Amit Sharma, Kshitij Shinghal, Neelam Srivastava / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 2, Issue 6, November- December 2012, pp.816-821

Design and Performance Analysis of Energy Efficient Routing Algorithm for Wireless Sensor Network

#Amit Sharma[1], Kshitij Shinghal[2], Neelam Srivastava[3]
Deptt. of E&C Engg., KIMT, Moradabad, UP., India
Deptt. of E&C Engg., MIT, Moradabad, UP., India
Deptt. of E&C Engg., IET, Lucknow, India
Author 1 is a research scholar at IFTM University Moradabad, UP, India

Abstract

Wireless Sensor Networks (WSNs) are communication networks, which integrate sensor techniques, embedded techniques and distributed information processing techniques. One of the issues in smart sensor networks is achieving energy efficient operation because of the limited available power. In many biomedical applications, the locations of sensor nodes are fixed and the placement can be predetermined. In this paper, the Directional Source Aware Protocol (DSAP) is described along with the principle and a new Energy Efficient DSAP is proposed to minimize the usage of available energy or power in sensor nodes.

A few extra bits are transmitted in the header to inform all the neighbors about next immediate receiver, which is the future source for the next transmission. Energy efficiency is achieved by keeping the neighbors of transmitting node in sleep mode and the intended receiver on.In this work different routes and topologies are considered. The energy consumed by the nodes and the lifetime of the network are analyzed.

I. INTRODUCTION

The recent advances in microelectronics and wireless communications have enabled the development of low cost, low power, high integration and small size wireless sensor nodes. These sensor nodes are networked together into wireless sensor networks to implement the assigned tasks. The nodes can be densely deployed in physical environment either inside or close to the phenomenon. The sensor nodes fitted with on-board processors have sensing, data processing and wireless communication capabilities[12]

The applications include building monitoring and control, environmental monitoring, health care, industrial process control, security and surveillance. Biomedical sensor networks have additional constraints that must be addressed before they are feasible for human use. Such implants are intended for long-term placement in the body since it does not dissipate large amount of heat. Besides that we have to overcome many problems such as limited energy, power consumption resources before using WSNs. In many cases, multiple sensor nodes are required to overcome obstacles like environmental characteristics, line of sight constraints, etc. In most cases, the environment to be monitored does not have an existing infrastructure for energy or communication. Sensor networks cannot survive for long on small, finite sources of energy to communicate through wireless communications.

In this paper, we will examine the power usage and Lifetime of the wireless sensor networks system parameters of the wireless sensor networks and then present our solution, Energy Efficient Directional Source Aware Protocol (EEDSAP). In studying the relation between the power performance and Lifetime of the network, we first need to identify some of these system parameters that we encounter in our study of the WSNs: (a) Distance between nodes,
(b) Network topology, (c) Routing algorithm, (d) Transmitted power, (e) Network capacity, (f) data encoding, (g) modulation cheme, (h) Channel RF bandwidth, and (i) Channel access.
We will study the effect of choosing different topologies on the power dissipated in the network with all other parameters fixed. In a WSN, the definition of the network topology is derived from the physical neighborhood. We concentrate only on 2D mesh topologies.

This paper is organized as follows. After an introduction, the existing routing protocols are briefly discussed in section II.. The existing DSAP (Not Power Aware) and DSAP (Power Aware) are described with principle in section III. In section IV, the Energy Efficient Directional Source Aware Protocol (Power Aware) is proposed. All types of DSAP are compared and the analysis on power consumed by the nodes and the network lifetime are analyzed in section V. Finally, the conclusion and possible enhancements are presented in section VI.

II ROUTING PROTOCOLS

Wireless sensor nodes are battery powered. So most of the routing protocols are concentrated on findings solutions to energy efficiency. By accepting a reduction in network performance [1]. Popular power saving ideas includes specialized nodes, negotiation, and data fusion, as discussed below.

LEACH (Low-Energy Adaptive Clustering Hierarchy) is a communication protocol that tries to evenly distribute the energy among the network nodes by randomly rotating the cluster head among the sensors [2, 3]. This assumes that we have a finite amount of power and aims at conserving as much as possible despite a dynamic network, as well as data compression to reduce the amount of data that must be transmitted to a base station. Performing some calculation and using data fusion locally conserves much energy at each node.

SPIN (Sensor Protocols for Information via negotiation) is a unique set of protocols for energy – efficient communication among wireless sensors [4,5]. The authors propose solutions to traditional wireless, communication issues such as network implosion caused by flooding and overlapping transmission ranges. The SPIN protocols incorporate two key ideas to overcome implosion, overlap, and resource blindness: negotiation and resource adaptation. Using very small meta-data packets to negotiate, SPIN efficiently communicates with fewer redundancies than traditional approaches, dealing with implosion and overlap.

