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Interoperable Geographic Forwading For Ad Hoc And Sensor Networks

S.V.Shajaini, P.Sinduja, S.Snehaa
III Year, CSE Department
Guide: Dr.P.Ezhumalai, Professor and Head
RMD Engineering College, Kavaraipettai, India

Abstract**—**In this paper, we propose a technique for forwarding the data packets among the nodes that are connected to the ad hoc network. The algorithm is designed in such a way the energy utilized by the battery-powered devices during data transmission can be minimized, so that the devices can stay alive for a longer period of time. This technique implements the concepts of geographic random forwarding and interoperability and cooperation. These techniques when used together, helps to save the energy of the battery powered devices. This also solves the problem of detection and isolation of uncooperative nodes. The key point of this algorithm is its simplicity. It also will guarantee easy portability and maximal compatibility.

Keywords*—Geographic forwading,interopability and cooperation,ad hoc networks, energy saving.*

I. INTRODUCTION

An ad-hoc network is a local area network (LAN) that is built spontaneously as devices connect. Instead of relying on a base station to coordinate the flow of messages to each node in the network, the individual network nodes forward packets to and from each other. In an ad hoc network all the devices have an equal status and are free to associate with any other device in the link state. The earliest wireless ad hoc network was the Packet Radio.

An ad hoc network is made up of multiple nodes connected together by a link. The network then allows any two nodes to communicate at a time through the link. In most of the cases nodes compete to obtain the access of the link to communicate which indeed leads to collision at times. Suitable algorithms are being designed to avoid the collisions that occur in the network. Also, the battery powered devices lose a lot of their energy while communication with the other nodes in the network. So, the sooner the battery gets over the sooner the device shuts down. Various algorithms are also being designed to overcome this problem. Many existing algorithms propose techniques to share the data between the nodes with minimal amount of energy consumption. This paper also focuses on overcoming this problem. Along with which the paper also focuses on achieving maximum compatibility. The geographic forwarding technique states that the contention arises at the receiver's side which is untraditional. Here, the sender node does not refer a relay node as its priori beforehand. Thus the intended recipient will not be known, and multiple nodes will receive the packet. Using the receiver contention scheme, single relay will be chosen to avoid the packet duplication.

A strategy of blocking the connectivity between the neighboring nodes and the sender node will enhance the previously mentioned strategy. The encapsulation of these two strategies will enable us to overcome to difficulties faced in the ad hoc sensor networks. A technique used to isolate the rogue nodes of a MANET can be used in wireless ad hoc network, in addition to geographic forwarding technique, to achieve greater optimality.

I. RELATED WORKS

An example of how topology can be maintained in the presence of sleeping nodes is provided by SPAN in, where the authors propose that, in a dense network, several disjoint sets of nodes be identified, each able to guarantee connectivity and bandwidth to all nodes. As long as one of these sets is active at any given time, the network is connected; on the other hand, since when one set is active.

STEM provides a way to establish communications in the presence of sleeping nodes. Each sleeping node wakes up periodically to listen. If a node wants to establish communications, it starts sending out beacons polling a specific user. Within a bounded time, the polled node will wake up and receive the poll, after which the two nodes are able to communicate. An interesting feature of STEM is that a dual radio setup is envisioned with separate frequencies used for wakeup and actual data transmission.

GAF is similar to SPAN in a sense since it envisions the use of only a fraction of the nodes at any given time. The specific approach of GAF is to divide the area in square regions, called grids, in such a way that any two nodes in neighbouring grids are within range of each other. With this provision, grids can be treated as equivalent (or virtual) nodes, in the sense that all nodes in the same grid can be interchangeably used for routing purposes. The price to pay for this guarantee is that the hop length is significantly smaller than the radio range which is the largest possible distance between two nodes in adjacent grids. This may result in inefficiency in terms of latency and energy consumption (more hops than possibly needed).

Studies where the relationship between transmit power and connectivity is explored, e.g., by evaluating how the radio range should be chosen or how many neighbours a node should have, can be found in. The effect of multihop operation and the related tradeoffs in terms of energy consumption are explored in. Ways to build minimum energy networks and the complexity of some associated algorithms are studied in. Other contributions on connectivity and power-efficient topologies include. As to MAC schemes, most papers in the literature assume either TDMA-based schemes or multichannel setups in which parallel transmissions can be performed without interference or variants of classic contention-based schemes, usually based on RTS/CTS handshake in order to mitigate the hidden terminal problem.

