A Smart Re-Clustered Reliable Energy Efficient Routing Protocol in Wireless Sensor Network

Dr. Matish Garg[1] Er. Sandeep Mehla[2] Ms. Samriti Gupta[3]
[1]H.O.D. in CSE Department [2]A.P. in CSE Department [3]P.G Scholar
[1, 2, 3]Department of computer science and engineering
[1, 2, 3]Shri Balaji Institute Of Engineering And Technology, Kurukshetra University, Kurukshetra

Abstract—*In this paper, we propose to design a new routing protocol which basically relies on two main factors i.e. reliability in terms of all data packet delivery and energy efficiency. Although previous protocols i.e LEACH is best amongst all the routing protocol for WSN still it has some drawbacks. One of the main drawback is it has no optimal data aggregation technique and it provides no reliability in terms of all the packet are delivered to sink or not. Better data aggregation technique may reduce the overall energy dissipation for a cluster in LEACH as battery consumption is important fact to be taken in to consideration which is a scarce resource and can't replace further in the network after battery loss. Reliability is also a major necessity in data aggregation. In this thesis a new optimal data aggregation scheme is developed which is bases of our proposed model named as smart re-clustered reliable energy efficient routing protocol. We initially form a cluster and cluster head is chosen based upon the cost value calculation which is described further. (SRREER) protocol is a protocol based on optimal data aggregation technique which helps to reduce the energy dissipation and reducing delay in terms of data delivery to BS.*

Keywords: - Wireless sensor network, Data aggregation, Cluster Node, Cluster Head, SRREER, Residual energy.General Terms-Reliability, Energy Efficient.

I. INTRODUCTION

A. *Wireless Sensor Network*

In our daily lives we are constantly surrounded by thousands of wireless networks, and in the past years, the number of those networks related with sensors has been increasing. Wireless sensor network have become an active area for researchers now a days. A sensor node carry small amount of resourcesin terms of processor, battery power, memory and communication range, but when a great number of sensor nodes work together they are able to complete a good volume of task. It is just because of Wireless Sensor Network we are able to interact with physical world directly. Shashi Phoha (Editor)etal [1]., presents that Wireless sensor networks would constitute an important part of the next evolution in automation and many other areas too. Wireless sensor network is made of several number of tiny sensor nodes. Each node has limited number of resources. When these large number of tiny sensor nodes form a wireless network and collaborate locally with each other in the neighborhood to perform some designated task, the task performed by the whole network is quite useful. Different kind of wireless sensor networks depends on the type of nodes or architecture of sensor networks.

B. *Network Architecture of WSN*

Wireless sensor network is a network consisting of several number of heterogeneous nodes called as sensors nodes which are spatially distributed all over the location and these networks are used to monitor physical or environmental conditions such as temp, pressure, sound, vibration at these locations. Wireless communication enables the co-operation of nodes to fulfill bigger tasks that single nodes cannot. Nodes in WSN are densely deployed and are greater in numbers as compared to mobile ad hoc networks. These nodes communicate with each other and pass data along from one to each other from source to sink. Basically Sensor nodes bridge the gap between physical world and the virtual world. Each node consists of processing capability, may contain many processing units like multiple types of memory, have a RF transceiver, have a power source like battery, and accommodate various sensors and actuators.

