Energy Efficient Aggregation in Wireless Sensor Networks with Some Selfish Nodes

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Abstract - *Wireless sensor networks are composed of distributed event-based sensors and a base station (sink) for data processing. These sensor networks contain severe energy constraints. Data aggregation mechanism combines several messages to reduce the energy consumption in these networks. In this paper, we present an energy efficient data aggregation mechanism for a wireless sensor network with some selfish nodes. Selfish nodes are those sensors that sense the environment conditions of the surroundings but gives either no or faulty values. Thus, these selfish nodes consume an extra amount of energy in sending the information to the sink individually. In this mechanism, the aggregation head node which is aggregating and transmitting the message to the base station is selected based on its energy and proximity to the base station (sink). The Participation relevance function is used by the nodes to participate in the aggregation process. The simulation result of this aggregation mechanism is shown in terms of number of dead nodes and the number of packets sent by aggregation head to the base station.*

Key Words: **LEACH, clusterhead, energy consumption, cluster selection.**

1.INTRODUCTION

The wireless sensor networks (WSNs) consist of a large amount of low-cost wireless nodes. Each node has computational power, sensing and communicating capability. The WSNs are getting more and more popular due to their wide range of applications, for example, vehicle tracking, environmental sensing medical monitoring and activity monitoring [1, 2]. Since the wireless nodes are powered by the non rechargeable and non changeable batteries, the power issue is very important in the case of wireless sensor networks. Moreover, the amount of energy consumption for communication is far better than the one used for processing. Thus, energy enhancement mechanisms focus on the optimization of the communication energy consumption. The energy of these sensor nodes can be saved through the data aggregation technology. Data aggregation recombines the information collected by a number of nodes into one message and transmits this message to the base station. The data aggregation increases the energy consumption in wireless sensor networks as shown in [3, 4, 5].

In this paper, we focus on data aggregation mechanism for wireless sensor network with some selfish nodes for energy saving. We propose a data aggregation algorithm in which the energy consumption is enhanced by choosing Energy Efficient Aggregation in Wireless Sensor Networks of the aggregator node (called aggregation head) and the participant nodes. The paper is organized as follows. The related work is presented in Section 2. In Section 3, we present our proposed work. The simulation results are given in Section 4. The conclusion and the future work are given in Section 5.

2. Related Works

A number of works deal with data aggregation in wireless sensor networks especially for the tree-based structure networks. The reliability of the communication in the WSN using an aggregation algorithm and message redundancy is discussed in [6, 7, 15].

i. **In [6, 15],** an aggregation algorithm against malicious attacks done by any compromised or faulty node in the network is presented by authors. In the proposed algorithm, a node broadcasts its total aggregated result estimation to all its neighbors instead of sensed information. This algorithm creates a tree for the aggregation and routing and guarantees the security of the algorithm by the messages redundancy.

ii. **Fauji et al. [7, 15]** presented an aggregation algorithm that is based on the spreading the information by means of gossip. In this algorithm, all the nodes are able to do selected message reception. The nodes can recognize the convergence of the aggregation early. Thus, this aggregation algorithm gives a better performance than the pure version of gossip in energy consumption. To enhance the lifetime of the sensor networks, the message redundancy is not the best choice to be used since it result into resources misuse.

iii. **Villas et al. [8, 15]** proposed to use a routing tree for data aggregation. The redundant data are aggregated at intermediate nodes to decrease the communication costs and energy consumption. This tree-based algorithm aims to construct the tree and to update it periodically which consumes an extra amount of energy.

iv. **Wen et al. [9, 15]** proposed a cluster-based data aggregation routing to reduce the energy consumption. The authors presented heuristics to construct the cluster based on the average energy consumption and the maximum number of source nodes. Compared to cluster-based algorithm (Highest Degree [HD], Lowest-ID Algorithm [LID], Average Energy Consumption [AEC], Low Energy Adaptive Clustering Hierarchy [LEACH] [10, 15], Low Energy Adaptive Clustering Hierarchy Centralized[LEACH-C][10, 15]), this technique improves the total energy consumption, but the energy cost is required in this algorithm to build the cluster based sensor network and update it. Most of the data aggregation algorithms are proposed for tree-based structure although they require high maintenance overhead. Thus, in this work, we are concerned with structure-free sensor networks.

v. **Chih-min et al. [11, 15]** presented a structure-free and energy balanced data aggregation technique for wireless sensor networks. This algorithm is composed of two parts. In the first part, some nodes are chosen as aggregators depending on their location and in the second part the aggregated data are sent to the sink. The authors assume that the nodes are synchronized and know their own location.

