



International Journal of Engineering Researches and Management Studies

ADDRESSING POWER CONSUMPTION FACTORS (APCF) TO MAXIMIZE WIRELESS SENSOR NETWORKS LIFETIME

Abdullah Said Alkalbani^{*1}, Sharifa Khadeem Al Mamari², Amna Rashid Al Isae³, Ta-foul Abdul Rahman Al Kaabi⁴ and RahabKhalifa Al Fahd⁵

^{*1}Assistant Professor, Electrical & Computer Engineering Department, College of Engineering, University of Buraimi, , Al-Buraimi, Sultanate of Oman

^{2,3,4&5}Students, College of Engineering, University of Buraimi, , Al-Buraimi, Sultanate of Oman

ABSTRACT

In this paper, popular energy saving schemes for Wireless Sensor Networks (WSNs) are studied. There are many challenges that limit network lifetime. High power consumption is one of the issues that reduce network lifetime. The objective of this paper is to address the main factors that cause energy consumption and analyze their effects. Performance, network efficiency and maximizing network lifetime are measured by simulation, analysis by considering factors and comparison with network without considering these factors.

Keywords: WSNs, Network efficiency, Power consumption, Residual energy, Routing period, Initial energy.

1. INTRODUCTION

A sensor network is an infrastructure comprised of sensing (measuring), computing, and communication elements that gives an administrator the ability to instrument, observe, and react to events and phenomena in a specified environment. The administrator typically is a civil, governmental, commercial, or industrial entity. The environment can be the physical world, a biological system, or an Information Technology (IT) framework. Networked sensor systems are seen by observers as an important technology that will experience major deployment in the next few years for a plethora of applications, not the least being national security. Typical applications include, but are not limited to, data collection, monitoring, surveillance, and medical telemetry. In addition to sensing, one is often also interested in control and activation [1].

WSNs are usually randomly deployed in inaccessible environments, disaster areas, or polluted places, where battery replacement or recharge is difficult or even impossible to be performed. For this reason, network lifetime is important to a WSN. To prolong network lifetime, there is a need for efficient power control mechanisms to reduce power consumption in sensor nodes and energy efficient techniques should be employed at all layers of the network [2], [3] which should take into account the following unique characteristics and application requirements of WSNs. A sensor node is equipped with a very limited power source. Sensor nodes that are dead cannot be recharged in most applications, and the network lifetime is limited. Therefore, proper power management is the key to maximize network lifetime. Power consumption of a sensor node occurs due to three events: sensing, data transmission, and data processing. Data transmission consumes maximum power and the researchers [4] found that each bit transmitted in WSNs consumes about as much power as executing 800–1000 instructions. Therefore, using security mechanism with power aware routing protocol will increase network lifetime [3].

In this work, the main factors that can effect on network lifetime if considered studied and evaluated by simulation. The remaining part of the paper is organized as follows: In section 2, the related work in this area is given. Section 3 describes the research model. Section 4 shows mathematical representation for sensors energy. In section 5 extensive experiments by simulation are conducted to prove the efficiency and quality of the idea. Section 6 presents the research contribution, results discussion, and analysis. Conclusion as well as the challenges encountered and future directions for research is given in section 7.

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 [5]; because of that efficient routing



International Journal of Engineering Researches and Management Studies

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.

More studies have conducted during recent years to increase the lifetime of the WSN. A number of studies have explored the issue of energy aware, lifetime-maximizing routing approaches for wireless sensor networks [6], [7], [8]. 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 [9].

In [10] 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 level of neighboring nodes in deciding next-hop while preserving the localized, scalable and nearly stateless property of geographical routing [11]. An online heuristic model, in which each message is routed without knowledge of future route requests, is proposed to maximize network lifetime [12]. Although the lifetime of the WSN can be defined in different ways; we adopt the definition that it is the time until the first node consumes its energy, which is a widely used. Researchers in [13], [14] are considered the problem of maximizing the time to the first node failure for a unicast session, where each data source generates data for delivery at a fixed rate. In [8] optimal solutions are proposed for maximizing the time to the first node failure for a static broadcast tree. An optimal solution for maximizing the time to the first node failure for a static multicast tree presented in [15].

