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Lifetime Enhancement Using Graph Traversing Controlling Node Topology Algorithm in Wireless Sensor Network

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Abstract

Wireless Sensor Networks consist of small nodes with sensing, computation and wireless communication capabilities. It is one of most critical network form because of lesser available resources and energy specifications. Many graph and topology control algorithms have been designed for WSNs. To achieve the effective utilization of these limited resources is one of critical challenge. One of initial phase approach to utilize the available resources is provide the topological reconfiguration so that the maximum gain from the network will be obtained. In this work an effective intelligent and dynamic model is provided for optimum reconfiguration of sensor network. In this paper firstly path is found based on maximum flow from source to destination then path is maintained with topology maintenance algorithm. This work is about to distribute the effective agents and workload to the sensor nodes so that the effective utilization of network resources will be done and efficiency of network system would be improved.

Key Words: WSN, Topology control algorithm, Graph theory, Graph traversing controlling node topology algorithm

Introduction

A Wireless sensor network consists of several nodes generally communicating with radio waves. The main feature of sensor node is sensing and data processing. Each sensor nodes operate with a battery. WSNs used in variety of applications like military, vehicle monitoring, forest monitoring, environment, healthcare, biological, industrial and other commercial applications. A sensor network consists of many sensor nodes which are deployed either inside the network or very close to it. The position of sensor nodes is not predetermined so it allows random deployment in disaster operations due to this it is impossible to recharge a battery in working field. It also indicates that sensor network protocols and algorithms must possess self-organizing capabilities. Sensor nodes are fitted with an onboard processor which carry out simple computations and transmit only the required information instead of sending raw data. In recent years due to technological advancement in embedded systems including energy efficient devices, hardware and software designing and network support, sensor nodes have been smaller in size and more efficient in data processing and transmission [1-5]. However, there are still limited in power, memory and computational capacities in sensor nodes. As a result, the key challenge is to maximize the lifetime of sensor nodes due to the fact that it is not feasible to replace the batteries of thousands of nodes.

The presented work is based on workflow analysis applied dynamically over the network to configure the network under load and work distribution. In the first phase of this work, the analysis over the network is applied to identify the critical network points. The analysis is here under load, connectivity and the communication strength parameters. The maximum workflow algorithm (Graph algorithm) is applied at this stage to identify the monitoring agent and the region so that the communication flow on a regular basis will be analyzed. Once the critical nodes are identified, the next work is to define the agent so that the optimal position and work of node that can be suitable to that node. In the final phase of this work, the network is reconstructed with effective positioning, work and connectivity parameters. The work is defined to improve the network communication and network life time. The architecture of wireless sensor network is shown in figure 1.

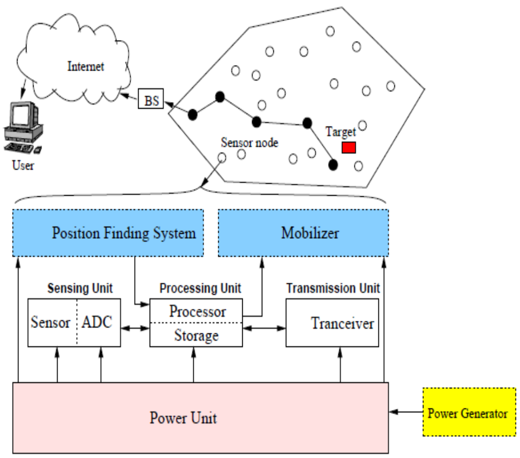

Figure 1: Wireless sensor network architecture

1. TOPOLOGY CONTROL ALGORITHMS:

A network topology is the pattern of links connecting pairs of nodes of a network. So it is a physical layout of the network's computers, terminals, and links. A network topology defines the placement of nodes and the connectivity among nodes in the network. In WSN large numbers of nodes are deployed randomly because of this topology is dense and has a dynamic nature which impacts on the power consumption of nodes topology control is important technique used to reduce energy consumption and interference in WSN and their performance. Topology control [6-7] is mainly used to provide connectivity between the network and it eliminates the redundant links in dense topology. Graph and Topology control algorithms [9], [10] are discussed below-

1. **Dijkstra Algorithm [8]** it is used to find shortest route to a destination node. The distance of arc is denoted by $D_{ij.}$ In this algorithm we use a priority queue in which vertices are arranged according to increasing distance (means ascending order). This is very fast algorithm, but it suffers from its inability to deal with negative edge weights.

