PRECISION CROP PROTECTION USING WIRELESS SENSOR NETWORK

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Abstract The Wireless Sensor Network (WSN) is a widely developing field, which provides many solutions to the real-world problems in various aspects of life. In this paper, monitoring process of the agricultural field by the sensor nodes has been discussed. The sensor node continuously monitors the crop and collects the data, then passes it to the Base station with the help of the Cluster head (CH). The Cluster head is responsible to collect all the data from the sensor nodes. Along with the data the location of the sensors is also sent to the cluster head. If more number of shortest paths in the network pass through the same node, then it is an articulation point. If one of the sensors fails to respond due to low energy or due to low power in the battery, then there is a risk of network partition. So the articulation point must be less in the network at the same time the between-ness centrality of the cluster head must be more. If cluster head, is an articulation point then there will be a huge network failure, to overcome this problem the cluster head has to be changed dynamically by finding the next between-ness centrality in the cluster region of the network. By following this mechanism, the energy consumption of the network can be reduced, the lifetime of the node can be increased, and the clustering efficiency and throughput is also comparatively increased.

***Index Terms* – Location aware routing, Articulation point, Between-ness Centrality.**

I. INTRODUCTION

Agriculture is the essential one for all the country; many technologies have been emerging in the past few years in the agricultural sector. Wireless Sensor Network (WSN) plays a vital role in the field of agriculture. It is one of the major technologies, which are widely used to improve the crop productivity and quality at the lowest cost. A wireless sensor network in an agricultural environment comprises integrated sensors deployed in the area of the farmland. These sensors cooperate with each other to perceive and monitor real-time soil and weather information. Continuous monitoring of the environment is essential to know the status or condition of the environment, in order to help the situation by taking necessary steps. The monitoring process of the wireless sensor networks is an important part with which one can get a continuous update of the entire scenario of the application which includes from the hardware part of the WSN nodes which senses the environmental conditions to the software interface that displays the monitored data. This monitoring process helps more in the applications such as air pollution monitoring, industrial sewage monitoring, agricultural field monitoring, etc. In this case, for instance, an agriculture field has to be monitored in order to help the crop for its healthy growth. The nutrient content of the crop such as water, minerals, soil texture, temperature, micro and macro nutrients is monitored so that the farmers can have a regular update of the crop’s conditions and will be able to help the crop to grow in a fertilized manner.

Here, in the monitoring process of the agriculture field, the hardware part of the wireless sensor networks such as the sensor nodes or motes plays an important work of sensing the crop’s condition. The sensor nodes are randomly distributed in a field that continuously receives the information from the crop, as the sensors are distributed in a form of clusters, the cluster heads are assigned to each and every region of clusters. In the existing system the LEACH protocol is used to collect the data from the nodes. The cluster heads are responsible to collect the data from the sensor nodes and then it aggregates those data into a single signal to pass the data to the sink. In this process, if a sensor node fails to send the monitored data to the cluster head due to the presence of the articulation points in the network, which will cause network partition and through which the data will not be able to pass on to the farmer. This may mislead the farmer to be ignorant of the issue that has been caused in the particular region and without the knowledge of the farmer the crops which are planted in that particular area are lost without any proper nutrition.

II. PROPOSED SYSTEM

In order to protect the crop from this kind of issues and problems certain measures has to be taken in such a way that the crops are monitored without any interruption of the articulation point in the network. For this issue, first and foremost using an existing protocol the sink node constructs a topology of an undirected graph and finds the position of all the nodes that are randomly distributed, then it also checks whether if this articulation node exists in the network, the number of data packets forwarded through the articulation node to the sink node. According to the identified articulation points the cluster heads can be changed dynamically. Secondly, using an existing algorithm for the articulation point of the distributed sensor nodes the evaluation can be obtained from the between-nus of all the neighboring nodes, the shortest path from one vertex of the node to all the other nodes are determined by broadcasting a request packet from source to destination. If the entire shortest path passes through the same edge then it is clear that it is the center node of the network where all the data packets are transmitted to the sink. The center node can also be the cluster head, if in case all the data packets are overloaded in the center node, the next center node can be determined by finding the shortest path as before. Each shortest path is considered while determining the total number of shortest path to find the articulation point.

