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Research Article

Cognitive Group Leader Selection Algorithm for Wireless Sensor Networks

[1]Sujatha Moorthy and [2]Raghuvel Subramaniam Bhuvaneswaran
[1]Prathyusha Institute of Technology and Management, Sathyabama University,
[2]Anna University, Chennai, Tamil Nadu, India

Abstract: Wireless Sensor Networks (WSNs) have profound applications in diverse areas. Industrial monitoring and control is one of the main applications of WSNs. In order to improve the quality of service of the network while reporting sensed information to the base station, grouping is one of the best known strategies available. A Group Head (GH) present in each group helps in aggregation of information with that of the other group members before reporting to the base station. In many existing methods many group head selection algorithms based on residual energy or quality of service or other factors exist. In this study, we propose a Cognitive Group Leader Selection Algorithm (CGLSA) for the efficient working of grouped WSNs. CGLSA assesses each group for the requirement on the type of GH selection would enhance the operation of WSN. The efficiency of the proposed system is proven by the simulation in the network simulator.

Keywords: Grouping, hierarchy, leader selection, quality of service, wireless sensor network

INTRODUCTION

Wireless sensor networks are found in most monitoring applications especially for those that report about hostile area conditions. The sensor nodes are all equipped with low powered batteries and require energy efficient communication strategies to conserve energy that would in turn extend the lifetime of the network. It is very essential and imperative to save the energy dissipated by these batteries which is practically very challenging. Grouping or clustering is one of the traditional methods to preserve the energy consumption in a network. Hierarchy after grouping is performed is shown with BS, GH and Members (M) in Fig. 1.

The challenges faced while grouping according to selected factors are listed below:

- Energy based routing may enhance the lifetime of the network but it does not provide consistent QoS support for the wireless sensor networks.
- Hidden node collisions may occur in wireless sensor networks which degrades the performance of the network.
- Improving the quality of service by provision of best routes all the time will bring down the residual energy of frequently used nodes.

There are many more challenges in real time in power management and in programming abstractions and other application areas (Gilbert *et al*., 2012). In order to overcome the challenges described above, in this study, we propose a CGLSA, a strategy that performs analysis of the requirement in a group and selects a group head accordingly.

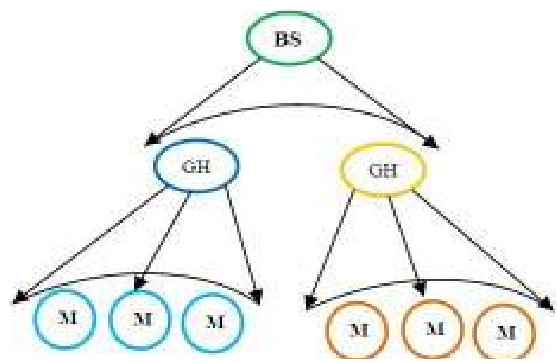

Fig. 1: Hierarchy after grouping in a WSN

LITERATURE REVIEW

Since the wireless networks are in use from quite a long time now, it is obvious that there are many existing methodologies present for their efficient working. General routing protocols (Singh *et al*., 2010) for wireless sensor networks do not provide maximum QoS support. Some of the group head selection algorithms pertaining to the work proposed in this study is reviewed in this section.

In a fuzzy logic based cluster head selection by Gupta *et al*. (2005), a fuzzy logic approach to cluster-

Corresponding Author: Sujatha Moorthy, Sathyabama University and Prathyusha Institute of Technology and Management, Chennai, Tamil Nadu, India

head election is proposed based on three descriptors-energy, concentration and centrality. According to the authors, the centrality plays a vital role in reducing the energy expenditure. The overall mechanism is summarized in four steps: fuzzification of variables to assess and determining the degree to which these inputs belong to each of the appropriate fuzzy sets; evaluation of fuzzy rules and finding the consequent mapped values; combination of all fuzzy rules and defuzzification at the end. This mechanism showed improvement in the lifetime of the network when compared with LEACH. Nonetheless, the factors like quality of service are not given much importance which is a major disadvantage of this study.

