Improving the Lifetime of Wireless Sensor Networks Based on Routing Power Factors

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Abstract. In this paper the power efficiency of Wireless Sensor Networks (WSNs) Power is studied. Power consumption is the main challenge during the routing of data. The objective of this study is to address three routing parameters that affect the network life time such as initial power of the nodes, the residual power in the nodes and routing period. Simulations of the effects of these parameters are presented in different network sizes. Contribution on how to improve network lifetime through consideration of power consumption factors during routing is added.

Keywords: WSNs, Power Efficiency, Power Consumption, Routing factor.

1 Introduction

Within the last decade, Sensor Networks and related technologies and applications have gained considerable momentum. This is due to the fact that the technology is maturing and moving out of the purely research driven environment into commercial interests. A number of factors have contributed to this effect: better chip technology allows for increased platform sophistication, higher integration, as well as lower power consumption and cost. Additionally, advances in low power radio technologies have created better wireless protocols and implementations suited for the Sensor Network market. This has led to more reliable operation which enabled credible pilot deployments in the commercial space.

WSNs are a main part of the networking infrastructure for pervasive computing. Pervasive computing and ubiquitous computing are terms nowadays used interchangeably, although they had different meanings in their early stages. Pervasive computing mean immersive computing whereas ubiquitous computing described techniques for embedded and invisible computing. With the development of the two computing paradigms, people gradually use the two terms interchangeably to mean both and combined aspects of the future trend of computing technologies. Pervasive computing has been forecasted by Mark Weiser in 1990's as the computing paradigm for the 21st century [1, 2, 3].

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Pervasive computing is a model of information processing that augments computers with sensing capabilities and distributes them into the environment. Many pervasive computing applications are reactive in nature, in that they perform actions in response to events (i.e. changes in state of the environment) [4]. However, these applications are typically interested in high-level complex events, in contrast to the low-level primitive events produced by sensors. However, these applications are typically interested in high-level complex events, in contrast to the low-level primitive events produced by sensors. Supporting complex event detection in pervasive computing environments is a challenging problem. Sensors may have limited processing, storage, and communication capabilities. In addition, battery powered sensing devices have limited energy resources. Since they are embedded in the environment, recharging may be difficult or impossible. The energy consumption of each sensor node is dominated by the cost of transmitting and receiving messages. To prolong the lifetime of the system, it is vital that these energy resources are used efficiently [5], [6], [6].

Energy-constrained sensor networks have been deployed widely for monitoring and surveillance purposes. Data gathering in such networks is often a prevalent operation. Since sensors have significant power constraints because battery life is limited, energy efficient methods must be employed for data gathering to improve network lifetime. In this paper we select the routing parameters that effect sensors power consumption during routing. Simulation displays the effect of these parameters on the network life time. Using appropriate consideration for these parameters in routing protocol maximizes network life.

The rest of the paper is organized as follows: In Section 2, the related work in this area is given. Section 3 shows our model for improving WSN life time. In Section 4, extensive experiments by simulation are conducted to evaluate the effects of power consumption factors during routing. The conclusion is given in Section 5.

2 Related Work

One important issue when designing wireless sensor network is the routing protocol that makes the best use of the severely limited resource presented by WSN, especially the energy limitation [8]; because of that efficient routing protocols are required to address power efficiency of the wireless sensor network. Shortest routing path is not always the best path from node to base station. A number of studies have explored the issue of energy aware, lifetime-maximizing routing approaches for wireless sensor networks [9], [10], [11], [12].The problem of these protocols that find optimal paths and then consume the energy of the nodes along those paths, leaving the network with a wide disparity in the energy levels of the nodes, and eventually disconnected the subnets [13].

In [14] an optimal energy efficient routing strategy proposed. In which nonlinear min–max programming problem with convex product form is applied. Geographical forwarding schemes are proposed to improve network lifetime by considering the residual energy of neighboring nodes in deciding next-hop while preserving the localized, scalable and nearly stateless property of geographical routing [15]. An online heuristic model, in which each message is routed without knowledge of future route requests, is proposed to maximize network lifetime [16]. Also much work has been done during recent years to increase the lifetime of the WSN from researchers [17], [18], [19], [20].

