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Review on Relay Node Placement Techniques to Increase System Capacity in WSN

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Abstract- A wireless sensor network consists of sensor nodes which are capable to perform sensing, computation and transmission. These sensor nodes have limited battery power which is difficult to replace due to hostile environment. Therefore to increase the lifetime of wireless sensor network, it is required to develop such techniques to consume lesser energy. Less consumption of overall energy of the network results in increase in the system capacity. One of these techniques is to deploy some relay nodes to communicate with the sensor nodes, other relay nodes and the base stations. The relay node placement problem for wireless sensor networks is concerned with placing the minimum number of relay nodes into the wireless sensor network to meet certain connectivity requirements

Index Terms –wireless sensor networks (WSN), sensor node, relay node placement, direct communication, Amplify and forward, decode and forward, system capacity

I. Introduction

Hundreds or thousands of Sensor Nodes (SN) are spatially distributed in WSN with the limited battery to sense the environment and send this information to sink or base station (BS). Sensor nodes act as a sensor and data router. Sink node is equipped with unlimited battery. The process of sensing and communication from sensor nodes to BS is shown in Figure 1. As SNs are deployed in hostile environment, it is quite impossible to replace these batteries. The various researchers proposed different techniques or methods in order to enhance the life time of WSN. Energy consumption in a transmission in WSN is directly proportion to square or forth power of the distance from source to destination node. when the sensor nodes are apart from each other and from sink and there is more energy consumption which is not economical. To overcome this problem the relay nodes may be placed to reduce the energy consumption. Comparing to the sensor nodes, relay nodes are much less costly. Relay nodes are needed to forward readings from each individual sensor in multiple hops to the sink

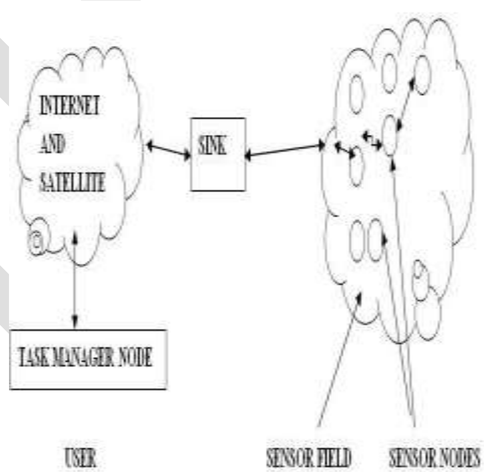

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Fig.1 Wireless Sensor Network

Relay node works like a repeater that amplifies the signal and forward to sink. Relay node job is only to relay data generated by other sensor nodes, without sensing the environment. Relay node can remove burden from the overloaded nodes. Relay node main task is to communicate with the sensor nodes and with other relay nodes. The placement of relay node plays a critical role in the system performance. One or more relay nodes can be placed between the sensor nodes and sink depending upon the situation. When the distance between the sensor node and sink is greater than the transmission range means sensor node cannot send data directly to the sink then there is need for relay node placement.

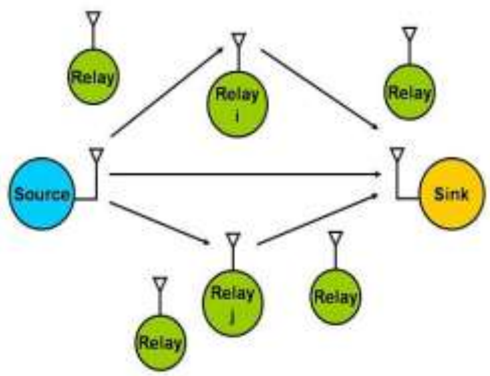

Figure 2: Showing Relay Node position with source and Sink

The deployment of relay nodes in sensor networks has been proposed for maximizing the network lifetime, energy-efficient data gathering to increase the system capacity, load-balanced data gathering as well as making the network fault tolerant, less energy consumption as energy conservation is directly related to the lifetime of sensor networks. *Relaying* will be especially beneficial when there is no line-of-sight path between the source and the destination. **Figure 3** shows the basic functionality of relay node. For enhancement of lifetime of the network, many researchers have presented many relay node placement techniques. In this pa per a survey of relay placement techniques is presented.

