



An Efficient Void Handling Technique for Geographic Routing in MANET: A Survey

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Abstract—*Geographic routing uses location information to forward data packets, in a hop-by-hop routing fashion. Greedy forwarding is used to select next hop forwarder with the largest positive progress towards the destination. Communication voids are the most intolerable events that occurred at the time of transmission in Mobile adhoc Networks, where geographic greedy forwarding fails to move a packet further towards its destination, This article presents a survey on effectiveness of various void-handling techniques for geographic routing based on void problem to find an efficient void-handling technique for Geographic routing.*

Keywords— *MANET, GPSR, POR, Boundhole, PAGER-M, PSGR, BLR, TENT*

I. INTRODUCTION

MOBILE ad hoc networks (MANETs) have gained a great deal of attention because of its significant advantages brought about by multihop, infrastructure-less transmission. However, due to the error prone wireless channel and the dynamic network topology, reliable data delivery in MANETs, especially in challenging environments with high mobility remains an issue. Traditional topology-based MANET routing protocols (e.g., DSDV, AODV, DSR [1]) are quite susceptible to node mobility. One of the main reasons is due to the predetermination of an end-to-end route before data transmission. Owing to the constant and even faster changing network topology, it is very difficult to maintain a deterministic route. The discovery and recovery procedures are also time and energy consuming. Once the path breaks, the data packets will get lost or be delayed for a long time until the reconstruction of the route, causing transmission interruptions.

Geographic routing, which is often called position based, location-based, or directional routing, was originally proposed for packet radio networks in the early 80's [2, 3]. In recent years, with the rapid application of Global Positioning System (GPS) [4] and the progress on self configuring localization mechanisms [5, 6], it has regained significant attention, as it provides a promising solution for information delivery in next-generation wireless networks like Mobile Ad Hoc Networks (MANETs), Vehicular Ad Hoc Networks (VANETs), Wireless Sensor Networks (WSNs), and Wireless Mesh Networks (WMNs). Geographic routing exploits the geographic information instead of topological connectivity information to move data packets to gradually approach and eventually reach the intended destination. In most geographic routing protocols, only one-hop geographic information of neighbouring nodes is exploited. Thus, geographic routing does not require the establishment or maintenance of complete routes from sources to destinations [7]. The localized operation and the stateless feature of geographic routing make it simple and scalable. Geographic routing also enables a geocasting service, which supports the delivery of packets to all nodes in a specified geographic region [8].

Geographic routing mainly relies on an extremely simple geographic greedy-forwarding strategy at every hop to move a data packet to a locally optimal next-hop node with a positive progress towards the destination node. It is straightforward to show that it is very likely for a loop to form on the route, provided that a negative progress is allowed. However, greedy forwarding may not always be possible. For example, what if all the neighbouring nodes of a sender are farther away from the destination node than the sender itself? That is, a sender fails to locate a next-hop node in its neighbourhood which has a positive geographic progress towards the destination node. This undesirable phenomenon, called a communications void, is often also referred to as local maximum phenomenon [7].

Communications void [9] is a challenging problem for geographic routing and, in order to enable the use of geographic routing in next-generation wireless networks, this problem must be tackled. Although a dense deployment of wireless nodes can reduce the likelihood of the occurrence of a void in the network, it is still possible for some packets to encounter voids that are

induced by obstacles, unreliable nodes, the boundaries of a wireless network, and the like. These packets have to be discarded when only a single greedy-forwarding strategy is used, even though a topologically valid path to the destination node may still exist. Thus, it is imperative to design a void-handling technique for geographic routing in an effective and efficient manner.

Our contribution in this article is to survey the various void-handling techniques for geographic routing in Mobile adhoc networks. First we have stated out the problems in Geographic routing and Void handling. We have given a brief description about the various Void Handling Techniques then we have made a survey based on these void handling techniques depending upon various Geographic Routing Protocols.

