Base Station and Zone Based Performance Evaluation of Optimal Clustering in Wireless Sensor Network

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Abstract –

The placement of base stations in wireless sensor networks affect the energy consumption for communication between sensor node and base station. In this paper we analyzed the performance of the zone based clustering protocol [2] under varying position of base stations, different zone sizes and the effect on network life time with multiple base stations. While evaluating the communication overhead of various cluster sizes, we observed that the optimal cluster size for a given network is complex, depending on a range of parameters. Simulation results show that communication overhead decreases as we increase the number of zone in the network. We show that placing multiple base stations in place of single base station in zone based routing protocol enhance the network life time.

Keywords-

zone based clustering protocol, Zone, Wireless sensor network, network life time.

1. Introduction

Sensor network is composed of a large number of tiny autonomous devices, called sensor nodes. Each sensor node has four basic components: a sensing unit, a processing unit, a radio unit, and a power unit. WSN is an emerging technology that can be deployed in such situation where human interaction is not possible like border area tracking enemy moment or fire detection system. Sensor network is composed of a large number of tiny autonomous devices, called sensor nodes. Each sensor node has four basic components: a sensing unit, a processing unit, a radio unit, and a power unit. Figure 1 shows an overview of WSN. Sensor are deployed in the environment which can be fire area, border or open environment. These tiny devices sense the area of interest and then communicate with Base Station (BS). On BS the gathered information is analyzed.

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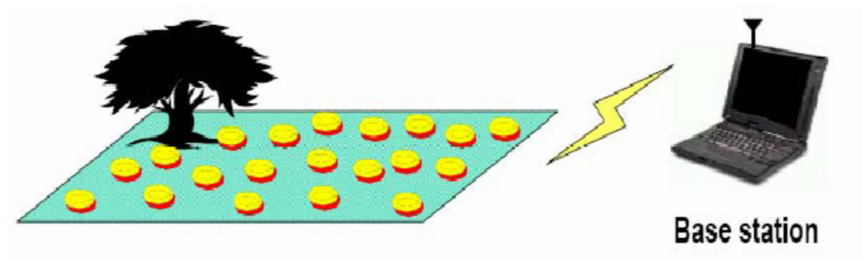

Figure 1. Overview of a wireless sensor network.

Clustering in wireless sensor networks (WSNs) is the process of dividing the nodes of the WSN into groups, where each group agrees on a central node, called the cluster head, which is responsible for gathering the sensory data of all group members, aggregating it and sending it to the base station(s).

Despite the wealth and variety of protocols and their individual evaluations through simulation, experimentation, and comparison to existing approaches, little help is available for the WSN application developer. We define the optimal cluster as the one sized such that routing data from the cluster member to cluster head and subsequently to base stations incurs the minimal communication overhead. We confronted this question of optimal clusters for zone based clustering algorithm ZBCA[2], a low energy, low overhead clustering protocol that divided the area into zone and create a cluster head per zone. While evaluating the communication overhead of various cluster sizes, we observed that the optimal cluster size for a given network is complex, depending on a range of parameters.

Therefore, in this paper, we explore the problem of optimal clustering in detail, through experimentation using MATLAB. Section 2 sketches the current state of the art of clustering algorithms, Section 3 Identifying the optimal cluster, Section 4 Energy model and Simulation parameters, Section 5 Experiments and Simulation Result, Section 6 conclusion.

2 Related Work

Routing is a process of selecting a path in the network between source and destination along which the data can be transmitted. Various protocols are available to route the data from node to base station in WSN in an energy efficient way, enhancing the network survivability. Battery power being limited in the sensor nodes let the node to expire on its full consumption. The expired node is called the dead node which results in its no contribution in the network further.
Grouping sensor nodes into clusters has been widely pursued by the research community in order to achieve the network scalability objective.[1] Sensors organize themselves into clusters and each cluster has a leader called as cluster head(CH), i.e. sensor nodes form clusters where the low energy nodes called cluster members (CM) are used to perform the sensing in the proximity of the phenomenon. For the cluster based wireless sensor network, the cluster information and cluster head selection are the basic issues. The cluster head coordinates the communication among the cluster members and manages their data.[3]

Low-energy adaptive clustering hierarchy (LEACH) is a popular energy-efficient clustering algorithm for sensor networks. It involves distributed cluster formation. LEACH randomly selects a few sensor nodes as CHs and rotate this role to evenly load among the sensors in the network in each round. In LEACH, the cluster head (CH) nodes compress data arriving from nodes that belong to the respective cluster, and send an aggregated packet to the base station. A predetermined fraction of nodes, p, elect themselves as CHs in the following manner

