# A PROPOSED ENERGY EFFICIENT MEDIUM ACCESS CONTROL PROTOCOL FOR WIRELESS SENSOR NETWORKS

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# A Proposed Energy Efficient Medium Access Control Protocol for Wireless Sensor Networks

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# Abstrak

Nod-nod Rangkaian Sensor Tanpa Wayar (WSN) digunakan secara meluas dalam pelbagai sector. Nod-nod ini walaubagaimananpun berdepan dengan pelbagai masalah pengoperasian khususnya pelanggaran paket data, nod terlindung dan lain-lain yang memberikan impak besar ke atas jangka hayat bateri. Nod-nod WSN amat bergantung ke atas jangkahayat baterinya dan penambahan kuasa bateri nod-nod ini adalah sukar kerana nod-nod kerapkali tersusun dalam keadaan *ad-hoc*. Oleh demikian, kuasa bateri dalam nod-nod WSN menjadi factor penting dalam kebolehgunaannya. Satu pendekatan untuk menjimatkan penggunaan kuasa ialah merekabentuk protokol *Medium Access Control* (MAC). Kajian terdahulu telah dijalankan untuk mengatasi masalah yang memberi kesan ke atas jangkahayat bateri. Disertasi ini bertujuan merekabentuk protokol MAC hybrid, Energy Efficient MAC (EE-MAC) untuk mengatasi masalah yang berkaiatan penggunaan kuasa oleh nod-nod WSN. EE-MAC mampu mengurangkan masalah *idle-listening* serta mempercepatkan masa penghantaran data sekaligus menjimatkan kuasa. EE-MAC dibangunkan menggunakan simulator ns-2. Keberkesanan protokol ini disahkan menggunakan model matematik serta dibandingkan dengan piawaian IEEE 802.11 Power Saving Mode (PSM). Simulasi yang dijalankan menunjukkan protokol yang dicadangkan mencapai prestasi yang lebih baik berbanding IEEE 802.11 PSM.

# Abstract

Wireless Sensor Network (WSN) nodes are broadly used in various sectors nowadays. WSN nodes experience a lot of problems that impact on battery life for sensor node such as, overhearing, collision, hidden node, idle listening, schedule drifts, and high latency. Moreover, WSN nodes are strongly dependent on its limited battery power, and replenishing it again is difficult as nodes are organized in an ad-hoc manner. Energy consumption is the most vital factor to determine the life of a sensor network because sensor nodes are driven by low battery resources. An approach to conserve energy in WSN nodes is to carefully design its Medium Access Control (MAC) protocol. Several previous work has been carried out to mitigate many problems that impact on battery life for sensor node such as overhearing, collision, and hidden node. This dissertation attempts to design, a hybrid Energy-Efficient MAC (EE-MAC) protocol to address the energy issues that are related to WSN nodes. This protocol aims to reduce idle listening times as well as lowering the latency time thus reducing the energy consumption. The proposed protocol has been developed and analysed using the ns-2 simulator. A mathematical model was used to verify and prove the efficiency of the proposed protocol. We have compared our proposed EE-MAC protocol with the existing contention-based IEEE 802.11 PSM protocol. The simulation results illustrate EE-MAC has achieved better energy conservation than the IEEE 802.11 PSM protocol.



**Keywords**: EE-MAC, WSN, Medium Access Control, Energy-efficiency, ns-2, IEEE 802.11 PSM.

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*Yasser AL-Rikabi*

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# List of Abbreviations

| | |
|---|---|
| **ACK** | Acknowledgment |
| **AS-MAC** | Asynchronous Scheduled MAC |
| **B-MAC** | Berkeley-MAC |
| **CCA** | Clear Channel Assessment |
| **CSMA/CD** | Carrier Sense Multiple Access/ Collision Detection |
| **CSMA/CA** | Carries Sense Multiple Access/Collision Avoidance |
| **DRAND** | Distributed Randomized |
| **EB-MAC** | Event Based MAC |
| **ECN** | Explicit Congestion Notification |
| **EE-MAC** | Energy Efficient MAC |
| **HCL** | High Contention Level |
| **LCL** | Low Contention Level |
| **LPL** | Low Power Listening |
| **MAC** | Medium Access Control |
| **µOS** | Micro Operating System |
| **P-MAC** | Pattern-MAC |
| **PSM** | Power save Mode |
| **RSS** | Received Signal Strength |
| **TDMA** | Time Division Multiple Access |
| **WiseMAC** | Wireless Sensor MAC |
| **WSN** | Wireless Sensor Network |
| **Z-MAC** | Zebra-MAC |

# CHAPTER ONE

# INTRODUCTION

## 1.0 Introduction

Wireless Sensor Network (WSN) nodes are compact-sized, low-power autonomous devices with wireless communication capabilities that are widely used in various real world applications today. Advancement in technology world wide witness applications of WSN nodes in various pace of life, such as military, health care, environmental issues and many more which needs monitoring. These nodes are basically used in various sectors which need close monitoring, hence deployed in a sensor field to measure environmental conditions such as temperature, pressure, humidity, movement, etc. WSN nodes are powered by limited power sources and often exhibit strong dependency on battery life making replenishment an arduous or impossible task as most nodes are positioned in an ad-hoc manner. Energy in WSN node, though often insufficient and limited in supply, is the most important parameter that determines the WSN lifetime. In designing a WSN energy efficiency is required, and the radio is distinguished as a main source of the power consumption in sensor nodes (Jang, Lim, & Sichitiu, 2013).

In WSN operation, energy can be dissipated by either “useful” or “wasteful” means. For example, as a part of useful operation, node requires energy to transmit or receive data messages, and processes query requests through which energy is consumed. On the contrary, energy consumption by means of overhearing, retransmitting due to rough environment, handling with the redundant broadcast overhead messages, as well as idle listening to the media are wasteful energy

The contents of the thesis is for internal user only

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