Energy Efficient Target Coverage Issues in Wireless Sensor Network

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***Abstract*—A critical aspect of applications in wireless sensor network is network lifetime. Wireless sensor network are usable as long as they can communicate sensed data to processed node. Sensing and communication are important activities and they consume energy. So power management and sensor scheduling can effectively increase the networks lifetime. There are many issues that can be considered for energy efficient target coverage. For example the coverage objective, i.e. maximize the lifetime of the network or minimize the required number of deployed sensors, the node deployment method, which may be random or deterministic, the homogeneous or heterogeneous nature of the nodes, i.e. whether all nodes have a common sensing or communication range ,the degree of centralization, i.e. .centralized vs. distributed algorithms, cover set independence, i.e. whether a node appears in exactly one of the generated sets (node-disjoint coverage algorithms) or not (non-disjoint coverage algorithms).**

In this paper we have presented an overview of WSN and some strategies of energy efficient target coverage in WSN.

***Keywords:-*Wireless sensor network, Energy efficient target coverage, Network architecture, Cover set, Coverage, Connectivity.**

I. INTRODUCTION

A wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants, at different locations. The development of wireless sensor networks was originally motivated by military applications such as battlefield surveillance. However, wireless sensor networks are now used in many civilian application areas like Home and Office application[1],healthapplication[2,3],Habitatmonitoring[4,5],Environmentforcasting[6] etc. 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:-

A. Random Deoloyment

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 [7].

B. Sense Deployment

Several sensors that perform only sensing can be deployed. The position of the sensors and communication capabilities topologies are carefully engineered.

In addition to a sensor, each node in a wireless sensor network is typically equipped with microcontroller, transceiver, sensors, memory, power unit. The sensor node senses the environment, collects the relevant data, process the information collected, store it in a buffer and forward this information to other nodes or base station in a wireless manner. An energy source (Power unit) supplies energy to the memory, sensing unit and transceiver. The processing unit is used to process incoming data and assemble them into packets to be transmitted using the wireless transceiver.

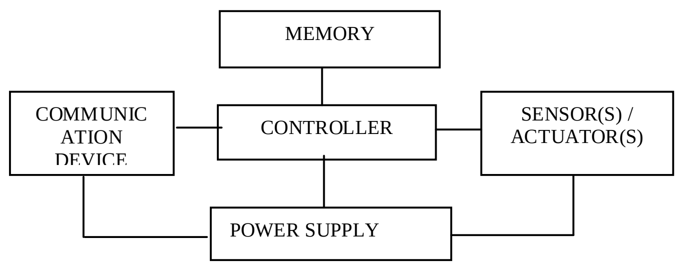


Fig.1 The components of a sensor node

There are many constraints in wireless sensor network. Among them Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, computation ,transmission range, storage. Important energy efficient target coverage issues are given below. Every target coverage issue effect more or less in some way the lifetime of WSN.

II. COVERAGE AND CONNECTIVITY PROBLEM IN WSN.

Coverage and connectivity are the basic requirement of WSN [8]. The coverage concept is a measure of the quality of service (QoS) of the sensing Function [9].Connectivity means the sensor network remain connected so that information collected by sensor nodes can be relayed back to data sink or controllers. R_c (Connectivity radius) is the radius up to which a sensor may communicate. Coverage means the area that has to be monitored by the sensor nodes. R_s (Sensing radius) are the radius up to which a sensor may cover the area. The lifetime of WSN depends upon battery consumption.

Lifetime means the amount of time for which the given sensor network remain active and provide sufficient information of the coverage area. The mainland is part of the network which contains the *sink* together with the sensor nodes those are connected to the sink, either directly or via other nodes. Sensor nodes in a mainland can send their messages to the sink, by definition. An island in the network contains one or more nodes which are not connected to the sink; hence, they can send messages to each other, but cannot send any message to the sink. A network is connected if every node in the network is part of the mainland and not connected if at least one island exists. The communication architecture of WSN is given below.

