WIRELESS BODY TEMPERATURE MONITORING FOR BIOMEDICAL APPLICATIONS

BY

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LIST OF ABBREVIATIONS

AP	Access Point
ADC	Analog to Digital Converter
CPU	Central Processing Unit
CT	Current Transformer
DBT	Deep Body Temperature
DL	Destination Address Low
DC	Dissipation Constant
DH	Destination Address High
ECOS	Embedded Configurable Operating System
GPRS	General Packet Radio Service
HART	Highway Addressable Remote Transducer PROTOCOL
IPV6	Internet Protocol Version 6
LCD	Liquid Crystal Display
LOS	Line-of-Sight
MCES	Mobile Comprehensive Emergency System
P2P	Per 2 Per
TSIC	Sensor for Converting The Digital Signal
PEROM	Programmable And Erasable Read Only Memory
RS485 or CAN	Controller Area Network

PAN	Personal Area Network
RF	Radio Frequency
RAM	Random-Access Memory
WLAN	Wireless Local Area Network
WSN	Wireless Sensors Network
WBAN	Wireless Body Area Network
WIFI	Wireless Fidelity (IEEE 802.11)

PENGAWALAN SUHU BADAN TANPA WAYAR UNTUK APLIKASI BIOMEDIK

ABSTRAK

Secara global, perkhidmatan komunikasi tanpa wayar kini digunakan secara meluas dalam persekitaran penjagaan kesihatan seluruh dunia. Sebagai kesannya, wujud keperluan untuk menyediakan perkhidmatan komunikasi berkualiti untuk menyukat suhu tubuh pesakit berasaskan teknologi tanpa wayar. Komputer riba yang berkelengkapan tanpa wayar semakin meluas penggunaannya. Nodus pengesan bergerak atau yang lain-lain dengan capaian tunggal dari satu AP (titik capaian) ke AP yang lain telah menyerlahkan kebergunaan pengesan-pengesan ini dalam menghantar dan menerima data. Kajian ini telah meninjau dan mengulas rangkaian pengesan biologi tanpa wayar yang berbeza dengan menyatakan kelebihan dan kekurangan sensor ini dalam memantau suhu tubuh badan. Kajian ini mendapati pelantar Zigbee menghasilkan prestasi komunikasi yang tinggi untuk sistem pemantauan tanpa wayar. Litar yang dikemukakan ini membantu menghasilkan amaran awal daripada isyarat yang duterima daripada tubuh pesakit. Sebagai tambahan, litar yang dikemukakan mempunyai keupayaan untuk menentukan suhu pesakit dalam status masa-sebenar di hospital. Kajian ini menyatakan keperluan peralatan dan perisian untuk pemantauan suhu tubuh tanpa wayar yang dicadangkan berasaskan tanpa wayar Zigbee, mikropengawal AT89C52, dan pengesan suhu (100K6A1A) untuk memenuhi keperluan bioperubatan. Akhirnya, cadangan reka bentuk telah mencapai prestasi yang dapat diterima dari aspek ketepatan suhu (±0.3 C), jarak liputan maksima dalam bangunan (49 m), dan kecekapan 100% penerimaan data dalam komunikasi pelbagai-tag.

WIRELESS BODY TEMPERATURE MONITORING FOR BIOMEDICAL APPLICATIONS

ABSTRACT

Globally, wireless communication services are now widely use in the worldwide health care environments. Consequently, there is a need to provide quality of communication services to measure the patient's body temperature based wireless technology. The notebook computers equipped with wireless are becoming widespread. Mobile or other sensors nodes with a single accessing from one AP (access point) to another AP have addressed the usefulness of these sensors in sending and retrieving data. This research has studied and reviewed different biological wireless sensors network by addressing the advantages and the disadvantages of these sensors for monitoring the body temperature. This research found that ZigBee platform provides a high communication performance for wireless monitoring systems. The proposed circuit is helping on generating early warnings from the received signals of the patient body. Moreover, the proposed circuit has the ability to determine the patient's temperature in real-time status inside the hospital. In addition, the adopted hardware and software requirements for this research were consisted on ZigBee wireless, AT89C52 microcontroller, and temperature sensor (100K6A1A). Finally, the proposed design has achieved acceptable performance in terms of temperature accuracy (±0.3 °C), maximum indoor coverage range (49 m), and 100% receiving data in multi-tag communications.

CHAPTER ONE

INTRODUCTION

1.1 Overview

This chapter majorly covers the prime idea of this research for monitoring the body temperature over wireless services. It also elaborates the reasoning of the research conducted and the involvement of the main element in the research. The first phase enlightens the overall idea of this study through the introduction and motivation which led to the implementation of the whole project. The next topic discussed the problem statement, objectives and motivation of the research. However, the last topic elaborated the way of this research is organized.

Deploy a sequence monitoring application is requiring to identify the diagnosis, and preventing risky disease within different healthcare environments. Patient's status is remotely monitored and reported by designing and developing wide range of wireless communication channels. This kind of communication justify the need for such services which provides cheaper and smarter way to manage and in addition also care for patients suffering from age-related chronic diseases (Lubrin, Lawrence, & Navarro, 2005).

