UNIVERSITI PUTRA MALAYSIA

TDMA SCHEDULING ANALYSIS OF ENERGY CONSUMPTION FOR IOT WIRELESS SENSOR NETWORK

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By

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Thesis Submitted to the Faculty of Computer Science and Information Technology, Universiti Putra Malaysia, in Fulfilment of the Requirements of the Degree Master of Computer Science

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Chairman: Dr Amir Rizaan Bin Abdul Rahiman

Faculty: Computer Science and Information Technology

Wireless Sensor Network (WSN) is one of the most explored topics of research in the field of computer science for many years and recently it gets more concern because of Big Data, IoT and 5G robustness. WSN getting more concern because it is the only best and easy way to collect data, communicate between device to device and device to human. Cost effectivity, easy configuration and distribution makes it more reliable to the users. It builds the communication bridge between device to event and device to event. The most advantages of WSN is it has multi-hop and self-organizing capacity which made it an important element of widespread applications such as home automation, smart city, monitoring, especially important for military to do testing and monitoring war field. WSN nodes are very small in size but very important in term of work. The main option to power up the nodes is battery. Nodes life depends on the battery capacity. And sometimes it is not possible to change the battery easily depends on the area it distributed. Few factors played important role in WSN nodes power consumption. The routing distance always important, signal interference and the computation cost of the routing are the main factor of energy consumption of the node. Long routing distance take more power to transmit the data, signal interference and computation always consume high energy in WSN. So, battery power is limited and if so many wastages by the node for unnecessary things then the network life time will reduce and network performance will decrease time to time. Many new algorithms are implemented to reduce nodes energy consumption including Time division Multiplexing algorithm (TDMA) for scheduling to allocate neighbor and reduce signal interference, Distributed Randomize (DRAND) Time Division Multiplexing to do nodes random distribution and allocation. The base-work paper of the research presents an improvement of DRAND algorithm based on energy consumption in IoT WSN to enhance the node energy consumption and

increase the network lifetime. The algorithm use time division multiplexing algorithm together with hello message to allocate the neighbors and their energy level to find the best way to communicate and reduce packet drop, less signal interference and increase throughput. The major objective for this project is to re-implement the proposed Energy Topology DRAND (E-T-DRAND) algorithm in IoT WSN using time slot allocation method and allocate nodes together with the node energy information and compare the obtained results with the corresponding results in the base paper. Network Simulator NS2.35 is the tool used for simulation of the project. For the evaluation of the performance the parameters used are Energy consumption (Joules). The results in the trace files are analyzed by using the awk script. Finally, represent the difference between experimental results and the old results of E-T-DRAND will determine if the algorithm has been efficiently re-implemented.

Keywords: Wireless Sensor Network (WSN), Time Division Multiplexing Algorithm (TDMA), Scheduling, Energy Consumption, distributed time slot allocation, Node energy, Energy Factor, Broadcasting.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Sarjana Sains Komputer