Another cluster selection zone based scheme Zone Based Clustering Algorithm (ZBCA) [2,4] involves dividing the area into rectangle grids called zones. In this algorithm, communication between the sensor nodes for the CH selection is reduced, so that the energy consumption for CH selection can be reduced. . The probability of a node to become CH is p, where p is the maximum number of CHs in network. CHs organize and control the cluster members in their cluster. All nodes have to establish a connection with a CH to join its cluster. The CH of each zone sends the join request to nodes of its neighbouring zones only. On the basis of distance the nodes select one CH, which is most near to it. Sensor nodes send data to CHs and CHs further to base station. Cluster head is responsible for data aggregation and compression that reduces the energy consumed for data transmission.

3 Identifying the optimal cluster

Our analysis considers the effect of key clustering parameters on the communication overhead. We follow an experimental approach for two reasons. First, it is hard if not impossible to derive generally valid formulas for the network communication overhead that consider all parameters, especially random topologies. Our motivation is to make our results applicable on a real application and the most relevant scenarios from our experiments directly derive the optimal clustering parameters. We performed our simulations in MATLAB. In the scenario, nodes have uniform random distribution in area. The network area is divided into equal-size zone and each node has a cluster. Results are presented for a variety of cluster sizes that allow the area to be precisely divided into such equal-size zone. The shortest distance in terms of ETX, expected number of transmissions, is computed between each node and its corresponding cluster head and between all cluster heads and the base stations. The energy expenditure is calculated as the sum of ETX and ERX (expected number of receivers) for one round of data gathering. Overhearing costs are included in ERX. Cluster formation energy is used Each of the reported experiments is the mean of 100 independent random topologies with random nodes selected as base stations Our goal is always to identify the optimal cluster size for scenarios, first studying the placement of base stations and then the varying size of zone for the clustering in Zone based routing Algorithm.

4 Energy model and Simulation parameters

We use the energy model for simulation as [3,5]. Following simulation parameters is used for the simulation.

Table 1: Simulation Parameters

Parameter	Values
Simulation Round	2000
Topology Size	200 X 200
Number of nodes	100
CH probability	0.5
Initial node power	0.5 Joule
Nodes Distribution	Nodes are uniformly randomly distributed
BS position	Located at (100,250)
Energy for Transmission (ETX)	50*0.000000001
Energy for Reception (ERX)	50*0.000000001
Energy for Data Aggregation (EDA)	5*0.000000001

5 Experiments and Simulation Result

Simulation is performed for two scenarios.

5.1. Multiple Base stations

In this experiment we change the location of the base station and number of base station. In the first experiment there is a single base station located at the boundary of the wireless sensor area. Table 2 show the distance from the first cluster head to base station. In each round cluster head send the aggregated data to the base station. According to energy model transmission energy depend on the distance. As the distance increases node required the more energy for transmission.

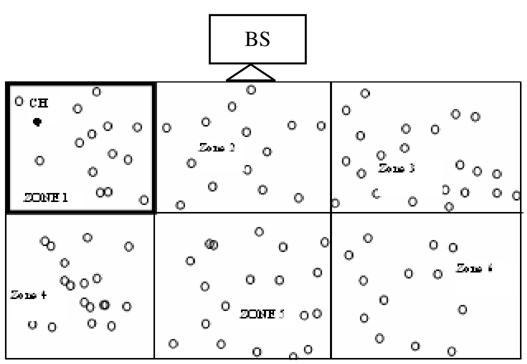

Figure 2: Zone based clustering with single base station

Table 2 : Energy consumption for a single transmission from cluster head to base station in single base station scenario

Zone ID	Distance from cluster to Base Station	Energy consumption for a single transmission E=ETX*PL+Emp*PL*(dist*dist*dist))
Z1	117.47	5.21073E-05
Z2	100.54	5.13212E-05
Z3	110.89	5.17726E-05
Z4	231.48	6.61244E-05
Z5	226.88	6.51821E-05
Z6	234.09	6.6676E-05

If we use 2 base station located at the boundary of the network area in opposite direction.

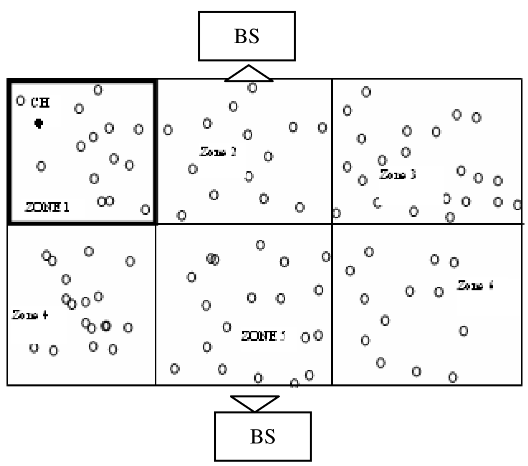

Figure 3: Zone based clustering with two base station

Following table shows the energy consumption for the single transmission from cluster head to base station.