II. BASIC CONCEPTS AND PROBLEM DESCRIPTION

Geographic routing [7] usually consists of two main elements: a location service and a geographic forwarding strategy. The location service is responsible for determining the position of the packet destination, before a packet can be sent from a source node. The position of the packet destination is then carried in the header of the packet so that intermediate hops can learn where the packet is destined for. Geographic forwarding operates in two modes: geographic greedy-forwarding mode and void-handling mode. In the greedy-forwarding mode, selection of a next-hop node for packet forwarding is made according to the positions of the current node, its neighbouring nodes, and the destination node. A node can determine its own position either by pre configuration if the node is stationary, or via a GPS receiver, or through localization algorithms. In Void handling mode the source node attempts to route the packet around the void because it is very likely that a topologically valid path from the source to the destination node exists.

The existence of communications voids is a serious problem and how to handle voids in an effective and efficient manner is an important technical challenge for any viable geographic routing protocol. Due to the unpredictable patterns of node deployment and the uncertain dynamics of time varying wireless network environments, it is impossible to predict when and where a void will occur. Without an appropriate void-handling technique in place, some data packets may get lost in the network, wasting precious network resources as well as disabling communications between some pairs of nodes in a wireless network. The simplest void-handling technique is flooding, initiated at a void node and executed afterward at all the nodes receiving the stuck packet for the first time. The technique will certainly enable the packet to reach the destination if at least a path exists. However, this technique is effective but inefficient in terms of resource utilization, because every other node in the network has to forward the packet once and the destination node may receive too many unnecessary copies of the same data packet from different paths. In addition, the first copy of the stuck packet arriving at the destination may not follow the optimal path from the void node to the destination [9]. Note that a void handling technique is invoked only when a data packet encounters a void and greedy forwarding fails at the void node. Once the stuck data packet overcomes the void or reaches a node that is closer to the destination than the void node, greedy forwarding is then reactivated for the packet.

III. VOID HANDLING TECHNIQUES BASED ON GEOGRAPHIC ROUTING

In this section we survey the five void-handling techniques. We present basic principles and inherent characteristics of these techniques, independent of other components of geographic routing as well as of any wireless network environment with specific network characteristics.

A. Planar-graph-based Void-Handling Technique

In graph theory, a planar graph is a graph that can be embedded in the plane so that no edges intersect. On an embedding of the planar graph, a simple planar graph traversal approach can be used to find a path towards the destination, based on the ancient idea of the right-hand rule, which states that it is possible to traverse every wall in a maze by keeping one's right hand against the wall while walking forward. In a wireless network, a set of nodes can be considered a unit disk graph in which the nodes are vertices and an edge exists between two vertices if their distance is less than r , where r is the radio range for a wireless node. Here, we assume that all nodes in the network have the uniform radio range of a disk of radius r . Theoretically, it has been shown that a planar-graph based technique guarantees packet delivery [10] because planar graph traversal ensures that a path is discovered if there does exist a topologically valid path.

The performance of a planar-graph-based void-handling technique depends not only on the performance of the planar graph traversal algorithm, but also on the performance of the distributed planarization algorithm. Perimeter Routing is one of the efficient planar graph-based void handling technique.

Perimeter Routing: Perimeter routing, as the complete void handling technique in the GPSR protocol [11], consists of a planar traversal algorithm, a distributed planarization algorithm, as well as some other protocol optimizations. In GPSR, a planar subgraph of the original graph is computed during a pre-processing phase using the RNG planarization technique or the GG planarization technique. When a packet gets stuck at a void node in greedy forwarding, perimeter routing is enabled and the planar traversal algorithm, similar to the Face2 routing, is used for the stuck packet to walk around the void. The header of a stuck packet usually carries information such as the position of the void node, the position of the last intersection that causes a face change, and the first edge traversed on the current face. Such information helps each node make all routing decisions locally. For example, this information makes a traversal algorithm terminate appropriately. As shown in Fig. 1, if the destination

D is not reachable from S , then the packet will loop around an interior or an exterior face of the planar graph. The information about the first edge traversed can be used to determine if a packet traverses the first edge on the current face for the second time. Perimeter routing is disabled if a node is encountered that is closer to the destination than the void node. Note that there is no guarantee that perimeter routing will find good-quality paths in the planar subgraph.