TDMA SCHEDULING ANALYSIS OF ENERGY CONSUMPTION FOR IOT WIRELESS SENSOR NETWORK

Oleh

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Januari 2019

Pengerusi: Dr Amir Rizaan Bin Abdul Rahiman

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Pengesan Rangkaian tanpa wayar (WSN) adalah salah satu topik yang paling diterokai penyelidikan dalam bidang sains komputer selama bertahun-tahun dan baru-baru ini mendapat perhatian yang lebih kerana Data Besar, IOT dan 5G keteguhan. WSN mendapat perhatian yang lebih kerana ia adalah satu-satunya cara terbaik dan mudah untuk mengumpul data, berkomunikasi antara peranti ke peranti dan peranti kepada manusia. Kos efektifitas, konfigurasi mudah dan pengedaran menjadikan ia lebih dipercayai untuk pengguna. Ia membina jambatan komunikasi antara peranti untuk acara dan peranti untuk acara. Kelebihan yang paling WSN adalah ia mempunyai multi-hop dan keupayaan sendiri menganjurkan yang menjadikan ia elemen penting dalam aplikasi meluas seperti automasi rumah, bandar pintar, pemantauan, amat penting untuk tentera untuk melakukan ujian dan medan perang pemantauan. Pilihan terbaik dalam penghantaran data multi-hop adalah WSN. Nod dalam penggunaan WSN untuk memantau parameter alam sekitar, rakaman objek perubahan dan memindahkan data tersebut melalui saluran tanpa wayar stesen pangkalan atau unit pemprosesan utama. Oleh kerana kelebihan kebanyakannya nod diedarkan di kawasan global seperti lautan, kawasan berbukit dan kawasan berbahaya di mana manusia tidak boleh mencapai. WSN nod penggunaan kuasa. Jarak routing sentiasa penting, gangguan isyarat dan kos pengiraan routing adalah faktor utama penggunaan tenaga nod. jarak routing Long mengambil lebih banyak kuasa untuk menghantar data, gangguan isyarat dan pengiraan sentiasa menggunakan tenaga yang tinggi dalam WSN. Jadi, kuasa bateri adalah terhad dan jika begitu banyak pembaziran oleh nod untuk perkara-perkara yang tidak perlu maka masa kehidupan rangkaian akan mengurangkan dan prestasi rangkaian akan berkurangan semasa ke semasa. Banyak algoritma baru dilaksanakan untuk mengurangkan nod penggunaan tenaga termasuk Masa bahagian Multiplexing algoritma (TDMA) untuk penjadualan untuk memperuntukkan jiran dan mengurangkan gangguan isyarat, Diedarkan Randomize (Drand) Masa Division Multiplexing untuk melakukan nod pengagihan rawak dan peruntukan. Kertas asas-kerja-kerja penyelidikan itu memberikan peningkatan algoritma Drand berdasarkan penggunaan tenaga di IOT WSN untuk meningkatkan penggunaan tenaga nod dan meningkatkan jangka hayat rangkaian. Penggunaan algoritma masa bahagian pemultipleksan algoritma bersama-sama dengan mesej hello memperuntukkan jiran dan tahap tenaga mereka untuk mencari cara terbaik

untuk berkomunikasi dan mengurangkan kejatuhan paket, kurang gangguan isyarat dan peningkatan keseluruhan. Objektif utama projek ini adalah untuk melaksanakan semula dicadangkan algoritma ET-Drand dalam IOT WSN menggunakan masa pengagihan, slot dan memperuntukkan nod bersama-sama dengan maklumat tenaga nod dan membandingkan keputusan yang diperolehi dengan keputusan sama pada kertas asas. Rangkaian Simulator NS2.35 adalah alat yang digunakan untuk simulasi projek. Untuk penilaian prestasi parameter yang digunakan adalah penggunaan tenaga (Joule). Keputusan dalam fail surih dianalisis dengan menggunakan skrip awk itu. Akhir sekali, perbandingan antara keputusan eksperimen dan keputusan lama ET-Drand akan menentukan jika algoritma telah cekap dilaksanakan semula.

Kata kunci: Pengesan Rangkaian tanpa wayar (WSN), TDMA Penjadualan, penggunaan tenaga, peruntukan slot masa diedarkan, tenaga Node, Tenaga Factor, Penyiaran.

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Declaration

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APPROVAL FORM

This thesis was submitted to the Faculty of Computer Science and Information Technology of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Computer Science.

The members of the thesis examination Committee were as follows:

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LIST OF ABBREVIATION

IoT	Internet of Things
WSN	Wireless Sensor Network
TDMA	Time Division Multiple Access
DRAND	Randomize TDMA Scheduling
E-T-DRAND	Energy-Topology Randomize TDMA Scheduling
DSDV	Dynamic Destination-Sequenced Distance Vector
AODV	Ad-Hoc On-Demand Distance Vector
RREQ	Route Request
RREP	Route Reply
ZRP	Zone Routing Protocol
MAC	Medium Access Control
WSN	Wireless-sensor-network
NS2.34	Network Simulator 2.34
DTSS	Distributed TDMA slot scheduling
FPRP	Five-Phases Reservation Protocol
MRCI	Multiple Requests Cooperative-Integration

CHAPTER 1

INTRODUCTION

1.1 Background

The recent revolution of technology is Internet of things. IoT is the new era of technology. Internet of Things development connection between different platforms. Internet of Things is the main reason for interconnection and co-operation between cloud computing, mobile internet, distributed network and many more. IoT slowly overtaking the modern wireless telecommunications, it's a novel paradigm. The wireless sensor network is the medium between this interconnection and communication. At present, IoT is one of the most important technological revolution which cover almost every smart move of technology. IoT becomes the hearth of smart cities, smart homes, smart ports implementation, smart environment monitoring, smart factories. [1]

