IMPLEMENTATION OF ROUTING PROTOCOL IN uIPv6-BASED WIRELESS SENSOR NETWORK

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Specially dedicated

To my beloved wife and son,

My beloved father and mother,

My beloved brother and sisters,

My beloved parent, brother and sisters in law,

All my colleagues,

All my lecturers,

For their encouragement, support and motivation through my journey of education.

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ABSTRACT

Wireless sensor networks (WSNs) become more important in various application areas. WSNs have been widely used in information collection and monitoring applications. These applications require numerous low cost, low power and low data sensor nodes that communicating over multiple hop to cover a large geographical area. Many applications require connectivity between WSNs and the Internet. Though WSN is typically not IP-enabled, connection to the IP network makes it easy to monitor sensors everywhere in the world. Introduction of uIPv6 will solve this issue. The objective of this research is to embed Contiki OS in Atmel RZRAVEN Development Kit and implement routing protocol in uIPv6-based WSNs. Then measure it performance in term of throughput. The routing protocol will takes into account link quality, route cost and the receive signal strength of next hop sensor nodes in making routing decision in the network. Operating System that used in WSNs are Contiki OS and programming code for routing protocol is written using C language. Then, developed code is programmed into Atmel radio sensors boards in WSN test beds. The result of single hop and multihop communication of the testbed is also presented. Atmel RZRAVEN enables development, debugging and demonstration of a wide range of lowpower wireless applications including IEEE 802.15.4, 6LoWPAN and ZigBee networks.

ABSTRAK

Rangkaian peranti pengesan tanpa wayar (WSNs) menjadi lebih penting dalam pelbagai kawasan-kawasan aplikasi. WSN telah digunakan dengan meluas dalam pengumpulan maklumat dan aplikasi pengawasan. Aplikasi ini memerlukan bilangan besar kos rendah, kuasa rendah dan data rendah nod peranti pengesan yang berhubung melalui banyak lompatan bagi meliputi kawasan geografi yang luas. Banyak aplikasi memerlukan penyambungan antara WSNs dan Internet. Walaupun WSN adalah lazimnya bukan IP-enabled, sambungan untuk rangkaian IP membuatkan ia mudah untuk memantau peranti pengesan di mana-mana dalam dunia. Pengenalan uIPv6 akan menyelesaikan masalah ini. Objektif kajian ini adalah untuk memasukkan Contiki OS dalam Atmel RZRAVEN Development Kit dan melaksanakan protocol laluan dalam WSN berasaskan IP. Kemudian mengukur kemampuananya berdasarkan kadar penerimaan. Protokol laluan ini akan mengambil kira kualiti hubungan, kos laluan dan kuasa isyarat yang diterima bagi lompatan berikutnya nod peranti pengesan dalam membuat keputusan laluan di dalam rangkaian. Sistem pengendalian yang digunakan dalam WSNs adalah Contiki OS dan kod program untuk protokol laluan ditulis menggunakan bahasa C. Selepas itu, kod yang dibangunkan diprogramkan ke dalam papan pengesan radio Atmel dalam WSN testbed. Keputusan komunikasi lompatan tunggal dan lompatan pelbagai juga ditunjukkan. Atmel RZRAVEN membolehkan pembangunan, penyahpepijatan dan demonstrasi pelbagai kuasa rendah aplikasi tanpa wayar termasuk IEEE 802.15.4, 6LoWPAN and rangkaian ZigBee.

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LIST OF ABBREVIATIONS

AODV	-	Ad-hoc On-demand Distance Vector
IC	-	Integrated Circuit
ICMP	-	Internet Control Message Protocol
IPv4	-	Internet Protocol version 4
Kb	-	Kilo Bytes
LAN	-	Local Area Network
MAC	-	Media Access Control
MCU	-	Microcontroller Unit
OS	-	Operating System
RAM	-	Random Access Memory
ROM	-	Read Only Memory
RREP	-	Route Reply Message
RREQ	-	Route Request Packet
RRER	-	Route Error Message
TCP/IP	-	Transmission Control Protocol / Internet Protocol
TTL	-	Time To Live
UDP	-	User Datagram Protocol
uIP	-	Micro Internet Protocol
uIPv6	-	Micro Internet Protocol version 6
WLAN	-	Wireless Local Area Network
WSN	-	Wireless Sensor Network