Kifayat *et al*. (2009), proposed an Efficient Multi-parameter scheme for the Group Head Selection process (EMGHS). The group head is selected based on the available energy of a node, neighboring nodes and location of a new group leader node and the level of trust of a node. These parameters help in not only electing an energy efficient group head but also a trust worthy node. The quality of service degradation of the network is not monitored and hence the threat for a network to keep running for a longer time with less productivity is possible.

In order to overcome the shortcomings of the strategies discussed here and to perform efficient routing, the CGLSA is proposed and simulated in the network simulator.

METHODOLOGY

The CGLSA scheme is designed to overcome some of the critical challenges of the WSNs. Keeping in mind some of the critical requirements for a well functioning WSN, group leader of head is selected using the CGLSA algorithm. The GH or leader selection algorithm should contain the following considerations.

Maximum No. of non hidden nodes: There is a lot of significance for the number of hidden nodes to the GH. Hidden node problem[3] is one of the main reasons why there is degradation in the quality of service in a wireless sensor network. Collisions due to hidden node problem may occur frequently in a clustered wireless sensor network. The number of non hidden nodes (η_i) is the total number of nodes with which a node *i* is able to communicate directly within the group containing *G* nodes. In other words η_i is the node degree of each node. It is generally estimated by broadcasting requests and obtaining replies from the nodes that send a reply.

Residual energy: The energy available is also called as residual energy or the energy remaining in a node re_i. This parameter is equally important as the number of non hidden nodes, as it determines the lifetime of the sensor network (Kifayat *et al*., 2009). The initial energy provided to all nodes is indicated by e_i. The residual energy can simply be represented by the Eq. (1) given below:

$$re_i = e_i - tr_m(e_{tr}) - rc_n(e_{rc}) - e_o \tag{1}$$

where, e_{tr} and e_{rc} are receive and transmit powers that are reduced from the initial energy e_i depending on the number of times the transmit operation (tr_m) and receive operations (rc_n) take place respectively. The parameter e_o indicates the sum of the energies required for electrical, radio amplification, energy that is consumed for both free space and multipath losses (Cheng *et al*., 2011).

Quality of service: The quality of service provided by the nodes QoS_i can be obtained from the parameters like packet delivery rate, packet loss rate and the delay caused by a node *i* relative to the average QoS of *G* nodes. Where t is the current instant time at which QoS is measured during cluster head selection. The proposed scheme contains this parameter so as to prevent any QoS related degradation in the network as in Eq. (2) Mahapatra *et al*. (2006), Ray *et al*. (2005) and Shah and Rabaey (2002) have also contributed to the field of wireless sensor network design:

$$QoS_i = \frac{\sum_{0}^{t} PDR(i) + PLR(i) + Delay(i)}{t} \tag{2}$$

History as a GH: Nodes repeating as a group head (R times) should not be exploited because of the other parameters in the network favoring a node to become the GH again. To implement this, the average number of time a node is selected as a cluster head is measured and half of that value is set as a threshold to prevent such exploitation. The average number of times a node has been the GH is given as R_{AVG} and the threshold is give in Eq. (3):

$$R_{TH} = \frac{R_{AVG}}{2} \tag{3}$$

The number of non hidden nodes, residual energy and quality of service will be collectively evaluated, whereas the history as a GH will be an exceptional condition. The working flow is shown in Fig. 2. The GH selection scheme is the third step in overall WSN operation. The algorithm used for GH selection utilizes the parameters that are explained mathematically further below.

Since location based grouping is the most efficient and practical grouping strategy to determine the maximum number of non hidden nodes, a location based or minimum distance clustering is assumed in this scheme. The cognition about the current requirement in such a group is done by the formula in Eq. (4):

$$\alpha = w_1 * \frac{\eta_i}{G} + w_2 * \frac{re_i}{e_i} + w_3 * \frac{QoS_i}{QoS_G} \tag{4}$$