Table 3: Energy consumption for a single transmission from cluster head to base station in two base station scenarios

Zone ID	Distance from the Cluster head to base station near to it.	Energy consumption for a single transmission
		E=ETX*PL+Emp*PL*(dist*dist*dist))
Z1	182.44	5.78941E-05
Z2	177.13	5.72247E-05
Z3	187.88	5.86215E-05
Z4	176.92	5.7199E-05
Z5	150.36	5.44192E-05
Z6	180.49	5.76437E-05

If we use base station located at the center the network area.

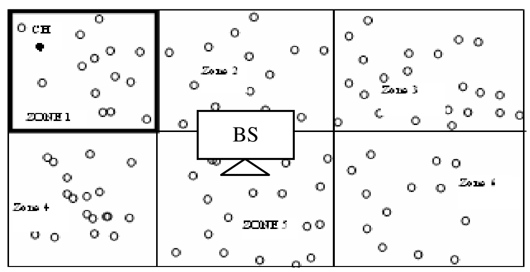

Figure 3: Zone based clustering with base station at center

Following table shows the energy consumption for the single transmission from cluster head to base station.

Table 3: Energy consumption for a single transmission from cluster head to base station in base station at center scenarios

Zone ID	Distance from cluster to Base Station	Energy consumption for a single transmission
z1	87.658	5.87562E-05
z2	90.789	5.97284E-05
z3	106.3	6.5615E-05
z4	96.438	6.16597E-05
z5	51.07	5.17316E-05
z6	117.46	7.10675E-05

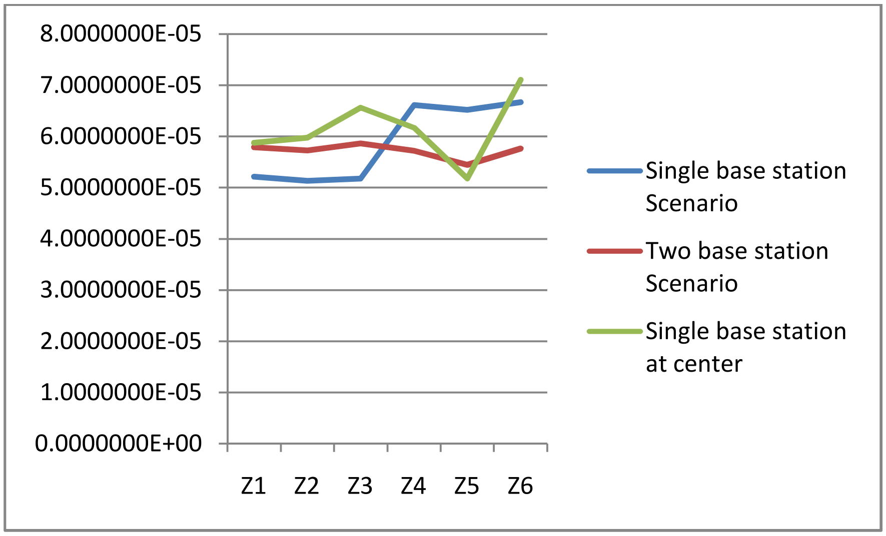

Figure-4 : Comparison in energy consumption for a single transmission from cluster head to base station in one and two base station scenarios

5.1.1. Network performance can also be defined in terms of number of round in which first node dead. In above scenarios we find the number of round in which first node dead for 10 simulation runs.

Table 4 : Number of round in which first node dead in single base station scenario and two base station scenario and base station at center

Simulation run	**Number of round in which first node dead in case of single Base station located at boundary**	**Number of round in which first node dead in case of 2 base stations located at boundary in opposite direction**	**Number of round in which first node dead in case of base stations located at center**
Simulation run 1	667	669	722
Simulation run 2	682	862	608
Simulation run 3	754	912	704

Simulation run 4	860	862	546
Simulation run 5	594	820	606
Simulation run 6	822	970	590
Simulation run 7	710	685	716
Simulation run 8	781	750	847
Simulation run 9	745	970	641
Simulation run 10	611	770	683

As above the range of first node dead in single base station is from 594 to 860 and in the two base station scenarios it range from 669 to 970. This shows the enhancement in network life time.

