Hierarchical centralized routing approach to optimize power consumption in wireless sensor networks

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Abstract— Wireless sensor network consists of hundreds or thousands of micro sensor nodes, networking together, allows user to accurately monitor a remote environment intelligently combining the data from the individual nodes. One of the most critical issues in wireless sensor networks is represented by the limited availability of energy on network nodes. For this we proposed a new protocol with named Hierarchical Centralized and Power optimized Routing Protocol (HCPOR). In HCPOR, initially the base station request to all nodes to send their neighbour list and residual energy. After having the information about the whole network, the base station performs computation to form the better cluster in such a way that there is less energy consumption. In HCPOR, the election of cluster heads is not randomized but is based on the residual energy of the cluster nodes and the logical structure of the whole network. So the life span of the whole network is increased.

Keywords:
WSN,BCDCP,LEACH,HCPOR,ADC,QOS(Quality of service

1.1 Wireless Sensor Node

A sensor node 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. The main components of a sensor node are microcontroller, transceiver, external memory, power source and one or more sensors.

1.2 Description of Wireless Sensor Network

Wireless sensor networks consist of many small compact devices, equipped with sensors (e.g. acoustic, seismic or image sensors), that form a wireless network. Each sensor node in the network collects information from its surroundings, and sends it to a base station, either from sensor node to sensor node i.e. multi hop, or directly to a base station i.e. single hop. Many Routing protocols are existent in the wireless sensor network. Depending on how the sender of a message gains a route to the receiver, routing protocols can be classified into three categories, namely, proactive [1], [2], reactive [3], [4], and hybrid protocols [5], [6]. In proactive protocols, all routes are computed before they are really needed, while in reactive protocols, routes are computed on demand. Hybrid protocols use a combination of these two ideas. According to nodes' participating style, routing protocols can be classified into three categories, namely, direct communication [7], flat [2], [8]–[9], and clustering protocols [1], [3], [9] In direct communication protocols, a sensor node sends data directly to the sink. Under this protocol, if the diameter of the network is large, the power of sensor

nodes will be drained very quickly. Furthermore, as the number of sensor nodes increases, collision becomes a significant factor which defeats the purpose of data transmission. Normally, the probability of participating in the data transmission process is higher for the nodes around the sink than those nodes far away from the sink. So, the nodes around the sink could run out of their power soon. In the clustered routing architecture, nodes are grouped into clusters, and a dedicated cluster head node collects, processes, and forwards the data from all the sensor nodes within its cluster. One of the most critical issues in wireless sensor networks is represented by the limited availability of energy on network nodes[43]; thus, making good use of energy is necessary to increase network lifetime.

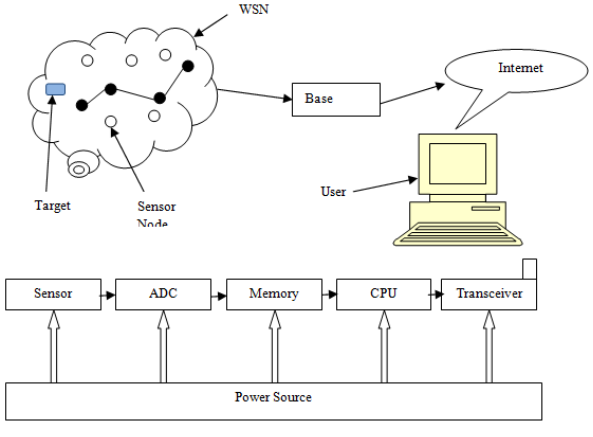

Figure 1.1: Wireless Sensor Network

1.3 Approaches used in routing protocols

Energy- Aware Routing [21] is designed to choose sub optimal paths using a probability function, which depends on the energy consumption of each path. By doing this, the hope is that the network lifetime will be extended to its fullest. One assumption that the protocol places on the overall network is that the nodes themselves are addressable via a class based addressing scheme, which includes the location and type of the node. Hierarchical Routing is divided in to two types.

(a)Non –Centralized Hierarchical Routing

(b) Centralized Hierarchical Routing

In non-centralized type of routing, the sensor nodes self configures for the cluster head. it includes **Low Energy Adaptive Cluster Hierarchy (LEACH)** which makes the use of local coordination among the nodes to enable scalability and robustness for sensor networks. So, LEACH is an energy conserving communication protocol where all the nodes in the network are uniform and energy constrained.

In centralized routing, the base station is responsible for formation of cluster head.

