

CHAPTER I

INTRODUCTION

1.1 INTRODUCTION

There has been growing interest in wireless sensor network (WSN) in the last decade. This is because WSN has been very useful in the monitoring of the physical world. It is built on self-organizing networks of battery-powered wireless sensors that is capable of sensing, processing and communicating (Jia, Chen, Chang, & Tan, 2009). The deployment of a WSN is very cheap and can be done rapidly. This enables large-scale, on-demand monitoring and tracking. The application of WSN in tracking has been used extensively over a wide range of applications, notably, vehicle tracking, danger alarm, battle field surveillance, habitat monitoring (I.F. Akyildiz, Su, Sankarasubramaniam, & Cayirci, 2002; Cardei & Wu, 2006).

There are limitations to the longevity of sensor nodes in WSN. This is as a result of the limited capabilities of the power, the on board processors and wireless communication. Another critical challenge is the inability or impracticality to replace batteries when energy in the sensors is depleted in most applications. Most applications demand continuous operation and monitoring, such as in surveillance or habitat monitoring. In such cases, the WSN available in domestic or public edifices are expected to continue to function without interruption or outage, that is, most of these systems requires an operational lifetime of several years.

As such, some have proposed high density deployment of sensors for sustainability of a WSN. It is recommended that there should be up to 20

nodes/m³(Shih et al., 2001)for the network lifetime to be sustained. Other factors that tremendously affect the longevity of a WSN and depletion of energy include operation of sensor nodes simultaneously, redundant data sensing, collision in corresponding wireless communication and interference (Lin, Yen, & Lin, 2009). Given this scenario, there are concerns that require consideration. For example, how to maintain the coverage of the sensing area with minimal number of active nodes, removal of blind-points and significant connectivity? Similarly, in large scale WSNs, such as with hundreds and thousands of nodes, coverage of sensing area becomes an issue of great concern due to interference and other factors as mentioned above.

From the foregoing, it can be acknowledged that the coverage of sensing area is of great importance and one of the underlying issues in wireless sensor networks. It is a measure of the efficiency and capability of the sensor network. It is often considered as the benchmark for QoS in a WSN (Meguerdichian, Koushanfar, Potkonjak, & Srivastava, 2001). Existing approaches to address these problems are based on node scheduling. The underlying idea is focused on determining the optimal number of active nodes and at the same time ensuring efficient coverage and connectivity. Previous work such as Slijepcevic and Potkonjak (2001), attempts to deduce the maximum number of covers in a sensor network. A cover, literally refers to a set of nodes needed to fully provide coverage for a monitored area. This is often implemented in a centralized arrangement. Slijepcevic and Potkonjak (2001) deduced the NP-completeness of this problem showing that the numbers of nodes that must be deployed in order to completely cover the whole Monitored area is required to be higher than if a deterministic procedure were used. It is also noteworthy that networks

with stochastically placed nodes, activating only the necessary number of sensor nodes at any particular moment can save energy.

Using a heuristic strategy that selects mutually exclusive sets of sensor nodes, the authors demonstrate from their experimental results that by using only a subset of sensor nodes at an instance, it is possible to achieve considerable energy conservation yet maintaining coverage where the members of each of those sets together completely cover the monitored area. There is a very close relation between network coverage and network energy consumption. Furthermore, as shown from the Sensor Medium Access Control (S-MAC) scheme proposed by Ye, Heidemann, & Estrin, (2002), implements an approach that randomly designated sensors to go into the sleep mode and waking up periodically to retrieve the stored packets from their neighboring nodes in order to conserve energy consumption. Similarly, a distributed probing-based density control scheme (PEAS) for robust sensing coverage proposed in (F. Ye, Zhong, Cheng, Lu, & Zhang, 2003) selects set of nodes to be made active to maintain coverage while others are put into sleep mode to conserve energy. The scheme has a mechanism for regulating the probing range of nodes to achieve a different coverage redundancy can be achieved. The downside of this algorithm is that while it guarantees that the distance between any pair of working nodes is at least the probing range, it however cannot assure complete preservation of the original sensing coverage when some nodes are turned off.

