Applied Mathematics & Information Sciences
An International Journal

http://dx.doi.org/10.18576/amis/150407

Improving Network Lifetime in WSN for the application of IoT

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Received: 2 Apr. 2021, Revised: 12 May 2021, Accepted: 13 Jun. 2021.
Published online: 1 Jul. 2021.

Abstract: In this paper, we improve the strength of enhancing the network lifetime problem using the awake sleep mechanism and extending network lifetime. The results showed that network lifetime has been extended to more than previous studies. Our study used the Effective Energy Sensitive Threshold Network (TEEN) as a homogeneous protocol and distributed energy-saving clusters (DEEC) as heterogeneous protocol. Our results are very important and the benefit when processing and designing WSN for the IoT application.

Keywords: Wireless sensor network, IoT, Heterogeneous and homogeneous protocols, Packet-to-BS, Dead nodes, Alive nodes, End-to-End Delay, Overhead.

1 Introduction

In the wireless sensor network (WSN) the nodes are deployed randomly, where nodes near the sink area take more energy than the remote nodes. These nodes die quickly creating an energy hole problem surrounding the sink nodes. The data sent to the sink will be completely lost causing the end of network lifetime. Kevin Ashton from MIT coined the term "Internet of Things" in the early 2000s. It stands for a "worldwide network of interconnected objects uniquely addressable, based on standard communication protocols" [1]. Though IoT is a widely used term, its definition is still fuzzy. IoT is a technological revolution that represents the future of computing and communications. It aims to increase the ubiquity of the Internet by integrating every object for interaction via embedded systems, which leads to a highly distributed network of devices communicating with human beings as well as other devices [2]. When we compare the IoT with the traditional information networks, we find that the IoT has three new goal: it is widely extensive interconnection, supplementary intensive information perception, and further comprehensive intelligence service.

The emerging IoT has various application scenarios equipped with a wide range of network devices [3]. As shown in Figure 1, WSN acts as a gateway to the IoT. A wireless sensor network is a collection of sensor nodes with limited power supply and constrained computational and transmission capability. The main responsibility of the sensor nodes in a network is to forward the collected information from the source to the sink for further operations, but the resource limitations [4], unreliable links between the sensor nodes in combination with the various application demands of different applications make it a difficult task to design an efficient routing algorithm in wireless sensor networks. Designing suitable routing algorithms for different applications, has been considered an important issue in wireless sensor networks. In many IoT applications, sensing of data must be sent to Base Station (BS) for various operations. This can be done through effective routing protocols that are integrated to improve data transfer, energy and scalability of the WSN network. There are a lot of challenges when we design effective communication protocols, such as limited resources and low-power wireless connectivity. Thus protocols and paths are therefore needed to transfer data with reduced delay, loss rate and minimum power needed for various IoT applications.

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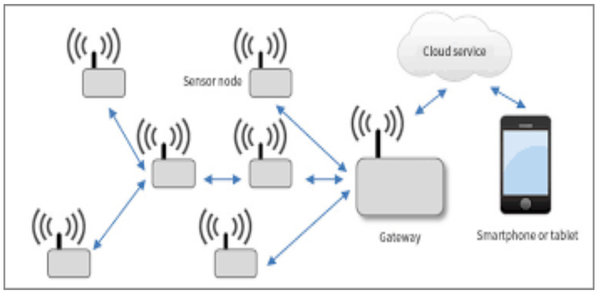


Fig.1: WSN as a gateway for IoT.

This paper is an expansion of a previous work [3, 5, 6]. It improves end-to-end delays and overheads with different node density in a small and large network. The network's lifetime in two heterogeneous and homogeneous protocols of the State has also increased compared to previous work. This paper is organized as follows: Section 2 presents an overview of previous work. Sections 3 illustrates simulation experiments and their results. Section 4 involves conclusion of this paper and its contributions. Section 6 is devoted to references.

2 Overview

The problem of energy hole and nodes near the sink is that they have a larger load of data and so consume more energy. Therefore, the nodes near the sink drain more energy and die quickly, causing the so-called EHP around the sink. In this case, no more data will be transferred to the sink. Thus, the lifetime of the network expires due to energy depletion near the sink. Further sensor nodes may interfere due to dense deployment in any area and increase the cost of devices. However dense deployment is another reason for creating a problem holes in WSNs.

Rasheedl et al. [5,6] proposed an energy-efficient HOle removal mechanism (E-HORM) technique to remove energy holes. In this technique, they use the sleep and awake mechanism to hold the sensor to save energy. This approach finds the maximum distance node to calculate the maximum energy of data transfer. It also represents a good background to the problem of energy hole. It also gives us the energy consumption model and the EHORM scheme.

