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Literature Review for Data Gathering in Wireless Sensor Networks

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Abstract: Wireless sensor networks constitute a special kind of ad hoc network. Fostered by recent advance in Micro-electro-mechanical system (MEMS) and wireless communication technology, sensor node can be made as very inexpensive while with certain calculation ability. Deployed in a large amount and by collaborative effort, these sensor nodes can finish lots of sensing task, data processing and communicating useful information. Data gathering is a broad research area in wireless sensor network. In wireless sensor network, it considers the problem of routing between the base station and remote data sources via intermediate sensor nodes in a hierarchical sensor network. Sensor nodes having limited and unreplenishable power resources, both path length and path energy cost are important metrics affecting sensor lifetime. In this paper it has to discuss the protocols have been developed to find the best energy efficient way to transmit the data collected to the base station (BS). LEACH, PEGASIS, and TEEN are some protocols developed to make this process more energy efficient and to have the best connectivity among the nodes.

Keywords*:* wireless sensor networks; energy efficiency; data gathering; LEACH; PEGASIS; and TEEN.

I. INTRODUCTION

Over the years, there have been recent advances in Microelectromechanical systems (MEMS)-based sensor technology, low-power analog and digital electronics, and low-power RF design have allowed the development relatively inexpensive and low-power wireless microsensors. Although these sensors are not as trustworthy or accurate as their expensive counterparts, macrosensors, their size and cost allows applications to network hundreds or thousands of these microsensors making it able to attain high quality, fault-tolerant sensing networks. Reliable monitoring different types of environments such as commercial or military applications are very vital [1, 2, and 3].

Hundreds even thousands of sensing nodes can be held in a microsensor networks. Since data gathering is relying on the large number of nodes to obtain high quality results, making them as cheap and energy-efficient as possible is sought-after. All of these nodes are to collect and transmit data and the data is transmitted to cluster heads (CH) before going to a control center or base station (BS). Knowing this, many routing protocols have been developed to find the best energy-efficient way to transmit the data collected to the BS. LEACH, PEGASIS, and TEEN are some protocols developed to make this process more energy-efficient and to have the best connectivity among the nodes [4, 5].

II. FIRST ORDER RADIO MODEL

Currently, there is a great deal of research in the area of low-energy radios. Different assumptions about the radio characteristics, including energy dissipation in the transmitting and receiving modes, will change the advantages of different protocols. In our work, we assume a simple model where the radio dissipates E_{elec} = 50 nJ/bit to run the transmitter or receiver circuitry and €amp = 100 pJ/bit/m2 for the transmitting amplifier to achieve an acceptable $\frac{E_b}{N_o}$ (see Figure 1 and Table 1). These parameters are slightly better than the current state-of-the-art in radio design1. We also assume an r^2 energy loss due to channel transmission. Thus, to transmit a k-bit message to a distance d using our radio model, the radio expends:

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

$$E_{Tx}(k,d) = E_{elec} * k + €_{amp} * k * d^2 \qquad (1)$$

And to receive this message, the radio expends:

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

$$E_{Rx}(k) = E_{elec} * k \qquad (2)$$

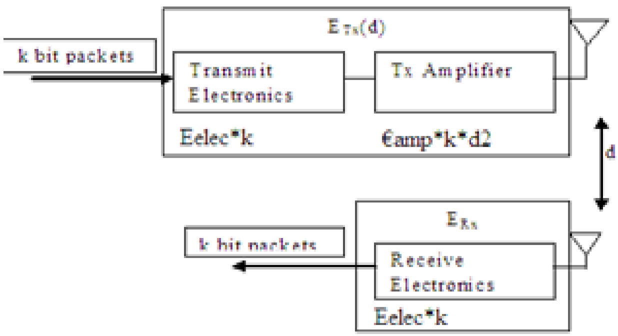

Figure: 1 First Order radio Model

Table 1. Radio Characteristics

Operation	Energy Dissipated
Transmitter Electronics($E_{Tx\text{-}elec}$) Receiver Electronics($E_{Rx\text{-}elec}$) ($E_{Tx\text{-}elec}$=$E_{Rx\text{-}elec}$=E_{elec})	50nJ/bit
Transmit Amplifier(E_{amp})	100pJ/bit/m^2

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

$$E_{Tx}(k,d) = E_{elec} * k + €_{amp} * k * d^2 \qquad (1)$$

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

$E_{Rx}(k) = E_{elec} * k$ (2)

For these parameter values, receiving a message is not a low cost operation; the protocols should thus try to minimize not only the transmitting distances but also the number of transmitting and receiving operations for each message[1][6,7,8].

