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Introducing a Collaborative Approach to Improve the Lifetime and Energy Consumption in Wireless Sensor Networks

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Abstract

Utilizing interoperability in nodes is a good method used to maximize the lifetime of wireless sensor networks. One of the major challenges of wireless sensor networks is using publish broadcasts and irrelevant nodes that are used to send interest and discovering routing plan, which, with the increase of energy consumption due to increased traffic and additional processing, leads to increased mean intake, and ultimately reduce the lifetime of the network. The purpose of this article is to increase the lifetime of the network by restricting relative submission loads, turning off irrelevant nodes, and utilizing clustering techniques to achieve said goal. In the proposed procedure the sink node first produces an interest package to act as an agent with limited lifetime and sends it randomly to one neighbouring node so as to be processed in the network to find the source. In the proposed method, the operation of the irrelevant nodes is stopped and avoided and by using clustering techniques and interoperability, network lifetime is increased. The simulation results show that the proposed method, as compared to other methods, leads to reduced average energy consumption and traffic load, and an increase in delivery rates, which, in turn, means an increase in the network's lifetime. The proposed method, as compared to previous methods, has caused some slight network delay too.

Keywords

Wireless Sensor Networks, Node, Sink, Routing Based on Interoperability, Increasing Lifetime

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1. Introduction

A sensor network consists of many small sensor nodes, which are widely distributed in an environment, and gather information from the environment. The nodes relate to each other wirelessly, and each node works independently, without human intervention, and has limitations in processing power, memory, power supply, etc., and their location is not necessarily predetermined and evident. These characteristics provide the opportunity to leave them inrisky or inaccessible locations. These sensors gather information from the environment and, after initial processing, send the data to the monitoring stations, who, after processing and decision making,the desired action is executed by the relative part. Such a network expands simply by adding more nodes and requires no complex configuration. The general structure of a wireless sensor network is depicted in Figure 1.

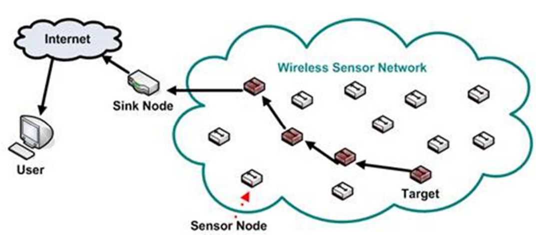

Figure 1. The general structure of the sensor network [1].

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In this paper, due to the limited energy of nodes and network traffic problem issues, we want to present an algorithm to reduce the average energy consumption, control network traffic,and prevent the activation of additional irrelevant nodes, and ultimately improve the network'slifetime compared to the earlier methods, and have theability to keep the network active forlonger.

2. Literature Review

In many applications, such as sensor networks, nodes are small and require little energy sources which in many cases are not rechargeable or replaceable; therefore, energy conservation is a determining factor in the lifetime of such networks. Therefore, the issues of performance and energy efficiency and communications on the basis of energy efficiency in sensor networks have received much attention in recent years. In this section, we review existing works on energy efficiency and cooperation in wireless sensor networks.

DD (Directed Diffusion) routing protocol has many benefits, but due to the inherent characteristics of WSN, it does not have a well aggregation of routing control to adapt to a dynamic topology and uncertain parameters. In [2] appropriate balance to control aggregation is considered, reliability of data gatheringis improved, and data gatheringtime delay and energy consumption are reduced. In the DD method, intended message and discovered data are sent as flooding and, therefore, their broadcast leads to increased energy consumption. Grid-based DD, presented in [3], is able to improve energy consumption. But data broadcasting is doneby the cluster-head nodes. In accordance with the different roles that a node can be used in, different regulatory approaches are used, which can discover malicious data and filter them out.The proposed scheme to collect reliable data does not use certification and cryptography, so it is light enough to be implemented in WSN with no overhead. DECSA routing algorithm, proposed in [4],regardsboth the criteria of distance and residual energy of the nodes that can improve cluster head selection process and data transmissions in the network.This method decreases the adverse effect on the energy of the sensors which is due to the fragmented distribution of nodes throughout the network, and prevents direct connection between the station and the cluster-head sensor. The proposed improved algorithm can balance the energy consumption. In [5], DD is simulated to act as a data gathering procedure and a dissemination paradigm for wireless sensor networks. In some circumstances and on the basis of DD as presented in [5] examples of this model are suggested to be usedto simulate DD In wireless sensor networks in regards to performance detection, performance evaluation, and analysis of design errors that lead to unpredictable results or performance violations. The efficiency ofDD is comparedin two modes, the first mode being sink cut pathway repair (SPR) and the second local lost path repair (LLPR), in which case the nodesare responsible for detecting, reporting, and adapting to dead nodes,so that the cut is properly detected and path repair is done at that point. Another method is presented in [6] to improve load balancing and energy consumption. In [7] the effects of the symmetrical and interoperate energy allocations are studied,in order to show when symmetry and/or inoperability are beneficial.In the proposed method,with consideration as to whether a certain node has a packet to send or not, the node is either activated or made dormant, and, ultimately, investigates energy delay. MPCR algorithm [8] allows full use of the shared communication routewhile providing a minimal power route, which it does in the form ofa wave of minimal power single relayedbuilding blocks from the source to the destination. In this algorithm, with throughput guarantee, all routes are used to find the optimal path. In [9], a new developed interoperate MAC protocol is suggested to improve the lifetime of WSN; BER analysis is used for M-QAMmodulation, and M-PSK for interoperate and non-interoperate circumstances. Cooperative MIMO schemes [10] can lower both send energy and energy consumption in WSN idle mode. In [11] the three cooperative MIMO schemes, Beam forming (BF), STBC, and Spatial Multiplex(SM), arecompared and it is shown that when send power is lowthe three MIMO schemes are better than SISO in terms of energy efficiency,while BF scheme is,in terms of energy efficiency and delay, better than SM and STBC. In [12, 14] an algorithm based on interoperability is used for clustering, and powerful and energy-efficient communication protocols are used to reduce energy consumption.

