Novel and Energy Efficient Routing in Wireless Sensor Networks

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ABSTRACT
This paper presents a new approach to energy efficient routing in wireless sensor network. Here multiple routing paths are created based on the energy status of the nodes and they are used one after the other resulting in utilizing the energy equally from all the nodes in the network. The periodic update messages are minimized by using back up node and having every node broadcast its energy status to its neighbors prior to its death i.e. when energy of a node goes below minimum threshold.

General Terms
Cluster head, Fuzzy Logic, Virtual circuits

Keywords
Clustering, Backup node, Cluster member, Intra cluster routing, Inter cluster routing, Energy status table, Base station

1. INTRODUCTION
Wireless sensor networks is distribution of nodes that are autonomous and varying from 100's to 1000's in number which senses the environmental conditions and other physical conditions like temperature, pressure, weather report, pressure, etc. All the sensor nodes function cooperatively and send the information to BS or the gateway which processes it and takes the appropriate actions and forwards the data accordingly. The motivation to this paper is the military applications where enemy activities are sensed and the same is sent to action camp and the weather report which is very helpful in predicting disasters.

With the growing needs the smaller networks are extended to larger networks day by day and there is need to increase the performance. The major concern with the sensor nodes is that they have very less amount of life time and we have to make sure that their energy is used wisely in computing and communicating the information and the design issue concerned with sensor networks is the results have to be tested and the deployment has to be done under various hostile environments i.e. under the water (sea), in the air, on the ground.

Since the sensor nodes have very limited power or energy it is important to perform routing efficiently and also consume less power. There are plenty of routing and energy efficient algorithms that exist and describe their own unique approach to routing in the WSN namely LEACH [1], LEACH – C [1], Ant Colony Optimization [2] where they establish the network as a collection of clusters and route the information based on.

2. RELATED WORKS
There are numerous routing protocols which have come in the past and they concentrate on energy efficient routing. There are few which use novel intelligent protocols, for example ant colony optimization [2], LEACH based clustering [1], LEACH–C based clustering [1], Bee Sensor networks. There are hierarchical routing protocols which are in existing where the network is deployed as a tree and artificial intelligent is applied for dynamic routing.

2.1 Ant colony optimization (ACO)
This is a novel routing protocol which uses artificial stigmergy as each ant tries to find a route between its nest and a food source and at the same time it lays down the phenorome and it makes use of the phenorome to find the route initially. Once route is found the same is intimated to other ants which follow the initial Ant. Here an ant is referred to as packet which makes use of acknowlgement messages from the neighboring nodes that provides various information in terms of next hop selection, Shortest distance. This algorithm finds the best route between source and destination but here they are not concentrating on the energy balance where only one set of nodes are been used to forward the packets where the energy consumption from all the nodes is not uniform.

2.2 LEACH Protocol
There are energy efficient routing algorithms which are based on clustering as well as on non clustering techniques where in the clustering technique the network is divided into bunch of groups called clusters and each cluster has cluster head who manages cluster members. Cluster heads (CH) in some cases communicate to other cluster heads based on the network architecture. The clusters are made so that energy consumption of the Cluster member (CM) is minimized as they will be routing the information to the CH instead to outer network. CH collects the info from all CM's and route to appropriate cluster in the network. LEACH protocol is a routing protocol that uses the clustering technique in order to minimize the energy consumption the network. Here CM communicates to CH and CH forwards it to other CH's. The CH once looses energy it starts a CH elects new CH and the update about same is sent across the network. Here we are having message overhead.

2.3 LEACH C
This is an enhanced version of LEACH protocol where the energy consumption is minimized as compared to LEACH and here the idea of cluster head (CH) selection follows centralized approach where instead of choosing the randomized node as CH, it broadcasts messages to all the

nodes and waits for the reply from the nodes who would like to be CH. Now on receiving request for new CH, it processes the energy status of all requested nodes and selects the node with higher energy as the CH or it might also select the CH with any other criteria.

2.4 Adaptive Clustering Based Dynamic Routing Via Generalized Ant Colony Optimization

This is protocol that makes use of the foraging which is a natural behavior of the ant where the ants that are moving or in motion try and find the phenorome in the mid way of food source and their home. Each ant passes the information to the other ants by putting the phenorome and communicates the same with ants and environment. So here group of ants operate as collaboration agents and carry out various operations such as choosing the minimum trail to food source. As phenorome vanishes with time the new ways are found out by ants where all the ants collaborate together and find the minimum path with high amount of phenorome. According to phenorome trails and heuristic details several routes are possible with particular probability.

