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Computational Intelligence Routing For Lifetime Maximization in Heterogeneous Wireless Sensor Networks

G. Umarani Srikanth, M. Akilandeshwari

Abstract: ***In wireless sensor networks, sensor nodes are typically power-constrained with limited lifetime, and thus it is necessary to know how long the network sustains its networking operations. Heterogeneous WSNs consists of different sensor devices with different capabilities. One of major issue in WSNs is finding the coverage distance and connectivity between sensors and sink. To increase the network lifetime, this paper proposed Swarm Intelligence, routing technique called Ant Colony Optimization (ACO). Ant colony optimization algorithm provides a natural and intrinsic way of exploration of search space of coverage area. Ants communicate with their nest-mates using chemical scents known as pheromones, Based on Pheromone trail between sensor devices the shortest path is found. By finding the coverage distance and sensing range, the network lifetime maximized and reduces the energy usage. Extensive Java Agent Framework (JADE) multi agent simulator result clearly provides more approximate, effective and efficient way for maximizing the lifetime of heterogeneous WSNs.***

Index Terms: wireless sensor networks (WSNs), Ant colony optimization (ACO), connectivity, coverage, network lifetime, JADE.

I. INTRODUCTION

Wireless sensor networks (WSNs) consists a large number of sensor nodes in a target area for performing surveillance tasks such as environmental monitoring, military surveillance, animal tracking, industry, agriculture and home applications [1][2]. Each sensor nodes collects data by sensing its surrounding region and transfers the data to a sink (also called a base station). In the WSNs, a lot of sensor nodes operate on limited batteries, making energy resources the major bottleneck. Therefore, an economical and frugal management for improving the lifetime of wireless sensor is important. WSNs are much more demanding on energy conservation than the other kinds of networks. How to maximize the network's lifetime is a critical research topic in WSNs. The goal of coverage distance in WSNs is to have each location in the physical space of interest within the sensing range of at least one sensor. To maximize network coverage and to provide a reliable data transfer, energy-efficient monitoring depends on selecting minimum number of sensors in active mode to cover all the areas. By using swarm-based algorithms to address both network routing, and lifetime maximization. The existing methods focus on the issues of device placement[7], data processing ,routing[8][9], topology management, and device control Device placement is a fundamental factor in determining the coverage, connectivity, cost. Another problem is sleep/active mode operation not performed properly because of coverage problems. In routing as router table increase finding coverage between the sensors are difficult. Therefore, the lifetime of a WSN can be prolonged by planning the active intervals of devices. At every point during the network lifetime, the active devices must form a connected cover to fulfill sensing coverage and network connectivity. But this also led to failure result.

In existing system, it is very difficult to use different sensors with different functionality and capabilities .All sensors sent monitored information to single sink as shown in fig 1, Due to this there may overlapping, collision may occur in networks . It's also difficult to find the maximize number of connected coverage and sensing range. Greedy algorithms [8] are used to represent connectivity only in Homogenous Wireless Sensor Network, and also finding optimal path between sensors and sink is difficult when the network size increases.

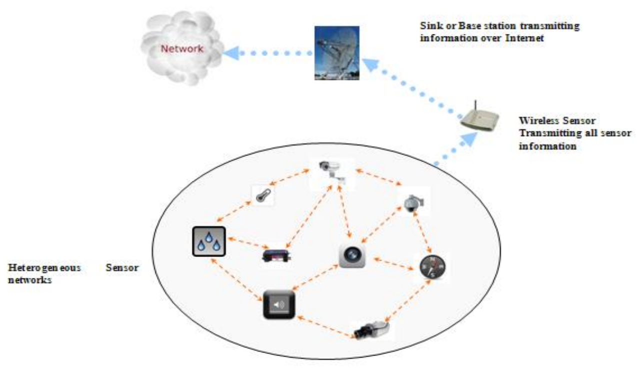

Fig 1: System Architecture of existing WSNs

II. PROPOSED SYSTEM

In this we paper proposed ACO-MNCC based approach for maximizing the lifetime of heterogeneous WSNs by finding the maximum number of connected covers. Heterogeneous WSNs means sensor with different capability, size like (audio, video, multimedia sensors).

