MONITORING OIL PIPELINE AND TANKS USING WIRELESS SENSOR NETWORK

By

Ola Ibrahim Abd-Elfatah Elnaggar

A Thesis is submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
In
Computer Engineering

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Under the Supervision of

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Key Words:
Wireless sensor network; Genetic algorithm; Ant Colony Optimization; Brain Storm Algorithm; Monitoring oil pipeline

Summary:

Wireless sensor network (WSN) is a network for real time applications that uses very tiny devices called wireless sensor nodes with very limited power, coverage and communication range. In WSN, sensor nodes exceptionally have restricted power because of equipment imperatives. Packet losses and retransmissions that generate from crowding are the most problems that waste precious energy and shorten the network lifetime. This problem is solved by finding the best technique to deploy the sensor nodes to prolong the network lifetime. There are many techniques that help in exploring the best deployment to nodes in WSN such as Genetic Algorithm (GA), Ant Colony Optimization (ACO), Brain Storm Algorithm (BSA), etc. This thesis discusses a lot of techniques to solve problems of monitoring oil pipeline and oil tanks.

Disclaimer

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: Date:
Signature:

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Nomenclature

ACO	Ant Colony Optimization
ACR-BPA	Adjustable Communication Range with Best Path Algorithm
AS	Ant System
BFO	Bacterial Forging Optimization
BPA	Best Path Algorithm
BS	Base Station
BSO	Brain Storm Optimization Algorithm
DNAA	Divided Network Area Algorithm
GA	Genetic Algorithm
GPS	Global Positioning System
GUI	Graphic User Interface
HTTP	Hypertext Transfer Protocol
MILP	Mixed Integer Liner Problem
OPU	Oil Pumping Unit
PSO	Particle Swarm Optimization
RF	Radio Frequency
SMT-MSP Steiner	Minimum Tree with Minimum Number of Steiner Point.
SN	Sink Node
WSN	Wireless Sensor Network
WUSN	Deployment problem of wireless underground sensor networks

Abstract

In recent years, Wireless sensor networks (WSN) have become a leading area of research especially in real-time applications including borders monitoring, battlefield monitoring, and pipeline monitoring. A wireless sensor node is the main component in the network that sense, record, and send some type of data such as temperature, pressure, light to the sink node to take the decision depends on the application target. Limitations of the WSNs comes from the limitations of the sensor nodes. Sensor nodes have limited power, sensing, and communication ranges.

Due to the finite lifetime of the sensor nodes and the hardness of changing the damage node, the maximization of the network lifetime become the great challenges in WSNs. So, the researchers try to find the best deployment of sensor nodes to prolong the network lifetime.

The proposed algorithm using smart deployment to the sensor nodes in order to prolong the network lifetime using Genetic Algorithm (GA), Ant Colony Optimization (ACO) and Brain Storming optimization Algorithm (BSO).

In addition to the lifetime problem, there are some other problems such as the WSN connectivity. This problem comes from nodes' random deployment or due to the nature of the WSN applications such as monitoring oil tanks. The researchers looking for the best deployment of the relay nodes with minimum relay nodes number and maximize the network lifetime.

In this thesis, our focus is on the deployment problem of sensors to monitor oil pipelines and oil tanks. In monitoring oil pipelines problem, the target is find the best deployment of certain number of sensor node on linear pipe line with certain length with maximum network lifetime. The proposed satisfies the target of the problem by using GA and ACO. In monitoring oil tanks, the proposed algorithm find the minimum number of relay nodes to make the network connected and return the optimal deployment of sensor nodes and relay nodes and maximize network lifetime using BSO.

Different test cases have been used to support the proposed algorithms using different criteria. The performance of the proposed algorithms in monitoring oil pipeline and oil tanks are compared to previous work in terms of the network lifetime and the number of relay nodes.

From the results we can see the improvement of the proposed algorithms compared with the greedy algorithms:

In monitoring oil pipeline problem: ACO enhances the WSN lifetime with average (5.5%) more than the greedy algorithm in most of the cases, whilst GA gives results very close to the greedy algorithm.