3. Research Model

One method to prolong WSNs lifetime is controlling the factors that effect on power consumption during data routing and transmission. This job optimizes such scheme for Addressing Power Consumption Factors (APCF) by considering initial energy, residual energy and routing path.

As shown in Figure 1, three factors balanced to optimize a scheme for prolong network lifetime.

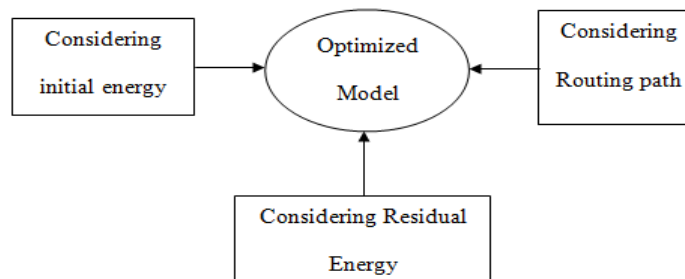


Fig.1. Research model for maximize network lifetime.

4. Energy Mathematical Model

In this section, the mathematical model for nodes and all network energy consumption during routing is presented. The energy consumed for node (i) is the total energy used when receiving data and energy used for transmission as follows:

$$E_i = E_{\text{transmit}} + E_{\text{receive}} \quad (1)$$

In details, the equation that represents energy consumed when the sensor receives a message of size k is

$$E_{\text{receive}} = E_{\text{elec}} * k \quad (2)$$

where E_{elec} is electronics energy, and the energy consumed on sending a message of size k is



International Journal of Engineering Researches and Management Studies

$$E_{\text{transmit}} = E_{\text{elec}} * k + E_{\text{amp}} * r^2 * k \quad (3)$$

where r is the sensor sensing range and E_{amp} is amplifier consumed energy [16]. So, the total energy consumed for the network is

$$E_{\text{total}} = \sum_{i=1}^n E_i \quad (4)$$

5. Experiments and Simulation Results

Simulation Tool and Definitions of Parameter

In this research, The Wireless sensor network simulator version 1.1 used to simulate Wireless Sensor Network . 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. Each sensor node is assumed to have an initial energy of 100 joules. A node is considered dead if its energy level is 0 joules. Simulation parameters and default values used in the experiments are summarized in Table 1.

Table 1. Simulation and network parameters.

Parameter	Value	Comments
N	100	Number of nodes
E_0	100 j	Node Initial Energy
rx power	1.0 rp	Receive power
tx power	1.0 tp	Transmit power
Data packet	50 bytes	Max packet in Ifq
max Packet	50000 bytes	Max packet limit
I_t	10.0 s	Interval set for packet transfer
B	512,1024,1500,2000,2500 bytes	Broadcast packets
P_{opt}	0.05	Optimal probability

In addition, this research assumed that all sensors are homogeneous, so each sensor has the same communication range. Also, sensors can only communicate with the neighbors within communication range due to limited power. Multi-hop is required to communicate with farther ones.

Experiments Results

Since some of the essential constrains that effect on WSNs are battery limits, high energy consumption during transmission and reception, and network throughput, a WSN is simulated in our experiments by considering some factors that effect on network efficiency. These factors are the initial energy level for the network sensors, the residual energy remains in the sensors after a certain time and the routing path from source to destination. In the following sections, simulation results for addressing power consumption factors are shown and discussed.

Sensors Initial Energy

This section presents the results of our simulation for WSNs with and without considering initial energy of the network sensors during packets routing from source to destination. Table 2 Shows the results of in terms of packets received, power consumption and network lifetime. Figures 2, 3, and 4 proves the advantages of looking to the initial energy of the sensors on the path of packets transmission. This improve the network efficiency



International Journal of Engineering Researches and Management Studies

Table 2. WSNs simulation with/without considering initial energy

PACKETS RECEIVED (BYTES)	Network size		Packets Received (bytes)		Power consumed (mj)		Network Life Time (seconds)	
	considering	Not considering	considering	Not considering	considering	Not considering	considering	Not considering
14	57	50	288	280	240	233		
182	150	135	949	902	340	325		
328	270	260	1340	1290	410	370		

