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Clustering Based Topology Control Protocol for Data Delivery in Wireless Sensor Networks

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Abstract:

For Wireless sensor networks, there is an optimization criteria for the network impact on the lifetime can be sustained with the energy and it can be non-renewable of sensor nodes. Optimization can be done for the current and existing techniques based on three mechanism and they are adaptive radio transmission power, exploiting node redundancy and topology control. My work is based on sensor nodes especially weak and strong nodes which can be implement on residual energy and propose a topology called Clustering based topology control protocol (CTCP). This protocol extends network lifetime of which the connectivity may be optimized. Our proposed protocol evaluates Java Simulator (J-Sim). Various metrics measures the performance criteria especially average delay, network lifetime and energy utilization minimum.

Keywords: Clustering, Operational lifetime, Strong & weak nodes, Topology control.

INTRODUCTION:

In wireless Sensor Network examines the network connectivity by using topology which makes impact on routing algorithms related to the network. One more feature which influences the topology was the cost based on the communication of the nodes. Presently researches analyses the energy utilization issue on wireless sensor networks.

All these issues can be controlled using the network based on topology. These several different constraints can be implemented and designed by using topology control protocols.

To designed node density in the network, Topology control protocols are used to the network lifetime and establish connectivity. The key concepts for designing topology control protocols have been identified as for wireless sensor networks.

a) Changing network dynamics Sensor nodes should be able to configure itself.

b) Distributed localized algorithms can be maintained on redundant nodes.

c) Minimum connectivity in the network can be analyzed with the Topology control protocols, so that it cannot be partitioned.

d) To control the energy in the network, the advantage of the high node density in large-scale wireless sensor using topology control protocols.

LITERATURE SURVEYS OF TOPOLOGY CONTROL PROTOCOLS FOR WIRELESS SENSOR NETWORKS:

When we design a network layer or MAC layer protocol .The key factor is to maintain the sensor networks for extending network operational lifetime for sensor networks which can identified the redundant nodes and it can be classified into two groups.

1. Protocols like ASCENT [2], CEC [1], GAF [1], and LEACH [3] identifies the redundant nodes and also uses information from the routing layer.
2. Protocols like PAMAS [4] [6], STEM [5] use MAC Layer is to identify the information and the redundancy in the network.

In our proposed Clustering based control protocol (CTCP) GAF and CEC are the two main protocols which provide the base and this protocol is used for our extension.

Geographic Adaptive Fidelity (GAF):

The most important conversation protocol is GAF [1] a location based energy conservation protocol. Based on the geographical locations GAF can identified the redundant nodes. To balance the load in the network, the radio of a node is switched off periodically. Global positioning System (GPS) is used to store the information of the location in GAF. In terms of connectivity with the other nodes intermediate and equivalent nodes are same based on communication.

In GAF, small virtual grids can be obtained from network area ,and the adjacent grids in others radio range. Routing can be provided by using each of the virtual grid. In GAF, switching off the radios in all sensor nodes and makes active in one sensor node can saves the energy in the network. Grids are rotated periodically active to maintain balance in the energy dissipation per virtual grid at an instance of time

The main Issues with GAF are:

a) GAF can be used in less number of applications, because GAF is dependent on global positioning system. Geographic location information is not working automatically no application can work.

b) In GAF virtual grid contains only one node energy can be balanced in the network , definitely partioning can be done in the network because it is having low energy.

Cluster Based Energy Conservation Protocol (CEC):

CEC protocol directly measures Network connectivity of which the energy conversation identifying in nodes when the power is CEC [1] makes the nodes into overlapping clusters. For maintaining connection in network CEC also has cluster-head node and gateway node for each cluster. Some problems in GAF can be rectified by using CEC. One important method to design scalability is clustering.

The algorithm re-arranged the network into number of nodes which is less than the original network and each nod with a cluster-head at the center of each cluster. Maintaining good cluster can be obtained from high level cluster [6].. IT also eliminates the need for global positioning systems and algorithms designed locally can be used to reduce the coordination and only their neighbors reducing cost on communication. CEC defines a cluster which can be reachable in two hops.

