AN ACCESS POINT BASED MULTICAST ROUTING MODEL FOR MAXIMUM UTILIZATION OF RESOURCES IN WIRELESS SENSOR NETWORKS

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Abstract

Scarcity of resources is a major issue in wireless sensor networks. Routing is one of the areas which plays important role to manage the scarcity of the resources. To address the resource scarcity issue, we propose a heuristic model Single Path Position Based Multicast Tree (SPPBM). The Single Path Position Based Multicast Tree model is based on geographic(position based) routing. This network model contains nodes with one node works as Access Point, where an access point is selected as a gateway. The performance comparison is done with other available multicast routing techniques.

KEYWORDS: *Wireless Sensor Network; Multicasting;Protocols.*

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1. INTRODUCTION

A wireless sensor networks is made up of large number of small size,low-cost and low power sensor nodes. In most sensor network scenarios, devices acquire data from the environment, and send it to other nodes for further processing and analysis. Routing protocols for Wireless Sensor Networks(WSN) are used to transmit messages from sources to destinations. It can be classified as Unicast, Broadcast and Multicast. Multicast protocols try to minimize the consumption of network resources in comparison of Unicast and Broadcast protocols. Multicasting protocols try to minimize the consumption of network resources in comparison of unicast and broadcast protocols.

Multicasting communication technique leads to a source node to send a message to a group of destination nodes. In wireless sensor networks communication among nodes happen via radio signals, which are broadcasting in nature that leads a node's transmission to be received by all nodes within transmission range of the node. This way

multicasting saves energy consumption of a sensor node of data transfer to other nodes individually in one to one manner There are many multicast routing techniques to route the information to nodes of the network e.g. Position Based Multicasting[5], Geographical Multicast Routing[2] and Dijkstra's algorithm[7]. In this paper we propose a new heuristic model to construct the location based routing tree, namely Single Path Position Based Multicast tree(SPPBM). We have considered a sensor network of nodes with location information. To get the energy efficient tree according to the proposed model during the construction of geographic multicast tree in sensor networks, less messages must be transmitted. Which ultimately require efficient position based routing.

The remainder of the paper is organized as follows: Section II gives overview of few multicast routing techniques. section III presents a new heuristic model called Single Path Position Based Multicast Tree (SPPBM).In section IV we evaluate the performance of SPPBM and other multicast routing protocols using simulation. Finally, section V provides some conclusions.

2. RELATED WORK

There are several multicast routing protocols available for wireless sensor networks. In this paper we are giving details of few geographic multicast routing protocols.

2.1. Geographic Multicast Routing Algorithm (GMR)

Geographic Multicast Routing (GMR)[2], a multicast routing protocol for wireless sensor networks. The general operation of geographic unicast routing is very simple. A node currently holding a message, selects one of its neighbors as next relay to reach the destination. This selection is done solely based on the positions of the current node, its neighbors and the position of the estimation. Whenever possible, geographic routing chooses neighbors which are closer to the destination than the current node. This is called greedy mode. GMR uses cost over progress metric ratio to select the next hopes towards destinations. In the multicasting problem, where a source node wishes to send a packet to a number of destinations (sinks) with known positions. Assume that a node X, after receiving a multicast message, is responsible for destinations A1,A2,A3,A4, and that it evaluates neighbors Y1,Y2 as possible candidates for forwarding. The whole task can be sent to a single neighbour (e.g. if there exist one that is closer to all destinations than X), or can be split to several neighbors, each with a subset of destinations to handle. Hop count is assumed to be proportional to distances.Let us consider the case in Figure 1 as illustration of the general principle. The current total distance for multicasting is

T1 = |XA1| + |XA2| + |XA3| + |XA4|

If X considers Y1 and Y2 as forwarding nodes, covering A1, A2, A3, and A4. respectively, the new total distance is

T2 = |Y1A1|+|Y1A2|+|Y1A3|+|Y2A4|

And the progress made is T1−T2.