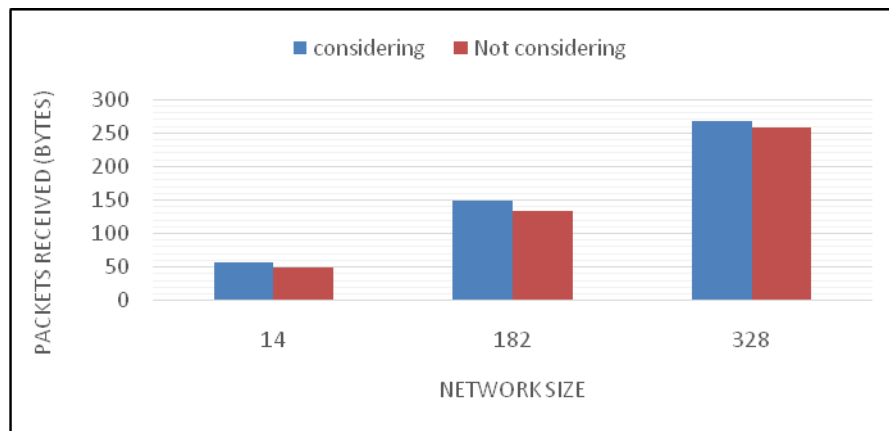


Fig.2.Packets received vs. network size by considering/ without considering nodes initial energy

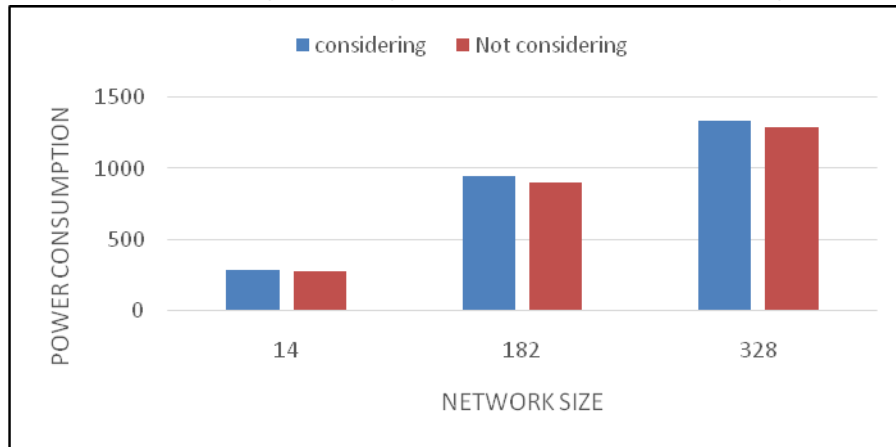


Fig. 3. Energy consumed vs. network size by considering/ without considering nodes initial energy

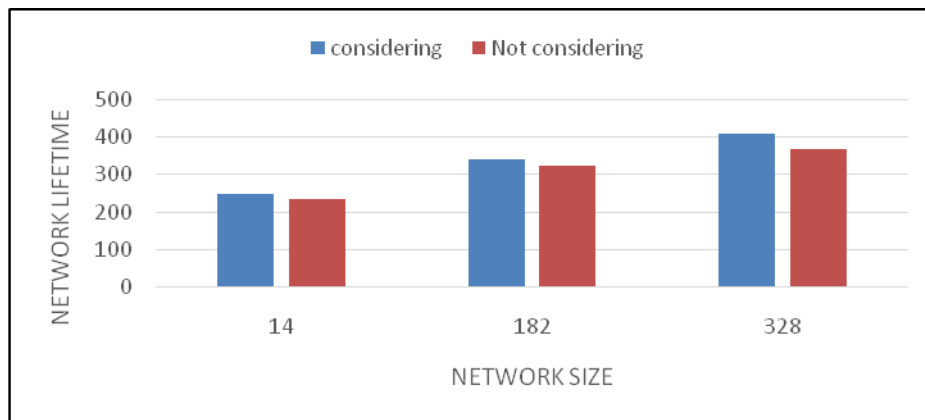


Fig. 4. Network lifetime vs. network size by considering/ without considering nodes initial energy

Residual Energy

This section presents the results of our simulation for WSNs with and without considering nodes residual energy during packets routing from source to destination. Table 3 Shows the results of simulation in terms of packets received, power consumption and network lifetime.



