DEVELOP A PARTICLE SWARM OPTIMIZATION-BASED K-MEANS CLUSTERING PROTOCOL FOR EXTENDED COVERAGE AREA AND ENERGY EFFICIENCY IN WSN

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This project and research work is dedicated to my beloved family.

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ABSTRACT

In this information technology era, wireless communications are getting more and more popular. The demand of everything to go wireless is not possible and it is definitely not a thing only in future. Wireless sensor network (WSN) is getting more attention since the mid-1990s. It is a network which consists of sensor nodes that is used in various industries such as security. The developers of WSN usually faced challenges such as limited energy and coverage area. Therefore, this project is made to improve the coverage area and energy efficiency in WSN by using an algorithm called Particle Swarm Optimization-based K-means Clustering Protocol. Particle Swarm Optimization algorithm is used to locate the cluster heads and K-Means Clustering Protocol is used to cluster the sensor nodes. This project is simulated using Matlab program. The energy efficiency and coverage area for three different size of area are obtained by using Particle Swarm Optimization-based K-means Clustering Protocol is compared with Derivative Harmony Search algorithm-based K-means Clustering Protocol and Genetic Algorithm-based K-means Clustering Protocol. The results show that Particle Swarm Optimization-based K-means Clustering Protocol has better coverage area but Derivative Harmony Search algorithm-based K-means Clustering Protocol and Genetic Algorithm-based K-means Clustering Protocol have better energy efficiency.

ABSTRAK

Dalam era ledakan teknologi maklumat, komunikasi tanpa wayar telah mendapat lebih banyak perhatian. Rangkaian sensor tanpa wayar (WSN) semakin lebih banyak perhatian sejak pertengahan tahun 1990-an. Ia adalah satu rangkaian nodus autonomi digunakan untuk memantau persekitaran. Para pengembang WSN biasanya menghadapi cabaran seperti tenaga yang terhad dan kawasan liputan. Oleh itu, projek ini dibuat untuk meningkatkan kawasan liputan dan kecekapan tenaga dalam WSN dengan menggunakan algoritma yang berasaskan pengoptimum dengan menggunakan Zarah Swarm Optimization dan pengelompokan dengan menggunakan K -means Protokol. Pengoptimum dengan menggunakan Zarah Swarm Optimization digunakan untuk mencari ketua kluster dan mengelompokan nodus dengan menggunakan K -means Protokol. Projek ini menggunakan program simulasi Matlab. Kecekapan tenaga dan kawasan liputan untuk tiga saiz kawasan yang berbeza yang didapat dengan menggunakan pengoptimum dengan Zarah Swarm Optimization dan pengelompokan dengan K -means Protokol telah dibandingkan dengan pengoptimum menggunakan Derivatif Harmoni Search dan pengelompokan dengan K -means Protokol dan pengoptimum dengan Genetik Algoritma dan pengelompokan dengan K -means Protokol. Keputusan menunjukkan pengoptimum dengan Zarah Swarm Optimization dan pengelompokan dengan K -means Protokol mempunyai liputan kawasan yang lebih baik tetapi pengoptimum menggunakan Derivatif Harmoni Search dan pengelompokan dengan K -means Protokol dan pengoptimum dengan Genetik Algoritma dan pengelompokan dengan K -means Protokol mempunyai kecekapan tenaga yang lebih baik.

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LIST OF ABBREVIATION

WSN	Wireless Sensor Network
VANET	Vehicular Ad-hoc Network
SI	Swarm Intelligence
ACO	Ant Colony Optimization
PSO	Particle Swarm Optimization
LEACH	Low-Energy Adaptive Clustering Hierarchy protocol
HEED	Hybrid Energy-Efficient Distributed clustering protocol
BCDCP	Base-Station Controlled Dynamic Clustering Protocol
CH	Cluster Head
MATLAB	Matrix Laboratory
DHSA	Derivative Harmony Search algorithm
GA	Genetic algorithm

CHAPTER 1

INTRODUCTION

1.1 Chapter Overview

This chapter will introduce about wireless sensor network (WSN), Particle Swarm Optimization algorithm and K-means clustering protocol. This chapter will give a brief explanation on the problems faced in WSN in real life and how Particle Swarm Optimization-Based K-means clustering protocol can solve it.

1.2 Introduction

Wireless sensor network (WSN) is a network with randomly distributed sensor nodes. It is distributed to keep track of the environmental conditions, such as temperature, sound and many more. The nodes are connected with other sensor nodes to pass their data through the network to a main location. Figure 1.1 shows the overview of how WSN is connected.

