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Research Article

Efficient Routing Protocol for Gateway Node Selection in WSNs

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Abstract

Advances in Wireless Sensor Network (WSN) technology has provided the availability of small and low-cost sensor nodes with capability of sensing various types of physical and environmental conditions, data processing, and wireless communication. In WSN, the sensor nodes have a limited transmission range, and their processing and storage capabilities as well as their energy resources are also limited. Routing protocols for wireless sensor networks are responsible for maintaining the routes in the network and have to ensure reliable multi-hop communication under these conditions. In this paper, we give a routing protocol for WSN and define the transmission on the basis of residual energy of Cluster Head (CH).

Keywords: *Wireless Sensor Network, Cluster Head, Gateway Node.*

1. Introduction

New trends and technologies are coming up these days in the field of networking. Wireless Sensor Network (WSNs) is one of them it is an emerging field where lots of research work has been done involving hardware and system design, networking and security factor. WSNs include applications such as target tracking, environmental monitoring and battlefield applications. WSN is a collection of large number of Sensor Node (SN) to form a large network. SN All SNs can communicate either with each other or with external base station via some intermediate SNs. Energy efficient data forwarding will be a critical challenge in WSNs applications as energy sources are scarce and constrained. SNs are low powered, short transmission range and energy constrained. SNs send data packet which reaches to the base station via some intermediate Single hop neighbor SNs, Cluster Head (CH) and Gateway Node (GN).

Routing is a method to finding out a path between the source node and destination node. In this paper, we give a routing protocol for WSN in which CH and GN are chosen from the pre-determined number of clusters by comparing the residual energy of nodes by their energy level. CH is selected so that efficient operation of data aggregation and transmission is done. In Gateway Node (GN) selection we select that node having best residual energy after the CH node which is one hop distance from CH and can communicate with other clusters.

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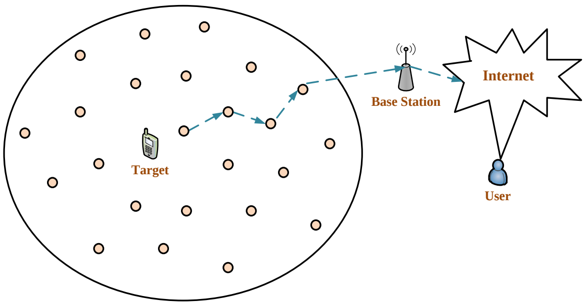

Figure 1: Architecture of wireless sensor networks

SNs are having highly limited energy and storage capabilities. SNs are densely deployed so we perform data aggregation at CH and GN. Transmission of compact data will reduce global data and also reduce localized individual traffic.

Transmission and reception of data are main sources of energy consumption. After designing energy-aware routing protocols for WSNs, we must efficiently control and manage energy consumption at cluster head and gateway node. There will be quick loss and the destruction of energy resources of the cluster due to data aggregation at CH. In the majority of routing algorithms, the periodical choice of the optimal path and the energy inefficiency leads to impact on the life time of WSNs. The major problem in such routing protocols is that they minimize total energy consumption at the expense of non-uniform energy drainage in the network. The lifetime of WSNs will be enhancing with the selection of shortest path, reducing packet retransmission and balancing of energy consumption. In this paper, we have proposed a new energy-efficient Efficient Routing Protocol for Gateway Node Selection in WSNs (ERPGNS) routing protocol to maximize network lifetime of WSNs.

In this paper, the simulation of (ERPGNS) were compared with existing traditional routing protocols in terms of average remaining energy and number of active nodes. There exist sensors in the network for generating the data which are initially deployed in the network as a random state.

2. Related Work

This section presents performance modeling implementations are available in the literature, which aims to compare types of routing and data dissemination protocols and data aggregation schemes for WSNs. A review of research works that aimed to reduce energy consumption and increase the lifetime, throughput and stability has been provided. In Monica R Mundada *et al*, (2012), A Study on consists of low cost, low power, small in size and multi-functional sensor nodes. Routing protocols in WSNs emphasize on data dissemination, limited battery power and bandwidth constraints in order to facilitate efficient working of the network, thereby increasing the lifetime of the network. Routing protocols in WSNs are also application specific which has led to the development of a variety of protocols.