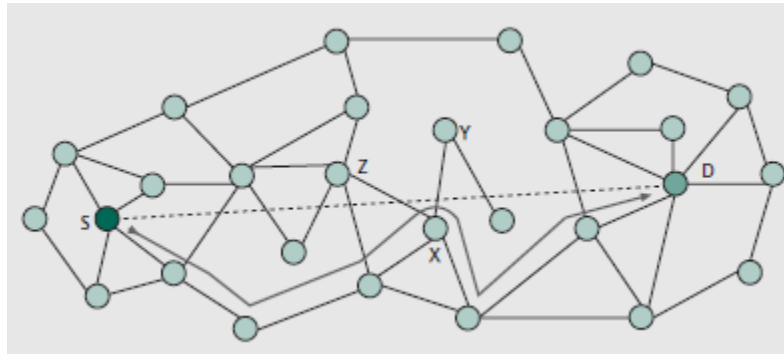


Fig. 1 Planar Traversal using Perimeter Routing

B. Geometric Void Handling Technique

The main principle behind techniques in this category is to identify holes in a network by making use of the geometric properties of deployed nodes. Depending on application requirements, these paths can be found on demand (i.e., only when a packet gets stuck at a void node), or they can be discovered in a pre-processing phase and stored locally along the boundaries of holes. In order to identify a hole around a void node, a node should first use a rule to detect if it can possibly be a void node. This task is implemented by the TENT rule [12]. Boundhole is the effective Geometric void handling technique.

Boundhole: The following description demonstrates how a geographic routing protocol can exploit hole-surrounding paths discovered by BOUNDHOLE [14] to handle voids. As shown in Fig. 2 from [12], when greedy forwarding is in use, a packet gets stuck at a void node p . According to the BOUNDHOLE algorithm, we know that p must be on the boundary of a hole. The boundary connects the void nodes and possibly some non-void nodes into a cycle bounding an area in a network topology. The void node then routes the packet along the boundary of the hole. When the packet reaches a node closer to the destination q than node p , the packet is greedily forwarded again. Fig. 2a shows an example where the destination is outside the hole. In this case, such a node which is closer to the destination q than node p must exist (e.g., node u). In fact, if we connect the line pq , it crosses the boundary of the hole at edge uv . Both u and v are closer to q than p itself. Thus, the packet will always get to the destination. Note that BOUNDHOLE tends to impose higher load on nodes near the hole boundaries. Also, in [14] the use of *restricted flooding* is proposed to handle voids in the case that the destination q lies within the hole, as shown in Fig. 2b, which will be presented in detail subsequently.

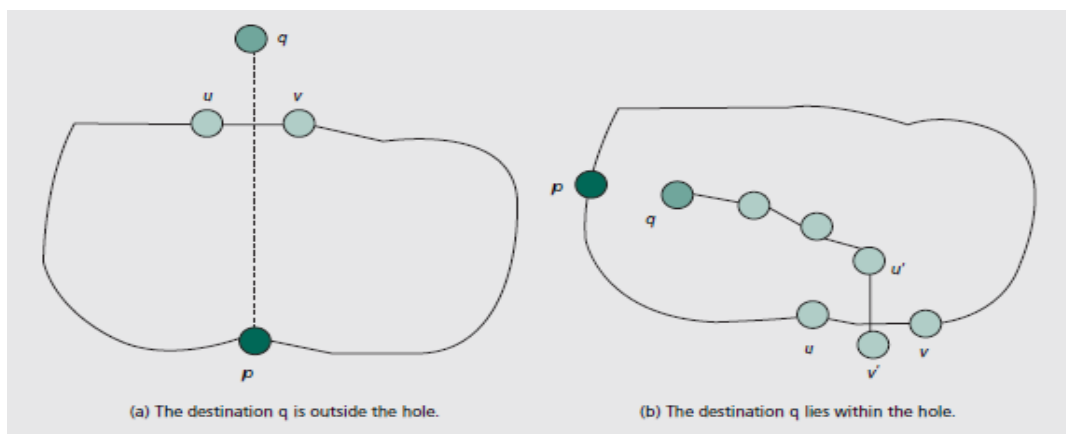


Fig. 2 BOUNDHOLE Technique

C. Flooding based Void Handling Technique

Void-handling techniques in this category exploit the simplest communications means in a network (i.e., flooding), to get a stuck data packet to get around a void. As we know, original flooding, in which every node in the network is supposed to receive a copy of stuck packets, is a simple and effective technique to handle voids. We call it as original flooding (full flooding). However, full flooding is inefficient in terms of resource utilization and they still cost too much while handling voids,

