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ENERGY EFFICIENT ROUTING ALGORITHM USING DIRECTIONAL SOURCE AWARE PROTOCOL (DSAP)

AMIT SHARMA[1], P. V. SINGH[2], SAMEER ANAND[3] & NEELAM SRIVASTAVA[4]

[1] Research Scholar, IFTM University, Moradabad, Uttar Pradesh, India

Department of E&C Engineering, KIMT, Moradabad, Uttar Pradesh, India

[2,3]Department of E&C Engineering, KIMT, Moradabad, Uttar Pradesh, India

[4]Department of E&C Engineering, IET, Lucknow, Uttar Pradesh, India

ABSTRACT

This paper presents the different problems encountered in sensor networks today, precisely the problem of routing. The directional source aware routing protocol (DSAP) is described along with its principle and is simulated using the network simulator OMNET++ useful for debugging, illustration purposes or performance evaluation, and providing a collection of tools that help modifying or implementing new features in an easy fashion. The results of the simulation are commented, the limitations of the current version of DSAP are analyzed along with possible enhancements.

KEYWORDS: Simulations, Wireless Sensor Networks, Routing Algorithm, OMNET++

INTRODUCTION

Wireless Sensor Network is one special type of wireless networks without fixed infrastructure consisting of a collection of sensor nodes, and operating on limited amount of battery energy consumed mostly in transmission and reception. In the WSNs, every sensor node can sense, process data and communicate to base station (BS). WSNs have attracted much attention during the recent two years and some commercial implementations such as environmental surveillance applications are being developed because of their many advantages such as limited size, minimal memory and energy requirements and good computation ability, as well as their cheap and dense deployment compared to fixed infrastructure wireless networks and even traditional ad hoc networks. But the major problem of reducing sensor node energy consumption in WSNs has not been solved perfectly [1,2]. If all sensor nodes transmit packets directly to the base station, the furthest nodes from the base station will die early. On the other hand, among sensor nodes transmitting packets through multiple hops, sensors closest to the base station tend to die early, leaving some network areas completely unmonitored and causing network partitions. In order to maximize the WSNs lifetime, it is essential to prolong each individual sensor node's lifetime by minimizing transmission energy consumption and sending packets via paths that can avoid sensor nodes with low energy and minimizing the total transmission power.

DIRECTIONAL SOURCE AWARE PROTOCOL (DSAP)

First, we consider the standard DSAP schemes. Wireless sensor networks have power constraints. The small size node and the absence of wires imply the lack of an external power supply such as battery packs. Therefore, it is necessary to extend the battery life of individual sensors so that the network can remain functional as long as possible. Due to the limited power that the nodes have, we restrict the routing to the neighboring nodes only.

Directional Source Aware protocol is a routing protocol that depends on the local information that is available from neighbors of the transmitting node. That is, the node collects the information from the neighbors and decides which neighbors should receive the packet. There are two types of DSAPs namely, DSAP (Not Power Aware) and DSAP (Power Aware). In the first case the routing path is decided by the directional value calculated for the neighbors and in the second case the directional value along with the available power in the individual nodes are considered to decide the routing path.

- **Assumptions**
  - All sensor nodes are identical and have the same limited energy capacity.
  - Each sensor knows the location of its nearest neighbors with whom it can communicate.
  - Each sensor knows the power available at each neighbor.
  - Each sensor knows the direction in which to send the message[3].

- **Radio Model**

In this work, we assume a simple model where the radio dissipates Eelec = 50 nJ/bit to run the transmitter or receiver circuitry and Eamp = 100 pJ/bit/m2 for the transmit amplifier to achieve an acceptable Eb/N0 (see Figure 1) We also assume that the packet size is *k* = 512 bits[1]. Finally, the path loss exponent is assumed as 2[3].

