Topology control in wireless Ad-hoc and Sensor networks

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Abstract

WSNs consist of many nodes which are deployed closely to each other. A single node has many neighboring nodes and every node can directly communicate with their neighbor nodes. Due to this, nodes will consume lot of energy. Closely deployed nodes can create many problems like Energy loss, Load on a MAC protocol, Volatility in Routing Protocol.

The objective is to maximize lifetime of sensor nodes, minimize delay in the network and to remove coverage holes in sensor network using Color Based Topology Control (CBTC) algorithm.

In a network, I implement the Color Based Topology Control (CBTC) algorithm to calculate the amount of energy utilization using MAT LAB. The results are compared with Traditional dense WSNs. In the evaluation process it was observed that the numbers of CPU ticks required in traditional WSNs are much more than that's of CBTC Algorithm, both in Normal and Random deployments. So by using CBTC, delay in network can be minimized.

Keywords: *Color Based Topology Control, MAC protocol, Volatility in Routing Protocol.*

1. Introduction

Advances in wireless communication made it possible to develop wireless sensor networks (WSN) consisting of small devices, which collect information by cooperating with each other. These small sensing devices are called nodes and consist of CPU (for data processing), memory (for data storage), battery (for energy) and transceiver (for receiving and sending signals or data from one node to another). Sensor nodes can be used within many deployment scenarios such as continuous sensing, event detection, event identification, location sensing, and local control of actuators for a wide range of applications such as military, environment, health, space exploration, and disaster relief.

One of the challenging subjects and design constraints in WSNs is efficient energy consumption. Since a sensor node is a microelectronic device, it can only be equipped with a limited power source. Sensor node deployment and topology control (TC) are the two most important factors that can affect the performance of WSNs if not handled properly.

Worse deployment and TC of wireless sensor nodes creates many problems like loss of energy, coverage hole and delay in network.

In this research work, Color Based Topology Control (CBTC) algorithm is designed for wireless sensor networks in order to achieve maximum lifetime of sensor nodes, minimize delay in the network and to remove coverage holes in network. It prolong the sensor network lifetime compared with traditional WSNs.

I explained about the background information needed to precede the development of the work, the literature review depicts the theoretical viewpoints related to the topic. The information about the methodology which is used in the research work and the algorithmic approach. In the data analysis and the results are discussed and validated summarizes the entire research work and concludes the findings of the work.

2. Wireless sensor network

Recent advances in micro-electro-mechanical systems (MEMS) technology, wireless communications, and digital electronics have enabled the development of low-cost, low-power, multifunctional sensor nodes that are small in size and communicate untethered in short distances. These tiny sensor nodes, which consist of sensing, data processing, and communicating components, leverage the idea of sensor networks based on collaborative effort of a large number of nodes. Sensor networks represent a significant improvement over traditional sensors, which are deployed in the following two ways,

Sensors can be positioned far from the actual phenomenon, i.e., something known by sense perception. In this approach, large sensors that use some complex techniques to distinguish the targets from environmental noise are required.

Several sensors that perform only sensing can be deployed. The positions of the sensors and communications topology are carefully engineered. They transmit time series of the sensed phenomenon to the central nodes where computations are performed and data are fused. A sensor network is composed of a large number of sensor nodes, which are densely deployed either inside the phenomenon or very close to it. The position of sensor nodes need not be engineered or pre-determined. This allows random deployment in inaccessible terrains or disaster relief operations. On the other hand, this also means that sensor network protocols and algorithms must possess self-organizing capabilities.

Another unique feature of sensor networks is the cooperative effort of sensor nodes. Sensor nodes are fitted with an on-board processor. Instead of sending the raw data to the nodes responsible for the fusion, sensor nodes use their processing abilities to locally carry out simple computations and transmit only the required and partially processed data.

