ENERGY EFFICIENT PROTOCOL FOR LAYERED SUPERVISION OF COMMUNICATION MODEL IN WIRELESS SENSOR NETWORKS

Avdesh Kumar Sharma*

Anand Rajavat**

Abstract:

A wireless sensor network is a group of sensor nodes organized into a supportive network. Each node has processing capability that includes one or more microcontrollers, CPUs or DSP chips, multiple types of memory and RF transceiver, usually with a single Omni-directional antenna. The nodes converse wirelessly and often self-organize being deployed in an adhoc fashion. In our research, we identified the problem of management or intervallic data collection for stationary wireless sensor networks and present a practical, energy-efficient, and reliable solution. Energy-efficiency is achieved by our proposed methods. The finest scheme for balancing the communication load among all the nodes in the network is calculated flow optimization techniques. This gives the energy amount required in data collection process. Instead of using a fixed network topology, a set of optimized trees is constructed and the communication tree varies over different data collection cycles. We show that this method achieves an average energy consumption rate. The packet exchange process is developed based on collision-free schedules, to reduce the number of packets and the transmission and reception period for each node. Reliability of the process is certain by including many retransmit session opportunities in the schedules. We performed the simulation to evaluate the performance.

* M.E(Student), SVITS Indore, India.

** Associated Professor, SVITS Indore, India.

I.INTRODUCTION

Wireless systems pretense a novel set of protocol design challenges: Network lifetime and network reliability become two important design factors. The sensor nodes in the system are naturally small battery operated, and expected to live for years. Therefore, energy-efficiency is a crucial factor in all the tasks performed throughout the network's lifetime. Ensuring reliability is an significant component of a wireless system, since wireless as a physical medium of communication is more prone to errors than its wired counterpart

They are located strategically inside a physical medium and are able to interact with it in order to measure physical parameters from the environment and provide the sensed information [1]. The nodes mainly use a broadcast communication and the network topology can change constantly due, for example, to the fact that nodes are prone to fail. Because of this, we should keep in mind that nodes should be autonomous and, frequently, they will be disregarded. The desire to advance in research and development of WSN was initially motivated by military applications such as surveillance of threats on the battlefield, mainly because WSN can replace single high-cost sensor assets with large arrays of distributed sensors. There are other interesting fields like residence control, construction automation and medicinal applications. A number of hospitals and medical centers are exploring the use of WSN technology in a wide variety of applications, WSNs can also be found in environmental monitoring applications such as fire detection in forest and rural areas [5]. And marine fish farms [4] and As we already mentioned, sensor nodes in WSNs are usually battery powered but nodes are typically unattended because of their deployment in hazardous, hostile or remote environments. A number of power saving techniques must be used both in the design of electronic transceiver circuits and in network protocols. The first step towards reduced power consumption is a sound electronic design [6], selecting the right components and applying appropriate design techniques to each case. One of the major causes of energy loss in the WSN node is the idle mode consumption, when the node is not transmitting/receiving any information but listening and waiting for information from other nodes. There is also an energy loss due to packet collision, as all packets involved in the collision are discarded and must be retransmitted. A third cause of energy loss is the reception of packets not addressed to the node. The fourth major source of wasted energy is the transmission –and possible retransmission- of control packets, as these can be seen as protocol overhead. There are several studies that present different aspects related to power saving techniques, but all of them are focused in a single way to improve the energy consumption and save power in WSNs. The main objective of this paper is to present a survey of the different power saving and energy optimization techniques for WSNs and ad-hoc connections, so we will tackle this issue from several perspectives in order to provide a whole view in this matter. The paper is organized as follows. Section 2 shows some previously published surveys related to power saving techniques in WSN. Section 3 describes the main energy parameters that should be considered in the transmission system.

II. RELATED WORK

The increasing attention in WSNS and the recurrent appearance of novel architectural techniques stimulated some earlier efforts for surveying the individuality, applications and communication protocols for such a technological area [1,13]. In this section we emphasize the features that differentiate our survey and intimation the difference in scope. The goal of [1] is to create a inclusive survey of intend issues and techniques for sensor networks recitation the physical constraints on sensor nodes and the protocols planned in all layers of network stack. likely applications of sensor networks are as well discussed. That survey is a good quality preliminary for readers concerned in the extensive area. Although a number of routing protocols for sensor networks are covered, the paper does not make a classification for such routing protocols and the catalog of discussed protocols is not meant to be complete given the range of the survey. Our survey is further focused and can serve those who approximating deeper insight for routing issues and techniques in WSN. To the most excellent of our information, moreover, our work reflects the current state of art in routing research by including a comprehensive list of recently proposed routing protocols. Taxonomy of the different architectural attributes of sensor networks is developed in [13]. This work gives a high-level description of what is considered typical sensor network architecture along with its components. Sensor networks are classified by considering several architectural factors such as network dynamics and the data delivery model. Such classification is helpful for a designer to select the appropriate infrastructure for his/her application. However, the paper neither describes any routing protocol nor talks about the potential effects of infrastructure design on route setup. Our work is a dedicated study of the network layer, describing and categorizing the different approaches for data routing. In addition, we summarize different architectural design issues that may affect the performance of routing protocols.

