Energy Conservation Topology for Wireless Sensor Network using Manual Power Control

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ABSTRACT
In the last years, wireless sensor networks (WSNs) have gained increasing popularity from the research community and actual users because of their wide range of applications in fields such as medical, entertainment, tracking etc. As sensor nodes are generally battery-powered devices, the critical aspects are to face concern how to reduce the energy consumption of nodes, so that the network lifetime can be extended to reasonable times. Topology control is one of the vital points which should be kept in mind while creating wireless sensor network for the purpose of creating energy efficient network without affecting the connectivity or other properties. This paper goes through various strategies carried out to obtain a better scheme for topology control in terms of energy so that the lifetime of node as well as the network lifetime is increased. Using these strategies we have given some of the practical implementations and results which provide the efficient WSN topology.

Keywords
Power Control, power management, Wireless sensor network, practical implementation.

1. INTRODUCTION
Wireless sensor network (WSN) is one of the emerging technologies. WSN is actually a network of complex sensor nodes equipped with limited sensing, computing and radio communication capabilities. They can be used in various tasks such as environmental monitoring, security, entertainment etc. The sensors perform the data processing and then are controlled by the base stations. These sensors are the devices which work on battery. As we know that the batteries have a specific life time and in turn the sensors also have a limited lifetime which depends on the battery they are using. Consider the figure given

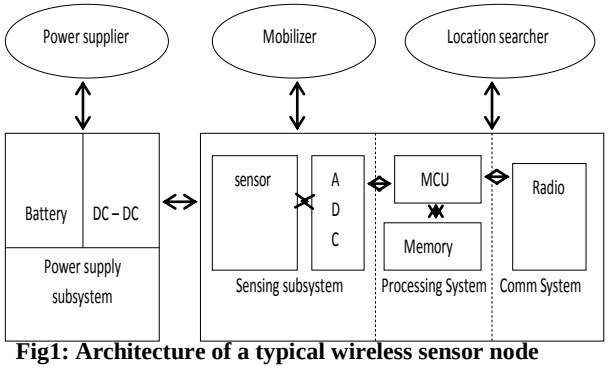

Fig1: Architecture of a typical wireless sensor node

Node consists of four main components: (i) a sensing subsystem with one or more sensors (with analog-to-digital converters) for data acquisition; (ii) a processing subsystem along with a micro-controller and memory for local data processing; (iii) a radio subsystem for wireless data communication; and (iv) a power supply unit. Depending on the application, sensor nodes may also include extra components such as a location finding system to determine their position, a mobilizer to change their location or configuration (e.g., antenna's orientation), and so on.[1]

In the figure it can be seen that the sensors require continuous energy supply from the battery denoted as power supply subsystem. So if the battery is not present any more than the sensors also are of no use. WSN needs a power source that supplies the energy needed by the device to perform the programmed task. This power source often consists of a battery with a limited energy budget as discussed earlier. The main requirement for various applications is to prolong the lifetime of the sensor network.

Each sensor node depends on small low capacity battery as energy source, and cannot have replacement [1][2][3][4]. In addition, it could be impossible or inconvenient to recharge the battery, because nodes may be deployed in a hostile or unpractical environment. On the other hand, the sensor network should have a lifetime long enough to fulfill the application requirements. In many cases a lifetime in the order of several months, or even years, may be required. Therefore, the crucial question is: "how to prolong the network lifetime to such a long time?" In some cases it is possible to scavenge energy from the external environment (e.g., by using solar cells as power source). However, external power supply sources often exhibit a non-continuous behavior so that an energy buffer is needed as well. In any case, energy is a very critical resource and must be used very sparingly. Therefore, energy conservation is a key issue in the design of systems based on wireless sensor networks.[1]

Aim of this paper is to provide a design for energy efficient topology or say such architecture so that it consumes minimum energy and the lifetime of the network is thus increased.

To overcome this problem of energy consumption we have basically two types of methods that can be given as:

1. Power Control mechanism
2. Power management mechanism

1.1 Power Control Mechanism

Adjusting the transmitting power of each node dynamically is termed as power control [4][5][6][7].

