ISSN : 0976-8491 (Online) | ISSN : 2229-4333 (Print)

Broadcasting through UDG in Manets by GPS Assistance

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Abstract

Ad-hoc Networks are useful in many Application Environments and donot need any infrastructure support. Collaborative computing and communication in smaller areas can be setup by using Ad-hoc networking technologies. Broadcast protocols play an important role in building wireless multihopAdhoc networks. Because of high mobility in the network, rapid topological changes occurs, message passing in between the network occurs collision, so to avoid collision and maximum utilization of bandwidth we are using crosslayer interaction. Some parameters (eg: radio propagation,hostileinterference ,traffic demandsetc) may dynamically change ,the protocol must be adaptively tuned. so, proper tuning requires exchange of information across layers, and protocol uses the unit disk graph model with FDMA And TDMA mechanisms.

Keywords

Ad-hoc Networks, Multiple Access Schemes, Unit Disk Graph (UDG).

I. Introduction

A Mobile Ad-hoc Network (MANET) is a self-configuring network of mobile devices (nodes) connected by wireless links. In such networks, each node has a limited transmission range, so that a message sent from a node can be received by all nodes within its transmission range. Two nodes that are not directly connected to each other can communicate by using one or more intermediate nodes as relay nodes (Multihop). Each node in a MANET can move independently in any direction, and as a result, communication links can change frequently in these networks. Broadcast is a fundamental operation in multihop, mobile, wireless ad hoc networks as it enables a source node to efficiently sends a message to all other nodes in the network. A large number of network protocols, services and applications depend on an underlying broadcast operation to work correctly. Examples include updating routing tables, disseminating sensor network commands, and disseminating emergency messages The problem of eliminating redundant broadcasts can be solved by using algorithmic approach is to determine a small subnet of nodes for broadcasting data such that every node in the network receives it. This subset is called the forwarding set. This problem is equivalent to finding a Minimum Connected Dominating Set (MCDS). In a Dominating Set (DS) a node is either designated as a dominator or is a neighbor of at least one dominator node. A Connected Domininating Set (CDS) is a DS such that the sub graph formed by considering only dominator nodes (and edges among them is connected). MCDS is a CDS of the smallest size

A. Broadcasting in MANETs is complicated by three important issues

1. Because wireless transmission is by nature broadcast based, there is the issue of interference in the wireless medium. When two or more nodes transmit a message to a common neighbor at the same time, the common node cannot receive any of these messages, because the wireless signals from the two sender nodes collide at the receiver node.

2. Due to the dynamic nature of MANETs where nodes may move at any time, there is no well-established infrastructure. As a result, maintaining routing tables is a major challenge.

3. Resources are relatively scarce in MANET. In particular, nodes have limited battery life and bandwidth is limited. Message transmissions consume both power and bandwidth. Hence, it is important to design broadcast algorithms that minimize overall power consumption and number of message exchanges.

There are four important criteria based on which a broadcast algorithm is evaluated:

(i). End-to-end latencyis

The time interval between the time when the source sends out a message and the time when the last node in the network receives the message. Naturally, it is desirable to have low end-to-end latency.

(ii). Coverage

Is the percentage of nodes in the network that successfully receive a broadcast message. While the goal is to get 100% coverage, it becomes to difficult due to node movements and collisions.

(iii). Power consumption

is the overall energy consumed by a broadcast. Past research has shown that message transmissions result in maximum power consumption. Thus, the number of messages exchanged must be minimized to reduce overall power consumption.

(iv). Finally

The ability to cope with dramatic changes in the network measures the variation in end-to-end latency, coverage and power consumption in the presence of different rates and frequency of node movement.

We describe the design, implementation and an extensive evaluation of a new broadcast protocol for MANETs. The protocol uses the unit disk graph model and a clever combination of FDMA and TDMA to provide significantly better performance than the currently existing broadcast protocols. In particular, this protocol provides lower end-to-end delivery latency and higher coverage than the existing protocols. It requires relatively small number of message exchanges, minimizes collisions, and tolerates quite well any dramatic changes in the network due to node movement.

(a). CDMA

Code Division Multiple Access is based on "spread" spectrum technology. Since it is suitable for encrypted transmissions, it has long been used for military purposes. CDMA increases spectrum capacity by allowing all users to occupy all channels at the same time. Transmissions are spread over the whole radio band, and each voice or data call are assigned a unique code to differentiate from the other calls carried over the same spectrum. CDMA allows for a "soft hand-off", which means that terminals can communicate with several base stations at the same time.

(b). FDMA

Frequency Division Multiple Access (FDMA) is the most common analog system. It is a technique whereby spectrum is divided up into frequencies and then assigned to users. With FDMA, only one subscriber at any given time is assigned to a channel. The channel therefore is closed to other conversations until the initial call is finished, or until it is handed-off to a different channel. A "full-duplex" FDMA transmission requires two channels, one for transmitting and the other for receiving. FDMA has been used for first generation analog systems.

