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ENERGY EFFICIENCY IN WIRELESS SENSOR NETWORKS

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Abstract: An important problem of the wireless sensor networks is the energy consumption. Each node of the wireless sensor network is equipped with a battery so the entire wireless sensor network has a limited energy. The lifetime of the wireless sensor network strongly depends on how efficiently the energy is distributed to its nodes. The wireless sensor networks nodes use their energy on sending or receiving data from or to their neighbors. The nodes can rout information using long or short paths. Implementing a method which can calculate the shortest path between two nodes can be a solution on efficiently spending the wireless sensor networks energy. In this paper is presented a method consisting in finding the shortest path to rout information between two nodes. This method is in fact a static routing method based on the sink tree methodology.
Keywords: wireless sensor networks, energy consumption, networks nodes , rout information

1. INTRODUCTION

Wireless sensor networks are based of sensors that are distributed on a large area for monitoring physical or environmental conditions. Nowadays applications require that the sensors should be autonomous. The wireless sensor networks are equipped with sensors which are battery powered, have a radio communication and cooperatively pass their data through the network to a main location. Although the first studies of the wireless sensor networks were made for military purposes, they impose in large ranges of applications: military, industrial, medical, domestic automations, environment monitor, transports because of their reliability, precision, flexibility, low cost materials [1].

The main constrains of wireless sensor networks are:

≡ nodes distribution: the location of the nodes can be distributed deterministic or stochastic and is strictly depending on the application, the nodes distribution affects directly the networks communication performances. In the deterministic distribution case the nodes are placed manually while in the stochastic distribution case the nodes are placed randomly.

≡ energy consumption: a very important issue is minimizing the energy consumption without affecting the data accuracy. The nodes have their own limited source of energy that is why we need communication and data processing techniques that minimize the local energy consumption.

≡ scalability: the number of the nodes placed in the monitoring area is very large. In some application it can reach hundreds or thousands of nodes.

≡ coverage: a networks sensor obtains and provides some specific information of the monitored environment.

≡ fault tolerance: sometimes some networks nodes temporary interrupt working because of an energy lack, a physical fault, or because of the environment inferences, but the global functionality of the network doesn't need to suffer.

≡ connectivity: It is said that a wireless sensor network is strongly interconnected due to the large density of the nodes which prevent nodes to isolate one from another.

≡ the transmission environment: due to the fact that in the multi-hop wireless sensor networks the communication between two nodes is realized wireless the problems that appear in the wireless communication may affect the functionality of the entire network.

≡ data aggregation: due to the fact that more sensors are placed in a large area and monitor the same physical parameters, they can provide redundant data [2] .

In case of a forest fire detection system, wireless sensor networks are used for monitoring temperature, humidity, smoke and gas detection. The main advantage of using wireless sensors network in a forest fire detection system is the possibility of maximizing the energy harvested within the environmental, financial and technical limitations:

- Harvard University developed in collaboration with AID Networks and Center for Integration of Medicine and Innovative Technology, a project called Code Blue, which consists of a wireless sensor network capable of monitoring the medical parameters of the hospitalized patients [3][4].
- Great Barrier Reef Ocean Observing System (GBROOS) is a wireless sensor network for ocean observing, placed on the Davis island area, in the north-east of Australia [5].
- Traceability System for Recirculation Aquaculture (RATS) is a wireless sensor network used for monitoring the water temperature, the salinity, the oxygen concentration and the PH from the aqua culture tanks [6].

The hardware progress and the wireless networks have contributed at the continuous development of the low power, cheap and small sensors.

Wireless sensor networks are reliable, precise, flexible, involve low costs, are easy to develop and that is why they are used in various fields.

More and more applications require wireless connection due to the disadvantages that wired connections have: wired devices can't be placed very close to the monitored phenomenon, limited devices mobility, high maintenance costs because of the large number of sensors that must gather data from large areas. However, in the specialized literature it is state that sending a single bit over radio is at least three orders of magnitude more expensive than executing a single instruction locally, so the wireless communication can have a higher cost in comparison with the local data processing [7].

2. SIMULATION STUDIES

The wireless sensor network consists of nodes or sensors which are distributed on a large area. The nodes gather information about the environment they are placed in.

The method we propose is a static routing tree introduced by its adjacency matrix.