2.2. Dijkstra's Algorithm for multicasting applications

Dijkstra's Algorithm[7] solves the single-source shortest-path problem on a weighted, directed graph *G = (V, E)* for the case in which all edge weights are nonnegative. in this section therefore, we assume that *w(u,v)≥0* for each edge ***(u,v)ЄE.*** Each node is labeled with its distance from the source node along the best known path. Initially no path are known so all nodes are labeled with infinity. As the algorithm proceeds path are found, the label may change, reflecting better paths. A label may either be tentative or permanent. Initially, all labels are tentative. When it is discovered that a label represents the shortest possible path from the source to that node, it is made permanent and never changed thereafter

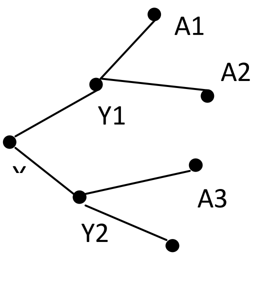

Figure: 1. Evaluating the candidate forwarding from X to Y1 and Y2

To illustrate how the algorithm works, let us look at the weighted, undirected graph of figure 2 where the weights represent, for example, cost of sending a packet on that link in terms of energy. We want to find the shortest path from *A to d*. We start out by making node *A* as permanent, indicated by a filled-in circle. Then we examine, in turn, each of the node adjacent to *A* (the working node), re-labeling each one with the distance to A. Whenever a node is re-labeled, we also label it with the node from which the probe was made so that we can reconstruct the final path later.

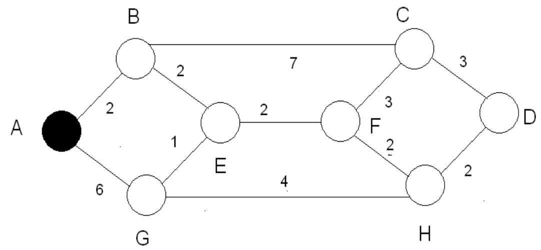

Figure: 2 Example Graph of Dijkstra Shortest Path Algorithm

Having examined each of the node adjacent to *A*, we examine all the tentative labeled nodes in the whole graph and make the one with the smallest label permanent. At last This one becomes new working node.After all the nodes adjacent to the working node have been inspected and the tentative labels changed if possible, the entire graph is searched for the tentative-labeled node with the smallest value. This node made permanent and becomes the working node for the next round illustrated in Figure 3. This algorithm is recursively applied until all nodes are labeled permanently.

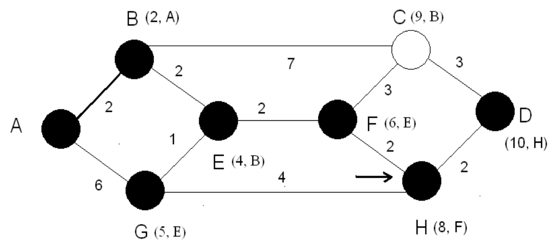

Figure :3 Example Graph of Dijkstra Shortest Path Algorithm

2.3. Position Based Multicast (PBM)

Given the difficulty of adapting existing ad hoc multicast protocols to a fully-localized operation, new protocols have been proposed to meet those requirements. One of such protocols is Position Based Multicast Routing (PBM) protocol proposed by Mauve, F¨uβler, Widmer, and Lang,in [5]. This protocol, although not initially thought for sensor networks, fulfils most of the desired design criteria of localness and limited network overhead. It is a generalization of GFG (Greedy-Face-Greedy) routing to operate over multiple destinations. It builds a multicast tree, whose shape can vary from the shortest path tree, to an approximation of a minimum cost multicast tree depending on a parameter denoted as λ. Authors in PBM try to find a good tradeoff between the total number of nodes forwarding the message and the optimality of individual paths towards the destinations. Each node evaluates all possible subsets of neighbors (W) using a function to evaluate each w ∈ W.

$f(w) = \lambda N + (1 - \lambda)S, 0 \le \lambda \le 1,$

where N is the number of neighbors in the considered subset (|w|) divided by the total number of neighbors (n), and S is the summation of the minimal distances from nodes in W to destinations, normalized by the summation of distances from the current node to all destinations.

