETs. However, geo-graphical routing protocols are particularly efficient in highly dynamic environments. With geo-location information, packets are greedily forwarded to the vehicle bringing the maximum progress toward the destination node on each step.

The most well known geo-location routing protocol for the vehicular environment is Greedy Perimeter Stateless Routing (GPSR) protocol. Packets are forwarded using a greedy forwarding in normal situation. The greedy method is known for a sub-optimal way to forward packets to a specific location. A node cannot forward a packet in the greedy mode when the node meets with the local maximum, and then the packet is handed over an appropriate next relay not in greedy location. That is called the perimeter routing and is the recovery mode of the protocol. The perimeter mode is involved in geographic routing for a correct delivery if and only if a vehicular graph is planar.

Some literatures have been focused on building a planar vehicular graph, other works do not require planar graphs in their recovery mode. In Greedy Distributed Spanning Tree Routing (GDSTR), it makes use of two null trees instead of planarization as a recovery mode when a greedy forwarding fails. In Greedy Perimeter Coordinator Routing (GPCR) a packet which meets up with the local maximum is transmitted backward until the packet arrives in a junction point, such as, an intersection. In order to distinguish the junction point from others, the protocol involves a junction advertisement process. GPSR recovers from the local maximum using digital maps. Those works accommodate additional schemes to escape from building a costly planar graph.

In order to accomplish a greedy strategy successfully, each node should maintain its neighbor list in coherent. And the list is maintained by HELLO beacons in general.

However, the list includes some stale information for neighbor nodes out of its transmission range because of the beacon interval and update policy. When a node has a packet to forward to a destination, the node selects the farthest node among its neighbor nodes toward the destination based on its neighbor list. If the next node is one of stale nodes, then the packet can not be correctly forwarded to the next relay node because an ARP (Address Resolution Protocol) could be failure. Then the packet will be dropped it. Such events can happen easily during forwarding by means of the greedy routing policies. Although the stale information can be detected by lower layer protocols, that increases a transmission delay and requires additional cross layer interfaces in the protocol stack. Therefore, this scheme is difficult to be directly applied to most of routing protocols.

In GPSR, a node in the recovery mode generates a vehicular planar graph which has no cross link using local connection information and selects an appropriate next hop out of the graph. Unfortunately, a lot of useful redundant links are eliminated during building the planar graph, and besides, the length of the remained links is relatively short. As a result, the packet is ineffectively forwarded through the remained links in the recovery mode.

In this paper, we propose a new recovery mode along with an Adaptive Neighbor list Management (ANM) scheme with the same assumptions to GPSR. With the ANM scheme, each node can easily distinguish stale nodes on its neighbor list. Not only the packet delivery ratio but also the time to recover from the local maximum are improved by the new recovery mode which called Greedy Border Superiority Routing (GBSR); besides, the average hop delay is decreased and the average hop distance is increased. Our two contributions are as follows:

- 1) An adaptive neighbor list management scheme effectively manages stale nodes on its neighbor list
- 2) An improved recovery method has a longer hop so that a packet can reach to a conversion point as fast as possible. The GBSR protocol accomplishes nearly a stale-free neighbor list in combination with the ANM scheme.

2. Greedy Perimeter Stateless Routing

GPSR protocol is a position-based routing one, where a routing node forwards a packet to one of its neighbor node which is geographically closer to the destination node among the neighboring nodes. That is called a greedy forwarding. In order to select a next relay node among the neighbor nodes, each node makes use of location information on the neighbor list. To do this, it assumes that each node needs to be aware of its own location, the

location of neighboring nodes. A node obtains its location from a location device, such as, a GPS device, and acquires the locations of neighboring nodes by means of periodic HELLO beacons. It also assumes that a source node obtains the location of the destination node from a global location service which supports a location registration and lookup service that maps nodes' addresses to locations. The scope of GPSR is limited to geo-graphic routing. For developing our protocol, we make use of exactly the same assumptions as the GPSR protocol.