The above described features ensure a wide range of applications for sensor networks. Some of the application areas are health, military, and security. For example, the physiological data about a patient can be monitored remotely by a doctor. While this is more convenient for the patient, it also allows the doctor to better understand the patient's current condition. Sensor networks can also be used to detect foreign chemical agents in the air and the water. They can help to identify the type, concentration, and location of pollutants. In essence, sensor networks will provide the end user with intelligence and a better understanding of the environment. We envision that, in future, wireless sensor networks will be an integral part of our lives, more so than the present-day personal computers.

Realization of these and other sensor network applications require wireless ad hoc networking techniques. Although many protocols and algorithms have been proposed for traditional wireless ad hoc networks, they are not well suited for the unique features and application requirements of sensor networks. To illustrate this point, the differences between sensor networks and ad hoc networks are outlined below

- The number of sensor nodes in a sensor network can be several orders of magnitude higher than the nodes in an ad hoc network.
- Sensor nodes are densely deployed.
- Sensor nodes are prone to failures.
- The topology of a sensor network changes very frequently.
- Sensor nodes mainly use broadcast communication paradigm whereas most ad hoc networks are based on point-to-point communications.
- Sensor nodes are limited in power, computational capacities, and memory.
- Sensor nodes may not have global identification (ID) because of the large amount of overhead and large number of sensors.

Since large number of sensor nodes is densely deployed, neighbor nodes may be very close to each other. Hence, multi hop communication in sensor networks is expected to consume less power than the traditional single hop communication. Furthermore, the transmission power levels can be kept low, which is highly desired in covert operations.

Multi hop communication can also effectively overcome some of the signal propagation effects experienced in long-distance wireless communication.

One of the most important constraints on sensor nodes is the low power consumption requirement. Sensor nodes carry limited, generally irreplaceable, power sources. Therefore, while traditional networks aim to achieve high quality of service (QoS) provisions, sensor network protocols must focus primarily on power conservation. They must have inbuilt trade-off mechanisms that give the end user the option of prolonging network lifetime at the cost of lower throughput or higher transmission delay.

3. The Proposed Algorithm

The proposed Color Based Topology Control (CBTC) algorithm for wireless sensor networks is used in our system. It achieve maximum lifetime of sensor nodes, minimize delay in the network and to remove coverage holes in network.

3.1 Color Based Topology Control Algorithm

In densely deployed and fully connected WSNs as shown in Figure 1, large amount of energy is consumed due to multiples neighbor's node. To control multiple neighbors' nodes different strategies are used. In some approaches neighbors are con- trolled but energy consumption and coverage holes are created or after some time energy holes are produced. In some cases, it was observed that if coverage holes are removed then the topology cannot be controlled properly. The proposed Topology control was designed in which energy consumption due to multiple neighbors' nodes was minimized and coverage holes were removed.