Regardless of temporal and spatial constraints, wireless network services differ from traditional services in their ability to provide service offerings that are delivered through per-to-per or from other types of e-services. Few examples such e- services are online services, where the service delivery is linked to a specific fixed local area network or specific assigned location. Rather than a technology perspective or formal classifications or categorizations (Yuan-Hsiang, et al., 2004), an increasing number of academic researchers are starting to focus on wireless services as a part of service management perspective. Therefore the use of wireless communication in different health measurements sector has been coined to denote the ways in which communication technologies can be applied. In addition, this also address the health issues especially as it relates to patients and doctors that need to access a varied range of applications and services through wireless access devices.

Health monitoring systems as on date use several techniques such as “Bluetooth” as the wireless communication protocol and “Wireless technology (WiFi)” as a P2P communication protocol (Rigby, 2007). Furthermore, within full duplex identification, ZigBee is one of powerful wireless communication services for sending and receiving the data. This kind of services (ZigBee) has a high dependency on wireless body area network (WBAN) in measuring the body temperature, based upon wireless body area network components structure. WBAN in healthcare system enables continuous physiological signal monitoring. In addition, it also supports health consulting information anywhere and anytime (Akyildiz, Su, Sankarasubramaniam, & Cayirci, 2002). Moreover, Wireless Sensors Network (WSN) presents multi nodes classification for ad hoc network which could be used along with other communication services. The Biomedical sectors provide a reliable monitoring and analysis of the medical status along with Healthcare systems. In addition to one or more sensors, each node in a sensor network is typically equipped with following: a radio transceiver or other wireless communications device, a small microcontroller and an energy source which is usually a battery. Depending on the size of the sensor network and the complexity required of individual sensor nodes, the cost varies ranging from few cents to hundreds of dollars (Lubrin, et al., 2005; Romer & Mattern, 2004).

Wireless services such as, 100K6A1A, a sensor used for analog signal within accuracy from ±0.25°C to far below ±0.1°C and also medium (0.1°C) to high (0.034°C, 0.004°C) signal resolution for optimal temperature control (Jianchu, Schmitz, & Warren, 2005), has been used for this study. In addition with minimum overload, this research has generated customized IEEE 802.15.4 standards requirements for its reliable wireless communication. For continuous monitoring of patients outside the healthcare grid (Akyildiz, Su, et al., 2002), this research has evaluated several RF devices and techniques for remotely measuring body temperature.

1.2 Problem Statement

Telecommunications market and healthcare systems are being pushed by wireless system and the internet for supporting these environments with the appropriate communication needs. Consequently, there is a need to provide quality of communication services to measure the patient's body temperature. Mobility is provided by the user through mobile or other sensor nodes that connect from one AP (access point) to the other AP while connecting to the internet. However, inefficient signal transfer (Digital signal) has been extensively addressed through the current difficulties in determining the patient's body temperature over different wireless communication means. In addition, based on single parameters devices, it has been recognized that the traditional wireless sensors are unable to deliver the exact patient's body temperature.

Moreover, another loophole of current measurements and monitoring services is the disability in providing a sequence measurement of body temperature (Chengcheng et al., 2009).

This means, that only a few detail of body temperature such as humidity, sound, vibration, pressure, and motion are delivered within wireless body network devices. Most of these devices work on measuring the incoming patient signal from other monitoring devices which sometimes result in difficulties in identifying the patient status during the movements. Specifically, measuring the body temperature based WSN is remotely unable to determine the vital signs of the patient body. In addition, it is unable to monitor the patient status especially when the patient moves around and also unable to provide a high level of communication.

The study has reviewed and compared a different accuracy levels from (Xinbo and Guanbao, 2008; Chengcheng et al., 2009; Nabil Hamza, 2009), the accuracy level in these studies were lacked to provide a high and reliable accuracy during the measurement of patient temperature, which effects on observing and monitoring the exact body temperature with a high level of accuracy. From the other hands, the measurements in these studies were obtained manually. Thus, this study aimed to provide a reliable and high level of accuracy to measure the body temperature automatically and sequentially.

1.3 Research Objectives

Using wireless technology, this research generally aims to design and develop a body temperature monitoring system via wireless technology. By leveraging wireless technology, the proposed monitoring circuit been made by combining several signal parameters. Following are the particular aims of this research:

- To design a sequence monitoring application based on wireless ZigBee technology platform for measuring the body temperature embedded with RFID functionalities.

- To implement the proposed monitoring application to measure the body temperature sequentially.

- To analyze the performance of the proposed circuit in monitoring the body temperature in real world environment in term of coverage and power usage measurement and temperature sensing capabilities.

1.4 Standard of Main Hardware Requirements

1- XBee 2.4 GHz

XBee modems are one of the easiest ways to create a wireless point-to-point or mesh network. They have error correction, are configured with AT commands and the communication module is selected due to its High performance, low power, low cost and Advanced Networking and security.

- Power output: 1mw (0dbm) international version.
- Indoor/Urban range: Up to 100ft (30m).
- Outdoor/RF line-of-sight range: Up to 300ft (90m).

- RF data rate: 250 Kbps.
- Interference data rate: Up to 115.2.
- Operating frequency: 2.4 GHz.
- Receiver sensitivity: -92dbm.

2- Medical temperature sensor.

Medical temperature sensor helps to measure the body temperature due to its small size, low cost and fast response.

- DC (Dissipation Constant) = 0.75 mw/ºC typical in still air at 25 ºC.
- Tight tolerance available ±0.1 ºC from 0 ºC to 70 ºC.
- Min/Max temperature exposure = −80 ºC to + 150 ºC.