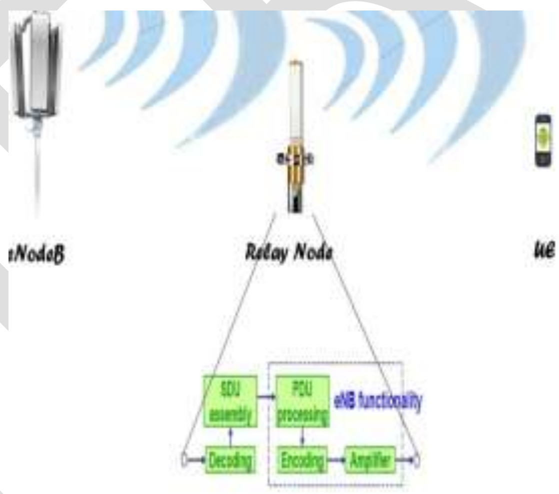

Figure 3: Basic functionality of Relay node

Exiting Techniques

Wireless networks support relay-based communication, in which a well-placed relay node receive a message from a source node, amplify it, and forward it to its destination node as shown in **Figure 4.** This will result in performance gains for end-users. *Relaying* will be especially beneficial in cases when there is no line-of-sight path between the source and the destination. Relay node act like an intermediate between sender and receiver.

Bredin et al. [9] extended the relay node placement problem to the case of k-connectivity, instead of the 1-connectivity, that is the problem of deploying relay nodes to provide desired fault tolerance through multipath connectivity (k-connectivity) between all sensor nodes in WSN and presented the polynomial time O (1)-approximation algorithms for any of fixed k.

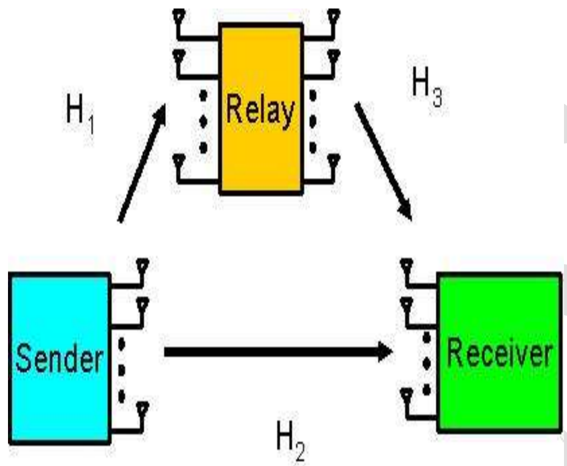

Figure 4: Show relay with sender and receiver

In [10], Kashyap et al. presented a 10-approximation algorithm ensuring 2-connectivity. In this assume that the transmission range of the relay nodes is the same as that of sensor nodes such that relay nodes can send the data at the same rate as the sensor node.

In [11], Lloyd and Xue refer to the case where relay nodes have transmission range greater than the transmission range of sensor nodes. There is need for the relay nodes because sensor nodes cannot directly transfer the data to sink due to their less transmission range.

MIMO Relay Channels: SISO relay channels are those channels where each terminal employs a single antenna. Under this type of setup, though, there are many channel conditions where the relay may not be able to assist the source in its transmission. For example, the minimum of the source-relay and relay-sink channel gains may be less than the source-sink channel gain. To avoid this issue by considering MIMO relay channels, where each terminal employs multiple antennas. MIMO relay channels introduce additional degrees of freedom that allow for partial cooperation between the transmitter and the relay. Under this setup, one can exploit the multiple antennas at the source node and the relay node to perform more sophisticated encoding and decoding schemes, which will lead to improved performance.