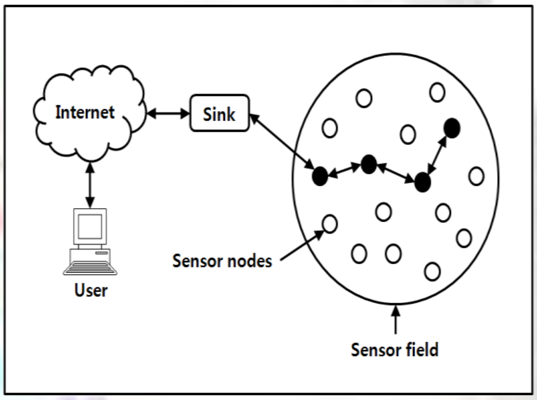

Fig. 1: Network architecture of Wireless Sensor

A sensor network generally consists of several tiny sensor nodes and a few powerful control nodes also called base stations or called as sink. Sensor nodes are usually densely set up in a large area and communicate with each other in short distances through wireless communication. Although particular sensor nodes have limited number of resources, they are able to achieve worthy task of big volume when they work as a team member. Information gathered by and transmitted on a sensor network of wireless networks describes conditions of physical environments of the area where the sensor network is set up. Feng Zhao et al [3] present that sensor networks may interact with an IP network via a number of gateways. A gateway tracks the user queries or commands to appropriate nodes in a sensor network. It also directs or routes sensor data, sometimes aggregated and summarized, to users at user end who have requested it or expected to use the information. They presents that for optimization in performances and resources such as energy, we may need to reconstruct TCP/IP stack so that our needs and constraints are satisfied. Although different application demands a different set of tasks to be carried out during functioning of network, there are three basic types of tasks carry out those tasks in a sensor network: sensing, processing, and communication. Sensing task uses different types of sensors to capture different signals from the physical world of the network. All signals faces delay as they travel away from the source. A dense set up of sensors helps to avoid this delay and maintain the sensed signal. Each Individual sensor node is capable of lightweight processing. In sensor networks, processing often binds multiple sensor outputs from local neighboring nodes. This is called as collaborative signal and data processing. Collaborative processing has the advantages that processing is more accurate and reliable, and only the aggregate of result needs to be sent to a user over the network. The sensor nodes works as a front end in a computing hierarchy and perform preprocessing for later stages [2]. WSN management must be automatic, i.e., self-managed with least interface with human and robust to changes in service (QOS) [4].

II. Existing work

In exiting work the main drawback is a small number of clusters are formed in self-organized manner. Data of each cluster is send to its own cluster head and then to base stations directly how far the base station is situated. And the problem arises due to this far location of base station because packets may be lost in between the path. And moreover measuring loss ratio at the base station or sink causes high delay. Another major drawback is calculating loss ratio at BS is itself time or energy consuming. Cluster head in leach protocol are randomly generated and energy consumption can be evenly distributed in the network; but, it ignores residual energy of nodes, geographic location and other information in the election of cluster head node. Due to this reason it can easily lead to exhaust the energy quickly in cluster head nodes. It is quite essential to design energy-efficient communication strategies for data gathering operation because considerable amount of communication in WSN involves data gathering. Data reliability is major concern in existing protocol. As sink is located far from each cluster head so more transmission energy is required to send aggregated data to sink. Delay occurs because data fatal ratio is calculated at sink itself. Data fatal ratio is the ratio of loss of how many packets transmitted and received back during the communication of each cluster.

III. Proposed work

A. How to choose cluster head?

In this thesis our main focus is how to choose cluster head.

– Initially we form clusters in which sensor nodes are fitted. Then we randomly select a supervisor node which is around the cluster and closest to it. Supervisor node's duty is to choose cluster head.
– Neighboring nodes M of cluster head are chosen by the supervisor node which depends upon node density.
– Sensor nodes give information about the M number of closest neighbors to the supervisor node SN.
– Distance of nodes is determined by RSSI. RSSI is defined as Received signal strength indicator.
– Candidate set of cluster heads (CH) is choose by SN with the help of K-theorem.
– When SN sent request for candidate set of cluster heads then sensor nodes reply their expense value (EV)
– Each node of candidate cluster head set determines its own expense value based on the residual energy, and its distance to SN. Cost value calculation is explained later in the topic.
– A node is elected as cluster head based upon the EV by supervisor node. A node which has highest EV it has more chances of being cluster head. After selection of cluster head by SN; SN acknowledge each cluster for their CH.

B. How to choose M for clustering?

M is defined as the node density which is relative to ratio of cluster heads in any wireless sensor network. M value is defined by the SN. This ratio must lie in the range 0.01 to 0.99 and should be below than 0.50. Many of local optima can be achieved using value of M. using value of M the best sensor nodes which are suitable for cluster head can be obtained. By providing alternate suboptimal options by M; optimal sensor node for cluster head can be selected.

Selection of M closest neighbor for each node in the cluster relies on the distance. Distance between the sensor nodes is calculated by RSSI. For long distance, closet neighboring nodes is determined using multi-hop communication route. Compared to direct communication energy dissipation is less when we choose a neighbor by multi-hop communication.