International Journal of Engineering Researches and Management Studies

Table 3. WSNs simulation with/without considering sensors residual energy

PACKETS RECEIVED (BYTES)	Network size		Power consumed (mj)		Network Life Time (seconds)	
	considering	Not considering	considering	Not considering	considering	Not considering
14	63	50	482	440	208	193
182	73	63	492	402	263	225
328	98	95	1220	1211	329	270

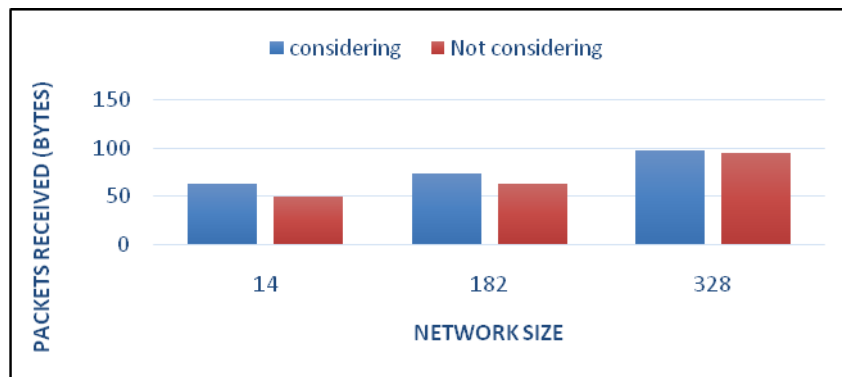


Fig. 5. Packets received vs. network size by considering/ without considering nodes residual energy

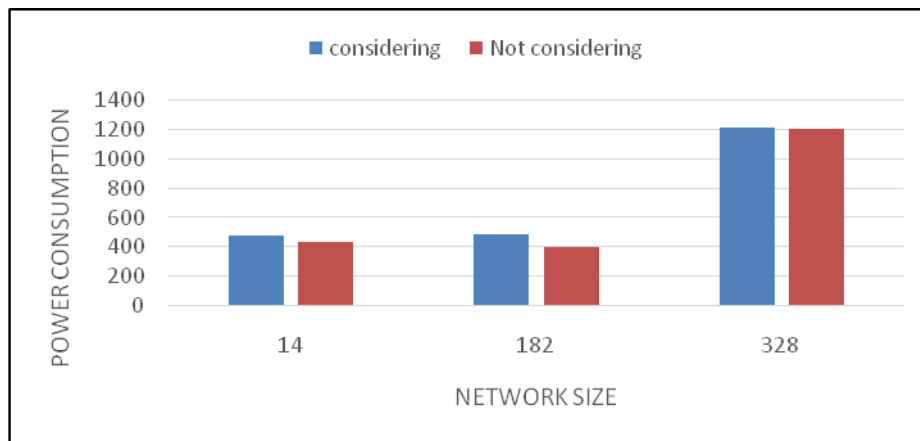


Fig. 6. Energy consumed vs. network size by considering/ without considering nodes residual energy



International Journal of Engineering Researches and Management Studies

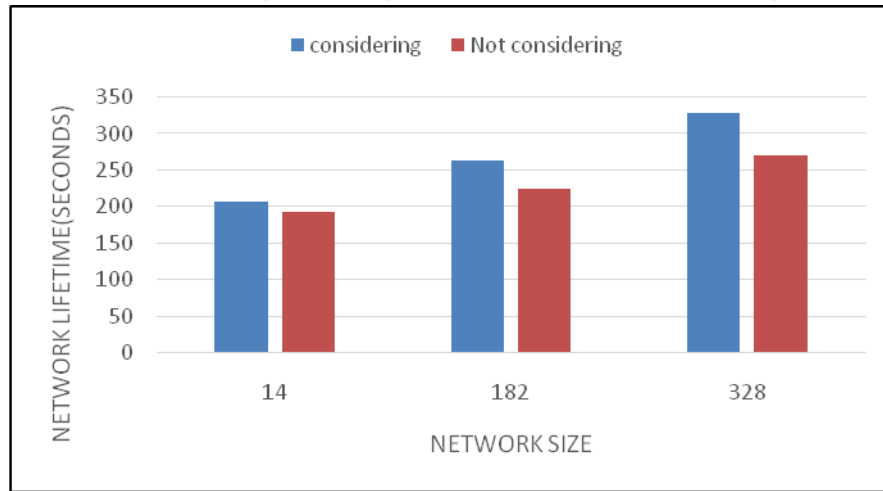


Fig. 7. Network lifetime vs. network size by considering/ without considering nodes residual energy

From figures 5, 6, and 7 we can conclude, taking care about sensors residual energy during data packets routing effect positively on the network performance. This increase the network lifetime, data packets received and at the same time minimizes power consumption.