GPSR protocol makes a routing decision depending on local information, and includes a recovery mode in order to escape from the local maximum situation. A node holding a packet to forward cannot find a proper forwarder being closer to the destination than itself. In order to recover from this local maximum, the protocol transmits the packet to backward with respect to the destination node. The packet will be continuously detoured until it reaches a node whose distance to the destination node is closer than the former recovery node. When the packet reaches the node, the mode of the packet may be resumed to the greedy mode.

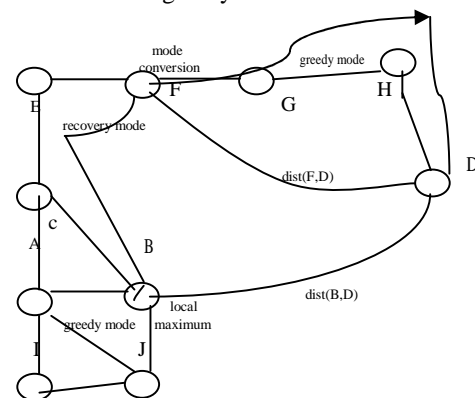


Fig. 1. GPSR routing modes in a local maximum

When the packet reaches the node, the mode of the packet may be resumed to the greedy mode.

Fig. 1 describes the brief operations of GPSR. Node A is going to send a packet to node D. Then node A forwards a packet to node B through the greedy mode. But the packet meets the local maximum on node B. In order to escape from the local maximum, node B forwards the packet to node C which is backward after writing its location in the packet header. Nodes receiving the packet extract the location of the former recovery node and the destination node from the packet header. They then

calculate the distance between the nodes, and compare it with their distance from the destination. When the packet arrives on node F , the distance $dist(F,D)$ is shorter than $dist(B,D)$ and then the packet's mode is returned back to the greedy mode loads. Many recovery algorithm have been proposed to solve this problem. GPSR recovers from the local maximum by a perimeter mode. In the perimeter mode, a node generates a planar network graph which is a neighboring node topology graph without crossing links. To build the planar network graph, GPSR algorithm applies either Relative Neighborhood Graph algorithm (RNG) or Gabriel Graph algorithm (GG). The node selects a vertex from the graph using a right-hand rule. This rule states that when a node firstly enters into the recovery mode, its next hop is a node which has a minimum included angle toward counterclockwise to the destination node. Afterwards, the next hop is sequentially a counterclockwise node for the previous node until the packet reaches a mode conversion node where the packet's mode is returned back to the greedy mode. Whenever a node has a packet to forward in the recovery mode, the node generates a planar graph for the packet and that involves much processing cost.

2.1 The Weakness of Greedy Forwarding in High Mobile Vehicular Communications

The role of HELLO beacon is very important in the most of geo-graphical routing protocols. These protocols make use of neighboring nodes' location to make a route decision. In order to exchange location information among nodes, every node periodically broadcasts a HELLO beacon which includes its ID and position information. Every node keeps the information obtained from the beacon on its neighbor list, and removes out-of-date information from the list using a timeout mechanism.

Greedy routing protocols are influenced much to the integrity of neighbor lists according to their routing policies. In the vehicular networks, the integrity of location information on the neighbor list goes down because of the high mobility of vehicles. The coherency of neighbor list can be strong by assigning a shorter period of HELLO beacon, but it sharply increases the network loads. No matter how the period is reduced, neighbor lists may include some stale information in the VANET environment. In the greedy forwarding mode, a node selects the most close neighbor node toward the destination node among its neighbors and forwards a packet to the node. The probability of staleness can be relatively high to the farthest node, and is closely connected with routing failures.