LEACH-C: A centralized version of LEACH, LEACH-C, is proposed in [11]. Unlike LEACH, where nodes self-configure themselves into clusters, LEACH-C utilizes the base station for cluster formation. The cluster groupings are chosen to minimize the energy required for non-cluster-head nodes to transmit their data to their respective cluster heads

Base station Controlled Dynamic Clustering Protocol (BCDCP):A centralized routing protocol called Base-Station Controlled Dynamic Clustering Protocol (BCDCP), which distributes the energy dissipation evenly among all sensor nodes to improve network lifetime and average energy savings. This protocol utilizes a high-energy base station to set up clusters and routing paths, perform randomized rotation of cluster heads, and carry out other energy-intensive tasks. The key ideas in BCDCP are the

formation of balanced clusters where each cluster head serves an approximately equal number of member nodes to avoid cluster head overload

1.4Proposed Work & Proposed Algorithm (Hierarchical Centralized and Power optimized Routing Protocol -HCPOR)

The foundation of HCPOR lies in the realization that the base station is a high-energy node with a large amount of energy supply. Thus, HCPOR utilizes the base station to control the coordinated sensing task performed by the sensor nodes. In HCPOR the following assumption are to be considered.

• A fixed base station is located far away from the sensor nodes.

• The sensor nodes are energy constrained with a uniform initial energy allocation.

• The nodes are equipped with power control capabilities to vary their transmitted power.

• Each node senses the environment at a fixed rate and always has data to send to the base station.

• All sensor nodes are immobile.

The sensor nodes are geographically grouped into clusters and capable of operating in two basic modes:

• The cluster head mode

• The sensing mode

1.5 Methodology:

Step 1: Initially, base station deploys the nodes in Network area with constant energy E.

Step 2: After receiving the "START" message, each node broadcasts the hello message "HELLO". Each node receiving hello message "HELLO" sends "REPLY" message containing its ID. When a node gets reply, it will note down the ID of the node from where the reply has been acknowledged. In this way each node will have their individual routing table.

Step 3: After receiving the information about their neighbours the nodes, for which the base station is within their range, sends a STATUS message to the base station. This STATUS includes ID, routing table, and Energy of the node. Base station sends an acknowledge (ACK) to all sending nodes.

Step 4: After acquiring acknowledge ACK, the nodes declare itself as parent node and broadcast to all its neighbouring nodes.

Step5: the node receiving the parent node's message will check their status whether it is parent node or not, if it is not a parent node then it will become a child node of the parent, from where it has received the parent node message first.

Step6: parent nodes send the STATUS to its grand-parent or direct to Base Station.

Step7: The nodes which are directly sending the STATUS to Base Station, becomes the Cluster Head for the current round. Steps 5-7are repeated until single node is alive.

Step8: For second round the nodes directly communication with Base Station and having max. Energy becomes the Cluster Head.

STEP9: Cluster Head will receive data from nodes that comes in its cluster area.

Step10: After collecting data, Cluster Head sends the aggregated data to the Base Station.

Steps 9-10 are repeated until system is alive.

Each node, during its allocated transmission time, sends to the cluster head quantitative data concerning the sensed events. Each cluster head receives the data

from its cluster nodes. The base station collects all the messages transmitted to it.

1.6 Simulation Result

Simulation is a relatively fast means to obtain an estimate of network performance and tuning. There are the most widely used simulators for WSNs are Omnet++ [39], CASTALIA [40], Network Simulator 2 (ns-2) [41], and Java Simulator (J-Sim) [42].

To access the performance of HCPOR, we simulated HCPOR using OMNET++ and compared its performance with other centralized based clustering routing protocol BCDCP and LEACH-C using MATLAB. Performance is measured by quantities matrices of average energy dissipation, system lifetime and number of nodes that are alive. Throughout the simulations we consider network node configuration with 100 nodes where, each node is assigned an initial energy of 2J.

Figure 1.3 shows the average energy dissipation of the protocols under study over the number of rounds of operation. This plot clearly shows that HCPOR has a much more desirable energy expenditure curve than that of BCDCP and LEACH-C.

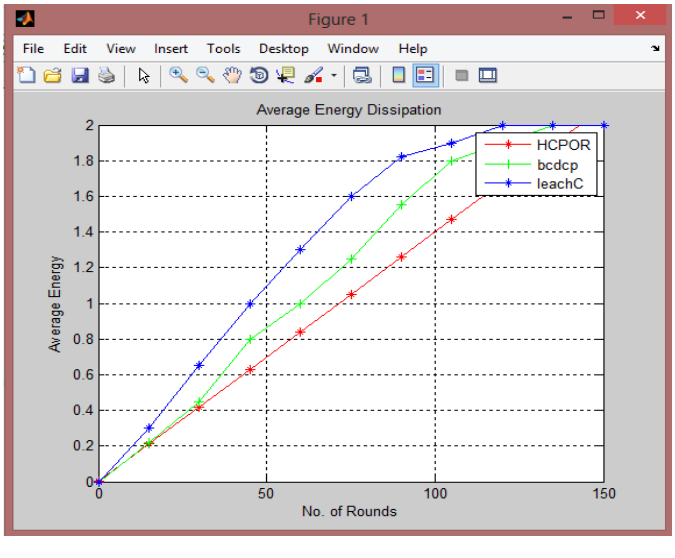

Figure 1.2: A Comparison of HCPOR's Avg. energy dissipation with other centralized routing protocol LEACH-C and BCDCP.