(c). TDMA

Time Division Multiple Access (TDMA) improves spectrum capacity by splitting each frequency into time slots. TDMA allows each user to access the entire radio frequency channel for the short period of a call. Other users share this same frequency channel at different time slots. The base station continually switches from user to user on the channel. TDMA is the dominant technology for the second generation mobile cellular networks.

II. Related Work

Williams and Camp classified broadcasting protocols by various properties such as node densities, mobility, and traffic rates, and broadly defined them into four categories: simple flooding, probability-based methods, area-based methods, and neighbor knowledge methods. Our protocol is a combination of area-based and neighbor knowledge methods.An important issue that should be addressed in wireless ad hoc networks is the problem of interference and conflicts, e.g., when the same broadcast message from two different nodes collides due to simultaneous transmissions. Our protocol also avoids collisions, but uses positional information to schedule broadcasts.We describe our broadcasting algorithm which employs a subset of nodes to forward the message. The selected forwarding nodes would construct a dominating set on the networks graph and cover all nodes. In order to construct the dominating set, we use a hexagonal tessellation of the entire grid (terrain). The size of each hexagon is proportional to the transmission range of a node. For simplicity, we assume that the transmission range of all nodes is same. Also, we use the unit disk graph (UDG) model to derive the network graph. This means that two nodes are connected to each other if a disk with a radius equal to the transmission range around one of the nodes would cover the other as well. In a hexagonal tessellation, the plain is covered with non-overlapping hexagons of equal size. We say that a node j belongs to a hexagon i if it is either inside that hexagon or on its boundaries, and we show this relationship with j £ i. In this manner, each hexagon would have six other hexagons as its neighbors. We denote this set of neighboring hexagons for hexagon i with H(i).We compute the size of each hexagon in such a way that a node placed inside or on the boundary of hexagon i would cover all nodes inside or on the boundaries of H(i).

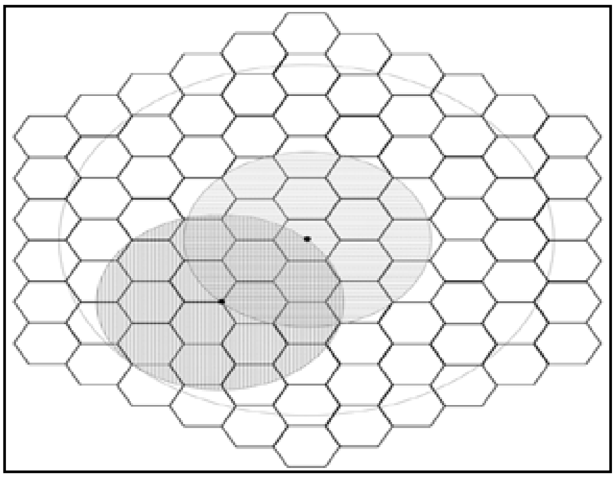

Fig. 1:

Transmission from two nodes can collide if the two nodes transmit at same time and distance between them is less than or equal to twice the transmission range. In other words, a collision occurs when two nodes are two hop neighbors and they are transmitting at the same time.

If we color the hexagons so that all the hexagons covered by a disk of radius 2* transmission range are assigned different colors, we have a collision free broadcasting if the message is transmitted by a single node from every non-empty hexagon at a timeslot which corresponds to the color assigned to that hexagon. This way we obtain our goal of minimizing the number of transmission collisions. Assuming that the transmission time for each direct link between two nodes is 2, the end to end delay at node j cannot be less than BFS(j)*α where BFS(j) denotes the height of j in the breadth first search tree with the source of the broadcast being the root of the BFS tree Let C_1(i) and C_2(i)denote the first and second layer colors of hexagon i. This coloring is done in such a way that every pair of hexagons that are covered by a disk of radius 2* transmission range and have the same first layer color are assigned different second layer colors. This second layer of coloring can be mapped to different frequencies, which can be achieved by employing Frequency Division Multiple Access (FDMA), or smaller timeslots using Time Division Multiple Access (TDMA).

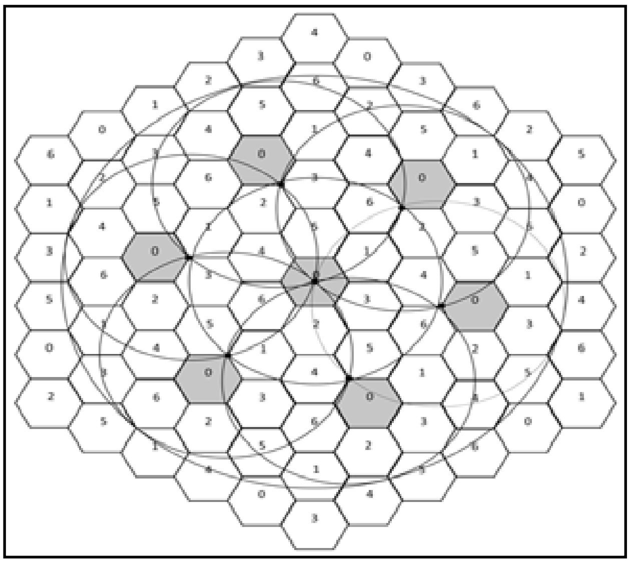

Fig. 2:

A. FDMA

Using different frequencies means that each node belonging to hexagon i would transmit at timeslot corresponding to $C_1(i)$ using frequency $C_2(i)$. Nowadays, different wireless standards allow for different wireless channels to be used, and this approach can be employed if the standard allows for seven different non-overlapping frequencies. Of course in this scenario each receiving node needs to tune into a particular frequency at each timeslot in order to receive the packet. This approach would result in a maximum end to end delay of 7*(BFS(j) + β) at node j, where β is the frequency tuning time.