2.2 The Weakness of Recovery mode of GPSR in City Scenarios

Planar graphs are not useful in the vehicle scenarios. Two planar graph algorithms, the RNG and the GG, have been presented to solve the local maximum problem in GPSR. Both of them are based on local geometric information and can make a good sub-graph from the original network topology. While the algorithms perform well when nodes are uniformly or randomly distributed, they do not perform as well for vehicular networks in city scenarios. In the vehicular networks, not only vehicles are only placed and run on roads, but also they are distributed non-uniformly along the roads. The network topology is composed similar to the topology of roads. If a node generates a planar graph in the network topology, the routing efficiency will be dropped due to a lack of redundant information which is one of the tangible advantages of ad hoc networks.

3. Greedy Border Superiority Routing (GBSR)

The GBSR protocol is a position-based routing protocol which utilizes the greedy forwarding. The protocol consists of two modes like GPSR algorithm; one is a greedy mode, the other is a recovery mode. In the greedy mode, packets are forwarded to nodes which are closer to the destination node of the packets than the current node. When a packet reaches a local maximum, the node switches to the recovery mode for the packet. In the recovery mode, it is not efficient to forward backward in short distance through planarized links in the vehicular network scenarios. The best way to recover from the local maximum is to make the packet reach a conversion point as fast as possible. A packet can be hopped up to a radio boundary node in the recovery mode of GBSR. It is possible to involve some stale nodes on its neighbor list, and the probability of routing failure will be raised. In order to overcome this shortcoming, the GBSR protocol manages its neighbor list adaptively. When a node receives a HELLO beacon from a neighbor node, the node compares the current location of the neighbor node with the previous location of that. The node can obtain some useful information during the procedure. Every node takes advantage of this information and manages its neighbor list more effectively.

3.1 Adaptive Neighbor List Management

All of the nodes in a network periodically broadcast a HELLO beacon including their location. Nodes receiving the HELLO beacon get the distance variation, speed, and moving direction of originator of the beacon with

comparing the current position with the previous position of the node.

When a node receives a HELLO beacon from an unknown neighbor, the node regards that the neighbor node is getting closer. In other case, the node receives a HELLO beacon from a known neighbor node. When the node is aware that its current position is farther than the previous position of the neighbor node, it can predict that the neighbor will be a stale node in a certain time. A HELLO beacon is processed by the below rules:

- 1) If a node receives a beacon came from an unknown node, the node makes an entry for a new neighbor node and regards as a node getting closer. The STALE flag of the entry is set by FALSE. This node's entry can be referenced for routing decision.
- 2) When a node receives a beacon coming from a known node, the node compares that node's current location with the previous one. If the distance between two nodes is less than before, then the node just updates that node's information. Otherwise, the node calculates the expected position of that node in the next period using the current speed and direction. If the expected position is out of its coverage, the node assigns TRUE on the STALE flag of that node's entry. Else, the node updates that node's entry.
- 3) When a node did not receive any beacons from a known node for the neighbor timeout period, the node removes that node's entry from its neighbor list. Every node does not use the stale node being set TRUE to the STALE flag for routing decisions. The stale node entries are naturally purged by a timeout mechanism.

3.2 Enhanced Recovery Mode

A packet in a recovery mode is needed to forward as far as its radio range allows until the packet reaches a junction point on the road segment. In order to generate a border superior sub-graph, the GBSR protocol eliminates the overlaid links from the neighbor list if only both of nodes are on the same road. The road segment can be distinguished with the direction of nodes.

Each circle indicates the radio coverage of node u and w respectively. The node v , v' , v'' , and w are neighbor nodes of node u . The $link(u,v)$ and $link(u,v'')$ are overlaid by the $link(u,w)$. So, the $link(u,v)$ can be eliminated by $link(u,w)$, but the $link(u,v'')$ can not be eliminated by the $link(u,w)$ because they have different directions. The $link(u,v')$ is not deleted since the link is not overlaid by the $link(u,w)$. The algorithm of GBSR sub-graph is as follows:

```

for all  $v \in N$  do for all  $w \in N$  do
if ( $v == w$ ) then continue;

else if ( $dist(u,v) > dist(u,w)$ ) &&
 $dist(u,v) > dist(v,w)$  &&  $is\_same\_direction(v,w)$ 
then
   $eliminate\ edge(u,w); break;$ 
end if end for
end for

```

T Where N is a full list of u 's neighbors, v and w are u 's neighbors, $dist(u, v)$ means the distance between u and v , and $is_same_direction(v,w)$ function returns a value among the 1(the same direction), 0(other direction), and -1(the opposite direction). If and only if the two nodes are the same direction or the opposite direction the link can be eliminated from the full graph so that the road-end nodes can be selected among the vehicles on the road.