The power of sensors can be controlled by controlling their transmission range. The reason is that reducing the maximum transmission range increases network lifetime. In a dense network, increasing the transmission range is undesirable because it leads to a higher channel interference, collision, decreased throughput and high energy consumption. So in order to increase the performance it is desirable to decrease the transmission range. It can be illustrated by the given figure 1.2 ahead:

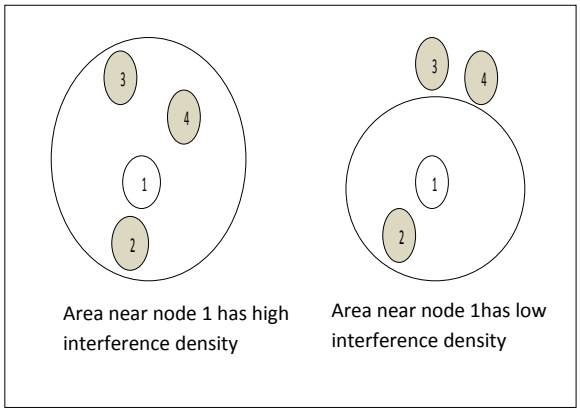

Fig 2: Network using minimum and Maximum Transmission Ranges

As shown in the figure if node 1 transmits with its maximum range then it will include all the three nodes that is node 2, 3, and 4 with in its range and if within that time either of the adjacent node also makes any transmission then interference area will increase and interference will again lead to energy wastage of the nodes. On the other hand if node 1 transmits at lower range or minimum transmission range such that it is reachable only up to node 2 then interference area will also be less and hence less energy consumption by nodes.

On the other hand it can be said that when a node is transmitting with maximum range it will cover all other node present along with the destination node. Those other nodes have no requirement of the traffic that node 1 is transmitting but still they are receiving it leading to traffic increase as well as if at the same time other nodes also start transmitting then it will lead to collision and in turn wastage of energy of node 1 as well as other nodes in making useless transmission.

So as a conclusion, transmission range of the nodes should be kept low. The two advantages can be pointed as :

1) Lower the transmission range less the energy consumed in transmission.
2) Low transmission range will avoid the collision among nodes hence the energy of nodes will not be wasted in collision.

1.2 Power management mechanism

Power management is switching off the redundant nodes that are not involved in transmission nor reception [8][9][10][11][12]. So the power management of sensors can be done by switching off those nodes which are not in use at any particular instance of time. This is basically called the sleep state of nodes. In this method generally the nodes which are not in use at particular instant of time are turned into sleep state. This is basically done so that they don't consume energy unnecessarily. Whenever required they are again converted into up state. Thus it also increases the lifetime of nodes and in turn increasing the lifetime of the sensor network. One of the most common approaches for this task is the concept of "Duty Cycling".

Duty cycling is mainly focused on the networking subsystem. The most effective energy-conserving operation is putting the radio transceiver in the (low-power) sleep mode whenever communication is not required. Ideally, the radio should be switched off whenever there is no more data to send/receive, and should be resumed as soon as a new data packet becomes ready. In this way nodes state differs between active and sleep periods depending on network activity. This behavior is generally called duty cycling, and duty cycle can be defined as the fraction of time nodes are active during their lifetime. [13]

The nodes are kept in sleep state when not required, the sleep time of nodes depends on the task to be performed and the frequency of the appearance of the useful data in the particular area where node is present. So the sleep and up conversion state of the nodes is decided by the user according to the factors taken into consideration for the area being covered by the node.

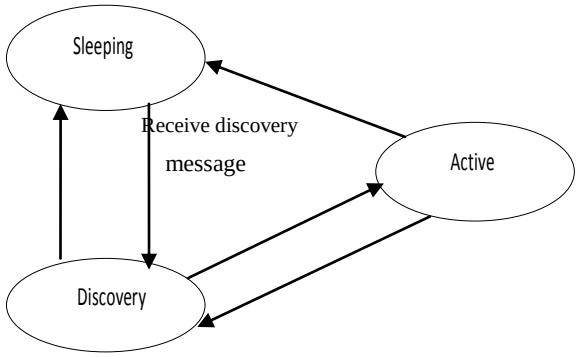

Fig 3: Working of nodes with their state conversion

So these are the two efficient methods by the use of which we can create energy efficient topology for wireless sensor network. In this the implementation which have been done already is that the nodes while transmission should keep its range low and also the nodes which are not working at present or say are idle should go to sleep state. This will lead to less energy consumption by the nodes. On this basis, further a new foundation for preventing energy can be given.

