Cluster Head Selection Using Balancing the Load

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Abstract*- An emerging class of Wireless Sensor Network (WSN) applications involves the acquisition of large amounts of sensory data from battery powered, low computation and low memory wireless sensor nodes. This paper focuses on minimizing and optimizing energy consumption based on the routing method as a general model for WSN deployment and development. The model deals with all common aspects of energy consumption in all types of WSNs. The proposed work presents an improved version of LEACH protocol which aims to reduce energy consumption within the wireless sensor network and prolong the lifetime of the network. This paper improves LEACH protocol by improving the selection strategy of the cluster-head node based on remaining the previous performance with respect to failure of sensor nodes as being a cluster head.*

Keywords- Wireless Sensor Networks, Sensors, Leach Protocol, Probability, Entropy.

I. INTRODUCTION

One of the main applications of Wireless Sensor Networks is monitoring remote and isolated areas, and collecting information about unexpected phenomenon like a Fire in Forest, volcano eruptions or enemy movement in the battle field. In these applications the channel state is expected to be continuously varying because of the dynamic changes in environmental factors. Also vehicles and rocks movements can crash some nodes which may be the separate parts of the network [4]. In this context it is hard for the network to deliver the collected information, even when transmitting at the maximum power, without strong error correction techniques [7]. Energy conservation in wireless sensor networks (WSNs) is the primary performance parameter, because of their limited energy resources. Thus, some energy saving technologies should be applied.

II. WIRELESS SENSOR NETWORK

Wireless Sensor Network (WSN) comprises of spatially circulated independent sensors to screen physical or ecological conditions, for example, temperature, sound, pressure and so on and to helpfully go their information through the system to a fundamental area [11].

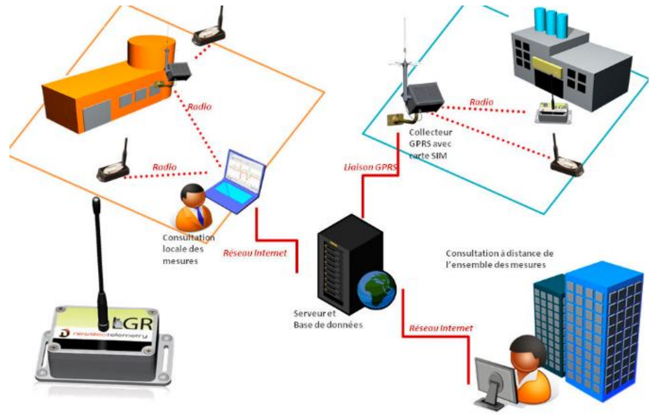

Fig-1 Wireless Sensor Networks

The progression of remote sensor frameworks was energized by military applications, for instance, forefront perception. Today such frameworks are used in various present day and customer applications, for instance, mechanical procedure checking and control, machine prosperity watching, and so forth. The WSN is worked of "hubs" from a couple to a few hundreds or even thousands, where every hub is associated with one or a few sensors. Each such sensor arrange hub has routinely a couple of segments: a radio handset with an internal gathering device or relationship with an external accepting wire, a microcontroller, an electronic circuit for interfacing with the sensors and a vitality source, a battery or an embedded type of vitality reaping. The spread strategy between the jumps of the system can be steering or flooding. Some more applications are air contamination checking, woods fire recognition, avalanche discovery, water quality observing, cataclysmic event anticipation, modern checking, machine wellbeing observing and so forth [14].

III. LITERATURE REVIEW

Enrique J. Duarte-Melo and Mingyan Liu et al 2002 [1], analyzes the exhibition just as vitality utilization issues of a remote sensor system giving intermittent information from a detecting field to a remote collector. The sensors are thought to be haphazardly sent. We recognize two kinds of sensor associations, one with a solitary layer of indistinguishable sensors (homogeneous) and one with an extra overlay of less yet progressively incredible sensors (heterogeneous). We detail the vitality utilization and concentrate their assessed lifetime dependent on a grouping instrument with shifting parameters identified with the detecting field, e.g., size, and separation. We evaluate the ideal number of groups dependent on our model and tell the best way to apportion vitality between various layers [9]. Sokwoo Rhee, Deva Seetharam and Sheng Liu et al 2004 [2], have displayed a few methods to limit control utilization at various dimensions of the framework progressive system of low information rate remote sensor systems. In certain cases, we have indicated how the individual hubs can be intended to be proficient. In different occurrences, we exhibited strategies for creating vitality productive system calculations and conventions.