vi. **In [12, 15],** the authors presented a partial data aggregation technique. This paper discusses the tradeoffs between the data accuracy, transmission delay and energy consumption. The network model used here is a simple, and the results are not proved to be the same for more complex networks.

vii. **Sardouk et al. [13, 14, 15]** proposed a multi-agent data aggregation method for structure-free event-driven wireless sensor networks. Each sensor network decides whether to participate or not in a data aggregation session depending on: the importance of the information, its density, the criticism of its location and its residual energy. These constraints are weighted and used in the decision function and thus, enhances the energy consumption of the sensor network. However, the aggregator node is chosen depending on the event detection (the first node to detect an event is the aggregator node) and its residual energy is not considered. We note that most of data aggregation mechanisms are developed for the structure-based wireless sensor networks. Moreover, the data aggregation algorithms for structure-free sensor networks must to be improved to enhance the sensor network lifetime.

3. Proposed Work

In this paper, we focus on the structure-free wireless sensor networks. We use the decision metric presented in [13] to let the nodes decide if they participate in the data aggregation session or not. This decision metric called the participation relevance R in a data aggregation session is computed as

$$R = \alpha * E + \beta * (1/D) + \theta * P + \omega * I$$

where

– α, β, θ and ω are weighting factors,

– E is the residual energy,

– D is the density,

– P is the criticity of the node's position,

– I is the importance of the information

We propose to choose the aggregation head depending on its residual energy and its distance from the sink.

3.1 Aggregation Mechanism

Here, the energy consumption in data aggregation is discussed in detail. When the node i detects an event, it broadcasts a data aggregation request *AgRq* to all its neighbors (N neighbors). Let *EAgRq* be the energy needed to broadcast the data aggregation request. If i has *N* neighbors, N nodes will receive the message sent by i and consume *EAgRqR* in receiving the message. Each of these *N* nodes calculates its participation relevance metric to decide whether to participate in the current aggregation session. Each node accepting to participate sends an aggregation response *AgResp* message to the node *i*. Let *k* be the number of nodes participating in the aggregation session and *EAgResp* the energy consumed by the transmission of each aggregation response message[21]. The energy used by the aggregation *EiA* is given by

EiA= max_dis * *EAgRq* + *(k-s)* * *EAgRespR.* (1)

Here, *EAgRespR* is the energy consumed by the node i in receiving a data aggregation response message. s is the number of the selfish nodes that participates in aggregation session.

Let *ETX* and *ERX* be the energy needed to transmit and to receive a message. The energy used to transmit the message to the base station *ETT* is equal to

*ETT = distance * (ETX+ERX)*

The total energy consumption *E* using the aggregation mechanism is given by

$E = (ETX + EDA + EiA)$. (2)

The total energy consumption without using the aggregation mechanism is equal to

E =k * (ETX+EiA). (3)

Based on (2) and (3) we can notice that the energy consumed when aggregation is used can be highly lower if distance to the sink is small and if *EiA* corresponds to a reasonable amount.

3.2 Aggregation Head Selection

The aggregation head are the nodes which detect the event and initiate the aggregation session. This node sends the aggregation request, receives the aggregation responses and transmits the messages. Thus, it consumes

*Max_dis * EAgRq* + *(k-s) * EAgRespR* + distance * *ETX + EDA.*

Since, the aggregation head consumes more energy than the other nodes participating in the aggregation session, it should be selected carefully to increase the network lifetime and ensure better reception rate. The factors used to select a node *i* as an aggregation head are:

i. Its residual energy *Eres*

ii. Its distance from the sink

iii. Its identifier *id*

The aggregation algorithm is presented in Figure 4. The algorithm to select an aggregation head is as follows:

a. If a node *i* detects an event, *i* sets it to be the aggregation head (*AgHd =true*) and it sends an aggregation request message to its neighbors (*N*). The *AgRq* message contains the residual energy *Eres*, the distance to the base station *distance* and the node identifier *id*.

b. When receiving an *AgRq* message from a node *j*, the node *i* checks if he has detected the same event (*AgHd = true*). Then he decides if he is still the aggregation head by comparing first the residual energy, then the distance to reach the base station and finally the identifiers. Identifiers will specifically be used when two or more nodes have the same residual amounts of energy and are at same distance of the sink.

