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Review on Multiple Sink Placement Strategies in Wireless Sensor Networks

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Abstract: *Wireless Sensor Networks (WSN) consists of numerous tiny sensors deployed at high density regions requiring surveillance and monitoring. The sensors are deployed at a cost much lower than the traditional wired sensor system. A large number of sensors deployed will enable for accurate measurements. In this paper, the sink placement problem has been explained i.e. where the best places for the sink nodes are calculated depending on Candidate Location with Minimum Hop (CLMH) and Geographical Sink Placement (GSP) strategies. Both strategies are compared so as to know which strategy is better. From this it can be concluded that finalising Sink position, will impact energy efficiency and network lifetime.*

INTRODUCTION

A wireless sensor network (WSN) sometimes called a wireless sensor and it consists of spatially distributed autonomous sensors[9] to monitor physical or environmental conditions such as temperature, sound, pressure, etc. and to cooperatively pass their sensed data through the network to a main location.Wireless sensor networks depends on a simple equation: Sensing + CPU + Radio = Thousands of possible applications. A WSN is a type of wireless network which is small and infrastructure less. Basically WSN consist a number of sensor node, called tiny device [4]. WSNs are also known as self-organizing networks [3] in which sensor nodes with limited resource are scattered in an area of interest of users.WSN is built of "nodes" – from a few to several hundreds or even thousands, where each node is connected to one or sometimes several sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna for generating radio waves, a microcontroller which controls monitoring, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting, different types of wireless communicating devices and they work simultaneously. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth [4].

WSN has two types: structured and unstructured. Unstructured WSN is a collection of sensor nodes and these are deployed in adhoc manner into a region. In Structured WSN, all sensor nodes are deployed in pre-designed manner. The benefit of structured WSN is that some nodes can be deployed with lower network maintenance and management cost. Fewer nodes can be deployed as nodes are placed at specific locations to provide coverage while ad hoc deployment can have uncovered regions. Wireless sensor network aim is to provide efficient connection among the physical environmental condition and internet worlds.

APPLICATIONS OF WSNS

Surveillance operations, patient monitoring and disease analysis, equipment monitoring and fault prediction, pollution monitoring and source detection, sea searching and tide monitoring, Disaster Management, Intelligent

Alarms, Indoor Climate Control, Precision Agriculture, Home automation and Smart environment, Vehicle tracking and detection, Detecting accidents and monitoring traffic[4].The main goal of WSNs is to monitor their surroundings for local data and to forward the gathered data toward a sink node through multi-hop communication so efficient data gathering is one of the most important issues for WSNs as well as WSNs based application.

FEATURES OF WSNs

Scalability to large scale of deployment, unattended operation, Ability to cope up with node failures, Limited power storage, Ability to withstand harsh environmental conditions, Mobility of nodes, Ease of use, Network topology is dynamic [9]

CHALLANGES OF WIRELESS SENSOR NETWORKS

Most envisioned sensor network applications encounter many challenges like Ad hoc deployment, Dynamic environmental conditions, unattended operation, Physical Resource Constraints, Fault-Tolerance, Scalability, Quality of Service, Security [4].

ADVANTAGES OF WIRELESS SENSOR NETWORKS

Implementation cost is cheaper than wired network, Ideal for non-reachable places; it can accommodate new devices at any time, Avoids a lot of wiring, Flexible to go through physical partitions, it can be accessed through a centralized monitor [9].

DEPLOYMENT

During the design phase of WSNs, the designer knows only the number of sensor nodes and sinks to be deployed. Both sinks deployment and nodes deployment affect the performance of the WSN. The nodes deployment can be either planned or random. In a planned node deployment, sensor nodes are manually placed so that their locations are known, whereas for a random deployment, sensor nodes are positioned at locations which are not known with certainty. Planned node deployments are usually only suitable for small-scale WSNs for cost issues. Due to interest in large-scale WSNs, in this paper focus is on random node deployments. To illustrate where a random node deployment would be inevitable, it is assumed that sensor nodes are distributed by an airplane, for example, in an environmental monitoring application [10].