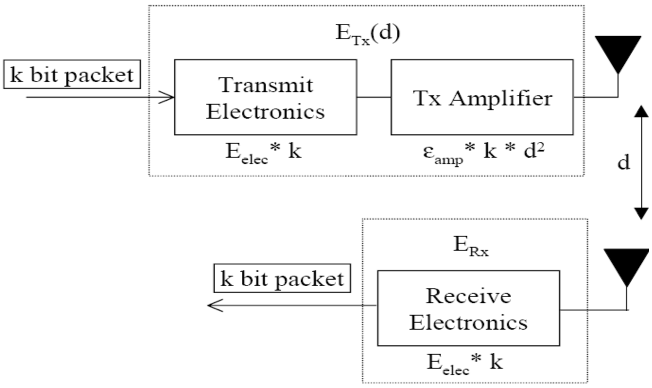

Figure 1: First Order Radio Model

To transmit a *k*-bit message at distance *d* meters using this radio model, the radio expends:

ETx (*k*, *d*) = ETx-elec(*k*) + ETx-amp(*k*, *d*)

= Eelec* *k* + Eamp* *k* * *d*2

To receive this message, the radio expends:

$$E_{Rx}(k) = E_{Rx-elec}(k)$$
$$E_{Rx}(k) = E_{elec} * k$$

- **Topologies**

For simplicity of calculation, we will assume for local routing between nodes and the transmission reaches only its nearest neighbors. The topologies that we are going to evaluate are as follows:

  - 2D Mesh with maximum of 4 neighbors.
  - 2D Mesh with maximum of 6 neighbors.
  - 2D Mesh with maximum of 8 neighbors

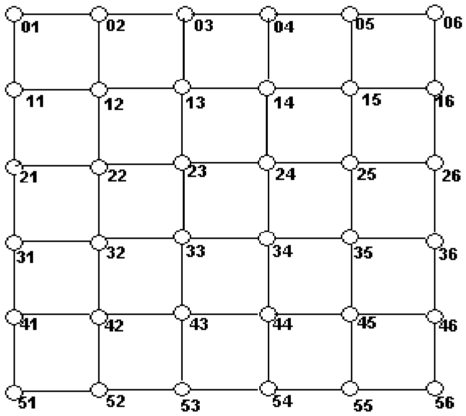

Figure 2: 2D Topology with 4 Neighbors

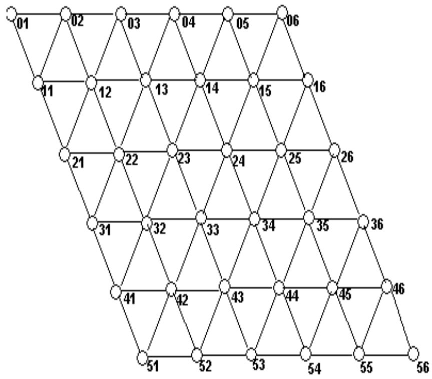

Figure 3: 2D Topology with up 6 Neighbors

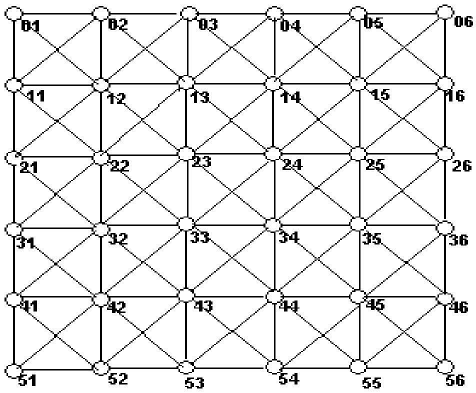

Figure 4: 2D Topology with 8 Neighbors

- **Algorithm for DSAP without Power- Aware**

Step 1: Get source (S) and destination (D) identifiers

(For example, in Figure 2 the node 13 identifiers = 2 1 3 4.

In Figure 3, the node 13 has identifiers = 2 11 3 4 2.