Thirdly the cluster head can be changed dynamically with the help of the matrix generated by the previous graph that is drawn. Using the matrix value that is obtained by calculating the between-ness of the each node in the graph, the centrality of the cluster head is determined. By evaluating all the centrality of the node in the shortest path of the entire graph, the cluster head can be changed automatically when it faces overload of data packets or if the energy goes low.

III. TOPOLOGY CONSTRUCTION

Topology construction is a mechanism which helps the wireless sensor networks to increase its lifetime and to conserve the energy of the each sensor node. The topology of a sensor network has to be constructed in such a way that the sensor nodes don't face any overheads. Then each node will know its nearby node's position, the same way the next hop node will know its surrounding node positions. For example, consider the undirected graph given below. The node A knows the position of its neighboring node B and C which are directly connected to it, then the B node knows the position of its surrounded neighboring node D and F. Now the node D will know it's surrounded neighboring nodes B, C, F and G.

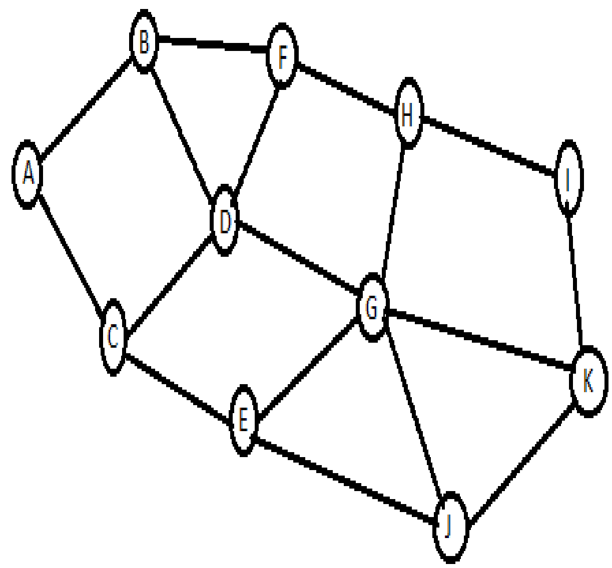

Figure.1. Topology Construction

The graph is constructed by passing the request message to the destination node. The destination node will receive the request message from all the directions of the neighboring nodes. The destination node will wait for certain period of time, until it receives all the request messages. Once the destination receives the request message, it finds the shortest path to the source node in order to send the response message back to the source node. Using these request and response messages the graph is constructed to help the nodes to communicate with the cluster head.

Algorithm for Topology Construction:

Step.1: Request packet is broadcasted to all the sensors in the region

RREQ => Broadcast (ID, IP address)

Step.2: The location of each node is identified

Step.3: Once all the request packets reach the destination node, it broadcasts the response packet back to the source node.

RREP => Reverse path (ID, IP address)

Step.4: Based on the RREQ and RREP the topology is constructed.

IV. ARTICULATION POINT FINDING

Once, after the topology of the sensor network is constructed, the articulation points in the network should be identified. The articulation point is a vertex in the undirected graph that connects the graph mostly at the center part. If this vertex is removed or any failure occurs, there may be a loss of connectivity within the nodes that are directly connected to it. This may cause network partition of the topology constructed. Due to the network partition, the one end of the sensors will not be able to communicate with the other end of the sensors in the region.

Using the existing Depth First Search (DFS) algorithm the articulation point is determined, the number of shortest paths in the graph is identified, and then the centrality of the each node is examined. The point in the network, which has number of edges passing through the same center point, will be an articulation point or the critical node. All possible shortest paths in the network are identified, so that the total number of shortest paths can be determined. After determining the total number of shortest paths, the edges of the each node in the network is evaluated. The between-ness among the nodes in the shortest path is evaluated so that the number of data transmission that passes through the same particular shortest path can be identified. Based on this evaluation the articulation point is determined. The destination node in an adjacency matrix collects the node and edge details of the graph

Algorithm for Articulation Point:

Step.1: Find the location of each node in the network

Step.2: Also find the shortest path from the source to the destination node

Step.3: Determine the number of edges in each shortest path

Step.4: If many numbers of edges pass through the same node, then it is an articulation point

