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An Enhanced Aggregated Data Forwarding and Distributed Clustering Strategy for Lifetime Maximization in Wireless Sensor Networks

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Abstract: In a wireless sensor network, the clusterhead is used to transmit the aggregated data to the sink or base station. In this paper, a model of distributed layer-based clustering algorithm isproposedbasedonthreeconcepts.In this proposed method, theaggregateddataisforwardedfromclusterheadtothebasestationthroughclusterheadofthenexthigherlayer with shortest distance between the cluster heads. Also, cluster head is elected based on the clustering factor, which is the combination ofresidual energy and the number of neighbors of a particular node within a cluster. Moreover, each cluster has a crisis hindrance node, which does thefunction of cluster head when the cluster head fails to carry out its work in some critical conditions. This paper corresponds to the formulation of an enhanced aggregated data forwarding and distributed clustering strategy for lifetime maximization in wireless sensor networks. The proposed method is compared with the existing clustering methods HEED and LEACH for assessing the overall network lifetime.

Keywords:*Clusterhead, Remainingenergy,Networklifetime, Energyefficiency, Sensor nodes.*

1. Introduction

Tounderstandtheperformanceofavailable protocols,themobilitypatternsand mobility metrics have to be subjectively considered. Since WSNs has many advantages like self-organization,infrastructure-free, fault-tolerance and locality, they have a wide variety of potential applications like bordersecurityandsurveillance,environmentalmonitoringandforecasting,wildlifeanimalprotectionandhomeautomation, disaster management and control. Considering that sensor nodes are usually deployed in remotelocations,itisimpossibletorechargetheirbatteries.Therefore,waystoutilizethelimitedenergyresourcewiselytoextendthelifetimeofsensornetworksisa verydemandingresearchissue forthesesensor networks [1],[2]. Figure 1 shows elementary components in a wireless sensor node.

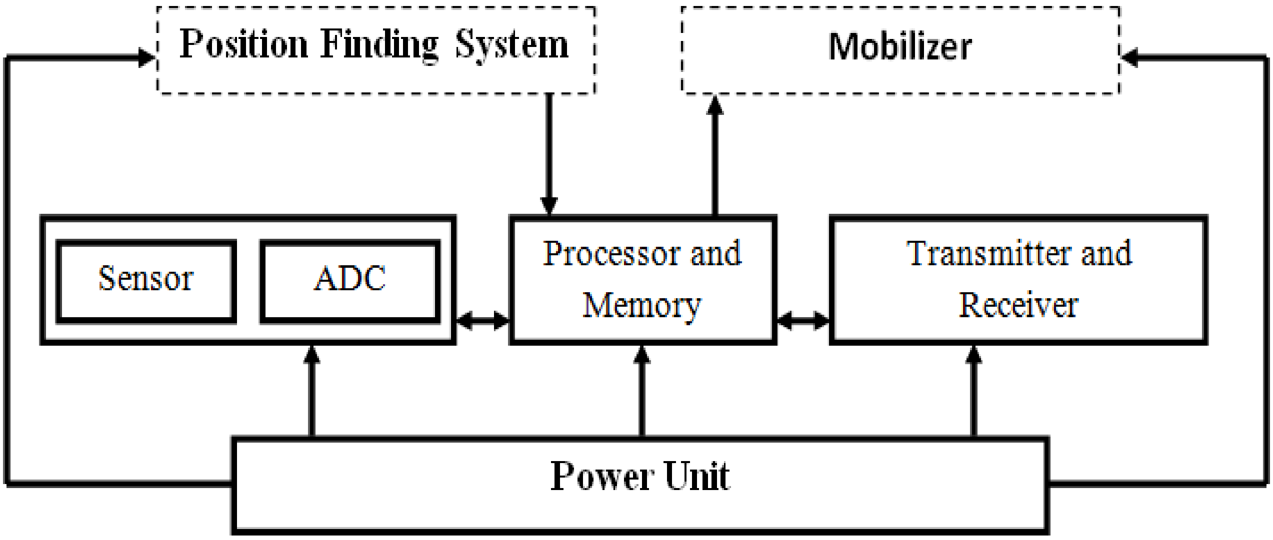


Figure 1. Elementary components in a WSN node

Clustering is an effectual topology control approach, which can prolong the lifetime and increase scalabilityforthesesensornetworks.Thepopular criterionforclusteringtechniqueistoselect acluster head(CH)with more residual energy and to spin them periodically. The basic idea of clustering algorithms is to use the dataaggregationmechanismintheclusterheadtolessentheamountofdatatransmission.