SINK PLACEMENT

Wireless sensor networks consist of a distributed set of sensor nodes that cooperatively monitor physical or environmental conditions, and send their data to a “sink” node over multihop wireless links. Since the main constraint in wireless sensor networks is limited energy supply at the sensor nodes, it is important to deploy the sink at a position with respect to the area of interest, a specific area that is of more interest to the end-user, such that total energy consumption is minimized. In this paper an approach is proposed to find the optimal position [8] for the sink with the goal of reducing the total energy consumption which has a direct effect on the network’s lifetime.

RELATED WORK

W.Y. Poe et al. [3]:- In this paper author had described the problem of inadequate energy supplies of wireless sensor networks (WSNs).To optimize energy consumption network designer focuses on energy issues with respect to system performance. So a local search technique was designed for sink placement in WSNs which tries to minimize the maximum worst-case delay and extend the lifetime of a WSN. For this a Self-Organised Sink Placement (SOSP) strategy was proposed.

Pardesi et al. [14]:- This paper proposed a mechanism to improve and optimize the existing Multiple Sink placement strategy i.e. Geographic Sink Placement (GSP) strategy using network division in concentric circular rings around the central circular region where sinks placement was in uniform and random manner. It was observed that the

proposed strategies provide better performances with respect to energy usage and lifetime.

D Das et al. [10]:- This paper introduced sink placement strategy Candidate Location with Minimum Hop (CLMH) and was compared with Geographical Sink Placement (GSP) strategy. Both strategies were implemented and evaluated in a simulation environment. It was observed that the proposed strategy exhibit better performances with respect to energy usage and lifetime in comparison with GSP.

J.Flathagen et al. [5]:- In this paper author concentrates on multiple sink deployment problems. Different methods to estimate the optimal placement of a given number of sinks are discussed to improve both the lifetime and the durability of WSNs.

Blagojevic et al. [7]:- In this paper the problem of sink placement for Gossip-based Wireless Sensor Networks (GWSN) was addressed. Sink placement plays an important role in planning and deployment of sensor networks. It was an efficient means to improve performance and achieve design objectives.

E.Ilker Oyman et al. [1]:- The battery resource of the sensor nodes should be managed efficiently, so as to prolong the network lifetime in WSNs. This paper focused on multiple sink location problems in large scale WSNs. Different problems based on design criteria were presented. In this paper solution for Best Sink Locations (BSL) problem and Minimize the Number of Sinks for a Predefined Minimum Operation Period (MSPOP) problem was implemented.

PROBLEM FORMULATION

In large scale, wireless sensor networks (single sink placement strategy), nodes closer to the sink becomes bottleneck due to heavy traffic load for packet transmission. As these nodes not only collect data within their sensing range but also forward data to nodes which are far away from the sink (multi-hop communication) which leads to unbalanced power consumption.
The basic idea is to use the concept of multiple sink placements, in order to reduce multi-hop communication, which results in improvement of network lifetime and reduce energy consumption.

