



Ain Shams University
Faculty of Engineering
Computer & Systems Engineering Department

Energy Efficient Routing Protocol for Wireless Sensor Networks

Thesis submitted for the partial fulfillment of Degree of
Doctor of Philosophy (Ph.D.) in Computer & Systems Engineering

Submitted by

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In the Name of

Allah,

Most Gracious,

Most Merciful

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Abstract

In the last few years, wireless sensor networks (WSNs) have gained a lot of interest in both research and industrial fields. Recent advances in wireless communications and electronics have enabled the development of low power, low cost, multifunctional sensor nodes that are small and able to communicate in short distances. A WSN consists of small nodes with sensing, computation, and wireless communications capabilities. These sensors have the ability to communicate either among each other or directly to a sink.

WSN are currently used for gathering data in many applications and according to this, many routing protocols have been proposed for WSNs. Most of the hierarchical protocols proposed for WSNs concentrate mainly on maximizing the lifetime of the network by trying to minimize the power consumption. Delay is almost not considered, while it is an important metric especially in time critical applications. In addition, previous protocols assume that all sensor nodes have the same energy level at startup, which is not always the case.

We propose Pairs Energy Efficient Routing (PEER) protocol, a new routing protocol for wireless sensor networks that uses dual power management and focuses on minimizing both the energy dissipated and the transmission delay. The protocol consists of three phases: joining pair phase, transmission phase, and changing pair phase.

The joining pair phase is based on grouping the randomly deployed sensor nodes into pairs. Each two nodes forming a pair should be chosen to be close to each other to ensure minimum energy consumption for the transmission between both nodes. We have used random graph theory as a mathematical model for forming pairs.

In the transmission phase, each node has a dual power assignment. One node of a pair transmits data toward the sink using high power level, and the other node transmits data to its partner using low power level. The roles of two nodes forming a pair should be changed periodically to fairly distribute the far-transmission load between both nodes.

The third phase is the changing pair phase. Only nodes that loose their partners due to partner death will be concerned with this phase to form a new pair.

In the simulations, four important metrics have been taken into consideration, namely, energy consumption, network lifetime, distribution of nodes alive, and average delay. In addition, two models have been simulated for the protocol. In the first model, all the sensor nodes have been given the same amount of energy at startup; while in the second model, sensors start the simulation with different energy levels.

We have compared our results with LEACH, a well-known recognized hierarchical wireless sensor protocol. In terms of energy consumption, network lifetime, and average delay, our protocol has performed better than LEACH by more than 200%, 200%, and 400%, respectively. Moreover, in PEER protocol the nodes alive are distributed over all regions, while in LEACH nodes alive are always concentrated near the sink with all nodes in far regions dead. Finally, PEER with nodes having different power levels at startup has almost the same performance as PEER with an insignificant difference of about 5% increase in energy consumed and less than 5% decrease for the network lifetime. In LEACH, the change in energy levels will lead to a significant change of about 25% increase in energy consumption and 20% decrease in network lifetime.

Contents

ACKNOWLEDGEMENTS	V
ABSTRACT.....	VII
CONTENTS.....	IX
LIST OF FIGURES	XIII
LIST OF TABLES	XIX
LIST OF ABBREVIATIONS	XXI
CHAPTER 1: WIRELESS SENSOR NETWORKS.....	1
1.1 INTRODUCTION	1
1.2 PROBLEM STATEMENT	6
1.3 DIFFERENCE BETWEEN WSN AND MANET	8
1.3.1 <i>Application Specific</i>	8
1.3.2 <i>Environment Interaction</i>	9
1.3.3 <i>Scale</i>	9
1.3.4 <i>Energy</i>	9
1.3.5 <i>Self Configurability</i>	9
1.3.6 <i>Dependability and QoS</i>	10
1.3.7 <i>Data Centric</i>	10
1.3.8 <i>Simplicity</i>	10
1.3.9 <i>Mobility</i>	11
1.4 HISTORY OF SENSORS NETWORKS	11
1.4.1 <i>Early Research on Military Sensor Networks</i>	12
1.4.2 <i>Distributed Sensor Networks</i>	13
1.4.3 <i>Military Sensor Networks in the 1980s and 1990s</i>	14
1.4.4 <i>Sensor Network Research in the 21st Century</i>	14
1.5 SENSOR NODE COMPONENTS	15
1.5.1 <i>Sensing Unit</i>	16
1.5.2 <i>Processing Unit</i>	16
1.5.3 <i>Power Unit</i>	17