1.5 Scope and Limitation

The scope of this research carries the mixture of wireless sensor with the hardware devices to produce an accurate result for measuring and monitoring the body temperature

Nevertheless, the research limited to wireless devices, without considering the network infrastructure.

1.6 Thesis Outline

For this research, the first chapter is begins with the introduction section out of the five chapters. This chapter explains in detail about the background of the research and the research problems that need to be solved. This gives adequate motivation to this research. The objective, scope and chapter summary have been identified and described. Based on chapter one's introduction, an overview of the content of the following chapters is necessary for the understanding of concept used in later chapters and overview of the research. Chapter two discusses about literature reviews, previous related work, and more information to understanding the research. Chapter three is discussing the methodology that has been used in this project. Chapter four concentrate the design, development and result phase of the proposed system. And finally, chapter five discusses on conclusion of this research.

1.7 Summary

Based on the area studied, the first chapter gives the insight of the project by describing the motivation factors. It also explains the objectives of conducting the study, as well as its significances to the real world situation. These elements are extremely important as it ignites the implementation of the project. This research focused on monitoring the patient's body temperature over wireless technology by using 100K6A1A sensor and the modified ZigBee Wireless Module Series 1 meet IEEE 802.15.4 standard and support unique characteristic needed to be involved in this research. The next chapter deals with the literature review which elaborates on related works that have been established in the same field.

CHAPTER TWO

LITERATURE REVIEW

Chapter two presents the literature review of the area of the project studied. Conceptually, it gives an insight or reviews on the previous and existing works that have been conducted on the same area. This chapter is organized in two sections of subtopics according to the title of the project that deals with the circuit components, which consists of the deployed sensor and the microcontroller. The first sections reviews on the wireless sensors network (WSNs) technology and the implementation of this technology in today's life. In addition it covers those existed during earlier days. Previous and related works in relevant fields as a part of subtopic is covered in last chapter.

2.1 Introduction

Nowadays, wireless technology usage in different communication sectors helps to determine the functional requirements for deploying the different application based channels communication. However, for applications such as machine manufacturing, process automation, automotive, aerospace/military/homeland security, and specialty markets (Fergus, Kifayat, Cooper, Merabti, & El Rhalibi, 2009), wireless sensors are being used and integrated in different health sectors. Furthermore, for reporting the patient's temperature status, wireless sensors are used as a monitoring tool in the medical sectors. In addition, WSN used along with other sectors such as; engineering/architectural, R&D, wholesale/retail utilities, and many more (Akyildiz, Weilian, Sankarasubramaniam, & Cayirci, 2002).

Recently, enhancements in embedded computing systems have brought the abilities of developing different monitoring application to the emergence of wireless sensor networks, consisting of small, battery powered with limited computation and radio communication capabilities (Milenkovic, Otto, & Jovanov, 2006). Based on certain distributing algorithms, the classification of the wireless network in these sectors justifies the need for sensors to monitor and execute several computing operations. Most of these wireless sensors are deployed successfully in the physical environment (Buckland et al., 2006). Wireless sensors network has the potential to showcase the further development in the communication and controlling sectors. This has potential to impact the delivery and study of resuscitative care by allowing vital signs of a person to be automatically collected and fully integrated into the patient care record which can be further used for real-time triage, correlation with hospital records, and long-term observation (Callaway, et al., 2002).

2.2 Body Temperature Monitoring System

Many applications in areas such as entertainment, travel, retail, industry, medicine, care of the dependent people, emergency management and many others can be potentially changed using wireless sensor network technology. This includes wireless sensors and sensor networks, pervasive computing, and artificial intelligence research which all together have built the interdisciplinary concept of ambient intelligence (AmI) in order to overcome the challenges we face in everyday life (Cook, Augusto, & Jakkula, 2009). Continuous elderly population increase in the developed countries has been one of the major challenges of the world for the last decade. In the next 20 years as per forecast of Population Reference Bureau, 65-and-over population in the developed countries will be nearly 20% of the overall population. Hence the important issue is to delivering quality care to a rapidly growing population of elderly while reducing the healthcare costs. One promising application in that area is the integration of sensing and consumer electronics technologies which would allow people to be constantly monitored (Schmidt & van Laerhoven, 2001).

Residents and their caregivers assist by providing continuous medical monitoring, memory enhancement, control of home appliances, medical data access, and emergency communication (Stanford, 2002), by using In-home pervasive networks. Constant monitoring will increase early detection of emergency conditions and diseases for patients who are at risk. In addition it also provides wide range of healthcare services for people with various degrees of cognitive and physical disabilities (Stankovic et al., 2005). These systems derive benefits not only for the elderly and chronically ill but also for the families in which both parents have to work. In addition, these systems will derive benefit for delivering high-quality care services for their babies and little children.

Researchers in computer, networking, and medical fields are working together in order to make the broad vision of smart healthcare possible. Researchers have already addressed the importance of integrating large-scale wireless telecommunication technologies such as 3G, Wi-Fi Mesh, and WiMAX, with telemedicine. Further improvements will be achieved by the coexistence of small-scale personal area technologies like radio frequency identification (RFID), Bluetooth, ZigBee, and wireless sensor networks, along with large-scale wireless networks to provide context-aware applications (Ng, Sim, Tan, & Wong, 2006). The development of unobtrusive small sensor devices enabling not only provides accurate information but also reliable data delivery which is of significant importance. Besides, this also provides pervasiveness with existing and relatively more mature wireless network technologies. Moreover, the glue combining all these technologies is the application, which is the coordinator between the caregivers and the caretakers (Mcfadden and Indulska 2004). This also connects between the sensor devices and all of the actors in the overall system cycle. Since the application is the core of the high-quality healthcare service concept, the need for intelligent, context-aware healthcare applications will be increased.