METHODOLOGY

Tool used for this is MATLAB

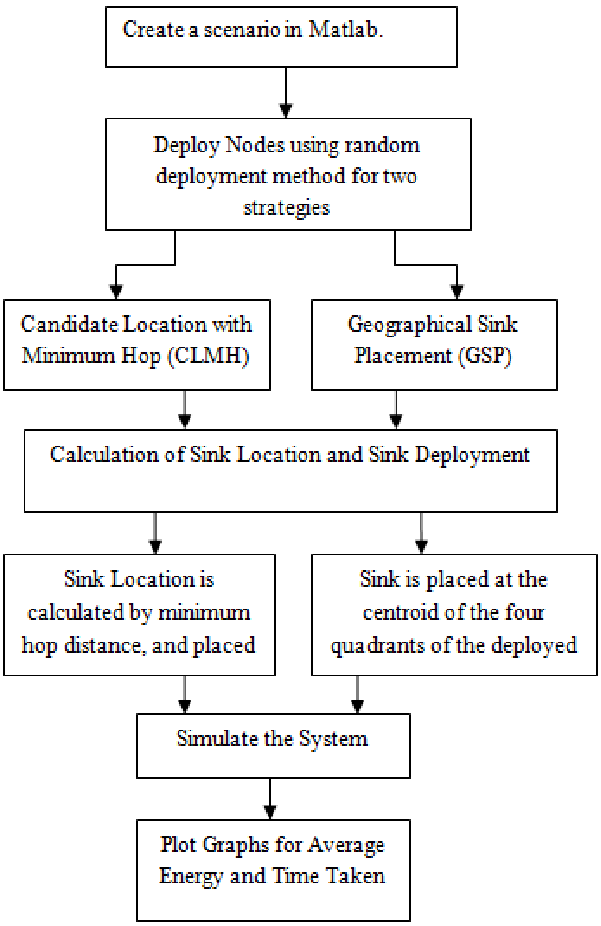


Figure 1: Flowchart

CLMH ALGORITHM

Input: Centroid of grid cell.

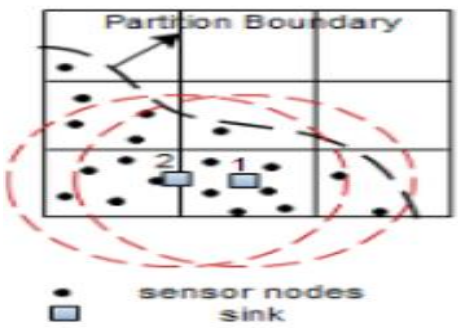
Output: Position of Sink Node.

Step A: For Finding Candidate Locations

1. For each partition, it is identified that which grid cell contains nodes.
2. Centroid of that particular grid cell is calculated → Initial Sink Position.
3. Find Denser Area:-
   3.1 Count and mark one-hop neighbour nodes of initial Sink Position.
   3.2 Calculate new centroid of these sensor nodes where the node count is higher.
 NewCentroid→NEXT-LOC.
 Where NEXT-LOC is considered as next location for Sink
4. Then number of 1-hop neighbour nodes of Next location is counted. If these are higher than that of initial Sink, then Sink is relocated to the NEXT-LOC position.
5. This process continues until there is no increase in neighbour nodes.
6.If number of neighbour nodes of NEXT-LOC is same or less than the number of neighbour nodes of Sink, then Sink remains at same position, otherwise Sink is placed at the position where neighbour nodes of NEXT-LOC is found to be higher.

Step B: For Deciding Final position:

1. Let C_1 to Cp be the candidate locations in a partition.
2. Let F_i be the farthest node from i^{th} candidate location having Hi hop distance where i∈1 to p.
3. Find such candidate location C_i which has minimum hop count Hi from the farthest node (F_i) from C_i. Thus the final location S is given by [5]:
S $\{C_j$ distance $(C_j, F_j) = \min (H_j)\ \forall\ C_j, 1 \leq j \leq p\}$



(a)

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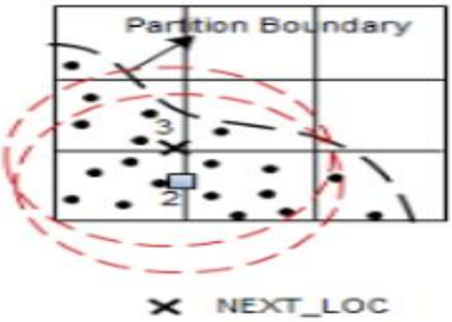

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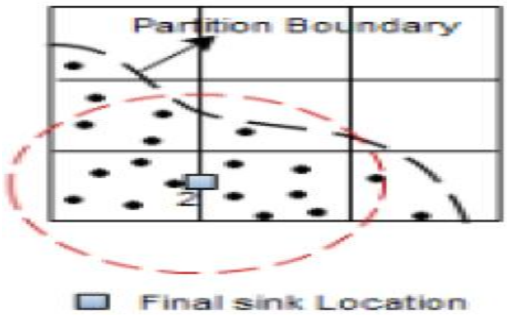

(c)

Figure 2: Finding Candidate Locations [5]

GSP ALGORITHM

Input: Radius (R), angle (α).