III. DEMANDING FACTORS DISTRESSING THE DESIGN ISSUES FOR ENERGY-EFFICIENT ROUTING PROTOCOLS

WSNs, regardless of their countless applications, there several limitations about, mostly, incomplete energy deposits, limited processing power, and limited bandwidth of the wireless links connecting sensor nodes. One of the most significant design goals of WSNs is to go through data communication while trying, at the same time, to contribute to the longevity of the network and to preclude connectivity abasement through the use of aggressive energy management techniques. The design of energy-efficient routing protocols in WSNs is influenced by many challenging factors. These factors must get over before efficient communication can be achieved in WSNs.Here is a list of the most common factors affecting the routing protocols design [3]:

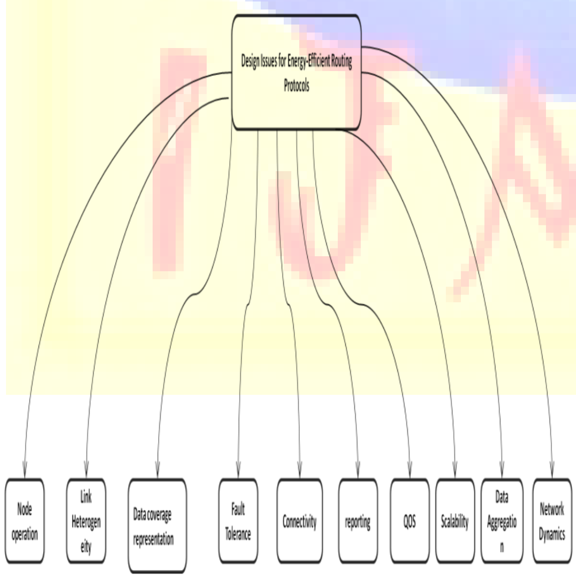


Fig 1 : issues for energy-efficient routing protocols

Node operation, is an application reliant operation moving the routing protocol performance, and can be randomized. The survival of heterogeneous set of sensors gives rise to many technical problems related to data routing and they have to be overcome. Data sensing, measurement and reporting in WSNs is dependent on the application and the time criticality of the data reporting. Data reporting can be categorized as either time-driven (continuous), event-driven, query-driven, and hybrid [6]. In Energy Consumption scenario, energy-conserving mechanisms of data communication and processing are more than necessary. Wireless sensor network routing protocols should be scalable enough to respond to events, e.g. huge increase of sensor nodes. Mobility of sensor nodes is necessary in many applications, despite the fact that most of the network architectures assume that sensor nodes are stationary [7]. The overall task of the sensor network should not be affected by the failure of sensor nodes.

Sensor nodes are expected to be highly connected. Connectivity depends on the random distribution of nodes. Transmission media in a multi-hop wireless sensor network has communicating nodes that are linked by a wireless medium. One approach of MAC design for sensor networks is to use TDMA based protocols that conserve more energy compared to contention based protocols like CSMA (e.g., IEEE 802.11). In WSNs, a given sensor's view of the environment is limited both in range and in accuracy. It can only cover a limited physical area of the environment. Quality of Service should be maintained so that data should be delivered within a certain period of time. However, in a good number of applications, conservation of energy, which is directly related to network lifetime, is considered relatively more important than the quality of data sent. Hence, energy-aware routing protocols are required to capture this requirement.

IV. PROTOCOL DESCRIPTION

In this section we describe the different steps of the protocol with the help of an example shown in

Fig. 2 (a).

A. Layer task

In the first step we assign a layer to each node to create a hierarchy in the network. For a given node at a particular layer, only nodes at lower layers can be selected as its parents. The base station is assigned to layer zero and the nodes connected to the base station are assigned to layer one.