3 Routing Factors Model for Improving the Lifetime of WSN

We need to consider other factors such as initial power of the nodes i.e. the emphases placed on the initial energy of the nodes in making routing decision. Another important factor is the residual power in the nodes i.e. the emphases placed on the residual energy of the nodes in making routing decision. The third factor is routing period which is the amount of time between packet-routing decision updates. So to do this we need to choose balanced routing schema of messages through sensors considering these factors.

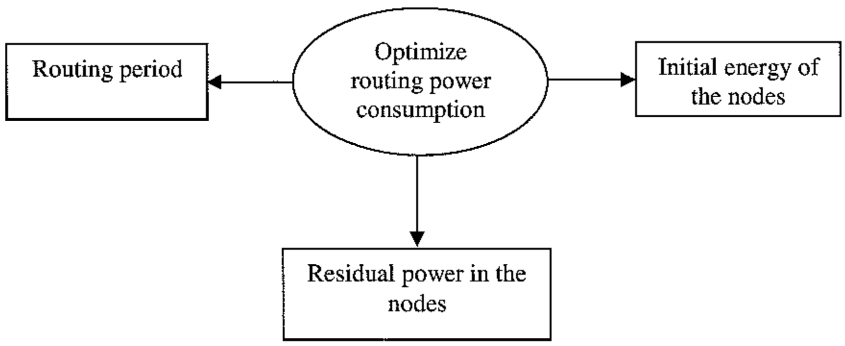

Fig. 1. Routing Factors Model

Figure 1 shows the factors that must be considered during the implementation of the routing protocol. In the next step we are going to simulate different WSN sizes considering these factors individually and together.

4 Simulation and Results

In this section, we evaluate the WSN performance of the proposed approach through simulations. The simulation was applied for several networks sizes with different routing factors. We compared the results of our approach when the three factors namely the initial power, residual power and routing period to the ones of did not consider the proposed factors in their simulations.

4.1 Simulation Tool

The Wireless sensor network simulator version 1.1 used to simulate routing. This simulator has the ability to run successive simulations on a network and report the mean network lifetime across 1,000 trials. The network routing parameters can be changed to allow testing of different network sizes and configurations.

The network may be deployed based on a wide range of parameters such as network size (number of nodes or sensors), communication distance, energy costs for transmitting and receiving data packets, etc. The network can then be used to simulate the detection of vectors traveling across the sensor network field. In this simulation, when a vector trips the sensor of a network node, the node generates a data packet and sends it to a downstream network node. The packets are routed appropriately until they reach a sensor within the area. Each node also simulates an energy store, which is depleted by sending receiving packets, and by detecting vectors. Since the nodes have limited energy, they will eventually power down and drop out of the communications network, causing network failure.

In this research, simulation applied for four different network sizes. These networks contain 35, 169, 212 and 410 sensors respectively. The three proposed factors initial power; residual power and routing period are used as parameters for simulation. These parameters tested individually and at the end all the factors considered together. In the following sections, the simulation results and evaluation for proposed factors will be presented.

4.2 Simulation Using Initial Energy of the Nodes

In this simulation we tested the effects of considering initial energy level for nodes when the routing path created. Table 1 show the comparison of the simulation results with and without considering the initial energy of the nodes during routing.

Table 1. Simulation results with considering/ without considering the initial energy of the nodes

# of sensors	The emphases placed on the initial energy	# of received packets	Mean lifetime test (Average steps)
35	Y	259	566
35	N	99	555
169	Y	441	412
169	N	211	395
212	Y	772	409
212	N	493	381
410	Y	1402	379
410	N	1231	385

Figures 3 and 4 indicates that initial energy factor have small effect on the network life time improvement whereas its effects more in increasing number of received packets during network life.

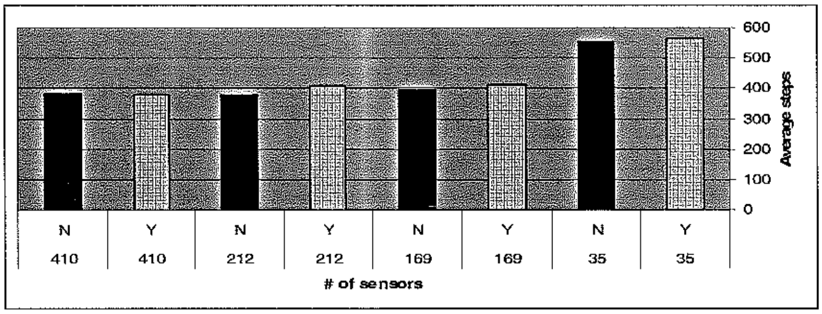

Fig. 2. Comparison of network lifetime with considering/ without considering the initial energy of the nodes for different network sizes