Network partitioning which is caused by the energy whole problem in WSNs and unbalanced energy consumption are regarded as critical challenges in WSNs and hence will affect the network lifetime of WSNs in routing protocols. Thus, prolonging network lifetime in WSNs has received significant consideration. In recent years, energy-efficient routing algorithms have been proposed to enhance the network lifetime of WSNs. In this section, we will review the literature on improving and prolonging WSNs' lifetime. Many data forwarding schemes use clustering techniques in order to reduce and balance energy consumption via data aggregation and periodical selection of different nodes as the cluster head (CH). LEACH (W. R. Heinzelman *et al*, 2000) is regarded as an important clustering protocol that has been proposed for WSNs. In this protocol, all cluster heads transmit their aggregated data directly to the sink. In a former paper A. Ghaffari *et al*, 2011, we proposed an energy-efficient QoS-aware Geographical Routing (EQGR) protocol for WSNs which maximizes network lifetime and uses optimum cost function to select the best neighbor node. In A. E. Abdulla *et al*, 2012, the authors presented Hybrid Multi-Hop routing (HYMH) protocol which combined flat and hierarchical multi-hop routing algorithms with data aggregation scheme in order to optimize energy consumption and improve the lifetime of WSNs. In J. Kim *et al*, 2010, a new scheme was proposed for improving the lifetime of WSNs with any cast and optimal sleep-wake scheduling for each sensor node. In Y. Zhao *et al*, 2012, the authors introduced a novel sleep-scheduling method called VBS (Virtual Backbone Scheduling). VBS uses overlapped backbones which work alternatively to prolong the network lifetime. In this work, only backbones forward data and the remaining nodes turn off their radios in order to conserve and save energy. The backbone-node selection is in a rotation scheme that balances the energy consumption of all nodes. Alshavi *et al*. in 2012 proposed a new routing protocol to increase WSNs' lifetime and balance energy consumption. In this proposed method, each node has to send their residual energy to the sink in each round to determine new CH so that energy level is maintained hence; the consequence is better consumption of energy and long term performance of CH.

Hence, having reviewed the literature related to increasing the network lifetime of WSNs, we can conclude that taking important parameters such as node's residual energy, path's hop count and balancing data transmission among multiple paths into account can remarkably improve the network lifetime. In this paper, we selected optimal and shortest path between source and sink based on parameters such as node's residual energy, free buffer and link quality between sensor nodes.

3. Proposed Scheme

The main criterion for the selection of Gateway Node (GN) is residual energy because energy consumption in gateway node is really expensive. Our proposed protocol, namely Efficient Routing Protocol for Gateway Node Selection in WSNs (ERPGNS) has been designed to minimize energy consumption in WSNs by reducing the number of sensor nodes that take part in transmission. There are two phases in our scheme one is Network creation phase in which CH for each cluster and GN is selected and the other is Data transmission phase in which transmission of data takes place.

A. Network Creation Phase of ERPGNS

Clusters are created and the Cluster Head is selected whose residual energy is maximum among all SNs. The SN sends data to their CH. After receiving the data CH performs aggregation on the data and forwards the aggregated data to the base station via intermediate node i.e. GN and SNs. By using the GN communication related energy consumption will be reduced and it is expected that average energy per packet gets reduced. GN can increase the lifetime of the network.

Gateway Node Creation: It is the process of finding the GN which is common in more than one cluster. GN having best residual energy after the CH node which is one hop distance from CH and can communicate with other clusters. Two cluster regions are connected via node which is placed in intersection region of two clusters called Gateway. The algorithm employs CH, namely GN, which are less energy constrained than SNs.

The grouping of SNs into clusters to achieve high energy efficiency is called clustering. Cluster Member select node which has maximum residual energy and which can act as a CH. In case of tie if two or more nodes have maximum residual energy, CH is selected with minimum node_id. In gateway node selection we select that node having best residual energy after the CH node which is one hop distance from CH and can communicate with other clusters.

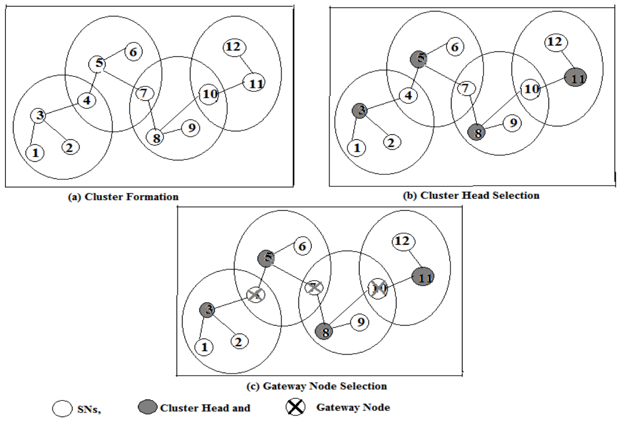

Figure 2: Cluster head and gateway node selection

Figure 2(a) shows cluster formation in which each SN belong to at least one cluster. Figure 2(b) shows CH selection process in which in cluster 1 SN3 has maximum residual energy so it become CH for cluster 1. Suppose in cluster 3 if SN11 and SN12 have same residual energy so SN11 which has minimum node_id become CH.