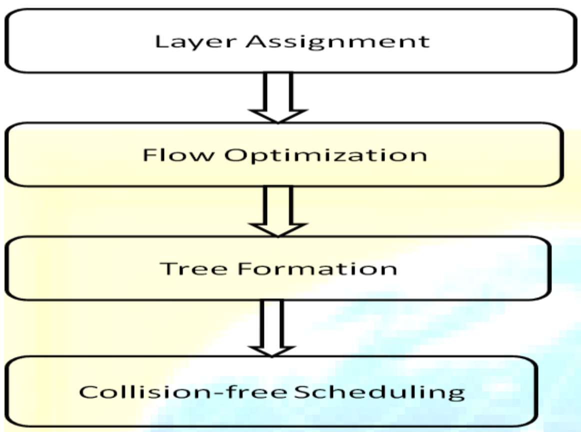
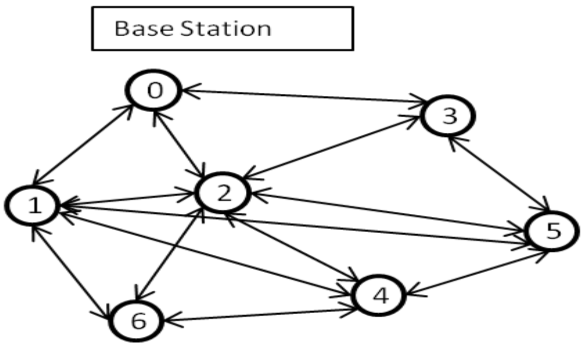
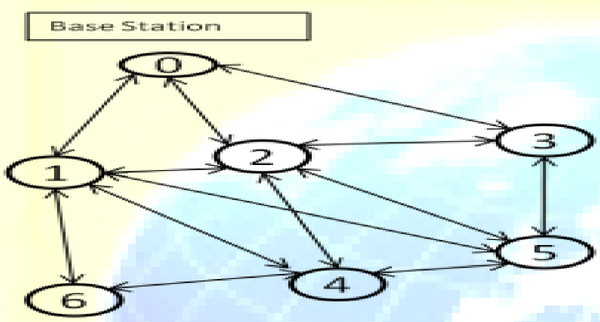


Fig 2: Layer task

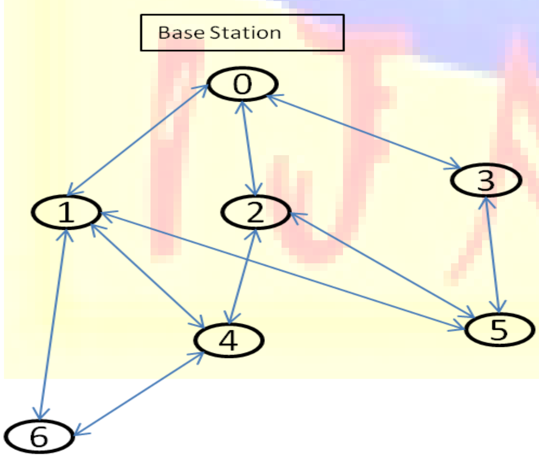
The algorithm (a) The network connectivity graph, (b) Graph after layer assignment, (c) Parent graph, (d) Optimal link usage distributions then starts assigning layers in the breadth-first order (finding the minimum possible layer for each node). Afterward, some of the nodes are moved to higher layers such that the number of potential parents for all nodes in the network is maximized. Algorithm describes the layer assignment procedure. Fig. 2 (b) shows the graph with node 6 in layer 3. In the original graph in (a), node 6 has only node 1 as a potential parent, but after moving node 6 to the third layer it can select node 4 in addition to node 1 as its parents. After layer assignment, all the links among nodes in the same layer are removed to create the parent graph shown in Fig. 2 (c). After the layer assignment, the parent and children sets (P_N, C_N) for each node are defined. The set of the potential parents of node n is denoted by P_N, and C_N is defined as the set of nodes that can select node n as their parent.


Base Station
0
3
1
2
5
4
6

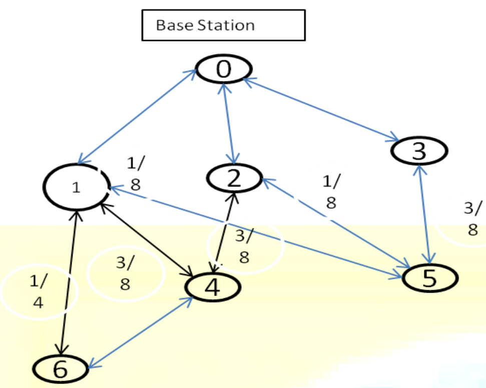
a)


Base Station
0
3
1
2
5
4
6

b)


Base Station
0
3
1
2
5
4
6

c)



d)