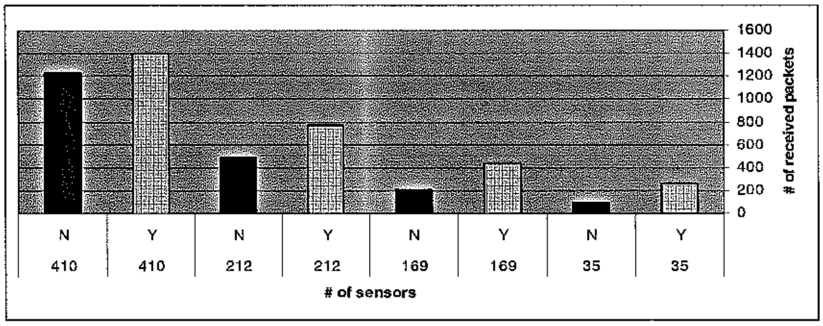

Fig. 3. Comparison of number of received packets with considering/ without considering the initial energy of the nodes for different network sizes

Figure 3 plots the comparison between number of received packets with and without considering the initial energy of the nodes for different network sizes. We can observe that the increase in the number of packets received is approximately 14% for large networks. Such increase could significantly improve the WSN performance.

4.3 Simulation Using the Residual Power in the Nodes

From simulation that considering residual power in the nodes during routing shows that in small WSNs this factor increases the network life time and the number of packets received.

Table 2. Simulation results with considering/ without considering residual power in the nodes

# of sensors	The emphases placed on the Residual power	# of received packets	Mean lifetime test (Average steps)
35	Y	215	821
35	N	92	518
169	Y	707	491
169	N	593	472
212	Y	1032	740
212	N	958	662
410	Y	1409	532
410	N	1256	496

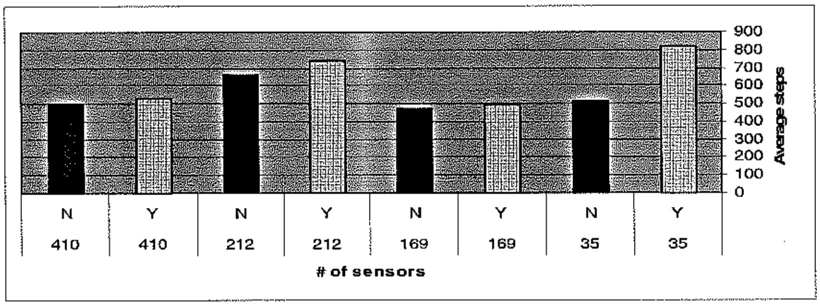

Fig. 4. Comparison of network lifetime with considering/ without considering the residual power of the nodes for different network sizes

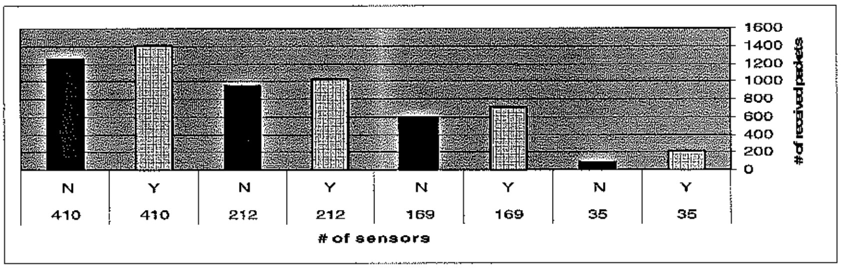

Fig. 5. Comparison of number of received packets with considering/ without considering the residual power of the nodes for different network sizes

Figure 4 displays the comparison between mean network lifetime with and without considering the residual power of the nodes for different network sizes. We can find that the increase in the network lifetime is approximately 37 % for small networks. In addition, Figure 5 plots the comparison between number of received packets with and without considering the residual power of the nodes for different network sizes. We can infer that by considering the residual power of nodes during routing the increases are approximately 58 %, 17 % and 11% for small, medium and large networks respectively.

