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Clustering Based Routing Schemes for Wireless Sensor Networks: A Case Study

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***Abstract*:** A WSN can have network structure based or protocol operation based routing protocol In wireless sensor network, Routing can be divided into Flat Routing, Hierarchical Routing, Location - aware Routing. Hierarchical Routing can be further divided into two parts: Dynamic and Static Hierarchical Routing or Clustering based routing.

Dynamic Clustering based protocols are those in which the clusters are formed and diminished dynamically. Static Clustering based Routing Protocols are those in which clusters once formed remain same throughout the network lifetime. In our paper, we discuss all Dynamic and Static Clustering based Routing Protocols and its pros and cons.

A Wireless sensor network is an infrastructure comprised of sensing (measuring), computing, and communication elements that gives an administrator the ability to instrument, observe, and react to events and phenomena in a specified environment. The administrator typically is a civil, governmental, commercial, or industrial entity. The environment can be the physical world, a biological system, or an information technology (IT) framework. Routing is very difficult in wireless sensor network due to a large number of sensor nodes.

***Keywords*:** Wireless Sensor Networks, **Network Lifetime Routing Protocols**, Routing challenges, WSN applications.

I. Introductionof WSN

Wireless Sensor Networks (WSN), consisting of a large number of sensor nodes connected through wireless medium has emerged as a ground-breaking technology that offers the unprecedented ability to monitor the physical world accurately. Because of resource-constrained nature of sensor nodes, a number of issues have emerged out of which energy-efficiency is an important matter of concern. In this work, we propose an energy-efficient routing scheme called Enhanced Energy-Efficient Protocol with Static Clustering (E 3 PSC) which is basically a modification of an existing routing scheme, Energy-Efficient Protocol with Static Clustering (EEPSC). Similar to EEPSC, the present work partitions the network into distance-based static clusters A WSN can have network structure based or protocol operation based routing protocol .A WSN is a specialized wireless network made up of a large number of sensors and at least one base station. Theforemost difference between the WSN and the traditional wireless networks is that sensors are extremely sensitive to energyconsumption. Energy saving is the crucial issue in designing the wireless sensor networks [1]. Since the radio transmissionand reception consumes a lot of energy, one of the important issues in wireless sensor network is the inherent limited batterypowerwithin network sensornodes. In order to maximize the lifetime of sensor nodes, it is preferable to distribute theenergy dissipated throughout the wireless sensor network.

So it is essential to design effective and energy aware protocols inordertoenhancethenetwork lifetime..In this paper, a review on Dynamic and Static Clustering based Routing protocols which are the part of networkstructure protocol is carried out. Energy consumption and network life time has been considered as the major issues wirelesssensor network (WSN) requires an enormous breadth of knowledge from an enormous variety of disciplines, so its studybecomes challenging [1].Awirelesssensornetworkbasicallyconsistsof small devices called sensor nodes having thecapability of sensing the environment around them, computation thetask,andperformingwirelesscommunications.Sensornetworksmay alsoconsistof differenttypeof sensors such as seismic, low sampling rate magnetic, thermal,visual, and infrared, radar and acoustic, which monitor a wide variety of ambient conditions that includes [2] habitatmonitoring, temperature fluctuation, air pollution control, traffic control.

In wireless sensor network, each node is connectedto one or more sensors, because it is built of nodes from a few to several hundreds or even thousand **.**Thatsensornetworknodehavingseveral parts:a radiotransceiverwithaninternal antenna, a microcontroller, an electronic circuit forinterfacing with the sensors and an energy source, usually a battery. An important feature in wireless sensornetworks is the battery lifetime of the node. Energy efficiency is a main challenge in wireless sensor networks and energyuse is dominated by the energy required.

In wireless sensor networks the size and cost ofthe sensor nodes may vary frommicro to macro and from one to few hundred dollars respectively.

Battery power decides whether the sensor nodes sense for long time or for short time even the battery can not be recharged or replaced.

II. RoutingChallenges

Routing in Wireless sensor Network is very challenging due to its wireless nature. There are many reasons: a)WSNs have a large number of sensor nodes, it is not possible to apply a global addressing scheme for the deployment of alarge number of sensor nodes as the overhead will be high to maintain the Ids of the sensor Network. b) Sensor nodes aretightly constrained in terms of energy, processing, and storage capacity. So there must be some mechanism to manage theresources.Therearemanychallengesand designissuesthataffecttheroutingprocessinWirelesssensorNetwork.