1: **while** true **do**

2: *AgHd* ← *false*;

3: **if** an event is detected **then**

4: *AgHd* ← *true*;

5: send AgReq(*Eires*,*distance*,*idi*);

6: initiate(timeout);

7: **end if**

8: **if** receive(AgRq(*Ejres*,distance,*idj*)) **then**

9: **if** *AgHd* = *true* **then**

```
if Ejres > Eires then
AgHd ← false;
else if distancej > distancei then
AgHd ← false;
else
if idj < idi then
AgHd ← false;
end if
end if
end if
if AgHd = false then
ParticiptationRelevance ←
    computeParticipationRelevance()
if ParticiptationRelevance > threshold then
send AgResp();
end if
end if
end if
if receive(AgResp) then
extract data from AgResp and compute aggregated data (mean) ;
end if
if timeout = 0 then
send aggregated data();
end if
end while
```

Figure 1 Data aggregation algorithm [15]

4. Simulation Results

This section describes the simulation results obtained using the MATLAB 7.12.0.635 (R2011a) .To have a fair comparison with the algorithm where all nodes send their data directly to the base station without aggregating we use same number of nodes in a network with same energy. The simulation result had been computed under two parameter settings. In all cases, the performance of the algorithm using the data aggregation in a network with selfish nodes gives better result. Hence, it is proved that our proposed algorithm performs well.

In this section we compare the performance of the data aggregation technique proposed for the WSN with selfish nodes by the WSN without selfish nodes. In order to evaluate the performance of our proposed algorithm, we use the sensor network lifetime metric by focusing on the failure time of each individual nodes in the network. We consider that when more than 50 nodes are dead, the wireless network loses its connectivity and the coverage of the sensed area.

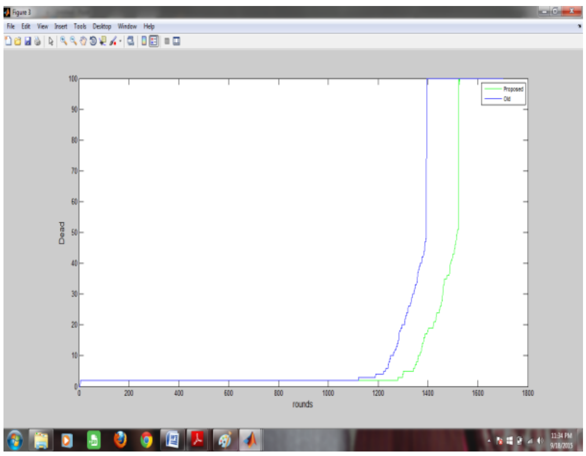

Figure 2 Graph generating the number of dead nodes for the WSN with selfish nodes compared to the network without selfish nodes.

Figure 2 presents the instants of death of different number of the sensor nodes (from 0 to 100) for 2 approaches: without data aggregation (called without aggregation) and with selfish nodes and other, with data aggregation and with selfish nodes. If we compare the number of dead sensor nodes for the sensor networks with and without data aggregation, we find that the sensor nodes without the data aggregation lose their energy before the one aggregating their messages. As first conclusion and contribution, the data aggregation mechanism improves the wireless sensor networks lifetime.

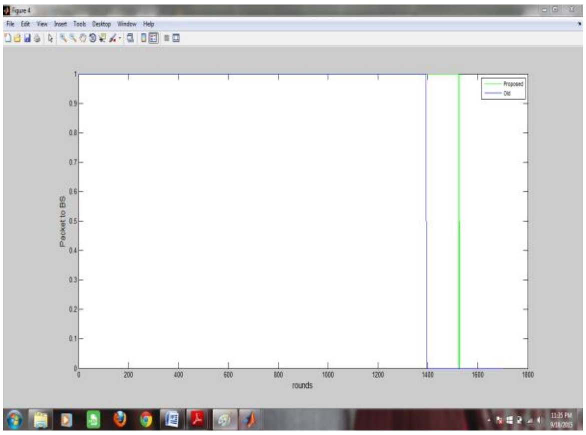

Figure 3 Graph generating the total number of sent packets to the sink

Figure 3 presents the instants of packets sent to the base station by the aggregation head (from 1 to 0).Again here if we compare the number of packets sent by the aggregation head to the base station with and without the data aggregation and selfish nodes, we find that the sensor nodes without the data aggregation lose their energy before the one aggregating their messages. As the second conclusion and contribution, the data aggregation mechanism enhances the wireless sensor networks throughput.

Thus, our proposed work has longer lifetime. This proves the efficiency of our solution.