In our studies we considered that the wireless sensor network can be seen as a routing tree where the first node is the root and all the other nodes of the network are the tree's branches. The wireless sensor networks tree is created by introducing the adjacency matrix, which elements are "0" if there is no edge between two nodes or "1" if there is an edge between the two nodes. The edge is created if there is an exchange of information between the wireless network sensors nodes. Also we can consider that the "0" from the adjacency matrix represent the sleeping mode of the wireless sensor networks nodes and the "1" the active mode of the wireless sensor networks nodes. In Figure 1 is presented the adjacency matrix for a wireless sensor network consisting of 30 nodes. We can see that the routing tree is not symmetric and also it is given the number of the edges of the tree, in this case 42 edges.

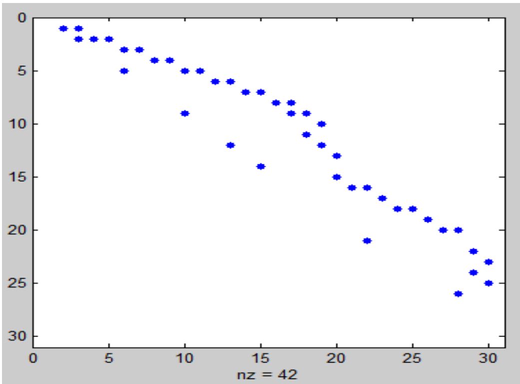

Figure 1. The adjacency matrix for a wireless sensor network of 30 nodes

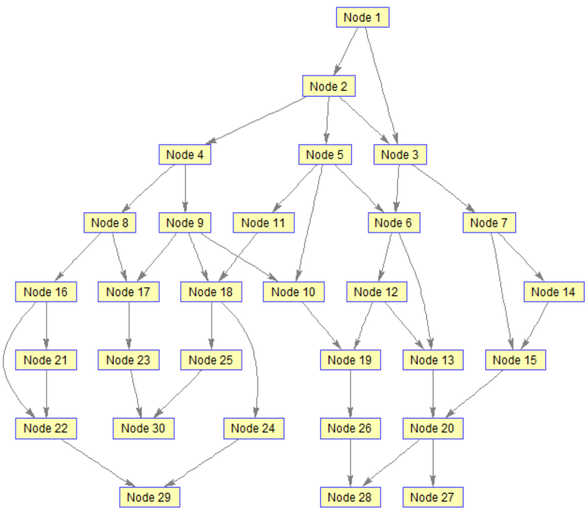

Figure 2. The routing tree for a wireless sensor network of 30 nodes

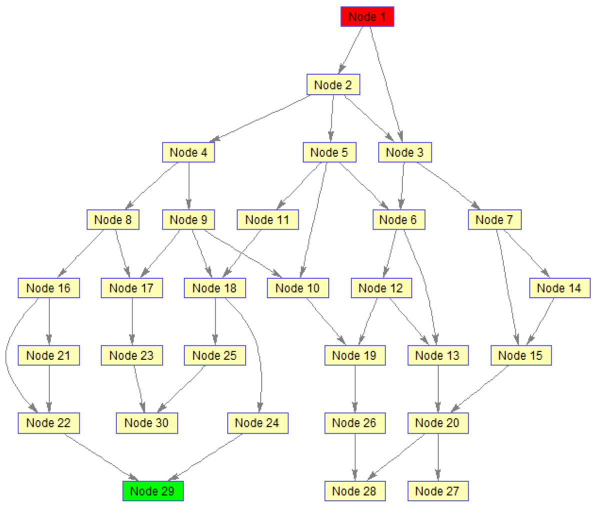

Figure 3. The routing tree for a wireless sensor network of 30 nodes

In Figure 2 is presented the routing tree created from the given adjacency matrix of a wireless sensor network consisting of 30 nodes. This routing tree is a static routing tree because the edges of the information are manually introduced by giving the adjacency matrix.

The main problem of a routing tree is how to find the shortest path between two given nodes so the energy of the nodes should not be wasted. This problem can be solved by using the sink tree methodology. The sink tree method provides a set of optimal paths from a given node considered to be the starting node to another given node considered to be the stop node.

In our studies we considered the starting node to be "Node 1" and the stopping node to be "Node 29", as it is presented in Figure 3.

The sink tree method provides all the optimal paths between "Node 1" and "Node 29", but the shortest path between the two nodes is the one who interests us, this path is presented in Figure 4. The nodes of the tree are in fact the sensors of a wireless sensor network so finding the shortest path between two nodes of the network can optimize the energy consumption. If the path is shorter the information has to travel a short distance between two nodes so the other nodes of the wireless sensor network can be in the sleeping mode while the nodes which create the path are the only active ones. So the nodes which are in sleeping mode only listen to the network without any energy consumption while the nodes which are in the active mode are the only ones which have energy consumption.