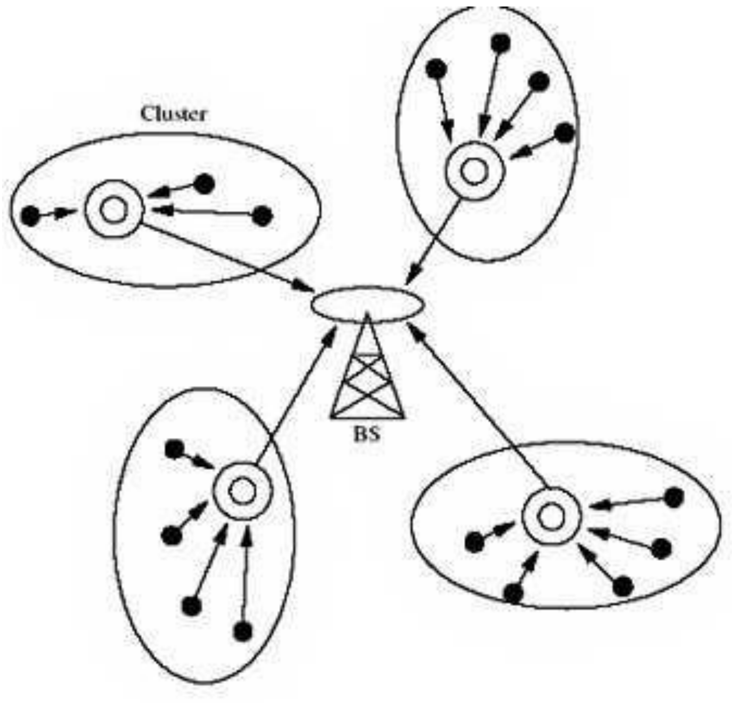


Figure 2. Articulation of cluster formation

Clusteringgoesbehindsome advantages like network scalability, localizing route setup, uses communication bandwidth efficientlyand takes advantage of network lifetime [3]. By the data aggregation process, unnecessary communicationbetweensensornodes,clusterheadandthebasestationisevaded [4],[5].Inthispaper,awell-definedmodelofdistributedlayer-based clustering algorithm is proposed based of three concepts: the aggregated data is forwarded from thecluster head to the base station through cluster head of the next higher layer with shortest distance between thecluster heads, cluster head is elected based on the clustering factor and the crisis hindrance node does the functionofclusterheadwhentheclusterheadfailstocarryoutitswork.Theprimeaimoftheproposedal gorithmistoattainenergyefficiencyandincreased networklifetime. Figure 2 shows the clustering architecture in multiple WSNs.

2. Related Works

The algorithm CLUBS was implemented, which is executed with an idea to form overlapping clusters withmaximumclusterdiameteroftwohops.Theclustersarecreatedbylocalbroadcastinganditsconv ergencedependsonthelocaldensityofthewirelesssensornodes.Thisalgorithmcanbeimplementedi nasynchronousenvironmentwithoutdroppingefficiency.Themaindifficultyistheoverlappingofcl usters,clustershavingtheirCHswithinonehop range of each other, thereby both the clusters will collapse and CH election process will get restarted.

The methodology FLOC was suggested, which shows double-band nature of wireless radio-model forcommunication. The nodes can commune reliably with the nodes in the inner-band and unreliably with the nodesthatareintheouter-band.Thechiefdisadvantageofthealgorithmis,thecommunicationbetweenthenodesintheouterband isunreliable andthe messageshave maximumprobabilityof gettinglostduringcommunication.

Themethod EECS was formulated, which is based on a supposition that all CHs can communicatedirectlywiththeBS.Theclustershavevariablesize,thosecloserto theCHarelargerinsizeandthosefartherfromCH are smaller in size. It is really energy efficient in intra-cluster communication and shows an excellentimprovementinnetworklifetime.EEUCisanticipatedforuniformenergyconsumptionwithinthesensornetwork.Itformsdissimilarclusters,withaguessingthateachclustercanhavevariablesizes.ProbabilisticselectionofCHisthe focalshortcomingof this algorithm.