Step.5: Find the least number of articulation points

The lowest-numbered vertex, low(v), is the minimum of

1. Num (v)
2. The lowest Num (w) among all back edges(v, w)
3. The lowest low (w) among all three edges (v, w)

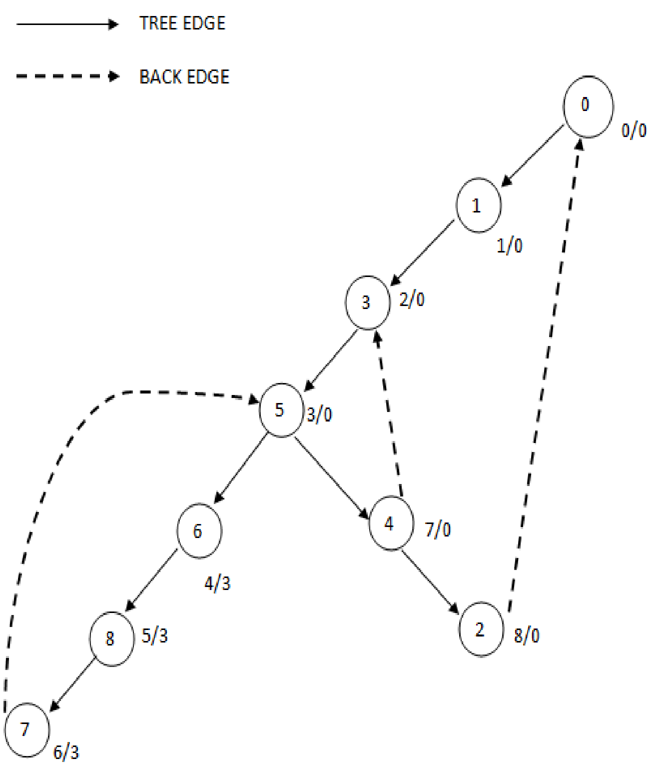

Figure.2. Finding Articulation point using a graph

The graph shows the nodes in a particular cluster region. The articulation point in this graph is found with certain conditions such as,

i. The root is an articulation point if and only if it has more than one child.
ii. Any other vertex *v* is an articulation point if and only if *v* has some child *w* such that $low(w) \geq num(v)$.

Here, for node 5, num(v) is 3 and low(w) is 3 which satisfies the condition, $\boldsymbol{low(w) \geq num(v)}$. Therefore, **node 5** is an articulation point.

V. CLUSTER HEAD CHANGING

Cluster Head is an important node in each cluster region. The Cluster Head communicates with each and every node in the cluster. Cluster Head is responsible for all the nodes in the cluster, so it sends and receives information from each node. It works as a temporary base station in the cluster region, once after it collects the data from the nodes, it sends those data to the sink node. In this process, if the Cluster Head is an articulation point, then it would be at a risk of network partition. In order to overcome this problem the cluster head has to be changed dynamically using the method of between-ness centrality.

Between-ness centrality is the measure that determines the vertices in the network that lies in the path of the other vertices. It is important that the cluster head must have the higher between-ness centrality. So that it will be easy for the other cluster members to communicate with the cluster head. The between-ness centrality of the node is measured using the expression:

$$\mathbf{g(v)} = \sum_{s \neq v \neq t} \sigma st\ (v)\ /\ \sigma st$$

Where $\boldsymbol{\sigma st}$ is the total number of shortest path from the source ***s*** to destination ***t.*** And $\boldsymbol{\sigma st(v)}$ is the number of paths which passes through the node ***v.***

Algorithm for Dynamic change of Cluster Head:

Step.1: Find the between-ness of articulation when the current node is the destination

Step.2: If the number of nodes uses the same edge to transmit the data packets and if it is an articulation point, change the cluster head or else don't change.

Step.3: To change the cluster head, find out the node which has, the more between-ness centrality excluding the articulation point.

If (BC = AP = 1)

{

"Change Cluster Head"

}

Else If (BC = AP ≠ 1)

{

"Don't Change Cluster Head"

}

Where BC is Between-ness Centrality and AP is Articulation Point.

Step.4: If the cluster head is a destination node, it will be easy for all the nodes to send the data packets.