1.5.4	<i>Communication Unit</i>	19
1.6	APPLICATIONS	20
1.6.1	<i>Military Applications</i>	21
1.6.2	<i>Environmental Monitoring</i>	23
1.6.3	<i>Human-Centric Applications</i>	26
1.6.4	<i>Commercial Applications</i>	27
1.6.5	<i>Applications to Robotics</i>	28
1.7	ARCHITECTURAL CHALLENGES	28
1.7.1	<i>Power Consumption</i>	29
1.7.2	<i>Production Cost</i>	29
1.7.3	<i>Hardware Constraints</i>	30
1.7.4	<i>Environment</i>	30
1.7.5	<i>Transmission Media</i>	30
1.7.6	<i>Remote Management</i>	30
1.7.7	<i>Usability</i>	31
1.7.8	<i>Standardization</i>	31
1.8	TECHNICAL CHALLENGES.....	32
1.8.1	<i>Ad Hoc Network Discovery</i>	32
1.8.2	<i>Network Control and Routing</i>	32
1.8.3	<i>Collaborative Signal and Information Processing</i>	34
1.8.4	<i>Tasking and Querying</i>	35
1.8.5	<i>Security</i>	35
CHAPTER 2: WSN ROUTING PROTOCOLS.....		37
2.1	ROUTING CHALLENGES AND DESIGN ISSUES	39
2.1.1	<i>Network Dynamics</i>	39
2.1.2	<i>Node Deployment</i>	39
2.1.3	<i>Energy Consideration</i>	40
2.1.4	<i>Data Reporting Method</i>	40
2.1.5	<i>Node Capabilities</i>	41
2.1.6	<i>Data aggregation</i>	42
2.1.7	<i>Fault Tolerance</i>	42
2.1.8	<i>Scalability</i>	43
2.1.9	<i>Classification of Routing Protocols</i>	43

2.2	FLAT ROUTING PROTOCOLS.....	44
2.2.1	<i>Sensor Protocols for Information via Negotiation</i>	45
2.2.2	<i>Directed Diffusion</i>	48
2.2.3	<i>Gradient-Based Routing</i>	51
2.2.4	<i>Energy-Aware Routing</i>	52
2.2.5	<i>Rumor Routing</i>	53
2.2.6	<i>Information-Driven Sensor Querying and Constrained Anisotropic Diffusion Routing</i>	55
2.2.7	<i>COUGAR</i>	56
2.2.8	<i>ACQUIRE</i>	57
2.3	HIERARCHICAL ROUTING PROTOCOLS.....	59
2.3.1	<i>LEACH</i>	59
2.3.2	<i>PEGASIS and Hierarchical-PEGASIS</i>	62
2.3.3	<i>TEEN and APTEEN</i>	65
2.3.4	<i>Self Organizing Protocol</i>	66
2.4	FLAT VERSUS HIERARCHICAL	68
2.5	LOCATION-BASED ROUTING PROTOCOLS	70
2.5.1	<i>MECN and SMECN</i>	70
2.5.2	<i>Geographic and Energy-Aware Routing</i>	72
2.5.3	<i>Geographic Adaptive Fidelity</i>	74
2.5.4	<i>Two-Tier Data Dissemination</i>	76
2.6	NETWORK FLOW AND QOS-AWARE PROTOCOLS	77
2.6.1	<i>Maximum Lifetime Energy Routing</i>	78
2.6.2	<i>Minimum Cost Forwarding Algorithm</i>	79
2.6.3	<i>Maximum Lifetime Data Gathering</i>	80
2.6.4	<i>Sequential Assignment Routing</i>	81
CHAPTER 3: MATHEMATICAL MODEL.....		83
3.1	PROTOCOL ALGORITHMS	84
3.1.1	<i>Joining Pair Phase</i>	85
3.1.2	<i>Transmission Phase</i>	88
3.1.3	<i>Changing Pairs Phase</i>	98
3.2	RANDOM GRAPH THEORY	99
3.2.1	<i>The Erdős-Rényi model</i>	100

