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Energy Efficiency In Chain-Based Hierarchical Data Gathering Protocol For Wireless Sensor Networks

Namisha Bhateja
M.Tech (IT)
Chandigarh Engineering College, Landran

Sachin Majithia
Asst. Prof., IT Department
Chandigarh Engineering College, Landran

Abstract

Wireless sensor network nodes are very tiny in size and their cost is also not very high. They are deployed in any geographical region in a random fashion. During the process of data sensing, data gathering and data transmission, the charge of the power unit associated with any node gets low, after certain time, i.e., each node has its life time. The life time of nodes directly affect the life time of the sensor network. Therefore, it is very important to conserve the power of the nodes so that the life time of the entire network can be conserved. Hence the requirement of a power efficient data gathering protocol is very important to serve the purpose in wireless sensor network. In the proposed work, it is being tried to change the idea relating to the data gathering and transmission of the existing model, as, chain leaders belonging to certain covering angle will only transmit the gathered data to the another chain leader of the same covering angle. This research can provide better efficiency, resource consumption and longer network lifetime.

Keywords: Wireless Sensor Networks, CHIRON, Energy Efficiency

1. Introduction

1.1. Wireless Sensor Network

The early wireless system consisted of a base station with a high power transmitter and served a large geographic area. Each base station could serve only a small number of users and was costly as well. The systems were isolated from each other and only a few of them communicated with the public switched telephone networks. Today, the cellular systems consisted of a cluster of base station with low power radio transmitters. Each base station serves a small cell with in a large geographic area. The total number of users served is increased because of channel reuse and also larger frequency bandwidth. The cellular system connects with each other via mobile switching and direct access the public switched telephone networks.

A wireless sensor network (WSN) consists of spatially distributed *autonomous sensors* to monitor physical or environmental conditions, such as *temperature*, *sound*, *vibration*, *pressure*, motion or pollutants and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, enabling also to control the activity of the sensors. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer application, such as industrial process monitoring and control, machine health monitoring.

WSNs are networks of typically a large number of small nodes that communicate in a wireless way. Figure 1.1 shows the representation of wireless sensor networks.

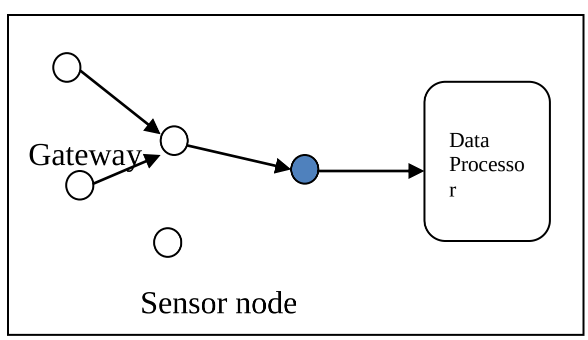

Fig 1.1 Representation of WSN

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The WSN is built of "nodes"- each node is connected to one or more sensors. A sensor node, also known as a mote (chiefly in *North America*), is a node in a *wireless sensor network* that is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network. A mote is a node but a node cannot always be a mote .The size of a single sensor node can vary from shoe box sized nodes down to devices the size of grain of dust, although functioning 'motes' of genuine microscopic dimensions have yet to be created.

1.2. Working of WSN

A typical wireless sensor network, shown in Figure1.2, consists of a base station and several nodes positioned in the environment. The base stations are one or more distinguished components of the WSN with much more computational, energy and communication resources. They act as a gateway between sensor nodes and the end user. Each node is expected to detect events. The resulting information at a node needs to be transmitted to the base station either directly or in “multi-hop” fashion. Implementation of such a network requires hardware components and corresponding software modules to program these components in a cooperative manner. A commercial hardware platform consists of processor cum radio boards commonly referred to as “*motes*”. Reception and transmission is available at different frequencies.

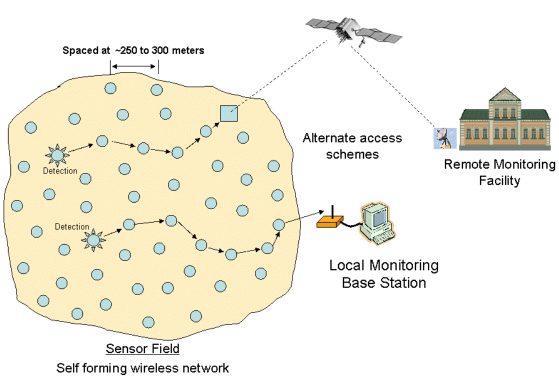

Fig 1.2 Wireless Sensor Networks

2. CHIRON

CHIRON is an Energy-Efficient Chain Based Hierarchical Routing Protocol which was proposed to alleviate the deficiencies of the previous chain-based routing protocols such as PEGASIS, EPEGASIS.

The common flaws of these protocols were data propagation delay and redundant transmissions. In CHIRON the sensing area is split into a number of smaller areas so that multiple shorter chains are formed to reduce the propagation delay and redundant path, and also conserve the energy of the sensor network.