The use of linear programming techniques has been explored by several authors to determine the minimal set of active nodes to maintain coverage set. A particular relevance is the work of (Chakrabarty, Iyengar, Qi, & Cho, 2002; Meguerdichian & Potkonjak, 2003) where application of linear programming

techniques has been explored to determine the right number of nodes to be active and those to be in sleep nodes. There have been tremendous work in the area of that has proposed sleep nodes schemes to conserve energy yet, the existing work has not completely resolve the set of requirements in wireless sensor networks.

Other proposed algorithms have focused on finding a close-to-optimal solution based on local information. In maintaining energy in WSN, the algorithm is designed to set the energy of node to sleep or active and has mechanism to know the best arrangement of which nodes to turn its radio on. Work such as (Chen, Jamieson, Balakrishnan, & Morris, 2001), algorithm is designed to randomize the process of turning off nodes based on the necessity for neighbour connectivity. However, they focus on how to conserve energy consumption but do not significantly lessen the connectivity of the network.

An algorithm, called Geographical Adaptive Fidelity (GAF) was proposed in (Rey et al., 2001), which uses geographic location information system to divide the area into fixed square grids. This approach works by keeping only one node active to forward packets in a given grid. The above schemes keep nodes inactive from a communication perspective disregarding sensing coverage. This is unrealistic in that the primary role of each node is sensing in wireless sensor networks though unusual events could happen at any time at any place in the sensor networks. Consequently, certain areas in the deploying area are rendered redundant and become blind points as a result of turning off nodes which are not directly participating in data forwarding at a particular time (F. Ye et al., 2003). It is often necessary that the sensor network remain connected to facilitate that the effective relaying of information collected by sensor nodes back to data sinks or controllers. The work of (Zhang & Hou, 2005)

demonstrates an important result that shows that given a communication range R_c is at least twice the sensing range R_s , that makes it possible to have a complete coverage of a convex area which in turns guarantees connectivity of the working nodes. Consequent on these results, the work proposed Optimal Geographical Density Control (OGDC) that promises a distributed and localized scheme. The underlying assumption in this scheme is that given that a high sensor density then a sensor can be found at any desirable point. This claim may not be realistic in practice. Furthermore, (X. Wang et al., 2003) proposed the Coverage Configuration Protocol (CCP), that attempts to address three key concerns about existing connectivity or coverage maintenance. Firstly, CCP that is capable of different levels of coverage as demanded based on requests. Given this flexibility, the network then possesses a self-configuration capability suitable for a wide range of applications and dynamic environments. Secondly, the work provides a geometric analysis of the relationship between coverage and connectivity is provided. From this geometric analysis some key insights which are in sharp contrast to several existing approaches that address the two problems in isolation for treating coverage and connectivity in a unified framework were observed. Lastly, the work provides an integration of CCP and SPAN in order to guarantee both coverage and connectivity and further demonstrates the capability of their schemes using geometric analysis and simulations to provide guaranteed coverage and connectivity configurations. The approach in Wang et al, (2003) is meant to dynamically configure the network to provide different coverage degrees requested by applications since sensing coverage requirement varies in different applications. In some applications, monitoring every location in a region with a single node may be sufficient, while in some other more demanding applications higher degrees of coverage.

Moreover, there is a link between coverage requirement and the number of faults that must be tolerated. With a higher degree of coverage it is possible to sustain satisfactory coverage in case there are higher rates of node failures. Changes in environmental conditions or the changing needs of different applications may also demand change in coverage requirement after a network has been deployed. In order to determine the intersection points, each node keeps record of its neighbour information in a table and periodically broadcasts a hello beacon that contains its current location and status.

The scheme may not guarantee network connectivity when $(R_c < 2R_s)$. They proposed an algorithm that sought to extend the network lifetime by saving energy while meeting the coverage requirement using a novel searching algorithm referred to as Energy-efficient Coverage Control Algorithm (ECCA). This scheme is inspired by the Multi-Objective Genetic Algorithms (MOGAs) proposed by (Srinivas & Deb, 1994). The approach proposed in the scheme search to minimize the number of working nodes while maintaining full coverage, representing the sensor field in a two-dimensional grid and the dimensions of the grid provide a measure of the sensor field. In ECCA, there is the possibility to adjust the granularity of the grid, that is, the distance between grid points, in order to manage computation time with the effectiveness of the coverage measure. The ECCA is similar to the Virtual Force Algorithm (VFA) ability to handle the arrangement of the cluster head of the sensor nodes. This is possible because the cluster head is equipped with a greater processing capability, thereby saving the processing power at each of the nodes.