because only the destination node wishes to receive stuck packets from void nodes. Thus, some advanced flooding-based void-handling techniques are desired to efficiently handle voids. The main goal is to make every effort to control the range of flooding as well as the frequency of occurrence of flooding at void nodes to a desired extent, so that the flooding cost is minimized while effectively handling voids. Such a flooding mechanism is called restricted flooding or partial flooding [13]. One hop Flooding is the best Flooding based void handling technique.

One-Hop Flooding: One-hop flooding [14] is a kind of restricted flooding and it is used at a void node to broadcast the stuck packet only to its one-hop neighbouring nodes instead of flooding to every node in the network as full flooding does. After flooding the packet to all its neighbouring nodes, a void node remembers the stuck packet ID via an entry in its cache corresponding to a specific destination and refuses to accept the same packet from any of its neighbouring nodes. After accepting the stuck packet, every neighbouring node of the void node acts independently and exploits greedy forwarding to forward its own copy of the stuck packet. If any of neighbouring nodes has to select the void node from which the stuck packet originally came from in its greedy forwarding, the void node, upon the receipt of the packet, initiates a rejection packet back to acknowledge the neighbouring node, so that the neighbouring node will select the next best node from its own neighbouring nodes. If no appropriate node can be selected, the node becomes a new void node. One-hop flooding can again be executed at the new void node and the above process is repeated. Fig. 3 shows an example to illustrate how one-hop flooding handles a void. This similar idea can be further extended into an n -hop flooding technique where n is larger than or equal to two.

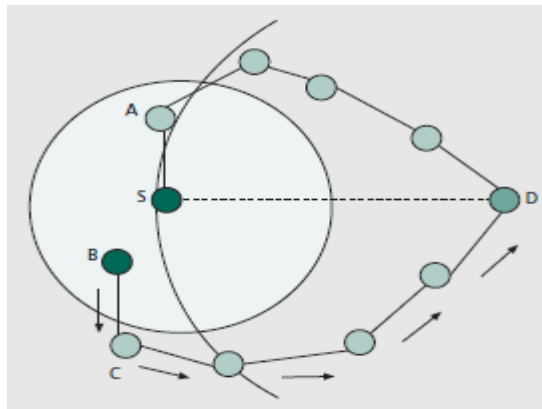


Fig. 3 One Hop Flooding Technique

D. Cost based Void Handling Technique

Void-handling techniques in this category exploit a cost based idea to handle voids. In cost-based void handling, a packet flows from a node with a higher cost to a node with a lower cost [15]. The definition of cost varies between different contexts. When designing a cost-based void-handling technique, each node in the network is first assigned a cost, which may be equal to its Euclidean distance to the destination. A packet is still forwarded greedily until it gets stuck at a void node, then cost-based forwarding is enabled. The void node increases its cost to a value larger than its Euclid distance to the destination, so that the packet can finally be directed by the high-cost-to-low-cost rule along efficient paths to get around the void. DUA is a Cost based void handling technique.

Distance Upgrading Algorithm: DUA, the basic cost based idea similar to cost-based forwarding in PAGER-M, is presented more formally in [16], which also investigated two possible problems caused by such cost-based void-handling idea. The first one is that DUA may produce inefficient routing paths. The second problem is that when a void disappears, the routing graph may need to be modified in order to make use of shorter paths. Routing paths processed by distance upgrading and downgrading algorithms beforehand may remain correct but not optimal in terms of shortest paths. Thus, the distance recovery algorithm proposed in [16] is required to dynamically adjust costs at some nodes, in response to network dynamics, to take advantage of optimal paths available in the network.