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Ant Colony Optimization (ACO) technique is an optimization technique to solve optimization problem .It has been developed for combinatorial optimization problems. ACO are multi-agent system in which the behavior of each single agent, called ant, is inspired by the behavior of real ants In This paper we also presents a new communication protocol for WSN called energy efficient ant-based routing algorithm (EEABR), which is based on the Ant Colony Optimization (ACO) Here we also activated the sensor active/sleep mode increase the lifetime efficiently.

III. PRELIMINARY AND RELATED WORK

In this section, the problems of finding the maximum number of disjoint connected coverage between sensors are defined. Next the coverage, collection, routing problem are examined.

A. Problem definition

Let as consider Randomly deploy a set of sensors with SE1, SE2.. And sink SI1, SI2....And target area of 300x750sq.feets according to our simulation as shown in fig 2.

A. The coverage constraint represents the coverage [3] [4] according to sensor placed in target area. Here various types of coverage that has to be examined.

- Area coverage: objective is to cover an area.
- Point (target) coverage: objective is to cover a set of points (targets).
- Best case coverage: for any point on the path, the distance to the closest sensor is minimized.
- Worse case coverage: similar but the distance to the closest sensor is maximized.

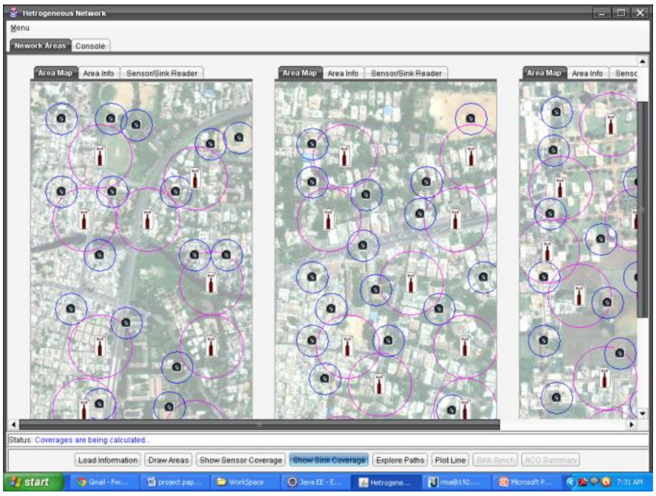

Fig 2: Illustration of coverage of sensor and sink. Each sensor s is marked as a dot and sink in red color .Each circle of blue circle represents the Sensing area of the corresponding sensor and pink circle represents the sensing range of sink

B. The ***collection constraint***, the sinks collects all the monitored results obtained by the sensors and transmits it to destination (means user).

C. The ***routing constraint***, the sinks form a connected network for transmitting the collected monitoring results to the destination.

B. Proposed System Architecture

By using proposed approach will increase Robustness, Reliability, Routing is easy, Energy compaction, energy efficiency, Easy to in finding optimal path, Load balancing .By using this methods for prolonging the lifetime of WSNs will overcomes issues of Topology Management, Device Control, Greedy Algorithm, Device Placement, Data Processing Routing in existing work.

The sensors monitor the target and transmit the monitoring results to the sinks which are nearer to it, based on ACO-MNCC. Here we used more sinks to increase the sensor lifetime, as the sensor chooses the shortest path nearest to it as shown in Fig 4.The time of sending monitoring results can be reduced. In existing only single sink used, which lead to congestion between sensors, due to this the network lifetime decrease. By using more then one sink will increase the lifetime of WSNs and finding nearer optimal path when transmitting the data from sensor to sink will also increase the lifetime of WSNs, since if we use more then one sink, sensor doesn’t know to transmit to which sink. So this can be achieved by ACO algorithm.