In Figure 4, the node 13 has identifiers = 2 1 1 1 3 3 4 2)

Step 2: Subtract D from S.

Step 3: Choose non-negative directions only.

Step 4: Calculate Directional Value (DV) of each non-negative direction.

(DV = future source – destination) and Choose the minimum.

Step 5: If (DV in step 4 is equal to zero) then

{found the direction of final destination, forward to the destination and exit}

Else {forward message in the direction with the minimum DV}

Step 6: Set source (S) = new source

Step 7: Repeat Step 2.

- **Algorithm for DSAP with Power- Aware**

Step 1: Get source (S) and destination (D) identifiers.

Step 2: Subtract D from S.

Step 3: Choose non-negative directions only.

Step 4: Calculate Directional Value (DV) of each non-negative direction.

(DV = future source - destination). Divide DV/(Power Level at each new source) and Choose the minimum.

Step 5: If (DV in step 4 is equal to zero) then

{found the direction of final destination,

forward to the Destination and Exit}

Else {forward message in the direction with the minimum value in Step 4}

Step 6: Set Source (S) = New Source

Step 7: Repeat Step2.

EEDSAP-ENERGY EFFICIENT DIRECTIONAL SOURCE AWARE PROTOCOL (POWER AWARE)

In our work DSAP (Power Aware) is extended to include an efficient power management scheme. Since the message knows in which direction to head, there is no need to broadcast to all its neighbors. Hence the neighbors of transmitting nodes are kept in sleep. A few extra bits are transmitted in the header to inform the intended next/immediate receiver to keep awake. For example, the header might contain TX address, immediate RX address and final RX address. Only 2 or 3 bits are needed to specify the intended immediate neighbor. As soon as the unintended node receives the immediate RX address, it will go to sleep mode instead of staying awake for whole frame [4,5]. This will reduce the power dissipation of individual unintended receive nodes and allow the network to function for a longer time. Hence the EEDSAP (Power Aware) becomes more energy efficient than other DSAPs. When the node is in sleep mode, we assume the Esleep as 50pJ.

Algorithm for EEDSAP with Power Aware

Step 1: Get source (S) and destination (D) identifiers

Step 2: Subtract D from S.

Step 3: Choose non-negative directions only.

Step 4: Calculate Directional Value (DV) of each non-negative direction.

(DV = future source- destination). Divide DV/(Power Level at each New Source) and Choose the minimum.

Step 5: If (DV in step 4 is equal to zero) then {found the direction of final destination. Keep other neighbors of transmitting node in sleep. Forward to the destination and exit}

Else {forward message in the direction with the minimum value in Step 4. Keep other neighbors of transmitting node in sleep. }

Step 6: Set source (S) = new source

Step 7: Repeat Step 2.

COMPARATIVE ANALYSIS AND SIMULATION

We now analyze the power dissipation with respect to the network topology with variable number of neighbors. In the first analysis, we consider two-dimensional networks with four, six and eight neighbors (Figure 2, 3 and 4) and compare the protocols DSAP (Not Power Aware), DSAP (Power Aware) and EEDSAP (Power Aware). [6,7]. In this analysis, we fixed the source and destination nodes. Number of transmissions trial is taken as six. The total energy used for one round of transmission is calculated and summarized. Tables 1 and 2 show that the power dissipated is less in EEDSAP (Power Aware) than other DSAPs. The degree of routing freedom is the number of alternative paths that a routing protocol can select. Figure 2 to 4 show that, as the number of neighbors increases, the degree of routing freedom increases.