Routing Path

This section presents the results of experiment simulation for WSNs with and without considering packets routing path. Table 4 Shows the results of simulation for packets received, power consumption and network lifetime. From Figures 8, 9, and 10 its clear that considering routing path will improve the network efficiency by improving network lifetime, received packets, and reducing power consumption.

Table 4. WSNs simulation with/without considering data routing path

PACKETS RECEIVED (BYTES)	Network size		Packets Received (bytes)		Power consumed (mj)		Network Life Time (seconds)	
	considerin g	Not considerin g	considerin g	Not considerin g	considerin g	Not considerin g	considerin g	Not considerin g
14	54	50	766	730	253	233		
182	72	70	929	902	288	243		
328	94	80	1272	1230	350	320		

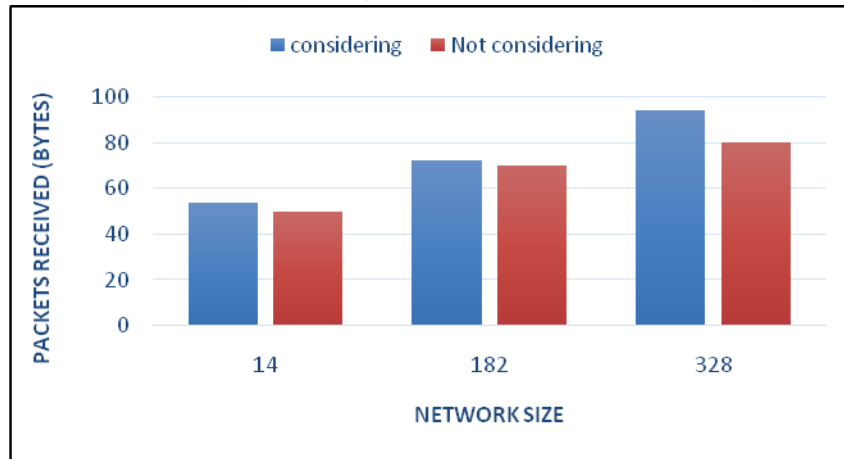


Fig. 8. Packets received vs. network size by considering/ without considering nodes routing path

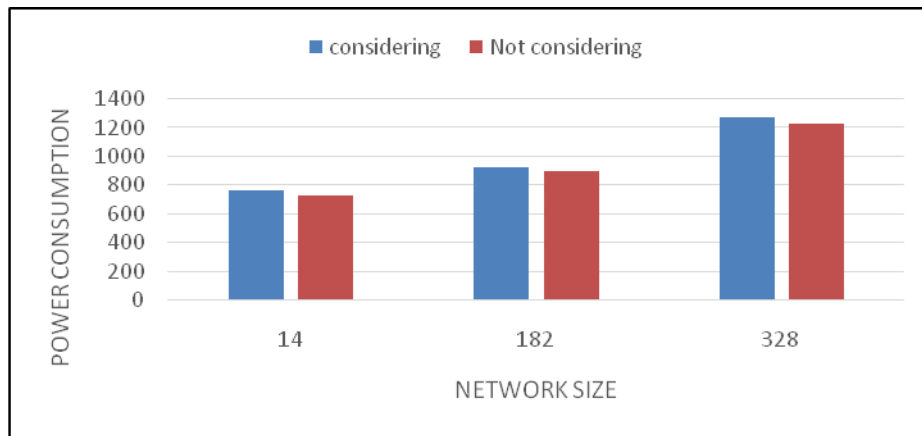


Fig. 9. Energy consumed vs. network size by considering/ without considering nodes routing path

