

Distributed Algorithm for Energy Efficient Multicasting in Wireless Adhoc Networks

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Abstract— On wireless computer networks, ad-hoc mode is a method for wireless devices to directly communicate with each other. Operating in ad-hoc mode allows all wireless devices within range of each other to discover and communicate in peer-to-peer fashion without involving central access points (including those built in to broadband wireless routers). An ad-hoc network tends to feature a small group of devices all in very close proximity to each other. Performance suffers as the number of devices grows, and a large ad-hoc network quickly becomes difficult to manage. Nevertheless, as electronic devices are getting smaller, cheaper, and more powerful, the mobile market is rapidly growing and, as a consequence, the need of seamlessly internetworking people and devices becomes mandatory. The problem area is availability of limited energy at nodes of a wireless ad hoc network (WANET) has an impact on the design of multicast protocols. For example, the set of network links and their capacities in WANETs are not pre-determined but depends on factors such as distance between nodes, transmission power, hardware implementation and environmental noise. This survey paper presents an overview of issues related to energy efficiency in distributed network and any further possibilities of improvement.

Index Terms— Ad hoc network, Wireless sensor network, broadcast tree, multicast tree, energy optimization.

1 INTRODUCTION

The limited battery power characteristic of ad hoc networks has an impact on the design of multicast protocols [1]. Some approaches have been proposed to reduce the Total Energy Consumption (TEC) of broadcast/multicast trees [2], or to extend System Lifetime (SL) [3], where SL is the minimum lifetime of nodes in a multicast tree. In this paper, we assume that there exists topology control protocols in the system to deal with interference with other nodes. We assume that nodes use omni-directional antenna. We also assume a wireless communication model. In the rest of the paper, we restrict our discussion to the construction and refinement of a single multicast tree. There are three algorithms which we have taken into account and tried to find out the possibilities of each algorithm focusing on P-ReMit, G-ReMit & S-ReMit algorithms. We propose a distributed algorithm B-REMiT which refines an existing tree with an assumption that there are some fixed nodes in the WIRELESS Multicast and others are moving. For example, the set of network links and their capacities in WANETs are not pre-determined but depends on factors such as distance between nodes, transmission power, hardware implementation

and environmental noise so we are trying to implement the nodes in two categories fixed and moving and then minimize the usage of energy using two different ways of searching and multicasting. This paper presents an overview of issues related to energy efficiency in distributed network and any further possibilities of improvement.

2 PROBLEM DESCRIPTION

2.1 P-REMIT ALGORITHM

We make assumptions on the network model: nodes with omni-directional antennas are stationary, and each node knows the distance between itself and its neighboring nodes in the ad hoc networks. The energy cost $E_i(T,s)$ of node i in a source-based multicast tree T is defined in [1].

3 LITERATURE BASIC TECHNIQUES FOR CONSERVING ENERGY

In general, there are four basic techniques for energy-efficient communication [1].

1. The first technique is to turn-off non-used transceivers to conserve energy. E.g. PAMAS protocol [2].
2. The second technique is scheduling the competing nodes to avoid wastage of energy due to contention. This can reduce the number of retransmission and increase nodes' lifetime by turning off the non-used transceivers for a period of time. For example, a base station in a infrastructure based wireless network can broadcast a schedule that contains data transmission starting times for each node as in [3].
3. The third technique is to reduce communication overhead, such as defer transmission when the channel conditions are poor [4].
4. The fourth technique is to use power control to conserve energy. The transmit power P_{ij} needed to reach a node at a distance of r is proportional to $r^{-\alpha}$, where α is a transmission medium dependent constant. Hence, a node can adjust its transmission power to a level which is sufficient to reach the receiving node. This has the added advantage of reducing interference with other on-going transmissions.

4 SYSTEM MODEL AND ASSUMPTIONS

In this paper, we assume that there exists topology control protocols in the system to deal with interference with other nodes. We assume that nodes use omni-directional antenna. We also assume a wireless communication model. We also assume that each node can dynamically select its transmission power level p^{RF} , where $0 \leq p^{RF} \leq p_{max}$. In the rest of the paper, we restrict our discussion to the construction and refinement of a single multicast tree.