Every sensor node do calculates its own frequency of occurrence and minimum frequency needed for a cluster to become a CH is also computed. Frequencies weighted mean is calculated and it is enhanced by adding 1 to it. Weighted mean is calculated as product of each frequency of occurrence and number of sensor nodes having that frequency. The obtained frequency value is then rounded to its nearest integer. The value of nodes having frequency F or larger are identified and these nodes become the candidates for cluster head (CH) and added in cluster head set. The nodes which can be candidate cluster head nodes would always be equal to value of F.

C. Factors for expense value

The expense value (EV) is determined based on following factors:

1) Residual energy (E)

The residual energy of a node preferably is greater than the approximate energy dissipated in previous round by the cluster head.

2) Distance to coordinator node (D)

We know that energy consumption is directly proportional to the square of distance. The nodes which are having the less distance from supervisor node should have greater probability to become cluster head of cluster.

Expense value depends upon what is the residual energy of a node how much distance from the supervisor node. The cost is greater when the residual energy is more and the less distance to the supervisor node.

Formula for EV is given by

$$EV = (a \times E) + (b \times (1/D)) \quad \ldots\ldots\ldots (1)$$

Where *a* and*b* are taken as normalization constants.

And E and is defined as residual energy and distance to coordinator node respectively

D. Data loss ratio calculation

We are considering the forward node count for each node which defines the broadcast and rebroadcast probability of a node. Forward node count is denoted by FNC.

Initially FNC [Nk] = FNC min, for all the nodes Nk, k=1,2…..
FNC (min) is defined as the minimum number of forwarding nodes. Without any loss of packet in general case we can consider that
FNC (min) =1, steps involved in Adaptive energy efficient forwarding phase are described below:

– If N wants to forward the data collected to the BS, it adds its cost to the data packet and then broadcast the data packet to the closest neighbors.
– When neighbor N1 gets the packet from N. it first determines whether its cost is low than that of N. in case of less cost, it further send out or forward the packet. Otherwise if N1 is not in the direction of BS, it drops the packet.
– Destination D calculates the loss ratio (LR) when packets reach to it. Loss ratio is defined as ratio of total packets broadcast and total packets dropped from the source.
– D gives back this value of LR as a feedback to the Source node N.

After receiving LR by source node N, it analyzes this value of LR. It then changes the value of FNC as
FNC=FNC+ α, if LR> LR max……. (b)
Where we are taking α as min. decrement of the increment count and LR max is defined as the max threshold value of LR.

Then after modifying FNC it rebroadcast the data packets. When the rebroadcast packets receives by the destination D, it again find out the LR and gives back to N. It then reassigns the value of FNC.
For LR< LR max, then

FNC=FNC-α,
Until FNC>=FNC min……………………………………………(c)

This method of data aggregation is efficient in terms of reliability and energy since,

– As loss ratio is measured by the SN itself delay is decreased. Because when we measure the LR at the BS it creates high delay.
– As we are modifying the size of the cluster energy dissipation is lowered. And it provides reliability also.

E. Data loss ratio calculation in our network:

Figure 2 shows that we are considering the case of three clusters with their corresponding supervisor nodes SN 1, SN 2, SN 3. Clusters DLR is measured by SNs itself. DLR is measured in terms of how many packets have been transmitted by CN to BS and how many packets have been received back by CN.

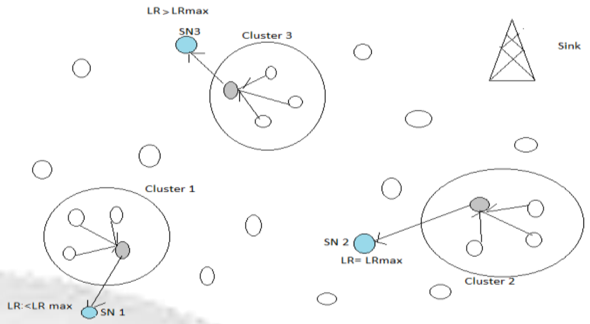

Fig. 2: loss ratio calculation for clusters

In figure 3, the forward count of the node is reassigned based upon the loss ratio. In cluster 1, since the loss ratio is greater than the threshold value, the forward node count can be increased and thus one more node is included in the cluster. In cluster 2, the forward count value is maintained as the same. In cluster 3, the loss ratio is lesser than the threshold value and the forward node count is decremented. One sensor node is excluded from the cluster.