B. Flow Optimization

In this step, the algorithm determines the optimum percentage of time each parent should be used to balance the overall communication load. Based on the parent graph we calculate the optimal flow rates that minimize the maximum energy consumption among all nodes. We define the flow variables fnp between nodes N and P where node P is a potential parent of node N. The variable fnp shows the amount of data flow or equivalently percentage of time that node N uses its parent P. In general we have the following flow conservation equation where A_N denotes the amount of flow/data generated by node n and r $(0 \leq r \leq 1)$ shows the aggregation ratio. Equation (2) guarantees that the amount of flow coming out of a node is equal to what is generated by the node added to the total incoming flow after aggregation and preprocessing.

$$\sum_{P \in P_N} f_{NP} = s_N + r \sum_{c \in C_N} f_{cN}$$

For network supervision we can assume that the generated flow is constant for all nodes, i.e., sn = 1. Also the parent nodes can fully aggregate the collected data, so r is equal to zero. So for our problem (supervision/full aggregation) the flow conservation equation becomes Energy consumed by a node is determined by the amount of incoming flow from its children. From (1) we have where

$$e_N = h_1 \left(\sum_{c \in C_N} f_{cN}\right) + h_2$$

fcn_ shows the (average) number of children of node n. In order to maximize the network lifetime, we compute the flow rates {fij} to minimize the maximum energy consumption among all the nodes. This can be formulated as the following linear programming problem:

Minimize f_{max}

Subject to $\sum_{c \in C_N} f_{cN} \leq f_{max}, \quad \forall N,$

$\sum_{p \in P_N} f_{Np} = 1, \quad \forall N,$

$f_{ij} \geq 0, \quad \forall i, j.$

The variables are fij and fmax where fmax is the maximum incoming flow or equivalently the maximum number of children assigned to a node. The optimum values for the example network are shown in Fig. 2 (d).

C. Tree Formation

The algorithm constructs a set of trees based on the usage percentages obtained in the previous step. Each tree is used in one data collection cycle. The trees are formed such that the average use of each link/parent is close to the optimal distributions from flow calculation step. Let Q denote the total number of trees. In order to construct the trees, the first step is to find the number of usages Y_{Np} between a node n and its parents $p \in P_N$, such that during the total M data

transmission cycles the average usages $u_{Np}/\ Y$ are close to the optimal flow rate f_{Np}. Given the value of Q and flow rates f_{Np} we initially approximate the number of usages Y_{Np} for each node n by $u_{Nl} = [Qf_{nj}]$. Then we adjust the values of u_{np} such that is equal to Q. We form the set of trees by creating an X ×Q table such that each row of the table corresponds to a node and each column of the table corresponds to a data collection cycle .The element in ith row and jth column is the parent of node i at cycle j. We fill the elements of the X ×Q table row by row such that parent p appears exactly Y_{Np} times in row N. As long as the number of appearance of each node p in row N satisfies the usages values of Y_{Np}, no matter what the order of the elements in a row is, we get the same approximation to the optimal flow rates. We use the network in Fig. 2 (d) as an example to demonstrate how to fill the elements in the table. Given the fij and

Q = 8, we calculate uij, (e.g., u41 = 3, u42 = 5). Since nodes 1, 2, and 3 are connected to the base station, which will be their parent in all cycles, we fill 0 (base station) in rows 1, 2, and 3. For node 4 we know that during the 8 cycles, it should choose node 1 as its parent three times (u41 = 3) and node 2 as it parent five times (u42 = 5). So we fill three 1's and five 2's in the 4th row. Using the same method to fill the rows 5 and 6, we obtain Table I as the final tree table. Fig. 2 shows a set of eight trees for our example network. If the network uses only one data collection tree and does not change the tree over time, even in the most balanced tree there will be at least one node with one child. So the maximum number of children (over all nodes) will be at least one. However, by forming multiple trees and switching it over each data collection cycle, the maximum number of children can become less than one (as happened in our example case).