3. Defining the Problem

One of the major challenges for wireless sensor networks is routing,which is used to find the proper path of a source, which, in turn, leads to send/receive data optimal route selection. So far two methods have been proposed, hierarchical and flat routing, each with its own algorithms used for routing.

One of the most widely used and efficient routing methods, is Direct Diffusion or GuidedDiffusion, one of whose problems is using flood broadcasting to send interest packageswhich leads to wasting energy and theactivationof irrelevant nodes, which, ultimately, means their activation and eventually lower the sensor network's lifetime with increased traffic and energy consumption.

4. Proposed Method

As we know a routing algorithm based on interoperability, determines a route with the lowest send energy need and theenergy-aware algorithmprevents the use of nodes that are less energy efficient. In this section we present an algorithm that combines interoperability with energy-awareness by using the production of a factor and clustering to maximize the network'slifetime. In fact, interoperability of nodes is used in order to improve energy consumption and increase productivity, therefore this is done by energy savingand less use of irrelevant nodes (active-idle). One of the limitations in wireless sensor networks that produces additional traffic load and power consumption is "broadcastinginterest packets to find the location of the source",after which all nodes in the network are aware of the sink node's request.Our goal in designing this method, is to prevent unnecessary sending of these packets and, therefore, irrelevant node involvement,by using the nodes' interoperability feature, and, by utilizing clustering, to control data send, and, once again, to decrease the involvement of irrelevant nodes as well.

```
//parameters.
//Ci: Unic code for message.
//d: distance from sink.
//Si: sender node id.
//L: Life time for agent.
//A: Atribute of interest message
//V: Value of interest message.
//Hi: Neighbor nodes.
//N: Number of nods on network.
//CH: Cluster head.
//CHh[i]: Neighbor cluster.
//select a nod between neighbors randomly
Main(){
//Create Agent
            Si=RND*H[i];
            d=0;
            L=N/2;
//send interest for node Si
            Set L=L-1,d=d+1,Si=Sender id,Ci,A,V;
            Send_interest(L--,1,sink id,1,01,11);
                  If Si=Disable then
                        Enable Si;
                  End-if
  For i=0 to N
        If (val(Ni[A])=val(S[A]) and (val(Ni[V])= val(S[v])) ) then
            //Discover route
          Set path;
            store (list[i].list) ;

            //update message header and propagate it
            Update(L,d,Si,Ci,A,V);

            //Inform sink about finding event
            Send_msg_Update(Ni,S);
        Else
            //forward Message.
            Set L=L-1,d=d+1,Si=Sender id,Ci,A,V;
            Send_interest(Ni,CHi);
                  If CHi=Disable then
                        Enable CHi;
                  End-if

            R=RND*CHh[i];
            Send_interest(CHi,CHhi+1);
                  If CHhi=Disable then
                        Enable CHhi;
                  End-if
        End-if
Next i
}
```

Figure 2. How sink node operates.

The proposed method the sink node randomly sends an interest packet to a neighboring node at the start of the network. It does so by considering the packet's lifetime half the number of nodes in the network and records that value in the variable L, where for each interest packet distance D is equaled to zero by default, whereas the value of the variable Si, which is indicativeof the sender node, is set like its own characteristic code. Since each messagehas its own unique code, the sink node also chooses a unique code for its agent packet andcopies the type of attribute and value in the variable A and V. Each node, receiving the interest packet, checks whether there is a message from a source or not. If there was a source,forms the gradients from all the nodes it has received an interest packet from, and adds a unit to the distance counter distance, and will do specific updates after the formation of the data send gradient. Figure 2 shows how the sink node operates.

