DESIGN AND IMPLEMENTATION OF GRID BASED CLUSTERING TECHNIQUE IN WSNUSING DYNAMIC SINK NODE

YASIR ADNAN HUSSIEN

UNIVERSITI KEBANGSAAN MALAYSIA

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YASIR ADNAN HUSSIEN

PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OFCOMPUTER SCIENCE (NETWORK TECHNOLOGY)

FACULTY OF INFORMATION SCIENCE AND TECHNOLOGY
UNIVERSITI KEBANGSAAN MALAYSIA
BANGI

2018

REKA BENTUK DAN PELAKSANAAN TEKNIK CLUSTERING BERDASARKAN GRID DALAM WSN MENGGUNAKAN NOD SINK DINAMIK

YASIR ADNAN HUSSIEN

PROJEK DIKEMUKAKAN UNTUK MEMENUITI SEBAHAGIAN DARIPADA
STARAT MEMPEROLEHI IJAZAH SARJAN SAINS KOMPUTER
(TEKNOLOGI RANGKAIAN)

FAKULTI TEKNOLOGI DAN SAINS MAKLUMAT
UNIVERSITI KEBANGSAAN MALAYSIA
BANGI

2018

DECLARATION

I hereby declare that the work in this project report is an authentic study based on my work, except for quotation and summaries, which have been duly acknowledged.

YASIR ADNAN HUSSIEN
GP06350

ACKNOWLEDGEMENT

My utmost thanks and gratitude must first be offered to Almighty Allah for all his blessing, and in granting me patience throughout the duration of this research.

Profound appreciation and thanks are given to my supervisor, Dr.Ravie Chandren Muniyandi, for his patient supervision, guidance, constructive suggestions and comments during the entire research period until its completion. His advice and support throughout the program have been invaluable. Without his tireless help, leadership, and confidence in my ability, the completion of this project would not have been possible. I also offer my gratitude for him for opening my mind to a new world of knowledge,opportunities, and experience, giving me a better understanding throughout.

Special thanks and gratitude also go to my father Dr. Adnan Hussain Ali for his time spent giving me advice, timely help and guidance.

Finally, I must thank all my family and my wife for all their help and continuous support at every stage of my research.

ABSTRACT

A wireless sensor network (WSN) has important applications, especially in remote environmental monitoring, which has been enabled by the availability of sensors that are smaller, cheaper, and intelligent. These sensors are equipped with wireless interfaces that can communicate with each other to form a network, which contains a number of distributed nodes. The closest nodes to the sink are exploited with the huge traffic load as the data from the entire region are forwarded through them to reach the sink. As a result, their energy gets exhausted quickly and the network is partitioned. This is solved by changing the sink node position in Grid based clustering technique, which considers the optimal method for this purpose. A simulation by MATLAB can be applied for Grid based clustering technique to evaluate the performance of WSN. The results show grid based dynamic sink node position outperforms in term of throughput increased by 22%, reducing energy consumption by 30% with residual energy increased by 20%, in addition to prolong the lifetime of the sensor nodes of the network.

ABSTRAK

Rangkaian sensor tanpawayar (WSN) mempunyai aplikasi penting, terutamanya dalam pemantauan alam sekitar jauh, yang telah didayakan oleh adanya sensor yang lebih kecil, lebih murah, dan pintar. Sensor ini dilengkapi dengan antaramuka wayarles yang boleh berkomunikasi satu sama lain untuk membentuk rangkaian ,yang mengandungi beberapa nod yang diedarkan. Nodus terdekat ke sinki dieksploitasi dengan beban lalulintas yang besar kerana data dari seluruh wilayah diteruskan melalui mereka untuk mencapai sink. Akibatnya, tenaga mereka menjadi cepat habis dan rangkaian dibahagikan. Ini diselesaikan dengan mengubah kedudukan nod sink dalam teknik kluster berasaskan Grid, yang menganggap kaedah optimum untuk tujuan ini. Satu simulasi oleh MATLAB boleh digunakan untuk teknik kluster berasaskan Grid untuk menilai prestasi WSN. Hasilnya menunjukkan kedudukan nod sinki dinamik grid yang melebihi prestasi melalui peningkatan 22%, mengurangkan penggunaan tenaga sebanyak 30% dengan tenaga sisa meningkat sebanyak 20%, selain memanjangkan jangka hayat nod sensor rangkaian.