1.2 Problem Statement and Its Significance

One of the major challenges in wireless sensor network (WSN) is parameters control. Such parameters may include energy-consumption, Bandwidth (BW) and, signal strength. Controlling these vital set of parameters shows how well the network is designed and organized, which means the quality of the network. There are many algorithms for controlling and optimizing wireless sensor network. However, most of them consider one parameter or two concrete parameters at most, or a certain hardware scheme along with one parameter. Leading to a gap in obtaining the optimal enhancement in the overall performance of the WSN. In addition, there are some cases where two WSNs are intentionally overlapped with different BWs for different uses. Thus, controlling the operation and quality for the best performance is still questionable. Therefore, Langendoen & Halkes (2004) said, there is a need for a network design and algorithm to cope with WSN operation and quality parameters through a concrete scheme.

1.3 Research Objectives

The main objective of this study is to develop and design a complete algorithm for controlling WSN energy-consumption, Bandwidth and signal strength using single fitness function management. This objective can be elaborated as follows:

- 1-To investigate all possible scenarios that can best optimize the distribution of energy-consumption, BW and signal strength using single fitness function management.
- 2-To develop an algorithm that controls energy-consumption, BW, and signal strength using single fitness function.

3-To build the wireless sensor network simulator and test it in real time based on the developed algorithm.

1.4 Scopes (Limitations) Of Study

This research focuses on nodes classification, detection and applying the integration of static, dynamic analysis and automated analysis for energy consumption and coverage area. The main issue in wireless sensors network for coverage area problem is the topology of nodes.

This study makes use a simulator that was built to cater for the above issues mentioned. The simulator was developed using c-sharp language and it is mentioned in the chapter on Methodology.

1.5 Expected Results and Contribution

After the research has been done, the expected results are as follows:

- 1- Obtain the optimized energy -consumption distribution, Bandwidth, and signal strength using single fitness function.
- 2- An algorithm that controls energy-consumption, bandwidth, and signal strength using single fitness function.
- 3- The wireless sensor network simulator and test it in real time based on the developed algorithm.

1.6 Research Methodology

In this study, a controlling algorithm for energy-consumption and user bandwidth in WSNs using single fitness function will be developed. The fitness function is an

increment function that measures the quality or performance of a solution, in this case a specific sensor network design. This function is maximized by the Genetic Algorithm (GA) system in the process of evolutionary optimization. A fitness function must include and correctly represent all or at least the most important factors that affect the performance of the system. In the design of Wireless Sensor Network (WSN), there are some factors that concern communication issues of the network, as well as others that concern the characteristics of the specific application of the sensor network, that is, the environmental measurements in the precision agriculture application examined here. In the network characteristics, those factors include the connectivity of the sensors, the operational cost of the system depending on the types of the sensors and the communication cost of the system, depending on the distances between sensors that communicate with their corresponding cluster head. The main goal of a WSN used in precision agriculture is to take uniform measurements over the entire area of interest, so that a uniform picture of the conditions of the area is realized.

The algorithm will be developed using both theoretical and practical manoeuvres. Practically, that will use energy-consumption and radio bandwidth to control the coverage area problem of wireless sensors network. However, theoretically, the study will make use of the ECCA algorithm that activates a minimum number of sensor nodes in a densely deployed environment, but the algorithm itself will be enhanced to suit our research. The developed WSN as well as the controlling algorithm will then be tested based on at USIM campus and the results will be validated. Finally, the developed protocol will be benchmarked with other protocols for assuring the performance the system.