Output: Center of gravity of a sector of circle (CGSC).

Steps:
1. Sinks are placed at the CGSC having angle α lies on middle radial line α/2 of sector.
2. CGSC is calculated by equation 1 which calculates the ratio where to place Sink at middle radial line of a sector.

$$F(\alpha) = (4/3 \sin(\alpha/2))/\alpha \qquad \textbf{Eqn…1}$$

Where α is in radians, $0 \leq \alpha \leq \pi/2$, R=radius.
F (α) = the ratio where to place the Sink.
3. Center of gravity is calculated by equation 2 i.e. by multiplying with radius R.

$$CGSC = F(\alpha)*R. \qquad \textbf{Eqn…2}$$

4. Sink location is calculated.
5. Repeat the steps until sinks are placed [5].

Work Done

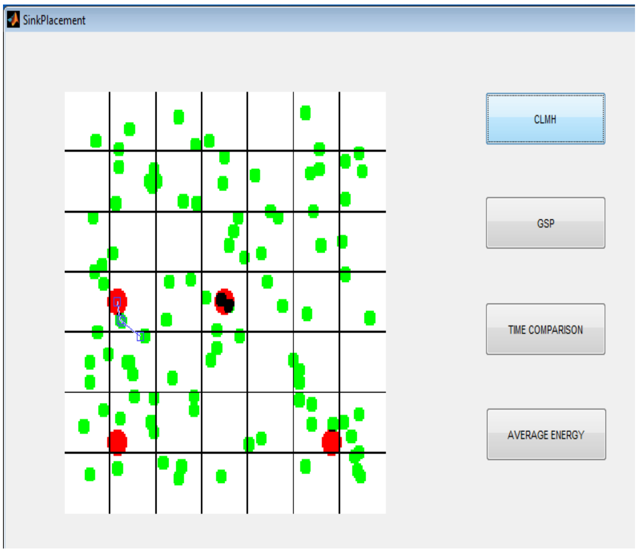

Figure 3: CLMH (Candidate Location with Minimum Hop)

In figure 100 nodes are randomly deployed (displayed with green color). Afterwards the grid structure is created. Sinks (red ones) are deployed on the basis of CLMH algorithm.

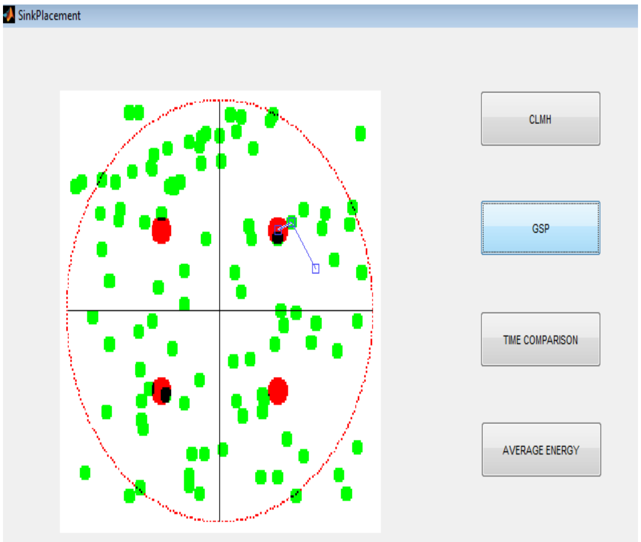

Figure 4: GSP (Geographical Sink Placement)

In this figure, firstly the nodes (green) are deployed in the deployment area. Then the deployment area is divided in quadrants and circular region has been drawn. Then the Sinks (red) are deployed based on GSP algorithm.