Figure 2(c) shows Gateway Node selection process in which SN 4, 7 and 10 are selected as a GN which having best residual energy after the CH node, one hop distance from CH and can communicate with other clusters.

Algorithm for cluster head and gateway selection

If SN whose Residual energy > Residual energy all SNs in cluster
Then SN with maximum Residual energy can act as a CH for that cluster
Else if two SNs having same maximum Residual energy
Then SN with minimum node_id can act as a CH
Else SN not eligible for CH selection process

For selection of GN

If the node which has higher Residual energy, after the Residual energy of CH can act as a GN
Else more energy consumption

B. Data Transmission Phase of ERPGNS

The proposed ERPGNS scheme is a query based model which is designed to reduce energy consumption.

A. Sink node broadcasts a query for particular type of objects to SNs of all clusters through their CH.
B. SN which senses the object of required type. SN waits for its waiting time and then informs its CH about object of required type.
C. CH performs data aggregation due to which size of data is reduced. The aggregated data is forwarded from source SN to sink node with the help of intermediate CHs and GNs.

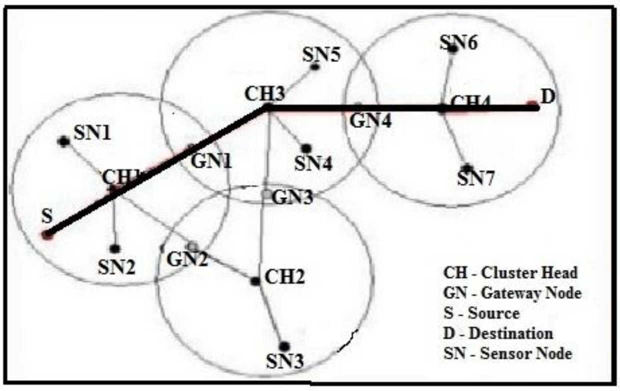

Figure 3: Transmission of data in WSNs

4. System Model

Attributes are used during query transmission

Waiting Time (W_T): After receiving information about object, CH waits for waiting period W_T which is calculated as follow:

$$W_T = \frac{\alpha}{I}$$

Where α is constant and I is the intensity of sensed object.
Periodical time T_P: It is the time duration after which all SNs start sensing.
Active time T_A: It is the time duration during which the node does not sense the target but its communications circuitry.
Sleep time T_S: It is the time duration during which the node is considered inactive and can turn off its sensing and communication circuitry. Energy consumption depends on the value of sleep time.

5. Performance Analysis

The following table shows various parameters that are explained earlier and we have taken certain values to perform the simulation. Calculate & verify the results from the equations defined in earlier chapters. The values are specified below in the table.

Table 2: Analysis of ERPGNS by simulation

Symbols	Parameter
N	200
Network Area [m*m]	200 *200
K	10
D	10 m
M	256 bits
E_{TX}(M)	0.5 J

Symbols	Parameter
$E_{RX}(M)$	0.6 J
ϵ_{fs}	0.01 J
$E_T(N)$	1.5 J
$E_R(N)$	0.6 J
E(N)	0.9 J
E(GN)	2.1 J
Esense(N)	0.1 J

Impact of Transmission

The impact of the number of transmission packets on the average remaining energy in two simulated protocols is illustrated in Fig. 4. It needs to be noted that the position of the sink was in two different spots, that is, at the top right corner, (200m, 200m), and at the center of the simulated area (100m, 100m).The purpose of changing the location of the sink node was to examine and compare the performance of the two CH. The simulation results in Fig. 4 indicated that the average remaining energy of the nodes in the ERPGNS is more than that of traditional methods under the conditions where CH is fixed. The generation of much more redundant packets in earlier methods leads to the reduction of the average remaining energy. This is because ERPGNS considers nodes' packet reception rate, remaining energy and nodes buffer state with minimum hop while selecting gateway node (GN). The figure indicates that the proposed scheme is superior to traditional methods in term of saving nodes energy.