B. TDMA

Using smaller timeslots (micro timeslots) means that each timeslot (macro timeslots) that corresponds to a single first layer color is divided into seven smaller timeslots each corresponding to a second layer color. There are two constraints that need to be considered when determining the length of the micro and macro timeslots: the length of each micro timeslot should be large enough to carry a single packet while the length of the macro timeslot should be small enough to accommodate the rate of packet generation at the source. This approach would result in a maximum end to end delay of 7 * 7* BFS(j) at node j.

C. TDMA over FDMA

While the IEEE 802.11a standard at 5 GHz provides 13 orthogonal (non-overlapping) channels, the widely used IEEE 802.11b and g standards would only provide 3 non-overlapping channels. This means that using the stand alone FDMA approach would be practically infeasible in many Wi-Fi networks. The problem with the TDMA approach is that the end to end delay is high compared to the FDMA approach.. The hybrid approach uses the TDMA solution over FDMA solution to achieve smaller delay while using smaller number of frequencies. The goal here is to use at most three different frequencies while minimizing the end to end delay. The hexagonal coloring is more complex in this approach comparing to the simple symmetrical coloring used in the previous two. In this approach, we have three layers of coloring as opposed to the two layer coloring introduced before. The first layer corresponds to the macro timeslots, while the second and third layers correspond to frequency and micro timeslots respectively. The main constraint is on the second layer coloring where we are bound to use at most three colors, which correspond to the three non-overlapping frequencies. The second layer implements FDMA and the third layer implements TDMA. With this approach, the maximum end to end delay at node j is 7 *3 *(BFS(j) + β).

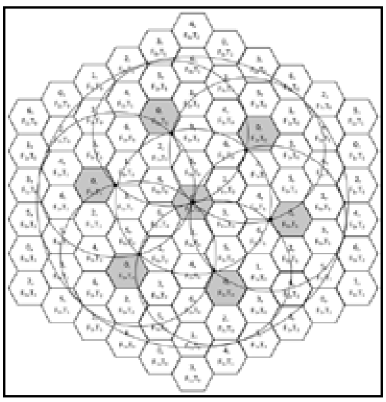

Fig. 3:

Depending on the approach being used, it will forward the packet in one of the following manners:

1. If the FDMA approach is used

Assuming that the current timeslot is TS using this approach node k transmits the packet with frequency $C_2(i)$ at time that corresponds to the start of timeslot x where x is computed as follows:

– in case (TS mod 7) < $C_1(i)$: x = TS + ($C_1(i)$ − (TS mod 7)).
– in case (TS mod 7) $C_1(i)$: x = TS + ($C_1(i)$ + 7− (TS mod 7)).

2. If the TDMA approach is used

Assuming that the current macro timeslot is MTS and the current micro timeslot is m TS node k transmits the packet at the start of macro timeslot x and micro timeslot y where they are computed as follows:

– in case (MTS mod 7) <$C_1(i)$ or (MTS mod 7)=$C_1(i)$ ^ (mTS mod 7)
$C_2(i)$: x = MTS + ($C_1(i)$ □ (MTS mod 7)) and y = $C_2(i)$.
– otherwise: MTS + ($C_1(i)$ + 7 □ (MTS mod 7)) and y = $C_2(i)$.

3. If TDMA over FDMA solution is used

This is very much like the TDMA approach except for the fact that node k would transmit the message with frequency corresponding to $C_3(i)$.

At each node a message would be forwarded at most once. This means that only the first copy of the message is forwarded. Computing the boundaries of the hexagon in which a node belongs to can be done in constant time using three hashing function one for every pair of parallel edges. The three layer colors can be computed with a linear time algorithm.

III. Conclusion

It is very robust to changing network environments (even more robust than simple flooding),efficient in terms of power consumption since each node would only transmit at most one copy of every packet therefore it is usable in sensor network and in general in scenarios where power is a scarce resource.It would implement a very low end to end delay broadcast which means that it can be used in many delay bound applications where a certain QoS needs to be satisfied in terms of end to end delay. It is practical and in fact can be implemented at software level without any need of modifying the hardware. In fact frequency hopping for the FDMA part has been implemented and used before. Another important advantage is that our protocol is completely distributed and would use minimal information to broadcast the packets.In practice the optimality ratio is very small (around 2 to 3) which makes the achieved end to end delay very acceptable as the experimental results verify.We intend to implement our protocols on a set of MICA 2 sensors to evaluate its performance on a real world scenario. We also intend to explore the use of our protocol and its impact n the discovery phase of a set or Ad Hoc routing protocols.

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