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LIST OF ABBREVIATIONS

ADC	Analog and Digital Convertor
AODV	Ad-hoc On-Demand Vector Routing protocol
BS	Base Station
CBRP	Cluster Based Routing Protocol
CH	Cluster Head
CM	Cluster Member
DSR	Dynamic Source Routing protocol
DUCA	Distributed Uniform Clustering Algorithm
DYMO	Dynamic MANET On demand protocol
GBCH	Grid Based Cluster Head
GFTCRA	Grid based Fault Tolerant Clustering and Routing Algorithm
GHND	Grid based Hybrid Network Deployment
GN	General Node
GPS	Global Position System
ID	Identifier
IP	Internet Protocol
LEACH	Low Energy Adaptive Clustering Hierarchy
MEMS	Micro-Electro-Mechanical System
MIMO	Multiple-Input and Multiple-Output
PDR	Packet Dilivery Ratio
PEGASIS	Power Efficient Gathering in Sensor Information System
PHY	Physical Layer
RN	Relay Node
SELEZOR	Secure and Low Energy Zone based Routing protocol
SN	Sensor Node

TDMA	Time Division Multiple Access
VGDC	Virtual Grid based Distibuted Clustering
WSN	Wireless Sensor Network

CHAPTER I

INTRODUCTION

1.1 INTRODUCTION

Wireless Sensor Networks (WSNs) are among the most significant technologies of the twenty-first century because they possesses computation, sensing and communication capabilities. However, they are limited in terms of energy, memory, transmission range and processing capability. Here, data loss occurs as a result of environmental and physical damage, power unavailability or obstruction.

In WSN, the reduction of rate of energy consumption and transmission of overhead can be achieved by generating an aggregated data alongside the data that is to be forwarded. The division of nodes into small groups referred to as clusters is possible, and the aim of this is to facilitate data aggregation within the network. The process of clustering involves the division of nodes into groups through the use of a specific mechanism. With the use of clustering, the lifetime of network which is a key indicator of sensor network performance, is improved.

There are many sensor nodes as well as cluster head that are found in each zone. Different tasks are performed by these different components which also try to establish a connection with the sink node.The use of sink node is employed in data collection and changing the position of the data randomly based on the mobility requirement. The mobility of sink node can occur in several directions such as diagonally within network, on top of network, the bottom of network and several other directions.Before the position of the sink is changed, it pauses for a given amount of time so as gather the data from the sensors that are within range; this is referred to as pause time. Within the pause period of time, a beacon frame is broadcasted by the sink to its neighboring node for the transmission of data packets.

After the data is sent by node, another beacon frame is sent by sink to end transmission which in turn decreases the drop-in packet. It is possible to extend the network lifetime if the traffic load of nodes is balanced by the sink. Thus, the shortest possible node is utilized in minimizing the traffic load.

Interaction does not occur among zones that are located close to one another, and this causes an increase in the consumption of energy. With this, there is need to conserve energy by connecting these nodes since they are stored by the smart grids; this also enables the increase in the network's reliability. The WSN system is illustrated in figure 1.1.

