PERFORMANCE EVALUATION OF A3 TOPOLOGY CONTROL IN WIRELESS SENSOR NETWORK

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To mom and dad

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ABSTRACT

Wireless sensor networks (WSNs) are short range personal communication networks that are widely used in environmental monitoring and other applications such as military and healthcare. A WSN is formed of a number of sensor nodes which are normally battery operated and have limited computational capability. The sensor nodes collaboratively collect the required data and disseminate the data from the source to the sink. Direct data transmission from the nodes to the sink consumes high amount of energy thus reducing the network lifetime. In addition, in a dense sensor network, the possibility of the nodes to have an overlapped sensing area is very high. If every node sends its data, the sink will receive the same data yielding to inefficient energy consumption. To solve the problem, topology control is used to improve the performance in term of network lifetime and energy consumption. Topology control consists of two phases which are topology construction and topology maintenance. The objective of this project is to evaluate the performance of A3 Topology Control protocol in WSNs. The simulation works are executed by using a WSN simulator called Atarraya. The run based of the selected parameter. By using CDS rule K as the reference topology expected result will get A3 is better than CDS rule K

ABSTRAK

Wiraless Sensor Network (WSNs) adalah jarak dekat rangkaian komunikasi yang digunakan secara meluas dalam pemantauan alam sekitar dan aplikasi lain seperti dalam bidang ketenteraan dan penjagaan kesihatan. WSN terbentuk daripada bilangan nod sensor yangbanyak mengandunig bateri dan menggunakan keupayaan komputeran yang terhad. Nod-nod sensor akan mengumpul data yang diperlukan dan kemudian dihantar ke sink. Penghantaran data dari nod ke sink memerlukan penggunaan tenaga yang tinggi menyebabkan jangka hayat rangkaian berkurangan. Di samping itu, dalam rangkaian sensor yang dipenuhi dengan sensor nod yang padat, kemungkinan nod mempunyai kawasan penderiaan bertindih adalah sangat tinggi. Jika setiap nod menghantar data, singki akan menerima data yang berulang menyebabkan penggunaan tenaga yang banyak. Untuk menyelesaikan masalah ini, kawalan topologi digunakan untuk meningkatkan prestasi dari segi jangka hayat rangkaian dan penggunaan tenaga yang kurang. Kawalan topologi terdiri daripada dua fasa iaitu pembinaan topologi dan penyelenggaraan topologi. Objektif projek ini adalah untuk menilai prestasi protokol A3 Topologi Kawalan dalam WSNs. Simulasi dilaksanakan dengan menggunakan simulator WSN dipanggil Atarraya. Simulasi dijalankan berdasarkan parameter yang dipilih. Dengan menggunakan CDS rule K sebagai topologi rujukan dinbandingkan denagn topologi A3.hasil kajian yang dijangka akan mendapat A3 adalah lebih baik daripada CDS rule K

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Wireless sensor networks (WSNs) consist of small nodes which can sense, compute, store and communicate wirelessly. The use of WSN use is limited due to using much memory, power consumption, wireless coverage and low lifetime. WSNs are used into many applications such as environmental monitoring, health care and military applications. Various architecture and deployment strategies have been developed depending on the application requirement. A good deployment strategy optimizes routing protocol to produce high coverage, reduced power consumption and extend the life of sensor network.

Topology control technique is used in WSN to reduce initial network topology in order to reduce energy consumption and extending the life of sensors network. Topology control is about reorganizing and managing certain node parameters and modes of

operation from time to time to modify the topology of the network with the goal of extending lifetime while preserving important characteristics such as network connectivity and sensing coverage. Topology control techniques are divided into two phase that are topology construction (TC) and topology maintenance (TM). A TC builds the reduced topology according to the algorithm. TM is the process of changing the reduced topology from time to time when the current is no longer optimal.

There are many types of topology control algorithms to reduce the power consumption and extending the lifetime during the deployment of sensor network such as Connected Dominating Set rule K (CDS rule K), Energy Efficient Connected Dominating Set (EECD), kneight tree, Atarraya 3 (A3). CDS rule K, A3 and EECD is a hierarchy based TC. CDS rule K is based on CDS pruning rule to reduce the power consumption. First rule in pruning is discard nodes whose neighbor form a connected graph and second rule is discards all nodes whose neighbors are covered by others. A3 starts at one point and add new nodes to the existing tree.

By using Atarraya simulation tools lifetime of nodes and energy consumption of sensors network can be calculated. Atarraya can calculate network lifetime and energy consumption from TC and TM by deploy random nodes. During the TC may not optimized through entire lifetime as the network parameter and constrain change from time to time. By using the TM, the reduced topology is maintained by rotating and recreating the sensors nodes from time to time. Atarraya will simulate and calculate how long it can last, how many energy consumption and check the coverage of the area.