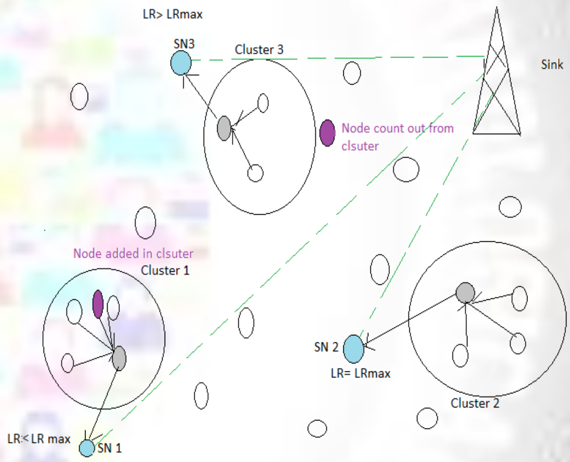

Fig. 3:changing the value of FNC based on DLR calculation.

This data aggregation technique proves to be efficient in terms of energy and reliability since,

– Energy is reduced effectively when the size of the cluster is altered based upon the loss ratio.
– The reliability can be maintained due to the change in the size of the clusters.
– Delay can be reduced due to that the loss ratio is measured in the CN itself. Measuring loss ratio at the sink causes high delay.

IV. SIMULATION RESULT

The performance analysis of SRREER is done by using MATLAB. Evaluation of SRREER is done by analyzing the packet delivery ratio in terms of rate. Rate & Energy and rate & delay. Simulation results are found based on varying rate. Packet delivery ratio in terms of rate defines ratio of number of packets transmitted and received successfully at the sink with no loss.

A. Behavior analysis

We ran the simulation environments with varying rate under certain condition of network for non-overlapping clusters. Rate range is varied from 100 kb to 250 kb.

1) Performance evaluation

The simulations results obtained on MATLAB analysis are shown by graphs.

2) A Rate vs delay graph for proposed protocol

In the figure 3, average end-to-end delay of our new proposed protocol is presented which is proven less than the existing previous routing protocol. We are comparing rate and delay ratio in terms of packet delivery. Congestion occurs when the sending rate will be increased from 100 to 250kb because it will result in increased traffic. Due to congestion there will be an increased amount of packet drops which will lead to increase in delay. But our proposed protocol delay is comparatively less because we are using cluster based approach having a supervisor node around the cluster which will lower the delay of data transmission from the sensor nodes to sink. The end-to-end-delay of network is averaged over total number of surviving data packets from the sources to the destinations. Surviving data packets are those data packets which are received by sink with no failure. Graph for average end to end delay is shown in figure 1

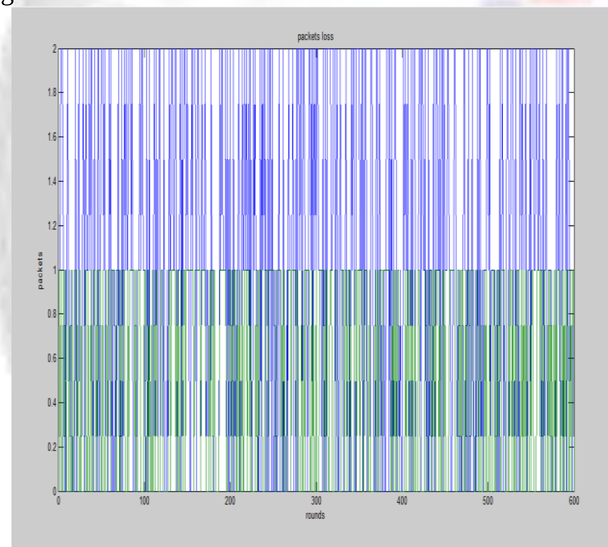

Fig. 1: Delay according to rate

B. Performance evaluation in terms of Rate vs packet delivery ratio

In figure 2, it can be evaluated that the packet delivery Ratio of our new proposed protocol is greater than the existing protocol. It is presented that with the increased rate there is increase in packet drop which will lead to reduction in delivery of packet. SRREER is beneficial here when compared to previous protocol because the new protocol calculates the data fatal ratio at the supervisor node and accordingly adjusts the cluster size based upon modification in their respective size.