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Sensors integrated into structures, machinery, and the environment, coupled with the efficient delivery of sensed information, could provide great benefits to society. Potential benefits include fewer tragic failures, conservation of natural resources, improved manufacturing productivity, improved emergency response, and enhanced homeland security. However, barriers to the widespread use of sensors in structures and machines remain. Bundles of direct wires and fibre optic “tails” are subject to breakage and connector failures. Long wire bundles represent a significant installation and long term maintenance cost, limiting the number of sensors that may be deployed, and therefore reducing the overall quality of the data reported. Wireless sensing networks can eliminate these costs, easing installation and eliminating connectors.

The ideal wireless sensor is networked and scaleable, consumes very little power, is smart and software programmable, capable of fast data acquisition, reliable and accurate over the long term, costs little to purchase and install, and requires no real maintenance.

Selecting the optimum sensors and wireless communications link requires knowledge of the application and problem definition. Battery life, sensor update rates, and size are all major design considerations. Examples of low data rate sensors include temperature, humidity, and peak strain captured passively. Examples of high data rate sensors include damage, acceleration, and vibration.

Recent advances have resulted in the ability to integrate sensors, radio communications, and digital electronics into a single integrated circuit (IC) package. This capability is enabling networks of very low cost sensors that are able to communicate with each other using low power wireless data routing protocols. In Figure 1.1, a wireless sensor network (WSN) generally consists of a base station (or "gateway") that can communicate with a number of wireless sensors via a radio link. Data is collected at the wireless sensor node, compressed, and transmitted to the gateway directly or, if required, uses other wireless sensor nodes to forward data to the gateway. The transmitted data is then presented to the system by the gateway connection.