We make the assumption that the radio channel is symmetric such that the energy required to transmit a message from node A to node B is the same as the energy required to transmit a message from node B to node A for a given SNR. For our experiments, we also assume that all sensors are sensing the environment at a fixed rate and thus always have data to send to the end-user. For future versions of our protocol, we will implement an"event-driven" simulation, where sensors only transmit data if some event occurs in the environment.

III. DIRECT TRANSMISSION

Using a direct communication protocol, each sensor sends its data directly to the base station. If the base station is far away from the nodes, direct communication will require a large amount of transmit power from each node (since d in Equation 1 is large). This will quickly drain the battery of the nodes and reduce the system lifetime [1]. However, the only receptions in this protocol occur at the base station, so if either the base station is close to the nodes, or the energy required to receive data is large, this may be an acceptable (and possibly optimal) method of communication. While direct transmission is a simple method, it is also very ineffective. In addition, sensor nodes must take turns when transmitting data to the base station to avoid collision. Thus, the delay is also very high. Overall, direct transmission method performs very poorly since the aim of data gathering approaches is to minimize both the energy consumption and the delay

IV. LEACH

LEACH is a self-organizing, adaptive clustering protocol that uses randomization to distribute the energy load evenly among the sensors in the network [1]. Looking back at the old algorithms, one could see how picking a random sensor and having it fixed to be the CH through the system lifetime that it would die very quickly cutting short the lifetime of all other nodes belonging to the cluster. LEACH changes this by randomly rotating among the various sensors in order to not drain the battery of a single sensor. Also, it reduces more energy dissipation and enhancing system lifetime by performing local data fusion to compress the amount of data being sent from the clusters to the base station.

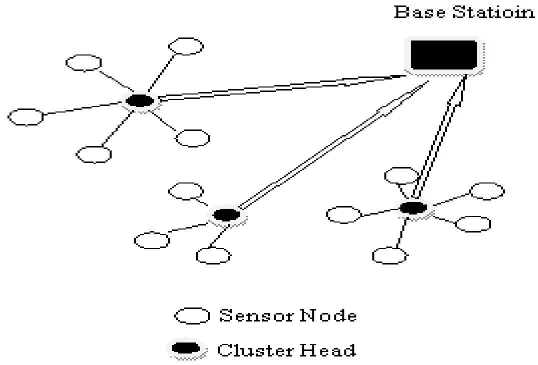

Figure 2. Graph showing construction of cluster in LEACH

Sensors elect themselves to be local CHs at any given time with certain probability and these CH nodes broadcast their status to the other sensors in the network [1][10]. The sensor nodes then chooses a cluster to be a part of by which CH requires the minimum communication energy. Although most of the time a sensor would choose the closest CH that connection could have a barrier interrupting the communication, so joining a cluster where the CH is further off would be much easier. When all of the sensors have been structured inside of each cluster, the CH creates a schedule for them in the cluster. This helps minimize the energy dissipated in the individual sensors, because it enables all non-CHs to shut off their radio components until their transmit time. Each sensor transmits its data to the CH and once the CH collects all of the data it aggregates it and transmits it to the BS. Normally the BS is a great distance away, so it will be high energy transmission. This method is described in figure2.

V. TEEN

Threshold sensitive Energy Efficient sensor Network protocol is said to be the first protocol developed for reactive networks. Reactive networks are networks where the nodes react immediately to sudden and drastic changes in the value of a sensed attribute [2]. In this protocol, with every cluster change time, in addition to the elements, the CH broadcasts to its members, a hard threshold and a soft threshold. A hard threshold is the threshold value for the sensed attribute and it is the absolute value of the attribute beyond which, the node sensing this value must switch on its transmitter and transmit [2]. A soft threshold is a small change in the value of the sensed attribute which triggers the node to switch on its transmitter and transmit [2]. The nodes in the environment sense the area continuously and the first time a parameter from the attribute set reaches its hard threshold, it switches on its transmitter and sends the sensed data.