The algorithm DECAselectsCHbasedonresidualenergy,connectivityandanodeidentifier.Itisgreatlyenergyefficient,asituseslessermessagesforCHselection.Themaintroublewiththisalgorithmisthathigh risk of wrong CH selection which leads to the discarding of every packets sent by the wireless sensor node.Ding, Holliday and Celik proposed DWEHC, which elects CH on the basis of weight, a combination of nodes'residual energy and its distance to the neighboring nodes. It produces well balanced clusters, independent ofnetwork topology. A node possessing largest weight in a cluster is designated as CH. The algorithm constructsmultilevel clusters and the nodes in every cluster reach CH by relaying through other intermediate nodes. Theforemost problem occurs due to much energy utilization by several iterations until the nodes settle in most energyefficient topology.

In HEED, CH selection is done by taking into account the residualenergy of the nodes and intra-cluster communication cost leading to prolonged network lifetime. It is clear that itcan have variable cluster count and supports heterogeneous sensors. The problems with HEED are its applicationnarrowedonlytostaticnetworks.

3. Algorithm Description

In LEACH protocol, sensor nodes are unified together to form a cluster. In each cluster, onesensor node is chosen arbitrarily to act as a cluster head (CH), which collects data from its member nodes,aggregates them and then forwards to the base station. It disperses the operation unit into many rounds and eachround consists of two phases: the set-up phase and the steady phase. During the set-up phase, initial clusters arefashionedandclusterheadsareselected.

Allthewirelesssensornodesproducearandomnumberbetween0and1.If the number is lesser than the threshold, then the node selects itself as the cluster head for the present round. Thethresholdforclusterheadselection inLEACHforaparticularroundisgiveninequation1.GoneselectingitselfasaCH,thesensornodebroadcastsanadvertisementmessagewhichhasitsownID.Thenon-clusterheadnodescanformulateanassessment,whichclustertojoinbasedonthestrengthofthereceivedadvertisementsignal.

Afterthedecisionismade,everynon-clusterheadnodeshouldtransmitajoin-requestmessagetothechosenclusterheadtospecifythatitwillbe amemberof thecluster.Therefore,itcanreceiveeverydatafromthenodeswithintheirownclusters.Onreceivingthedatafromthecluster,theclusterheadcarriesoutdataaggregationmechanismandonwardsittothebasestationdirectly.Thisistheentiremechanism of the steady state phase. After a certain predefined time, the network will step into the next round.LEACHisthebasicclusteringprotocolwhichprocessesclusterapproachanditcanprolongthe networklifetimeincomparison with other multi-hop routing and static routing. However, there are still some hiding problems thatshould be considered.LEACH does not take into account the residual energy to elect cluster heads and to construct the clusters. As aresult,nodes withlesser energymaybeelectedasclusterheadsandthendiemuchearlier.

Moreover,sinceanodeselects itself as a cluster head only according to the value of the calculated probability, it is hard to guarantee thenumberofclusterheadsandtheirdistribution.AlsoinLEACHclusteringalgorithm,theclusterheadsareselectedrandomly and hence the weaker nodes drain easily. To rise above these shortcomings in LEACH, a model ofdistributed layer-based clustering algorithm is proposed, where clusters are arranged in to hierarchical layers.Instead of cluster heads directly sending the aggregated data to the base station, sends them to their next layernearer cluster heads. These cluster heads send their data along with that received from lower level cluster heads tothe next layer nearer cluster heads.

The cumulative process gets repeated and finally the data from all the layersreachthebasestation.Theproposedmodelisdedicated withsomeexpensivedesigns,focusingonreducedenergyutilizationandimproved networklifetime of the sensornetwork.The proposed clustering algorithm is well distributed, where the sensor nodes are deployed randomly to sense thetarget environment. The nodes are divided into clusters with each cluster having a CH. The nodes throw theinformationduringtheirTDMAtimeslottotheirrespectiveCHwhichfusesthedatatoavoidredun dantinformation by the process of data aggregation.

The aggregated data is forwarded to the BS. Compared to theexistingalgorithms,theproposedalgorithmhasthreedistinguishingfeatures.First,theaggregate ddataisforwarded from the cluster head to the base station through cluster head of the next higher layer with shortestdistance between the cluster heads. Second, cluster head is elected based on the clustering factor, which is thecombination of residual energy and the number of neighbors of a particular node within a cluster. Third, eachclusterhasacrisishindrancenode,whichdoesthefunctionofclusterheadwhentheclusterheadfa ilstocarryoutitsworkin some conditions.In a network of N nodes, each node is assigned with an exclusive Node Identity (NID).