There has been comparison of multiple Protocols used in wireless sensor networks [6]. Although in [6] main focus is on energy efficiency due to battery power, it provides guidelines for designing access protocols for wireless sensor networks. It also recommends that the protocols should reduce the number of contentions to improve power conservation as well as using shorter packet lengths.

Research has also been conducted on the effect that topology has on wireless networking [7-9].The concentration has been on mobile networks rather than ones with fixed node placement.

DSAP (Directional Source Aware Protocol) is a protocol with two methods: DSAP(Not Power Aware) routing and DSAP (Power Aware) routing [10,11]. In DSAP, Directional Values (DV) of neighbor nodes are considered for finding out the next future source. While in DSAP (Power Aware),DV along with available power in nodes are considered. It has been proposed that it is not practical to use edge routing as a mechanism of choice, as it does not scale well. As the number of nodes increases, the number of edge nodes increases as a much smaller rate. This points to a variation of interior routing as the favored choice. SAP (Power Aware) can be extended to include more efficient power management schemes for fixed topology networks. We propose a new EEDSAP scheme in which we have modified the existing DSAP (Power Aware) by keeping the neighbors of transmitting node in sleep mode, except the intended receiver. Hence there is considerable amount of reduction in energy consumed by the sensor nodes. This requires a very small addition to the header file to include the address of the intended receiver. The overall lifetime of the network is increased because of the reduction in energy consumption by the individual nodes

III. 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.

A. 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.

B. RADIO MODEL

In this work, we assume a simple model where the radio dissipates E_{elec} = 50 nJ/bit to run the transmitter or receiver circuitry and E_{amp} = 100 pJ/bit/m^2 for the transmit amplifier to achieve an acceptable E_b/N_0 (see Fig. 1) . We also assume that the packet size is k = 512 bits[1]. Finally, the path loss exponent is assumed as 2.

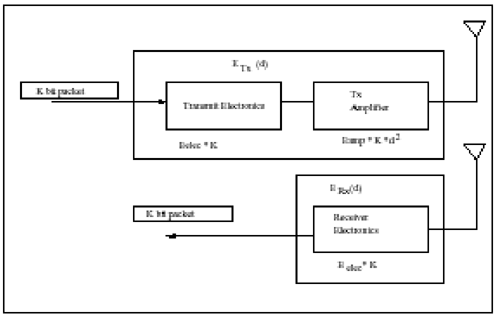

Fig. 1. First Order Radio Model

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

$$E_{Tx}(k, d) = E_{Tx\text{-}elec}(k) + E_{Tx\text{-}amp}(k, d)$$
$$= E_{elec} * k + E_{amp} * k * d^2$$

To receive this message, the radio expends:

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

C. NUMBER OF NODES AND 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

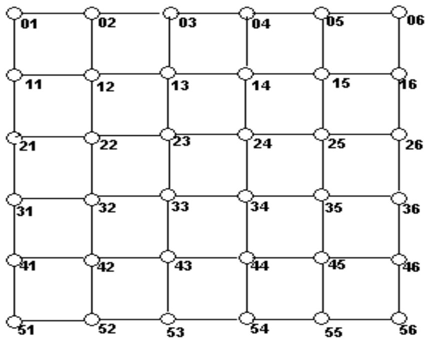

Fig. 2. 2D Topology with 4 neighbors

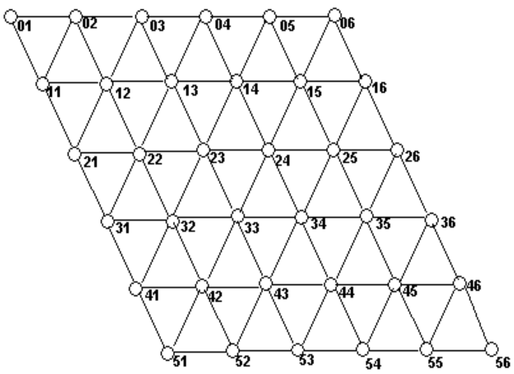

Fig. 3. 2D Topology with up 6 neighbors

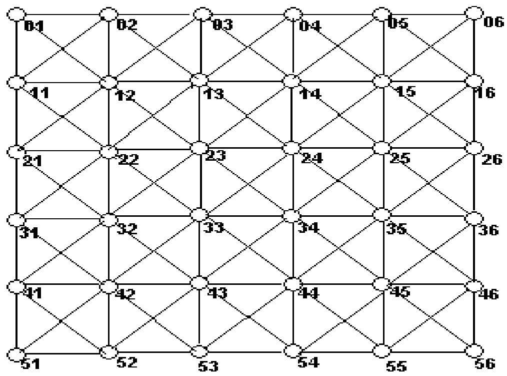

Fig. 4. 2D Topology with 8 neighbors

D. ALGORITHM FOR DSAP WITHOUT POWER- AWARE

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

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

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

In Fig. 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.