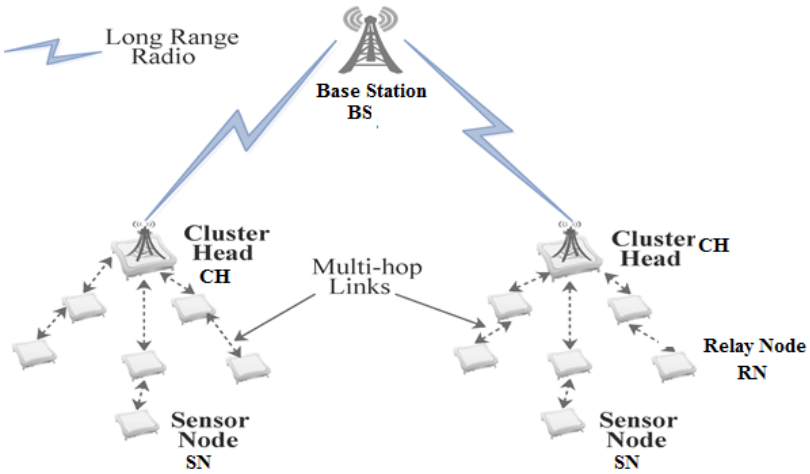


Figure 1.1 Wireless Sensor Network

(Ashwini & Asha 2017)

There are four major types of sensor nodes within cluster-based networks; these four types are derived based on the different roles played by the sensor nodes:

1. Cluster head (CH): this is an organized group of nodes found in the boundaries of the cluster. The cluster head is responsible for receiving, compressing and aggregating the data which has been sensed by the cluster members, as well as transmitting the data to the next hop.

2. Base station (BS): this is where all the aggregated data are processed and sent to the end user, because it is has an unlimited source of energy and high processing capabilities.

3. Relay node (RN): this node is also regarded as gateway node, because it is in-charge of relaying aggregated or sensed node towards the destination.

4. General node (GN): These are regarded as common nodes with the capabilities of sensing the physical environment and sending the data to their cluster heads (CHs) (Santar& Sharma 2015).

1.2 MOTIVATION

With the quick progress technologies of wireless communication, the attractiveness of Wireless Sensor Networks (WSNs) has fascinated the attention of both Academy and Industry in researching and developing promising and tremendous real life solutions during the last few years. Sensor-based infrastructure such as the Wireless Sensor Network (WSN) offers techniques for a promising Green Computing to enhance information collected on a specific environment to the end users.

A WSN is a powerful infrastructureless networking that is containing ten to some thousand independent low power sensors prearranged in an ad hoc manner. These sensors are capable of gathering and processing information from an environment, and communicating with each other.

In such networks, sensors are manually or randomly deployed in a physical environment which acts as the sensing layer of the Internet of Things (IoT) with a wide area of applications. The WSNs are typically used in both civilian and military applications to observe, instrument and react to an occurred event or phenomena, on a remote or inaccessible environment. These applications are both in tracking such as military strategies or seismic (earthquake) measurements; and in monitoring such as prevention of natural disasters or agricultural irrigation management.

In a WSN, each sensor is equipped with a sensing unit, a radio transmission module, a power supply, a processing and data storage devices. However, these components are designed with huge resource constraints like energy and processing capabilities. The limitation of sensor power supply is the main constraint in WSNs. In addition, due to the unattended and the hostile nature of the sensing environment, it is not easy to replace the batteries of thousands of deployed sensors. Therefore, the energy saving of sensors is a challenging issue that needs investigation in order to prolong the network lifetime from months to years.

1.3 PROBLEM STATEMENT

In most cases all sensor nodes of WSNs are battery-powered and located in the unattended or harsh environment. Battery replacement is difficult or even impossible for battery replacement. Once nodes energy exhausts, the node is disabled. It will affect the network operation and even split the network to shorten network lifetime. Therefore, in WSNs, network lifetime is the important indicator of network performance An important criteria for the extension of the lifetime and increase in the efficiency of wireless network sensor, is nodes energy. In hierarchal protocols in which the sink node is positioned in a fixed location due to disconnection of networks, the energy of nodes located close to the sink gets exhausted rapidly. The use of sink node can be employed under dynamic position for improving the energy balance throughout the network with the aim of prolonging the network lifetime and solving the aforementioned problem. The transfer of data that has been gathered from the sensors to the sink node can be done without high energy consumption. More so, the delay in relaying events can be avoided by means of an efficient routing. The previous method in is limited in terms of network transmission range. This is due to the fact that the GBCH algorithm is suitable for just large scale sensor networks. The benefits of packets scheduling are yet to be used in obtaining the ideal solution in terms of periodization of packets that are capable of causing large traffic load within the whole network; this consumes more energy. It is very important for scalability of WSN to be ensured, and the WSN must be able to handle node failures. In case of large scale of deployment, inherent features like heterogeneity and nodes mobility must be addressed.