1.2 Objective

This project aims to evaluate the performance of A3 protocol in WSN. To achieve the aim, we list the following three objectives:

1. To Simulate the topology control of A3 and CDS rule K
2. To investigate the performance of topology control in terms of energy efficiency and network lifetime.
3. To determine the performance of A3 and CDS rule K with combination of two different of TM that is static and dynamic

1.3 Problem Statement

In dense and random nodes topology, the probabilities for two or more nodes to sense the activity in the same area is very high. The closer nodes will surely sense the same activity and send the same data to the base station (BS). In the original topology, number of collisions increases because all nodes send and receive data from multiple nodes. This will provide several copies of the same information from similarly located nodes. Redundant transmissions consume a lot of energy, therefore shorten the network lifetime. By using topology control, the original topology can be reduced into more energy efficient network.

1.4 Scope

This project will simulate 300 nodes in 500 x 500m network. There are two types of the TM will be used in this project which are dynamic and static. Dyanamic TM consists of Dynamic Global Time-Based Topology Recreation (DGTTRec) and

Dynamic Global Energy-Based Topology Recreation (DGETRec). While static TM consists of Static Global Time-Based Topology Rotation (SGTTRot) and Static Global Energy-Based Topology Rotation (SGETRot).

1.5 Importance Of The Project

The project is important is to maintain the connectivity of nodes in Wireless Sensor Network while keep the coverage area. To maintain the connectivity it is important to save energy consumption.

CHAPTER 2

LITERATURE REVIEW

2.1 Wireless Sensor Network

Wireless Sensor Network has been use in many applications such as in military, hospital health monitoring, smart home, environmental monitoring and etc. it also has been use in many communication protocol such as ZigBee, IEEE 802.15.4, JenNet and 6oLWPLAN. Lavric Alexandru et al[5], has research about which topology control algorithm is most suitable for a large scale street lighting control system. The research in [5] compared three algorithm that is EECDS, A3 and CDS rule K. It using visual basic simulator to generate street lighting control system to deploy nodes in wide geographical distance in communication range about 100m. From the result A3 are using less number of active node, number of packet send and energy consumption than CDS rule K and EECDS. A3 is recommended in street lighting system according from the result.

In Wireless Sensor Network sensor deployment is important to cover the area of sensing. Naregalkar Akshay et al[6] write how to deploy sensors efficiently to cover the area. This paper has write coverage is main factor to consider in deployment of Wireless Sensor Network. Furthermore it is important to maintain connectivity. It is in order the sensor communicate with each other the connectivity must be maintain. Therefor the sensor must be deploy with respect to each other, cannot be too far or too close. From research that has been made coverage can be classified into three classes that is area coverage, point coverage and barrier coverage. Coverage problem is basically
caused by three main reasons that is not enough sensor to cover the whole area, limited sensing range and random deployment. To solve this problem is by using grid based strategy during the deployment of sensor. There are three types of grid that is commonly used that is square, triangular lattice and hexagonal grid. Square grid is usually be used because it provide fairly performance for any parameter and triangular lattice is the best use because it has the smaller overlapping area. The size is depend on dense of the area. From [6] result triangular get the best result because the experiment use a dense area so triangle can covered it with more efficient where the ratio is 0.818 and efficient coverage area required is $8.88m^2$.

In Wireless Sensor Network the nodes need to be protected to keep the connectivity and to prevent the attackers capture the nodes. Yong Sik Choi research how to keep the network safety by using attestation protocol in Wireless Sensor Network. The step of using this method is inter-connective attestation between surrounding sensor nodes and if there is abnormality, the nodes will inform the Base Station (BS) and request attestation. From [9] attestation proves that the modification in the target device have not been attack. [9] Suggest an inter-connective attestation protocol is suitable for Wireless Sensor Network to keep the connection in safety.

2.2 Topology Control

Topology control is used to reduce the energy consumption and extending lifetime in WSNs. Earlier topology control was used to reduce topology to reduce topology in order to conserve energy and extend the network lifetime. Wightman and Labrador[2] has introduced new topology control by upgrading it to maintain the energy consumption and the lifetime from time to time. The new topology control is divided into two phases which are TC and TM. The function of TC to reduce the topology based on specific algorithm while TM is the process that restores, rotates or recreates the reduced topology from time to time when the current one is not optimal. Pedro M. Wightman investigated the performance of A3 and CDS rule K and with reference to a no TM network. Experiment has been made to compare the topology control from dense and sparse network. Result from the sparse network show that using static technique only showed improvement by using energy based on A3 topology, by using time based the result only decrease on A3 and CDS rule K. By using hybrid on A3 is the best result by getting the number of active nodes is decrease linearly and the number of active nodes is the highest. In the dense network the result can be seen clearly the effect of having TM or not having TM for A3 topology. CDS rule K is not having much effect may because it is using the same topologies from time to time. The best result can be seen on hybrid technique at A3 topology.