In monitoring oil tanks problem: in term of network lifetime, BSO enhances the WSN lifetime more than ACR-BPA and the greedy algorithm in the large area.

In term of the number of relay nodes, ACR-BPA enhances the number of relay nodes that added to the network (use the minimum number) followed by BSO algorithm.

Chapter 1 : Introduction

In this chapter, the WSN is defined; challenges and applications are discussed, and the roadmap of the thesis is illustrated.

1.1 Wireless Sensor Network Overview

Wireless sensor network (WSN) is a new technology that has small devices called sensor nodes [1]. These nodes have very bounded power due to hardware chains. Sensor nodes consist of a central processing unit CPU (for data processing), memory (this part to store data), transceiver (this part for sending and receiving sensing information between sensor nodes) and battery. They collect information about the environment and send it to a Base Station (BS) node to take the correct decision based on the WSN applications, see Figure 1.1.

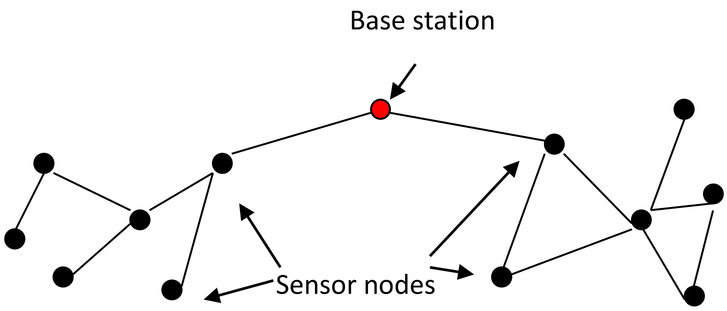

Figure 1.1: Wireless Sensor Network

The Following is a simple scenario of a WSN:

- The WSN contains sensing nodes called sensors which are located in a wide area. They collect information about the environment such as temperature, humidity, pressure, etc. These sensors are deployed according to the WSN target application.
- The base station (Sink Nodes (SN)) is the node which collects the sensed data from sensor nodes; communicates with the user who is responsible for collecting data then takes the best decision depending on the WSN target application. SNs have more propelled elements than sensor node in more than one element. For example, in memory, energy transmissions and processing capabilities. The sensor network is usually composed of a large number of sensors; some of these sensors may measure

redundant data. At the same time, sensor networks do not have a single point of failure due to a large number of nodes deployed in the monitored field [1].

- Energy consumption is the main factor in WSNs during sending and receiving sensed data between sensor nodes. In WSN one of the most important target is saving energy, so that the batteries don't get exhausted or depleted rapidly as these are not effortlessly replaceable in applications.

- Protocols should carefully check for network stability and repetitive data transferred through the network for any type of traffic distribution. It also needs to keep up certain resource limitation parameters such as SN buffer size, memory and bandwidth.

- Sensor nodes can use multi-hop or single-hop routes depending on the network topology that has been chosen to be compatible with the network target.

- In WSN, sensor nodes can be self-organizing where stationary nodes and mobile nodes are required to cooperate together to form the network. This cooperation has to be through smart sensors and protocols.

1.2 WSNs Challenges

WSNs factors that influence their design and performance [3-6] are as follows:

Energy: sensor nodes consumes power in many operations such as sensing, sending, collecting data. Due to the hardness of recharge or change the batteries of the sensors, WSNs researchers aim to design the network to minimize the network power consumption.

Network self-management: the network should be able to work and manage the configuration, maintenance by itself.

Network topology: It is based on deployment method for sensor nodes. There are two types of deployments which are random or fixsed deployment. A good deployment is the one that extends the network lifetime and minimizes the disconnected points in WSNs.

Operating environment: For example, WSN can be deployed on floating ocean water, attached to animals, near the volcano, or attached to people according to the requirements of the application.

Operating system: the operating system of WSNs should be less complex and easy programing than the general operating system.

Data collection nd transsimation: in WSNs the sensor nodes act to sense and send the data to the sink node. Sometimes the data that collected is redandant and there is no need to send all of this data and consume more energy.