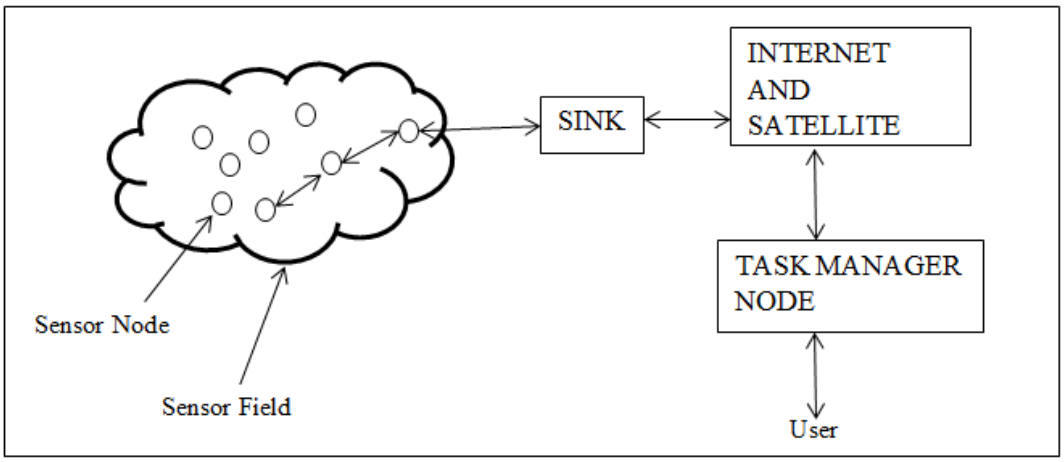

Figure 1.1: Overview of a wireless sensor network [1]

Sensor nodes are small, lightweight and portable. They are made up of a microcomputer, transceiver, transducer and a power source. The function of a microcomputer is to store and process the output from the sensor. The transceiver is to receive instructions from a central computer and send data to that computer. Transducer is used to generate electric signals based on the surrounding. Lastly, the power source of a sensor node is from a battery. The sensor node communicate with each other by using radio transmitters and receivers. They create links with other nodes in different configuration to maximize the performance for each node. The links will be connected to the 'parent' node and the 'parent' node will send the information to the attached device that is used to collect and process data.

The energy efficiency issue has been the main concern in wireless sensor network. Due to the characteristic on being powered by battery, the energy level of the sensor nodes can be depleted very quickly. This is because a large part of their

energy has been used in transmitting and receiving data. Besides that, in order to conserve energy, the ways on placing the sensor is crucial. The issue on coverage area is also important and it is closely related to the energy efficiency in wireless sensor network. Therefore, researcher has researched many ways to work out the problems in wireless sensor network, for example using Genetic Algorithm, Particle Swarm Optimization and many more other algorithm. In this project, Particle Swarm Optimization algorithm is used. Besides that, clustering is also important in conserve energy in wireless sensor network. Clustering is the process of grouping data together based on the relationship among them. In this project, K-means clustering protocol is used. Further explanation on Particle Swarm Optimization algorithm and K-means clustering protocol will be explained in Chapter 3.

1.3 Objectives

1. To develop a Particle Swarm Optimization in wireless sensor network.
2. To implement the developed algorithm with K-means clustering protocol
3. To analyse the performance of Particle Swarm Optimization-based K-means Clustering Protocol in terms of energy efficiency and coverage area.

1.4 Problem Statement

Wireless sensor network can be applied in many fields such as data collection in farming, habitat monitoring, and security [2]. It can be applied in many field due to its versatility and robustness. However, one of the main constraints of WSN is the limitation of battery power [3]. Most of the energy used that is used by sensor nodes are sensing the surrounding and uploading the sensor nodes readings to a central user location known as base station. Moreover, the location and the physical distance to the base station are important in conserving their energy [4]. Therefore, it is very important for the utilization of clustering technique to promote energy efficiency. The coverage area of the wireless sensor network is defined as the fraction of the target area observed by the sensor nodes [5]. The aim of wireless sensor network coverage problem is to minimize the number of sensor nodes activated and at the same time maintain a good coverage in the monitoring area [6]. Most of the applications in wireless sensor network require strong coverage [7]. Therefore, this project uses Particle Swarm Optimization algorithm to locate the strategic position for the cluster head among the sensor nodes. K-means Clustering Protocol is used in this project to cluster the sensor nodes to improve energy efficiency. K-means Clustering Protocol clusters the sensor nodes by the minimum distance between the sensor nodes and cluster heads.

1.5 Scope of Work

There are many ways can be used to solve the problems faced in WSN. The algorithm used for this project is Particle Swarm Optimization-Based with K-means clustering protocol. The developed algorithm will be implemented in wireless sensor network. Besides, the area of the wireless sensor network will be $10000m^2$ to $250000m^2$. Moreover, there will be no limitation on the number of wireless sensor node. The battery of the sensor nodes are fix at 3J and the transmission radius are 5m.

1.6 Report Organization

This report is divided into five chapters. The contents of each chapter were summarized as below.

Chapter 1 is an introduction about the overview of the objective and scope of the project. It also summarizes the content of this report.