A number of recent papers also propose specific energy efficient routing schemes for sensor networks. The authors of propose LEACH, which is a cluster-based routing protocol in which the role of cluster head is rotated among the sensor nodes to avoid stressing only some of them. An improvement of LEACH, called PEGASIS, which is chain-based and provides near optimum energy and delay performance is proposed in. Similarly, energy aware routing avoids using the lowest-energy routing paths consistently, as this may lead to energy depletion of nodes in key locations; instead, it allows the use of suboptimal paths. Routing is coupled with a thresholding mechanism in where transmissions are inhibited when the sensed attribute is not significant or not significantly different from what sensed/transmitted in the past, thereby reducing the transmission/relaying activity of nodes.

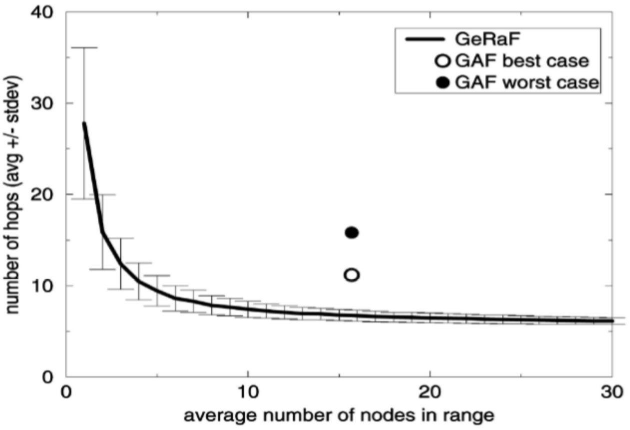
A routing scheme which minimizes the control traffic in the network is proposed in. Traffic shaping to make the network load more uniform, thereby improving the energy utilization of the nodes in the network, is proposed in. An algorithm based on constrained shortest paths, which tries to minimize energy consumption while retaining good end-to-end performance. Some authors introduce the maximum flow-life curve as the routing objective and propose a new routing scheme based on this concept. Techniques to improve packet forwarding in sensor networks (using minimum cost paths) (using multicast trees). The authors propose modifying the sensor node layering architecture so that forwarding decisions can be made by the hardware, thereby greatly improving the energy (and latency) performance of the overall system. Routing protocols based on geographic information have been considered in the past. GPSR is a scalable greedy algorithm with the ability to go around low-density network regions.

GEAR also uses geographic information to deliver packets to a certain service region (rather than to a specific node). Other protocols, which make use of geographic information to improve efficiency, include LAR and DREAM. A common characteristic of the above schemes is that, at the MAC layer and often also at the routing layer, when a node decides to transmit a packet (as the originator or a relay) it specifies the MAC address of the neighbour to which the packet is being sent. (Notable exceptions are Gradient Broadcast and Gradient Routing.) Knowledge of the network topology (though in many cases only local in extent) is required since a node needs to know its neighbours and possibly some more information related to the availability of routes to the intended destination.

This topological information can be acquired at the price of some signalling traffic and becomes more and more difficult to maintain in the presence of network dynamics (e.g., nodes which move or turn off without coordination).

III.GEOGRAPHIC RANDOM FORWARDING: BASIC IDEA

We assume that each node has some knowledge of its own position and of the position of the sink node .While this is certainly a crude model for propagation, it is assumed here .As a first step toward understanding fundamental behaviours. Extension to more realistic models, e.g., including Rayleigh fading is being studied.



The basic idea is the following: Once a node has a packet to send, it sends it using some type of broadcast address while specifying its own location and the location of the intended destination. All active (listening) nodes in the coverage area will receive this packet and will assess their own priority in trying to act as a relay, based on how close they are to the destination.

The message can be the full packet or an RTS message if a collision avoidance mechanism is used. As a first step, suppose a mechanism is in place to make sure that the relaying node is, in fact, the one closest to the destination. The MAC/routing scheme then continues similarly. The relayed packet is, in turn, sent to a broadcast address and contains the locations of the transmitter and of the final destination, thereby providing a means to geographically route it without any routing tables or topological information If the density of active nodes is appropriate, it is likely that the node closest to the destination will be almost the best possible.