3. PROPOSED ALGORITHM

We have come up with an approach where we are using the concepts from the existing protocols and adding few of our ideas into it to try and make a better routing protocol that can consume less energy and also perform efficient routing.

3.1 Clustering

We are clustering entire network into group of clusters. And initially each cluster is provided with a 2 energized nodes than normal nodes one is kept active which acts as CH for other.

CM's in the cluster and other is kept in idle state which acts as a backup node and becomes active whenever CH dies. The number of cluster is decided on number of CH and total no of CM in the network

No of clusters = No of CH/No of CM

3.2 Routing

We have intra as well as inter cluster routing.

3.2.1 Intra cluster routing

Here every node (CM) has to pass the information to the CH.

Every CM has two table's i.e. residual energy table and neighbor hop distance metrics table. The aim here is to pull the energy from each of the CM equally. So the routing takes as below.

As it is a multipath routing protocol. In order to choose the next hop for routing the information, it scans the residual energy table and uses that node as next hop which has higher residual energy so that the energy is utilized equally from all the CM's. But it costs us a bit in routing time the cause due to this is minimized by using the second table which has neighbor distances. It is also made sure that we are not compromising in the routing for any important information i.e. a prioritized packet is always sent by the shortest path and to do the same the sensor node starting the communication must indicate the information to be important.

There is also a limit fixed on the deviation from the shortest path routing time to alternate Or new routing path for normal packets failing which energy is compromised to keep up the descent routing time. Again fuzzy logic is used to select the appropriate route.

A=Cost(Shortest Path), N=Cost(New Path)
D=Deviation
D= (N-A)/A * 100
Fuzzy Logic
IF D<30 THEN take new route
IF D>30 THEN take existing route

3.2.2 3.2.2. Inter cluster routing

Each CH contains the neighbor CH information table and it also knows the distance to the base Station. Both details are to be updated in case of dynamically changing network.

Here CH communicates the info collected from CM's and route it to either neighbor CH or base station based on the distance it is at from base station. We are making use of Fuzzy Logic Rules to perform this action.

3.3 Fuzzy Logic

R: Transmission Range
IF R(CH) > R(BS) THEN route to BS
IF R(CH) < R(BS) THEN route to CH

To simplify the routing we are using the concept of virtual circuits (VC) where the initial route discovery is performed by establishing the VC. here when ever next hop is selected in the route discovery, same is been entered into the routing table of that particular CH so that the follower packets don't waste time discovering the route and simply follow the path established by virtual circuits. The bottleneck is, it's difficult to re discover the route if there is failure of the node in the discovered route. So we are finding two or three routing paths while establishing VC initially which can act as back up paths or the alternate paths. Again we have CH also intimating its status to its neighbor CH's whenever it is about to die and whenever residual energy crosses certain minimum energy threshold so that Neighbor CH can update their routing tables.

3.4 Cluster head Election

In order to minimize the overhead due to communication messages, we try and avoid the CH election procedure whenever the CH is down instead we are using a back up node which serves as a CH till the CH is up and running mean while this updating information is not sent to any of the CM or CH's. The CM's and CH's get to know this whenever they have information to be sent to CH and they don't get response, after timeout of which it sends the message to BN.

It's the responsibility of the CH to activate the idle BN as new CH before it is about to die or whenever it crosses certain minimum energy threshold. By this we are able to reduce the overhead due to communication. This is the reason why BN is used. Because if the cluster head is continuously changing then we have go for updating this information to all CM and CH which is an overhead. In some cases there may be network failures due to which there is no response from the CH in that case the information is sent to BN which refuses the info sends an advise message that the CH is active and try again learning which the node transmits the data again and it is a success if the network is up and running else it concludes that cluster head is dead and this is a limitation of our proposed routing protocol.