Step.5: The destination node must not be an articulation point, so the cluster head must be changed dynamically by finding out all the possibility of between-ness centrality in the network.

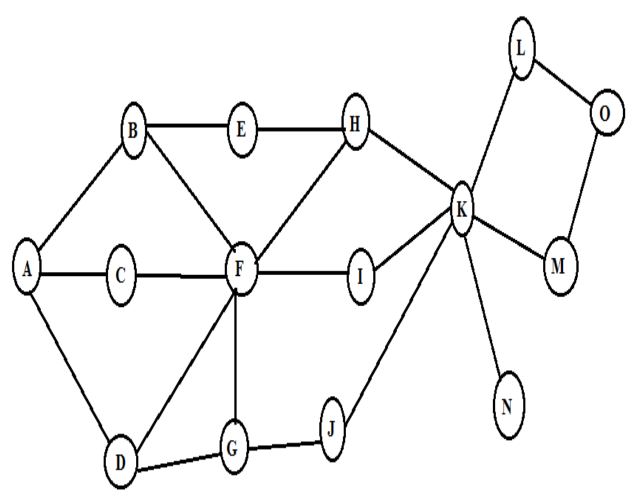

Figure.3. Dynamic change of Cluster Head

VI. SIMULATION PARAMETERS

The simulation of this paper is carried out by the NS-2 simulator, which is an open-source simulation tool. It is a tool for simulating the real-time application event as a simulated result for analysis. It gives a simple network simulation for various different types of network models. Here the simulation parameter is listed below in the given table.1.

The parameter for the simulation is taken as a sample for analyzing the energy consumption of the network to get the throughput of the existing and the proposed system. The energy parameter is measured using the unit of Joules (J). Here the number nodes considered is 350 and the initial node power is assigned as 0.5J. Each node is measured to determine the energy consumed by them in the network. The same way the clustering efficiency is also determined to know the efficiency of clustering the each region in the network. The efficiency of clustering is measured between the existing and the proposed system.

Parameters	Values
Simulation Round	500
Network Size	100 x 100
Number of nodes	350
Initial node power	0.5J
Nodes Distribution	Uniform Distribution
Data Packet size	4000 bits
Energy dissipation (Efs)	10*0.000000000001 Joule
Energy for Transmission (ETX)	50*0.000000000001 Joule
Energy for Reception (ERX)	50*0.000000000001 Joule

Table.1. Simulation Parameter

These parameters are used to get the simulation results more accurately and are used for the performance evaluation of the proposed system.

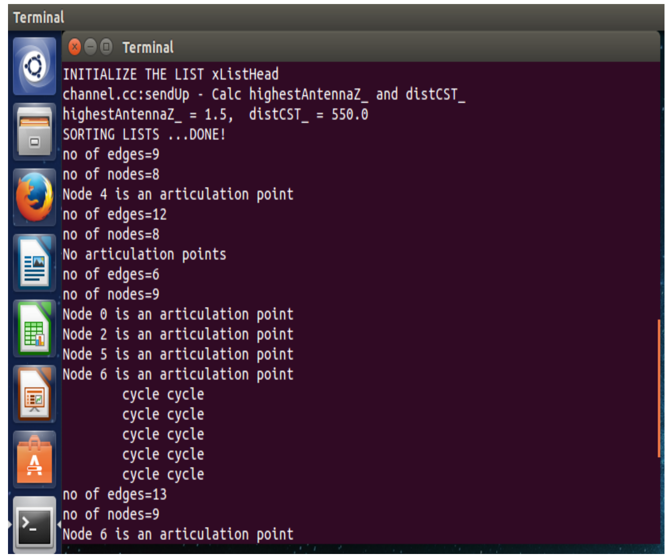

Figure.4. Finding the Articulation Point

The articulation point is determined by generating the node positions and their required values with the help of NSG 2.1. The output of the articulation point is displayed in the terminal