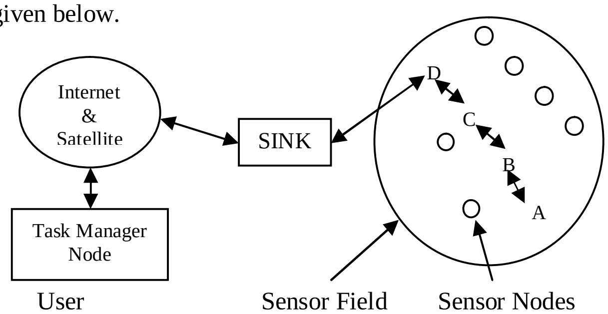


Fig.2 Sensor nodes scattered in sensor field

III. Q-COVERAGE AND P-CONNECTIVITY

Coverage and Connectivity are most fundamental requirement of a wireless sensor network. We know that every target in the network should be covered by more than one node so that it may remain connected even if one sensor fails. Higher order of communication is also required for appropriate communications. So single connectivity often is not sufficient for many sensor networks because a single failure can disconnect the network and single coverage is also not sufficient. So we have the requirement of Q-Coverage and P-connectivity.

Q-coverage: Every point in the plane is covered by at least p-different sensors [10].

P-connectivity: there are at least q disjoint paths between any two sensors [10].

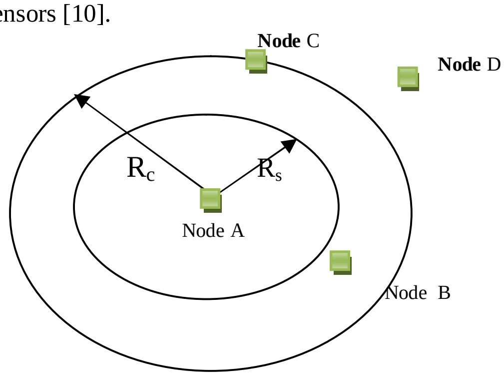


Fig.3. Coverage and Connectivity diagram

As we can see from the figure that there are four sensor nodes A, B, C, D. R_c is the connectivity radius of node A and R_s is the sensing radius of node A. Node B and node C are under the communication radius of node A. Means node B and node C can communicate with node A easily and exchange the information with each other. Node D is not under the communication radius of node A. So node D cannot communicate with node A.

IV. ENERGY EFFICIENT TARGET COVERAGE PROBLEM IN WSN

Energy efficient target coverage means all the targets should be covered with the objective of maximizing network lifetime. A sensor nodes radio can be in one of the following four states depending upon their energy consumption.

1)Transmit : When the transmitter is transmitting.

2)Receive : When the receiver is receiving.

3)Idle: When the transceiver is neither transmitting nor receiving.

4)Sleep: When radio is turned off.

Thus we can see that a node consumes highest power when it is in transmitting and receiving state. For a wireless sensor node, power saving techniques can generally be classified in the following categories.

Schedule the wireless nodes to alternate between active and sleep mode.

*1)*Power control by adjusting the transmission range of the wireless nodes.

*2)*Energy efficient routing, data gathering.

*3)*Reduce the amount to data transmitted and avoid useless activity.

V. CLUSTERING

Grouping sensor nodes into clusters is widely used in order to achieve the network scalability objective. Every cluster have a leader, often referred to as the cluster-head (CH).The clustering techniques vary depending on the node deployment and bootstrapping schemes, the network architecture, the characteristics of the CH nodes and the network operation model. A CH may also be just one of the sensors or a node that is richer in resources. The cluster membership may be fixed or variable. In addition to supporting network scalability, clustering has numerous advantages. It can localize the route set up within the cluster and thus reduce the size of the routing table stored at the individual node. Clustering can also conserve communication bandwidth since it limits the scope of inter-cluster interactions to CHs and avoids redundant exchange of messages among sensor nodes [11]. Moreover, clustering can stabilize the network topology at the level of sensors and thus cuts on topology maintenance overhead. A CH can Schedule activities in the cluster so that nodes can switch to the low-power sleep mode most of the time and reduce the rate of energy consumption. A CH can aggregate the data collected by the sensors in its cluster and thus decrease the number of relayed packets.

VI. EFFECT OF Q-COVERAGE ON NETWORK LIFETIME

We have the requirement of higher order of coverage for better sense of information about targets. But at the same time as we increase the order of coverage, lifetime of network decreases. So by taking consideration of both these issues we have to consider the value of order of coverage for better coverage.

VII. MOBILITY IN WIRELESS SENSOR NETWORK

A Mobile Wireless Sensor Network (WSN) is a collection of sensor nodes deployed in a surveillance area to extract information; where each sensor node has sensing, processing, communication, and locomotion capabilities [7]. Mobility is possibly the most important as mobility have advantages such as:

Mobility Enables connectivity of clusters when there is a hole between the mainland and the islands.