Recent years, advance technology making communication devices small to smaller with highly integrated but low power consumption. Sometimes those devices are including tiny microprocessors, energy supplies on small scale. [2] Wireless Sensor Networks (WSNs) is combination of advance micro devices that use to collect IoT data. It is cost effective, low power consumption, easy to implement with multifunctional wireless system. WSN is the bridge between physical space and information space. One of the greatest advantages of WSN is it can distribute over a large geographical area which can be even between two city or country or can be into the ocean to monitor events like earthquake, tsunami etc. WSN reduce work complexity and environmental limitation for the human in many sectors. WSNs become important for IoT network because of its convenient deployment and good scalability. But one of the main limitations of WSNs is the limited energy source. Wireless Sensor nodes only power option is small batteries which has limited life time. And it is hard to change or add new battery or energy resource due to the rugged environments and it makes energy consumption by the nodes and managing the limited power supply in a proper way become an important task for WSN-assisted IoT. [3] Therefore, WSN is one of the important parts of research direction. Researchers are working on achieving long life service and high reliability with real-time transacting of data. New technology moving forward to improve WSN because of its low cost, easy maintenance and easy to implementation over a large area. WSN system improving so fast because of its real-time processing system and easy deployment. The way of communication in WSN is often time and space correlated, this is why many nodes proximity start transmitting data at a same time. So, it is very important for Wireless Sensor Network to be stable and long-lifetime. And the biggest challenge for WSN is the stability. There are many reasons of nodes breakdown it can be because of changing network, power consumption, wireless signal interrupt. This problem

becomes new challenge for stable wireless sensor network with allocation and optimization of the time slot of Wireless Sensor Network.

With the advancements in new technology wireless sensor become one of the major parts of research. And IoT push researchers' interest into the higher level. Wireless Sensor Network is the most important part of the embedded system. Wireless Sensor

Network use as the bridge of communication between the physical space and information space which contribute a lot to agriculture, industry, transportation, military and medical etc. IoT becomes the new era of technology, it reduced the

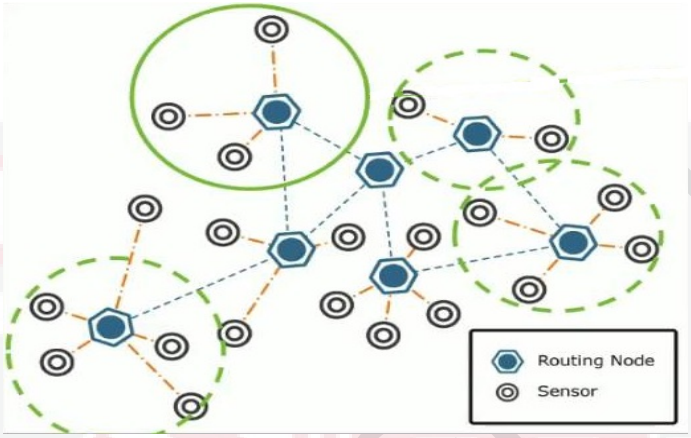

Figure 1: Distributed Wireless Sensor Network

complexity of long endurance, wide coverage work. WSN have the ability to work in the ruler or forbidden area for monitoring the environmental condition or an emergency condition. That is why in resource allocation and optimization WSN become an important part of the research for researchers to achieve good life time and high reliability. The reason for using wireless sensor network is it can deploy easily and the cost of the sensor is very low, it helps the WSN market to grow large to larger within a short time. In a large Wireless Sensor Networks, it is essential to have a good resource allocation rules/algorithm for maintaining the operation of the nodes. Forgetting the best performance from the wireless sensor it is important to make sure the network is stable. Network stability can interrupt because of power consumption, join or reject of the network, wireless signal interference or congaing of mobile nodes etc. Even sometimes dynamic changes of network topology bring challenges to the WSN to optimization and resources allocation in the network. The biggest challenge for WSN is the time slot allocation at the beginning.

In wireless communications energy, efficient low, high data rate network is a challenging topic nowadays. Because the sensor usually battery driven. On the other hand, Medium access control (MAC) protocol has been employed for WSNs to schedule the transmission process over the shared radio channel and exchange data among multiple sensor nodes effectively. Random based and schedule access based are the two main category of MAC protocols. Random access does not requir any clock

information to resolve contention between neighboring nodes for every data transaction. The performance under high contention suffers because of high overhead in resolving contention and collisions. [4] Message collision happens because of contention and this degrades the data transmission reliability and waste energy of the sensor nodes. The core component of the sensor network is slot assignment. If does not allow any collision then MAC protocol is contention free. Considering sensor nodes clock synchronized. Data transmission by nodes are scheduled to avoid interfering between nodes during transmission. Many works have been done on centralized scheduling in nature but it does not make the network scalable. To improve global topology in large IoT networks, many schemes have been proposed based on distributed slot assignment to improve IoT network as well as WSNs energy consumption.