Yunxia Chen and Qing Zhao et al 2005 [5] determine a general equation for the lifetime of remote sensor systems which holds autonomously of the hidden system demonstrate including system design and convention, information accumulation inception, lifetime definition, channel blurring qualities, and vitality utilization show. This equation distinguishes two key parameters at the physical layer that influence the system lifetime: the channel state and the remaining vitality of sensors. Subsequently, it gives not just a measure to execution assessment of sensor organizes yet additionally a rule for the plan of system conventions. In view of this recipe, we propose a medium access control convention that abuses both the channel state data and the lingering vitality data of individual sensors [13].

IV. PROBLEM FORMULATION

Motivation to work in this research area is the Energy efficiency techniques which play a significant role in saving the energy. In general algorithm a node becomes a cluster-head by a stochastic mechanism of tossing biased coins. Hence non group head nodes having a place with the nearest locales, which are relied upon to transmit every now and again, disperse more energy in transmitting information to a remote bunch head situated far. This prompts non uniform energy scattering over the system decreasing the system lifetime [11]. Additionally it expects that each time a node turns into a bunch head, it disperses an equivalent measure of energy. This is mistaken; as group heads situated a long way from the base station spend more energy in transmitting information than those nodes situated close to the base station [9]. Energy minimization challenge has been surveyed from different aspects but there are still unsolved problems that should be taken into account. The strategy of the present research comprises three main stages:

1. Problem definition,
2. Developing new approaches,
3. Evaluation.

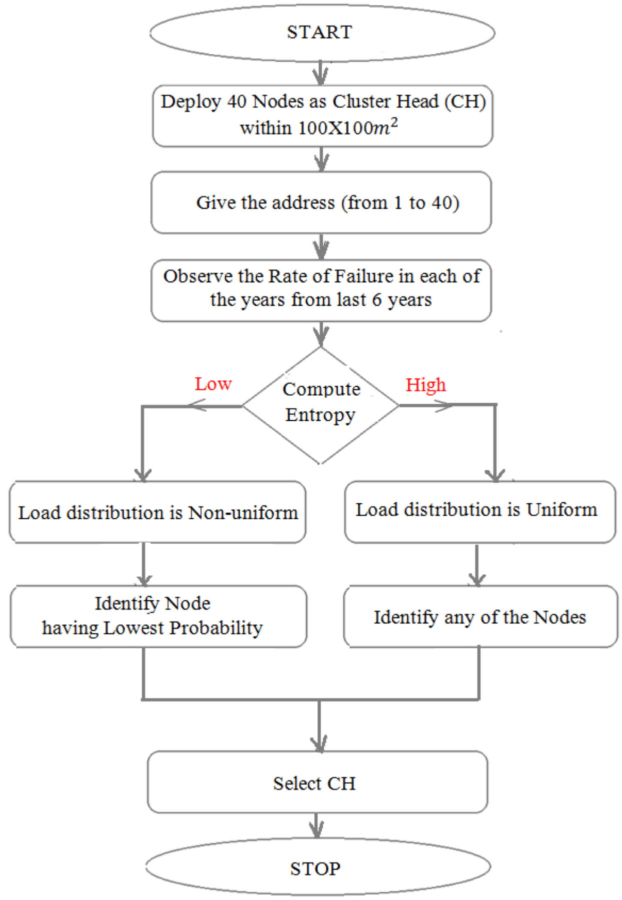

Fig-2 Flow of the Proposed Methodology

In our simulation, 40 sensors are deployed in 100X100m^2 area that generates data from environment events at random times and places within the area. Sensing applications could equally environment temperature, pollution, or others. We considered the prevalent parameters of energy consumption of process, memory and radio units as constant in the individual constituent of all sensors. Also the duration of the experiments was assumed as constant 60 seconds. Monitoring neighbors and providing a secure communication with neighbors at the local level. The global constituent is concerned with maintenance of the whole network, selection of a suitable topology and an energy efficient routing strategy based on the application’s objective. This may include energy wastage from packet retransmissions due to congestion and packet errors. The global constituent is defined as a function of Energy Consumption (EC) for topology management, packet routing, packet loss, and protocol overheads. The sink constituent includes the roles of manager, controller or leaders in WSNs. The sink tasks include directing, balancing, and minimizing EC of the whole network and the collection of generated data by the network’s nodes. Execution of these tasks requires sensor resources, CPU, memory, radio, and sensing units.