3. PROBLEM FORMULATION, DEFINITIONS AND ALGORITHM

3.1 Network Model

A graph $G=\{N, D\}$, where the node set $N=\{b, n1, n2,\ldots,nm\}$, each sensor node ni $\{i=1,2\ldots,m\}$. In this model assumption is that every node N∊V has an transmission range t, equal for all nodes. Let dist (n1, n2) be the distance between two vertices n1, n2∊N . An edge between two nodes v1, v2 ∊ V exists ⇔ dist (v1, v2) ≤ r (i.e. v1 and v2 are able to communicate directly).This proposed model is designed to seek an optimal tree from source node to multiple destination nodes for transmission of data.

3.2. Single Path Position Based Multicast Tree (SPPBM) Model

Overview

In this paper the geographic multicast region is defined as a smallest area which covers all the destination nodes. In geographic multicast routing, we assume each node knows its position and the position of its neighbors. The distance between two nodes can be computed with help of location algorithms. Then a node is selected as an Access Point which is closest to geographically to the source node of the network as shown in fig. 4. Access Point node in multicast region works as the gateway between the sink and the destination nodes. As per the new model we have defined a new algorithm in which initially a route selected using Dijkstra's algorithm from the source to Access Point and in the remaining region of the network a multicast tree is built based on cost over progress ratio metric.

This model initially transforms the problem of multicasting to unicasting and then within a small area it generates a multicast tree based on on greedy algorithm using local information. In very first phase, we define an Access Point node in the network. This Access Point node works as the gateway between the source and the destination nodes, which is the node nearest in position to the source node in the specified multicast region. In this region using Dijkstra's algorithm the shortest path from the source node to the Access Point can be measured. In first phase data transfer made to multicast region come from the source can be forwarded along the path and arrive at Access Point at last. The second phase performs a search for a multicast tree based on greedy algorithm using local information between the access point and the destination nodes. This is based on cost over progress[2] as a metric of the efficient selection of neighbor nodes. The cost-aware neighbor selection is based on a greedy set merging scheme achieving a $O(Dn \min(D, n)^3)$ computation time, where n is the number of neighbors of current node and D is the number of destinations.

As progress the difference between distance to destinations from the node taken the routing decision and the distance from the set of source node is evaluated..The use of such a difference is to calculate an advance towards destinations by maintaining low energy consumption. Figure 4 shows the scenario of using the method of Single path Position Based Multicast Tree

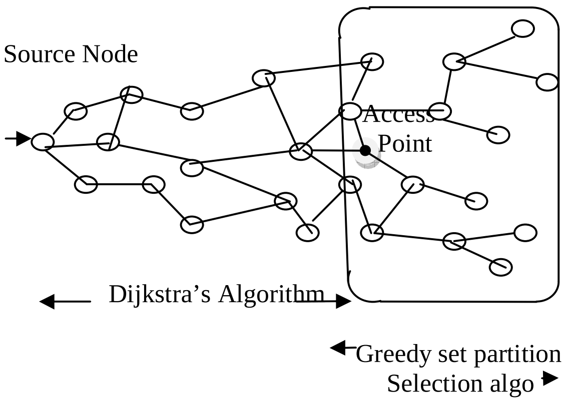

Figure 4. Single Path Position Based Multicast Tree(SPPBM)

3.3. Proposed SPPBM Algorithm (Pseudo code):

SPPBM works in two phases. In first phase we apply the Dijkstra's algorithm. Consider a graph G from source node to Access Point. We need to apply the Dijkstra's algorithm[7] with source's'. 'w' represents the weight matrix of the graph. π [v] represents the parent node as discussed in the description. Then, the required algorithms are:

```
DIJKSTRA (G, w, s)
    INITIALIZE-SINGLE-SOURCE (G, s)
    S ← Φ
    Q ← V [G]
    while Q ≠ Φ
        do u ← EXTRACT-MIN (Q)
            S ← S U {u}
            for each vertex v adjacent to u
                do RELAX (u, v, w)
INITIALIZE-SINGLE-SOURCE (G, s)
    for each vertex v Є V [G]
        do d[v] ← ∞
    d[s] ← 0
RELAX (u, v, w)
    if (d[v] > d[u] + w (u, v))
        then d[v] ← d[u] + w (u, v)
            π[v] ← u
```