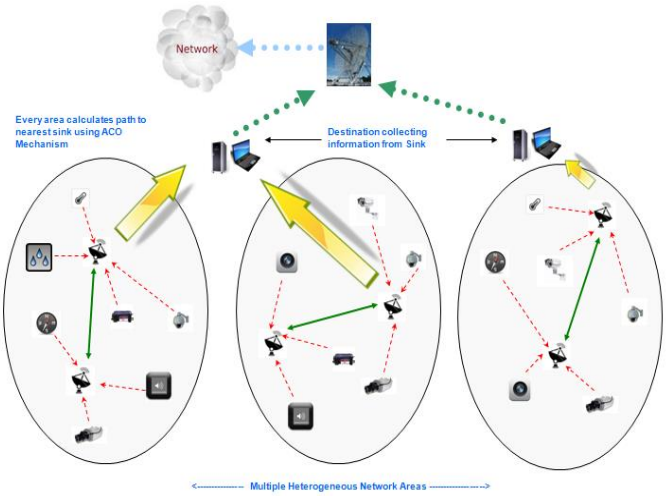

Fig 4: Heterogeneous Wireless sensor Networks – Proposed System Architecture

IV. ANT COLONY OPTIMIZATION-BASED APPROACH IN WIRELESS SENSOR NETWORKS

A. General Concept of ACO

Real ants foraging for food lay down quantities of pheromone (chemical cues) marking the path that they follow [12]. An isolated ant moves essentially guided by a heuristic function and an ant encountering a previously laid pheromone will detect and decide to follow it with high probability thus taking more informed actions based on the experience of previous Artificial 'ants' - simulation agents - locate optimal solutions by moving through a parameter space representing all possible solutions.

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Real ants lay down pheromones directing each other to resources while exploring their environment. The simulated 'ants' similarly record their positions and the quality of their solutions, so that in later simulation iterations more ants locate better solutions.

V. HOW ACO APPLIED IN WSNs IN LIFETIME MAXIMIZATION

- The pheromone concentration on trail B will increase at a higher rate than on A, and soon the ants on route A will choose to follow route B
- Since most ants will no longer travel on route A, and since the pheromone is volatile, trail A will start evaporating
- Since the route B is shorter, the ants on this path will complete the travel more times and thereby lay more pheromone over it.

- The initial target area of 300*750 taken and the sensor coverage range is 50meter and sink coverage is 100meter taken.
- Ants (blind) navigate from nest to food source ie(from sensor to sink)
- Shortest path is discovered via pheromone trails
  - ➢ each ant moves at random(in target area)
  - ➢ pheromone is deposited between sensor and sink(in target area)
  - ➢ more pheromone on path increases probability of path being followed

- According to ACO technique first the sensor and sink coverage calculated and
- First trial ant move in all path were and sensor placed, in first trial transmit the data to all path as shown in fig 5.

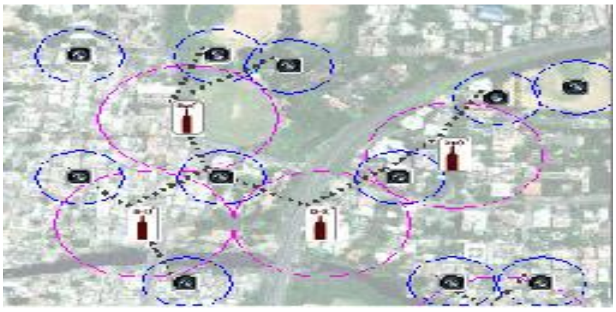

Fig 5: ACO calculation in all paths

- Second trial finds shorted distance according to algorithm and remaining sensor send the monitoring result to sink as shown in fig 6.