Chapter 2 is about the literature review that covers the related theory and previous work regarding to this project.

Chapter 3 is about methodology for this project.

Chapter 4 is about the result and analysis of this project.

Chapter 5 is about the future works and conclusion of this project.

CHAPTER 2

LITERATURE REVIEW

2.1 Chapter Overview

This chapter will discuss on the literature review and the theoretical part of this project. This will help to enhance the knowledge that is important for the completion of this project. Besides that, this chapter will give explanation about the main points in this project which are wireless sensor network, optimization, clustering and related work that combined optimization and clustering algorithm.

2.2 Wireless Sensor Network

Wireless sensor network is a network that has large number of interconnected sensor nodes and can be used for calculation and wireless communication. Each sensor node is composed of a sensor, processor, transceiver, memory, location measurement system and battery. The task of the sensor node is not limited to collect

and transmit data but it also has the ability to transmit received data to another sensor node [8]. Wireless sensor network is widely used in area such as environmental monitoring, transportation and defense sector [9].

The widespread of inexpensive wireless sensor nodes offers a more accurate result from monitoring the environment when compared to traditional sensing method. This makes wireless sensor network a suitable choice to be used in environmental monitoring. There are two types of environmental monitoring which are indoor and outdoor monitoring. Indoor monitoring is used to check the quality of the air in offices and buildings. Outdoor monitoring includes earthquake detection, floods detection, eruption of volcano and weather forecast. There are several projects with real implementation in the real world, such as the wireless sensor network in Tunguruhua volcano, located in central Ecuador [10]. The network consists of five sensor nodes. Three of the sensor nodes have an attached microphone to monitor infrasonic signals from the volcano eruptions. The data that is collected by the sensors will be relayed to the local sink and the results will be displayed in a computer located 9km away via radio links [10]. Based on the examples above, wireless sensor network enable researchers to do their researches in dangerous environment without the need of directly in contact with it.

In transportation, wireless sensor network can be used to prevent road death and injuries. Road accidents can cause traffic blockage, causing user to waste significant amount of time and fuel. Therefore, the Vehicular Ad-hoc Network (VANET) is a solution to the problem mentioned. In VANET, the sensor nodes are represented by the vehicles and will exchange data from other nodes (vehicles) and this information will help the driver to be able to have a better concentration on the road. This application helps the driver to be more alert and able to react appropriately when there are car accidents or traffic jams. Besides that, VANET also enables vehicles to communicate to the base station (Roadside Unit) that is located at the side of the road. The Roadside Unit is the base station that will transmit and accept information from the network if any mishap occurs [11]. This is a very good innovation as this system will be able to lower the accident rate.

In defense sector, wireless sensor network (WSN) is used in soldier detection and tracking. The sensors will be placed in the military sites and buildings at specific points to detect whether enemy soldiers are approaching [12]. In WSN-based military tracking system, there are four categories, which are GPS-based, Acoustic-based, RF-based and camera-based. In GPS-based system, the GPS satellite will transmit signals to the GPS receiver, and the GPS receiver will computes its location. The GPS-based tracking system has been integrated with WSN to enhance localization accuracy for tracking mobile targets that move through the wireless sensor's area of interest. Figure 2.1 shows the GPS receiver. In Acoustic-based system, the distance between reference node and target node will be computed in acoustic behaviors. In order to be tracked, the target nodes have to emit sounds to be detected. Figure 2.2 shows the acoustic wireless sensor device. Besides that, in RF-based system, radio waves are used to determine the target location. To estimate the location of target node, the ways on how signal is propagated and the size of the building are used to convert RSS values into distance values. This is known as fingerprinting localization method. The camera-based system is a sensing modal used to track applications. Special device is not needed in this system as it already has a camera attached to it [13]. Figure 2.3 shows the camera-based wireless sensor device.

Figure 2.1: GPS receiver [13].

Figure 2.2: Acoustic wireless sensor device [13].

Figure 2.3: Camera-based wireless sensor device [13].

The advantages of wireless sensor network include low cost and ease of operation. However, there are some problems faced in wireless sensor network. For example, the problems usually faced in wireless sensor network are limited battery power and coverage area. Environmental factors such as sensor nodes could be crushed by the animals within the forest, by enemy troopers within the battle field also contributed to the coverage issue in wireless sensor network [14]. Moreover, sensor node that is used in wireless sensor network is battery powered. Due to random deployment in various types of terrain, it is very difficult to replace or recharge the battery in sensor node. Sensor nodes need energy to senses data, receives data, besides transmits and processing data. Among the task in sensor nodes, transmitting data and receiving data uses the most battery power. Study shown that transmitting a bit of data thru wireless means is equal to the amount of energy needed to process approximately 1000 of CPU instructions [15]. Therefore, it is very crucial to use optimization and clustering to curb the problems faced in wireless sensor network.