2. **Bellman- Ford Algorithm [8**] is used to find shortest path. In this algorithm direct path is founded and try to ignore more number of hopes and it also removes the limitation of Dijkstra algorithm it can handle negative edge weights.

3. **Maximum Flow Algorithm [22]** is used to find a path with maximum allowed flow rate for data between sensor and destination in a network. On each iteration after finding maximum flow the link with minimum flow rate is deleted. This method is done recursively until there is no path between source and destination. Finally maximum of maximum allowed flow rate is calculated.

4. **Geographic Adaptive Fidelity (GAF) [11]** it is an energy awareness location based routing protocol. In this the whole networks is divided into fixed areas and form a virtual grid. Inside each zone, nodes will select one sensor node to stay awake for a certain period of time and then they go to sleep. This node is responsible for monitoring the data to BS on behalf of other nodes in the zone.

5. SPAN (Self Power Ad-Hoc Network) [11] in this algorithm co-ordinators build from those nodes who cannot reach directly to each other (3 hops reach ability). The co-ordinators form a network backbone which is used to send messages. It is need to maintain the positions of two or three hop neighbours in the complicated SPAN. So it is less efficient.

6. **CTBC (Cone Based Topology Control) [15]** this protocol is designed for static network topologies. It maintains network connectivity as well as minimizing energy consumption by removing energy inefficient way. This protocol divides the whole network into angles (cones). There must be one node in each cone. Directional antennas are used for transmission in each cone. Its major limitation is its increase message overhead, as high numbers of messages are exchanged to construct the network topology by satisfying network connectivity.

7. **K-neighbor [15]** it is an energy saving topology control algorithm, which does not need any directional antenna like CTBC. It only requires that each node is able to measure the receiving signal strength during communication. K-neighbors maintain number of neighbor of every node equal to or less than the value of k. The assumption is all nodes have common and maximum transmission power. The node computes its k-closest neighbor according to distance calculation. It is light weight protocol with low message overloads. Total message

exchange in this network restricted to 2n only. Its limitation is it does not preserve network connectivity at worse case.

8. **CONREAP [16]** it is an opportunity-based topology control algorithm and it is based on reliability theory in wireless sensor networks. The CONREAP has the guaranteed network reachability and the energy cost can be significantly reduced. In order to increase the total network lifetime, the set of active nodes cannot be active all the time. A topology maintenance mechanism should be in place to build a new reduced topology, consume their energy in a fair manner, and increase the lifetime of the network.

9. **HCT (Hierarchical Cooperative Technique) [18]** HCT is used to overcome the problem of k-neighbor based topology control algorithm about bounded time for maintaining connectivity. It provides full connectivity in networks.

10. **Distributed Topology Control Algorithm [19]** in this both topology construction and maintenance has been done. In topology construction phase, reliable topology is made to reduce data retransmission. In this intermittently link is used for data transmission between nodes and any node can receive packet when it is in coverage range. In topology management phase, energy consumption can be balanced by multi-level energy threshold. In this high network reachable probability is calculated to extend the network lifetime.

2. GRAPH TRAVERSING CONTROLLING NODE TOPOLOGY APPROACH:

There are number of topology control algorithms which have its own advantages and limitations. Some of techniques are discussed under topology control algorithms. To achieve the effective utilization of the limited resources is one of critical challenge. One of the initial phase approaches is to utilize the available resources which provide the topological reconstruction so that the maximum gain from the network will be obtained [20], [21].

Graph traversing controlling node topology algorithm is proposed in this paper and is based on the workflow analysis follows as:

I. The nodes are deployed randomly after deployment the analysis over the network is applied to identify the critical network points under load, connectivity and communication strength parameters.

II. Then agent is defined so that optimal position and work of node that can be suitable to that node and the list is maintained with calculation of parameters for all nodes like distance between nodes, failure probability and residual energy.