2.1. Network Model Assumptions of CHIRON

A WSN of n energy-constrained sensor nodes is considered, which are randomly deployed over a sensing field. The BS is located at a corner of the sensing area, and equipped with a directional antenna and unlimited power. As a result, the BS can adaptively adjust its transmission power level and antenna direction to send control packets to all nodes in the WSN.

2.2. Basic Notations:

- ***R*:** the transmission range of the BS. For simplicity, we use distinct integers (1 … n) to represent various ranges.
- ***θ*:** the beam width (covering angle) of the directional antenna. Also, similar to the definition of R, different integers (1 … n) are used to indicate distinct angles.
- ***Gθ, R* :** the group id. Theoretically, by changing different values of θ and R, the sensing area can be divided into $n * n$ groups. Those are $G1, 1$, $G1, 2$, …, $G1, n$, …, $Gn, 1$, …, $Gn,, n$.
- ***ni*:** the node i; the node set $N=\{n1, n2, n3, …, ni\}$, where $1 \leqq i \leqq |N|$.
- ***cx,y*:** the id of a chain which was formed in group Gx,y. the chain set $C=\{c1,1, c1,2, ….\}$.
- ***lx,y*:** the leader node id of chain cx,y. The leader set $L=\{l1,1,l1,2, ….\}$.
- ***neighbor*(*ni*):** the neighboring nodes of ni. The neighboring nodes mean the nodes which are locating in the transmission range of a specific node.
- ***Res*(*ni*):** the residual energy of node ni.
- ***dis*(*x, y*):** the distance between nodes x and y. The BS can be deemed as a special sensor node.

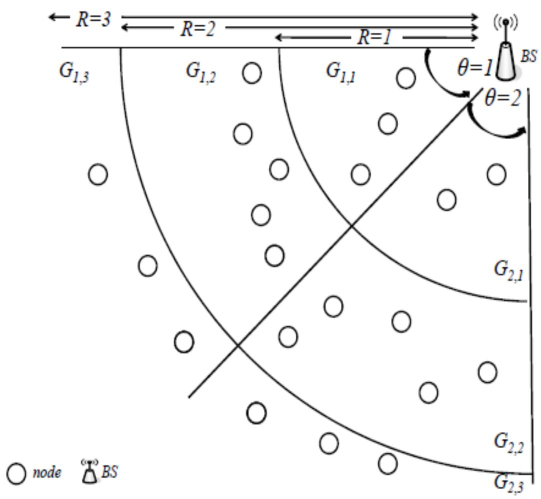

Fig.2.1 Grouping Example with R=1..3 and θ=1..2

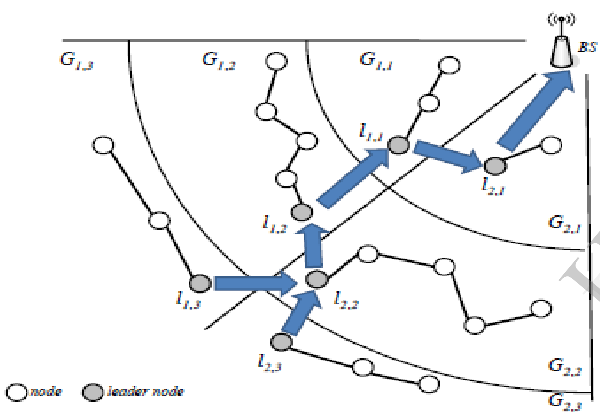

Fig.2.2 Data transmission in CHIRON

3. The Proposed Protocol – Energy Efficient Protocol

In our work, it is being tried to change the idea relating to the data gathering and transmission of the existing model, as, chain leaders belonging to certain covering angle will only transmit the gathered data to the another chain leader of the same covering angle. This research provides better efficiency, resource consumption and longer network lifetime.

3.1. Problem Formulation

The network model assumptions and the basic notations are same as used in CHIRON.

- The chain leaders belonging to certain covering angle will only transmit the gathered data to the other chain leader of the same covering angle.
- In this way, the data will be transmitted to the sink through multiple data streams, so that the burden of data transmission is being shared by the chain leaders of different covering angles, which will reduce the consumption of power required by head nodes to transmit huge amount of data through a single data stream.
- It is also expected that the model will reduce the latency, because the number of hops required for transmission of data through multiple streams are less than it required for a single data stream.

3.2. Working of Energy Efficient Protocol

The area is divided in smaller areas. The data from one chain leader is transmitted the next chain leader belonging to the same covering angle.

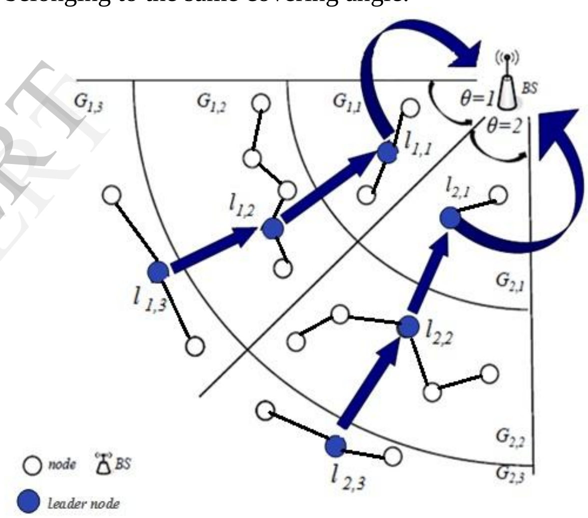

Fig 3.1 Data Transmission in Energy Efficient Protocol

4. Results

The results are simulated for the three areas: 100x100 m. sq. , 200x200 m. sq. and 300x300 m. sq. These results show that the number of nodes surviving at the particular time, are more than that in CHIRON.