Cluster formation in CEC takes place in distributed fashion and all the clusters are connected to each other through a group of overlapping nodes. Each cluster can be defined with a cluster- head and all the estimated nodes are within direct radio range of the cluster-head. The cluster formation in CEC as follows.

a) Node ID, cluster ID and estimated lifetime are initially maintained for each node to display message.

b) Node itself has maintained cluster-head and broadcasts messages when it receives highest energy among all its neighbors.

c) Non-cluster head node also receives cluster-head messages from group of nodes ,one of the cluster-head declares itself as a gateway node and broadcasts information. The cluster-head and the gateway nodes are selected first to make anew connection to the clusters. By defining the node id of a cluster, a node elects itself as the cluster-head of which it has longest connection between their neighboring nodes. The highest priority can be assigned for the gateways which is having the longest priority.

d) To conserve energy cluster-head and gateway nodes all other nodes are powered off. After some interval of time the process of entire clustering is reiterated.

We propose CTCP (Clustering based topology control protocol), a clustering protocol of which it makes minimum connectivity in the network to consume energy compared to the connectivity in CEC. In CTCP our proposal also defines the concept of strong and weak sensor nodes which can be recognized with the operational lifetime.

CLUSTERING BASED TOPOLOGY CONTROL PROTOCOL (CTCP):

Initially define the following:

a. A cluster is nothing but set of nodes reachable in at most two hops. 1.cluster-head that is directly reachable from all members of the cluster.

b. A gateway interconnection between the clusters and itself can be designed as a node which is a member of more than one cluster .In CTCP, while clustering a node in one of the four states, namely, cluster-head, gateway, potential cluster-head, and ordinary node.

c. Re-clustering Interval (RI) is defines the time after re-clustering is initiated to a cluster. Both the value of the estimated lifetime of the cluster-head as well as I change with time. Each cluster has its own re-clustering interval.

$RI = \propto Lifetime\ of\ cluster\ head, where\ 0 < \propto < 1.$

d. Strong and Weak nodes: when a node’s lifetime is greater than RI that node is defined as a strong node otherwise it is defined as weak node.

Cluster Formation:

Phase 1: cluster head selection

Node ID, its Cluster ID, and estimated lifetime scan be maintained initially. Delete node id, a node itself elects as a potential cluster-head when it has longest life time. After, it is elected as a potential cluster head it broadcasts this information to the neighbors.

Phase 2: gateway of selection

Primary gateway means a node directly reaches from more than one cluster-head. A node interconnection with cluster of nodes, which initiates the another nodes is called secondary gateway head, the secondary nodes manages the gateway of cluster of nodes, it monitors the information of weak node and strong node and pass the information to the cluster header, A main node between the two monitor nodes will manage the weak nodes for better and efficient data communication. The difference of two information is potential led to the cluster-heads.

Phase 3: Cluster-head selection and cluster formation

Cluster-head reaches the information from the gateway, that all its potential heads are strong and they can broadcast the information to the near-by nodes, which provides the cluster id to the all the nodes and inform to the cluster-head.

If a potential cluster-head receives the information that all its gateways are strong then it elects itself as the cluster-head and broadcasts this to all its neighbors which set their cluster Id to that of the cluster-head and a cluster is formed. The cluster-head broadcasts the value of re-clustering interval RI to all the members of the cluster. If a potential cluster-head receives the information that one or more of its gateways are weak nodes it elects itself as the cluster- head but while broadcasting this information to its neighbors it reduces the value of $\propto$ hence reducing the re-clustering interval. After the cluster formation except for the cluster-head and the gateways all the other cluster members switch off their radios for an amount of time equal to the re-clustering interval to minimize the energy consumption.

Figure 1 shows an example of a cluster formation according to CTCP. Here node 2 and node 3 are strong gateways since their remaining energy will allow them to survive the usual re-clustering interval (when α= 0.50) while node 7 is a weak gateway since its remaining energy will not allow it to survive the re-clustering interval RI if $\alpha = 0.50$.

