Home agent based location update and destination search schemes in ad hoc wireless networks

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Abstract

All previously proposed position based routing algorithms for wireless ad hoc networks were based on forwarding the actual message along multiple paths toward an area where destination is hopefully located (except our previous report [SV]). In [SV], we proposed to reduce significantly the communication overhead by changing the routing strategy. The source node issues several search 'tickets' (each ticket is a 'short' message containing sender's id and location, destination's best known location and time that location is reported, and constant amount of additional information) that will look for the exact position of destination node. When the first ticket arrives at the destination node *D*, *D* will report back to source with brief message containing its exact location, and possibly creating a route for the source. The source node then sends full data message ('long' message) toward exact location of destination.

In this paper, we propose to use a home agent based strategy for location updates and destination searches. Each node designates a certain circular area as its home agent, and informs other nodes about it. He subsequently sends its location update messages only to the nodes located in its home agent (in addition to local updates of its position). Destination search is then performed by sending a query toward its home agent, which will supply the latest available information about the position, and forward the request toward destination. We show through simulation that the proposed routing and location update schemes provide high success rates with reasonable communication overhead.

1. Introduction

The reader is referred to our previous technical report [SV] for an introduction and literature review. That report [SV] described a quorum based location update and destination search strategies. It also suggests to solve the routing problem in ad hoc network by dividing the problem into four components, as follows.

1) *Location update* messages are initiated by each node, which acts on its movement. Location updates are required by some other tasks as well (e.g. clustering, broadcasting, quality-of-service routing etc.).
2) *Destination search* messages, initiated by a source node, when it wants to route a message toward destination.
3) *Path creation* messages, initiated by destination upon receiving the first copy of a search message. The destination learns the location of sender from the search message and is able to find the best path accurately. Since the transmission speed is

far greater than node movement speed, the path creation phase in a localized routing may, to a large extent, be considered as the operation performed on a static network. Thus routing algorithms for static networks (with known location of destination), may be applied for the path creation phase. This assumption is justified since each node mountains the list of neighbors and learns the exact location of destination, which is the only information needed for making a routing decision at each node.

4) *Data traffic* messages, initiated by source upon receiving reply from destination containing its exact location, possibly together with the path toward destination. Alternatively, the source may attempt to create another path, knowing destination location accurately, by applying any localized routing algorithm defined on static networks.

In this routing scheme, we may also divide all messages into short and long ones. Short messages do not have the real information (to be forwarded to destination) as part of message (unless it is a very brief message, e.g. alarm), and therefore has much lesser number of bits than the message that contain the real information. Location update, destination search, and path creation messages are short messages. Location update messages are generated independently on routing request, as a preparation for successful destination search. Destination search and path creation messages are generated by routing requests. They are still a communication overhead. When the real message, containing data to be forwarded to destination, is long compared to first three kinds, this routing scheme is justified.

Note that, with this general routing scheme, the routing problem is divided into two components that may be investigated separately, as follows.

Component 1: *Location update and destination search schemes.*

Component 2: *Routing to a destination whose position is known* (includes path creation from destination to the source, and data traffic from source to destination).

Satisfactory localized solutions for path creation and data traffic phases are already proposed. Because of drawbacks of existing solutions for the location updates and destination search schemes, we shall concentrate on these two components in this paper. We shall propose new solutions for them in the next two sections.

The main difference between our proposed location update and destination search strategies and previously proposed analogous solutions (including non-GPS based route discoveries and route maintenance) is that full flooding was previously used as regular technique to construct the route, maintain the route or update the location in many cases. For example, when destination moves extensively but far way from the source, no solution other than full flooding was suggested. In [SV], we proposed to deal with such movement pattern by reducing full flooding to row and column paths of certain thickness. In this paper, we propose to use home agent circles instead.

2. Location update

The location update idea proposed in this paper is similar to the one used in cellular phone networks and mobile IP [P]. When a phone user moves away from his home server (agent) to a new place (e.g. new city), it send periodically the message from visitors location to home agent, giving its current coordinates. When a phone call is to that user, the call is first sent toward the user's home agent. Home agent then directs the call toward his visiting position. This idea is adapted for the use in case of mobile ad hoc or sensor networks.