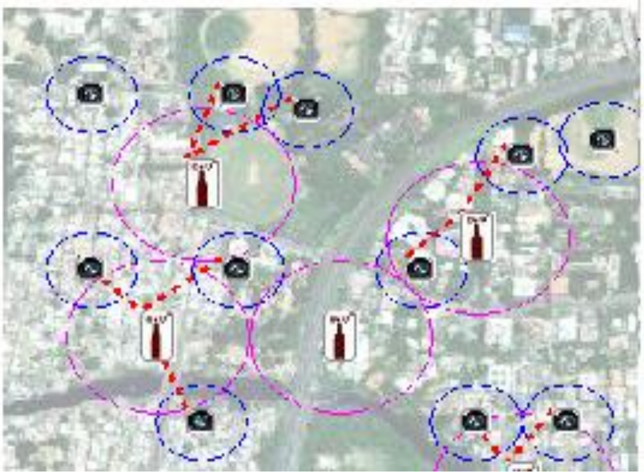

Fig 6: Finding optimal path according to ACO concept

A. Pseudocode for the ant colony optimization algorithm in WSNs

[1] Initialize pheromone Trail in target area
[2]Load the configuration (like sensor reader which contains the information about temperature, pressure information's)
[3] Add the target area
[4]Do While
[5] Calculate the coverage distance between sensors, sink then
[6] Find the distance then
[7] Add all datas to area starting from sensor to sink
[8] While
[9]Calculate all paths according to aco algorithm then find optimized path
[10]Update in aco table by distance, coverage, sensors details
[11] Do until (Each Ant Completes a round) – round Loop **Pheromone Management**
[12] Local Trail Update (all path calculation between sensor and sink) End Do End while Analyze round
[13] Global Trail Update (shortest distance calculation updated) End Do
[14] Finally shortest distance between sink and destination are calculated.
[15] Repeat the same.

VI. PERFORMANCE EVALUATION

Various performance metrics are used for comparing different routing strategies in WSNs. We have used the following:

- Average Energy
- Energy consumption
- Network lifetime
- Load balancing

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VII. EXPERIMENTS AND SIMULATION DISCUSSIONS

This section of the paper discusses the simulation of the proposed routing protocol and evaluates its performance. To evaluate the implementation of the proposed ACO routing, simulation was carried out in Java Agent Development Framework (JADE-1.6), multiagent simulator Developed by JDK1.6. This software provides a high fidelity simulation for wireless communication and sensors with detailed communication between sensors and sinks. This demonstrates the increased WSNs lifetime.

JADE (Java Agent Development Framework) is a software framework fully implemented in Java language. It simplifies the implementation of multi-agent systems through a middle-ware that claims to comply with the FIPA specifications and through a set of tools that supports the debugging and deployment phase. The agent platform can be distributed across machines (which not even need to share the same OS) and the configuration can be controlled via a remote GUI. The configuration can be even changed at run-time by creating new agents and moving agents from one machine to another one, as and when required. The only system requirement is the Java Run Time version.

The communication architecture offers flexible and efficient messaging, where JADE creates and manages a queue of incoming ACL messages, private to each agent. Agents can access their queue via a combination of several modes: blocking, polling, timeout and pattern matching based. The full FIPA communication model has been implemented and its components have been clearly specified and fully integrated: interaction protocols, envelope, ACL, content languages, encoding schemes, ontology's and, finally, transport protocols.

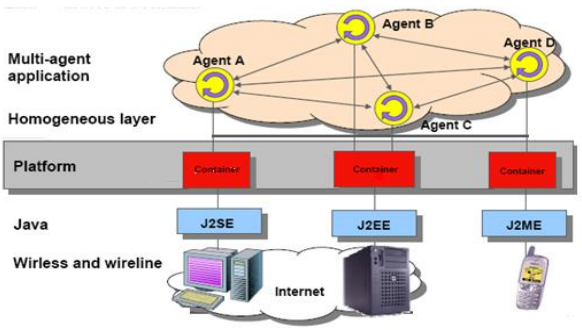

Fig 7: Architecture of Jade

In this project we used java swings to represent graphical user interface(GUI) .GUI is used for representing the target area, connection, collection constraints and coverage, and JADE frameworks is used for communication between sensors and sinks which is developed through container and it is a multiagent simulator . In JADE container all information about the sensors and sinks can be stored. Finally configurations are set for linking to JADE and JAVA.