RESULTS AND DISCUSSIONS

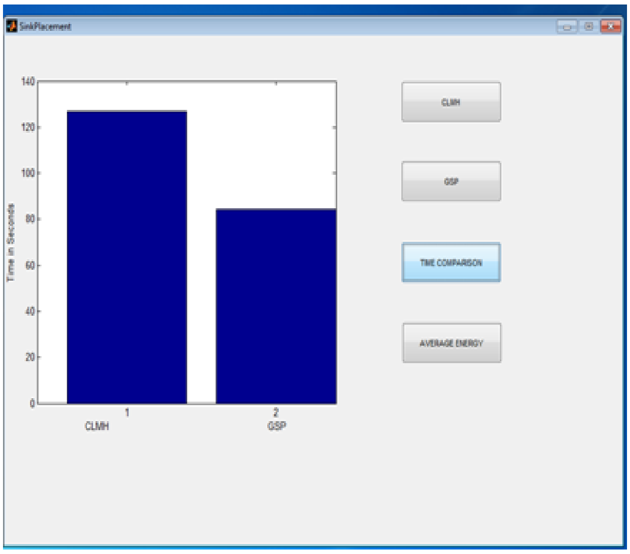

Figure 5: GRAPH TIME COMPARISION

This graph shows the comparison between the two strategies i.e. CLMH and GSP with respect to time taken by nodes to complete 100 rounds for communicating with Sink. Time Taken by CLMH is more than in GSP as it does not waste time in deciding the sink position i.e. GSP is better than CLMH.

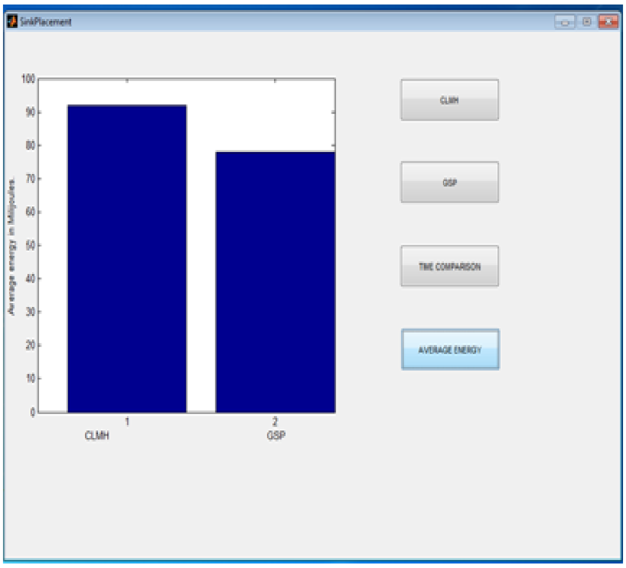

Figure 6: GRAPH AVERAGE ENERGY

This Graph shows the comparison between the two strategies i.e. CLMH and GSP on the basis of Energy left of nodes. In CLMH energy left of nodes is more than in GSP as sinks are placed in denser region i.e. CLMH is better than GSP.

CONCLUSION AND FUTURE SCOPE

In large scale single sink wireless sensor networks, nodes closer to the sink becomes bottleneck due to heavy traffic load for packet transmission, because these nodes not only collect data within their sensing range but also forward data to nodes which are far away from the Sink which leads to unbalanced power consumption.

So as to improve the Network Lifetime and Power Consumption multiple sink placement strategies were implemented.

If Energy Consumption is considered as an evaluating parameter then CLMH is better than GSP, as it deploys sink in denser region w.r.t at centroid of the quadrant in GSP.

If Time Consumption to complete mentioned rounds, GSP is better than CLMH, as it does not waste time in selecting sink position w.r.t GSP..

In this analysis, energy and time has been observed. Further this research can be extended in a way that the implementation of an advanced version of these strategies and other strategies can be applied for improved energy efficient sink placement strategy.

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