D. CGS

For each tree we create a collision-gratis schedule list. Each element in the list is a 4-tuple: (A,B, T, Z) which shows that sender s can transmit to receivers r ∈ B in time slot t using frequency channel Z. The algorithm adds elements (A,B, T, Z) one after another to the schedule list based on a greedy scheme. It starts from the first time slot and frequency channel, and tries to add as many schedules in the current time slot using current frequency channel. If no new schedule can be added, the algorithm moves to the next channel and once it goes through all the channels, it moves to the next time slot. When adding a schedule (A,B, T, Z) the algorithm checks the following conditions to ensure that the schedules are collision-free: Sender s and all receivers r ∈ B are not already scheduled in the current time slot T. No node in the interference range of sender A is scheduled to receive in time slot T and channel Z. No node in the interference range from any of receivers r ∈ B is scheduled to send in slot T and channel Z. The senders/receivers and the order in which the nodes are scheduled are determined by the packet exchange procedure and the acknowledgment mechanism. Fig. 2 illustrates the schedule order for a network with three layers. First step is to schedule all the nodes in layer three to send their messages to their parents. After that, all the layer two nodes are scheduled to send a combined acknowledgement to their children and parent. The retry slots are arranged after that. The calculated schedules are simply repeated to create the second retry opportunity. The procedure is repeated to calculate the schedule for next layers. If a child does not get the acknowledgement in the previous round and tries to send the message again, the parent should reply back with another ack. So even after the parent receives the message successfully, in the next retry slot for the same child, it goes to the receive mode for a short period of time and samples the signal level on the channel. If the parent senses a high signal it assumes that the node is trying to send the message again and since it already has the message it sends another acknowledgement in the next acknowledgement time slot. Note that sampling signal level consumes much less energy than receiving the whole packet.

V. CONCLUSIONS

A protocol description algorithm for management or data compilation in wireless sensor network was proposed. We primary showed that the energy expenditure speed can be abridged by minimizing the *standard* number of children. Then, by making the network topology active, the near-optimal network lifetime was achieved. Our proposed scheduling algorithm includes a retransmission mechanism which allocates many retry opportunities to assurance high consistency of the protocol. Simulations were conducted to verify the optimality of the proposed methods.

VI. REFERENCES

[1] Huang Lee, Abtin Keshavarzian., Towards Energy-optimal and Reliable Data Collection via Collision-free Scheduling in Wireless Sensor Networks, IEEE INFOCOM 2008 .

[2] Z. Yuan, L. Wang, Lei Shu, T. Hara, Z. Qin. A Balanced Energy Consumption Sleep Scheduling Algorithm in Wireless Sensor Networks. In the 7th International Wireless Communications & Mobile Computing Conference (IWCMC 2011), Istanbul, Turkey, July 5-8, 2011.

[3] Lei Shu, Y. Zhang, L. Yang, Y. Wang, M. Hauswirth, N. Xiong, TPGF: Geographic Routing in Wireless Multimedia Sensor Networks. In Springer Journal of Telecommunication Systems (JTS), Vol. 44(1-2), 2010

[4] V. Raghunathan, S.Ganeriwal and M.Srivastava, "Emerging techniques for long lived wireless sensor networks," IEEE Communications Magazine, vol.44, no.4, pp. 108- 114, April 2006

[5] N. A. Pantazis and D. D. Vergados, "A survey on power control issues in wireless sensor networks", Journal IEEE Communications Surveys and Tutorials, Vol. 9, Pp. 86- 107, 2007

[6] S. Saxena, S. Mishra, A. Kumar and D. S. Chauhan, "Efficient Power Utilization Techniques for Wireless Sensor Networks–A Survey", International Journal on Computer Science and Engineering, vol.:3, Issue:2, Pp. 905-925, February 2011

[7] G. Halkes, T. V. Dam, and K. Langendoen. Comparing energy-saving MAC protocols for wireless sensor networks. ACM Mobile Networks and Applications, Vol. 10, Issue: 5, Pp.783–791, 2005.

[8] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "Wireless sensor networks : a survey," Computer Networks, vol. 38, pp. 393-422, 2002.

[9] S. Slijepcevic, and M. Potkonjak, "Power efficient organization of wireless sensor networks," in Proc. IEEE International Conference on Communications, Helsinki, Finland, 2001, vol. 2, pp. 472-476.

[10] B. Krishnamachari, and F. Ordónez, "Analysis of energy-efficient, fair routing in wireless sensor networks through non-linear optimization," in Proc. IEEE Vehicular Technology Conference – Fall, Orlando, FL, 2003, vol. 5, pp. 2844-2848.

[11] R.Dhaya , Dr.V.Sadasivam, Dr.R.Kanthavel," Reliable Point to Multipoint Hierarchical Routing in Scatternet Sensor Network", Int. J. Advanced Networking and Applications 738 Volume: 02, Issue: 04, Pages:738-744 (2011).

[12] A. Valera, W. Seah and S. Rao, "CHAMP: A Highly-Resilient and Energy-Efficient Routing Protocol for Mobile Ad hoc Networks", In Proceedings of 4th IEEE Conference on Mobile and Wireless Communications Networks (MWCN 2002), Sep 9 - 11, Stockholm, Sweden, 2002.

[13] Kiran Yadav, Jyotsna Singh and Bindu Singla, "Proactive Vs Reactive Protocols for Adhoc Networks," In Proceedings of the IEEE January 2005, Germany.