1. The More Relay Nodes, the More Energy Efficient?

It is not possible to greatly reduce the energy consumption by increasing the number of relay nodes. Slightly increasing the number of relay nodes can significantly reduce energy consumption. On the contrary, blindly adding the relay nodes does not necessarily improve the energy efficiency when the number of relay nodes exceeds a certain threshold. Zhu et. al. has proved it in 2009[1].

1. Relay Node Placement Techniques:- For the proper placement of relay nodes different researchers gave different techniques which are discussed as follows:-

1) **Minimum-energy transmission model**: In the minimum-energy transmission model, nodes located closer to the base station need to relay data at much higher rate than the nodes located further away from the base station. This uneven energy dissipation among the nodes may lead to the faster death of the burdened nodes, assuming that initial energy provisioning for all nodes are equal. Such death of some nodes due to the unbalanced energy dissipation may cause an undesirable effect on the functionality of the sensor networks, as the dead nodes will neither be able to perform the sensing nor the routing. This may even cause the network to lose its usefulness. This problem has been addressed to optimally balance the energy dissipation among all nodes in a

sensor network. To solve the problem of balancing of energy dissipation in the network, relay nodes can be placed in the transmission path of longer distances. Star, Steiner Minimum Tree (SMT-11) is the two techniques used for optimal relay node placement**.**

1.1 STAR Technique: - In this technique sensor node and sink are in line of sight so as to reduce the energy consumption as energy consumption is directly proportional to the distance. When distance increases between sensor nodes and sink, more energy will be consumed. A Star topology is the most efficient structure for minimising the distance between sensor nodes and sink. In this technique each of the sensor nodes has to send data to the sink means all the sensor nodes sends its own data directly to the sink. Relay nodes are placed in a straight line between each of the sensor node and sink.

1.2 SMT-II (Steiner Minimum Tree):- The minimum number of relay nodes needed to maintain the network connectivity. This has been modelled as the Steiner Minimum Tree. One can show a transmission structure SMT, which connect the entire sensor network using the approximate minimum number of relay node, such that every node can send their data directly, one hope or more than one hope. The general idea is to start with an initial structure generated from SMT and then gradually adding the remaining relay nodes in such a way so as to reduce the average energy consumption of the network and increase the system capacity.

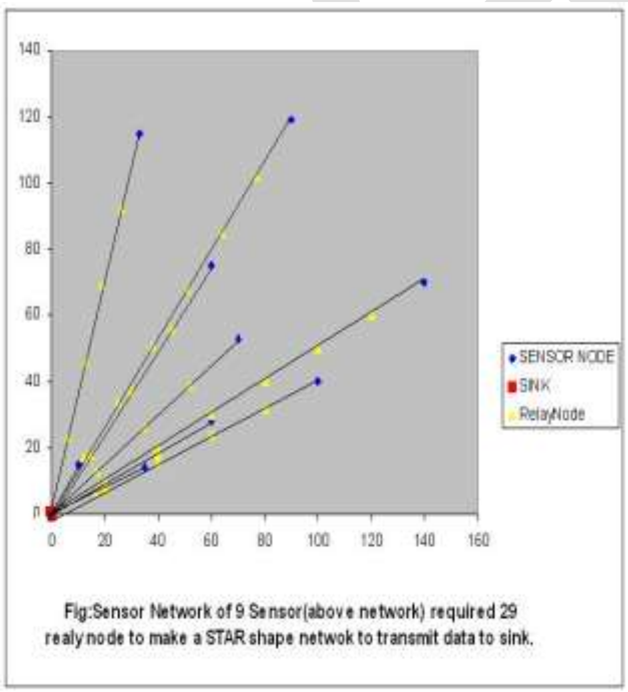

Fig:Sensor Network of 9 Sensor(above network) required 29 realy node to make a STAR shape netwok to transmit data to sink.