Mobility increases coverage of the cluster by relocating redundant nodes to the holes

It provides fine-tuning the sensor nodes within a cluster when better coverage and connectivity can be performed after relocation

It heals the network by connecting the islands to the mainland by the migration of sensor nodes.

VIII. CENTRALIZED VERSES DISTRIBUTED ALGORITHM

Coverage algorithms may be centralized or distributed in nature [14]. In a centralized coverage algorithm the schedule is first calculated on the base station and is then sent to the sensor nodes for execution. The advantage of this scheduling approach is that it requires little processing power from the sensor nodes, which usually have limited processing capabilities. In distributed coverage algorithms a number of sensor nodes perform the required calculations cooperatively and they then disseminate the scheduling information to the rest of the sensors. This scheme may require some processing from the sensors involved, but it scales better to accommodate larger networks. On the base station and is then sent to the sensor nodes for execution. The advantage of this scheduling approach is that it requires little processing power from the sensor nodes, which usually have limited processing capabilities. In the case of non-disjoint algorithms, nodes may participate in more than one cover sets. In some cases, this may prolong the lifetime of the network in comparison to the disjoint cover set algorithms.

IX. CATEGORIES OF COVERAGE ALGORITHMS

WSN coverage problems are divided into point coverage and area coverage scenarios. The objective in point coverage is to cover a set of points with a subset of the randomly deployed sensor nodes. Every point is monitored by at least one sensor. In the area coverage problem, the monitored space is divided into smaller areas called fields [15]. Each field is uniquely identified by a set of covering sensors that completely cover (monitor) this field. The goal in area coverage is to produce sets of sensors that completely cover all fields and consequently the entire area. The area coverage problem is closely linked to the point coverage problem [16], since the fields are equivalent to the points. As far as the coverage algorithms are concerned, the area coverage problem provides an algorithm with much more targets rather than sensors, while the opposite is true for the point coverage case.

X. NETWORK ARCHITECTURE

WSN network architecture is broadly classified into two:-

Layered architecture:-In layered architecture each node communicates with fusion centre by multipath communication.

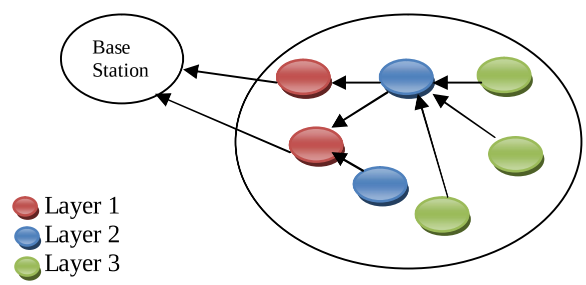
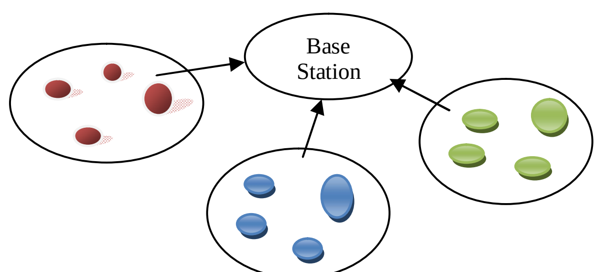


Fig.4 Layered architecture

Clustered architecture:-In clustered architecture there are many clusters and each cluster is having a cluster head. A larger node denotes cluster nodes.



Larger nodes denotes the cluster head

Fig.5 Layered architecture

XI. CONCLUSION

Wireless sensor network are battery powered .So prolonging the lifetime of wireless sensor network through a power aware node organization is highly desirable. There are many techniques for power saving. One method is reducing the density of active nodes and thus reducing contents at the

MAC layer. Battery lifetime is limited and it is not feasible to replace battery in many applications. So power consumption is main requirement. An efficient method for energy saving is to schedule the sensor node activity such that every sensor node alternates between sleep and active state. We schedule the set cover in such a way that at a time only one set cover is responsible for sensing the target, while other set covers are in sleep mode. Several research work has been carried out in the energy efficient target coverage problem. In future scope of our work we will design an algorithm for energy efficient target coverage in wireless sensor network, to achieve improved lifetime and minimum energy consumption.

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