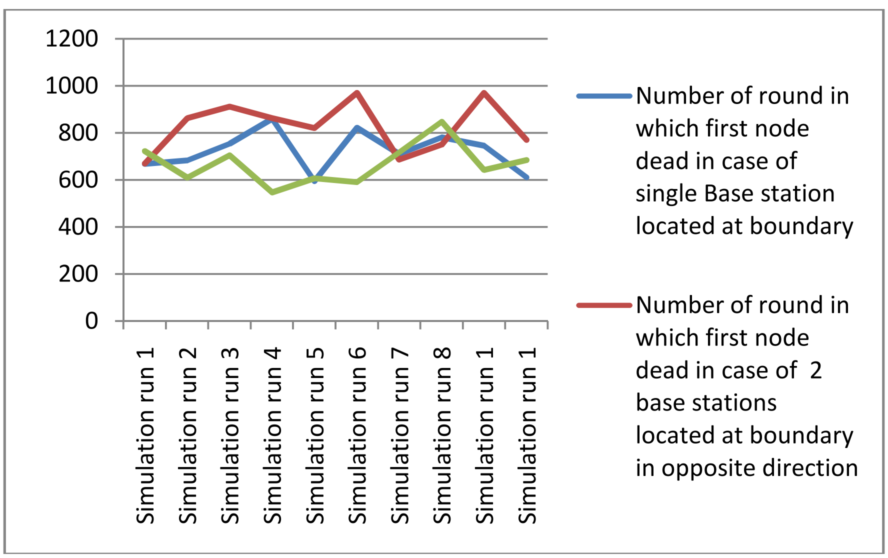

Figure-5: Number of round in which first node dead in single base station scenario and two base station scenario and single base station at center

5.3. Using different zone size

We also perform simulation with the same simulation parameter but with different zone size.

Simulation is done with 2 zone , 4 zone , 6 zone, 16 and 64 zone of network area. Following table shows the number of round in which first node dead.

Table 5:Number of rounds in which first dead node occurs with different zone size.

Simulation Run	with 1 zone	with 4 zones	with 6 zones	with 16 zones	with 64 zones
1	516	608	745	1054	1205
2	552	591	792	1070	1340
3	541	650	683	970	1190
4	494	710	782	1140	1423
5	511	704	743	1005	1322
6	520	622	740	1280	1306
7	535	698	692	750	1155
8	549	598	699	1153	1465
9	562	550	763	1295	1537
10	501	601	635	929	1211

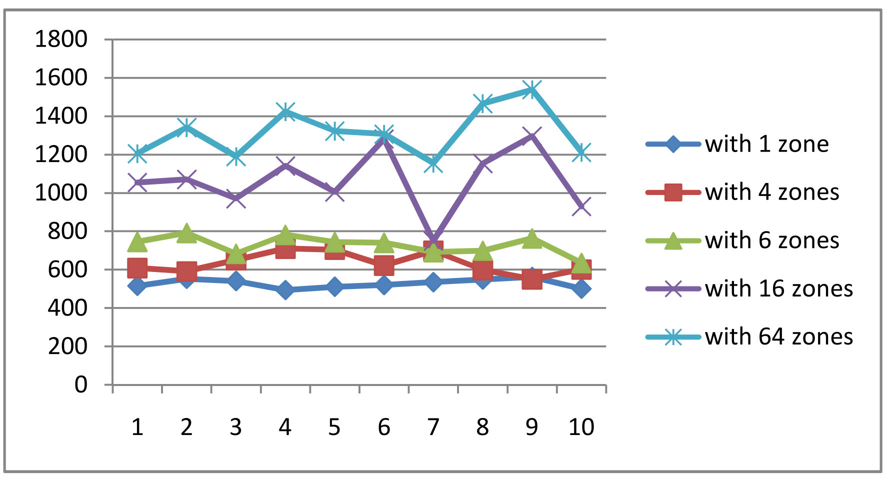

Figure-6 No. of round in which first dead node occurs with different zone size

As shown in above table as we reduce the area of zone the round number in which the first node dead occur is increased. For a large network area the area can be divided in the smaller zone to increase the network lifetime.

Conclusion:

In wireless sensor area network clustering is used to increase network lifetime. As the simulation result show if we increase the number of base station than the energy required for communication will be decrease. And if the base station is in center than it will also reduce the communication cost. Transmission energy depends on the distance and distance for the communication is less in multiple base station scenarios. In zone based algorithm the size of the zone will also affect the residual energy of the node. Less zone area will increase the life time of network. Although this is a theoretical simulation result for homogeneous network, but it can be easily used for the live application.

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