Finally, HCPOR is compared with already developed routing protocol Low Energy Adaptive Clustering Hierarchy-Centralized (LEACH-C). A comparison between two is done on the basis of energy dissipation with time and the system lifetime of network. System lifetime is basically for how long the system works.

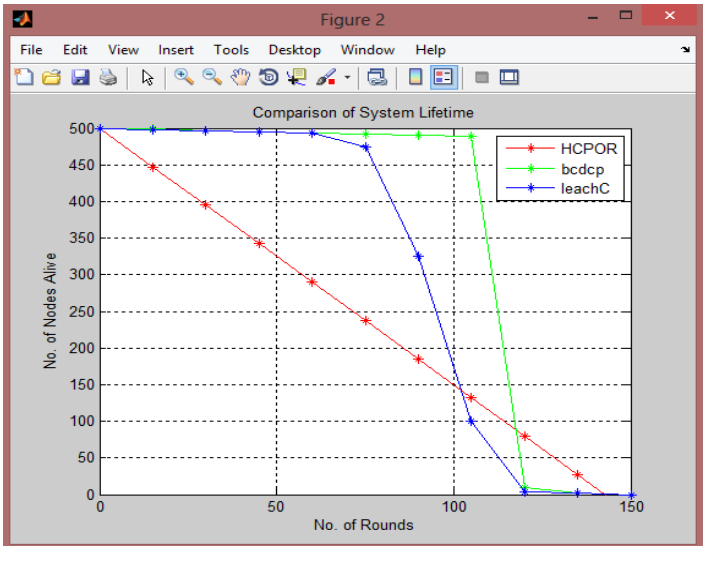

Figure 1.3: Comparison of HCPOR's System lifetime with other centralized clustering based routing protocol LEACH-C and BCDCP.

1.7 Conclusion and Future Scope

A wireless sensor network is a multi-hop ad hoc network of hundreds or thousands of sensor devices. The sensor nodes collect useful information such as sound, temperature, and light. Moreover, they play a role as the router by communicating through wireless channels under battery-constraints. In this work, we look at routing protocols, which can have a significant impact on the overall reliability and energy dissipation of these networks.

It is a fact that the batteries of sensor nodes have a restricted lifetime and are difficult to be replaced. Therefore, all protocols must be designed in such a way as to minimize energy consumption and preserve the longevity of the network. That is why, routing protocols in WSNs aim mainly to accomplish power conservation while in traditional networks they focus primarily on the Quality of Service (QoS).

This new routing protocol named Hierarchical Centralized & Power optimization Routing Protocol (HCPOR) which is hierarchical routing based with the whole control to the base station or we can say that base assisted. Basically, the question is how the cluster formation between the senor nodes will be? In non-centralized hierarchical routing, sensor nodes self configure them for the formation of cluster head. While self configuring, the nodes are unaware about the whole logical structure of the network. But in HCPOR, the base station first collects information about the logical structure of the network and residual energy of each node. So, with the global information about the network base station does cluster formation better in the sense that it has information about the residual energy of each node. The designed protocol HCPOR is simulated in OMNET++.OMNeT++ is a public-source, component-based, modular and open-architecture simulation environment with strong GUI support and an embeddable simulation kernel. It provides component architecture for models. Components (modules) are programmed in C++, and then assembled into larger components and models using a high-level language (NED).It runs well on LINUX, most other Unix-like systems, Win32 platforms (NT4.0, Window 2000, XP).

Finally, HCPOR is compared with already developed routing protocol Low Energy Adaptive Clustering Hierarchy-Centralized (LEACH-C) by the help of MATLAB. A comparison between two is done on the basis of energy dissipation with time and the system lifetime of network. System lifetime is basically for how long the system works.

In WSN, hundreds or thousands of sensor nodes are randomly scattered in the sensor field. These nodes sense the data and send this sensed data to the cluster head (in case of hierarchical routing) or directly to the base station according to the TDMA (time division multiplexing access) given by cluster head or base station resp. But there is no security and authentication while communicating. So this can be another research area where this can be considered. So in future, security can be applied to HCPOR.

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