2. THEORETICAL FOUNDATION OF RESEARCH

WSN is one of the important aspects as discussed earlier and the nodes which are used in this are working on low power battery. So to overcome this energy factor of nodes many energy efficient topologies have been given. But those researches have used either the power control or the power management mechanism. But the proposed research

is given for creating an energy efficient topology by combining the features of both of the method i.e. "Power Management" and "Power Control". Further to create more efficient topology for wireless sensor network we have one more point to take into consideration. It can be explained as given below:

1 Initially any source nodes when wants to reach up to the sink node it will first select the path to reach up to there.
2 It may notice multiple paths to reach to the sink node and will notice all the paths firstly by considering all the available paths.
3 Now out of multiple path using the protocol used for routing it will select the best path to reach from source to the sink node.
4 Now it might be possible that the sensors of the path selected don't have enough power to make the transmission and in the time period it is making the transmission the node goes down due to the lack of power. So the transmission which was made till then remains of no use and a new transmission are to be started via a new path.
5 According to this research work what can be implemented is that on the path selected the node which has to make the transmission will first off all check its power level.
6 The power level conditions can be set manually by the user or say the controller present at the base station.
7 When the node will check its power levels then
8 If it have the desired power level to make the transmission at required transmission range then it will start transmission on that path towards the sink node
9 But if it don't have the desired energy level or say its energy is not sufficient to make that specific transmission on desired range then it will not start the transmission.
   (i) In that case it will show the message to the user informing about insufficient power.
   (ii) After that the node can inform its parent or say the neighbor about the condition and its power status and itself will go into the sleep mode.
   (iii)The neighbor can now go further and can search for next new which can make the desired transmission up to the sink node.
10 The node which went into sleeping state can after regular intervals of time come into active state to check is there something to discover.
11 If again it discovers something and finds its power level sufficient for that transmission then it makes the transmission else it repeats the step 7.

On this basis we come to conclusion that a node will make transmission only if it have energy levels sufficient for desired transmission else it will not make unnecessary transmissions which will come to an end without complete transmission due to low energy level. And the node will go to sleep mode and will make any transmissions only if it have enough energy left with it for that particular transmission.

This will preserve the energy and hence will increase the sensor lifetime as well as the lifetime of the network.

3. PRACTICAL IMPLEMENTATION AND RESULTS

As discussed above it can be said that it is better by not allowing a sensor to transmit if it doesn't have enough energy levels and converting it into sleep state. Whenever a source node is decided first it checks for its energy level that does it have sufficient energy level for transmission at required range. If it have it then it makes the transmission else just informs the neighbor about its status converting itself to sleep state and shows the message to the user "cannot find more power". For example let the source node 42 is selected which have the energy level of 21.256 (which is less then 50). So the source will not make the transmission due to insufficient energy and will show the message as ahead :

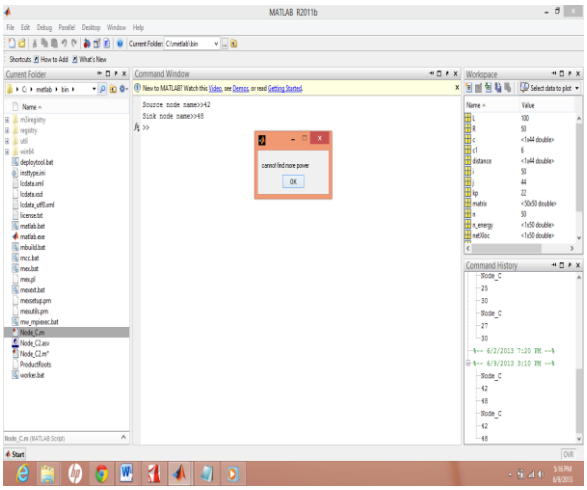

Fig 4: Message shown if node have insufficient power

Further even if the energy factor is considered a controlled topology with less number links will be obtained i,e. there will be a controlled topology which in turn will consume less energy. It will be clear as ahead in the discussion.

4. DISSCUSSION

Here if the power factor in not taken into consideration then the number of links will be increased which will consume large amount of energy and due to this the batteries will soon discharge and the life time of the network will be small. Instead of this if we control the topology by energy efficient methods implementation then the number of links will be reduced and energy will even not be wasted in making useless transmissions. This will form energy efficient topology for wireless sensor network and in turn will also increase the lifetime of the network.It can be clarified by the given cases ahead :

CASE 1 : Without considering the energy factor

As discussed in the above implementation energy was not taken as an important factor.Here lets take the same case i,e. let 21 be the source and 30 be the sink node. So here the number of links will be many as shown ahead :