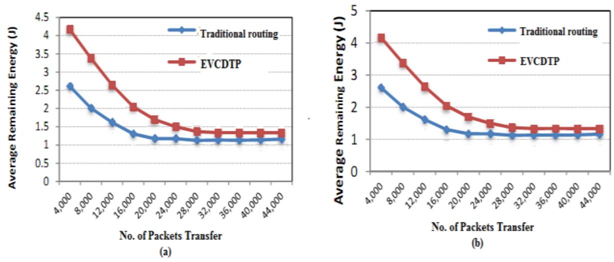

Figure 4: Average remaining energy (a) Sink in [200, 200] (b) Sink in [100, 100]

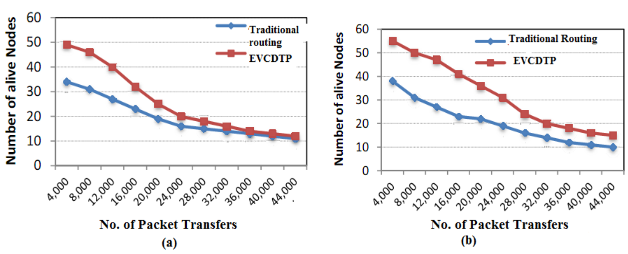

Figure 5: Number of active nodes; (a) Sink in [200, 200]. (b) Sink in [100, 100]

Furthermore, the Fig. 5 shows that the number of active nodes in ERPGNS is more than the other method because the low consumption of energy results in an increase in the number of active nodes. The difference in the simulation results of the two compared methods is very tangible and noticeable when number of transmission packets is low.

Furthermore, as the simulation results in Fig. 6 (b) indicates, the average remaining energy of nodes in the ERPGNS is higher than traditional flat routing the reason for this is that, in the proposed approach, the number of transmitted packets by the nodes is lower than that of the traditional flat routing method.

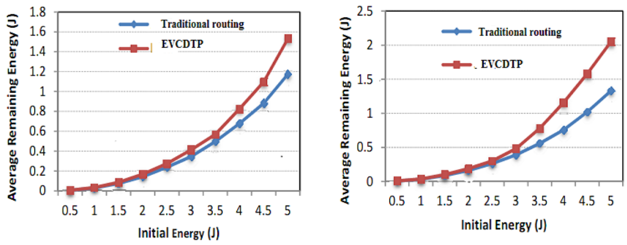

Figure 6: Average remaining energy as a function of initial energy; (a) Sink in [200, 200]. (b) Sink in [100, 100]

Fig. 7 shows that number of alive nodes in ERPGNS is higher than that of traditional routing due to the low consumption of energy of nodes for transmitting the packets. If the number of transmission packets in the network is low, consequently, the performance of the simulated packets will be very sensible. It is noteworthy that when the sink is located at the center of the area, the energy consumption will be reduced and as a result the average remaining energy increases.

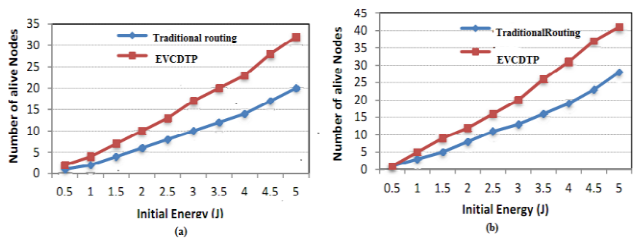

Figure 7: Number of active nodes as a function of initial energy; (a) Sink in [200, 200]. (b) Sink in [100, 100]

Conclusion

Latency and reliability are two important QoS factors. Since battery-powered sensor nodes have limited energy, enhancing the lifetime of the WSNs is considered to be an important issue. This paper proposed a new scheme to improve the lifetime of WSNs. In ERPGNS scheme, we studied cluster head and gateway node selection algorithm in wireless sensor networks. We have proposed the most favorable Algorithm for the efficient gateway node selection in which selection of gateway node saved lots of energy in the wireless sensor network. The outstanding characteristic of the proposed scheme was that it allocated the task of data transmission to the sensor node with higher residual energy in order to prevent packet dropping as a result of energy termination. Simulation results showed that our proposed was capable of increasing the network lifetime when compared with traditional routing scheme.

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