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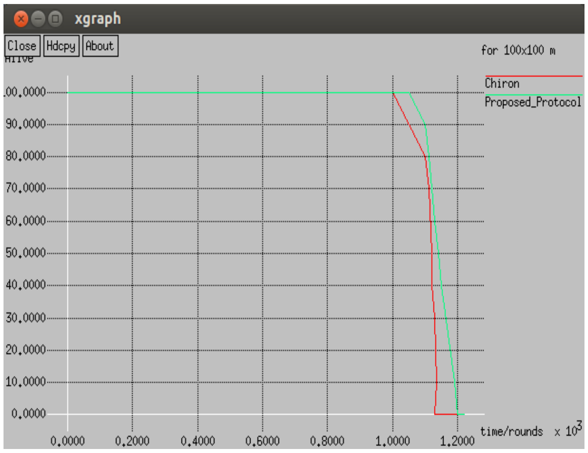

Fig.4.1.Network lifetime comparison in 100x100 m. sq. sensing area

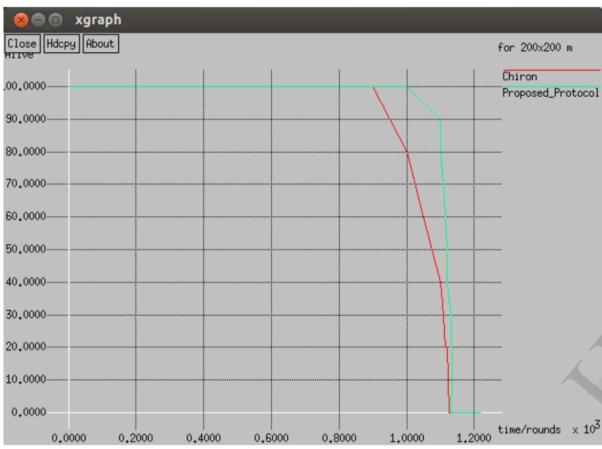

Fig.4.2.Network lifetime comparison in 200x200 m. sq. sensing area

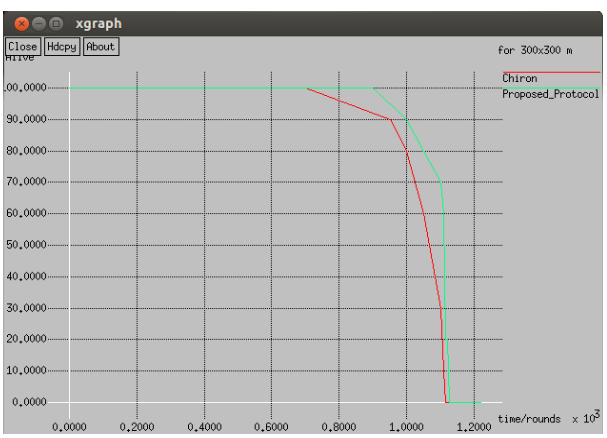

Fig.4.3.Network lifetime comparison in 300x300 m. sq. sensing area

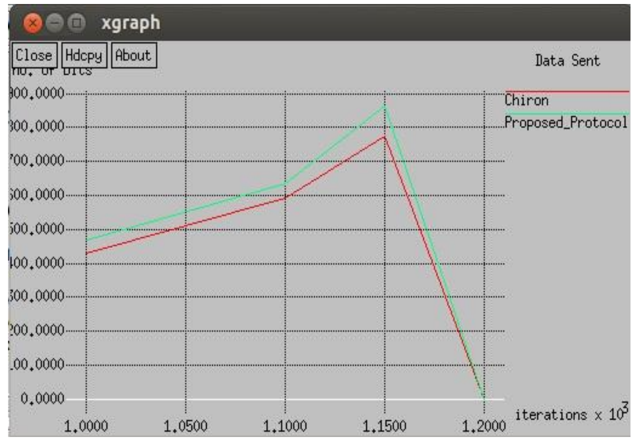

Fig.4.4.Comparison of Data sent in CHIRON and Energy Efficient Protocol

5. Conclusion

In our work the sensing field is divided into a number of smaller areas, and in those smaller areas, multiple shorter chains are created. The data transmission is through the chain leaders in each chain. Each chain leader transmits the data to the next chain leader in the same covering angle of the divided area. This increases the energy efficiency in data gathering in wireless sensor networks. Also, the latency is reduced because when the data travels in multiple streams, the congestion in network is less and hence, the delay is less. There is maximum utility and minimum usage of resources in terms of control plan functions. The performance of the transmission is improved by neighbor discovery.

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