The basic update procedure is performed by each moving node whenever it observes that, due to its movement, an existing edge will be broken (that is, the distance between two nodes becomes $>R$). The node will broadcast a message containing its new location information to all neighbors which are at distance tR. For $t=1$, the radius is same as the radius for transmitting data traffic. In this case, former neighboring node is assumed to have received new location information and will also record broken edge. However, nodes may adjust transmission power, and spend more energy for short messages. Lin and Liu [LL] discussed this difference and even proposed an extreme difference in radii for short and long messages. Nodes in [LL] are able to send their new location to all other nodes in network with a single broadcast (single-hop network for location updates). However, when sending exact data, the network is treated as multi-hop one. Note that the single-hop location update broadcast may fail to reach a number of nodes due to obstacles in the field. Next, those obstacles are not accounted for in the shortest weighted path QoS routing algorithm [CN]. Thus we believe that assuming single-hop network for location updates may not be justified, since it may require too much power from nodes to reach all other nodes (the transmission power is proportional to square, or higher degree, of the transmission radius). However, we still allow larger power for location updates, and may consider location update with radius tR, where t is network parameter. Spending larger power for update may be justified by better destination search efficiency. We thus assume a single broadcast at distance tR. Each node which is, at the moment of transmission, located inside that circle (of radius tR) is assumed to receive the new location accurately, without acknowledging the message. However, new neighbors will reply to node (using radius R), and other nodes within radius R will also learn updated position of that node.

Each node A will send similar location updates (at radius tR, where t could be same or different parameter) when it discovers new neighbors, according to the last information they have about location of that new neighbor. That new neighbor B will acknowledge with exact location information, if indeed neighbor, and will use R as the transmission radius. If B is not within distance R but within tR, it will respond, by adjusting transmission radius to exact distance, and other nodes within that transmission radius also hear that transmission. If B is not within tR, it will not respond, and A will adjust location information for that node to new position, at distance $(t+1)R$, in direction of old position (keeping old timing information, though).

The main location update is performed by each node as follows. At the beginning, each node informs every other node about its initial position, which will be its home agent. More precisely, home agent will consist of all nodes that are currently located inside a circle with radius pR, where p is network parameter, centered at the initial position of the node. Each node A uses a counter to count the number of previously made changes in edge existence (the number of created or broken edges). When the counter reaches a fixed threshold value *e*, node *A* sends a location update message to its home agent, using *GEDIR* algorithm. That is, node *A* and each intermediate node *B* will send the update message to one of the neighbors that is closest to the center *C* of home agent circle (using radius *R* for transmission). Each neighbor of current node *B* also hears the location update, and will update its information about both *A* and *B*. That is, each node, transmitting anything, will use the opportunity to broadcast its own new location as well. This message forwarding will stop at a node *B* in two cases. The transmission will stop if the selected neighbor at B is the one that sent message to *B* in the previous step. If current node B is inside home agent base, the condition will be stricter, and the message will be forwarded only if a neighbor closer to the center *C* (of home agent circle) than *B* is found. Let *B* be the node that stops the transmission (for one or another reason). Node *B* will transmit the location update message about *A* using transmission radius *pR* (that is, each node which is, at the moment, located at distance at most *pR* from *B* will receive the transmitted message).