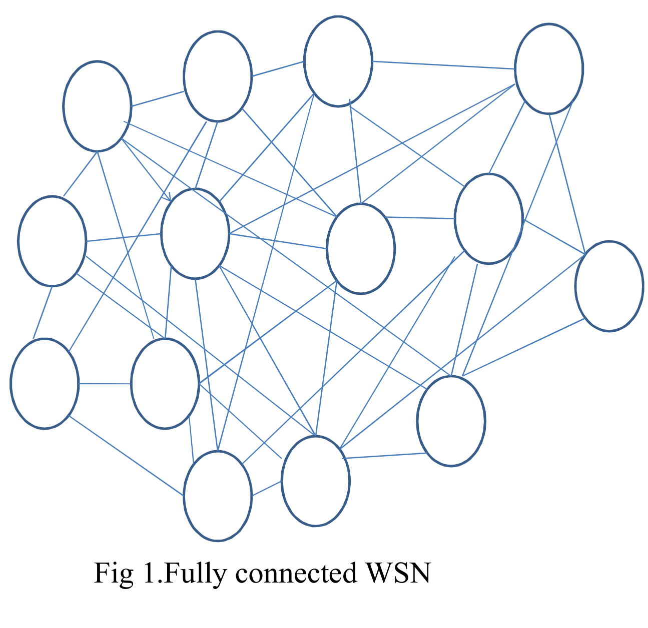


Fig 1.Fully connected WSN

3.2 New Topology Control for WSNs

For reducing the numbers of neighbor nodes and the numbers of links between sensor nodes, a new topology control algorithm is introduced, known as "Color Based Topology Control (CBTC) algorithm". Through this algorithm, an identifier i.e. "color flag" is used inside the code area of the sensor node, denoting the color of that node. Five color flags are used i.e. blue, black, red, green, and white. All the sensors nodes are sensitive for some particular application, such as humidity, temperature or pressure etc. A node of same color flag can sense another node in its coverage area and communication between them is possible. The topology control is supposed to be used in two scenarios i.e. Uniform Deployment and Random Deployment of nodes. In case of Random Deployment it can select node of other color.

Suppose that the sensors nodes are deployed in uniformed way; such that every node of the same color flag is equidistance from each other and there is no coverage problem. Communication between same color nodes is possible. Suppose that if someone wants to deploy 50 nodes, then there must be 10nodes of each color flag.

When network size is large or the sensor field is remote and hostile, random sensor deployment might be the only choice e.g. scattered from an aircraft. Suppose that sensor nodes are deployed in random manner then there may be the possibility that the distance between two nodes of same color flag is greater than their required range (far from the coverage area of some other sink or sensor node). But there exist a node of other color flag. In such scenario, a node of other color flag can be selected within its coverage area..

3.3 Removal of Coverage Hole

In sensor network when a node; which is on the way to some sink node become dead then there occur a coverage hole. Through this coverage hole other nodes cannot transmit their data to the sink node. The encircle node represent dead node due to which coverage hole is created. To remove this problem in the color based topology algorithm, when a node of some color, suppose the node of color flag "blue" becomes dead, then it should work by choosing some node of other color flag within its coverage area.

```
Procedure for CBTC
Case No. 1
START
CF: = COLOR
CFX: = GetColor (X)
IF CF = CFX THEN
TRANSMISSION () ↔ X
END IF
END
Case No. 2
```

```
START
CF: = COLOR
CFX: = GetColor (X)
IF CF = CFX THEN
TRANSMISSION () ↔ X
ELSE
RESENSE (COLOR)
S = SHORTESTNODE ()
TRANSMISSION () ↔ S
END IF
END
Note:
CF means color_flag
CFX means color_flagof X
```

Evaluation of CBTC with respect to Time

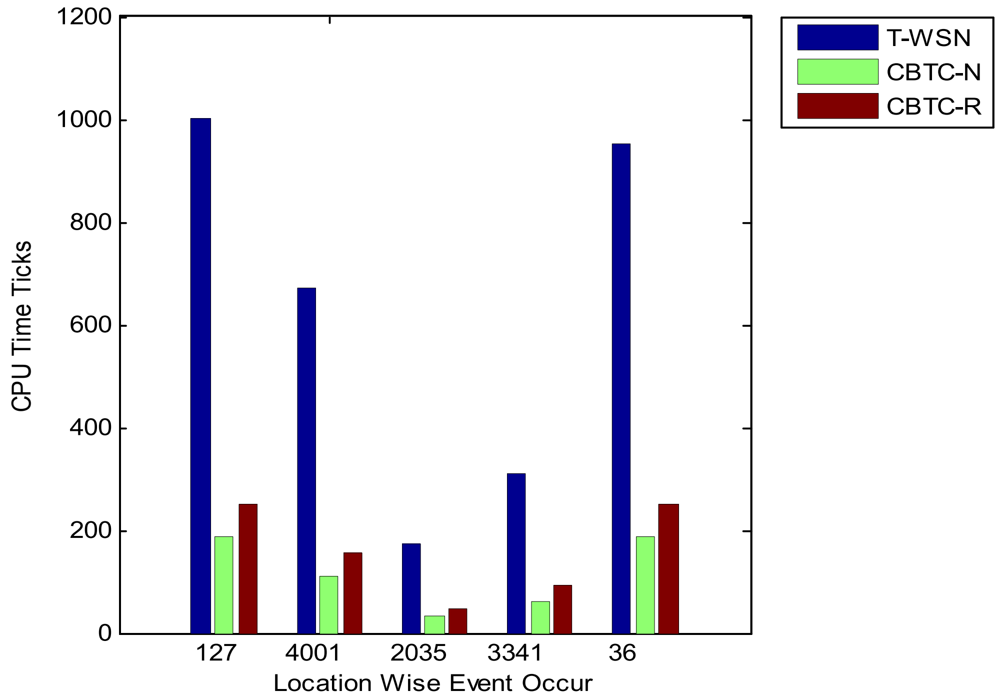
For reducing delay in network in CBTC, time of propagation is measured and compared with T-WSN. Time is measured in clock-ticks generated by CPU. From single experiment I cannot conclude result confirmedly so I performed and compared five experiments *i.e.* repeatedly execute the program five times, for five different nodes where the event has occurred, like shown in our project. For each event we observed clock- ticks of CPU as given in.

