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A Survey on Approaches for Extending Network Lifetime Topology

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Abstract: ***In WSN applications sensor nodes having limited batteries are deployed. Hence sensors lifetime is strongly restricted by the battery lifetime. So managing energy consumption is big challenge to WSN. In this paper I have consider various approaches for extending network Lifetime. These approaches are Duty Cycling, Topology Control, Clustering, Controlled Mobility and Mobile Node Rotation. Mobile node rotation approach is best overall approaches for extending network lifetime.***

Keywords: WSN; Mobile Node Rotation; Network Lifetime; Clustering; Topology Control

I. INTRODUCTION

Wireless sensor network (WSN) refers to a group of spatially dispersed and dedicated sensors for monitoring and recording the physical conditions of the environment. A sink node(Gateway) collects data from sensors through single or multi-hop communication and processes it by ensuring that end-user can access data.

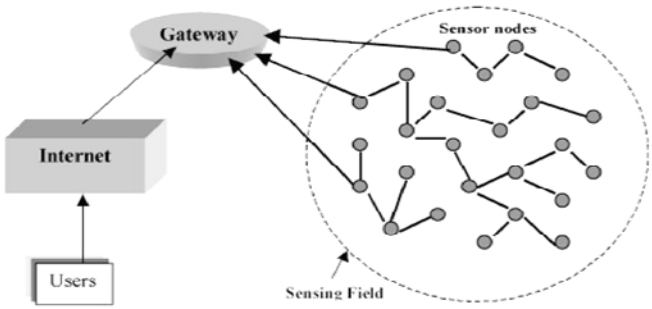

Fig. 1 Wireless Sensor Network

Fig. 1 shows Architecture of WSN. Sensors collect data through single or multi-hop and transfer it to gateway, called as sink. Through internet user can access this data. Sensors are energy constrained. Sensors lifetime is strongly restricted by battery lifetime.

In most of WSN applications sensors would remain without recharge or replace their batteries. So How to extend network lifetime is big problem for WSN. We know Network lifetime is the time until the first sensor node or group of sensor nodes in the network runs out of energy. So network lifetime is depend on sensor lifetime.

Therefore, we consider WSN applications with three requirements:

1. We should consider monitoring coverage area for deployment of sensor nodes. The location of nodes and communication topology are not mutable.

2. Nodes experience differential power consumption. Hotspot problem i.e. node closer to the sink consumes more energy.

3. Many applications require few nodes having more energy consumption and should perform complex motion planning.

II. APPROACHES

Consider various approaches that are extends Network lifetime.

A. Duty Cycling

A **duty cycle** is the percentage of one period in which a signal is active. A period is the time it takes for a signal to complete an on-and-off cycle. As a formula, a duty cycle may be expressed as:

$$D = \frac{T}{P} \times 100\%$$

where ***D*** is the duty cycle, ***T*** is the time for which the signal is active, and ***P*** is the total period of the signal. Thus, a 60% duty cycle means the signal is on 60% of the time but off 40% of the time.

In this approach, we turn off radio when there is no need of communication for energy saving and wakeup the radio by providing some mechanism when communication is necessary. For this we can use number of wakeup schemes.

Periodic listen and sleep can be achieved by using medium access control (MAC) technique. In this technique ,the node turns off its radio during sleep and sets a timer to awake itself later. By applying different application scenarios, duration of time for listening and sleeping can be selected.

B. Topology Control

Network topology determines transmission distances between sensors. Different applications have different topology requirements. The sensor nodes communicating with each other use various types of topologies like mesh, tree, chain etc. The main aim of topology control is to save energy, reduce interference between nodes and extend lifetime of the network. It minimizes average delay.

In this approach we reduce initial topology of network i.e. model network as a (minimum spanning tree)graph. We maintain the communication links between network nodes. Topology control is an iterative process, having, initial, construction and maintenance phase.

There are many ways to perform topology construction:

- Change the transmission range of the nodes
- Turn off the nodes from the network
- Create a communication backbone
- Clustering
- Adding new nodes to the network to preserve connectivity

Topology control can be classified based on Direction, Neighbour and Location. It uses various algorithms for extending network's lifetime like CTCA,A3,WDTC.

C. Clustering

It is an effective topology control approach. In cluster based WSN, the entire network is divided into clusters, with each cluster having a Cluster Head with extra privileges and cluster members. Cluster head aggregates data from cluster members and sends it to the sink. We can form cluster dynamically and periodically.

This technique proposed various protocols for cluster head selection, cluster formation and data gathering applications. We can use the cluster head rotation protocol for balancing energy consumption among the nodes within the cluster. So the cluster formation takes place only once in network lifetime to avoid re-clustering. A distributed low complexity clustering algorithm is more suitable for WSN. By this approach we reduce energy consumption. Large number of clustering algorithms are present but energy consumption during cluster formation and maintenance is still high.