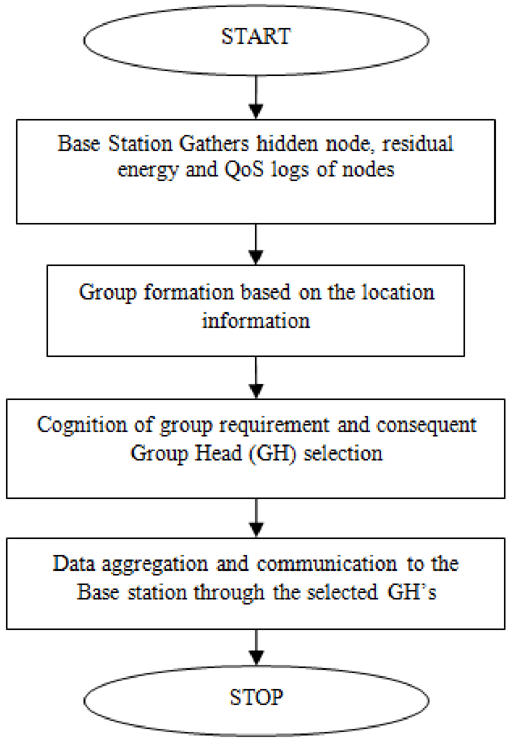

Fig. 2: Working flow of CGLSA

where, w_1, w_2 and w_3 are the weights using which α is normalized to 1.

Averaging the weights of every group it is possible to estimate the requirement in each group as shown in the following Eq. (5) to (7):

$$W1_{avg} = \frac{\sum_0^G w_1}{G} \quad (5)$$

$$W2_{avg} = \frac{\sum_0^G w_2}{G} \quad (6)$$

$$W3_{avg} = \frac{\sum_0^G w_3}{G} \quad (7)$$

The greatest of the three weighted coefficients determine the requirement in the network. And hence the corresponding GH selection is performed based on the cognition in the group. It is observed that there is performance improvement and balanced routing when compared with the existing schemes.

Algorithm:

```
While |L>0| {//K_L groups with G nodes each
for (G = 0; G<k1; G++)
{
set i = k1 (G),
obtain the η_i, re_i and QoS_i values
set R = 0;
if (R<R_TH) {
Calculate w1 w2 and w3 for every group
    if (w1>w2 && w1>w3)
    {
        Max. No of non hidden nodes = GH;
        R++;
    }
    elseif (w2>w1 && w2>w3)
    {
        Node with max residual energy = GH;
        R++;
    }
    else
    {
        Node with high QoS = GH
        R++;
    }
 } end if
 L++
}
```

The algorithm is used to find out the best cluster head that would balance and stabilize the network performance and operation.

RESULT ANALYSIS

Analysis of the proposed scheme is performed using simulations in the network simulator. Network simulator is an event simulator used for research extensively to simulate various network scenarios. It not only helps analyze the scenario but also aids in the investigation of discrete information about the various factors to facilitate networking efficiency.

The simulation parameters using which the analysis of CGLSA and EMGHS schemes is performed are tabulated in Table 1 below.

The parameters assessed are: Packet Delivery Ratio, Packet Loss Ratio, Delay and Energy consumption.

Packet delivery ratio: Packet Delivery Ratio is nothing but the ratio of the total number of packets received successfully with respect to the total packets sent in the network. CGLSA has higher PDR than EMGHS in the PDR plot in Fig. 3.

Packet loss ratio: Packet Loss Ratio indicates ratio of the total number of lost packets to the packets sent. The PLR for CGLSA is lesser than EMGHS as observed in Fig. 4.

Delay: The average end to end delay occurred in the network is plotted against the total simulation time. It was found that the delay occurred during the execution

Table 1: Simulation parameters

Parameter	Value
Channel type	Wireless channel
Radio propagation model	Two ray ground
Network interface type	Wireless phy
Antenna model	Omni antenna
Simulation time	60 msec
Number of nodes	50
Topology area	700×700 m
Routing protocol	AODV

