A testbed implementation of energy efficient wireless sensor network routing protocols

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Declaration

I, Joubert Krige hereby declare that the dissertation entitled “A testbed implementation of energy efficient wireless sensor network routing protocols ” is my own original work and has not already been submitted to any other university or institution for examination.

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Signed on the 15th day of November 2013 at Potchefstroom.

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Abstract

Wireless Sensor Networks (WSNs) consist of Sensor Nodes (SNs) spatially removed from one another, that can monitor a variety of environmental conditions. SNs then collaboratively communicate the collected information to a central location, by passing along the data in a multi-hop fashion. SN energy resources are limited and energy monitoring and preservation in WSNs are therefore very important. Since multi-hop communication takes place, the routing protocol used may have a significant effect on the balanced use and preservation of energy in the WSN.

A significant amount of research has been performed on energy efficient routing in WSNs, but the majority of these studies were only implemented in simulation. The simulation engines used to perform these studies do not take into account all of the relevant environmental factors affecting energy efficiency. In order to comment on the feasibility of a routing protocol meant to improve the energy efficiency of a WSN, it is important to test the routing scheme in a realistic environment.

In this study, a SN specifically designed to be used in an energy consumption ascertaining WSN testbed was developed. This SN has a unique set of features which makes it ideal for this application. Each SN is capable of recording its own power consumption. The design also features a lithium battery charging circuit which improves the reusability of the SN. Each node has a detachable sensor module and transceiver module which enables the researcher to conduct experiments using various transceivers and sensors. Twenty of these SNs were then used to form an energy consumption ascertaining WSN testbed.

This testbed was used to compare the energy consumption of a Minimum Total Transmission Power Routing (MTTPR) scheme to a shortest hop path routing scheme. The results show that each SN's transmission power setting dependant efficiency has a significant effect on the overall performance of the MTTPR scheme. The MTTPR scheme might in some cases use more energy than a shortest hop path routing scheme because the transmission power setting dependant efficiency of the transceiver is not taken into account. The MTTPR scheme as well as other similar routing schemes can be improved by taking the transceiver efficiency at different transmission power settings into account. Simulation environments used to evaluate these routing schemes can also be improved by considering the transceiver efficiency at different transmission power settings.

Keywords: *Energy Aware Routing, Energy Efficient, Sensor Node, Testbed, Wireless Sensor Network, Minimum Total Transmission Power Routing*

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List of Acronyms

AODV Ad Hoc On-Demand Distance Vector

AFE Analog Front End

API Application Programming Interface

AS Autonomous System

CCA Clear Channel Assessment

CCL Command and Control Scripting Language

CMMBCR Conditional Max-Min Battery Capacity Routing

CSMA-CA Carrier Sense Multiple Access with Collision Avoidance

DSN Data Sequence Number

ED Energy Detect

EIRP Equivalent Isotropically Radiated Power

ETSI European Telecommunications Standards Institute

ETX Expected Transmission Count

FCS Frame Check Sequence

FPGA Field-Programmable Gate Array

GPIO General-Purpose Input/Output

GTS Guaranteed Time Slot

GUI Graphical User Interface

I2C Inter-Integrated Circuit

IOS International Organization for Standardization

ISM Industrial, Scientific and Medical

LEACH Low Energy Adaptive Clustering Hierarchy

LED Light-Emitting Diode

IETF Internet Engineering Task Force

LDO Low-Dropout Regulator

LQI Link Quality Indicator

LR-WPAN Low-Rate Wireless Personal Area Network

MAC Medium Access Control

MANET Mobile Ad Hoc Network

MBCR Minimal-Battery Cost Routing

MiMAC Microchip Wireless (MiWi) Media Access Controller

MLME MAC Sublayer Management Entity

MMBCR Min-Max Battery Cost Routing

MPDU MAC Protocol Data Unit

MPR multipoint relay

MTTCP Minimum Total TransCeiving Power

MTTP Minimum Total Transmission Power

MTTPR Minimum Total Transmission Power Routing

MTRTP Minimum Total Reliable Transmission Power

OSI Open Systems Interconnection

OLSR Optimized Link State Routing

SN Sensor Node

OS Operating System

OSPF Open Shortest Path First

OSR Oversampling Ratio

P2P Point to Point

PAN Personal Area Network

PCB Printed Circuit Board

PHY Physical Layer

PLL Phase-Locked Loop

PLME Physical Layer Management Entity

PPDU PHY Protocol Data Unit

RIP Routing Information Protocol

ROLL Routing Over Low Power and Lossy Networks

RTCC Real-Time Clock and Calendar

SAP Service Access Point

SCS Statistical Consultation Service

SPCO Single Pole Changeover

SPI Serial Peripheral Interface

TDMA Time Division Multiple Access

TEEN Threshold Sensitive Energy Efficient Sensor Network Protocol

TWIST TKN Wireless Indoor Sensor network Testbed

USART Universal Synchronous/Asynchronous Receiver/Transmitter

WSN Wireless Sensor Network

ZC ZigBee Coordinator

ZED ZigBee End Device

ZR ZigBee Router

List of Symbols

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I	Current
d	Distance
E	Energy
f	Frequency
G	Gain
P	Power
R	Resistance
c	Speed of light
t	Time
V	Voltage
λ	Wavelength