E. Heuristic Void Handling

Void-handling techniques in this category exploit some heuristics to handle voids. These techniques are based on some intuitive ideas that are non amenable to a strict theoretical analysis on their effectiveness and efficiency. The basic principle is either to utilize some extra resources or to directly exploit some inherent properties of network topology and some geographic properties of void areas. INF is a good example for Heuristic void handling technique.

Intermediate node Forwarding: Intermediate node forwarding (INF) [17] is a probabilistic solution for routing around voids via intermediate geographic locations. When a packet is stuck at a void node, the void node discards the packet and sends a notification to the source node of the packet. The source node of the packet then chooses a single intermediate position randomly for a circle around the midpoint of the line between the source node and the destination node. Packets have to traverse

that intermediate position. If the packet is discarded again, the radius of the circle is increased and another random position is chosen. This is repeated until the packets are delivered to the destination or until a predefined value has been reached and the source node assumes that the destination is unreachable. Fig. 4 from [17] demonstrates an example of INF. Source A is sending a packet to destination G and their midpoint is m. There exists a topologically valid path: A-B-C-D-E-F-G. The packet initially traverses AB and gets stuck at node C, because C is closer to G than D. C drops the packet and sends a NAK packet back to A. A then initiates INF with a radius of r_1 , with L_1 randomly chosen as the intermediate location. A new copy of the packet traverses AB, and this copy is again dropped at C because C is close enough to L_1 to switch the packet out of the INF mode, but still cannot locate a neighbouring node closer to G. A has to choose another new intermediate location L_2 from the disc with a radius of r_2 , another new copy of the packet can now pass through C to D, from which the packet is delivered to G via E and F using greedy forwarding.

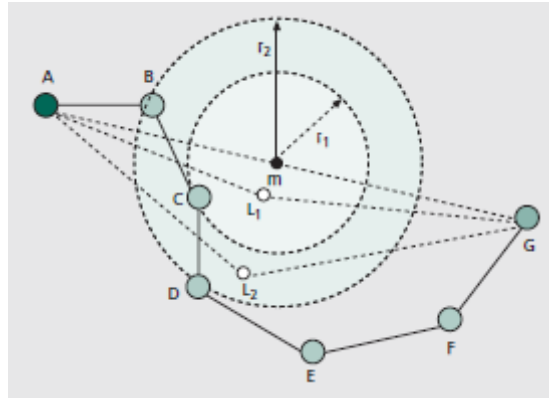


Fig. 4 Intermediate Node Forwarding

F. Virtual Destination based Void Handling Technique:

Virtual Destination based Void Handling Technique is a new concept proposed in [18]. In this method it first selects the Trigger node in which it is responsible for transmitting data in Void situations. To handle communication voids, almost all existing Mechanisms try to find a route around. During the void handling process, the advantage of greedy forwarding cannot be achieved as the path that is used to go around the hole is usually not optimal. More importantly, the robustness of multicast-style routing cannot be exploited. In order to enable opportunistic forwarding in void handling, which means even in dealing with voids, we can still transmit the packet in an opportunistic routing like fashion; virtual destination is introduced, as the temporary target that the packets are forwarded to. Flooding, a packet will always reach the destination. POR is the Effective and Efficient Virtual Destination based void handling technique.

Position based Opportunistic Routing: POR [19] is based on geographic routing, the only information exchanged is a node's location obtained via GPS-like equipment. When a source node wants to transmit a packet to the destination, it should get the location (x, y) of the destination through a location service. Here we assume that a location registration and look up service which maps node addresses to locations has already been available just as in. Position-based property makes POR robust and scalable. In POR first question is at which node should packet forwarding switch from greedy mode to void handling mode. In many existing geographic routing protocols, the mode change happens at the void node, e.g., Node B in Fig. 5. Then, Path 1 (A-B-E-__ _) and/or Path 2 (A-B-C-F-__ _) (in some cases, only Path 1 is available if Node C is outside Node B's transmission range) can be used to route around the communication hole. From Fig. 5 it is obvious that Path 3 (A-C-F-__ _) is better than Path 2. If the mode switch is done at Node A, Path 3 will be tried instead of Path 2 while Path 1 still gets the chance to be used. A message called void warning, which is actually the data packet returned from Node B to Node A with some flag set in the packet header, is introduced to trigger the void handling mode. As soon as the void warning is received, Node A (referred to as trigger node) will switch the packet delivery from greedy mode to void handling mode and re-choose better next hops to forward the packet. Of course, if the void node happens to be the source node, packet forwarding mode will be set as void handling at that node without other choice (i.e., in this case, the source node is the trigger node).