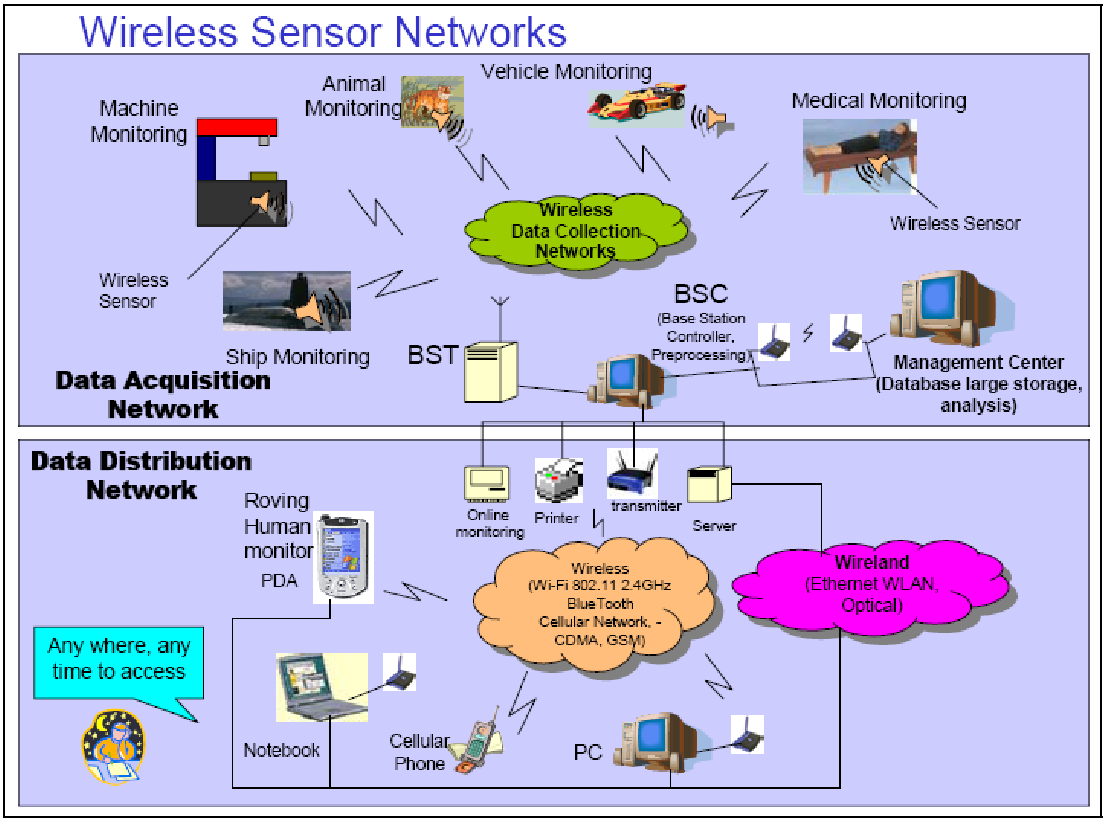

Figure 1.1 : Wireless Sensor Networks

1.2 APPLICATION OF WSNs

1.2.1 Industrial Automation

In addition to being expensive, direct wires can be constraining, especially when moving parts are involved. The use of wireless sensors allows for rapid installation of sensing equipment and allows access to locations that would not be practical if cables were attached. In this application, typically ten or more sensors are used to measure gaps where rubber seals are to be placed. Previously, the use of wired sensors was too cumbersome to be implemented in a production line environment. The use of wireless sensors in this application is enabling, allowing a measurement to be made that was not previously practical. Other applications include energy control systems, security, wind turbine health monitoring, environmental monitoring, location-based services for logistics, and health care.

1.2.2 Agriculture

Using wireless sensor networks within the agricultural industry is increasingly common. Gravity fed water systems can be monitored using pressure transmitters to monitor water tank levels, pumps can be controlled using wireless I/O devices, and water use can be measured and wirelessly transmitted back to a central control center for billing. Irrigation automation enables more efficient water use and reduces waste.

1.2.3 Greenhouse Monitoring

Wireless sensor networks are also used to control the temperature and humidity levels inside commercial greenhouses. When the temperature and humidity drops below specific levels, the greenhouse manager must be notified via e-mail or cell phone text message, or host systems can trigger misting systems, open vents, turn on fans, or control a wide variety of system responses. Because some wireless sensor networks are easy to install, they are also easy to move as the needs of the application change

1.3 PROBLEM STATEMENT

Minimize node's power consumption is the important issues to meet the requirement. The sensor's node energy is very limited and it is comes from common power source such as battery. A sensor node must operate for few months or years without external supply or battery replacement or being recharged. Power management capability will provide by proposed routing protocol in order to prolong the WSN lifetime.

The seconds issue is that the sensory data valid only for limited time duration and needs to be delivered within a deadline. WSN demands real-time communication which means messages in the network are delivered according to their end-to-end deadlines (packet lifetime). The routing protocol must able to provide this functionality.

The thirds issue is low link quality in WSN because WSN is based on IEEE 802.15.4 that has very limited bandwidth and low transmits power. This will cause link quality can be influenced by environmental factors Recent experimental results obtained on the Berkeley mote platform indicate that wireless links are highly probabilistic, asymmetric, and the link quality depends on the transmission power and the distance travelled by a packet. Therefore, communication delays in such system are highly unpredictable. The link quality between sensor nodes in WSN should be considered while designing multi-hop routing in order to achieve high throughput for WSN.

The lasts issue is integrating wireless sensor network with Internet because wireless sensor network is only stand alone network. However in order to equip very large amount of sensor node with IP is almost impossible due to limited available addressing with current IPv4. Introduction of uIPv6 in wireless sensor network has become the best solution because uIPv6 provide large number of addressing. Beside that, uIPv6 can provide anycast mechanisms to speedup the queries in the system and to implement load-balancing. This will extend the life of the wireless sensor network.

The integration of uIPv6 with low power and low rate wireless sensor network is called SICSLowPAN.

1.4 THESIS OBJECTIVE

The objectives of the project are as follow:

- To embed Contiki OS in Atmel RZRAVEN Development Kit
- To implement AODV routing protocol in uIPV6-based WSNs using Contiki OS

1.5 SCOPE OF WORK

There are few limitations did on this project in order to ensure the obtained result is clarified and lies under the specific scope. The first scope of works is to use Contiki OS in Atmel Development Kit. Then, AODV routing protocol will be use for multihop transmission. After that, the packet will use uIPv6–based WSN in Contiki OS environment using C programming language. Atmel RZRAVEN Development Kit will be use in the node in the testbed. Later, wireshark will be use to observe the activities of the testbed.