If a node discovers an event, it produces a packet with a specified lifetime, and randomly selects a neighbor,and processes the packet in the network until its lifetime is either exhausted or it encounters and interest packet. The operation the node takes at the time of the event and update is shown in Figure 3, and also the operation of proposed algorithm is shown in Fig 4.

```
Recive Event send Agent;
if Event=True then
        {
            Set L=L-1,d=d+1,Si=Sender id,Ci,A,V;
            Send_interest (L--,1,Node id,1,01,11);
                  If Si=Disable then
                        Enable Si;
                  End-if

For i=0 to N
        If (val(Ni[A])=val(S[A]) and (val(Ni[V])= val(S[v])) ) then
            //Discover route
          Set path;
            store (list[i].list) ;

            //update message header and propagate it
            Update(L,d,Si,Ci,A,V);
        Else
            //forward Message.
            Set L=L-1,d=d+1,Si=Sender id,Ci,A,V;
            Send_interest(Ni,CHi);
                  If CHi=Disable then
                        Enable CHi;
                  End-if

            R=RND*CHh[i];
            Send_interest(CHi,CHhi+1);
                  If CHhi=Disable then
                        Enable CHhi;
                  End-if
        End-if
Next i
}
```

Figure 3. How node operates at the time of event and update.

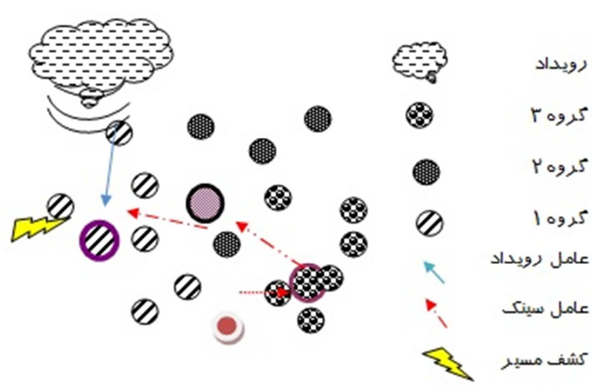

Figure 4. The operation of proposed algorithm.

5. Simulation

5.1. Simulation Details

Diffusion 3.2.0 code is used to implement the algorithm alongside the Ns-allinone-2.34 software package. In this package there are two versions of broadcast algorithm, which are Diffusion and Diffusion. 3; the proposed method is implemented by making changes in the Diffusion. 3 algorithm. In the simulation, atotal of 300 nodes in an area of 160x160 squared meters are used, and the test was carried out using 100-byte packets, sent usingthe standardIEEE 802.11b. The simulation details are presented in Table 1, whererouting protocol is Diffusion, and direct diffusion is done with Flooding filter.

Table 1. Parameters used in the simulation.

Parameter	Value
Routing Protocol	Diffusion
MAC Protocol	IEEE 802.11b
Radio Transmission Power	0.660mw
Radio Reception Power	0.395mw
Radio Idle Power	0.0375mw
Sensing Power	0.0325mw
Radio Propagation Model	Two-Ray
Packet Size	100 bytes
Data Rate	1Mbps
Radio Range	90 meter
Sensing Range	13 ~ 48 meter
Area	160m×160m
Number of nodes	300

5.2. Network Model and Energy

In the simulator Ns, the 802.11 protocol is used whensimulating wireless scenarios. Energy model and 802.11 parameters are in accordance with the main broadcasting and direct diffusion codes, and the amount of energy required are, respectively, 0.660 watts to send and 0.395 watts to receive data, which match the consumption of the PCM-CIA WLAN card introduced in Ns2.

6. Evaluation of the Proposed Method

In this section, simulation results are presented and relative graphs aredrawn. Comparisons are done based on the two direct diffusion filters; that is to say DD and the proposed method. Considering that DD broadcast results in the activation of disabled nodes, therefore we prevented such occurrence, as well as energy waste, using node interoperability. Furthermore, node distribution is done using random distribution and grid distribution. As can beseen in figures 4 and 5, average energy consumption shows obvious reduction compared to the previous method, but since in both random and grid distribution instances the clustering technique was used, therefore, compared to occurred distributions, the reduction is not much.

