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INVESTIGATING IEEE 802.15.4 FOR WIRELESS BODY SENSOR NETWORK: THE PERFORMANCE EVALUATION

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INVESTIGATING IEEE 802.15.4 FOR WIRELESS BODY SENSOR NETWORK: THE PERFORMANCE EVALUATION

RABEI RAAD ALI

A thesis submitted
in fulfillment of requirements for the degree of Master of Computer Science
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2012

DECLARATION

I declare that this thesis entitle **INVESTIGATING IEEE 802.15.4 FOR WIRELESS BODY SENSOR NETWORK: THE PERFORMANCE EVALUATION** is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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DEDICATION

I would like to dedicate my thesis to my father and my mother who have supported me all the way since the beginning of my study. They never hesitated to provide me all the facilities to push me foreword as much as they can. This work is a simple and humble reply to them.

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الاهداء....

إلهي لايطيب الليل إلا بشكرك ولايطيب النهار إلى بطاعتك .. ولاتطيب اللحظات إلا بذكرك .. ولا تطيب الآخرة إلا بعفوك .. ولا تطيب الجنة إلا برؤيتك.

.....

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(وَقُلِ اعْمَلُوا فَسَيَرَى اللَّهُ عَمَلَكُمْ وَرَسُولُهُ وَالْمُؤْمِنُونَ وَسَتُرَدُّونَ إِلَى عَالِمِ الْغَيْبِ وَالشَّهَادَةِ فَيُنَبِّئُكُمْ بِمَا كُنْتُمْ تَعْمَلُونَ)

صدق الله العظيم (التوبة:105)

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LIST OF ABBREVIATIONS

Synopses	StandFor
ACK	Acknowledgement
BAN	Body Area Network
BASN	Body Area Sensor Network
BE	Backoff Exponent
BI	Beacon Interval
BO	Beacon Order
CAP	Contention Access Period
CCA	Clear Channel Assessment
CFP	Contention Free Period
CSMA/CD	Carrier Sense Multiple Access/Collision detection
CSMA	Carrier Sense Multiple Access
CSMA/CA	Carrier Sense Multiple Access/Collision Avoidance
CW	Contention Window
DES	Discrete Event-based Simulation
ECG	Electro Cardio Gram
ED	Energy Detection

EEG	Electroencephalography
EMG	Electromyography
EU	European Union
FCS	Frame Check Sequence
FDMA	Frequency Division Multiple Access
FFD	Fully Functional Devices
GSM	Global System for Mobile Communication
GTS	Guaranteed Time Slot
GUI	Graphical User Interface
IEEE	Institute of Electrical and Electronics Engineers
IFS	Inter-Frame Spacing
ISTAG	Information Society Technologies Advisory Group
JIST	Java In Simulation Time
LIFS	Long Inter-frame Spacing
LQI	Link Quality Indication
MAC	Medium Access Control
NB	Number of Backoff (periods)
NFC	Near Field Communication
NS2	Network Simulator version-2
PAN	Personal Area Network
PDA	Personal digital assistant

PHY	Physical layer
PPDU	Physical Layer Protocol Data Unit
PSDU	Physical Layer Service Data Unit
QoS	Quality of Service
RFID	Radio Frequency Identification
RFD	Reduced Function Devices
RMS	Root Mean Square
RS	Recommended Standard
SD	Superframe Duration
SFO	SuperframeOrder
SHR	Synchronization Header
SIFS	Short Inter-frame Spacing
SO	Superframe Order
TDMA	Time Division Multiple Access
TX	Transmit or Transmitter
USB	Universal Serial Bus
WBAN	Wireless Body Area Networks
WBSN	Wireless Body Sensor Networks
WLAN	Wireless Local Area Network
WPSN	Wireless Personal Sensor Network
WSN	Wireless Sensor Network

ABSTRACT

Wireless body sensor networks (WBSN) are a specially type of wireless sensor networks (WSN) have gained in recent years thanks to the development of innovative wearable, wireless and implantable biosensors tremendous international interest. The applications of WBSN extend from intervention to everyday healthcare and in-vivo monitoring and , also fitness, sport and security. This study provides a brief introduction to the 802.15.4 standard and investigates its use in WBSNs. WBSN applications require high reliability in data transfer, but I is not dense enough to ensure there is enough redundancy in the deployment of sensors to avoid the use of the confirmation messages reaching the level of the MAC. The simulation design in this project is focused on determining the performance of the Contention Access Period (CAP) protocol of the IEEE 802.15.4 standard in WBSN by employed to predict latency, energy consumption and throughput. As well as, the simulation is executed based on Markov chain under MATLAB tool environment. However, the simulation result shows how the energy consumption in WBSN networks experiences a high path loss, this uncovers one of the main problems of using IEEE 802.15.4 in a human body environment, that is the hidden node problem, which have a significant impact on the performance WBSN, both in terms of productivity and energy consumption that cant solved without increasing the transmitted power.