There are many type of CDS topology for example CDS rule K, A3 and EECD. Hassan Khaliq Qureshi research for new type of CDS and compare it with other TC that is Clique-based Connected Dominating Set (CCDS). It used clustered-base which allow nodes outside the CDS to enter sleep mode to reduced energy consumption thus extending it lifetime. [8] Use connected graph and find number of 2 clique that is vertex set between pair-wise adjacent vertices present in the network and merge it until it can't clique. By using this technique other clique can be turn off while keeping the network connected and covered. CCDS technique is discovered by solve the problem that happen

in CDS rule K and EECDS that with increase the number of neighbor will increase the number of exchanged message. To solve this problem is by exploiting the inherent broadcast nature of wireless medium and use it to reduce the multiple explicit messages. CCDS do not know the position of the nodes but It can recognize other nodes ID that contain in the received network message. [8] Has done a simulation to compare CCDS with CDS rule K, EECDS and A3. The result show that CCDS use less total number of message with the effect changing of transmission range and network size because CCDS use clique discovery message by neighbor nodes. However in terms of residual energy use A3 get the better result.

Designing topology is important to keep the lifetime of the nodes longer. In the designing topology process it important to consider the length of connectivity to reduce the energy consumption and avoid packet message loss. Ren Yueqing research topology characteristic in Wireless Sensor Network based complex network. [10] By adding few wires connection to create shortcut in wireless sensor can reduce path vertex. Type of topology in Wireless Sensor Network is star, cluster, mesh or hybrid. Star network is a simple structure and low power consumption but if one node is off all nodes also off, cluster network collect data and transmit them to their cluster heads rather to the BS and cluster head will sent to BS, mesh topology is better fault-tolerant that all nodes can transmit to any neighbor than transmit to BS lastly hybrid type that combine two or three type of topology. Mesh network is usually use because of it fault tolerance but using hig power consumption. To measure the network topology is by degree and degree distribution, clustering coefficient and distance. Degree and degree distribution is number of it connected edge and variable due to change of network properties. Clustering coefficient is k connected edge between its neighbor that is

$$C(N) = \frac{E(1)}{k(\frac{N}{2})} \qquad (2.1)$$

Clustering of network is average of all individual C. Distance network is average length of the network.

2.3 Topology Construction

Topology construction is a reduced topology by algorithm in deployment of sensor network. By TC energy consumption can be reduce and extending the node lifetime while conserving important network properties such as network coverage and connectivity.

2.3.1 A3 Topology Contruction

A3 algorithm do not know the position of nodes therefore, the nodes do not have geometric view of the topology. Nodes can determine the distance node base on the signal strength received to select the optimal CDS tree. The A3 executed in three steps that is neighborhood discovery, children selection and second opportunity.

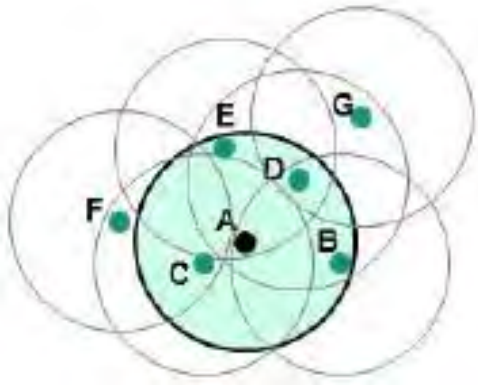

Figure 2.1: A3 Algorithm

2.3.1.1 Neighborhood discovery

The first step in building the CDS is predefined node that might be sink node. The sink node will send first “hello message” that allow its neighbor know its parent node which can be seen in figure 2.1. Node F and G is not covered by sink. If the nodes that receive the message has not been covered by another nodes, it state as covered and answered back with “parent recognition message”. If the receiver has already covered by other nodes, it ignores the “hello message” and turn off. The selected node that been selected according the signal strength received. For example nodes E and B are selected and turn off.

2.3.1.2 Children selection

The parent node set a timer to get feedback from its neighbor than store the nodes as list of candidate. As the timer finish sort the list in decreasing order parent node then send “children recognition message” to the candidates. As in figure 2.1 nodes A send the sort list to nodes B, C, D and E. Once the candidates receive the list, they set a timeout period proportional to their position on the candidate list. During the timer count to finish the nodes wait “sleeping message” from their brother. If the nodes receive the message during the period it is set to turn off. The best node according to metric will sent the message first. For example node D receive “sleeping message” from E before the timer finish so it will turn off. Otherwise, it sends the message to turn the brother off. At that time the particular node become a new parent node and start to find its child. For example node C will find its child F.