In the GBSR protocol, the next hop is selected by the right-hand rule like GPSR protocol. A node extracts a border superior sub-graph from its neighbor list and selects a neighboring node having the shortest included angle toward counterclockwise from the virtual edge between the corresponding node and the destination node. The selected node becomes the next hop in this mode. With the sub-graph, packets in the local maximum are greedily transmitted through detour route. As soon as arriving at mode conversion point, the packets are forwarded with greedy mode.

4. Performance Evaluation

In this section, we show the performance of the ANM and evaluate the GBSR protocol by comparing the protocol with GPSR protocol. This paper focuses on the improved recovery mode in the GBSR. The practical performance variances are appeared in the recovery mode because the operations of both GPSR and the GBSR are identically same in greedy mode.

Network simulation parameters

The simulations were implemented using the NS-2 simulator. All of the simulations have been measured GIS (Geographical Information System) and Manhattan mobility model to evaluate the protocols. We utilize the mobility models offered by Generic Mobility Simulation Framework (GMSF). The area size of both models is 3000m \square 3000m. The map for the GIS model is located in the downtown area of Zurich, Switzerland.

The GIS mobility model applies the car-following model where cars do not overtake others and the traffic light model where cars follow traffic signal at intersections. Each node either accelerates or decelerates as its situation and follows the speed limitation. The Manhattan mobility model applies the car-following model and the stop-sign model. Each node stops at the intersection for a while and either accelerates or decelerates as its situation too. The maximum speed of nodes limits by 15m/s (54km/h). If a node reaches a border line, then the node returns to the area in the both mobility models so that the number of nodes is not changed during simulations. Both of mobility model include macro- and

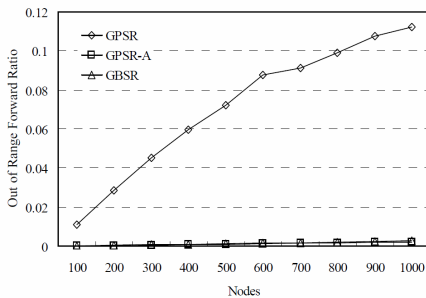


Fig. 4. The out of range forwards ratio

Experiment Results

The adaptive neighbor list management scheme performance .A routing node can distinguish stale nodes from its neighbor list with the ANM.

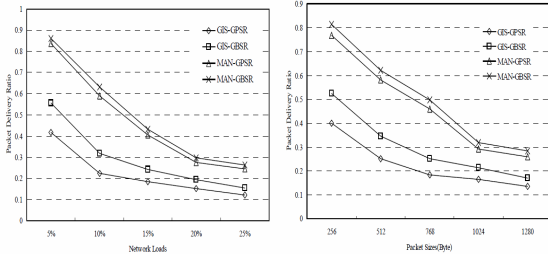


Fig. 6. The packet delivery ratio as network load Fig. 7. The packet delivery ratio as packet sizes

micro- mobility features. Every experiment makes use of the same mobility models and different network traffic models. We get the average values after simulating 10 times with different network traffic models.