ABSTRACK

Jaringan penderia badan wayarles (WBSN) ialah satu jaringan istimewa seperti penderia wayarles (WSN). Terima kasih kepada pembangunan inovatif biosensors yang telah diperolehi dalam tahun-tahun kebelakangan ini, kerana ia amat sesuai digunakan wayarles dan juga boleh diimplan kepentingan hebat peringkat antarabangsa. Permohonan-permohonan WBSN dilanjutkan pengunaannya dari gangguan untuk setiap hari bagi penjagaan kesihatan dan pengawasan in-vivo begitu juga untuk kesukanan dan keselamatan. Kajian ini menyediakan satu pengenalan pendek bagi tahap 802.15.4 dan menyiasat penggunaannya dalam WBSNs. Permohonan-permohonan WBSN memerlukan kepercayaan yang tinggi dalam pemindahan data, tetapi ia tidak akan mencukupi ketebalannya bagi memastikan kelebihan sensornya yang mencukupi dalam penggunaan pengesan-pengesan bagi mengalak penghantaran mesej-mesej untuk mengesahan sampai tahap MAC. Reka bentuk simulasi dalam projek ini akan menentukan prestasi Contention Access Period (CAP) protokol IEEE 802.15.4 yang setaraf dalam WBSN untuk bekerjasama meramalkan kependaman, penggunaan tenaga dan daya pemprosesan. Simulasi ini juga akan mengikut semua dasar rangkaian Markov di bawah persekitaran peralatan MATLAB. Bagaimanapun , similasi tersebut telah menunjukan bagaimana penggunaan tenaga dalam jaringan WPSN mengalami satu kehilangan laluan tinggi, ini akan membuka satu daripada masalah utama penggunakan IEEE 802.15.4 dalam persekitaran kehidupan manusia, ia adalah masalah nod yang tersembunyi, begitu juga ia akan memberi kesan yang penting bagi prestasi WBSN, kedua-duanya mempunyai masalah produktiviti dan penggunaan tenaga di mana ia tidak akan diselesaikan tanpa penambahkan kuasa penyampaian.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Electronic embedded systems are pervasive or widespread; from mobile phones to cars, from alarm clocks to PDAs, every day; most of the appliances that we use are controlled by internal or embedded electronics. In relation with the recent advances in technology, in technology with the recent advances today, almost all of the microprocessors produced are used in such embedded systems, and recently the number of embedded systems in use has increased and developed. Ambient intelligence are reflects the vision that technology will be embedded, not only develop, it be fully hidden in our natural surroundings, and invisible, but present whenever we need it, enabled by easy interactions and simple (Basten, Geilen and De Groot, 2005). According to the EU Information Society Technology Program (ISTAG) the ambient intelligence has been defined as "the convergence of three major key technologies: ubiquitous computing, ubiquitous communication, and interfaces adapting to the user" (Benini, Farella and Guiducci, December 2006).

According to (Yick, Mukherjee and Ghosal, 2008) Wireless Sensor Network (WSN) technology is developing at a surprisingly high speed. Lots and many areas have begin to use the wireless sensor network technology and discover the features of WSN, such as environmental observing, smart home, military applications, forecasting system,

structure monitoring and medical care. (Lee and Chung, 2009) Referring that the scientific society as the prospect of environmental monitoring increasingly considers WSN, providing at a low cost the possibility to process after gather all sorts of data with a time and place decision unimaginable before, WSNs are out looked as a critical factor of the revolution of ubiquitous computing.

(Ahmed, Kanhere and Jha, 2010) defined WSN as a network of lots of sensor nodes, having communicate with each other through wireless channel. Without any predefined communication link and centralized control, WSN can transport signals to the external world. The nodes are able to be active as sink node or source at the similar time. Because of their tiny physical size, these nodes have a limited processing power, which limits the size of battery and capacity of processor. Those nodes have an ability to collect information of the physical environment, when collectively works mutually. Which mean a communicated between the virtual world and the physical world happen depend on the transceiver. Furthermore, based on the transmission power available at a nodes, the routing topology was be used for the network; as well as depends on the location of node, which may vary time to time.

