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Efficient Localized Multihop Routing in Wireless Sensor Network

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Abstract
In the current years, wireless sensor network are increased rapidly in variety of fields. It comprises of many small sensors with low cost which are limited in capacity, data processing, cache and communication capabilities. Single-hop network with various transmission, choose a single node to help in the transmission between a source and a destination in geographical area. In this paper designing a multihop wireless sensor network protocols should be efficient and also scalable, using multiple hops improves the communication. Geographic greedy forwarding technique is a routing algorithm is known to be scalable but "local minimum phenomenon" situation is met. We propose an interesting new approach by using efficient localized multihop routing protocol and utilize the benefit of GF technique which ensures packet delivery. The simulation result shows that the proposed approach ensures proofs for its correctness and energy consumption.

Keywords
Localized multihop routing, local minimum problem, distributed algorithm

I. Introduction

To design protocols for multihop wireless networks major issue are efficiency and scalability [1] because wireless components use batteries and have limited computing capability while the number of such devices could be large which can achieve efficiency by carefully selecting the forwarding neighbours and high scalability by using only local information to make routing decisions. Localized means decision to choose an upcoming nodes which are carried out by each node inside the geographical area depends on local information. GF strategy [2] are efficient and scalable, all node must knows their geographic location by obtaining from localization phase [3],[4] and service location [5], begins after classification. This routing protocol not only sufficient for average case [6] but most favourable to worst case with the count of each hop and path will results in O (d^2) where d distances of the path where the process is simpler but does not take extra data externally but each node must know its neighbour but met with "local minimum problem" when node is closest to destination packet cannot deliver.

In this paper we focus on designing routing protocols for multihop wireless sensor networks. Numerous routing protocols [7] have been proposed recently using various techniques and our approach makes use of technique called geographic greedy forwarding. Localized geographic routing protocols [8], [9] have been proposed to improve the scalability. In these localized routing protocols, with the assumption of known position information, the routing decision is made at each node by using only local neighbourhood information.

Most of the proposed routing methods incorporate traditional routing metrics such as delay or hop count to reduce local minimum problem. It uses two approaches (a) graph based and (b)non-graph based. By using GF technique helps in delivering the packet and it is of local in nature and does not keep any memory and provides efficient routing path by better performance. To select the optimal energy route, those methods usually need the global information of the whole network for graph based approach; whereas non graph based approach uses long routing path without memory.

Two more efficient way without memory are bound hole [10] and GAR (Greedy Anti Void Routing) [11]. The first approaches uses sweeping line for selection of next node but forms a loop. It handle intersection situation but creates false boundary so it cannot deliver message. To solve this, brute force method is used which floods network. Routing overhead leads to degrade network performance. GAR operates by using rolling ball from stuck node. However GAR resolves false boundary but it selects unnecessary nodes.

Our contribution is using curved stick instead of sweeping line which resolves false boundaries by construction and by deriving efficient path than GAR protocol. CS guarantees it will not form loop and CS is used instead of rolling ball in GAR protocol which limits high number of entered nodes.

The rest of this paper is organized as follows. In Section II, we briefly review related work. In Section III, we model the network under study. In Section IV, we propose the CS approach which handles the intersection situation. In Section V, we conduct extensive simulations to proof its correctness. In Section VI, we conclude this paper.

II. Related Work

In several practical situations, every node in the network is not simultaneously concerned in all transmission; therefore, protocols are required to form groups or subsets of nodes for the purposes of cooperation. Greedy routing is simple and efficient but cannot guarantee the packet delivery. One natural improvement is to make use of greedy routing to recover the fails in local minimum. The latter type of algorithms is often referred to as localized algorithms. In contrast; localized algorithms can enable each network node to independently control its local topology by using its local neighbourhood information while keeping the connectivity of the network or connected with high probability. In general, localized algorithms have higher scalability than that using global information.

The geometric nature of the multihop wireless sensor networks as author [12] localized routing protocols. The most popular localized routing is greedy routing where the current node always finds the next relay node which is the nearest to the destination. Though greedy routing (or its variation) was widely used, it is easy to construct an example where greedy routing will not succeed to reach the destination but fall into a local minimum. Many routing protocols [13], [8], [9] used this approach, such as greedy face routing (GFG) [8].