A. **Node Deployment**: Node deployment in WSNs is depend on the applications and can be either manual or randomized.In manual deployment, the sensors are manually placed and data is routed through predetermined paths. In random nodedeploymentthesensornodesarescatteredrandomly,creatinganadhocroutinginfrastructure.Iftheresultantdistribution of nodes is not uniform, optimal clustering becomes necessary to allow connectivity and enable energy-efficient network operation. Inter sensor communication is normally within short transmission ranges due to energy andbandwidthlimitations.Therefore,itismostlikelythata routewillconsistof multiplewirelesshops.
B. **FaultTolerance**:Somesensornodesmayfailduetonaturalinterferences,lowbatterypower,anyphysicaldamage.One damaged sensor node can affect the overall performance of the sensor network. If many nodes fail, medium accesscontrol(MAC)and routingprotocolsmustaccommodateformationofnewlinksandroutestothedatacollectionBSs.
C. **Quality of Service**: In some applications, data should be delivered within a certain period of time from the moment it issensed, or it will be useless. Therefore, bounded latency for data delivery is another condition for time-constrainedapplications.
D. **Transmission Media:** In a multihop sensor network, communicating nodes are linked by a wireless medium. Thetraditional problems associated with a wireless channel (e.g., fading, high error rate) may also affect the operation of thesensornetwork.
E. **Connectivity:** High node density in sensor networks precludes them from being completely isolated from each other.Therefore, sensor nodes areexpected to be highly connected. This, however,may notprevent the network topologyfrombeingvariableandthenetwork size fromshrinkingduetosensornode failures.
F. **Scalability:** The number of sensor nodes deployed in the sensing area may be on the order of hundreds or thousands, ormore. Any routing scheme must be able to work with this huge number of sensor nodes. In addition, sensor networkroutingprotocolsshould be scalable enoughtorespondto eventsintheenvironment.
G. **Heterogeneity:** The existence of a heterogeneous set of sensors raises many technical issues related to data routing. Forexample, some applications might require a diverse mixture of sensors for monitoring temperature, pressure, andhumidity of the surrounding environment, detecting motion via acoustic signatures, and capturing images or videotrackingofmovingobjects.

III. RoutingProtocols

In general, Routing in WSNs can be dividing into Flat-based Routing, hierarchical-based routing, and location-based routing depending on the network structure. In flat-based routing, all the nodes are typically assigned equal roles. Inhierarchical-based routing nodes have different roles like low energy nodes sense the environment and high energy nodesused totransmitit.The figure(1) depictsthe taxonomyofthe routingprotocols:

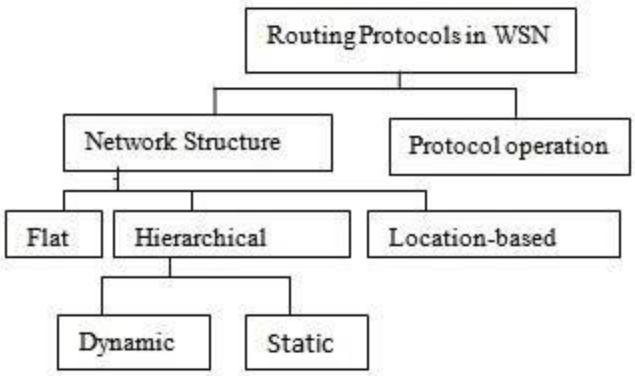

Figure-1TaxonomyofRoutingProtocol

Hierarchical Routing: In hierarchical routing, higher energy nodes can be used to process and send the information,while low-energy nodes can be used to perform the sensing in the targeted area. The creation of cluster can help to achievescalability, network lifetime,andenergy efficiency. Hierarchical routing is two layer routing where one layer is used toselectclusterheadsandtheotherforrouting.ItcanbefurtherdividedintotwopartsDynamicandStatic.InDynamic,cluster are changed with the rounds but in Static, once the clusters are created remain same throughout network lifetime.Followingisthe explanationofsome dynamic and static Hierarchical Routing.

LEACH: ItisDynamicHierarchicalRoutingforsensornetwork,calledLow EnergyAdaptiveClusteringHierarchy(LEACH). A routing protocol is considered adaptive if certain system parameters can be controlled in order to adapt tocurrent network conditions and available energy levels. LEACH randomly selects a few sensor nodes as cluster heads (CHs)and rotates this role to evenly distribute the energy load among the sensors in the network. In LEACH, the CH nodescompress data arriving from nodes that belong to the respective cluster, and send an aggregated packet to the BS in order toreduce the amount of information that must be transmitted to the BS. LEACH uses a TDMA/code-division multiple access(CDMA) MAC to reduce inter-cluster and intra-cluster collisions. However, data collection is centralized and performedperiodically. Therefore, this protocol is most appropriate when there is a need for constant monitoring by the sensor network.A user may not need all the data immediately. Hence, periodic data transmissions are unnecessary, and may drain the limitedenergy of the sensor nodes. After a given interval of time, randomized rotation of the role of CH is conducted so that uniformenergy dissipation in the sensor network is obtained. The operation of LEACH is separated into two phases, the setup phaseand the steady state phase. In the setup phase, the clusters are organized and CHs are selected. In the steady state phase, theactual data transfer to the BS takes place. The duration of the steady state phase is longer than the duration of the setup phaseinordertominimizeoverhead.Duringthesetupphase,apredeterminedfractionofnodes,*p*,electthemselvesasCHsas