III. The network is reconstructed with effective positioning, work and connectivity parameters.

3. MATHEMATICAL MODEL:

Firstly nodes are deployed randomly and then critical nodes are decided with parameters distance, failure probability as shown below:

Distance= $\mathrm{sqrt}[(x(i)-y(i))^2+(x(j)-y(j))^2]$

Failprobability= distance*min. (energy)+distance* dropprobability/100

Energy=Transmission+Recieving+(length(path1)-2)* Forwarding

Path distance=sqrt((x(path1(z1))-x(path1(z1+1)))^2+(y (path1(z1))-y(path1(z1+1)))^2)

4. STEPS FOR GRAPH TRAVERSING CONTROLLING NODE TOPOLOGY ALGORITHM:

Stage 1 Work Flow Analysis The first stage of this work is analyzing the network dynamically under different parameters so that the critical positions over the network will be identified. The parameters considered in this work include the node level connectivity, communication and the load on each node. The node energy and the communication strength on each node are observed. Once the nodes are analyzed, the strong and the weak node categorization are done. This work flow analysis is shown in figure 2 which is required to identify the nodes where the effective node replacement can be performed.

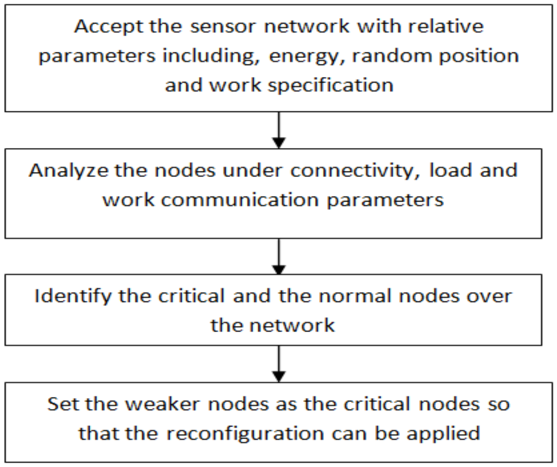

Figure 2: Work Flow Analysis

Stage 2 Setup Agents Dynamically Once the critical nodes are identified, the next work is to divide the network in smaller segments with specification of some controller nodes. The controller node is defined to analyze the relative region so that the identification of the node that can be replace the critical node. In figure 3 the agents are defined to identification of participation of the network nodes under criticality vector so that the improved communication will be formed. The connectivity, role and load parameters are here analyzed to identify the effective network configuration.

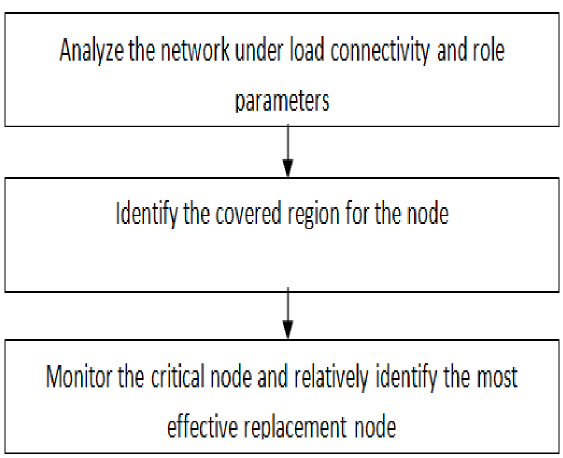

Figure 3: Agent Setup

Stage 3: Topological Reconstruction

The final phase of this work model is to identify the effective node that can replace the critical node and the topological reconfiguration will be applied. This topological reconfiguration is described to achieve the communication response so that the improved network reformation will be achieved.

5. SIMULATION RESULTS:

A network of 100 nodes is maintained with random deployment. The Base station was located at the location(x=97, y=100). Energy consumed to select the path was set to 0.5mJ/bit. Nodes are deployed with initial energy 0.75J. Energy loss is 0.0013 pJ/m^4 and the probability factor is 0.1. Path between source nodes to destination node is shown for 100 nodes. The simulation has been done for 50 rounds and the simulation result is shown for 42th round in figure 4.

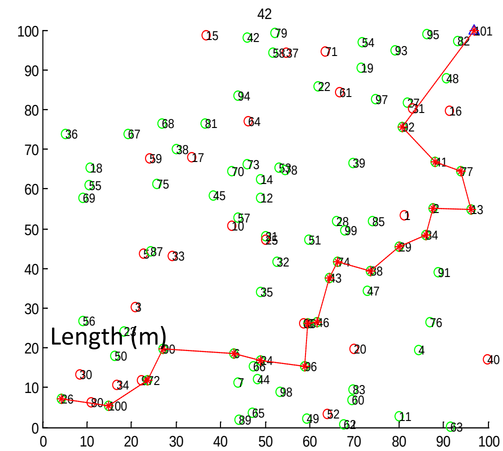

Figure 4: Path selection for 100 nodes in 42th round
Energy consumption analysis with various node densities

Energy consumption analysis has been done for various node densities (50, 100 and 150 nodes) with two parameters energy and number of rounds. Energy is calculated based upon all energy parameters like transmission energy, receiving energy, and path length and forwarding energy and its consumption is shown in figure 5. Initial energy is 0.75 J and sensing range is 40 m [23].