1.2 Problem Statement

Everyday the number of WSN nodes increasing as much as IoT grows. Every real-time system depends on wireless sensors to collect data, monitor environment and take decision base on the event occurs. Because of many advantages of wireless sensor nodes military experiment and dangerous work like checking volcano, ware zone or deep ocean mostly use wireless nodes. The period of monitoring can be few days, few months or can be few years so the for large and long period network battery is the only way to power the nodes. But battery power is limited and sometimes changing node battery is not possible. So, if nodes consume lots of power the network life time will reduce together with network performance.

The mobility of the nodes and not proper time slot allocation makes the network complicated. The dynamic network topology of IoT network and unutilized neighbor nodes discovery resulting on transmitting more message than usual which cause more energy consumption and reduce network performance. Moreover, it known that battery draining fast is among the biggest limitation of Wireless Sensor Network nodes.

Many experts are working to get better performance from WSNs with time slot allocation topological adaptability. Many distributed time slot allocation algorithms have been proposed (Ex. DRAND, E-T-DRAND, FPRP, DTSS, RPL, DICSA and many more to improve WSNs performance together with energy consumption. DRAND works for randomly distributed nodes but the algorithm takes more time and energy to allocate neighbor nodes. E-T-DRAND algorithm is one of the proposed algorithms among other tested algorithms for slot allocation and reduce energy consumption. E-T-DRAND algorithm proposed based on DRAND algorithm in a mash topology with limited data link capacity. When it comes to mesh topology the network range is less than 30ft, but now a days industrial and experimental network range more than 100ft (like manufacture company, rural development monitoring, geographical network etc.). Those area required more reliable network to get correct

data. Even for smart traffic management system required long distance network to monitor vehicle movement. On the other hand, every technology moving forward to catch up with speed internet like 3G, 4G and developed country already started to test 5G communication. It is expected that 5G will cover every single network device within its coverage. So, it is important to check behavior of the algorithms with high speed internet. E-T-DRAND tested with 2Mbps datalink capacity which is not good enough for 3G or 4G network. 4G already using by more than half countries of the world. So, it is important to catchup with high speed internet to check the node energy consumption and how network perform with high data link.

1.3 Research Objective

IoT is hard-real-time communication between nodes to nodes or nodes to the central processor. WSNs is the medium to collect information. So, it is important to keep the nodes alert to get immediate response as well as make sure nodes can serve for long time. In this paper, our goal is to overcome the range limitation of mesh topology by analyzing E-T-DRAND algorithm into star topology with long range network and using 10Mbps or above datalink capacity. The reason behind analyzing E-T-DRAND algorithm is because this algorithm can allocate TDMA time slots without collision, can implement priority control algorithm and more over less message complexity which are helpful for reducing energy consumption and increase performance. The rest of the paper organized as follows second section discusses the related papers worked on TDMA scheduling algorithm in a distributed system. Section 3 discusses E-T-DRAND algorithm work mechanism analysis the algorithm performance. Section 4 thesis plan and time scheduling and section 5 Conclude the paper with related work references.

1.4 Scope

The project implemented is to perform an experiment base on simulation to study the E-T-DRAND algorithm and the improvement of energy consumption of devices based on energy topology and experiment algorithm behavior with high speed internet. The network simulator (NS2) will be used to simulate the model.

1.5 Research Motivation

This experiment is motivated to overcome the energy consumption and the slot allocation for wireless sensor network by applying E-T-DRAND algorithm. The only way to improve WSN is by improving energy consumption so can do more process, network lifetime will increase together with network performance.

1.6 Organization of Thesis

This research has five chapters. This first chapter provides a review of IoT and WSN and also presents a brief background of WSN nodes mechanism, Furthermore, this chapter presents the idea behind the research problem and the manner by which I have addressed it. I have also presented the research objective, scope and motivation in this first chapter. Brief description of the remaining chapters is presented below.

Chapter two provides a brief background on IoT and WSN nodes and also presents an explanation on the time slot allocation, neighbor node discovery, mechanism to save more energy on WSN nodes.

Chapter three presents the methodology and algorithm of the work and explanations of the used terminologies as well as software requirements and simulation parameters that have been sued for implementation.

Chapter four presents the proposed enhanced scheme of E-T-DRAND algorithm with its residual energy. It will also present the results of the simulation with implementation of the algorithm to do the comparison with the previous test result.

Chapter five presents the conclusion of the thesis and future work.

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