Notice also that the fact that we do not address a specific node allows us to use one of the first available nodes within the coverage area, as opposed to STEM, in which we have to wait for a specific node to wake up. The rate at which any of N nodes wakes up is N times that of each single node and, therefore, we can maintain similar network connectivity while saving more energy if we increase N and decrease the rate by keeping their product constant. However, a major weakness GAF’s approach is precisely the requirement that this routing feature be guaranteed, which forces hops to cover less than half the distance allowed by the radio range.

IV.MULTIHOP ANALYSIS

Consider the following simple scenario: A source wants to deliver a packet to a destination in the absence of cross traffic (which corresponds to the case in which the network is mostly monitoring, and occasionally a message is generated). Nodes are randomly placed in the region according to a Poisson process with density. This model is adequate in situations in which nodes are randomly deployed and is also appropriate for a first evaluation of the performance of our scheme. Due to the use of sleep nodes, each node is available as a relay with probability d. Let the radio range be normalized to 1 and let D be the distance between the source and the destination. Finally, there occurs the average number of available relays in the coverage area. We initially assume an ideal operation whereby the neighbor closest to the destination is selected as the relaying node unless the destination itself is within range, in which case the packet is directly delivered. We are interested in computing the number n of hops necessary to reach the destination as a function of the distance D and of the density of active nodes. For which we set up a simple simulation to evaluate the number of hops which are necessary to reach the destination. We assume first that the transmit node is at distance D from the final destination.

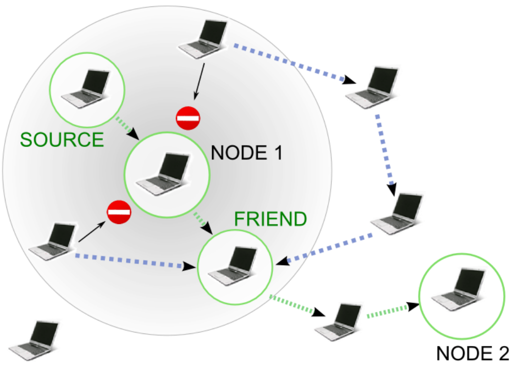
We randomly position a Poisson distributed number of relays in the coverage area and, among them, we select the one that is closest to the destination, which, in turn, becomes the transmit node for the next hop. This step is repeated until a relay within range of the destination is reached from which a single hop is needed. . If it happens that there are no nodes in range which are closer to the destination than the transmit node, one hop is counted, but the position of the transmit node is not updated. This corresponds to the fact that, if no relays are present to provide advancement toward the destination, a transmit node would try again and, in the next attempt, the set of possible relays is independently generated so that, with probability one, the packet arrives to the destination in a finite amount of time. The behavior is observed where simulation results for the average number of hops are plotted against the node density, expressed in terms of the average number of active neighbors. The expected behavior is observed. Interestingly, the results for different distances scale proportionally to the distance itself. While this is intuitive, the fact that the scaling is almost exactly proportional was not entirely obvious.

In GAF, which is the only other scheme with which we can compare directly, the area is divided into square grids. If we consider all nodes in a grid as a single equivalent node located at its center, each hop corresponds to a distance of exactly r. This distance is not necessarily the advancement toward the destination as this depends on the relative orientation of the source destination direction and the grid layout. In the best case (they are parallel), one hop leads to an advancement of r units toward the destination, whereas, in the worst case (they form a 45o angle), the one hop advancement r is three times shorter than allowed by the radio range. Regarding active node density, GAF requires that at least one node be present in each grid, which corresponds to an average node density of at least one in each 1=5 square unit area. This will increase the overall energy consumption. For which we can deliver packets in much fewer hops which is an effect of GAF's underutilization of radio coverage or, equivalently, for a given number of hops to the destination (which corresponds to latency, as well as transmission energy used to deliver a packet), we need much fewer nodes within range and this corresponds to a reduced duty cycle given the same density of physical nodes. Note that the points corresponding to GAF do not take into account details such as synchronization and coordination issues among nodes and the possibility of some grids being empty and, therefore, are be seen as somewhat optimistic estimates of GAF's performance. The curves for GeRaF are themselves idealized, but, as shown later, a practical scheme would almost itself.