Entropy calculation

A communication system not only dealing with a single node but with all possible nodes, hence a WSN may be described in average message per individual node, called Entropy.
Let M= Total number of nodes
Then entropy is maximum; if all the nodes have equal load.
$H_{max} = -\sum_{k=1}^{M} \frac{1}{M}.\log_2 \frac{1}{M}$ Selection of CH / Cluster
For example if we are tossing a coin, then there may be 2 outcomes Head & Tail; it means P=1/2 and Q=1/2. Now entropy for Binary Numbers [H & T] is-
$H_{max} = -[\frac{1}{2}.\log_2 \frac{1}{2} + \frac{1}{2}.\log_2 \frac{1}{2}]$
$H_{max} = -\log_2[2].$
$H_{max} = 1$ Outcome / Toss

Table 1: Entropy Calculation for 40 Nodes Failure Probabilities

Node	**Probability of Failure (PK)**			Log_{10}**(1/Pk)**	**PK *** Log_{10}**(1/Pk)**
Node 1	P1	2	0.02	1.70	0.034
Node 2	P2	3	0.03	1.52	0.046
Node 3	P3	5	0.05	1.30	0.065
Node 4	P4	5	0.05	1.30	0.065
Node 5	P5	3	0.03	1.52	0.046
Node 6	P6	1	0.01	2.00	0.020
Node 7	P7	2	0.02	1.70	0.034
Node 8	P8	5	0.05	1.30	0.065
Node 9	P9	4	0.04	1.40	0.056
Node 10	P10	3	0.03	1.52	0.046
Node 11	P11	3	0.03	1.52	0.046
Node 12	P12	2	0.02	1.70	0.034
Node 13	P13	1	0.01	2.00	0.020
Node 14	P14	5	0.05	1.30	0.065
Node 15	P15	2	0.02	1.70	0.034
Node 16	P16	3	0.03	1.52	0.046
Node 17	P17	3	0.03	1.52	0.046
Node 18	P18	2	0.02	1.70	0.034
Node 19	P19	1	0.01	2.00	0.020
Node 20	P20	1	0.01	2.00	0.020
Node 21	P21	2	0.02	1.70	0.034
Node 22	P22	6	0.06	1.22	0.073
Node 23	P23	5	0.05	1.30	0.065
Node 24	P24	1	0.01	2.00	0.020
Node 25	P25	0	0	0.00	0.000
Node 26	P26	3	0.03	1.52	0.046
Node 27	P27	2	0.02	1.70	0.034
Node 28	P28	2	0.02	1.70	0.034
Node 29	P29	0	0	0.00	0.000
Node 30	P30	0	0	0.00	0.000
Node 31	P31	5	0.05	1.30	0.065
Node 32	P32	0	0	0.00	0.000
Node 33	P33	3	0.03	1.52	0.046
Node 34	P34	2	0.02	1.70	0.034
Node 35	P35	0	0	0.00	0.000
Node 36	P36	1	0.01	2.00	0.020
Node 37	P37	4	0.04	1.40	0.056
Node 38	P38	6	0.06	1.22	0.073
Node 39	P39	2	0.02	1.70	0.034
Node 40	P40	0	0	0.00	0.000
TOTAL	**100**	**1**		**H (X) =**	**1.474**

Table 2: Entropy Calculation for 40 Nodes with equal Failure Probabilities

Node	**Probability of Failure (PK)**			Log_{10}**(1/Pk)**	**PK *** Log_{10}**(1/Pk)**
Node 1	P1	2.5	0.025	1.60	0.040
Node 2	P2	2.5	0.025	1.60	0.040
Node 3	P3	2.5	0.025	1.60	0.040
Node 4	P4	2.5	0.025	1.60	0.040
Node 5	P5	2.5	0.025	1.60	0.040
Node 6	P6	2.5	0.025	1.60	0.040