In CTCP, an alternative approach can be once a gateway discovers that it is a weak node with respect to a cluster-head it sends intermediate node search messages containing its cluster ID to all its neighbors at some fraction of its maximum transmission power (minimum transmission power is preferred so that the node can last for a longer time [7] [9]). If it gets a reply from its neighbors having the same cluster ID it then uses this neighbor as a bridge node between the cluster-head and it-self so that it can be operational for a longer duration of time and extend re-clustering interval. Clustering is expensive in terms of network resources and the number of re-clustering should be kept to a minimum.

Analysis of CTCP:

We next analyze CTCP in terms of message complexity as communication between nodes consumes significant energy. For the problem of cluster formation in CTCP the following network model is assumed.

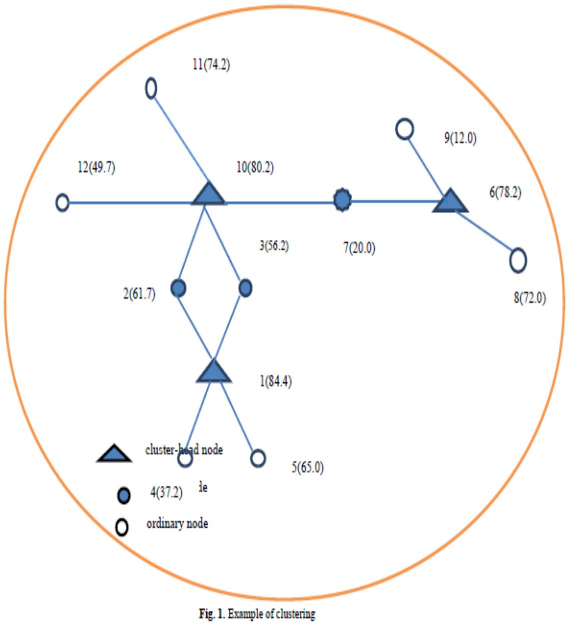

Figure:1. Example of Cluster

a) A node can directly communicate with its cluster-head.

b) A cluster-head has at least one neighbor which is a gateway.

c) An ordinary node has at least one neighboring node (a node within direct communication range) which is a cluster-head.

Conditions that should be satisfied by the clustering protocol:

To see all the above assumptions the algorithm, cluster formation protocol satisfies the following criteria similar to conditions on clustering.

a) Cluster formation which is maintained is completely distributed. Based on localized information, each node decides itself to join as a cluster.

b) The cluster formation terminates automatically after some fixed number of iterations.

c) By the end of one cluster formation period (FPc) a node is either a cluster-head, a gateway or an ordinary node. A gateway node given by the number of its neighbors denoted by (k).

d) The more number of messages exchanged reveals how efficient the clustering.

e) The assurance of Inter Connect clustering.

Correctness Proof and Complexity:

In this section we prove the correctness of CTCP and also show that it satisfies all the criterion of a good clustering algorithm. We assume that x denotes the total number of nodes in the network and the y denotes the number of neighbors (within direct communication range) of each node. Note that CTCP is a completely distributed algorithm. A node in CTCP can either become a cluster-head or join a cluster according to received messages. The decision whether to become a cluster-head or a gateway or an ordinary node is based on local information.

Lemma 1: By the end of the phase 3 of CTCP, a node is either a cluster-head, a gateway or an ordinary node.

Proof: Let us suppose that CTCP terminates and a node is neither of a cluster-head, a gateway or an ordinary node. Then by the definition of states of a node in CTCP, the node must be a potential cluster-head.

By the end of Phase 1, of CTCP a node may become a potential cluster-head.

By the end of Phase 2, a node may still be a potential cluster-head.

But by the end of Phase 3, of CTCP the cluster-head selection in the network is completed. Hence a node which is not a cluster-head or a gateway or an ordinary node by Phase 3, by Assumption 3 of 4, will have a neighbor which is a clustered and hence its status will change from potential cluster-head to an ordinary node. This contradicts our assumption proving the lemma.

Lemma 2: IN Network topology CTCP finishes clustering interval in O(1) iterations.

Proof: From Lemma 1 we see that at the end of one iteration cluster formation is complete and each node is either a clustered or a gateway or an ordinary node. Hence one clustering interval CTCP terminates in constant number of iterations.