3.2.2	<i>Subgraphs</i>	103
3.2.3	<i>Degree Distribution</i>	104
3.2.4	<i>Connectedness and Diameter</i>	105
3.3	MODELING WSNS USING RANDOM GRAPH THEORY	106
3.3.1	<i>Spatial Node Distribution</i>	108
3.3.2	<i>Connectivity Analysis</i>	109
3.4	DUAL POWER MANAGEMENT IN WSNS	112
3.4.1	<i>Dual Power Management Assignment</i>	112
3.4.2	<i>Dual Power Management Problem</i>	114
3.4.3	<i>Energy Consumption</i>	116
CHAPTER 4: SIMULATION MODEL		119
4.1	RADIO MODEL	119
4.2	NETWORK MODEL	120
4.3	PERFORMANCE EVALUATION	123
4.4	SIMULATION RESULTS	126
4.4.1	<i>Percentage of Nodes Forming Pairs</i>	126
4.4.2	<i>Average Energy Dissipated</i>	131
4.4.3	<i>Number of Nodes Alive (Lifetime)</i>	144
4.4.4	<i>Distribution of Nodes Alive</i>	154
4.4.5	<i>Average Transmission Delay</i>	159
4.4.6	<i>Average Weighted Delay</i>	164
CHAPTER 5: CONCLUSIONS AND FUTURE WORK		167
5.1	CONCLUSIONS	167
5.2	FUTURE WORK	169
5.2.1	<i>General Direction</i>	169
5.2.2	<i>Networking Direction</i>	170
5.2.3	<i>PEER Enhancements</i>	170
REFERENCES		173

List of Figures

Figure 1.1 Wireless Sensor Node (Mica2 mote)	2
Figure 1.2 Sensor nodes scattered in a sensor field.....	3
Figure 1.3 Components of a sensor node.....	15
Figure 2.1 The sensor networks protocol stack	37
Figure 2.2 Classification of routing protocols for WSN	44
Figure 2.3 The implosion problem	46
Figure 2.4 The overlap problem	46
Figure 2.5 SPIN protocol	47
Figure 2.6 Directed Diffusion protocol phases.....	49
Figure 2.7 COUGAR protocol architecture.....	57
Figure 2.8 Data gathering in a chain based binary scheme	64
Figure 2.9 Hierarchical clustering in TEEN and APTEEN.....	65
Figure 2.10 Relay region of transmit-relay node pair in MECN.....	71
Figure 2.11 Recursive geographic forwarding in GEAR	74
Figure 2.12 Virtual grid in GAF	75
Figure 2.13 State transitions in GAF	76
Figure 3.1 Joining Phase Flowchart Diagram.....	87
Figure 3.2 Area divided into two regions (using one bit).....	88
Figure 3.3 Area divided into four regions (using two bits)	89
Figure 3.4 Area divided into eight regions (using three bits).....	89
Figure 3.5 Area divided into 16 regions (using four bits)	89
Figure 3.6 Transmission phase (sink) flowchart diagram	90

List of Figures

Figure 3.7 Transmission phase (low node) flowchart diagram	92
Figure 3.8 Transmission phase (high node) flowchart diagram	95
Figure 3.9 Transmission phase (individual node) flowchart diagram.....	96
Figure 3.10 Changing pair phase flowchart diagram	99
Figure 4.1 Random 100-node topology for a 50m x 50m network.	122
Figure 4.2 Random 200-node topology for a 50m x 50m network.	122
Figure 4.3 Random 400-node topology for a 50m x 50m network.	123
Figure 4.4 Percentage of nodes forming pairs vs. low power coverage distance (m) for 100 random nodes in a 50m x 50m field.....	127
Figure 4.5 Percentage of nodes forming pairs vs. low power coverage distance (m) for 200 random nodes in a 50m x 50m field.....	127
Figure 4.6 Percentage of nodes forming pairs vs. low power coverage distance (m) for 400 random nodes in a 50m x 50m field.....	128
Figure 4.7 Percentage of nodes forming pairs vs. low power coverage distance (m) for 100, 200, and 400 random nodes in a 100m x 100m field	129
Figure 4.8 Percentage of nodes forming pairs vs. low power coverage distance (m) for 100, 200, and 400 random nodes in a 200m x 200m field	129
Figure 4.9 Percentage of nodes forming pairs vs. low power coverage distance (m) for different density values	130
Figure 4.10 Average Energy Dissipated (J) vs. Time (rounds) (0.25 Joule, 100 nodes, 50m x 50m).....	133
Figure 4.11 Average Energy Dissipated (J) vs. Time (rounds) ($m = 0.25$ Joule, $\sigma = 0.1$, 100 nodes, 50m x 50m).....	133