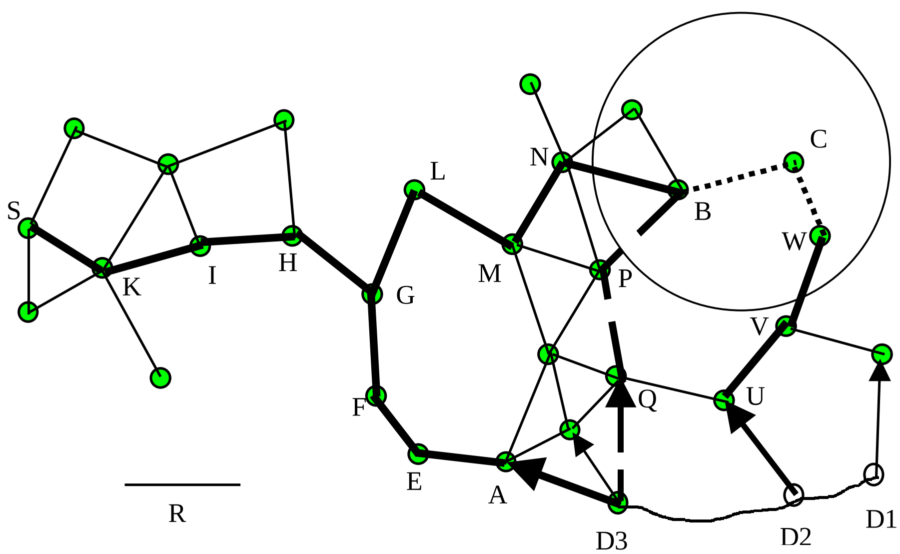

Figure 1. Location update from D2 and destination search from S

3. Destination search

Suppose now that source *S* wants to route a message to a destination *D*. Destination search messages will be issued, looking for *D. S* sends exactly two such messages. One is sent toward *D* using the location information about *D* currently available to *S*, applying *GEDIR* algorithm. More up to date location information will be taken on the way to destination (if any is available). The second message is sent toward the center *C* of home agent circle of *D*, which may be at completely different region than current position of *D* (applying again *GEDIR* algorithm). The search message will stop in the same way as the location update message, at a node *B*. Node *B* will then issue request for the destination location to all nodes located inside circle of radius *pR*, centered at *B*. *B* will also inform, in the same message, about the best location date collected on the way to it by that destination search message. All nodes inside the circle that have a better location information (more up to date) will reply. The experiment will simply count the number of such nodes, and allocate to each of them transmission radius *R* (not *pR*), in order to avoid collisions and preserve energy. In reality, message is send to a neighbor closest to *B*, which will choose best information from all its neighbors that reply, and forward it to even closer neighbor. Node *B* will then act on the basis of best information obtained, and redirect the message toward the location reported with that latest information, also applying *GEDIR* algorithm. Thus D may receive two search messages.

The location update and destination search schemes are illustrated in Figure 1. It shows an ad hoc network with radius *R* as indicated. Destination *D* is the only node that moves (for clarity), and let *D1*, *D2*, *D3* be its positions during the move. Upon every link change (making or braking), *D* informs its neighbors (indicated by arrow in Fig. 1). At position *D2,* it decides to inform its home agent, drawn as a circle in Fig. 1, about its current position. The location update message follows the path *D2-U-V-W* (indicated in bold line), and is broadcast from *W* to most nodes inside home agent circle (e.g. to nodes *B* and *C*, indicated by dotted lines). Suppose now that source *S* initiates destination search when destination is at position *D3.* The destination search message is forwarded toward the center of home agent circle, and follows path *S-K-I-H-G-L-M-N-B.* Node *B* then forwards the search message toward position *D2*, for which node *P* is the best neighbor (following a *GEDIR*-like method). On the path *B-P-Q-D3* (indicated as bold and 'long' dashed line), node *Q* has up to date location of *D* and destination is found. The destination *D* then initiates path creation phase following a *GEDIR*-like method and finds the source *S* using the path *D3-A-E-F-G-H-I-K-S* (indicated in bold lines). The source *S* may then send the data toward *D.*

4. Simulation and future work

The experiments will be done with presented version of location update and destination search procedures, but future work would include cases when all nodes move out of the home agent base, and such location update becomes inefficient. Possible repair techniques may include informing node *A* by any node *B* that stops transmitting without reaching home agent circle, and *A* acting upon certain number of such failures by choosing another home agent, and informing all nodes in the network about the change.

The parameters of simulation and experimental set up will be similar to the one described in [SV].The obtained data will be included in the paper after the experiments are completed.

The concept of internal nodes way be used to improve the performance of in destination search, location update and path creation phases, as described in [SV]. A variant of the method may choose to send location updates in a different way. Instead of counting the number of the number of link changes, node may act based on distance traveled since last location update, and act when this distance reaches *tR*, for some value of *t* (t=1, 2, 3, …).

Thus we believe that home based idea for routing in ad hoc networks has the potential to be very efficient, in terms of small hop counts, almost guaranteed delivery, and small communication overhead.

The full reference list is given in [SV].

References

[P] C. Perkins, IP Mobility Support, Network Working Group, Standards Track, October 1996.

[SV] Ivan Stojmenovic and Bosko Vukojevic, A routing strategy and quorum based location update scheme for ad hoc wireless networks, Computer science, SITE, University of Ottawa, TR-99-09, September 1999.