Although proposed approach that exploits greedy routing [14] can guarantee the packet delivery on planar networks and some localized routing protocols can guarantee the delivery if certain geometry structures are used as the routing topology, none of them guarantees the ratio of the distance travelled by the packets over the minimum possible. Classical routing algorithm [15] may be adapted to take into account rather than classical metrics such as delay or hop distance.Melodia et al. [16] proposed a partial topology knowledge forwarding for sensor network, where each node selects the shortest energy-weighted path based on local knowledge of topology. Many geographic routing protocols have been proposed to address the routing hole problem occurring in MANETs [17] in general and in WSNs in particular. Most of these began with GF and recovered from local minimum problems through different strategies. Based on these strategies, previously completed work falls into two categories: (a) graph-based strategies and (b) non graph-based strategies.

Graph-based strategies: in these approaches, such as GPSR, GOAFR, GOAFR+ [6], Compass Routing II, etc., recovery from local minimum scenarios are performed by routing along the boundary of holes, according to a local planar graph. Planarization techniques such as Gabriel Graph (GG), the Relative Neighbourhood Graph (RNG), etc., are usually used to derive a planar graph from the Unit Disk Graph of the underlying network. A planar graph represents the same connectivity as the original network with non-crossing links. Moreover, all nodes maintain the planar graph all the time, this information is used only by a sub-set of nodes; i.e., those facing local minimum situations.

Non graph-based strategies: The basic idea is to localize nodes on hole boundaries and to then derive a detour path so to avoid routing in the direction of holes. Jia et al. presented HAIR (Hole Avoiding In advance Routing) protocol to bypass holes in advance. HAIR operates as follows: during the first step, nodes recognize themselves as nodes facing holes (i.e., local minimum nodes). They then, during the second step, direct their neighbours to mark them as hole nodes. Routing is then performed on non-hole nodes when possible. This process is then repeated, leading thus to larger hole perimeters. Taking advantage of earlier knowledge about hole positions, HAIR achieves shorter routing paths, and thus reduces energy consumption.

However it suffers from a serious drawback: GEAR (Geographic and Energy Aware Routing) protocol also works in two phases; in phase 1, energy aware next hop selection is performed when routing a packet toward the region of interest; in phase2 flooding or recursive geographical forwarding is used to disseminate the packet inside the region. A probabilistic approach, named INF (Intermediate Node Forwarding), is proposed for non Unit Disk Graph networks (i.e., non-uniform radio ranges). To overcome local minimum scenarios, Negative Acknowledgment packets (NAKs) have been proposed to provide feedback to the source node. Based on these NAKs, the sender selects randomly intermediate nodes that do not drop packets.

III. Network Model

In this paper, we study a multi-hop wireless network, which can be modelled by G (V, E), where V is the set of nodes and E is the set of links connecting the nodes in G. The set of nodes and links in G are accordingly represented by V (G) and E (G), respectively. A link (u, v) ∈ E (G) means node u and v can communicate with each other directly. Specifically, if $d(u, v) \leq R$, then a link exists between node u and node v, where d (u, v) represents the geometrical distance between u and v, and R represents the maximum uniform transmission range of nodes in the network.

It is assumed that all nodes are aware of its location information, which can be obtained via certain localization techniques or devices, for example, GPS receivers. Further, each node keeps the location information of all its one-hop neighbour nodes. Such location information can be obtained via exchanging of hello messages among one-hop neighbour nodes when the network is initially deployed. If nodes can move, periodical exchanging of such hello messages is needed. A routing protocol is said to be a localized protocol if the information of the source node s and the target node t and the k-hop neighbourhood information is known. The current node u can decide which neighbouring node is to forward the message. Here k is a constant, usually 1 or 2.

We consider a geographic wireless network in which all nodes are homogeneous and static with as their communication range. The locations of the set are known each node is aware of its location by means of a positioning system like GPS or as a result of the localization process [3],[4]. Nodes are also aware of their neighbouring nodes with the corresponding locations. We further assume that the location of the destination node is known by the source node. Thus, intermediate nodes can only know the location of the destination node by receiving the packet from the source node. Under these assumptions, when two nodes want to communicate, GF approach could be performed by each intermediate node based only on local information until the packet reaches the destination node or falls into the local minimum problem as mentioned before.

When the local minimum situation is met CS approach is used to get the packet out of the hole by traversing hole boundary nodes. Hence, the main issue is how to design a boundary traversal algorithm that ensures true boundary detection while at the same time deriving efficient communication paths in terms of the number of hops.The details of our proposal, we first introduce some definitions and clearly state the false boundary detection problem.

Definition1 (Hole): We define a hole as a cyclic sequence of nodes: so that the closed region bounded by this non self-intersecting polygonal sequence is empty of any node.