Node 7	P7	2.5	0.025	1.60	0.040
Node 8	P8	2.5	0.025	1.60	0.040
Node 9	P9	2.5	0.025	1.60	0.040
Node 10	P10	2.5	0.025	1.60	0.040
Node 11	P11	2.5	0.025	1.60	0.040
Node 12	P12	2.5	0.025	1.60	0.040
Node 13	P13	2.5	0.025	1.60	0.040
Node 14	P14	2.5	0.025	1.60	0.040
Node 15	P15	2.5	0.025	1.60	0.040
Node 16	P16	2.5	0.025	1.60	0.040
Node 17	P17	2.5	0.025	1.60	0.040
Node 18	P18	2.5	0.025	1.60	0.040
Node 19	P19	2.5	0.025	1.60	0.040
Node 20	P20	2.5	0.025	1.60	0.040
Node 21	P21	2.5	0.025	1.60	0.040
Node 22	P22	2.5	0.025	1.60	0.040
Node 23	P23	2.5	0.025	1.60	0.040
Node 24	P24	2.5	0.025	1.60	0.040
Node 25	P25	2.5	0.025	1.60	0.040
Node 26	P26	2.5	0.025	1.60	0.040
Node 27	P27	2.5	0.025	1.60	0.040
Node 28	P28	2.5	0.025	1.60	0.040
Node 29	P29	2.5	0.025	1.60	0.040
Node 30	P30	2.5	0.025	1.60	0.040
Node 31	P31	2.5	0.025	1.60	0.040
Node 32	P32	2.5	0.025	1.60	0.040
Node 33	P33	2.5	0.025	1.60	0.040
Node 34	P34	2.5	0.025	1.60	0.040
Node 35	P35	2.5	0.025	1.60	0.040
Node 36	P36	2.5	0.025	1.60	0.040
Node 37	P37	2.5	0.025	1.60	0.040
Node 38	P38	2.5	0.025	1.60	0.040
Node 39	P39	2.5	0.025	1.60	0.040
Node 40	P40	2.5	0.025	1.60	0.040
TOTAL		**100**	**1**	**H (X) =**	**1.602**

This shows that Average or Entropy is maximum if all the probabilities are equal. It means to increase the security of propagation, routing should be such that all the nodes have handled equal traffic load. This is the condition of balancing the Load. If balancing is used then all the Nodes share equal amount of Load. Therefore, the Failure Probabilities of all the Nodes are almost equal. Now the Leach Protocol will be very secure because it can select any of the Nodes as Cluster Head. By this there is no problem of die the Cluster Head before completing the communication.

V. SIMULATION

One of the approaches to save energy in the link layer is to switch the radio to sleep mode. To take advantage of this opportunity, the link layer requires a time-based medium sharing, e.g., TDMA. In heterogeneous networks the nodes have different capabilities. Nodes with high capability may be assigned more responsibility and overall energy consumption can be reduced by optimizing arrangements, while in homogenous sensor networks, all nodes are the same and the routing tasks are assigned equally among the nodes. To implement our proposed method, first we are deploying 40 Nodes as Cluster Head (CH) in random manner within 100X100m2. Then give the address from 1 to 40. Now observe the Rate of Failure in each of the years from last 6 years. Calculate the Failure Probabilities of CH. Observe Cluster Head having Zero Failure Probability (Red Circle) and Non-Zero Failure Probability (Green Circle) separately. Finally compute Entropy. Remember the fact that the condition of applying Probability theory is that the summation of all the Probabilities must be equal to 1. Hence we have to select the number of CH by considering the Probability Theory. Here we are taking some random data for templates. The condition of applying Probability theory is that the summation of all the Probabilities must be equal to 1. Here summation is 100. Now, divide each of the Probability by 100, and then the summation of all the Probabilities will be equal to 1. Let, calculate the Entropy.
Let Total number of Cluster Head=40

$H_{max} = -\sum_{k=1}^{40} \frac{1}{40}.\log_2 \frac{1}{40}$ Selection of CH / Cluster

$H_{max} = 1.474$ Selection of CH / Cluster

Here, each of the CH has its own Failure rate. It means each of the CH has a different load which shows unbalancing or non-uniform load distribution. This system never is efficient and there is always fear of Failure of CH during propagation. Suppose, Failure Probabilities of all the CH are equal, then Entropy would be higher. Let, this Failure Probability is 0.025.