V.THE LET AND LIVE STRATEGY

A. Minimal active neighbor topology calculation

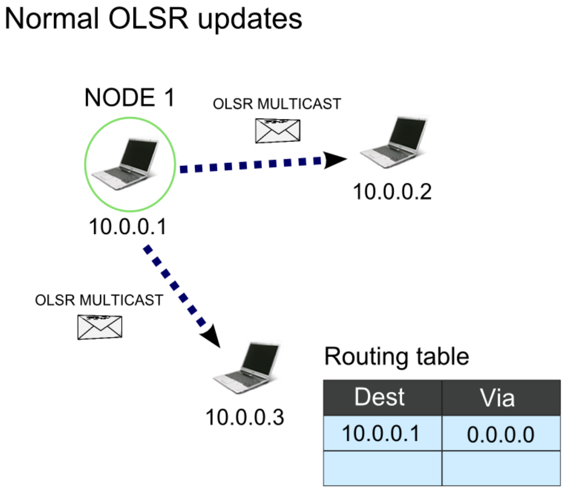
The general idea is that no node in any network really wants to forward the data of other nodes at its own expenses. If every element would treat others this way, the network would not work. On the other hand, every node needs to communicate. That is why it became part of the network. Our minimal active neighbor topology algorithm reduces the number of communication links between the nodes while keeping them all connected and being able to communicate with each other. The first step is to find the best next-hop for forwarding the local node's data (e.g. best next hop to the gateway). Then the direct connectivity to all other one-hop neighbors is temporarily terminated. After the changes in topology propagate, the local node checks if its one-hop neighbors are reachable thru the only enabled node, the best next hop. If not, one of the original neighbors is randomly chosen and enabled. The check for accessibility of other nodes is performed again. If they have any other way to access the network except of the local node, the local node will be able to hear of them thru one of the enabled nodes in their routing updates. This algorithm continues until all of the original nodes are accessible again. In every iteration the nodes that become reachable as a result of the actions during that iteration are deleted from the list of nodes that need to be checked. Algorithm is rerun whenever a topology change is detected. Topology changes are propagated extremely fast thanks to the OLSR MPR concept. The minimal neighbor topology calculation is only applicable for battery powered mobile devices. Other nodes with no power saving concern act as "center of topology", ideally a next-hop node for several mobile devices. Such approach creates a topology in which every battery powered device minimizes its number of connections and traffic load, but also acts as an entry point for all other nodes that have no other means of connecting to the network, keeping the network operational.



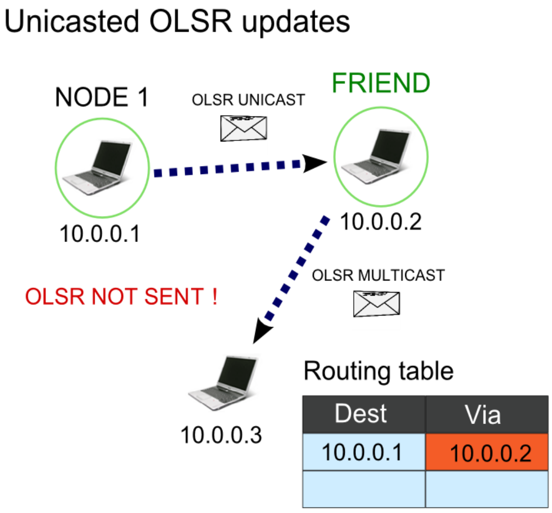
An example MANET topology. Node 1 has chosen the next hop (FRIEND) for delivering the traffic to its destination (Node 2). Two other nodes that are in the range are blocked as there is an alternate route to the network for their traffic. All nodes keep connectivity to each other.

B. Unicasting Multicasts and ARP filtering

To minimize the number of connections, the combination of ARP filtering and unicasting of the originally multicast OLSR update messages is used, so that the nodes are visible only to the nodes they want to be visible to and want to create links with them. By using this approach a logical topology inside the physical topology is created. Despite the fact that the nodes have mutual Layer 1 connectivity (e.g. they are in range of each other wireless adapter) they won't know of each other as of a direct neighbor unless the Minimal active neighbor topology calculation doesn't indicate otherwise.



OLSR updates as they are normally propagated to all nodes in range.



OLSR updates unicast to chosen locations. Excluded nodes do not recognize NODE 1 as a neighbor node, even though it is in their range.