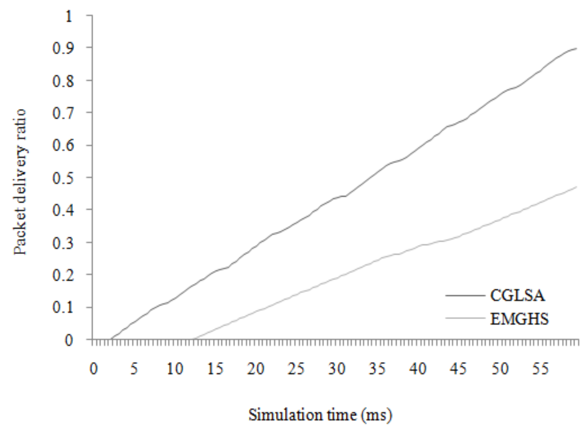

Fig. 3: Packet delivery ratio plot

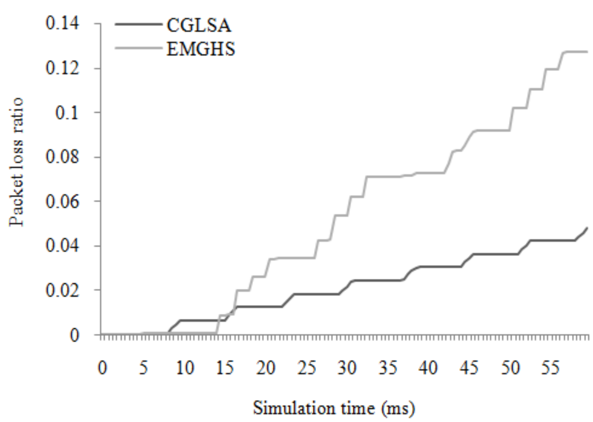

Fig. 4: Packet loss ratio plot

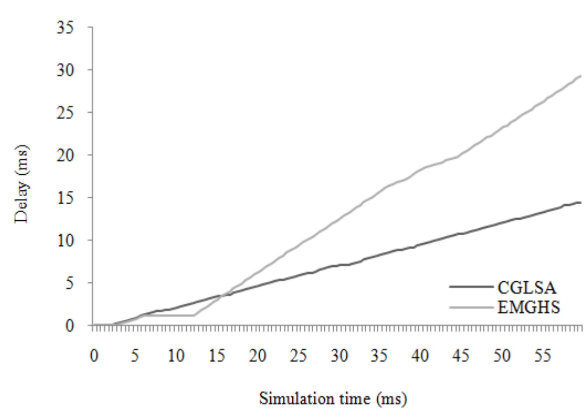

Fig. 5: Delay plot

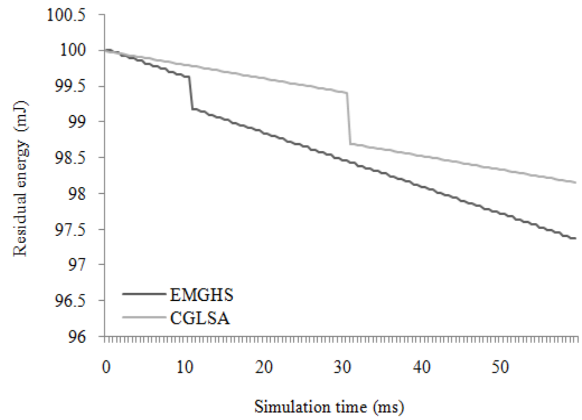

Fig. 6: Energy plot of CGLSA and EMGHS

of CGLSA is lesser than the EMGHS. This difference is because the quality of service of a node contains the delay factor and hence efficient group leader selection implies that the delay may be reduced to an obvious extent (Fig. 5).

Energy: In order to confirm the enhancement of lifetime of the network will be enhanced, we plotted the average residual energy of the nodes against simulation time. Figure 6 shows that the residual energy of the CGLSA over the EMGHS.

CONCLUSION

A group leader selection algorithm has a lot of significance in the current wireless sensor network operating in various application areas. In this study, we have proposed and analyzed a Cognitive Group Leader Selection Algorithm (CGLSA) that learns the type of group lead required in a group and selects the group lead accordingly. Simulation results have proved the efficiency of CGLSA over EMGHS.

Future work aims at investigating a real time implementation of the work presented in this study. The network performance can further be improved by the incorporation of security schemes. Since security is very much a demand in the current real world scenarios, a constant update is mandatory. Hence a dynamic security providing scheme needs to be amalgamated instead of simple trust estimation schemes.

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