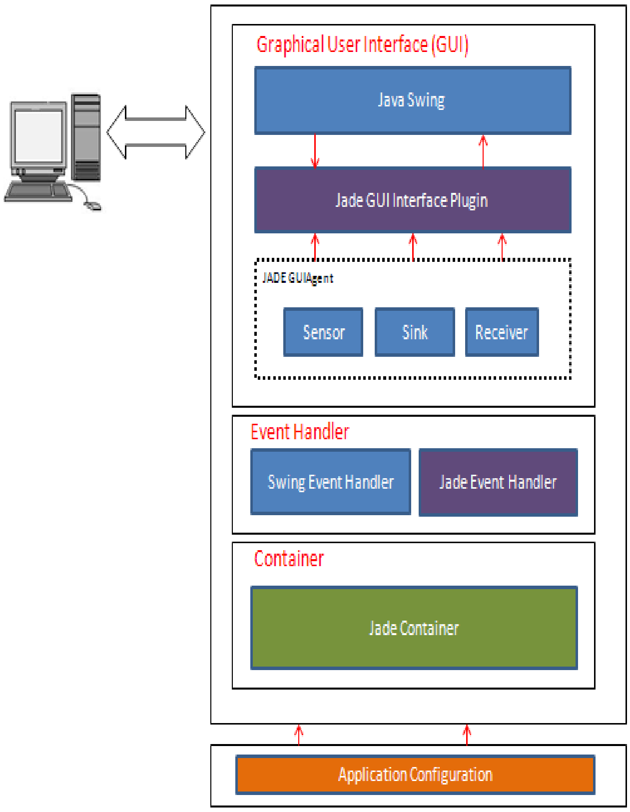

Fig 8: Techinal architecture for Simlation result- java agent development framework(JADE).

VIII. TECHINAL ARCHITECTURE EXPLAINATION

A. Graphic User Interface (GUI) in WSNs

Heterogeneous Wireless sensor Network application will be developed using Java Swing application. GUI acts a governing module of entire application and binds all other module intact. This is front end screen.

B. GUI Target Areas

Application has several areas collecting various information right from text message, pictures, videos, surveys, etc., GUI needs to provide provision in terms of displaying these areas, handle events specific to area and to perform ACO mechanism as shown in fig 7.

C. GUI communication process

As we know that application has many sensors, sinks & base station all of these networks may generate and receive various events like sending/receiving messages, sending/receiving pictures, etc., so separate event handling mechanism are used for this propose.

D. Jade Container processing unit

As a part of JADE integration, all GUI events have to be delegated to JADE. So this module acts an interface between GUI and JADE making it possible to pass on all messages.

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E. Configuration through container

To place sensors, sink, base station & etc., several data has to be collected from the user. To store/load and update this information, a module will be coded in a way it makes very convenient both for application and for the user to use data.