2.3 RFID (Radio Frequency Identification)

2.3.1 Reviews on RFID

RFID is a flexible technology that is convenient, easy to use, and well suited for automatic operation and it also combines advantages not available with other identification technologies. RFID can be supplied as read-only or read/write and does not require contact or line-of-sight to operate, can function under a variety of environmental conditions, and provide a high level of data integrity. In addition, RFID provides a high level of security because the technology is difficult to counterfeit. RFID and Bar coding are similar in concept. Bar coding systems use a reader and coded labels that are attached to an item, whereas reader and special RFID devices that are attached to an item is used for RFID. While, Bar code uses optical signals to transfer information from the label to the reader, RFID uses RF signals to transfer information from the RFID device to the reader. Radio waves transfer data between an item to which an RFID device and RFID reader is attached. RFID devices, such as tag or label, can be attached to virtually anything from a vehicle to a pallet of merchandise.

Frequency, within the range of 50 kHz to 2.5 GHz is used for RFID technology. They typically include the following components:

- An RFID device (transponder or tag) containing data about an item.
- An antenna used to transmit the RF signals between the reader and the RFID device.
- An RF transceiver that generates the RF signals.
- A reader that receive RF transmissions from an RFID device and pass the data to a host system for processing.

2.3.2 RFID Technology

2.3.2.1 Types of RFID Tags

Based on power source, active tags, passive tags, and semi-passive (semi-active) tags are the three major categories for RFID classification. An active tag contains radio transceiver along with a battery that is used to power the transceiver. A passive tag contains the RF signal transmitted to it from a reader or a transceiver and adds information by modulating the reflected signal. The passive tag discards use of any battery to boost the energy of the reflected signal (Chiesa et al., 2002). Each passive tag contains an antenna needed to collect electromagnetic energy in order to wake up the tag and to reflect (backscatter) the portion of the energy back to the reader. In addition, tags have transmitter/receiver circuits, power generating circuits and the state machine logic. The state machine logic is needed to follow the RFID protocol and support communication between the reader and tags. Similar to passive tags, for purpose of transmission, semi-passive tags use the radio waves of senders as an energy source. However, a semi-passive tag may be equipped with batteries to maintain memory in the tags or power some additional functions. Active tags are comparatively more powerful than passive tags/semi-passive tags. As an example, they have larger range/memory and more functions but equally more expensive than passive/semi-passive tags.

RFID tags can also be classified into two categories: tags with read/write memory, and tags with read-only memory based on memory type. As their names imply, the tags with read/write memory allow both read and write operations on the memory. In contrast, data in the tags with read-only memory cannot be modified after the manufacturing process. The tags with read/write memory are more expensive than the tags with read-only memory.

2.3.2.2 Radio Frequency

There are three frequency ranges for RFID tags to operate: low frequency (LF, 30–500 kHz), high frequency (HF, 10–15 MHz), and ultra high frequency (UHF, 850–950 MHz, 2.4–2.5 GHz or 5.8 GHz) (Jechlitschek, 2006). Because of the presence of fluids or metals when compared to the higher frequency tags, LF tags are less affected. LF tags are fast enough for most applications and are also cheaper than any of the higher frequency tags. However on flip side, LF tags have shorter reading ranges and low reading speeds. Applications of LF tags are typical in nature and include access control, animal identification and inventory control. The most common frequencies used for LF tags are 125–134.2 kHz and 140–148.5 kHz. HF tags do have medium transmission rates and ranges but then are equally more expensive than LF tags. Applications of HF tags which are quiet typical in nature includes access control and smart cards. The most common members of this group, working at 13.56 MHz are the RFID smart cards. UHF tags have the highest transmission rates and do range among all tags. They range from 3 to 6 meters for passive tags while it is more than 30 meters for active tags. The reading of a single tag is possible in a very short time due to the high transmission rates of UHF tags. This feature is of high importance in the application where tagged objects move very rapidly and remain within a reader's range only for a short time. However, fluids and metals severely affect UHF tags. Because of these unique properties, application of UHF tags is most appropriate in automated toll collection systems and railroad car monitoring systems. UHF tags are more expensive than any other tag. The typical frequency of UHF tags are 868 MHz (Europe), 915 MHz (USA), 950 MHz (Japan), and 2.45 GHz. While frequencies of LF and HF tags are exempted from license and can be used worldwide, frequencies of UHF tags require a permit and vary from country to country.

2.4 Wireless Sensor Network

2.4.1 Wireless Sensor Network Overview

Detecting or retrieving signals over single and multi point presents the development of communication. This further supports sensor technologies to detect such signals and translate the signal units based on the client side point of view. Wireless sensor network (WSN) has been emerged as a promising tool for real-time data collection and control in agricultural sector (Chung-Ping, Wei-Lun, & Devaney, 2000). WSN helps in achieving precise monitoring of various field conditions and the environment of greenhouse or animal facilities. Applications of WSNs in the area of agriculture include automated irrigation management, greenhouse control, and web based sensor network for field servers (Gonda and Cugnasca 2006) Figure 2.1 elucidated the Wireless Sensors Network Architecture.