4.4 Simulation Using the Routing Period

Simulation shows that considering routing period individually without regard to other factors will not improve the network life time. For small network this will decrease its life time. For large networks this factor can increase the number of packets received.

Table 3. Simulation results with considering/ without considering routing period

# of sensors	Routing Period	# of received packets	Mean life-time test (Average steps)
35	High	203	501
35	Low	154	647
169	High	588	432
169	Low	442	391
212	High	681	398
212	Low	924	390
410	High	1621	374
410	Low	1018	363

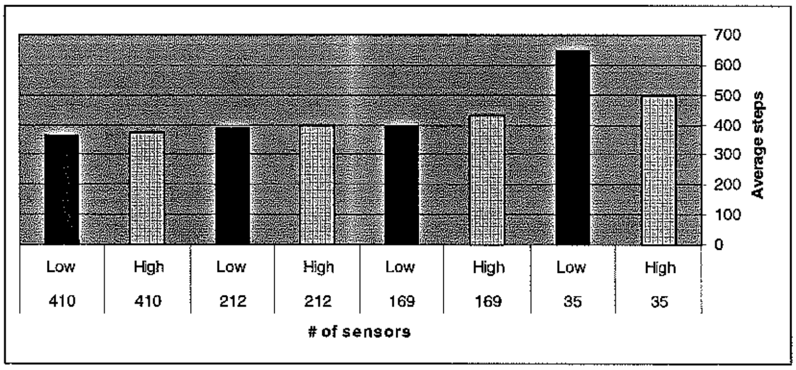

Fig. 6. Comparison of network lifetime with considering/ without considering the routing period for different network sizes

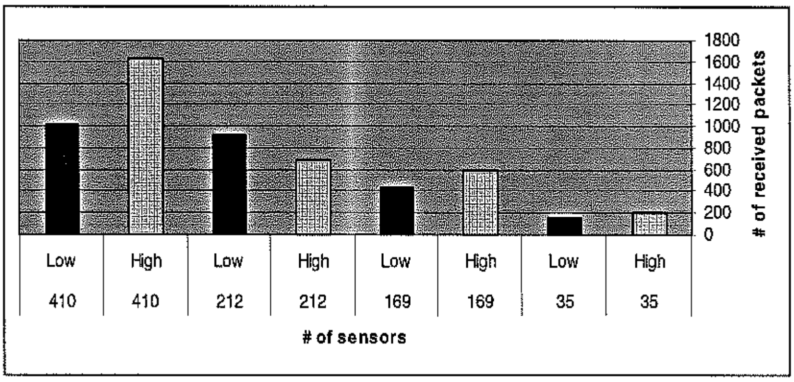

Fig. 7. Comparison of number of received packets with considering/ without considering the routing period for different network sizes

We can find from Figure 7 the increase in the number of received packets during network life is approximately 24 % for small networks and 38% for large networks.

4.5 Simulation Considering Initial Power, Residual Power and Routing Period

Simulation results indicates that considering the three factors (initial power, residual power and routing period) together during routing will effect widely on performance of the network. The life time will be increased and the data packets also. As shown in Figures 8 and 9 it's clear that for large WSNs the number of packets can be duplicated and the network life time is better three times if we considered these factors.

Table 4. Simulation results with considering/ without considering initial power, residual power and routing period

# of sensors	Considering all factors	# of received packets	Mean lifetime test (Average steps)
35	Y	222	849
35	N	192	581
169	Y	660	949
169	N	539	404
212	Y	963	968
212	N	766	388
410	Y	2211	1097
410	N	1196	363

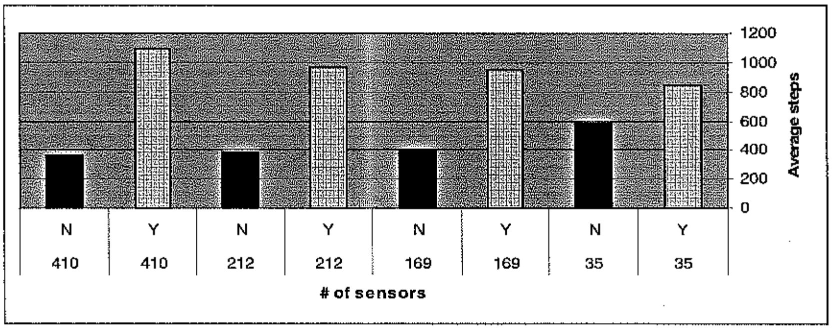

Fig. 8. Comparison of network lifetime with considering/ without considering initial power, residual power and routing period for different network sizes