ASSUMPTIONS

Let p^{RF} be the minimum power needed to transmit a packet over the link between nodes i and j . To obtain p^{RF}_{ij} , we need some additional hardware :

1. **A D/A converter that controls transmitter power level;**
2. **An A/D converter that gives received signal strengths; and**
3. **A calibrated "S-meter" that helps node j find.**

NOTE: The signal level just high enough to achieve an acceptable i, j bit error rate [14].

5 WORK DONE

An ad-hoc network tends to feature a small group of devices all in very close proximity to each other. Performance suffers as the number of devices grows, and a large ad-hoc network quickly becomes difficult to manage. For this reason, based on "S-meter" reading from signal level of the received messages, every node j responds to node i . So node i can know the minimum power level p^{RF}_{ij} to reach node j . We define the neighbors of node i to be all nodes j for which $0 < p^{RF}_{ij} < p_{max}$. We consider three causes of power depletion at a node: power expended for RF (Radio Frequency) propagation; power expended in the transmitting hardware for operation such as encoding and modulation; and power expended in the receiving hardware for operations such as demodulation and decoding. We assume that the expended transmission power and reception power are same for all nodes and denote them by p_T and p_R , respectively. We neglect any power consumption that occurs when the node is simply "on" (idling), although it would be easy to incorporate it into our model.

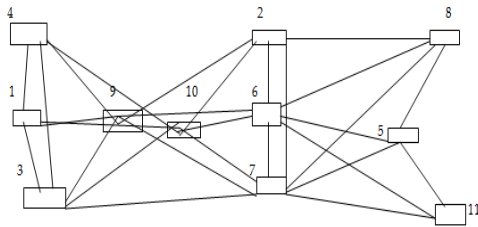


FIG - 1 MULTICAST TREE FOR POWER CONSUMPTION SCHEME

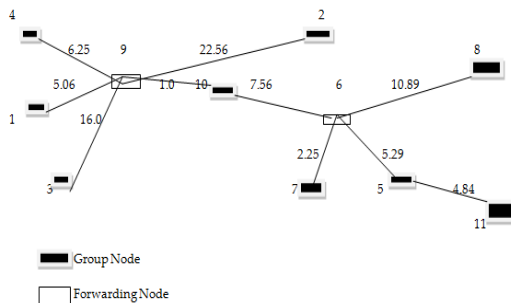


FIG - 2 TREE LINKS BETWEEN MULTICAST GROUPS

If a node i in the multicast tree needs to forward data to its neighbor in Fig. -1, nodes j and k , then node i can simultaneously forward packets to both nodes j and k by transmitting data at the power level $\max\{p_{i,j}, p_{i,k}\}$. Compared to wired networks, this feature reduces power consumption of forwarding in a wireless network from the sum of power consumption of each forwarding link ($p_{i,j} + p_{i,k}$ in the preceding example) to maximum of power required over all the forwarding links ($\max\{p_{i,j}, p_{i,k}\}$). This implies that in a wireless network, "shorter" and "broader" trees are more favorable than "taller" and "leaner" trees from energy-efficiency point of view. Intuitively, shorter and broader trees are also better from the perspective of minimizing multicast latency and bandwidth consumption. A multicast tree generated from Fig 1. Node 6 and 9 are forwarding

nodes. Other nodes are multicast group members. The figure only shows the tree links. Label associated with the edges are power cost of the link, such as $p_{RF} 10,6 = 7.56$ mW. In Figure 2, nodes 2, 6, 7, 8 and 11 are both neighbors and tree neighbors of node 5. Nodes 6 and 11 are connected tree neighbor of node 5. Nodes 2, 7 and 8 are non-connected tree neighbor of node 5. If node 5 uses transmission power p_{max} , it can cover nodes 2, 6, 7, 8 and 11. If node 5 uses transmission power $p_{5,6}$, only nodes 6 and 11 are covered.