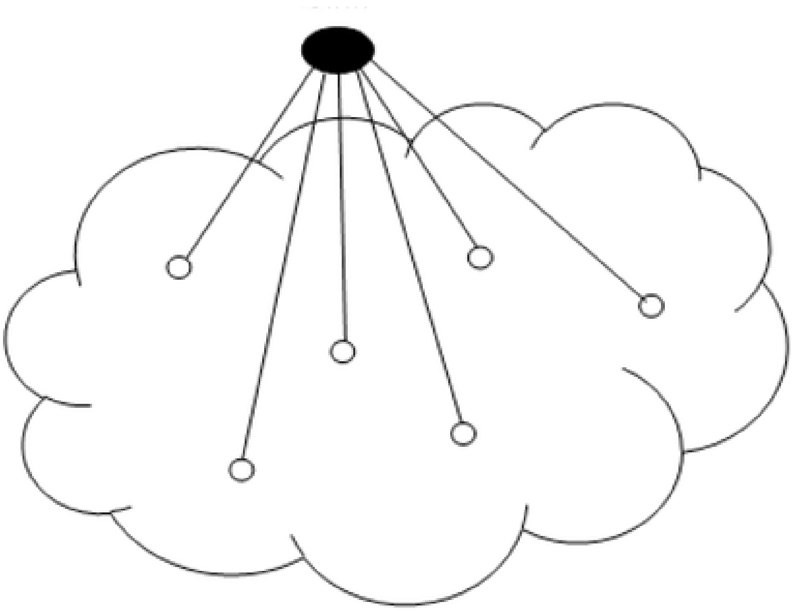


Figure3. Aggregation and Data forwardingscenario

The NID just serves asrecognitionofthenodesandhasnorelationshipwithlocationorclustering.TheCHwillbeplacedatt hecenterandthenodeswillbeorganizedintoseverallayersaroundtheCH.

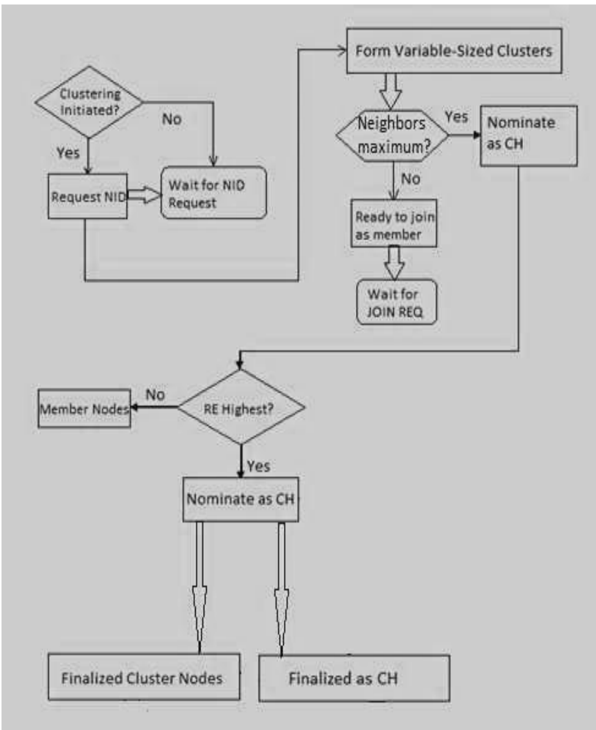
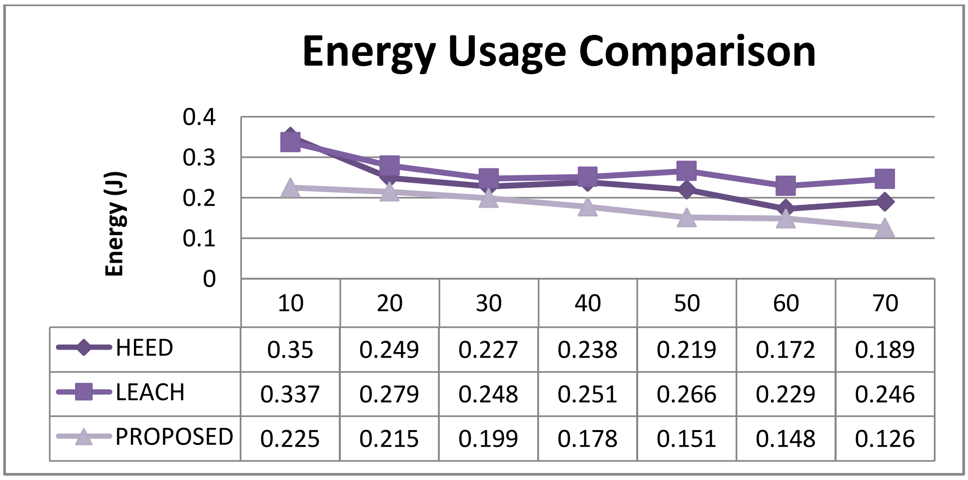