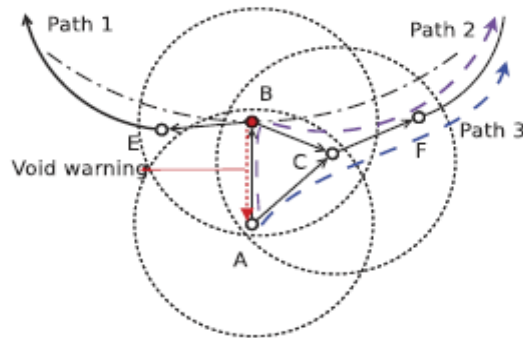


Fig. 5 Position based Opportunistic Routing

IV. COMPARATIVE SURVEY

Throughout this survey we have explained about various features of five most Void Handling Techniques in MANET. In this Comparative survey we compare these Void Handling techniques based upon some criteria's to evaluate the most efficient Void Handling Mechanism for Geographic Routing in Mobile adhoc networks. The Comparison is done based upon the works that was previously done in different articles to bring an effective conclusion. Table I shows the Comparison of various Void handling techniques based upon some important criteria's.

TABLE I
COMPARISON OF VOID HANDLING TECHNIQUES

	Optimal Path	States	Complexity	Scalability	Reliability
Perimeter Routing	No	Stateless	Medium	Yes	No
One hop Flooding	No	State Free	Low	No	No
BOUNDHOLE	No	Stateless	High	Yes	No
DUA	Yes	Stateless	Medium	Yes	Yes
INF	No	Stateless	Medium	No	No
POR	Yes	State Free	Low	Yes	Yes

Planar-graph-based techniques such as perimeter routing make unrealistic assumptions about radio ranges and neighbouring information makes it Unreliable and Stateless. In BOUNDHOLE, holes are discovered in advance for the future use of routing to avoid holes. However, in order to record the discovered path, it requires much greater resources such as memory storage compared to planar graph traversal, especially when holes have a very large boundary makes lack in forwarding data to nodes.

A key aspect of a one hop flooding-based void-handling technique is to minimize the flooding cost leads to Unreliability and Scalability. Thus, more efficient strategies for restricting the flooding range and rate while still being able to circumvent voids are needed. The DUA cost based void-handling techniques can handle a moderate number of void nodes with a limited number of destination nodes under a relatively static wireless network. Otherwise, network performance will get worse due to too much overhead incurred by cost adjustment and maintenance around void regions. INF only works with low density wireless networks make it unworthy when the Network size increases.

The Virtual Destination based Void Handling scheme serves well at the time of Communication void. In POR by the use of a strategy Virtual Destination that analyses the location of the Destination. If the Destination is nearby then it switches back to normal greedy forwarding mode from Void Handling mode. The realistic manner of data transfer at the time of Communication void made Virtual Destination based void handling scheme as one of the efficient techniques with highly reliable to data transmission in Mobile adhoc networks.

V. CONCLUSION

In this Survey we have examined various Void Handling Techniques for Mobile adhoc Networks. We have discussed about the strategies of these Void handling Techniques for Geographic Routing. The Comparative Survey about the Void Handling schemes states that each void handling technique has its own properties and techniques to void handling problem. Comparing all the void handling techniques Virtual Destination based void handling technique proves to be the efficient technique to deliver data at the time of Communication Void, due to its technique which it allows the node to change from void handling mode to

normal greedy forwarding mode when the data is near to its destination and provides a reliable data delivery in Mobile adhoc networks.