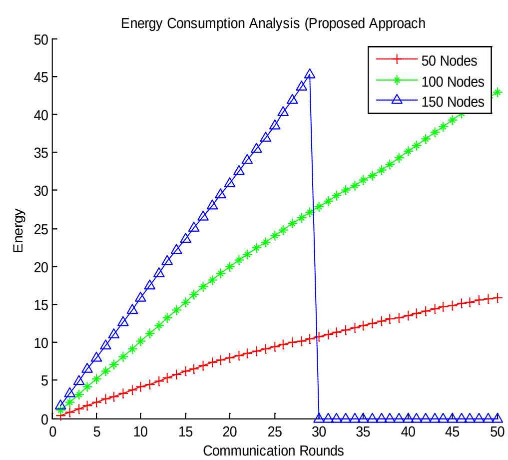

Figure 5: Energy consumption analysis with node density parameter

Dead node analysis

During network operations after some rounds when nodes die that nodes are called dead nodes. That nodes considered as dead nodes based on various factors explained below and shown in figure 6:

- If energy of nodes is less than threshold energy that nodes will not participate to form path.
- If that failure probability is greater than failure threshold probability then there is source or destination node will fail to communicate.

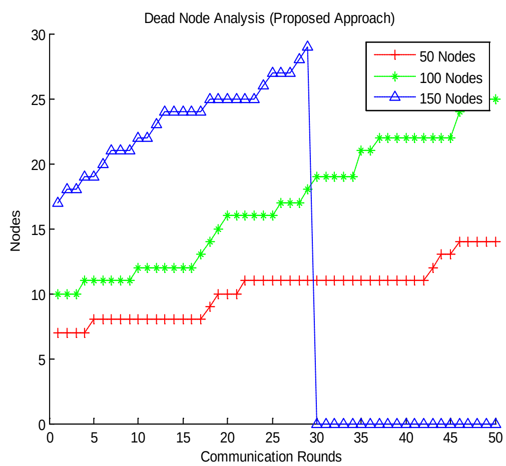

Figure 6: Dead Node Analysis

Alive node analysis

Alive nodes are calculated by subtracting the dead nodes from total number of nodes. Formula for alive node calculation = Alive nodes= Dead nodes – number of nodes.

In figure 7 alive node analysis has been done with two parameters number of nodes and number of rounds.

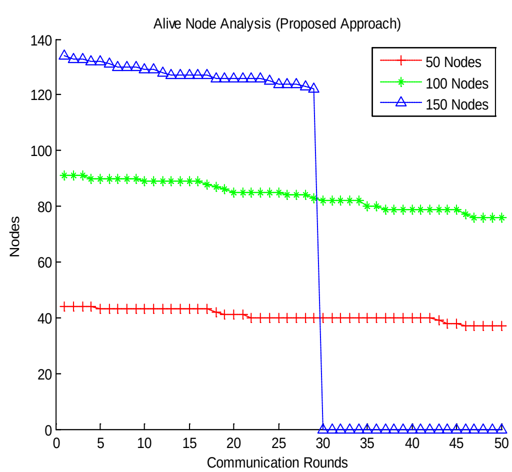

Figure 7: Alive Node Analysis

6. CONCLUSION:

In this work, a graph based topology control algorithm is designed and simulated at software for selecting best networking path by topology management technique to conserve the energy of network to perform the data transmission. In graph based topology control algorithm, after random nodes deployment firstly, critical nodes are analysed with consideration of parameter like residual energy, connectivity, work load, sensing range. After analysing about critical nodes topology construction has been done in this critical nodes are replaced with suitable nodes which have maximum value of all these parameters. In this random deployment technique is used. Node dead time is better for graph based topology control approach compared to other topology control techniques. In our experiment with graph topology control algorithm, the lifetime of wireless sensor network is directly proportional to node density. So node density is also a good parameter to judge network lifetime.

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