follows.Asensornodechoosesarandomnumber,r,between0and1.IfthisrandomnumberislessthanaThresholdvalue,T (n), the node becomes a CH for the current round. The threshold value is calculated based on an equation that incorporatesthe desired percentage to become a CH, the current round, and the set of nodes that have not been selected as a CH in the last(1/p)roundsdenotedasG.itisgivenby

T(n)=(p/(1-p(mod(1/p))))ifn€G

Where *G* is the set of nodes that are involved in the CH election All elected CHs broadcast an advertisementmessage to the rest of the nodes in the network that they are the new CHs. All the non-CH nodes, after receiving thisadvertisement, decide on the cluster to which they want to belong. This decision is based on the signal strength of theadvertisement. The non-CH nodes inform the appropriate CHs that they will be a member of the cluster. After receiving allthe messages from the nodes that would like to be included in the cluster and based on the number of nodes in the cluster, theCH node creates a TDMA schedule and assigns each node a time slot when it can transmit. This schedule is broadcast to allthe nodes in the cluster. During the steady state phase, the sensor nodes can begin sensing and transmitting data to the CHs.TheCHnode,afterreceivingallthedata,aggregatesitbeforesendingittotheBS.Afteracertaintime,whichisdetermineda priori, the network goes back into the setup phase again and enters another round of selecting new CHs. Each clustercommunicatesusingdifferentCDMAcodestoreduceinterference fromnodesbelongingto other clusters.

Limitation: It is not applicable to networks deployed in large regions. It also assumes that nodes always have data to send,andnodes locatedclosetoeach otherhavecorrelateddata.It is not obvious how thenumberof predeterminedCHs (p)isgoingtobe uniformlydistributedthroughthe network.

B.EECS(Energy Efficient Clustering Scheme): EECSisa LEACH-like clustering scheme, where the network is partitioned into a set of clusters with one cluster head in each cluster. Communication between the cluster head and BS isdirect (single-hop). In the *cluster formation* phase, we will use this distance to balance the load among cluster heads. In the*cluster head election* phase, well distributed cluster heads are elected with a little control overhead. And in the *clusterformation* phase, a novel weighted function is introduced to construct load balanced clusters. In the *cluster head election*phase, the cluster head is elected by localized competition which is unlike LEACH and with no iteration which differs fromHEED. The optimalvalue of competition range produces a gooddistribution of clusterheads. Furtherin the*clusterformation*phase, plain nodes join clusters not only taking intoaccount its intra-clustercommunication cost, but alsoconsidering cluster heads' cost of communication to the BS. EECS is autonomous and more energy efficient, and simulationresultsshowthatitprolongsthenetworklifetimemuch moresignificantlythantheother clusteringprotocols.

C.PEGASIS(Power-EfficientGatheringinSensorInformationSystems): Theprotocol,calledPower-EfficientGathering in Sensor Information Systems (PEGASIS), is a near optimal chain-based protocol. The basic idea of the protocolis that in order to extend network lifetime, nodes need only communicate with their closest neighbors, and they take turns incommunicating with the BS.

When the round of all nodes communicating with the BS ends, a new round starts, and so on.This reduces the power required to transmit data per round as the power draining is spread uniformly over all nodes. Hence,PEGASIS has two main objectives. First, increase the lifetime of each node by using collaborative techniques. Second, allowonly local coordination between nodes that are close together so that the bandwidth consumed in communication is reduced.Unlike LEACH, PEGASIS avoids cluster formation and uses only one node in a chain to transmit to the BS instead ofmultiple nodes. To locate the closest neighbor node in PEGASIS, each node uses the signal strength to measure the distanceto all neighboring nodes and then adjusts the signal strength so that only one node can be heard.

It will consist of those nodes that are closest to each other and forma path to the BS. The aggregated form of the data will be sent to the BS by any node in the chain, and the nodes in the chain will take turns sending to the BS. The chain construction isperformed in a greedy fashion. Simulation results showed that PEGASIS is able to increase the lifetime of the network totwice that under the LEACH protocol. Such performance gain is achieved through the elimination of the overhead caused bydynamic cluster formation in LEACH, and decreasing the number of transmissions and reception by using data aggregation.Although the clustering overhead is avoided, PEGASIS still requires dynamic topology adjustment since a sensor node needsto know about the energy status of its neighbors in order to know where to route its data.