Lemma 3: In CTCP the message complexity of one clustering interval per node is O(y), and the message complexity of one clustering interval for the whole network is O(x2).

Proof: By the end of one complete round of clustering, let xp_{ch}denote the number of potential cluster-heads, x_{gw} denote the number of gateways and x_{ch}denote the number of cluster-heads in the network.

a) The total number of messages exchanged in Phase 1 in the network due to the discovery and potential cluster-head messages is .In the worst case when the graph is fully connected, $x = y$ and the complexity becomes O(x2).

$$(x * y) + (xp_{ch} * y)$$

b) In Phase 2 total no of nodes are exchanged due to gateway messages.

$x_{gw} * y$

c) Total number of messages exchanged in the network in Phase 3 for cluster-head notification is

$$x_{ch} * y$$

Thus for a single clustering interval of CTCP the message complexity is O(x2).

Lemma 4: CTCP ensures minimum connectivity in the network once the clusters are formed.

Proof: By Phase 3, of CTCP the clusters are formed. Further, phase 3 of CTCP algorithm ensures that gateways are alive for the entire period of time till the next clustering takes place. Hence minimum network connectivity is ensured in CTCP.

SIMULATIONS OF CTCP:

The key factor of CTCP is to maintain network's energy conservation should be optimized. In general our work is based on small network with less number of nodes. Compared to CEC, CTCP provides better network connectivity. By concentrating on (J-Sim)java Simulator, our protocol is implemented. To observe and examines the performance of three protocols GAF,CEC and CTCP the network scenario is same. The randomness can be observed in nodes within speed of 0 to 20m/s in a 1500m by300m area. simulation can be done in wireless sensor networks .for routing 50 nodes are used whereas 10 nodes are for sources and links. The network traffic generated a constant bit rate(CBR). 512 bytes was set to the packet size. Mainly 10 nodes were given infinite amount of energy. These nodes give data and not present in data routing. Initial energy rates were assigned to 50 nodes and make them alive for 500s.CTCP performance measures can be based on network connectivity, network operational lifetime and energy consumption etc.

Network Operational Lifetime:

The three existing protocols CTCP,GAF and CEC based on the study of sustained and existence of the nodes . On average alive nodes in GAF is 36-37% and 1000s in CTCP and they can vary in simulation time. The total count of a live nodes is similar to CTCP. In weak gateways ,re- clustering is reduced in CTCP. It is more expensive in network criteria because every node exchange messages to and fro for the formation of clusters.

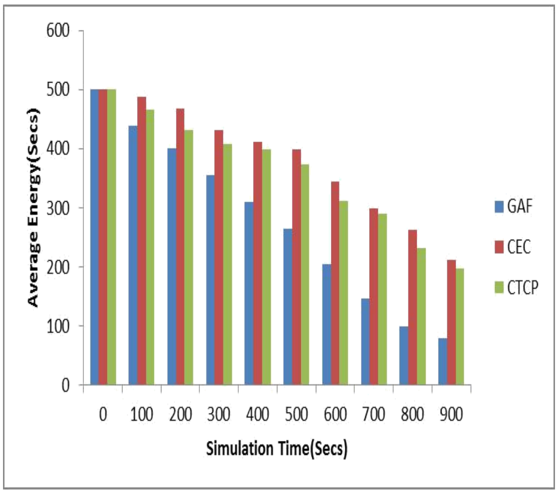

Figure. 2 The number of a live nodes with the simulation time

Residual Node Energy:

Average energy can be obtained at a particular time , we do summation of energy of all nodes at an instance of time . the average network energy in CEC and CTCP are higher compared to GAF. Compared to CTCP, CEC shows 20% more average energy. Residual energy levels which are varying in the network can be displayed at some occurrence of time. To ensure connectivity by using CTCP, re-clustering can be done frequently. CEC comes at the cost of partitions in the network increase average energy in the networks.