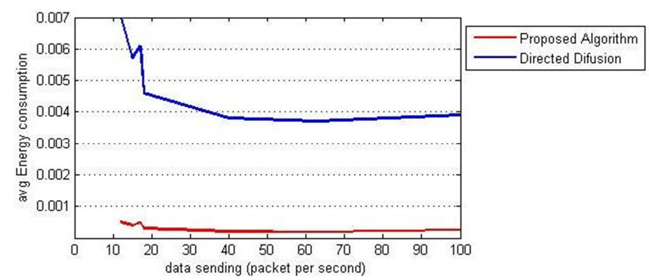

Figure 5. The diagram compares the average energy consumption per packet in a grid distribution.

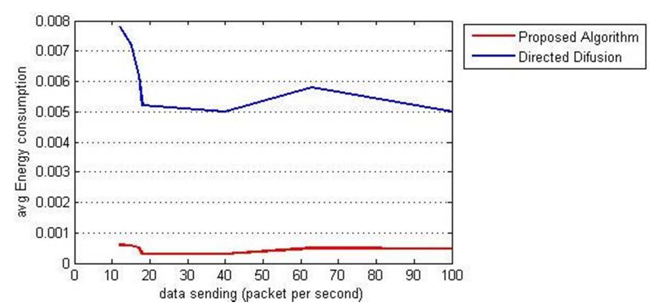

Figure 6. The diagram compares the average energy consumption per packet distributed at random.

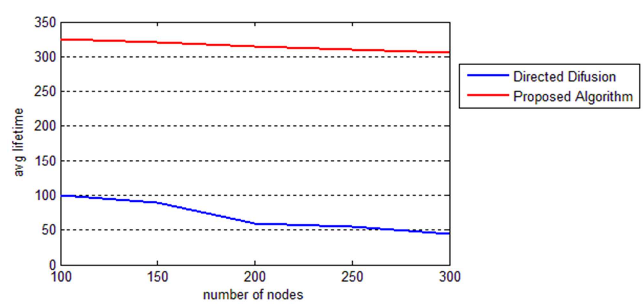

Figure 7. Comparison of network's lifetime when increasing number of nodes.

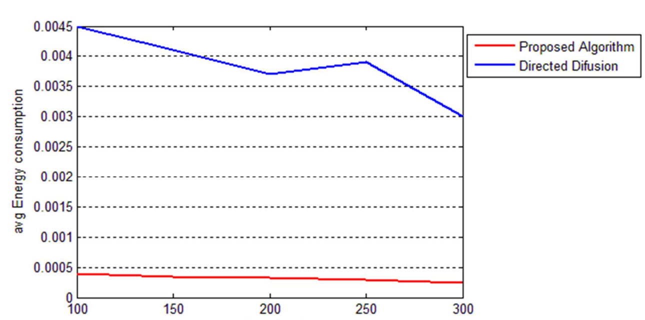

Figure 8. Comparison of average energy consumption when increasing number of nodes.

As shown in figure 6 and 7, it can be seen that with increasing the number of nodes, average energy consumption is increased as well, which has a great impact on the network's lifetime, andsince in the previous method all inactive and irrelevant nodes are used,consequently the total energy average is impacted too, and experiences great increase.But,since the proposed method uses interoperability, we could prevent the utilization of unnecessary nodes, decreasing total energy consumption, leading to an increase to the network'slifetime.

It should be noted that the Lifetime slope (Figure 8) forthe proposed method is softer than that of the Direct Diffusion's with flooding filter and does not jump either,whereas when the number of nodes increases from 150 to 200 in the previous method, there is a significant decline,which repeats itself when the number rises to 300 as well.

7. Conclusions

Some of the major challenges in wireless sensor networks are broadcasting and irrelevant nodes that are used to send interest and discovering routing maps. Bothhave high energy demands due to an increasingnetwork traffic and extra processing needs, which lead to a rise in average energy consumption, and, ultimately, reduce the lifetime of the network. The purpose of this paper is to increase the network's lifetime, which is achieved by limiting the volume of data packets,disabling irrelevant nodes, and taking advantage of the clustering technique. In the proposed method, first the sink node produces an interest packet with limited lifetime and sends it randomly to one of its neighbors to be processed in the network so as to find the source.On the one hand, all nodes are clustered based on energy and frequency range, and as soon as a node receives an interest packet or event, it is sent to the cluster-head node, and in the case of correspondence (attribute-value) the route is discovered, and if not, it is sent to a neighboring cluster-head node; on the other hand, with the occurrence of the first event, the first node to observe itproduces an agent packet again and sends it to the network for processing, and the route is discovered when the agent-interest packet's route intersects with that of the agent-event packet. In the proposed method,activation of irrelevant nodes is prevented using this algorithm, while, using the clustering technique and the interoperability feature, we increased the lifetime of the network. As for future works, we look to implement the competition between the head-clustersusing energy balancing, as well asto increase competition and balancing among nodes to become cluster-heads, and also to investigate reliability increases and fault-tolerance in another part.

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