Such topology adjustment canintroduce significant overhead, especially for highly utilized networks. Moreover, PEGASIS assumes thateach sensor nodeis able to communicate with the BS directly. In practical cases, sensor nodes use multihop communication to reach the BS.Also, PEGASIS assumes that all nodes maintain a complete database of the location of all other nodes in the network. Themethod by which the node locations are obtained is not outlined. In addition, PEGASIS assumes that all sensor nodes havethe same level of energy andare likely to die at the sametime. Note also that PEGASIS introduces excessive delay fordistant nodes on the chain. In addition, the single leader can become a bottleneck. Finally, although in most scenarios sensorswill be fixed or immobile as assumed in PEGASIS, some sensors may be allowed to move and hence affect the protocolfunctionality.

Static Hierarchical-based Routing Protocol: Static clustering based routing protocols are those in which once the cluster iscreated remainsamethroughoutthenetworklifetime. Wediscusssomestaticclusteringbased routingprotocol.

EEPSC (Energy Efficient Protocol with Static Clustering): EEPSC, partitions the network into static clusters, eliminatesthe overhead of dynamic clustering and utilizes temporary-cluster-heads to distribute the energy load among high powersensor nodes; thus extends network lifetime. The operation of EEPSC is broken up into rounds, where each round consistsset-up phase, responsible node selectionphaseandsteady-state phase.

Setup phase: cluster formation is performed only once at the beginning of network operation. For this aim, base stationbroadcasts*k-1* differentmessageswith differenttransmission powers,which*k*is thedesirednumberof clusters.Bybroadcasting the *k=1* message all the sensor nodes which hear this message (are in the radio range of this message) set theircluster ID to *k* and inform the base station that they are member of the cluster *k* via transmitting a join- request message(Join-REQ) backtothe basestation.

Responsible Node Selection Phase: After the clusters are established, network starts its normal operation and responsiblenodes (temporary-CH and CH) selection phase begins. At the beginning of each round, every node sends its energy level tothe temporary-CH in its time slot. Afterward, temporary-CH choose the sensor node with utmost energy level as CH forcurrent round to collect the data of sensor nodes of that cluster, perform local data aggregation, and communicate with thebase station; and the node with lowest energy level as temporary-CH for next round and sends a round-start packet includingthe new responsible sensor IDs for the current round. This packet also indicates the beginning of round to other sensor nodes.Since every sensor node hasa pre-specifiedtime slot, changing the CHs has noeffect on the schedule of the clusteroperation.

Steady State Phase: The steady-state phase is broken into frames where nodes send their data to the CH during pre-allocated time slots. These data contain node ID and the measure of sensed parameter. The duration of each slot in which anode transmits data is constant, so the time to send a frame of data depends on the number of nodes in the cluster. To reduceenergy dissipation, the radio of each non-cluster head node is turned off until its allocated transmission time, but the CHsmustbe awake toreceiveall thedata fromnodesinthe cluster.

Advantage:

- EEPSCbenefitsanewideaofusingtemporary-CHsandutilizesanewsetup andresponsiblenodeselectionphase.
- EEPSCutilizesstaticclusteringscheme,thereforeeliminates theoverheadofdynamicclustering.

EEEPSC (Enhanced Energy Efficient Protocol with Static Clustering): Enhanced Energy-Efficient Protocol with StaticClustering (E3PSC) which is basically a modification of an existing routing scheme, Energy-Efficient Protocol with StaticClustering (EEPSC). In EEEPSC, cluster-head selection is performed by taking into account both the spatial distribution ofsensors nodes in network and their residual energy with an objective to reduce the intra-cluster communication overheadamong the nodes making the scheme more energy-efficient base station computes the mean positions of node-distribution(Pmeani) of everyclusterwhere***i*** isclusteridwhich helpinreducingtheinter-clustercommunication.

IV. Conclusion

Overall, the routing techniques are classified based on the network structureinto three categories: flat, hierarchical, and location-based routing protocols. Furthermore, these protocols are classified intomultipath-based,query-based,negotiation-based,andQoS-basedroutingtechniquesdependingonprotocoloperation.Routing in sensor networks is a new area of research, with a limited but rapidly growing set of research results. In this articlewe present a comprehensive survey of Dynamic and static Clustering based routing techniques in wireless sensor networksthat have been presented in the literature. They have the common objective of trying to extend the lifetime of the sensornetwork while not compromising data delivery. Although many of these routing techniques look promising, there are still many challenges that need to be solved in sensornetworks.We highlightthosechallengesandpinpointfuture researchdirectionsinthisregard.

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