We perform role rotation i.e. swap position of cluster head and cluster member. Cluster based approach introduces more changes to network as each rotation requires new route computation.

D. Controlled Mobility(Robotic Mobility)

It is the ability of a network to move without human assistance. This approach satisfies second requirement of WSN applications. This approach reduces the data delivery latency.

It includes following approaches:

1)Mobile Base Station(Sink):In this approach the sink keeps on moving around/inside the sensor field for efficient data collection. Mobile sink increases coverage area, data fidelity, reliability, energy efficiency and throughput.

For large scale WSNs, multiple mobile sinks are necessary. For this we can use graph-partitioning algorithm. To control the movement of mobile sink we require extra sensors for measuring speed of node movement and passed distance.

2)Data Mules: Effective for delay tolerant networks. Mules are mobile nodes which collect data from static sensor nodes, buffer it and transfer to the base station. MULEs are referred to as Mobile Ubiquitous LAN Extensions. Mobile base station and data mules incur high latency to network. Failure of any particular mule does not disconnect sensor from network, because no sensor depends on any individual mule.

3)Mobile Relays: Wireless sensor networks consist of a few mobile nodes which have more processing power, memory and energy than other sensors are called Mobile relays. They move to different locations and then remain stationary to forward data along the paths from sources to the sink. They reduce communication delays as compared to mobile base stations or data mules. They also reduce energy consumption up to 45%.They can move where the node density is less. One mobile relay could increase the lifetime of the sensor networks by a factor of four.

E. Mobile Node Rotation(Mobile Sensors Swapping)

This is new controlled mobility approach. Node consumes more energy if it has lots of descendents or is the farthest from its parents. We rotate mobile sensors to balance energy consumption. So a node at high consumption location swaps its position with a node at low consumption location. Here multiple mobile sensors swap positions once or multiple times. New round starts when first node dies.

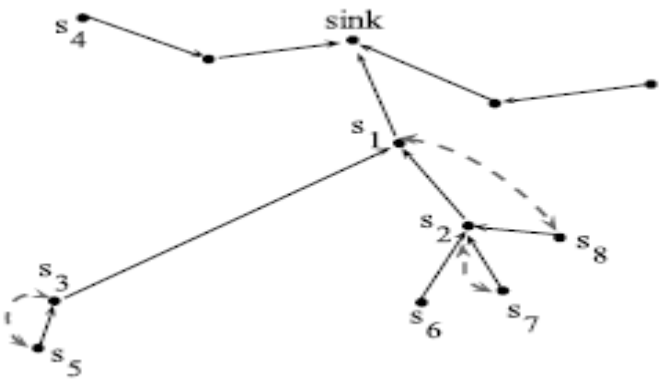

Fig. 2 Mobile Node Rotation

From Fig. 2 The nodes at bottleneck locations s1, s2 and s3 can rotate with nodes at locations s8, s7 and s5,respectively after a period of time to balance the energy consumption between high consumption locations and low consumption locations.

This approach fulfils all the above mentioned three requirements of WSN applications. Here, we perform rotations when nodes are in sleep mode. By rotating node once, network lifetime doubles and when we rotate node multiple times it exceeds eight times. To achieve limited mobility along fixed cables we can model NIMS sensors.

This approach is best over all the other approaches in the case of extending network lifetime. By this approach there is no change in the topology except during node rotation transient period and there is no need of powerful node for complex motion planning. Number of node rotations are smaller than number of cluster rotations as in cluster based approach. But it may take more time to perform node rotations. To remove this drawback we can apply this approach in conjunction with duty cycling.

Advantages:

1) Does not require powerful nodes capable of performing complex motion planning calculations.
2) Number of node rotations is significantly smaller than the number of cluster rotations.
3) Topology does not change.
4) Uses Low duty cycle to minimize the interruptions to the network.
5) Energy consumption due to communication can be computed for every position.
6) Energy consumption due to mobility can be computed.
7) Speed of the node does not have a significant effect on the lifetime improvement ratio.

Disadvantages:

1) It may take longer to perform a node rotation than to compute a cluster rotation.
2) Possibility of buffer overflow can be removed using congestion control techniques.

III. CONCLUSION

To save the energy of the nodes is main purpose in the designing of wireless sensor networks. Various approaches to extend network lifetime like Duty cycling, Topology control, Clustering, Controlled mobility and Mobile node rotation in WSN have been studied. From survey of various approaches used, it is clear that all the approaches have contributed towards network lifetime maximization. To achieve maximum network lifetime we can combine one or more approaches i.e.we can combine duty cycling and mobile node rotation approach. Extension to the work can be done by using mobile cluster head, mobile node rotation with aggregation.

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