The energy of nodes and distribution of energy consumption considered very important criteria to prolong the lifetime and increase the performance of wireless sensor network.

1. The hot spot problem which happened when the nodes closer to the sink are overburdened with the huge traffic load as the data from the entire region are forwarded through them to reach the sink node. As a result, their energy gets exhausted quickly and the network is partitioned.

2. The energy balancing problem caused the usage of energy not efficient in each node in the network to conserve energy and increased data transfer to the sink node, it is necessary to find the duration after which sensor node's role should be changed from CH to non-CH and vice-versa.

3. Short duration of the network lifetime because the energy consumption not distributed thateffect the performance of the WSN.

1.4 OBJECTIVES

The main objectives of the projectare to propose a grid-basedclustering techniquein WSN using hierarchical routing protocol. The specify objectives are explained:

1. To proposeagrid-basedapproach with random and static clustering in the WSN.

2. To implement two scenarios of grid-based clustering; random, and static clustering using hierarchical routing protocol.

3. To evaluate the performance of the two scenarios in term of network lifetime, the energy consumption, residual energy, and throughput.

1.5 SCOPE OF THE PROJECT

In this project, a WSN is used with two techniques (Grid Based random clustering and Grid Based Static Clustering designs) to develop, identify appropriate network design using hierarchical routing protocol with a comparison between the two scenarios, evaluate the performance of them under algorithms of them, for providing energy balancing inside the network by distributing the energy consumption among all the sensing nodes in the network. The system designs have been implemented under two different scenarios.

1.6 ORGANIZATION OF THE DISSERTATION

The contents of the remaining chapters of this project are as follows:

Chapter II: explain more details about literature survey wireless sensor networks are given, such as their architecture, characteristics, challenges, and application.

Chapter III: elaborate on the methodology used in this study in detail. In this chapter grid-based clustering under static and dynamic sink node position techniques are explained and compared to each other.

Chapter IV: dedicated to present the proposed designs for achieving appropriate network. This includes various scenarios aspects and algorithms being used. The software implementation details and simulation results of the grid-based clustering under static and dynamic sink node position are presented, discussed the result obtained from the simulation.

Chapter V: the last chapter in thisthesis to be concluded from the results that have been obtained and any future works that are suggested to develop our work.

CHAPTER II

LITERATURE REVIEW

2.1 INTRODUCTION

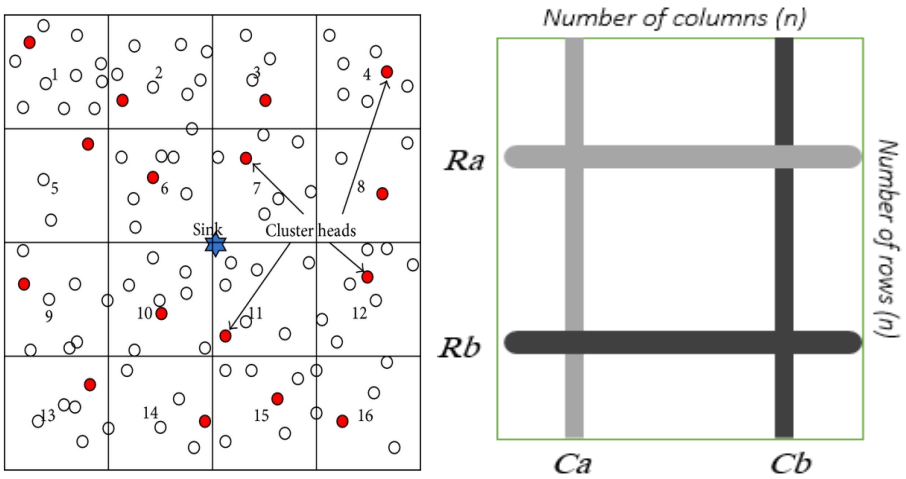
WSN which is described as a set of minute nodes, have received much attention from researchers due to its application in different domains. Without any supervision, these devices are capable of constantly reporting the parameters of an environment depending on the application. In order to facilitate the consumption of less energy, these minute nodes must make use of clustering because their energy is limited. This strategy will enhance a prolonged network lifetime. The use of node clustering is one way through which transmission overhead can be reduced in communication.