2.4.2 WSNs Applications

The rapid development in providing wireless application along with the recent enhancement for serving different sectors with the require connection has involved several integration of application in WSNs. Wireless sensors network determine some issues regarding temp monitoring, tracking or controlling (Hayes, Crowley, & Diamond, 2005). However, applications based wireless technology represents the specific need to monitor, track objects, nuclear reactor control, fire detection and traffic monitoring (Crowley, Frisby, Murphy, Roantree, & Diamond, 2005). In a typical application, with help of sensor nodes, WSN is scattered in a region where it is meant to collect data (Zhao and Guibas 2004) as shown in Figure 2.1.

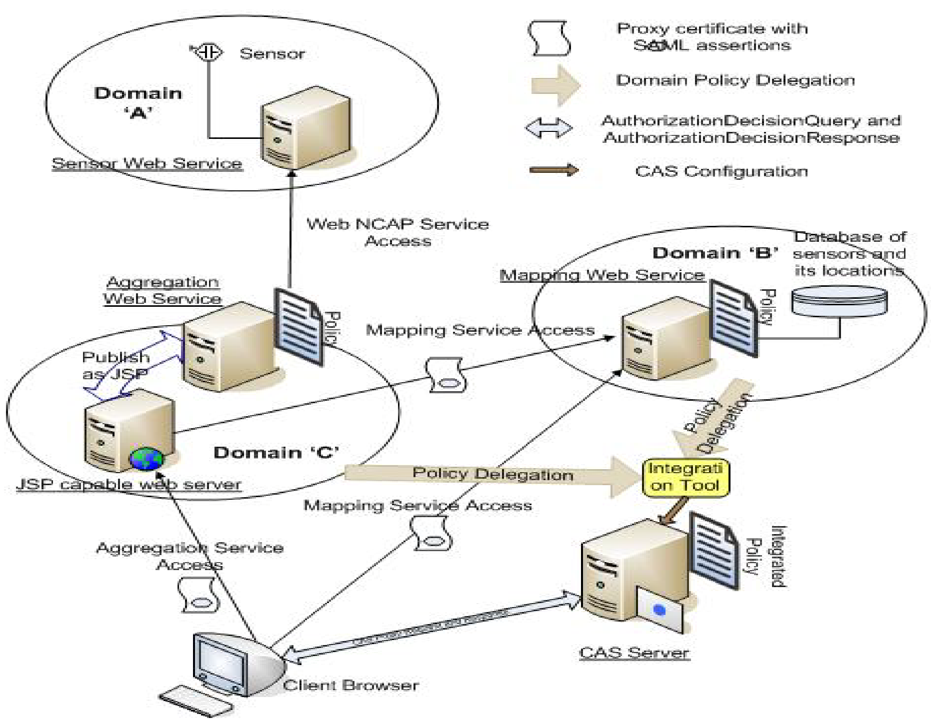

Figure 2.1: Wireless Sensors Network Architecture (Callaway, et al., 2002)

2.4.3 WSNs Area Monitoring

WSNs deliver the signal between two points. The signal presents a large quantity of sensor nodes, which focuses on determining the incoming signals and analyzes its object based signal components (Sapaty, Sugisaka, Delgado-Frias, Filipe, & Mirenkov, 2008). The workflow of deploying WSN starts its workflow deployment when the sensor is being monitored or detected (heat, pressure, sound, light, electro-magnetic field, vibration, etc) after detecting the incoming signal. The detected signal begin reported to one of the base stations and during such a stage, sensor will take in account an important step (e.g., send a message on the internet or to a satellite) (Schiller, Liers, Ritter, Winter, & Voigt, 2005). Different objective functions will require different data-propagation strategies depending on the exact application. It is also depending on things such as need for real-time response, redundancy of the data (which can be tackled via data aggregation and information fusion techniques), need for security, etc (Fan, Zhong, Cheng, Songwu, & Lixia, 2003).

2.4.4 WSNs Environmental Monitoring

Wireless sensors network are widely used to help and support different sectors and environments for monitoring/tracking signals over network connection. Figure 2.2 presents the implication of WSNs in the complex network, which customized for environmental communication needs (Roundy et al., 2003). Often due to the prototype nature of the projects, many of these have been short lived.