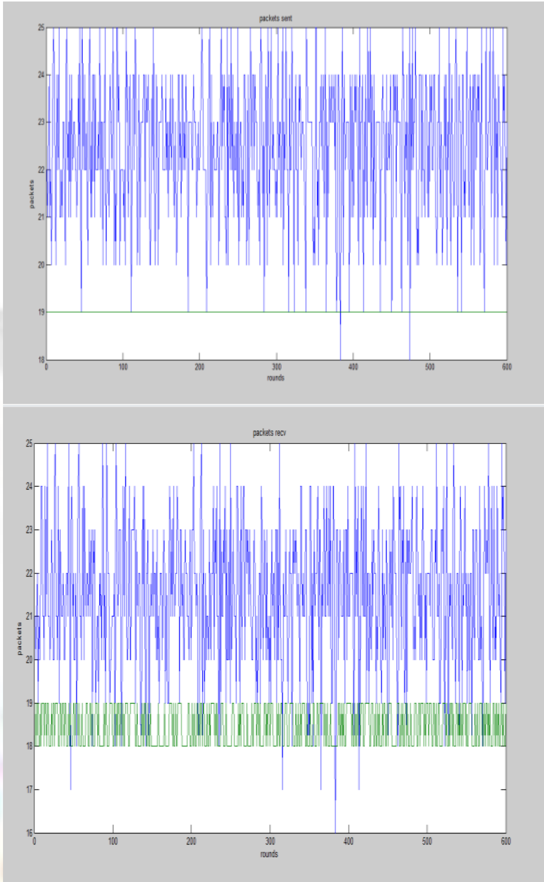

Fig. 2: Rate vs packet delivery ratio

C. Performance evaluation in terms of energy consumption

In the figure 3, we can see that with the increased rate in node, it consumes more amount of energy which increasing the network congestion and also increase in traffic which causing packet drop and resending of the packet which is causing wastage of energy. Proposed protocol is more efficient in terms of energy consumption because in this protocol we are selecting CHs based upon levels of energy where LEACH consumes more amount of energy compared to our proposed protocol.

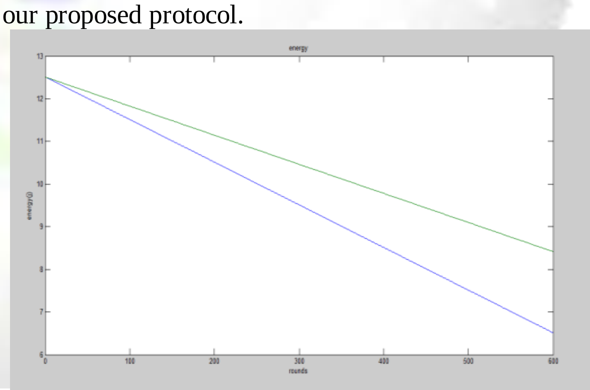

Fig. 3: Energy Consumption

D. Performance evaluation in terms of Average packet loss

In figure 4, it can be evaluated that the rate of packet loss of our new proposed protocol is less than the existing protocol. SRREER is beneficial here when compared to previous protocol because the new protocol calculates the data loss ratio at the supervisor node and accordingly adjusts the cluster size based upon modification in their respective size.

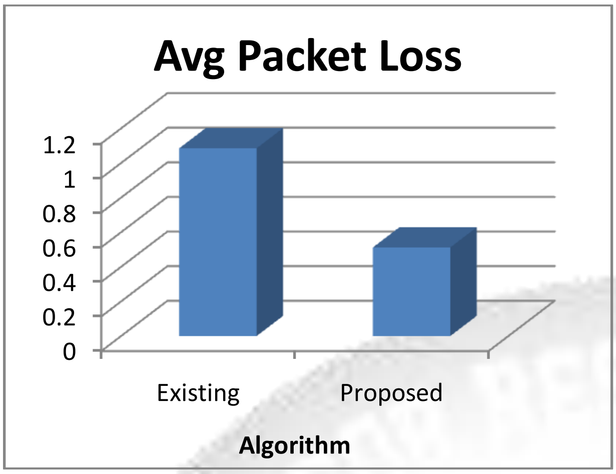

Fig. 4: comparison of average packet loss

E. Summary

Different simulations results were presented in this network. Proposed protocol shows the increased performance in terms of average end to end delay of packets, average delivery ratio of packets and energy consumption.