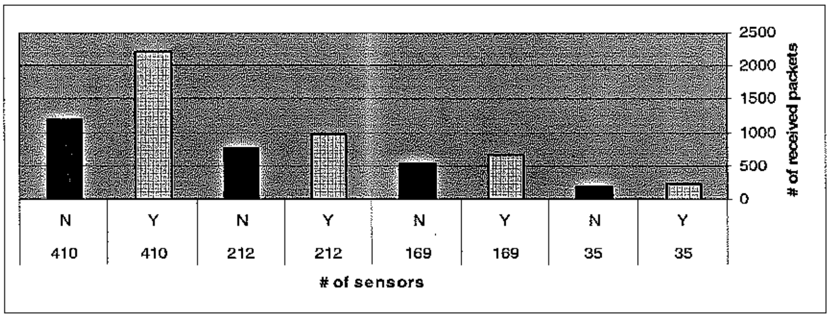

Fig. 9. Comparison of number of received packets with considering/ without considering initial power, residual power and routing period different network sizes

Table 5. Improvement percentage in the number of received packets and Mean lifetime fro different network sizes

Network size	Improvement percentage in # of received packets	Improvement percentage in Mean lifetime
35 nodes	15%	32%
169 nodes	18%	57%
212 nodes	20%	60%
410 nodes	46%	67%

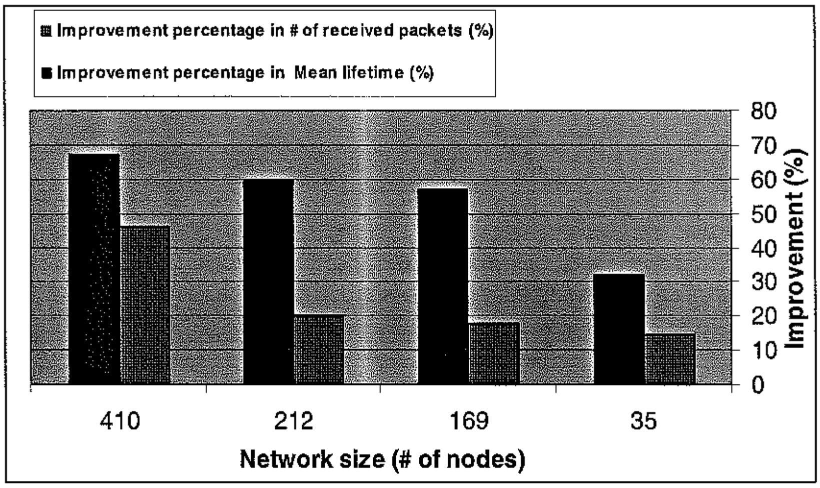

Fig. 10. Improvement percentage in the number of received packets and Mean lifetime fro different network sizes

Table 5 and Figure 10 show the approximate improvement percentage in the number of packets and the mean lifetime for different WSN sizes in case for combined consideration of power factors. We can observe that improvement percentage directly proportion with network size

Simulation results have shown the effects of power factors on the performance and mean lifetime of the WSNs. From this we can contribute the following:

a) Considering initial power factor individually improves the number of received packets during network life.
b) For the small WSNs the residual power in the nodes must be considered in the routing method.
c) For the large WSNs, considering all the three factors (initial power, residual power and routing period) will improve the network life time and increase the number of the packets can be received by the sink nodes.

5 Conclusions

It is well known that, efficient and optimize use of energy is critical issue for network lifetime. The goal of the proposed approach in this research is to reduce energy consumption. We first presented generic power consumption factors model for data gathering in WSNs. Three factors that mainly effect on the network life time addressed. These factors are simulated individually and together. We can contribute that considering residual power in the nodes individually can improve the small networks life time whereas considering all the proposed factors increase the performances of the all WSN networks especially large networks. As future work, we will optimize WSN routing protocol with consideration power factors stated in this research. This would lead to better results ensuring the prolongation of the lifetime of the WSN and improve the number of the packets can be routed during this lifetime.

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