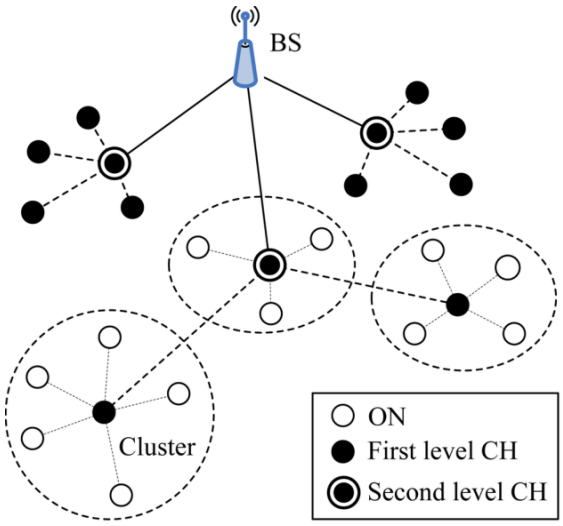

Fig 1: Structure of the wireless sensor network

Anyways we do use election algorithm to elect new CH whenever BN is also down and the lost CH is not yet up. And update the same as in existing systems

4. EXCEPECTED PERFORMANCE AND ANALYSIS

The study of number of novel routing algorithms was carried out with various aspects like the shortest path driven, the longer battery life, the routing is single hop or multi hop, the number of routing paths is single or multiple and other parameters like number of cluster heads. This gave us fruitful results which we are tabulating as a columnar data and also it helped to compare our solution with all these existing algorithms.

Importance of parameters we considered

Routing path: The cost of the routing path is important for any routing algorithm as it tells us how long does it take a packet to reach the destination and what will be total distance, cost and the energy needed for its successful transmission.

Battery Life: The power consumption is another major factor which will decide the life of the sensor networks as sensors are small in size they can't carry larger batteries and it is must for a routing protocol developer to make a transmission of a packet with lesser power by introducing various methods like alternate paths replacement nodes and all.

No of Routing Paths: The number of routing paths that are found for a packet transmission plays role as a backup route in case of route or network failure and route congestion. It is always better to keep the one optimal route and several backup semi optimal routes.

No of Hops: It matters for a routing protocol whether it is a single hop or a multi hop based on which the trace for particular route can be driven.

No of Cluster heads: This is our research area and we are proposing an idea to have 2 or more multiple cluster heads in the cluster as we know the cluster head performs lot of operations in the cluster when it is active like routing of the packet between cluster and within cluster. Allocation of resources, processing of the requests, handling cluster member failures

Below are the results of various routing algorithms

Table 1. Comparison Study of several Routing Protocols

Routing Protocols	Load Balancing	Shortest Route	No of Hops (single or Multiple or both)	No of Routing Paths	No of Cluster Heads	Presence of Backup Nodes
Ant Colony Optimization	No	Yes	Both	One	1	No
LEACH	No	Yes	Multi hop	One	1	No
LEACH C	No	Yes	Multi hop	One	1	No
Adaptive Clustering Based Dynamic Routing Via Generalized Ant Colony Optimization	No	Yes	Multi Hop	One	1	No
Proposed Algorithm	Yes by choosing alternate routes after a threshold	Yes	Both	Multiple	2 to 3	Yes

The performance of the routing algorithms or the routing protocols can be measured with various parameters like Throughput i.e. number of packets sent in particular time, the Life time of the network i.e. how long the network is active, Number of messages exchanged per failure or per an update and several other parameters like reliability, recover from failures, security, scalability.

Our algorithm is good at load balancing and energy efficient routing. The message communication is minimized between the CM's and CH's as compared to LEACH and LEACH C algorithms. The energy and time for the works like new CH election, finding the routing path are also minimized as compared to LEACH algorithm.

5. CONCLUSION AND FUTURE WORK

We know that the sensor nodes are having very limited power. The routing technique will consume less energy from the network i.e. there is a load balancing by several nodes in the network. It all depends on the requirement of the network and type of network architecture or infrastructure that is provided so that the clustering size and type of clustering can be changed accordingly and also based on either energy or routing time is important, we can choose different approaches in the routing. There might be some cases where the network is dynamic i.e. there are changes occurring in the design or architecture or configuration of the network. In this scenario lot of messages need to be exchanged between necessary CH and CM so that the routing is not affected. And this message communication overhead definitely costs us and again it is left to us to decide based on the network design and requirement.

The possible future work can be in the multipath routing by fetching data from all the neighbor nodes and if we get required data (shortest path) from the first node itself, it is redundant to keep fetching data from all the neighbor nodes and we will come up with an approach to minimize this delay in our next paper.

Also in the initial route discovery using virtual circuits, we are taking alternate paths just to fix from the failure of any node in the initially discovered path. We will come up with a better fix to this in our next paper.

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