The number of edges between the two nodes is the one who creates the shortest path. In Figure 4 the number of edges of the shortest path between "Node 1" and "Node 29" is 6.

Using the sink tree method we can also determine the shortest paths from each node to all the other nodes of the wireless sensor network. The shortest paths from each node to all the other wireless sensor network nodes is presented in Figure 5.

The way that the number of the edges between the nodes influences the routing tree is presented in Fig. 6. For the given routing tree was made a scenario to illustrate how a node out of service can influence the entire topology of the routing tree. If a node is out of service the edges which he had with other nodes disappear. For the given adjacency matrix we studied the routing tree without a node, starting from "Node 30" and ending with "Node 15". So the adjacency matrix we used was from a 30 by 30 matrix to a 15 by 15 starting from the given adjacency matrix.

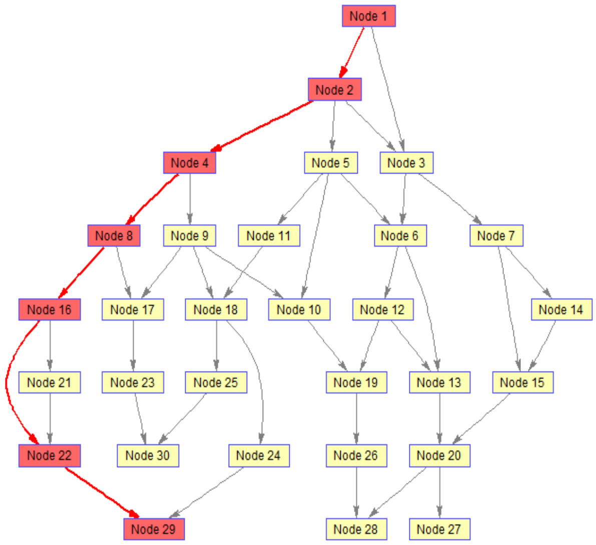

Figure 4. The shortest path between "Node 1" and "Node 29"

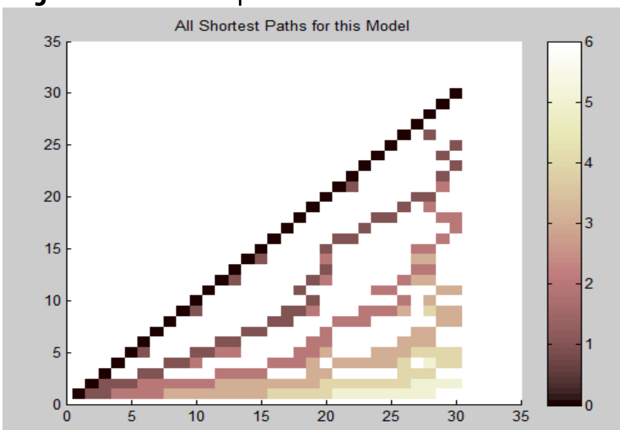

Figure 5. The shortest paths from each node to all the other nodes of the wireless sensor network

We can see that the number of communications between the wireless sensor nodes decreases.

3. CONCLUSIONS

An important problem of the wireless sensor networks is the energy consumption. Each node of the wireless sensor network is equipped with a battery so the entire wireless sensor network has a limited energy. The lifetime of the wireless sensor network strongly depends on how efficiently the energy is distributed to its nodes. The wireless sensor networks nodes use their energy on sending or receiving data from or to their neighbors. The nodes can rout information using long or short paths.

Implementing a method which can calculate the shortest path between two nodes can be a solution on efficiently spending the wireless sensor networks energy. In this paper is presented a method consisting in finding the shortest path to rout information between two nodes. This method is in fact a static routing method based on the sink tree methodology.

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The main problem of a routing tree is how to find the shortest path between two given nodes so the energy of the nodes should not be wasted. This problem can be solved by using the sink tree methodology. The sink tree method provides a set of optimal paths from a given node considered to be the starting node to another given node considered to be the stop nod.

The sink tree method is also useful for increasing the lifetime of the entire wireless sensor network because determining the shortest path that an information must cross from a starting node to a stop node is essential in wireless sensor networks. If we can determine the shortest path between two nodes the information is transmitted on that path, determining to be active only the nodes that compose this path while the other nodes may stay in the sleeping mode. So only the nodes which compose the path will consume energy while the nodes that are in the sleeping mode will not consume energy.

If a node is out of service the edges which he had with other nodes disappear, so he isn't consuming energy any more.

We can see that the number of communications between the wireless sensor nodes decreases.

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