REFERENCES

- [1] J. Broch, D.A. Maltz, D.B. Johnson, Y.-C. Hu, and J. Jetcheva, "A Performance Comparison of Multi-Hop Wireless Ad Hoc Network Routing Protocols," Proc. ACM MobiCom, pp. 85-97, 1998.
- [2] H. Takagi and L. Kleinrock, "Optimal Transmission Ranges for Randomly Distributed Packet Radio Terminals," IEEE Trans. Commun., vol. 32, no. 3, 1984, pp. 246-57.
- [3] T. Hou and V. Li, "Transmission Range Control in Multihop Packet Radio Networks," IEEE Trans. Commun., vol. 34, no. 1, Jan. 1986, pp. 38-44.
- [4] P. Misra and P. Enge, Global Positioning System: Signals, Measurements, and Performance, Massachusetts: Ganga-Jamuna Press, 2001.
- [5] A. Savvides, C. Han, and M. B. Strivastava, "Dynamic Finegrained Localization in Ad-Hoc Networks of Sensors," Proc. ACM MobiCom 2001, Rome, Italy, July 2001.
- [6] N. Bulusu, J. Heidemann, and D. Estrin, "GPS-less Low Cost Outdoor Localization For Very Small Devices," IEEE Pers. Commun. Mag., vol. 7, no. 5, Oct. 2000, pp. 28-34.
- [7] M. Mauve, J. Widmer, and H. Hartenstein, "A Survey on Position- based Routing in Mobile Ad Hoc Networks," IEEE Network Mag., vol. 15, no. 6, Nov. 2001, pp. 30-39.
- [8] J. C. Navas and T. Imielinski, "Geographic Addressing and Routing," Proc. ACM MobiCom 1997, Sept. 1997.
- [9] D. Chen and P. Varshney, "A Survey of Void Handling Techniques for Geographic Routing in Wireless Networks," IEEE Comm. Surveys and Tutorials, vol. 9, no. 1, pp. 50-67, Jan.-Mar. 2007.
- [10] P. Bose et al., "Routing with Guaranteed Delivery in Ad Hoc Wireless Networks," Wireless Networks, vol. 7, no. 6, 2001, pp. 609-16.
- [11] B. Karp and H. T. Kung, "Greedy Perimeter Stateless Routing for Wireless Networks," Proc. ACM MobiCom 2000, Boston, MA, Aug. 2000.
- [12] Q. Fang, J. Gao, and L. J. Guibas, "Locating and Bypassing Routing Holes in Sensor Networks," Proc. IEEE INFOCOM 2004, Hong Kong, Mar. 2004.
- [13] H. Frey, "Scalable Geographic Routing Algorithms for Wireless Ad Hoc Networks," IEEE Network Mag., July/Aug. 2004, pp. 18-22.
- [14] I. Stojmenovic and X. Lin, "Loop-Free Hybrid Single- Path/Flooding Routing Algorithms with Guaranteed Delivery for Wireless Networks," IEEE Trans. Parallel and Distributed Systems, vol. 12, no. 10, Oct. 2001.
- [15] F. Ye, A. Chen, S. Lu, L. Zhang, "A Scalable Solution to Minimum Cost Forwarding in Large Sensor Networks," Proc. IEEE ICCCN 2001, 2001.
- [16] S. Chen, G. Fan, and J. Cui, "Avoid 'Void' in Geographic Routing for Data Aggregation in Sensor Networks," Int'l. J. Ad Hoc and Ubiquitous Computing (IJAHUC), special issue on Wireless Sensor Networks, vol. 2, no. 1, 2006.
- [17] D. S. J. De Couto and R. Morris, "Location Proxies and Intermediate Node Forwarding for Practical Geographic Forwarding," Technical report MIT-LCS-TR-824, MIT Laboratory for Computer Science, June 2001.
- [18] Shengbo Yang, Chai Kiat Yeo, and Bu Sung Lee, "Toward Reliable Data Delivery for Highly Dynamic Mobile Ad Hoc Networks", IEEE TRANSACTIONS ON MOBILE COMPUTING, VOL. 11, NO. 1, JANUARY 2012.
- [19] Shengbo Yang, Feng Zhong, Chai Kiat Yeo, Bu Sung Lee, "Position based Opportunistic Routing for Robust Data Delivery in MANETs".