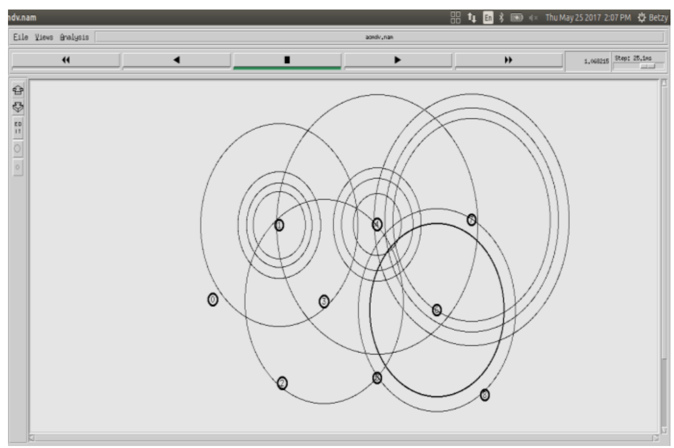

Figure.5. Node Communication

VII. RESULTS AND ANALYSIS

ENERGY CONSUMPTION OF NODE

The energy consumption is the amount of energy that is consumed during any process of mechanism; the energy may be of any kind in the system. Here in our paper, the energy is considered from the number of nodes present in the region of each cluster. The graph is plotted in order to measure the energy consumption of each node in the network. Approximately about 350 nodes are taken for sample analysis. Our proposed concept is more energy efficient when compared to the existing.

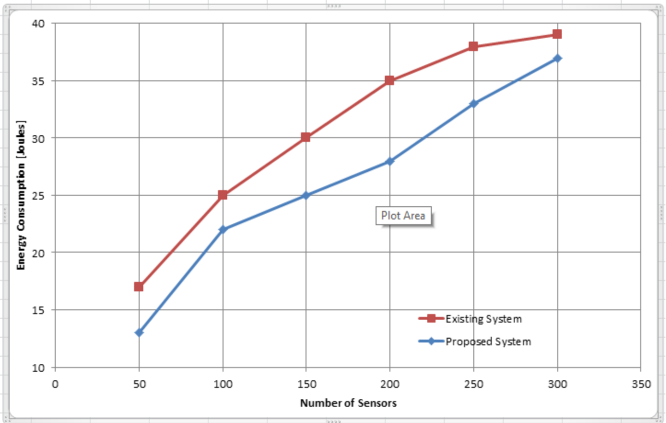

Figure.6. Measure of Energy Consumption

CLUSTERING EFFICIENCY

Clustering is the process of grouping the objects of the same or similar kind. The efficiency of clustering in the network is determined by the number of sensors in the network

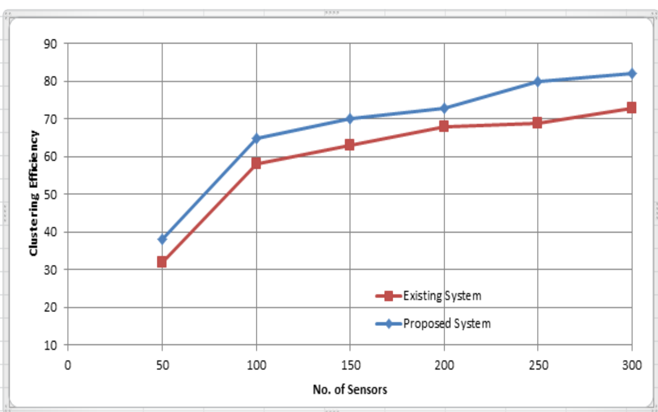

Figure.7. Measure of Clustering Efficiency

DRAINING SPEED

Due to the energy consumption of the nodes in the network and the task performed by the nodes, the energy of the each sensor drains faster. This draining speed in the network is calculated by the number of sensors present in the network.

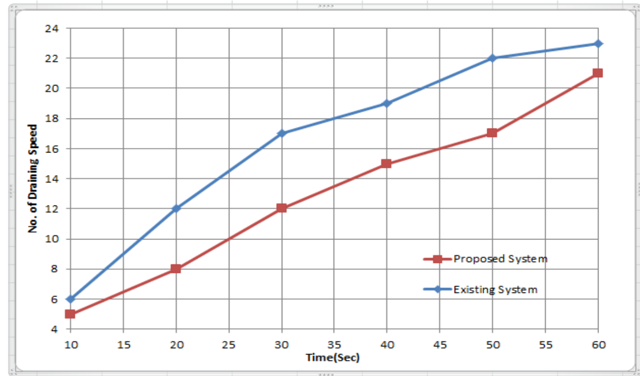

Figure.8. Draining Speed Evaluation

EVALUATION OF ALIVE NODE COUNT

The number of alive nodes is counted based on the number of nodes present in the network. During the transformation of the data between nodes, it is necessary to check whether the node is alive or not. The nodes which are alive send messages to the neighboring nodes to intimate that it is still alive. Here in this paper, our proposed alive node count is more efficient when compared to the existing system. The alive node count is accurate.