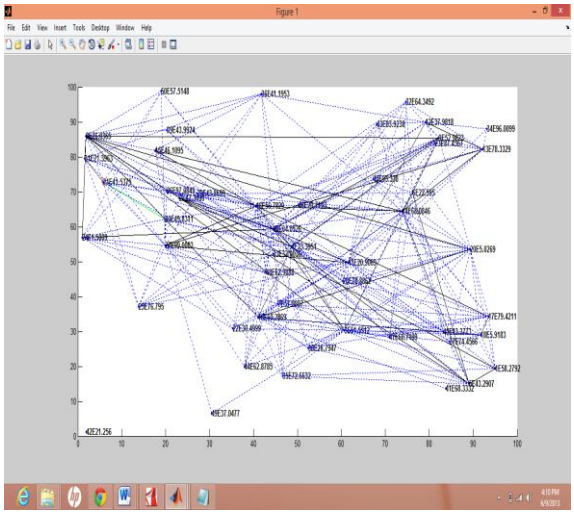

Fig 5 :Links formed without considering energy factor

Here from the figure it is clear that while not considering the energy factor the number of links are so many. It will lead to consumption of large amount of energy by the nodes. Due to this the batteries will go down soon and the network lifetime will also be reduced. So it is not an efficient method for Wireless sensor networks.

CASE 2 : Considering the energy factor

Now here in this case the energy factor for the transmission is taken as an important factor. Again assuming the node 21 as the source node and 30 as sink node. Now in this case the first point is that the node will do transmission only if it have the sufficient energy level else it will not waste the energy in useless transmission. Secondly the links considered by node 21 when energy factor was considered can be shown as :

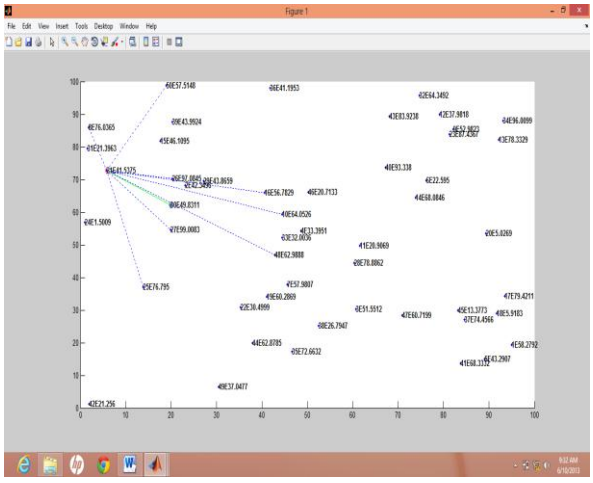

Fig 6 : Links formed after considering energy factor

So it is clear from the above figure that when energy factor is considered the number of links formed will be less as compared to previous structure or we can say that we have a controled topology which increases the network lifetime.

5. CONCLUSION

The objective of this paper is to develop energy efficient topology for wireless sensor network. Here for that purpose we considered the two methods of topology control i.e. “Power Control” and “Power Management”. In the proposed research the methodology that is adopted is that the node will make the transmission only if it has sufficient energy level to reach up to the sink node. If it doesn’t have the sufficient power for the transmission on required range then it will not make the transmission. It is so because let say the node have insufficient energy for transmission but it starts the process with its present power level then its transmission may stop in middle only when the energy level completely goes down. It will result in incomplete transmission and even the transmission that has been already made is also of no use if the transmission stops in middle. So to avoid this wastage the node will not transmit till it doesn’t find enough energy level with it. Instead of transmitting it will inform the neighbor about its status to perform the task and itself goes to sleep state so that its energy can be preserved in order to increase the network and nodes lifetime.

6. FUTURE SCOPE

It can clearly be seen and can be said that Wireless Sensor Network has various applications in the different fields such as given below:

1. Medical
2. Defense
3. Tracking
4. Entertainment
5. Whether forecasting

So due to its so many applications it can be concluded that Wireless Sensor Networks are of huge importance. But as discussed earlier they have the critical point of topology development as they work on small power batteries. So the topology should be made which is energy efficient so that network lifetime can be increased. In this implementation methods of developing an energy efficient topology for the WSN are produced. In future further work with this proposed topology can be done by implementing more energy efficient protocols and clustering of nodes in a particular area. Further researchers can improve it by improving the structure of the tables which the nodes will share between them and the information that the source node will provide to its neighbor when it doesn’t have required energy level with it. Thus more energy efficient topologies for the wireless sensor networks can be created.

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