IX. SIMULATION RESULTS

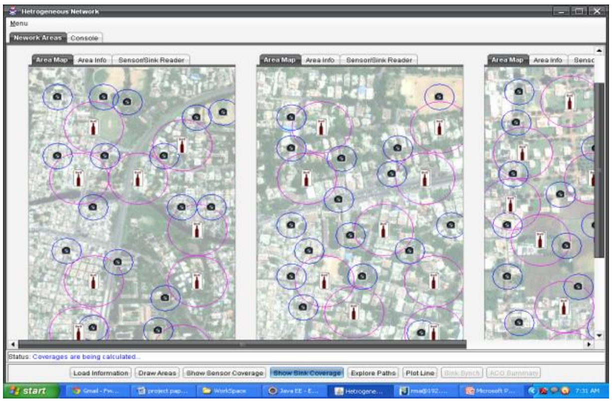

Fig 9: shows the result of sensor and sink coverage

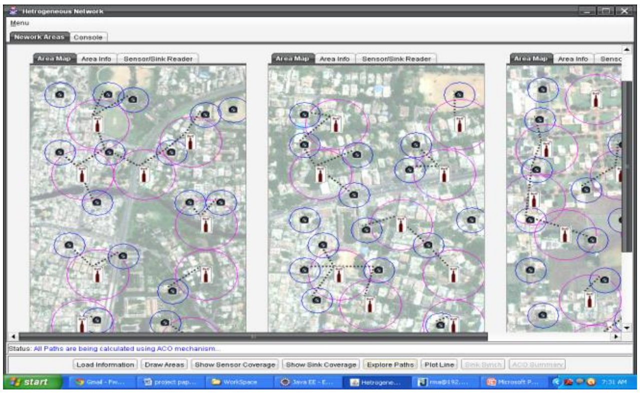

Fig 10: shows the result of routing of all route according to ACO concept

ACO Summary

Sensor Coverage: 50 Sink Coverage: 100

Sensor Name	Distance to Sink	Sink Name
Area 1		
sensor_A00	67.26812023536856	sink_A05
sensor_A01	53.14132102234569	sink_A00
sensor_A02	42.42640687119285	sink_A02
sensor_A02	57.0087712549569	sink_A01
sensor_A04	50.47771785649585	sink_A05
sensor_A06	70.45565981523414	sink_A00
sensor_A07	43.01162633521314	sink_A04
sensor_A08	51.478150704935004	sink_A02
sensor_A09	43.01162633521314	sink_A04
sensor_A010	57.0087712549569	sink_A03
sensor_A010	65.19202405202648	sink_A01
sensor_A010	68.00735254367721	sink_A00
sensor_A011	69.6419413859206	sink_A09
sensor_A012	25.0	sink_A09
sensor_A013	45.0	sink_A06
sensor_A013	53.85164807134504	sink_A08
sensor_A014	50.0	sink_A08
sensor_A015	60.41522986797286	sink_A08
sensor_A015	75.66372975210778	sink_A06
sensor_A016	67.62396025078685	sink_A07
sensor_A017	49.49747468305833	sink_A03
sensor_A018	69.6419413859206	sink_A03
sensor_A019	71.61005515987263	sink_A06
Area 2		
sensor_A10	55.90169943749474	sink_A14
sensor_A10	70.71067811865476	sink_A10
sensor_A11	67.08203932499369	sink_A14
sensor_A13	74.33034373659252	sink_A14
sensor_A14	55.0	sink_A16
sensor_A15	50.99019513592785	sink_A10
sensor_A16	58.52349955359813	sink_A19
sensor_A18	55.90169943749474	sink_A16

Fig 11: shows the result of routing of optimal path

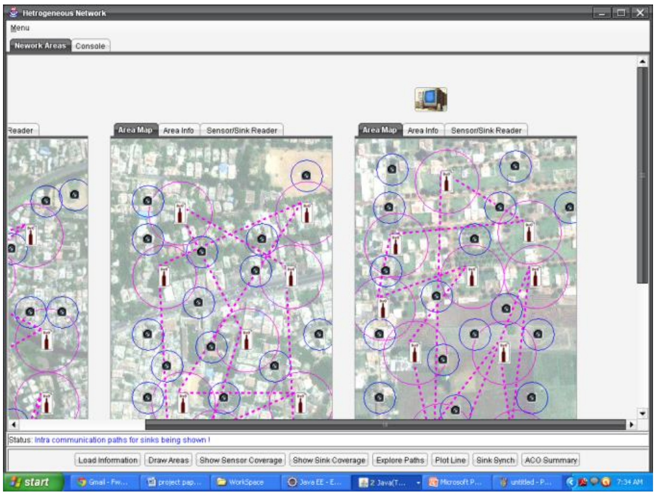

Fig 12: shows the synchronization between sink and destination for message transmission.

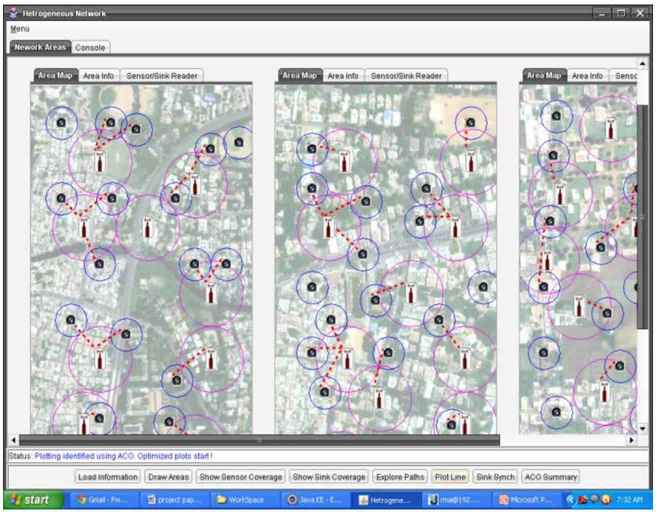

Fig 13: shows the result of ACO calculation for lifetime maximization.

X. CONCLUSION

In this paper, we presented a new objective for maximizing the network lifetime using ACO-MNCC algorithm to increase network lifetime and balance the node power consumption and as long as possible. Based upon finding coverage, connectivity between the sensor and sink and followed by finding optimal path, the lifetime of sensor is maximized. In further enhancement we can use active/sleep mode in sensors .finally the synchronization between sink take places and transmits al data's to destination. Extensive simulation result clearly shows that the proposed approach provides more approximate, effective and efficient way for maximizing the lifetime of heterogeneous wireless sensor networks

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