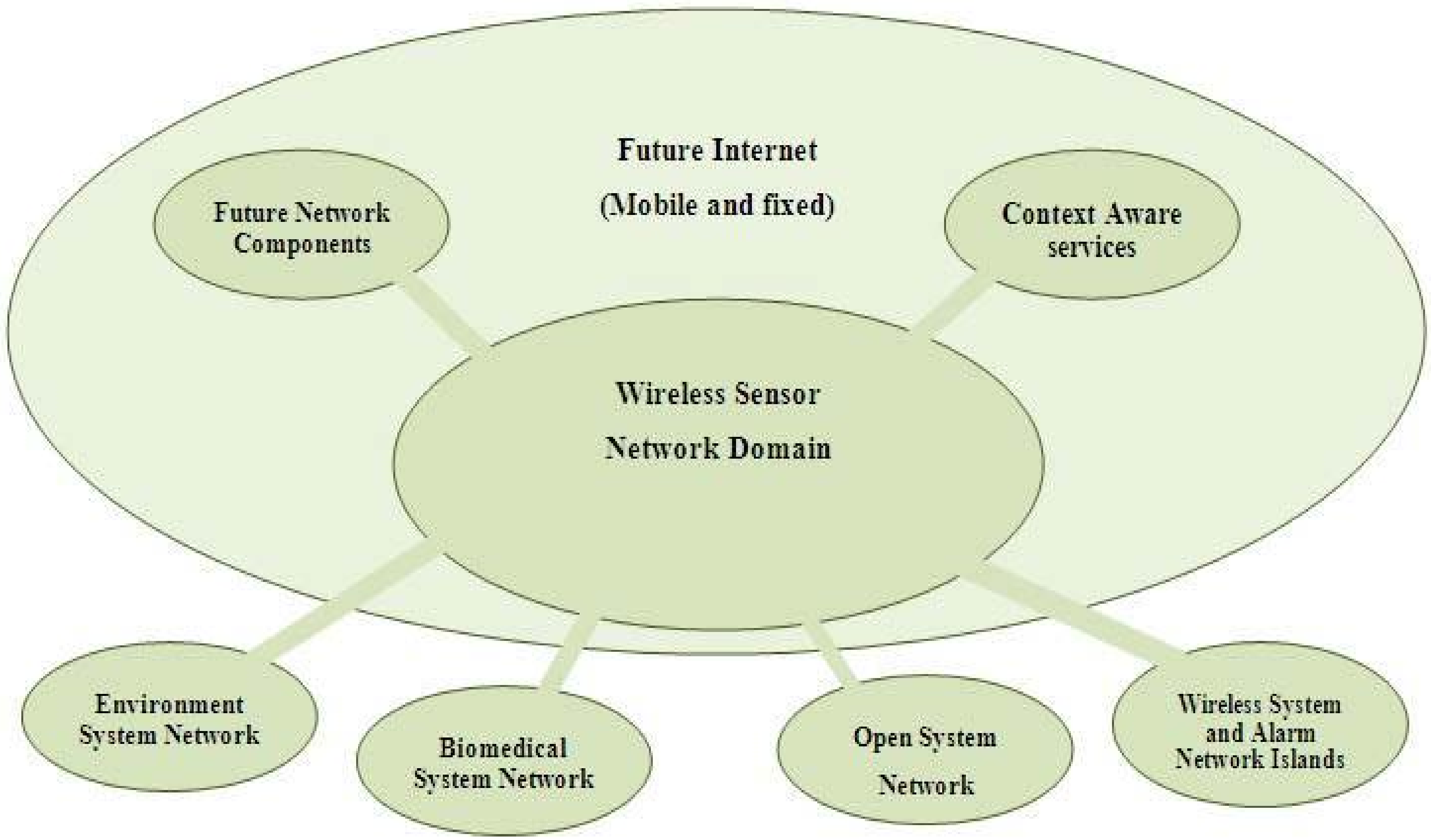

Figure 2.2: WSNs Environments (Roundy et al., 2003)

2.4.5 WSN Standards

For Wireless sensor network, several standards are currently either ratified or under development. There is also several classification of translating the received signal through different channels which kind of reflects the non-standard, proprietary mechanisms and specifications around (Pradhan, Routray, & Behera, 2006). An example of WSN is EnOcean. Based on hardware ports, this system addresses the communication in the building automation world by sending data to multi points. This system identify the required connection for certain standard with any of the generally approved standardization bodies (Anis Ibrahim & Morcos, 2001).

2.4.5.1 ZigBee Standard

ZigBee is a wireless sensor network. This module has been specifically engineered to meet ZigBee/IEEE 802.15.4 standards. In addition it also addresses the unique needs of low-cost, low-power wireless sensor networks. Between devices, the module requires minimal power and provides reliable delivery of critical data. Moreover, ZigBee is known for its modern representation for mesh-networking. It particularly focus on application such as embedded sensing, medical data collection, consumer devices, and home automation (Xu & Saadawi, 2001). This system has been provided by different industry players for serving small and medium environments (Eswaran, Rowe, & Rajkumar, 2005). Figure 2.3 presents the main components of the ZigBee network.