Prolonging the lifetime of the entire network has become a challenge which researchers must face and address. Some of the challenges that researchers are confronted with include Intracluster and Intercluster communication, as well as the rotation of CH and replacement (Shelpa&Pushpender, 2017).

2.2 GRID BASED IN WIRELESSSENSORNETWORK

The shape of a grid in network model is squared, and each of the square shapes are produced by the zone. Here, $n \times n$ represents the number of rows and columns. The top to bottom and left to right are the makeup of the grid. This simply means that the grid is made up of row s and columns. The rows start from the left side to the right side (n), while the columns start from the top and end at the bottom (n). Figure 2.1(b) is an illustration of the 2 x 2 grid-based network model. In the illustration, the rows are represented by *Ri*, and the columns are denoted by *Cj*(Pratibha & Laxmi, 2014). In Figure 2.1(a), the sensor network field that has been partitioned into grids is presented. A division of the network into equal sized non-overlapping square grids has been done,

with each of the grids having one node working at a time. The grid nodes cannot all work at the same time, as such, the nodes work one at a time so that the network lifetime is prolonged. It is expected that each grid will have one head node which is responsible for forwarding information about routing and transmitting data packets. Routing occurs in a grid-by-grid manner. The aim of using of the grid-based multi-path routing protocol is to facilitate fast packets routing, utilization and extension of sensor nodes energy. More so, this kind of routing protocol is used so as to hinder the occurrence of network congestion, or even to deal with network congestion if it occurs.



(a) (b)

Figure 2.1 Grid Topology (a) Grid in WSN (b) $n \times n$ Grid

(Pratibha & Laxmi 2014)

The use of clustering method was employed by (Wei et al. 2013) to arrange the nodes in the grid. The selection of cluster head is dynamic, and depends on cluster nodes energy dissipation. Afterwards, communication occurs between the head cluster and base station by a relay node. The algorithm is regarded as an algorithm that is effective in decreasing the consumption of energy by nodes, while increasing the system's lifetime. When the system lifetime is prolonged, network load balance can be achieved.

In a study conducted by (Banimelhem et al. 2014) a mechanism meant to help in regulating congestion was proposed. The mechanism is proposed to facilitate the

relieve of congestion in areas that are congested.Through the use of the algorithm, the network lifetime is prolonged, while the available storage can be used.

A joint priority-based algorithm network was proposed by (Zhibin et al. 2004) with the aim of eliminating congestion, while achieving weight balance in multi-hop and multipath wireless sensor networks. By using the proposed algorithm, the network lifespan can be increased, while the energy efficiency is increased. By so doing, the routing of packets prior to their deadlines is ensured. More so, the consumption of energy is reduced. In the subsequent section, previous studies related to multi-path routing and control congestion in WSNs are discussed.