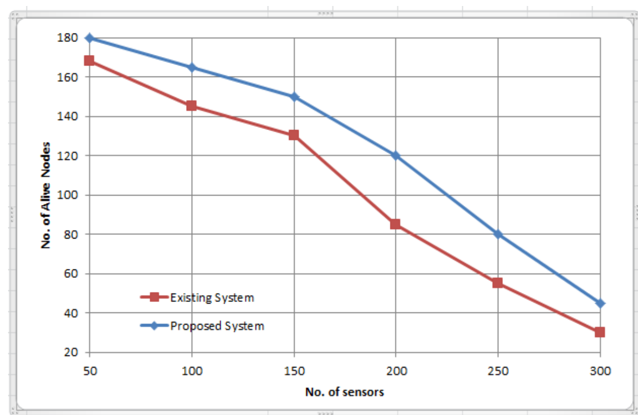

Figure.9. Evaluation of Alive Nodes

NETWORK LIFE – TIME

Network Life-time is an important thing for a network. If the life of a network is more, it will be highly reliable and will also have good performance level. Here in our paper the network life-time is more when compared to the existing.

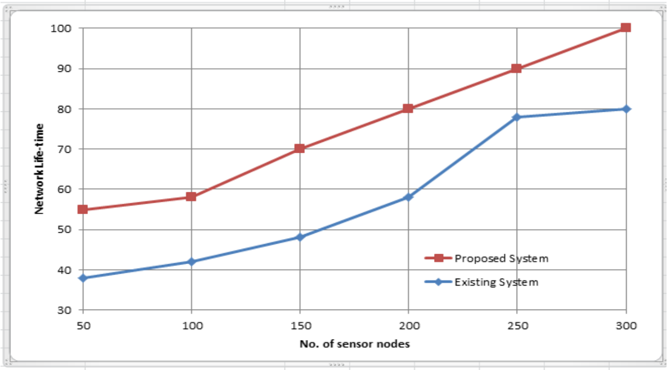

Figure.10. Network Life –Time

THROUGHPUT EVALUATION

The throughput is a measure of the transmitting rate of data from the source to the destination. The throughput is evaluated by:

$$\frac{No.of\ \ bits\ received\ per\ second\ (Kbps)}{The\ destination\ \text{node (sink)}}$$

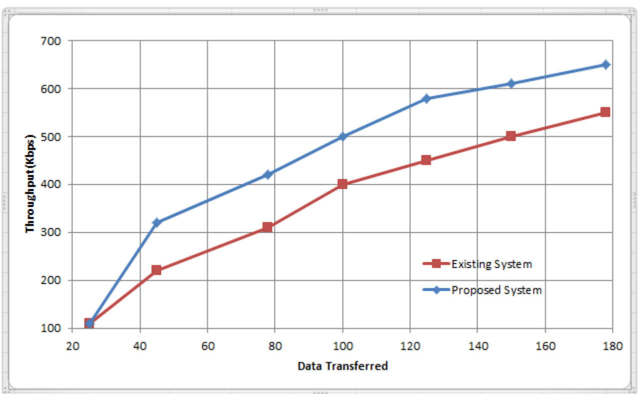

Figure.11. Throughput Evaluation

CONCLUSION AND FUTURE WORK

Constructing a topology to reduce the energy consumption and to improve the capacity of the sensors. The articulation points in the network are determined in order to prevent the network partition, and then the between-ness centrality of the network is determined. Finally, the cluster head of the each cluster region is changed dynamically to overcome the problem of network partition. And to reduce the energy consumption, to improve the clustering efficiency, life-time, and throughput of the network. The future work can be considered in certain issues such as reducing the draining speed of the nodes in the network, also can consider improving the throughput ratio even more

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