V. Future Work

Major issues like delay in terms of packet delivery, reliability in transportation of packets to BS of LEACH protocol is covered by our proposed protocol named as SRREER. We have overcome the effects of cluster head method creation of LEACH in our proposed protocol by using a special node outside the cluster for data aggregation. This technique is based on cluster formation and the data loss ratios of the clusters are measured so that the energy consumption can be effectively reduced. Reliable transmission can be served in the clusters using that special node.

For future work, the performance can also be compared with other protocol. Moreover, further research will be continued to expand this energy efficient formula to meet the requirements for WSN i.e. reliability and energy efficient.

References

[1] YingshuLi, My T. Thai, WeiliWu., “Wireless Sensor Networks and Applications”, Springer, 2008.
[2] Shashi Phoha (Editor), Thomas F. La Porta (Editor), Christopher Griffin (Editor). “Sensor Network Operations”,Wiley–IEEE Press. 2006
[3] Feng Zhao, Leonidas Guibas, ”Wireless Sensor Networks: An Introduction Processing Approach” Morgan Kauffman. 2004.
[4] Mohammad Illyas, ImadMahgoub, “Handbook of Sensor Network: Compact Wireless and Wired Sensing Systems”, CRC Press, 2004.
[5] C. S. Raghavendra (Editor), Krishna M. Sivalingam (Editor), Taeib F. Znati (Editor). “Wireless Sensor Network”, Springer. 2006.
[6] Shangwei Duan and Xiaobu Yuan, “Exploring Hierarchy Architecture for Wireless Sensor Networks Management” IEEE 2006.
[7] RichardZurawski, “Wireless Sensor Network in Industrial Automation”, IEEE.
[8] M.Ismail and **M.Y.Sanavullah, “Security Topology In Wireless Sensor Networks With Routing Optimisation”, IEEE 2008.
[9] Sung-Chul Jung, Hyoung-KeeChoi , “An Energy-aware Routing Protocol Considering Link-Layer Security in Wireless Sensor Networks”, ICACT 2009.
[10] Kihyun Kim, Junhyung Kim, Ick-Soo Lee, Honggil Lee Mahnsuk Yoon, Kijun Han, “An Efficient Routing Protocol based on Position Information in Mobile Wireless Body Area Sensor Networks”,2009 First International Conference on Networks & Communications.
[11] K. Romer and F. Mattern, “The design space of wireless sensor networks,” Wireless Communications, IEEE, Dec. 2004.
[12] S. Hadim and N. Mohamed, “Middleware: middleware challenges and approaches for wireless sensor networks,” Distributed Systems Online, IEEE, March 2006.
[13] Shijin Dai, Xiaorong Jing, Lemin Li “Research and Analysis on Routing Protocols for Wireless Sensor Networks, IEEE 2005.
[14] Baiping Li, Xiaoqin Zhang, “Research and Improvement of LEACH Protocol for Wireless Sensor Network, IEEE 2012.
[15] M. BaniYassein, A. Al-zou'bi, Y. Khamayseh, W. Mardini, “Improvement on LEACH Protocol of Wireless Sensor Network (VLEACH)”,International Journal of Digital Content Technology and its ApplicationsVolume 3, Number 2, June 2009.
[16] JiaXu, Ning Jin, XizhongLou ,TingPeng, QianZhou,Yanmin Chen, “Improvement of LEACH protocol for WSN”, IEEE2012.
[17] Yuling Li, Luwei Ding, FengLiu, “The Improvement of LEACH Protocol in WSN”, 2011International Conference on Computer Science and Network Technology IEEE.
[18] Ajay Jangra, Swati, Priyanka, “Securing LEACH Protocol from Sybil Attack using Jakes Channel Scheme (JCS).
[19] Approving Renold, R.Poongothai, R.Parthasarathy, “Performance Analysis of LEACH with Gray Hole Attack in Wireless Sensor Networks”, IEEE 2012.
[20] Mingming Lu and Jie Wu,“Utility-Based Data-Gathering in Wireless Sensor Networks with Unstable Links,” proceedings of the9th international conference on Distributed Computing andNetworking ICDCN’ 08, 2008.
[21] KiranMaraiya, Kamal Kant, and Nitin Gupta “Wireless Sensor Network: A Review on Data Aggregation” International Journal of Scientific & Engineering Research, 2011.