C. Neighbor forwarding traffic sensing mechanism

There are cases when technology is not used exactly like how it was supposed to be used. In an MANET network, there might be nodes unwilling to participate on common interest, which is reliable network with end-to-end connectivity for all elements. These uncooperative nodes would accept the traffic destined to them, but not forward and drop other traffic in order to conserve their battery. To prevent these rogue nodes from exploiting the network, each node (node A) checks its neighbor whose data it is going to forward (node B) by simulating another node (node C). That node then tries to connect to node whose data the local node is forwarding /A is simulating node C that wants to connect to node B/. Because node A is the only possibility for node B to send its data to the network, node A has to be able to hear node C fake data. This can be done by generating fake traffic (node C traffic) with different source MAC and IP address than the original interface. To make this check mechanism even more realistic and harder to detect, the interface can be temporarily configured with different L1 parameters as for example signal strength. This would effectively avoid possible recognition that node A and node C are the same nodes. If node B fails in any stage of this check, node A simply does not forward node's B traffic because there is a reason to believe node B is a rogue node. Another possible scenario is that the attacker would become the OLSR MPR and would drop other nodes traffic. To avoid that, it is needed that each node monitors its neighbors and finds out how cooperative they are by seeing its own traffic being forwarded by the neighbor by listening for packets with the source MAC address of the forwarding next-hop, and the original source and destination IP addresses and/or other packet identifiers as packet length etc. At this stage of algorithm, the topology is already minimized and most of the traffic is forwarded through the one chosen next-hop node. That fact makes the monitoring process much easier. Uncooperative nodes should be blocked and not included in further topology calculations.

VI.DISCUSSION AND PRACTICAL CONSIDERATIONS

So far, we have not discussed how a practical protocol based on this concept can be implemented and how it performs in terms of delay and energy consumption. Also, the impact of imperfect location information, MAC details, localization overheads, node failure, has not been addressed. The main focus of this paper is, in fact, on the basic concept and on the multi hop performance. In this section, we briefly address a number of issues which are related to the practical implementation of a protocol based on this idea, as well as other issues which may arise in a practical scenario. For a more complete description of the protocol and of its energy-latency performance, we refer the reader to. The mechanism proposed in is based on collision avoidance. Since sleep modes make it hard to use RTS/CTS handshakes effectively, the use of a busy tone was considered. Each node has two radios operating on different frequencies. One is used for data exchange, the other to issue busy tones while a node is receiving. When a node wants to send a message, it issues an RTS on a broadcast MAC address. This RTS explicitly contains the location of the transmitter and of the final destination for the message. Nodes who can hear this message will contend to be its relays according to their own location toward the destination. Note, in fact, that, based on the location information for the transmitter and for the final destination and based on the node’s knowledge of its own position, the determination of the priority region is a simple geometric calculation. Based on their own priority, potential relays will respond to the RTS with CTS messages. In the first CTS slot after the RTS, all relays in A1 will respond. If no CTSs are sent (i.e., A1 is empty), in the next CTS slot all relays in A2 send a CTS, etc. When a single CTS is received, the contention phase ends. If multiple CTSs are received, the nodes involved follow a collision resolution algorithm (any of the many existing algorithms can be used). If no relays are present, the transmitting node will retry and, in this case, due to the dynamics of the sleep modes, a different set of potential relays will be available. This mechanism is guaranteed to have a single winner. Once the contention phase is completed, the winner will relay the message by using the same mechanism.

VII.Advantages

This is a theoretical paper which discusses about an idea that can be used to achieve optimal solution out of ad hoc sensor networks. Based on the analysis of the theories the following are the advantages of this technique. This technique is mainly designed to achieve less power consumption by the devices to achieve high performance rate. This technique also provides a way to isolate the rogue node, which in turn helps in achieving high performance rate. The technique discussed in this paper is the amalgamation of two different techniques that have been proposed for the same cause, in the field of ad hoc sensor network. The two techniques exist separately as in case and serve the cause. The paper discussed here, provides a way to combine both of these techniques to achieve a higher optimality.

VIII. CONCLUSIONS AND FUTURE WORK

In this paper, we have described a novel forwarding technique based on geographical location of the nodes involved and random selection of the relaying node via contention among receivers. We first focused on the multi hop performance of such a solution in terms of average number of hops to reach a destination as a function of the distance and of the average number of available neighbors. The presented solution is a simple MANET implementation based on the popular Optimized Link State Routing Protocol which is enhanced in a way that it can provide a fair-use environment for the network users without rogue nodes and optimizes the topology so that the traffic directed thru battery driven nodes is minimized. An idealized scheme (in which the best relay node is always chosen) was discussed and its performance was evaluated by means of both simulation and analytical techniques. First practical tests with promising results were done during the MANIAC Challenge 2007, which finally led to the winning of the Strategy Award. Simulations and practical measurements are planned for the near future.

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