TABLE I
 NETWORK SIMULATION PARAMETERS

Parameter	Value
The number of vehicles	100-1000 nodes
The network traffic loads	10% of CBR source (5-25%) Interval 200ms
The packet size	512 bytes (256-1280 bytes)
MAC protocol	IEEE 802.11 MAC
MAC transmission rate	2 Mbps
Transmission range	300meter
HELLO beacon interval	1 second
Simulation time	300 second

As a result of the management scheme, the rate of out-of-range forwards was lessened almost 0%. Fig. 4 indicates the ratio of out-of-range forwards. We can see how many out-of-range forwards happened in the simulations with the graph. Every out-of-rane forward directly is connected with routing failure. In the original GPSR, the number of out-of-range forwards increased constantly according to the node density. The GPSR with the ANM(GPSR-A) and GBSR applied the ANM. The two protocols kept the almost 0% regardless of the density of nodes. The out-of-range forwards are a reason of significant routing failure. All GPSR experiments have been simulated using GPSR-A since now in our experiments

Packet delivery ratio

Because GIS and Manhattan mobility models are quite different, the packet delivery rates of each model are showed separately. Packet deliver failures were mostly occurred by packet collisions. Sometimes packets were fallen into loop, and the routing protocols dropped packets due to the time to live problem when the node density was relatively low. In Manhattan mobility model, two protocols showed few differences because most packets were forwarded with the greedy mode. But because there are a lot of recovery modes in GIS model, the GBSR shows better performance than GPSR in recovery mode.

Fig. 6 and Fig. 7 show packet delivery ratio as network load variation and packet size variation respectively. The number of packets steadily is increased according as the CBR source nodes are increased. Although the number of successful deliveries increases, the packet delivery ratio is dropped in both protocols according to the network load changes. It means that the packet collision rate is increased according as the number of forwards increases. The packet delivery ratio is decreased according as the size of packet is increased by the same reasons of the network loads. The length of packets is longer, it took more the transmission time. As a result, the packet collision rate is increased as

the size of packet increases due to the transmission time. The delivery ratio of Manhattan shows better performance than that of the other because nodes in the model are distributed more regularly than the GIS model. The GBSR protocol lessened the number of forwards with the enhanced recovery mode. The result of enhancement was emerged into the lower collision rate and it contributes to improvement of the network performance. The GBSR protocol shows better performance for all cases.

Forwarding related performances

Fig. 8 shows the proportion of greedy mode to recovery modes. As mentioned before, the nodes were more regularly distributed in the Manhattan mobility model than GIS model. As a result of those distributions, packets were likely to be forwarded with the greedy mode in the Manhattan model. If the greedy ratio is high, we can regard that it shows a good performance. The GBSR protocol showed better performance in both mobility models. Fig. 9 shows the average hop distance. Because both of GBSR and GPSR nodes selected the farthest neighbor node among its neighbor nodes in the greedy mode, the result of hop distance reveals the distances in the recovery modes. In the Manhattan model, two protocols do not show a lot of differences excepting low density situations.

As the simulation result of out-of-range forwards, the nodes easily manage the stale nodes using the ANM scheme.

This scheme can be applied to other geo-graphical routing protocols as well as both GPSR and GBSR in order to manage the out of radio range nodes. Packets are greedily forwarded to the detour nodes through the border superior graph in the recovery mode of the GBSR protocol.

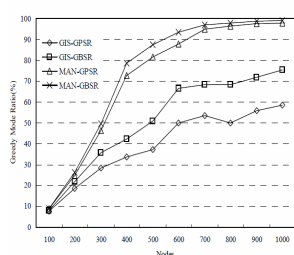


Fig. 8. The percentage of greedy mode

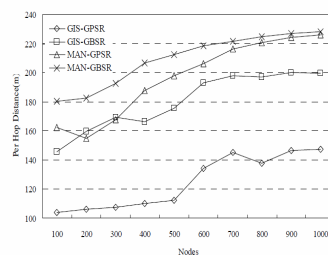


Fig. 9. The average hop distance

The GBSR protocol improved the routing performance by decreasing the number of hops for delivering packets from source nodes to destination nodes and increasing the average hop distance.