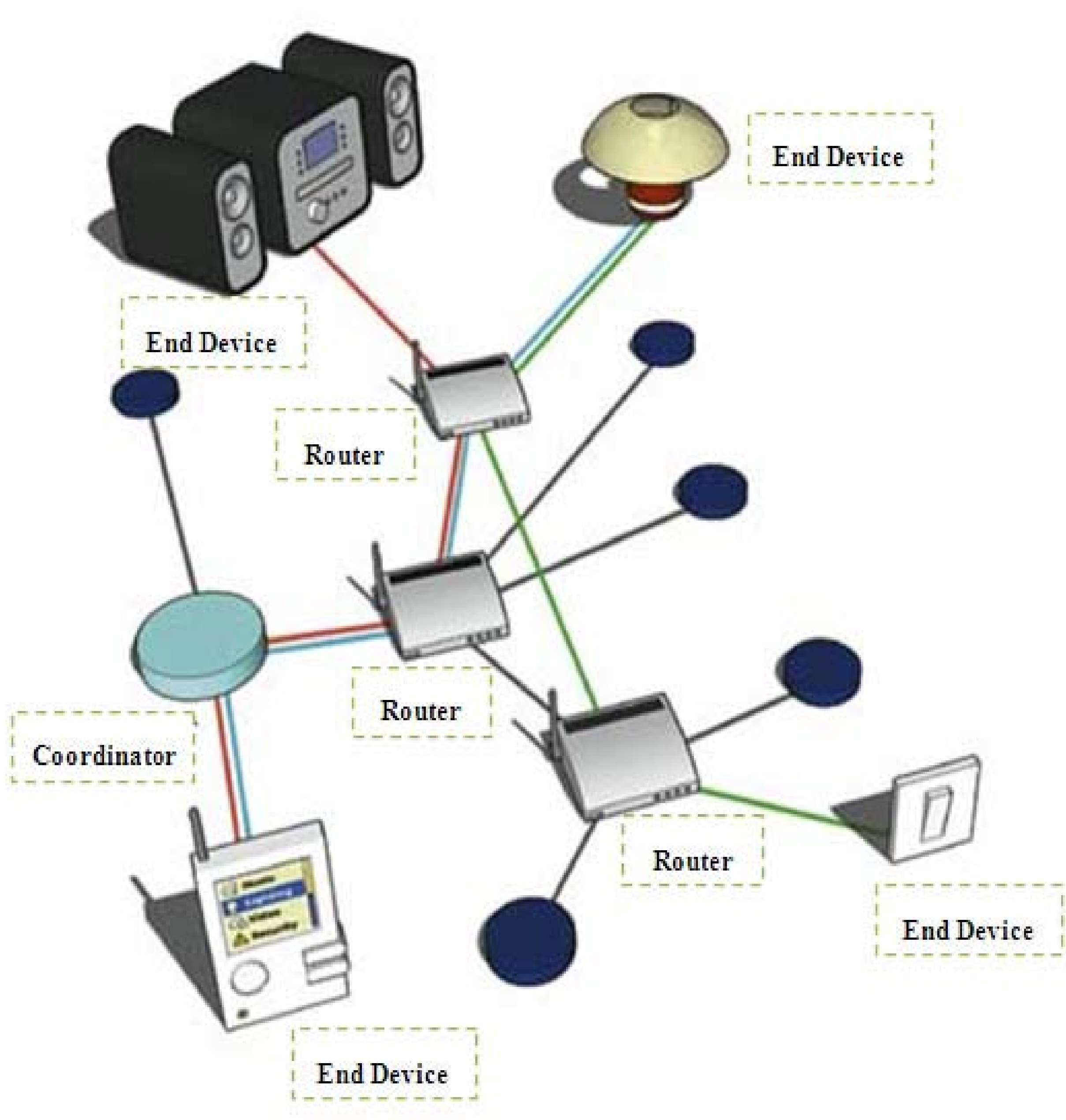

Figure 2.3: ZigBee Network (Eswaran, et al., 2005)

However, Wireless Hart standard is an extension of the Hart protocol. This again has been specifically designed and developed to point the needs of industrial environments with the appropriate applications such as process monitoring and control

(Giron-Sierra, et al., 2003). This protocol has been added to justify the overall HART protocol suite as part of the HART 7 Specification (Pereira, Postolache, & Girao, 2003). Through the gateway device, Figure 2.4 shows the workflow of the Wireless HART protocol over multi group network.

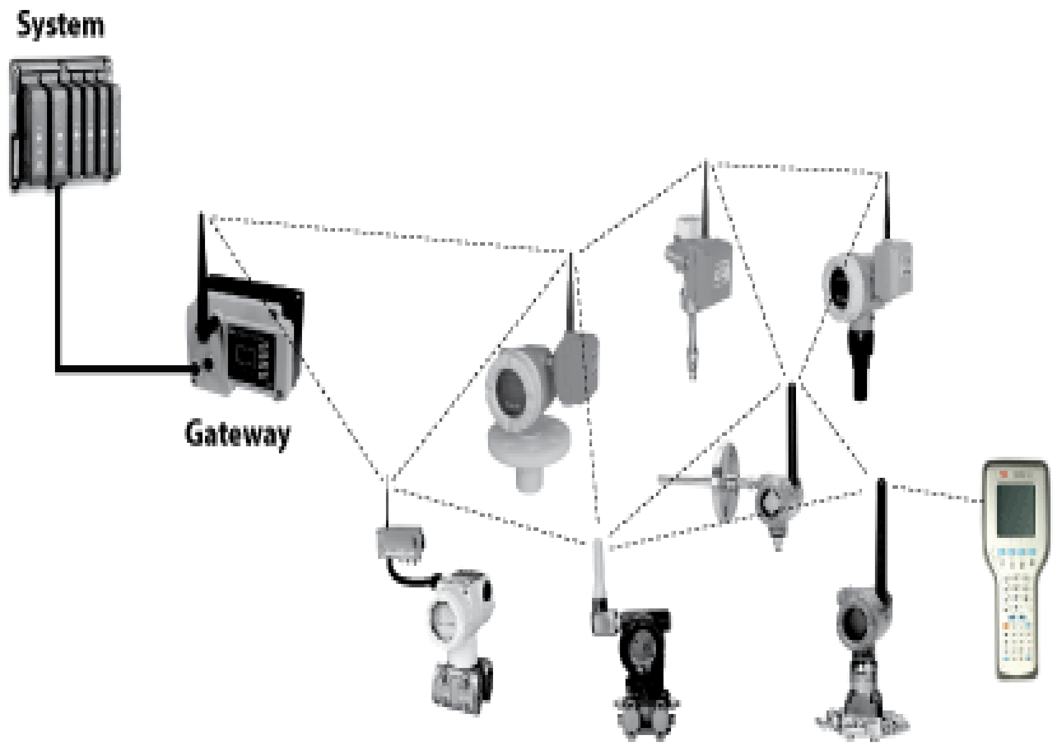

Figure 2.4: Wireless Hart Network over Multi Group Networking (Pereira, et al., 2003)