Table 1: DSAP (Power Aware and Not Power Aware)

Topology	No. of Txs	No. of Rxs	No. of Sleep Nodes	Total Energy Used ($x10^{-9}$) Joules
4 Neighbor	6	6	18	307508.1
6 Neighbor	6	6	30	307508.7
8 Neighbor	6	6	42	307509.3

Table 2: EEDSAP (Power Aware)

Topology	No. of TXs	No. of RXs	No. of Sleep Nodes	Total Energy Used ($x10^{-9}$) Joules
4 Neighbor	6	24	-	768307.2
6 Neighbor	6	36	-	1075507.2
8 Neighbor	6	48	-	1382727.2

Next, we consider the network with four-neighbor topology of 36 nodes and compare the energy consumed by each node when all the above protocols are used. The power dissipated by individual nodes after the completion of three rounds are calculated and given in Table 3. Here, source node is taken as 12 and destination node is taken as 44.

Table 3: Energy Consumption of Nodes after Completing Three Rounds of Transmission

Node	DSAP (Not Power Aware) 10^{-9} Joules	DSAP (Power Aware) 10^{-9} Joules	EEDSAP (Power Aware) 10^{-9} Joules
00	0	0	0
01	76800	76800	0.15
02	76800	51200	0.10
03	76800	25600	0.05
04	76800	25600	0.05
05	0	0	0
10	76800	76800	0.15
11	153753.6	153753.6	76953.75
12	230553.6	179302.4	102502.55
13	230553.6	128051.2	51251.35
14	230553.6	76851.2	51251.25

Table 3: Contd.,

15	76800	25600	0.05
20	0	25600	0.05
21	76800	153651.2	51251.4
22	76800	153651.2	51251.4
23	153600	128051.2	51251.35
24	230553.6	128051.2	51251.35
25	76800	25600	0.05
30	0	25600	0.05
31	0	76851.2	51251.25
32	0	128051.2	51251.35
33	76800	153651.2	51251.4
34	153753.6	102502.4	102502.4
35	76800	51200	0.1
40	0	0	0
41	0	51200	0.1
42	0	76851.2	51251.25
43	0	76851.2	51251.25
44	76800	76800	76800
45	0	0	0
50	0	0	0
51	0	0	0
52	0	25600	0.05
53	0	25600	0.05
54	0	0	0
55	0	0	0

It shows that in DSAP (not power Aware), there is no Power dissipation in nodes 00, 05, 20, 30, 31, 32, 40, 41, 42 43, 45, 50, 51, 52, 53, 54 and 55. Since there is a fixed path, these nodes neither transmit nor receive In DSAP (Power Aware), since there is routing freedom, there are more than one path for data transmission and reception, which varies in each round of transmission [8]. Hence there is even distribution of power dissipation than DSAP (Not Power Aware). Nodes 20, 30, 31, 32, 41, 42, 43, 52, 53 also participate either in transmission or in reception. There is considerable reduction of energy dissipated by the nodes 02, 03, 04, 12, 13, 14, 15, 23, 24, 25, 34 and 35. In EEDSAP (Power Aware), the nodes which are not in routing path are kept in sleep and therefore consume less power than DSAP (Power Aware). EEDSAP was be simulated using OMNET++ which is described in next section.

Table 4: Net Work Lifetime

Protocol	Lifetime
DSAP (Not power Aware)	Low
DSAP (power Aware)	Medium
EEDSAP (power Aware)	High

CONCLUSIONS

The lifetime of the wireless sensor network using all DSAP routing protocols are given in Table 4 It shows that in DSAP (Not Power Aware) the lifetime of the network is minimum because there is only one path available for the data transmission. On the other hand DSAP (Power Aware) allows more than one path and hence the lifetime is increased further. In EEDSAP (Power Aware) since the nodes are put in sleep when they are not involved in either transmission and reception the lifetime is increased than the other two protocols.

We have discussed the need to make the routing protocols power aware from a local point of view. Thus, the routing protocol tries to make its decision by what is available from its neighbours only. Basing the decision on the power remaining is not by itself enough. Using the DV and the sum of power remaining at the next neighbours will give the routing protocol a broader perspective about the condition of the network from a local point of view. Our simulations show that using the DV and the sum of power and also using the DV with power extends the lifetime of the network.

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