List of Figures

Figure 4.12 Average Energy Dissipated (J) vs. Time (rounds) (0.25 Joule, 200 nodes, 50m x 50m).....	134
Figure 4.13 Average Energy Dissipated (J) vs. Time (rounds) ($m = 0.25$ Joule, $\sigma = 0.1$, 200 nodes, 50m x 50m).....	134
Figure 4.14 Average Energy Dissipated (J) vs. Time (rounds) (0.25 Joule, 400 nodes, 50m x 50m).....	135
Figure 4.15 Average Energy Dissipated (J) vs. Time (rounds) ($m = 0.25$ Joule, $\sigma = 0.1$, 400 nodes, 50m x 50m).....	135
Figure 4.16 Average Energy Dissipated (J) vs. Time (rounds) (0.25 Joule, 100 nodes, 100m x 100m).....	136
Figure 4.17 Average Energy Dissipated (J) vs. Time (rounds) ($m = 0.25$ Joule, $\sigma = 0.1$, 100 nodes, 100m x 100m).....	136
Figure 4.18 Average Energy Dissipated (J) vs. Time (rounds) (0.25 Joule, 200 nodes, 100m x 100m).....	137
Figure 4.19 Average Energy Dissipated (J) vs. Time (rounds) ($m = 0.25$ Joule, $\sigma = 0.1$, 200 nodes, 100m x 100m).....	137
Figure 4.20 Average Energy Dissipated (J) vs. Time (rounds) (0.25 Joule, 400 nodes, 100m x 100m).....	138
Figure 4.21 Average Energy Dissipated (J) vs. Time (rounds) ($m = 0.25$ Joule, $\sigma = 0.1$, 400 nodes, 100m x 100m).....	138
Figure 4.22 Average Energy Dissipated (J) vs. Time (rounds) (0.5 Joule, 100 nodes, 200m x 200m).....	139
Figure 4.23 Average Energy Dissipated (J) vs. Time (rounds) ($m = 0.5$ Joule, $\sigma = 0.2$, 100 nodes, 200m x 200m)	139
Figure 4.24 Average Energy Dissipated (J) vs. Time (rounds) (0.5 Joule, 200 nodes, 200m x 200m).....	140

Figure 4.25 Average Energy Dissipated (J) vs. Time (rounds) ($m = 0.5$ Joule, $\sigma = 0.2$, 200 nodes, 200m x 200m)	140
Figure 4.26 Average Energy Dissipated (J) vs. Time (rounds) (0.5 Joule, 400 nodes, 200m x 200m).....	141
Figure 4.27 Average Energy Dissipated (J) vs. Time (rounds) ($m = 0.5$ Joule, $\sigma = 0.2$, 400 nodes, 200m x 200m)	141
Figure 4.28 Average Energy Dissipated (J) vs. Time (rounds) (0.5 Joule, 100 nodes, 200m x 200m, using extended radio model)	142
Figure 4.29 Average Energy Dissipated (J) vs. Time (rounds) (0.5 Joule, 200 nodes, 200m x 200m, using extended radio model)	143
Figure 4.30 Average Energy Dissipated (J) vs. Time (rounds) (0.5 Joule, 400 nodes, 200m x 200m, using extended radio model)	143
Figure 4.31 Number of Nodes Alive (%) vs. Time (rounds) (0.25 Joule, 100 nodes, 50m x 50m).....	145
Figure 4.32 Number of Nodes Alive (%) vs. Time (rounds) ($m = 0.25$ Joule, $\sigma = 0.1$, 100 nodes, 50m x 50m).....	145
Figure 4.33 Number of Nodes Alive (%) vs. Time (rounds) (0.25 Joule, 200 nodes, 50m x 50m).....	146
Figure 4.34 Number of Nodes Alive (%) vs. Time (rounds) ($m = 0.25$ Joule, $\sigma = 0.1$, 200 nodes, 50m x 50m).....	146
Figure 4.35 Number of Nodes Alive (%) vs. Time (rounds) (0.25 Joule, 400 nodes, 50m x 50m).....	147
Figure 4.36 Number of Nodes Alive (%) vs. Time (rounds) ($m = 0.25$ Joule, $\sigma = 0.1$, 400 nodes, 50m x 50m).....	147
Figure 4.37 Number of Nodes Alive (%) vs. Time (rounds) (0.25 Joule, 100 nodes, 100m x 100m).....	148