The power consumption at every tree node is determined by the power cost of the links between itself and its children nodes. **For example**, consider node 10's source based multicast tree shown in Figure 2. Node 10 will send each multicast message along the branch to nodes 6 and 9. Node 9 will forward them to nodes 1, 2, 3 and 4. Similarly, node 6 will forward them to nodes 5, 7 and 8, and so on. The power consumed at node 9 on the tree links in node 10's source-based multicast tree is

$$\{p_{9,1}^{RF}, p_{9,2}^{RF}, p_{9,3}^{RF}, p_{9,4}^{RF}\} = p_{9,2}^{RF}$$

Let p_i^{RF} be the power cost of the costliest link between i and i 's children. For example, in multicast tree 7 as shown in Fig.2, $p_9^{RF} = p_{9,2}^{RF}$, and node 2 is the costliest child of node 9. We calculate $P_i(T, s)$.

6 RESULTS

Our approach for source-based energy-efficient multicasting problem is improving the energy-efficiency of the initial multicast tree by switching some nodes from their respective parent nodes to new corresponding parent nodes so that the tree's TPC is reduced.

- 1) Criterion for a Node to Switch Parent: We call the difference of TPC of the trees before and after the branch exchange as an Gain. Formally, the gain for the entire tree is:

$$\text{Gain} = \text{TPC}(T,s) - \text{TPC}(T',s)$$

where T is the initial tree and T' is the refined tree. A positive gain for a multicast tree

denotes that the TPC of that tree has decreased. In our heuristic, the notion of Gain is used as the criterion for the switching parent of a node: the refinement is performed only if it is expected that $Gain > 0$. We use the operator $Change_{i \times j}$ to refer to the refinement step in which node i switches its parent from its parent x to node j . Let T be a multicast tree, and T^{\downarrow} be the resulting graph after refinement $Change_{i \times j}$ is applied to T . Formally, if T and T^{\downarrow} are the trees before and after performing the $Change_{i \times j}$ respectively, then:

$$T' = Change_{i \times j}(T) = T - (i, x) + (i, j).$$

Note that T^{\downarrow} may not be necessarily be a tree and TPC of T^{\downarrow} may not be necessarily lower than that of T . Hence, following are two basic questions which need to be answered for our multicast tree refinement approach to work:

1. Determining whether $Change_{i \times j}$ will result in another multicast tree.
2. Ensuring that $Change_{i \times j}$ results in positive power Gain.

The first question involves identifying those non-connected tree neighbors of node i which will be valid candidate for node i 's new parent node. The second question involves taking into account the impact of the $Change_{i \times j}$ operation on the total power cost of the initial multicast tree and determining whether there will be overall positive Gain as a result of $Change_{i \times j}$. Let $A_i(x)$ and $B_i(x)$ denote the subtree created as a result of deletion of the branch between node i and its parent node x from the multicast tree. Further, we assume that node i is in subtree $A_i(x)$.

B.F.S (BREADTH FIRST SEARCH ALGORITHM)

The BFS algorithm has been traditionally used to check the connectivity of a network graph. When we start the BFS algorithm on a randomly chosen node, we should be able to visit all the vertices in the graph, if the graph is connected. BFS returns a tree rooted at the chosen start node; when we visit

a vertex v for the first time in our BFS algorithm, the vertex u through which we visit v is considered as the predecessor node of v in the tree. Every vertex in the BFS tree, other than the root node, has exactly one predecessor node. When we run BFS on a static graph with unit edge weights, we will be basically obtaining a minimum hop multicast tree such that every node in the graph is connected to the root node (the source node of the multicast group) of the tree on a path with the theoretically minimum hop count.