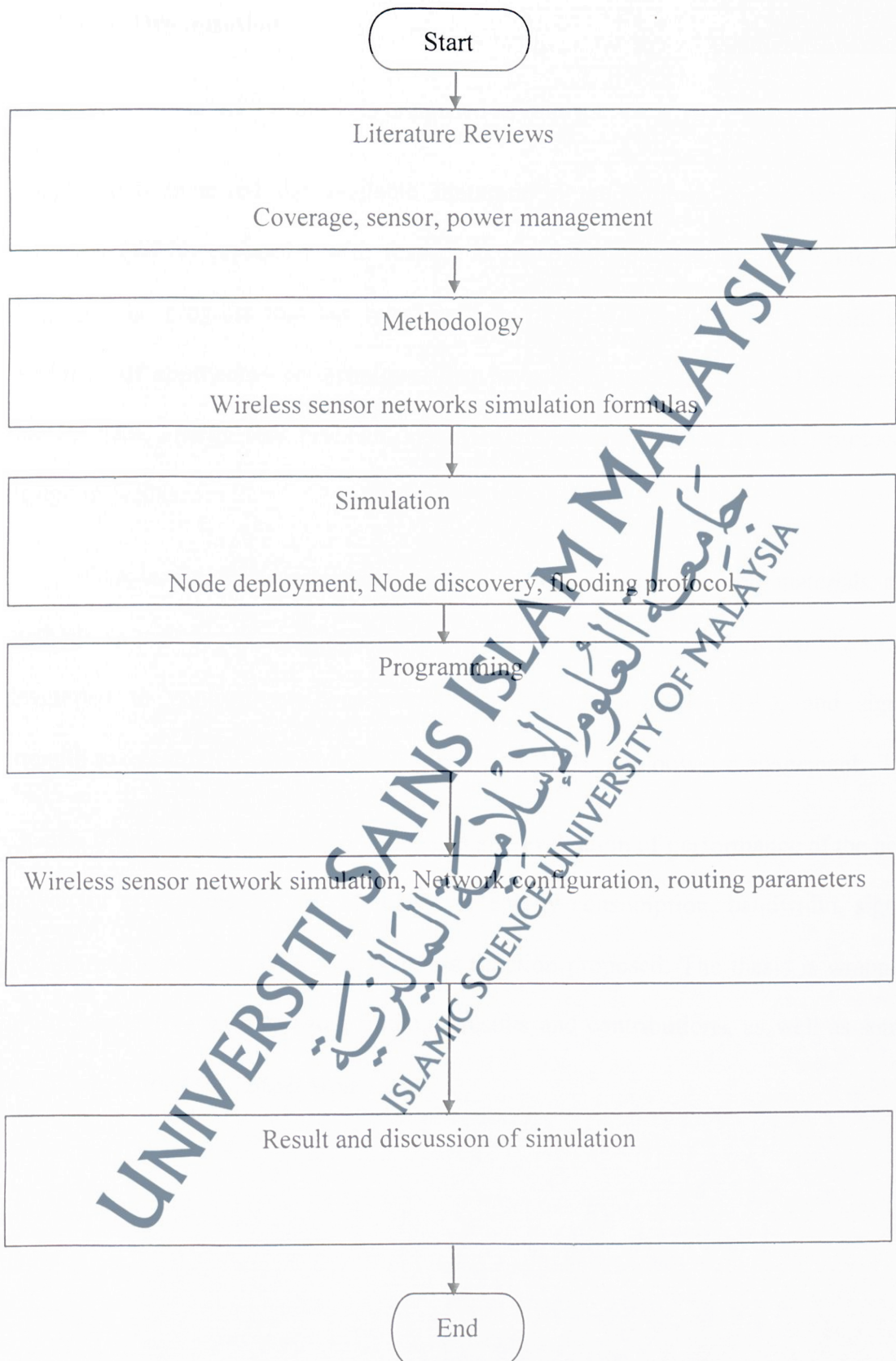


Figure 1: Flow of WSN Research

1.7 Thesis Organisation

The remaining part of this thesis is organised as follows:

Chapter two reviewed the available literature in the domain of wireless sensor networks (WSN) especially with respect to coverage optimisation. It outlines and evaluates the progress that has been made in order to highlight the strengths and weakness of approaches or techniques that have been used or proposed for energy management, energy loss problem, and Medium Access Control (MAC) protocols design in WSNs.

Chapter three discusses the theoretical background, formulation, materials, and methods as well as the simulations utilised for the single fitness function algorithm developed to control energy-consumption, Radio Bandwidth (BW), and signal strength to overcome Coverage Area Problems in WSNs and power management.

Chapter four presents a discussion of results and evaluation of performance of the new model for controlling WSNs parameters of energy consumption, bandwidth, signal strength and coverage, using single fitness function proposed. The thesis is wrapped up in chapter five with research findings, results and contributions, as well as some recommendations for further work.