In second phase we apply cost over progress metric[5] to prepare multicast tree. Given below in the Pseudo code which explains the greedy set partition selection algorithm:

```
    M = {M1,M2, ...,Mm} so that Mi ={Dj | same
    neighbour provides most advance}
    CRatio = |M| / Σ_{i=1}^{|M|} Pi

    repeat
        BestReduction = 0
        for all pairs {Mi,Mj} do do
        Find cost over progress reduction by
    merging of {Mi,Mj} Є M
            if reduction > BestReduction then
            BestReduction = reduction
            BestMerge = {Mi,Mj}
            end if
        end for
        if BestReduction > 0 then
        M = {M1,M2, ..., {Mi,Mj}, ...,Mm}
      CRatio = |M| / Σ_{i=1}^{|M|} Pi
        end if
    until BestReduction = 0
```

4. RESULTS

After the deep study of these protocols, here we have decided to evaluate the performance of the proposed SPPBM model, Dijkstra, GMR and PBM for sensor networks. For the proposed schemes we consider some of the performance metrics which are number of transmissions and computation time.In this part of this section, we compare the proposed SPPBM model with Geographic Multicast Routing , Dijkstra's Algorithm for multicasting and Position Based Multicast Routing. This study performance of SPPBM,GMR,PBM and Dijkstra have been evaluated with the help of TOSSIM[4] Simulator. There are 250 nodes randomly placed in an area of 500x500 m. Variable radio range is selected which provides different network densities in the same network. From the set of sensor nodes destination nodes were also selected randomly.

Number of transmissions: It is quite evident from the results in figure 5 that SPPBM proved better then PBM(λ=0.2) and Dijkstra's routing algorithm. SPPBM performs better with higher density and behaves similar to GMR in the same scenario.

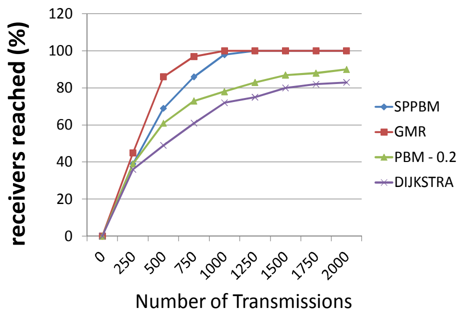

Figure: 5 Number of Transmissions Metric

Computation Time: From the results in figure 6 it is clear that GMR gives best average computation time followed by SPPBM. PBM(λ=0.2) and Dijkstra's are poor performers. In case of SPPBM the computation time decreases with increase in number of nodes and follows GMR. On the other hand in case of PBM and Dijkstra's the average computation time grows exponentially with increase in number of nodes.

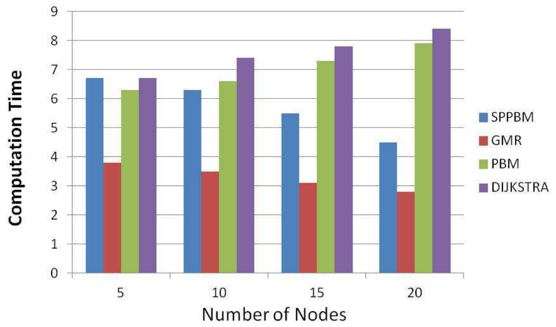

Figure :6 Computation Time metric

CONCLUSION

In this paper we propose a heuristic model Single Path Position Based Multicast Tree (SPPBM). The performance comparison is done with other available multicast routing techniques. This study performance of SPPBM,GMR,PBM and Dijkstra have been evaluated with the help of TOSSIM[4] Simulator and also performance analysis has been shown. To assess the performance of these protocols we considered Number of Transmissions and Computation Time performance metric. The results show that by using Access point approach, the efficiency of routing technique can be improved, thus enhancing the network lifetime. For future work, the algorithm can be compared with other routing schemes to see the performance of proposed one.

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