A survey of extant literature reveals that most of the studies conducted in the past made use of different routing techniques and topologies to proposed methods of addressing congestion and delay problems in WSNs. However, all these techniques have their strengths and weaknesses depending on their applications. Information can be collected by placing the sensors in any part of an environment or a house, even though, the problem of high energy consumption rate remains a significant problem in WSNs. Therefore, it becomes tantamount to reduce the energy consumption, so that the performance of the network in relation to lifespan prolongation and sensor nodes decongestion can improved. With this, network load balance can be achieved. The sink receives a huge number of packets in mesh and in circular topology, and the most at grid. In theory, grid topology is considered to be more energy efficient as compared with other existing topologies.

In WSNs a trustworthy surveillance coverage and communication connectivity is provided by grid topology. It is possible to propose different techniques of source routing based on the proportion and predictability of the Grid topology (Wenxiang et al. 2014). Through the exclusion of overhead discovery route and maintenance of routing-table, the grid topologies thrive over on-demand or table-driven routing techniques. It is important to explore the best tactics for source routing so as to improve the performance of the network in terms of prolonged lifetime and decreased delay of transmission since the energy and capacity of each sensor node is limited.

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2.2.1 Grid Based Cluster Network Model

The sole aim of using a grid-based cluster in WSNs is to reduce energy utilization in each node by means of traffic load reduction. The grid-based cluster head performs the functions of dividing sensing filed into square grids of equal size, increasing network lifespan, facilitating energy efficiency and selecting the CH in each grid. There are two main phases involved in the proposed technique, and they are initial clustering and transmission of data. In the initial clustering, the grids are constructed, CHs are selected and TDMA is scheduled. In the transmission of data phase, packets are forwarded from the CHs to the destination. The different assumptions associated with WSN are given as follows, and subsequently, GBCHS is described (Khaled &Kamalrulnizam 2015).

(i) Random deployment of all nodes is performed and the do not change.

(ii) In the grid, every sensor node has the same initial energy.

(iii) The BS has knowledge of the location information of all the sensor nodes.

(iv) CHs are performing the task of sending members to BS.

(v) Communication occurs among all the nodes through the same radio medium.

(vi) By means of a common bidirectional wireless medium, all the nodes communicate with one another.

2.2.2 Grid Based Cluster Head Method

Khaled &Kamalrulnizam (2015)introduced an extensive description of the grid-based cluster is provided subsequently:

> Step 1: it is assumed that a random deployment of the number of sensor nodes (n) is carried outwithin the network sensing field. At the start of every simulation phase, BS receives the information about the location of all sensor

nodes, and subsequently, the proposed scheme initiates the process of dynamically partitioning the entire network field into *K*homogenous size square grids according to the size of the network and nodes that are deployed. The base station organizes the sensor field into rows and columns that have been uniformly divided in order to form equal sized grids. All the grids that are constructed have equal size, with each of them regarded as a single cluster. The CH is selected as the node that performs the task of forwarding aggregated data to a sink node or BS. This is done so as to decrease the consumption of energy by sensor nodes, monitoring communication. The construction of grid and formation of clusters only occurs once the entire life of the WSN, so as to minimize energy consumption and re-clustering of overheads.

Step 2: after the grids which are equally sized are constructed, the process of CHs selection by the GBHCS begins within grids begins. The process of this selection requires the participation of just few nodes because of grids construction. When only few nodes participate, the energy efficiency and network lifespan is increased.

Step 3: here, the mid-point of each grid is determined by the BS, and the distance of the sensor nodes from the mid-point is determined by the sensor nodes themselves. The GBCHS allots a priority ID to all the nodes and organizes them in a liner order. Lastly, the node which is considered to be the closest to the mid-point is chosen as the CH.

Step 4: an announcement is made by all the selected CHs about their local TDMA, so that they can receive and aggregate the data from the sensor nodes. When the time slot is received by each sensor, the sense data is then sent by each sensor to the CH.

Step 5: most of the energy efficient schemes that have been proposed consist of mechanisms and rounds used for periodic re-clustering. This enables the rotation of CH roles among sensor nodes so that balance in the consumption of energy can be achieved. Due to the fact that this approach shortens the lifespan of the network and increases the communication overheads, it is regarded as