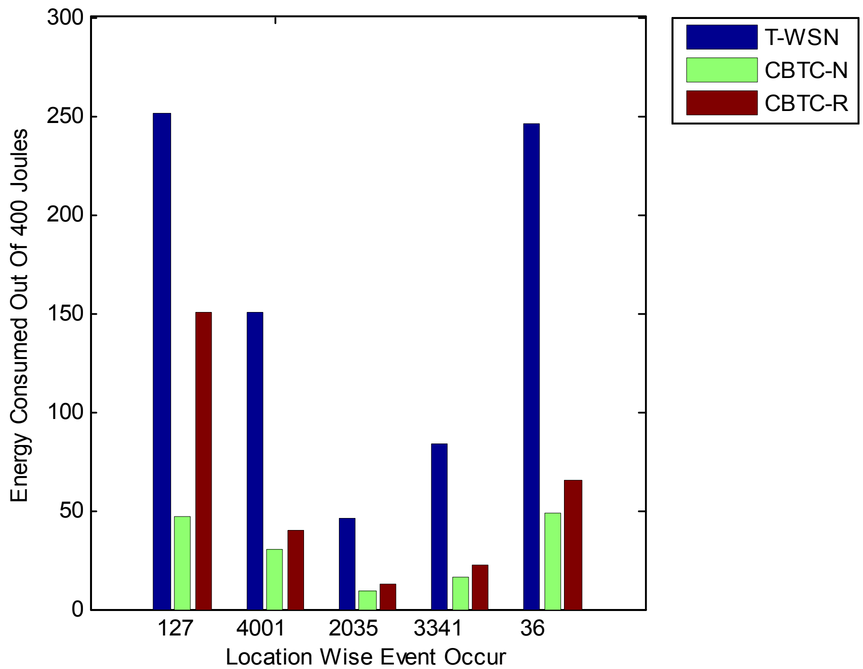
T-WSN stands for Traditional Wireless sensor Network, in CBTC-N and CBTC-R, N and R stands for Normal and Random deployments. It is clear numbers of CPU ticks required to T-WSN is much larger than other two types of CBTC. In CBTC, the CBTC-R takes larger time as com-pared to CBTC-N due to resensing and selecting other color node, in case of none – availability of its own color node

5.2.2 Evaluation of CBTC with respect to Energy

Energy consumption of sensor node is dominated by communication. If the time of communication is much then lots of energy will be consumed. In the evaluation 400 Joules energy was given to every sensor node then the consumption of energy with respect to different events with different locations.

The energy consumed by T-WSN is much greater CBTC algorithm. In CBTC, the CBTC-R takes greater amount of energy as compared to CBTC-N because of resensing and selecting other color node due to none-availability of its own color node. This thesis concluded that energy consumption in CBTC algorithm is much less than traditional dense WSNs.