5. Conclusion and Future Work

In this thesis, we proposed a data aggregation mechanism with a selection of the aggregation head. The simulation results show that this mechanism leads to the enhancement of the sensor network performance: lifetime and throughput. Here, the nodes are selected as an aggregation head based on their residual energy and their distance from the sink node. Nodes having more or equal energy than its initial energy always have higher chances to become an aggregation head, so the fair distribution of energy consumption is done.

Additional and advanced strategy to improve the performance of the wireless sensor network and make the network reliable and more efficient has to be desired. Some idea would be like that we can group the network into different clusters and select cluster head for each cluster and a single aggregation head for all clusters. We can also employ an energy-efficient security mechanism in heterogeneous sensor networks. This means, to achieve security in wireless sensor networks, efficient key distribution and management mechanisms have to be applied on lightweight sensors so that security is maintained.

5. References

[1] Sohraby,K., Minoli, D., Znati, T.:Wireless Sensor Networks Technology, Protocols, and Applications (2007)

[2] Song, Y.: Networked control systems: From independent designs of the network qos and the control to the co-design. In: 8th IFAC International Conference on Fieldbuses and Networks in Industrial and Embedded Systems (FET 2009) (2009)

[3] Krishnamachari, L., Estrin, D., Wicker, S.: The impact of data aggregation in wireless sensor networks. In: Proceedings of the 22nd International Conference on Distributed Computing Systems Workshops, pp. 575–578 (2002)

[4] Akkaya, K., Demirbas, M., Aygun, R.: The impact of data aggregation on the performance of wireless sensor networks. Wireless Communications and Mobile Computing 8(2), 171–193 (2008)

[5] Boulis, A.: Aggregation in sensor networks: an energy-accuracy trade-off. Ad Hoc Networks 1(2-3), 317–331 (2003)

[6] Sen, J.: A robust and secure aggregation protocol for wireless sensor networks. In: Proceedings of the 2011 Sixth IEEE International Symposium on Electronic Design, Test and Application, DELTA 2011, pp. 222–227. IEEE Computer Society, Washington, DC (2011)

[7] Fauji, S., Kalpakis, K.: A gossip-based energy efficient protocol for robust innetwork aggregation in wireless sensor networks. In: 2011 IEEE International Conference on Pervasive Computing and Communications Workshops (PERCOM Workshops), pp. 166–171 (March 2011)

[8] Villas, L., Boukerche, A., Filho, H.S.R., deOliveira, H.A.B.F., Araujo, R., Loureiro, A.A.F.: DRINA: A Lightweight and Reliable Routing Approach for in-Network Aggregation in Wireless Sensor Networks. IEEE Transactions on Computers 99 (2012) (PrePrints)

[9] Wen, Y.F., Anderson, T.A.F., Powers, D.M.W.: On energy-efficient aggregation routing and scheduling in IEEE 802.15.4-based wireless sensor networks. Wireless Communications and Mobile Computing (2012)

[10] Heinzelman, W.B., Chandrakasan, A.P., Balakrishnan, H.: An application-specific protocol architecture for wireless microsensor networks. IEEE Transactions on Wireless Communications 1(4), 660–670 (2002)

[11] Chao, C.M., Hsiao, T.Y.: Design of structure-free and energy-balanced data aggregation in wireless sensor networks. In: 11th IEEE International Conference on High Performance Computing and Communications, HPCC 2009, pp. 222–229 (June 2009)

[12] Li, W., Bandai, M., Watanabe, T.: Tradeoffs among delay, energy and accuracy of partial data aggregation in wireless sensor networks. In:2010 24th IEEE International Conference on Advanced Information Networking and Applications (AINA), pp. 917–924 (April 2010)

[13] Sardouk, A., Mansouri, M., Merghem-Boulahia, L., Gaiti, D., Rahim-Amoud, R.: Multi-Agent System Based Wireless Sensor Network for Crisis Management. In: 2010 IEEE Global Telecommunications Conference (GLOBECOM 2010), pp. 1–6 (December 2010)

[14] Sardouk, A.: Data aggregation in wireless sensor networks based on cooperative agents. PhD thesis, University of technology of Troyes (2010)

[15] Najet Boughanmi, Moez Esseghir, Le¨ıla Merghem-Boulahia, and Lyes Khoukhi" Energy Efficient Aggregation in Wireless Sensor Networks", V. Guyot (Ed.): ICAIT 2012, LNCS 7593, pp. 264–273, 2013. c_ Springer-Verlag Berlin Heidelberg 2013.