6LoWPAN is another type of wireless sensors network. Within the IETF, this type of sensor provides a multi working group for distributing the network signal. This distribution translates and retrieves from IPV6 packets over IEEE 802.15.4 (Whai-En, Yi-Bing, & Ai-Chun, 2005). However in order to provide additional representation of the industrial applications wish namely ISA100, recently, another standard has been integrated. In addition ZigBee, WirelessHART, and 6lowpan/ISA100 all are based on the same underlying radio standard: IEEE 802.15.4. Figure 2.5 presents the LoWPAN network representation based IPV6 packet (Andreasen, 2003).

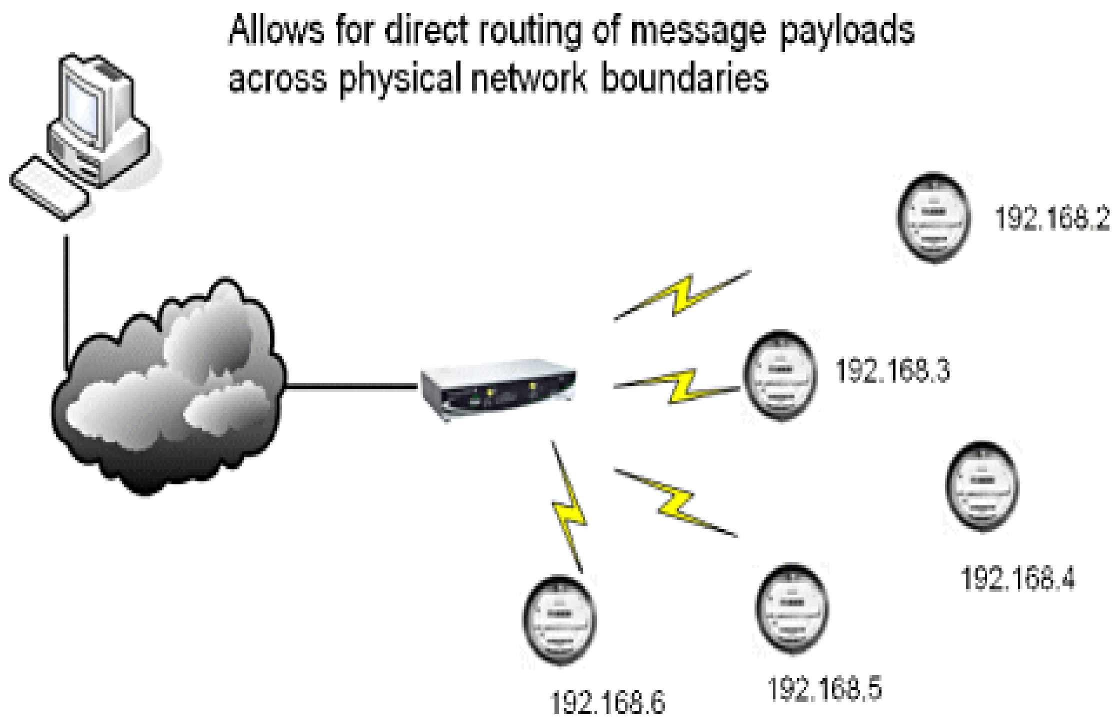

Figure 2.5: LoWPAN Network based IPV6 Packet (Andreasen, 2003)

2.4.6 WSNs Operating System

For presenting and generating the network connection in specific hardware platforms, Wireless sensor network requires an operating system (Lei, Zheng, Yinong, & Xiaosheng, 2007). In comparison with other operating systems which focuses on determining the sensor network requirements to be optimized with the available hardware units, operating systems of WSNs nodes are typically less complex. It is also because of the resource constraints in sensor network hardware platforms (Tillapart, et al., 2004). An example of WSNs operating system is eCos or uC/OS. These kinds of operating systems are unable to provide an interactive user interface compare with the other PCs application (Yi, Kim, & Ha, 2003). As a result of this, the operating system does not need to include support for user interfaces. It becomes either unnecessary or impossible to implement the resource constraints in terms of memory and memory mapping hardware support mechanisms such as virtual memory. The logical structure of these operating systems are customized and developed to be specifying real-time properties. In addition, operating systems specifically targeting sensor networks often do not have real-time support.

2.4.7 WSNs Algorithms

For simplifying the connectivity between the other nodes parts to retrieve and send the signal objects over wireless sensors devices which requires a distributed transmitting algorithm for such transmission, Wireless sensors network contain a large number of nodes. In WSNs the scarcest resource is energy and data transmission and idle listening (Pingping, Shangping, & Li, 2009) are one of the most energy expensive operations.

For this reason, algorithmic research in WSN mostly focuses on the study and design of energy aware algorithms. This saves energy by reducing the amount of data being transmitted using techniques like data aggregation, changing the transmission