1200
1000
800
600
400
200
0
CPU Time Ticks
127
4001
2035
3341
36
Location Wise Event Occur
T-WSN
CBTC-N
CBTC-R

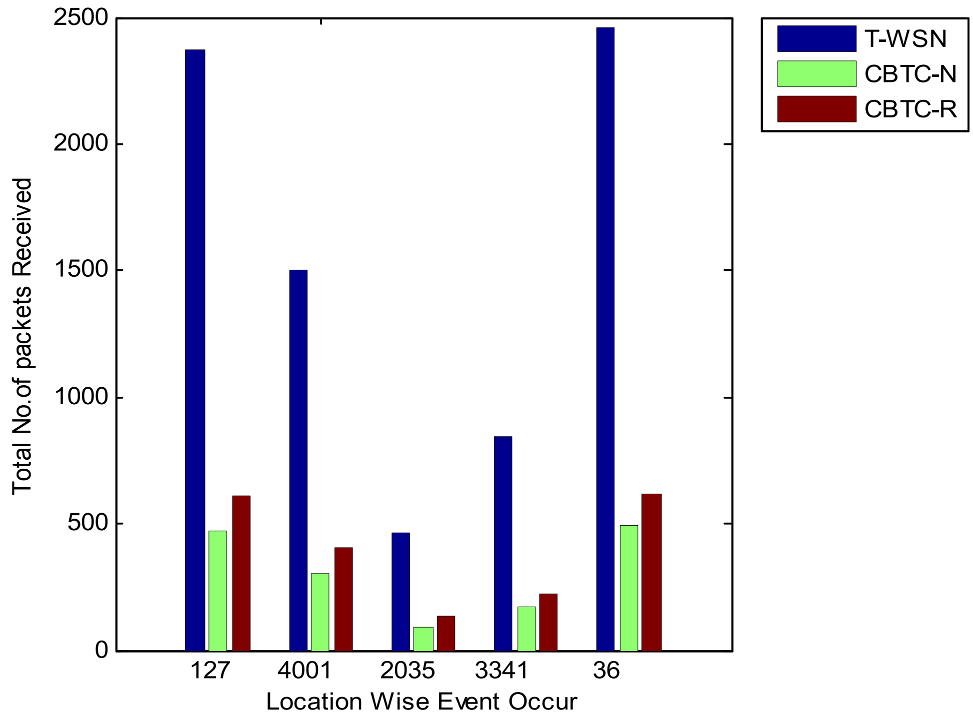

300
250
200
150
100
50
0
Energy Consumed Out Of 400 Joules
127
4001
2035
3341
36
Location Wise Event Occur
T-WSN
CBTC-N
CBTC-R

Evaluation of CBTC with respect to No. of Packets

A sensor node play two roles in the WSNs one is sending its own sensed data and other is forwarding the data sensed of other sensors nodes. If each node has to send the same amount of data then the energy consumed by each node is identical .Now in this thesis observed at the number of packet received in traditional Wireless Sensor Network, in CBTC-N and CBTC-R.

The graph comparing the numbers of packets received during different events are occurred is obtained from the above data.

In this research work concluded that the numbers of packets received in traditional dense WSNs are much more than CBTC-R and CBTC-N. And if fewer packets received and transmitted then less amount of energy will be consumed.



Comparison of T-WSN and CBTC with respect to numbers of packets received.

Conclusion

In wireless Sensor Networks energy is one of the primary issues and requires energy conservation of the sensor nodes. In the evaluation process it was observed that the numbers of CPU ticks required to T-WSNs are much more than that of CBTC-N and CBTC-R. So by using CBTC algorithm, delay the in network can be reduced and the network will be more efficient. Moreover in the evaluation it was also determined that the energy consumption in T-WSN is much more than that of CBTC-N and CBTC-R. By using CBTC algorithm energy can be conserved. Total numbers of packets received in T-WSN are much more than that of CBTC algorithm. So in all as- pects i.e. time, energy and no. of packets the CBTC is better than T-WSNs.

Moreover the problem of coverage hole is also resolved in CBTC by choosing node of other color within its coverage area, for sending its data.

Future Enhancement

The proposed algorithm was implemented in both uniform deployment and random deployment. In uniform deployment there is a less energy consumption compared with random deployments. In future this algorithm is enhanced to perform effective energy conservation in the network.

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