VI. PEGASIS

Power-Efficient Gathering in Sensor Information System (PEGASIS) is the improved protocol where only one node is chosen as head node which sends the fused data to the BS per round. This achieves a factor of improvement of 2 compared to LEACH protocol [1]. PEGASIS protocol requires formation of chain which is achieved in two steps:

A. Chain Construction:

To construct the chain we start from the farthest node from the BS and then greedy approach is used to construct the chain.

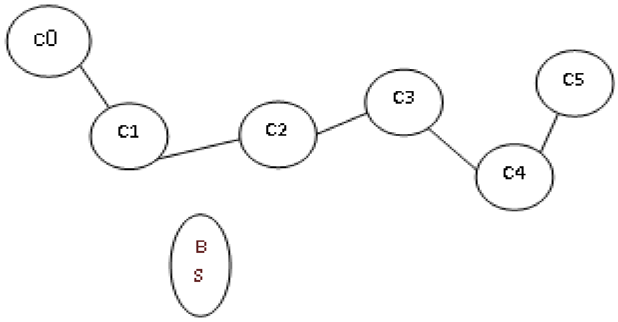

Figure 3. Graph showing construction of chain in PEGASIS using Greedy approach.

In figure 3, node c0 lies farthest from the base station, chain construction starts from node c0 which connects to node c1, node c1 connects to node c2, node c2 connects to node c3, and node c3 connects to node c4, node c4 connect to c5.

B. Gathering Data:

Leader of each round is selected randomly. Randomly selecting head node also provides benefit as it is more likely for nodes to die at random locations thus providing robust network. When a node dies chain is reconstructed to bypass the dead node [3].

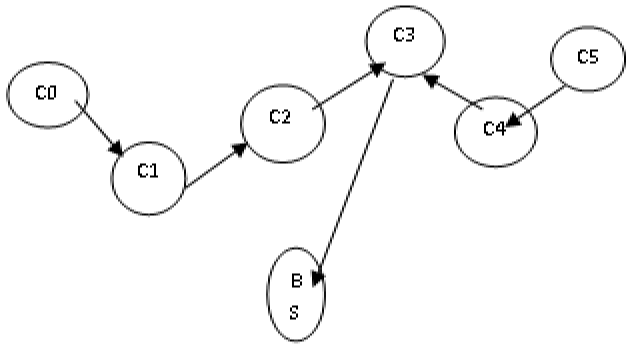

Figure 4. Describing data fusion at the head node and transmitting it to BS.

After the leader is selected it passes token to initiate data gathering process. Passing token also requires energy consumption but cost of passing token is very small because token size is very small. In figure4, node c3 is selected as head node for particular round. Node c5 passes the data to c3 along the chain. c0 passes the data to c3 along the chain. c3 receives the data, fuses all the data it has received and transmit to the base station.

Compare to LEACH transmitting distance for most of the node reduces in PEGASIS [4].Messages received by each head node are at most 2 in PEGASIS is less compared to LEACH [4].Experimental results show that PEGASIS provides improvement by factor 2 compared to LEACH protocol for 50m * 50m network and improvement by factor 3 for 100m * 100m network [4].Since each node gets selected once, energy dissipation is balanced among sensor nodes [4].PEGASIS has some drawbacks. When a head node is selected, there is no consideration how far the BS is located from the head node [5].When a head node is selected its energy level is not considered [5]. Since there is only one node head, it may be the bottle neck of the network causing delay [5].Redundant transmission of data as only one head node is selected [5].

VII. CONCLUSION

With the advances in technology, many things have enabled; things such as monitoring many environments whether it was weather or security of a building. In these environments, wireless sensors are dispersed to collect data, which makes the environments into wireless networks. Because of the sensors being inexpensive and low-powered, hundreds and thousands have to be dispersed for the data collected can be reliable. Also because transmitting, receiving, and fusing data takes energy, the sensors tend to die after a period of time so many protocols have been created to make this process more energy efficient.

Protocols such as LEACH, TEEN, and PEGASIS have been developed. Even though these protocols have minor problems, they each work respectively in their own environments. LEACH face high energy consumption problem and PEGASIS face extensive delay consumption. Then both has high energy*delay consumption problem. In future this paper has to create new algorithm on decreasing energy consumption for efficient data gathering.

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