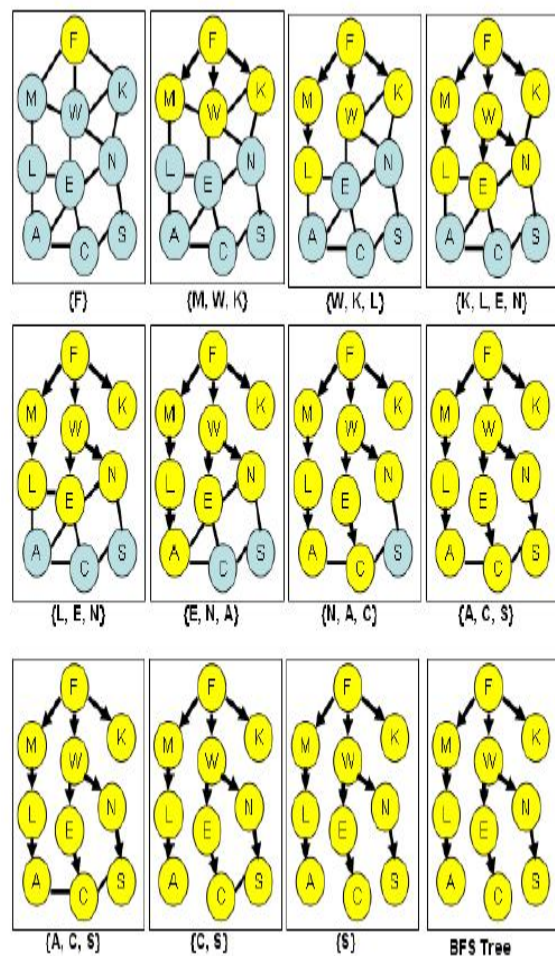


FIG 3. STATIC GRAPH GENERATION BY NETWORK TOPOLOGY

The simulations have been conducted in a discrete-event simulator implemented by the author in Java. The three multicast algorithms have been implemented in a centralized fashion. We generate

the static graphs by taking snapshots of the network topology, periodically for every 0.25 seconds, and run the three multicast algorithms. The simulation time is 1000 seconds. We consider a square network of dimensions 1000m x 1000m. The transmission range of the nodes is 250m. The network density is varied by performing the simulations with 50 nodes (low density) and 100 nodes (high density). We assume there is only one source for the multicast group and three different values for the number of receivers per multicast group are considered: 3 (small), 10 (moderate) and 18 (large). A multicast group comprises of a source node and a list of receiver nodes, the size of which is mentioned above. The node mobility model used is the Random Waypoint model [8]. Each node starts moving from an arbitrary location (i.e., waypoint) at a speed uniformly distributed in the range $[v_{min}, \dots, v_{max}]$. Once the destination is reached, the node may stop there for a certain time called the pause time and then continue to move to a new waypoint by choosing a different target location and a different velocity. A mobility trace file generated for a particular v_{max} value over the duration of the simulation time is the congregate of the location, velocity and time information of all the waypoints for every node in the network. In this paper, we set $v_{min} = 0$. The v_{max} values used are 5 m/s (low mobility), 25 m/s (moderate mobility) and 50 m/s (high mobility). The pause time is 0 seconds. The performance metrics measured are as follows. Each performance metric illustrated in Figures 7 through 13 is measured using 5 different lists of receiver nodes for the same size and the multicast algorithm is run on five different mobility trace files generated for a particular value of v_{max} .

1. TREE CONNECTIVITY: This metric refers to the percentage of time instants there exists a multicast tree connecting the source node to the receiver nodes of the multicast group, averaged over the mobility profiles generated for a particular value of v_{max} for a given

number of network nodes and number of receivers per multicast group.

2. LIFETIME PER MULTICAST TREE:

Whenever a link break occurs in a multicast tree, we establish a new multicast tree. The lifetime per multicast tree is the average of the time between successive multicast tree discoveries for a particular routing protocol or algorithm, over the duration of the multicast session. The larger the value of the lifetime per multicast tree, the lower the number of multicast tree transitions or discoveries needed.

3. NUMBER OF EDGES PER TREE:

This metric refers to the total number of edges in the entire multicast tree, time-averaged over the duration of the multicast session. For example, a multicast session uses two trees, one tree with 10 edges for 3 seconds and another tree with 15 edges for 6 seconds, then the time-averaged value for the number of edges per tree for the 9-second duration of the multicast session is $(10*3 + 15*6)/(3 + 6) = 13.3$ and not 12.5.

4. NUMBER OF HOPS PER RECEIVER:

We measure the number of hops in the paths from the source to each receiver of the multicast group and average it for the duration of the multicast session. This metric is also a time-averaged value of the number of hops from a multicast source to a receiver and then averaged over all the receivers of a multicast session.

7 CONCLUSION

Our proposed algorithm is a "best effort" algorithm, in the sense that does not consider QoS constraints and retransmission issues. Using BFS and DFS both in combination proposing a chunk based scheme.

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