Definition2 (Boundary Node): We define a node as a boundary node if it is located on the boundary of the network or of a hole inside the network. Now we introduce the communication intersection situation which is behind the false boundary detection problem in Boundhole approach.

Our objective here is to develop an approach that handles by construction the intersection problem while it guarantees at the same time packet delivery and generates efficient routing paths.

IV. Proposed Approach

The main idea behind our proposed approach is to characterize well nodes responsible for intersection situations when hole/network boundaries are traversed so that these nodes will be directly selected by the previous hop node. Of course, the localized nature of the proposed approach must hold; i.e., no extra-information other than the information mentioned before is needed. To this end, we have not made use of a sweeping line which generates, as mentioned before, the intersection situation; but, we used a curved stick that selects nodes behind intersection situations.

1. CS Form

There is a need to determine the optimum form of this curved

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stick in order to select, on one hand, nodes only responsible for intersection situations; and, on the other hand, the question of whether or not this curved stick will "miss" intersection cases.

2. CS Routing Algorithm

Having proved that the proposed CS resolves the false boundary detection problem, we provide details below on the proposed CS routing algorithm. Three phases characterize our proposal: (a) engaging phase, (b) CS boundary traversal phase and (c) termination phase.

A. Engaging Phase

Likeotherapproaches,CSalgorithmisofagreedynature:the message between two communicatingno desisgeographically forwardedhopbyhopuntilitreachesthe destinationnode or falls into the local minimum situation problem. When the messagegetsstuck (i.e., itcannotbedelivered) thecurrenthop node, called the initiator node, starts applying CS boundary traversal rule.

B. CS Boundary Traversal Rule

ToapplyCSboundarytraversalrule,eachvisitednodeneed s the location of the initiator as an input from the previously visitedhopnode.Thenodecomputesthetwo distancese.g.,itsown distancetodestinationandtheonefrom theinitiatortodestination. Ifitisclosertothedestinationthan the initiator, this means that the message will get out of the local minimum problem. In this case, the current node starts applying GF policy. Otherwise, the message is still on the boundaryofaholeandCSrulehastobeapplied. Tothisend, thecurrentnodedeterminesitsStartingPoint(SP), fromwhichpointthecurvedstickissweptuntilanodeishit.

C. Termination Phase

For the termination of the algorithm, there are only two possible cases:

1. In the first case, the message is received by the destination. This means that there is at least one routing path between the source node and the destination node.
2. Inthesecondcase,themessagetravelsthewhole boundaryusing CS rule and returns back to the initiatornode. Initiator node informs the source node that the message could not be delivered.

Algorithm 1 summarizes the proposed routing algorithm.
Algorithm 1: CS Routing Algorithm.
Require: Receive message M from the previous hop

if (M.Initiator.ID = null) then
// GF policy is used
select the next hop based on GF;
if (Local minimum problem occurs) then
set M.initiator.ID to MyID
select the next hop based on CS rule
end if
else
if M.Initiator.ID =MyID then
compute: d ($N_{current}$, N_{dest}) and d (N_{init}, N_{dest})
if d ($N_{current}$, N_{dest}) < d (N_{init}, N_{dest}) then
// the message is out of the hole
set M.initiator.ID to null
select the next hop based on GF
else
select the next hop based on CS rule
end if
else
// the message travelled the whole boundary and returns to the initiator
sweep the curved stick
if a node is hit then
select the next hop based on CS rule
else
inform the source node that the message could not be delivered
end if
end if
end if
send the message

3. Hop Count Reduction:

In the previously provided description of CS routing algorithm,w ehaveconsideredonlyonedirectionofsweeping for the curved stick. Nevertheless, exploring the other sweeping direction (clockwise) could be in somecasesmoreeffectiveintermsofhopcount reduction. Toincludethisoptimizationin ourapproach,wehaveadoptedthefol lowingrule:eachtime the message falls into the local minimum problem, the initiator node "clones" it into two messages; the initiator node includes in each message the hop count and starts applying CSrule,oneineachdirection.

V. Simulation Results

1. Proof of correctness

In this section, the correctness of CS approach is proven. In order to guarantee packet delivery, we first prove that CS approach generates a finite sequence of links which means that the algorithm terminates. From this point, we secondly prove that CS is able to find at least one path connecting the source node to the destination node where such path exists. Conversely, if any path between the two communicating nodes does not exist, CS is able to detect and to notify the source node.