Figure 5: STAR TECHNIQUE

SMT will provide a transmission structure that requires the minimum number of relay nodes at the price of very high energy consumption. So to avoid this there is need for SMT-II algorithm that will provide an energy efficient relay node placement and the transmission structure with the limited number of available relay nodes. In this technique take search radius to divide the sensor and relay nodes into different distance levels depending on their distance from the sink. If after doing this placement of relay nodes still there are relay nodes available, then increment the search radius. Divide the nodes into new distance levels and repeat the procedure again. This process will stop until all the relay nodes are placed or all the sensor nodes have the same distance levels.

2.2 Hierarchical Architectures: **-** in this architecture each sensor node belongs to only one cluster and the relay node act as cluster head. Each sensor nodes sends data to the respective cluster-head node. The cluster-head nodes, on the other hand bear much more responsibilities, e.g. data gathering, data aggregation and routing. These nodes may form networks among themselves and forward the data, gathered from its own cluster as well as from other cluster heads, towards the base station, using multi-hop paths. There are many schemes for the relay node placement in hierarchical architecture. One of these is cluster string topology [ ]. In this technique n relay nodes are divided into y clusters uniformly between source and sink as shown in figure 6.

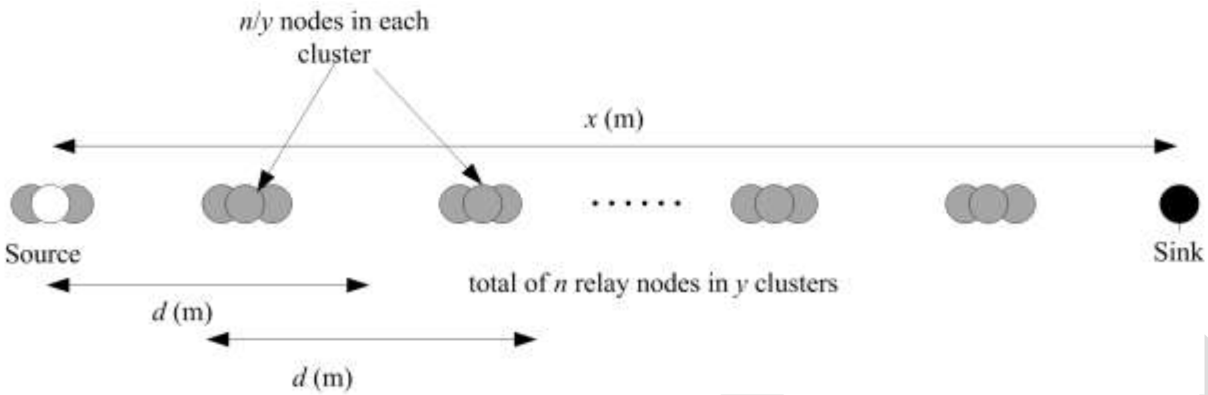

Figure 6: Cluster string topology

Assign one node in the left most clusters to be a source. To minimise the interference, any node in one cluster is only within communication range of the next immediate cluster/sink such that

$x/d-1<=y<2x/d-1$

Where x is the distance between source to sink and d is the distance between two adjacent cluster heads.

3. Single Tier Relay node placement: - in this sensor node sends the information to relay node or base station and both relay nodes and sensor nodes participate in forwarding of received packets.

4. Two Tier Relay node placement: -In this architecture relay nodes are added to overcome the problem of long distance communication between the base station and edge nodes. To specify relay node placement and mapping from edge nodes to relay nodes, one method is developed named binary integer programming (BIP). This is a three step recursive process.

1. Based upon the location of relay node, calculate power for each relay node to maximize its capability.
2. Make optimal relay routing table using BIP which provides mapping from edge nodes to the relay nodes.
3. Update each relay node position using clustering method.

Conclusion

In this paper, techniques for proper placement of relay nodes between source and destination pairs so as to decrease the energy consumption, increase link capacity and to increase the system capacity has been discussed. We have discussed various techniques for optimal placement of relay node which includes minimum energy transmission model, Star Technique, Steiner Minimum Tree (SMT-II), hierarchical architecture etc.

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