Figure4. Flowchart ofsuggestedalgorithm

Everyclusterarearrangedintohierarchicallayersandlayernumbersareassignedtoeachcluster.Thec lusterthatisfarawayfromthebasestationisdesignatedasthelowest layerandtheclusternearertothe basestation isdesignated as the highestlayer. Figure 4 shows the flow diagram of the proposed method. Thus, lower workload is assigned to the lower layers but thehigher layers are assigned with greater workload. The workload assigned to a particular cluster head is directlyproportionaltotheenergyutilizationoftheclusterhead.Inordertobalancetheenergyutilizati onamongtheclusterhead,theconceptofvariabletransmissionpowerisemployed,wherethetransmis sionpowerreduceswithincreaseinlayernumbers.InLEACH,eachclusterheadforwardstheaggrega teddatatothebasestationdirectlywhichusesmuch energy. The proposed algorithm uses a multi-hop fashion of data forwarding from cluster head to the basestationresultingin reducedenergyutilization.

Residual energy is defined as the energy remainingwithin a particular node after some number of rounds. This is generally believed as one of the main parameter forCH selection in the proposed algorithm. A neighboring node is a node that remains closer to a particular nodewithinonehopdistance.LEACHselectsclusterheadonlybasedonresidualenergy,butinthepro posedalgorithman additional parameter is included basically to elect the cluster head properly, thereby to reduce the node deathrate. The main characteristic feature of the proposed algorithm compared to LEACH is that, the base station doesnot involve in clustering process directly or indirectly. A node with highest clustering factor is selected as clusterhead for the current round.

Inaddition to the regular cluster head, additional cluster node is assigned the task of secondary cluster head, and theparticularnodeiscalledascrisishindrancenode.Generallytheclustercollapseswhentheclusterheadfails.Insuchsituations, crisis hindrance node act as cluster head and recovers the cluster. The main characteristic feature of theproposedalgorithmisthat,thecrisishindrancenodesolelyperformsthefunctionofrecoverymechanismanddoesnot involve in sensing process.



	10	20	30	40	50	60	70
HEED	0.35	0.249	0.227	0.238	0.219	0.172	0.189
LEACH	0.337	0.279	0.248	0.251	0.266	0.229	0.246
PROPOSED	0.225	0.215	0.199	0.178	0.151	0.148	0.126

Figure 5. Energy Utilization in LEACH, HEED & Proposed methods

Figure 5 shows the simulation results concerning energy utilization in LEACH, HEED and proposed methods. The average energy usage in LEACH, HEED and Proposed methods are 0.265 Joules, 0.234 Joules and 0.177 Joules respectively. The proposed method showed 33.20% and 24.35% reduction in energy usage when compared with LEACH and HEED algorithms respectively.

4. Conclusion

This paper gives a brief introduction on clustering process in wirelesssensor networks. A study on the well evaluated distributed clustering algorithm Low Energy Adaptive ClusteringHierarchy (LEACH) is described artistically. To overcome the drawbacks of the existing LEACH algorithm, amodel of distributed layer-based clustering algorithm is proposed for clustering the wireless sensor nodes. Theproposeddistributedclusteringalgorithmisbasedontheaggregateddatabeingforwardedfromtheclusterheadtothe base station through cluster head of the next higher layer with shortest distance between the cluster heads. The proposed method showed 33.20% and 24.35% reduction in energy usage when compared with LEACH and HEED existing methods.

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