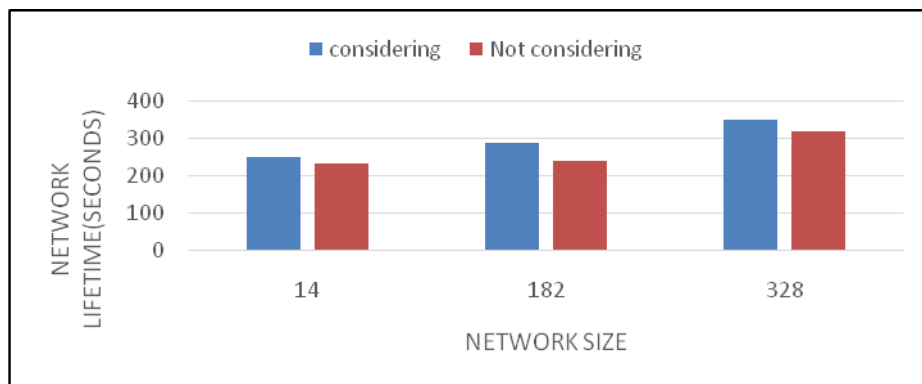


Fig. 10. Network lifetime vs. network size by considering/ without considering nodes routing path



International Journal of Engineering Researches and Management Studies

6. Results Discussion

Simulation results demonstrate that APCF achieved significant energy savings, increasing packets transmitted and increasing network lifetime compared networks without considering such factors. As a result, this mechanism can be used with different WSNs sizes with high performance. From the results of the simulation we can summarize the contribution of this paper in the following points:

- Simulation results have shown that total energy used to transmit data in the proposed scheme minimized if we consider power factors for different network sizes.
- The data rate increased for different WSNs sizes which mean the network throughput improved.
- The network lifetime enhanced compared to networks that not take care about the APCF.

7. Conclusions

The energy constraints and limited computing resources of the sensor nodes present major challenges in transmitting and processing data within the network. In this paper, we focused on how to minimize the node energy consumption since it has been proven to be the important area in wireless sensor networks. By Addressing Power Consumption Factors (APCF) for WSNs we can prolonging the lifetime of the network and increase the data transmission rate and also minimize power consumption.

As future work, scheme can be applied by using mobile sensors to increase energy saving and reach any isolated part in the network which will increase network productivity.

REFERENCES

- [1] Sohraby, K., Minoli, D. and Znati, T. *Wireless sensor networks: technology, protocols, and applications*. John Wiley & Sons (2007).
- [2] Pantazis, N. & Vergados, D. D. A survey on power control issues in wireless sensor networks, *IEEE Communications Surveys & Tutorials, IEEE*, vol. 9, no. 4, pp. 86 – 107, (2007).
- [3] Pantazis, N. A., Vergados, D. J., & Vergados, D. D. Increasing intelligent wireless sensor networks survivability by applying energy-efficient schemes. In *Artificial Intelligence Applications and Innovations*, Springer US, pp. 657-664, (2006).
- [4] Hill, J., Szewczyk, R., Woo, A., Hollar, S., Culler, D., & Pister, K. System architecture directions for networked sensors. In *ACM SIGOPS operating systems review, ACM*, vol. 34, no. 5, pp. 93-104, (2000).
- [5] Ming, Y., Wong, W., S.: An energy-efficient multipath routing protocol for wireless sensor networks. *International Journal of Communication Systems*. Volume: 20, Issue: September 2006, Publisher: IEEE, Pages: 747-766, (2007).
- [6] Al-Karaki N., Kamal, A.E.: *Routing Techniques in Wireless Sensor Networks: a survey*, *IEEE Wireless Communications*, Pages: 6-28, (2004).
- [7] Akyildiz I. F.: *Wireless sensor networks: a survey*, *Computer Networks*, Vol. 38, pp. 393-422, (2002).
- [8] Krishnamachari, B.: *Networking Wireless Sensors*, 214 Pages, Cambridge University Press, ISBN 0521838479, (2005).
- [9] Bhuyan, B., Sarma, H., Sarma, N., Kar, A., & Mall, R.: *Quality of Service (QoS) Provisions in Wireless Sensor Networks and Related Challenges*, *SciRes Journal, Wireless Sensor Network*, 2, pages: 861-868, (2010).
- [10] Shiou, C., Lin, Y., Cheng, H., Wen, Y.: *Optimal energy-efficient routing for wireless sensor networks*, in: *Proceedings of the 19th International Conference on Advanced Information Networking and Applications*, vol. 1, pp. 325–330, (2005).