E. 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 Step 2.

IV. 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.

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 E_{sleep} as 50pJ.

A. ALGORITHM FOR EEDSAP WITH POWER AWARE

Step1 : Get source (S) and destination (D) identifiers
Step2 : Subtract D from S.
Step3 : Choose non-negative directions only.
Step4 : 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.
Step5 : 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. }
Step6 : Set source (S) = new source
Step7 : Repeat Step 2.

V. 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 (Fig. 2, 3 and 4) and compare the protocols DSAP (Not Power Aware), DSAP (Power Aware) and EEDSAP (Power Aware). 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. Fig. 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
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.

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 can be simulated using MATLAB,SCILAB, VB, JAVA, NS or OMNET++.

Table 4. Net work Lifetime

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

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.

VI. CONCLUSION AND FUTURE WORK

In this paper, we considered three routing protocols, namely: DSAP(Not Power Aware),) DSAP(Power Aware) and EEDSAP (Power Aware). We observed that in EEDSAP (Power Aware) keeping neighbors of transmitting nodes which are not the intended receivers in sleep will reduce the energy consumption of individual nodes and increase the overall lifetime of the network We can also simulate EEDSAP for larger number of nodes. Fault tolerance is an issue in sensor networks, because in biomedical applications node failure should not interrupt the data transmission. So, EEDSAP can be enhanced to function in case of node failure. However, realization of this network needs to satisfy the other factors such as scalability, cost, hardware, topology change and environment

References

[1] C. Patel, S. M. Chai, S. Yalamanchili, and D. E. Schimmel.Power/Performance Trade-offs for Direct Networks. In ParallelComputer Routing & Communication Workshop, pages 193–206, July 1997

[2] W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan.Energy-Efficient Communication Protocol for Wireless MicrosensorNetworks. In Proc. Of Hawaiian Int'l Conf. On Systems Science, January 2000.

[3] A.Wang,W. R. Heinzelman, and A. Chandrakasan. Energy-Scalable Protocols for Battery-Operated Microsensor Networks.In Proceedings of the 1999 IEEE Workshop on Signal Processing Systems, pages 483–492, October 1999.

[4] W. R. Heinzelman, J. Kulik, and H. Balakrishnan. Adaptive Protocols for Information Dissemination inWireless Sensor Networks. In Proceedings of the Fifth Annual ACM/IEEEInternational Conference on Mobile Computing and Networking(MobiCom '99), pages 174–185, August 1999.

[5]J. Kulik, W. R. Heinzelman, and H. Balakrishnan.Negotiation-based Protocols for Disseminating Information inWireless Sensor Networks. In ACM MOBICOM, 99.

[6] J. Chen, K. M. Sivalingam, and P. Agrawal. Performance Comparison of Battery Power Consumption in Wireless Multiple Access Protocols. Wireless Networks, 5(6):445–460, 1999.

[7] L. Hu. Topology Control for Multihop Packet Radio Networks. IEEE Transactions on Communications, 41(10):1474–1481, October 1993.

[8] R. Ramanathan and R. Rosales-Hain. Topology Control of Multihop Wireless Networks using Transmit Power Adjustment.In *INFOCOM*, pages 404–413, 2000.

[9] Z. Tang and J. J. Garcia-Luna-Aceves. A Protocol for Topology-Dependent Transmission Scheduling in Wireless Networks. In IEEE Wireless Communications and NetworkingConference, 1999.

[10] A. Salhieh, J. Weinmann, M. Kochhal, and L. Schwiebert.Power Efficient Topologies forWireless Sensor Networks. In International Conference on Parallel Processing, pages 156-163, Sep 2001.

[11] Samir El Haddad, Marc Girod-Genet and Bachar El Hassan, Simulation and Refinement of Directional Source Aware Routing Protocol for Wireless Sensor Networks.Inforation and Communication Technologies Conference 2006

[12] Ian F. Akyildiz, weillian Su, Yogesh Sankarasubramaniam,and Erdal cayirci, Wireless Sensor Networks: Asurvey. Comput.er Networks, 38:393-422,2002.