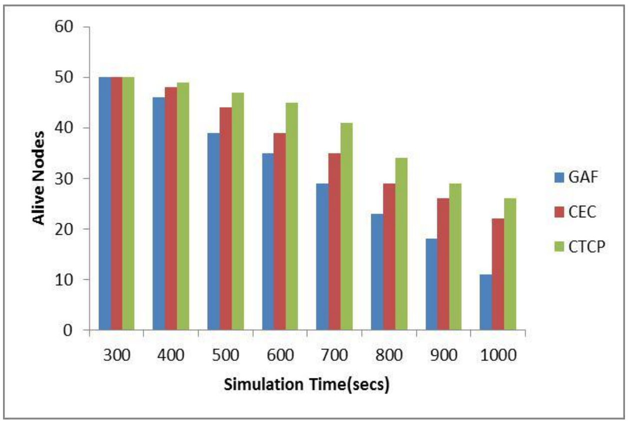

Figure.3 Average energy of the network with simulation time

Average Delay:

The connectivity in the network can be measures, from average data delivery delay can be used as received packets mean delay. Better data delivery ratio at higher mobility can be by GAF which is shown from above figure 4. To maintain balance in the virtual grid the nodes are moved in and out constantly at high mobility, but in case of GAF the node density decreases with the network connectivity at low density. In this, pause time is to indicate high and low mobility of the nodes. Two different Pause time are mentioned here ie.0s indicates that the nodes are constantly moving and 1000s indicates that the nodes are almost static. From the below graph of CEC denote network partitions shown in spikes causes the nodes in the gateway run out of energy. In CTCP these types of spikes cannot be observed for the energy consumption as well re-clustering of the nodes. But in CTCP nodes is exploited to conserve energy based on density. Therefore energy can be saved with the higher density.

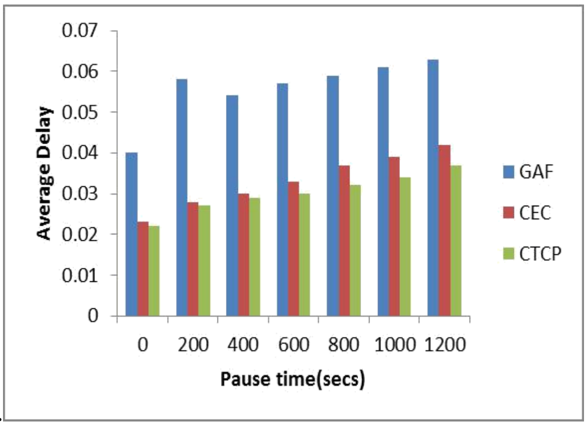

Figure. 4. Average delay with pause time

Trade-off between Network Connectivity and Residual Energy of the Nodes:

The performance metrics such as average energy of the network, network operation lifetime, etc can be measured from CEC and CTCP by observing all the above figures, but compared CEC ,CTCP outperforms based on connectivity. Therefore , for the real tome applications CTCP is best. While comparing GAF with CTCP ,CTCP out performs because performance metrics also well suited for the network connectivity . Simulation clearly gives the estimation of trade-off between network connectivity and energy conservation from the topology which is given in the network. The optimal value can be set for this application.

CONCLUSION:

To maintain the connectivity of the network Topology control protocols are used and these protocols are analyses the lower energy consumption. The routing protocol used which is independent in the network was CTCP. The node redundancy in large scale dense sensor networks exploits CTCP and this is also used for conservation of energy in the network. The classification based on residual energy of weak and strong nodes to maintain balance across the network.. The topology of overlapping clusters in the network can be organized by CTCP, gateway nodes and cluster head for each cluster can be maintained. except the cluster-head and gateway are identified in the cluster except the other nodes mean while the repeated nodes in the cluster are powered off. CTCP also works on power consumption in radio of a sensor nodes.

As for the research which has been proved previously in the sensor network mainly in energy dissipation but now CTCP maintained the control of energy via gateway nodes. In our research, our protocol uses both gateway nodes and cluster head can be done by reclustering and redundant gateways are optimized by consuming of energy in CTCP. Various performance metrics and also the performance in CTCP was simulated by Java Simulator(J-Sim) such as connectivity, average network energy, network operational lifetime, CTCP especially plays an important role in the connectivity and network energy optimization compared to the existing protocols like CEC and GAF.

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