(RÖMER, Mattern and Zurich, 2004) confirmed that current sensor network applications in ambient intelligence range from the industrial processes for tracking assets and people to the maintenance of buildings and the environmental monitoring of ecosystems, etc. Additionally, there are different requirements for each application domain and the nature of the problem based on restrictions. In this project will focus on one specific application, the application which driver depend on human body implantable sensors and wearable to monitoring of humans, that will be expand the role of such technologies in healthcare and to overcome new challenges from nature on human health. The important reasons for this choice are firstly for all of us, the human monitoring is an

extremely important field. Second, there are new challenges poses for the scope of human monitoring application such as security, low energy consumption and requisites for unobtrusiveness, etc. However, In fact, one of the WSNs types is Wireless Personal Sensor Networks (WPSN), which is becoming an important topic in the technological research community.

According to (Rodrigues, Pereira and Neves, 2011) defined the WPSN as a special purpose wireless-sensor network to enable remote monitoring in various environments that incorporates wireless devices and different networks. Medical environments are one of the targeted applications of WPSNs where conditions of a large number of patients are constantly being monitored in a real-time environment. One of the current needs is Wireless monitoring of physiological signals of a large number of patients so as to deploy a complete WSN in healthcare systems. WPSNs main goal is to provide biofeedback data, the ability to continuously monitor health parameters such as arterial blood pressure, heartbeat rate, body/intra-body temperature, in an efficient and unobtrusive way. As illustrated in Figure 1.1 the WPSNs consists of smaller, fewer opportunities for redundancy, less space covered, and less nodes. Unlike conventional WSNs.

Figure 1.1 Environment of WPSN

Moreover when working with the two to ten nodes typical of a WPSN the scalability can lead to inefficiencies. Adding path redundancy and sensor for network congestion problems and solving node failure cannot be a viable mechanism for a WPSN looking for to minimize resource usage and form factor; indicates that the hierarchical nature for WPSNs are a distinctly. Naturalistically that microprocessors should process to extract the needed information and they capture large amount of data constantly. Data processing must be hierarchical to ensure the availability of data, to maintain system efficiency, and exploit the asymmetry of resources, (Hanson et al., 2009).

WPSN technology has many potential applications, including wearable computing, medical sensing and control, identification and location awareness. In this area, the IEEE

802.15.4 standard was growth a response to support low data rate networks where latency; low power and bit rate are not so critical (Shrestha, Hossain and Camorlinga, 2011). The IEEE 802.15.4 MAC is since its ratification that has received much interest to assess energy performance and its throughput. In fact, that will spur the novel slotted access protocol featured in the Contention Access Period (CAP) particularly, as its beacon-enabled mode. Based on (Koubaa, Alves and Tovar, 2006) there are many preliminary simulation studies were conducted, and introduced a several accurate analytical models. In particular, the finalization of the IEEE 802.15.4 standard the development of those applications has been stimulated, which defines the physical layer (PHY) and MAC for low-rate wireless personal area networks, Figure 1.3 show the device architecture for IEEE 802.15.4.

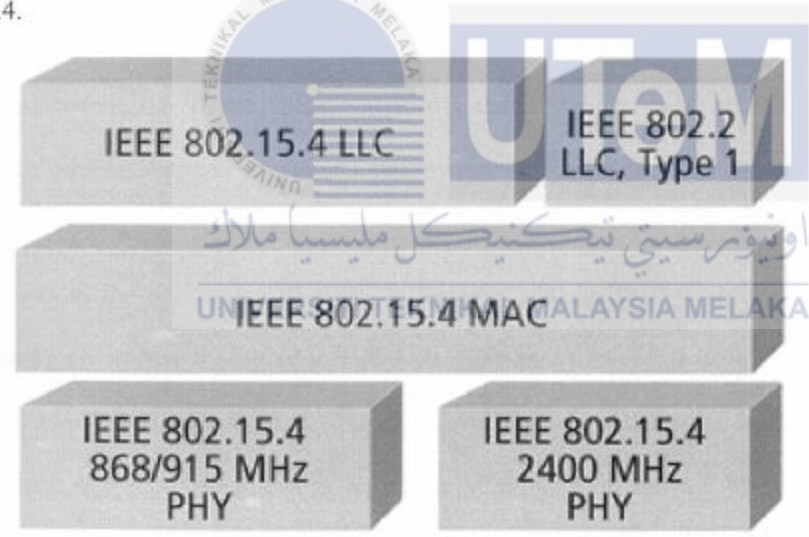

Figure 1.2 IEEE 802.15.4 Device Architecture

Slotted Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) is one of the MAC schemes proposed (Ndih, Khaled and Micheli, 2009). Through This project will analyzes the performance of MAC; Markov chain models will monitoring the behaviour of the MAC by using two sub model the channel state model and the per-node