$H_{max} = -\sum_{k=1}^{40} \frac{1}{40}.\log_2 \frac{1}{40}$ Selection of CH / Cluster

$H_{max} = 1.602$ Selection of CH / Cluster

Now, it is clear, that to increase the security of propagation, routing should be such that all the nodes have handled equal traffic load. This is the condition of balancing the Load. If balancing is used then all the Nodes share equal amount of Load. Therefore, the Failure Probabilities of all the Nodes are almost equal. Now the Leach Protocol will be very secure because it can select any of the Nodes as Cluster Head. By this there is no problem of die the Cluster Head before completing the communication. If balancing is not achieved then the Node having lowest Failure Probability should be selected as CH, which will give less risk of Failure.

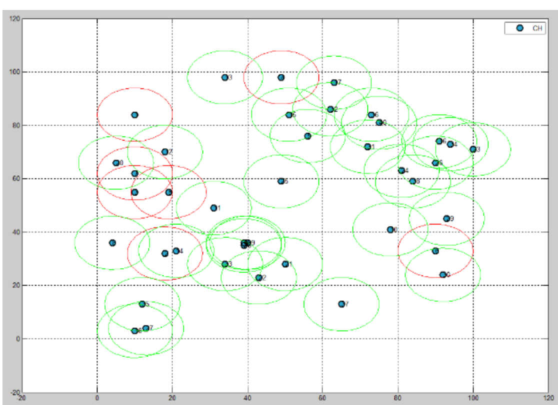

Fig-3 Output for Cluster Heads Deployment in WSN using MATLAB

VI. CONCLUSION

Design and development of energy efficient routing protocols for Wireless Sensor Network (WSN) is one of the active research fields. Cluster based routing protocols have proven to be energy efficient and LEACH is one of most popular cluster based routing protocol for WSN. But, LEACH suffers from several drawbacks such as possibility of choosing a low energy node as Cluster Head (CH) and non-uniform (unbalancing) distribution of CHs, etc. In the paper given by Md. Saiful Islam Rubel, Nahi Kandil and Nadir Hakem [11] proposed protocol EiP-LEACH (Energy influenced Probability based LEACH) is an enhanced version of LEACH protocol that is influenced by the energy parameter for CH selection. EiP-LEACH helps in deciding the better CH nodes. Furthermore, in both of the methods there is a risk of failure the CH during the propagation. Low Energy Adaptive Clustering Hierarchy (LEACH) is one of clustering routing protocols on Wireless Sensor Network (WSN). LEACH algorithm is divided to setup phase and steady state phase. In a busy network, LEACH Routing has a high packet loss. To solve the problem we need Delay Tolerant Network (DTN) [12]. In changing the number of node, LEACH-WSNoverDTN can improve performance by decreasing packet loss value by 50% of LEACH-WSN packet loss. In the test of energy consumption in two scenarios, LEACH-WSN and LEACH-WSNoverDTN have no significant differences but when we check the lifetime of node which depends on energy consumption, LEACH-WSNoverDTN has early death node. Here we concluded that if balancing is achieved then all the nodes are always at equal energy level, so that all the nodes will be dead almost simultaneously, which will increase the Life time. Although LEACH Routing has a high packet loss, but with the proposed methodology there will be less chances of Congestion, therefore LEACH-WSNoverDTN can improve performance by decreasing packet loss greatly.

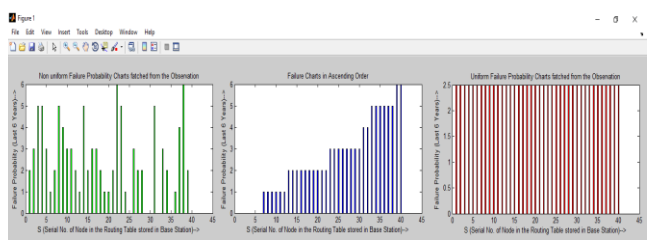

Fig-4 Output for Entropy Calculation in WSN using MATLAB

This method of selection of CH will be very useful for reducing the risk of Failure. In the future we will simulate Routing with the Leach Protocol and try to deploy the Nodes and implement the proposed methodology.

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