VI. Conclusion

We proposed localized routing protocol for wireless or ad hoc networks. Geographic routing approach that resolves the local minimum problem compared to the state-of-the-artapproaches. This makes our approach scalable and well suited for large distributed WSNs. We provided formal proof of its correctness (free of looping and data delivery guaranteed) and presented an optimized method for its implementation; taking into account the limited capabilities of sensor nodes. The simulation evaluation and comparison that we have conducted showsclearly theeffectiveness ofour approachin termsof deriving shorterpathsandthusreducingtheaverage end-to-enddelayaswellasthe overall energyconsumptionof the network in comparison to the state-of-the-art approaches. We have noted that the improvements are more noticeable in constrained networks; i.e., networks with many holes. In the near future, we plan to extend our work to 3D networks where GF remains very efficient.

Reference

[1] *K. Kar, M. Kodialam, T. Lakshman and L. Tassiulas, Routing for Network Capacity Maximization in Energy Constrained Ad-Hoc Networks, Proc. IEEE INFOCOM, 2003.*

[2] *R. Jain, A. Puri, and R. Sengupta, "Geographical routing using partial information for wireless ad hoc networks,"*

IEEE Pers. Com- mun. Mag., vol. 8, no. 1, pp. 48–57, Feb. 2001.

[3] J.Bahi, A. Makhoul, and A. Mostefaoui, "Localization and coverage for high density sensor networks, Comput. Commun" vol.31, no.4, pp. 770–781, 2008.

[4] A. Savvides and M. B. Strivastava, "Distributed fine-grained localization in ad-hoc networks," IEEE Trans. Mobile Comput, vol. 25, no. 1, pg. 146–155, Jan. 2003.

[5] J. Li, J. Jannotti, D. S. J. DeCouto, D. Karger, and R. Morris, "A scalable location service for geographic ad-hoc routing,"inProc.6th Ann. Int. Conf. Mobile Comput. Netw, 2000, pp. 120–130.

[6] F. Kuhn, R. Wattenhofer, and A. Zollinger, "Worst-case optimal and average-case efficient geometric ad-hoc routing," in Proc. 4th ACM Int. Symp.Mobile Ad Hoc Netw. Comput. (MobiHoc'03), 2003, pp. 267–278.

[7] T. Melodia, D. Pompili, and I. F. Akyildiz, "Optimal local topology knowledge for energy efficient geographical routing in sensor networks," in Proc. of IEEE INFOCOM, 2004.

[8] P. Bose, P. Morin, I. Stojmenovic, and J. Urrutia, "Routing with guaranteed delivery in ad hoc wireless networks," ACM/Kluwer Wireless Networks, vol. 7, no. 6, 2001.

[9] F. Kuhn, R. Wattenhofer, Y. Zhang, and A. Zollinger, "Geometric ad-hoc routing: of theory and practice," in Proc. of ACM PODC, 2003.

[10] Q. Fang, J. Gao, and L. Guibas, "Locating and bypassing routing holesinsensornetworks,"inProc.23rdAnn.JointConf. IEEEComput. Commun.Soc. (INFOCOM'04), vol. 4, pp. 2458–2468, 2004.

[11] W.-J. Liu and K.-T.Feng, "Greedy routing with anti-void traversal forwirelesssensornetworks, IEEETrans. MobileComput" vol.8, no. 7, pp. 910–922, July 2009.

[12] J.H. Chang and L. Tassiulas, energy conserving routing in wireless ad-hoc networks, Proc. IEEE INFOCOM, 2000.

[13] I. Stojmenovic and X. Lin, "Loop-free hybrid single-path/flooding routing algorithms with guaranteed delivery for wireless networks," IEEE Trans. on Parallel and Distributed Systems, vol. 12, no. 10, 2001.

[14] Q. Dong, S. Banerjee, M. Adler and A. Misra, Minimum energy reliable paths using unreliable wireless links, Proc. ACM Intl Symp .Mobile Ad Hoc Networking and Computing (MobiHoc), 2005.

[15] Q. Li, J. Aslam and D. Rus, Online power-aware routing in wireless ad-hoc networks, Proc. ACM Mobicom, 2001.

[16] T. Melodia, D. Pompili, and I. F. Akyildiz, "Optimal local topology knowledge for energy efficient geographical routing in sensor networks," in Proc. of IEEE INFOCOM, 2004.

[17] W. J. Liu and K. T. Feng, "Largest forwarding region routing protocol for mobile adhoc networks," in Proc. IEEE Global Commun. Conf. (GLOBECOM 06), 2006, pp. 1–5.