5. Conclusions

In this paper, we have presented an adaptive neighbor list management scheme along with greedy border superiority routing protocol. The adaptive neighbor list management scheme was easily treated without any additional information. The scheme distinguishes stale nodes among the nodes on the neighbor list in comparing the previous with current position of neighbors when a HELLO beacon is received. The GBSR protocol makes use of the border superior graph instead of the planar graph in the recovery mode. The graph of a node is a subset of the full local links to its neighbors, and only the links to road-end nodes in the boundary are remained on the graph. A packet in the local maximum can be greedily forwarded to next node with the graph. With GBSR, routing protocols could get a higher packet delivery ratio, lower delay, and larger hop distance as shown in the simulation results.

Reference

- [1] Vehicle Safety Communication Consortium Official Web-site.
- [2] B. Karp and H. T. Kung, "GPSR: Greedy Perimeter Stateless Routing for Wireless Networks," in *proc. ACM/IEEE MOBICOM'00*, Aug.2000. pp.243-254
- [3] C. Xing, C. Lu, R. Pless et al, "On Greedy Geographic Routing Algorithms in Sensing Covered Networks," in *proc. of ACM MOBIHOC'04*, May. 2004, pp.31-42
- [4] F. Kuhn, R. Wattenhofer, et al., "Asymptotically Optimal Geometric Mobile Ad-hoc Routing," in *proc. of the 6th ACM DIALM'02*, 2002, pp.24-33
- [5] Y.J. Kim, R. Govindan, B. Karp and S. Shenker, "Geographic Routing Made Practical," in *proc. of the 2nd NSDI'05*, 2005.
- [6] Y.J. Kim, R. Govindan, B. Karp and S. Shenker, "On the Pitfalls of Geographic Routing," in *proc. of the 3rd International Workshop on DIALM-POMC*, Sep. 2005. pp.34-43
- [7] Y.J. Kim, R. Govindan, B. Karp and S. Shenker, "Lazy Cross-Link Removal for Geographic Routing," in *proc. of the 4th International Conference on Embedded Networked Sensor Systems'06*, Oct. 2006
- [8] B. Leong, B. Liskov, R. Morris, "Geographic Routing without Planarization," in *proc. of the 3rd Symposium on Networked Systems Design & Implementation*, 2006, pp. 339-352
- [9] C. Lochert, M. Mauve, and H. Fubler, "Geographic Routing in City Scenarios," *Mobile Computing and Communications Review*, Vol.9 No. 1, 2004, pp.69-72.
- [10] K. C. Lee, J. Haerri, U. Lee, and M. Gerla, "Enhanced Perimeter Routing for Geographic Forwarding Protocols in Urban Vehicular Scenarios," in *proc. of Globecom Workshop'07*. Nov. 2007. pp.1-10
- [11] T. Camp, J. Boleng, and L. Wilcox, "Location Information Services in Mobile Ad Hoc Networks," in *proc. of the IEEE International Conference on Communications'02*, 2002, pp. 3318-3324
- [12] F. Kuhn, R. Wattenhofer, Y. Zhong, and A. Zollinger, "Geometric Ad-hoc Routing: of Theory and Practice," in *proc. of the 23rd ACM Symposium on Principles of*

- Distributed Computing '03*, Jul. 2003.
- [13] E. Kranakis, H. Singh, and J. Urrutia, "Compass Routing on Geometric Networks," in *proc. of the 11th Canadian Conference on Computational Geometry*, 1999, pp.51-54
- [14] G. Toussaint, "The Relative Neighborhood Graph of a Finite Planar Set," in *Pattern Recognition 12, Vol. 4*, pp.261-268, 1980.
- [15] K. R. Gabriel and R. R. Sokal, "A new Statistical Approach to Geographic Variation Analysis," in *Systematic Zoology, Vol.18*, pp.259-278, 1969.
- [16] The Network Simulator – ns-2, <http://nsnam.isi.edu/nsnam>
- [17] Generic Mobility Simulation Framework, <http://polar9.ethz.ch/gmsf/>
- [18] P. Sommer, "Design and Analysis of Realistic Mobility Models for Wireless Mesh Networks," *Master Thesis of ETH Zurich*, Sep. 2007. ame, and B. B. Name, Book Title, Place: Press, Year.