Trumpti M. Behira and Sushanta K. Mohapatra [3] showed the trade-off that is maintained between network lifetime and energy requirements by implementing the sleep-awake mechanism. Using ;MATLAB simulator they extended the network lifetime to nearly 300 and 700 rounds to TEEN and LEACH respectively. The results may be useful for the design process in WSN as well as the IoT application. They did a lot of work to solve the energy hole problem.

3 Simulation and Results

WSN contains 100,300, 500 and 1000 nodes that are randomly deployed. In the middle of the field, the sink is located. After the deployment sensor nodes are not moved. The sensor hold has limited initial energy, but the energy of the sink node is unlimited. Sensor node transmission ranges are adjustable according to the distance from the sink.

The nodes required to send data packets to a sink follow a time cycle. The sensor nodes selected in each round are set to work and the rest of the nodes to sleep mode to save energy. This mechanism is called sleep and wake process [5]. We implement this mechanism in some cluster-based protocols that TEEN [7] is a homogeneous protocol and DEEC [8] is a heterogeneous protocol.

Table1: simulation parameters value.

S. No.	Parameters	Values
1	Network Area	300*300
2	Number of Nodes	100,300,500,1000
3	Cluster head probability	0.03
4	Energy for each node	0.5
5	transmitter energy	50*0.000000001
6	receiver energy	50*0.000000001
7	Aggregation Energy	5*0.000000001
8	amplification energy	0.0013*0.000000000001
9	Number of Rounds	5000
10	Hard Threshold	100
11	Soft Threshold	2

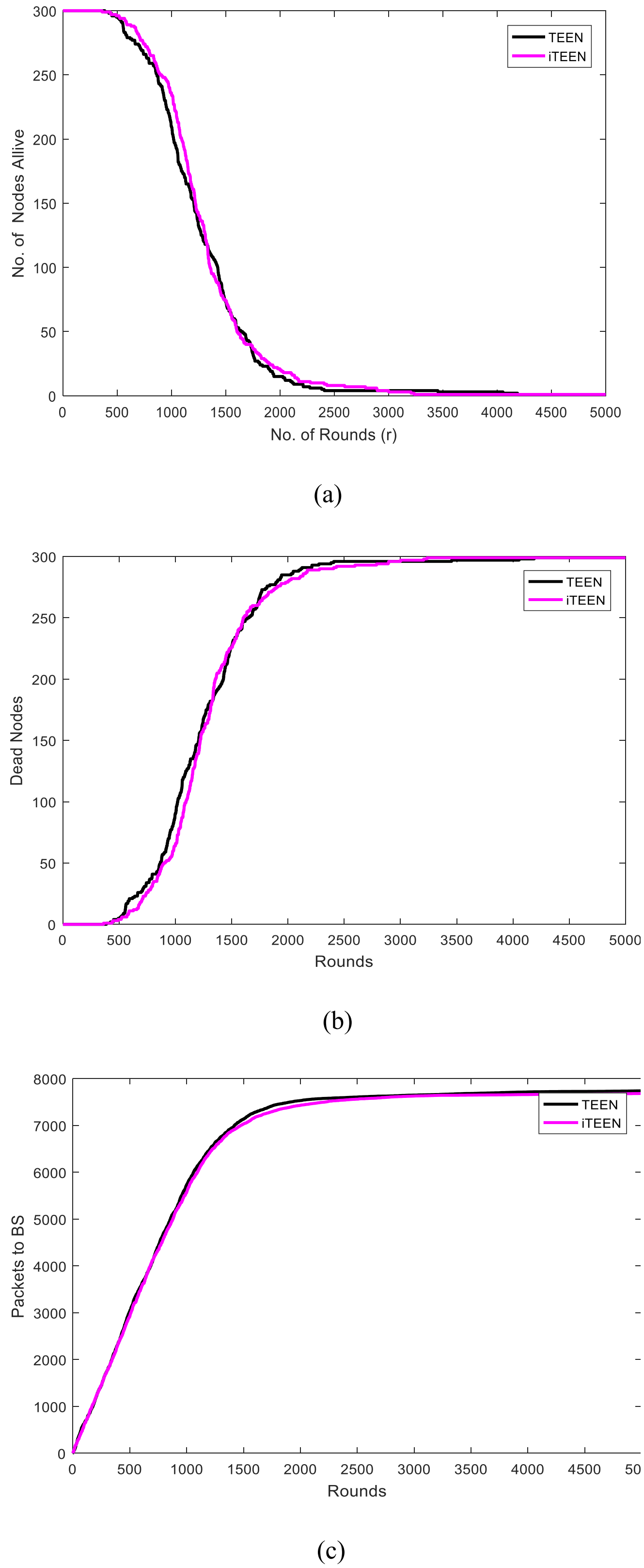


Fig. 2: Comparing TEEN and iTEEN protocols: (a) number of live nodes per 5,000 rounds, (b) number of dead nodes per 5,000 rounds, and (c) number of data packets to BS per 5,000 rounds.

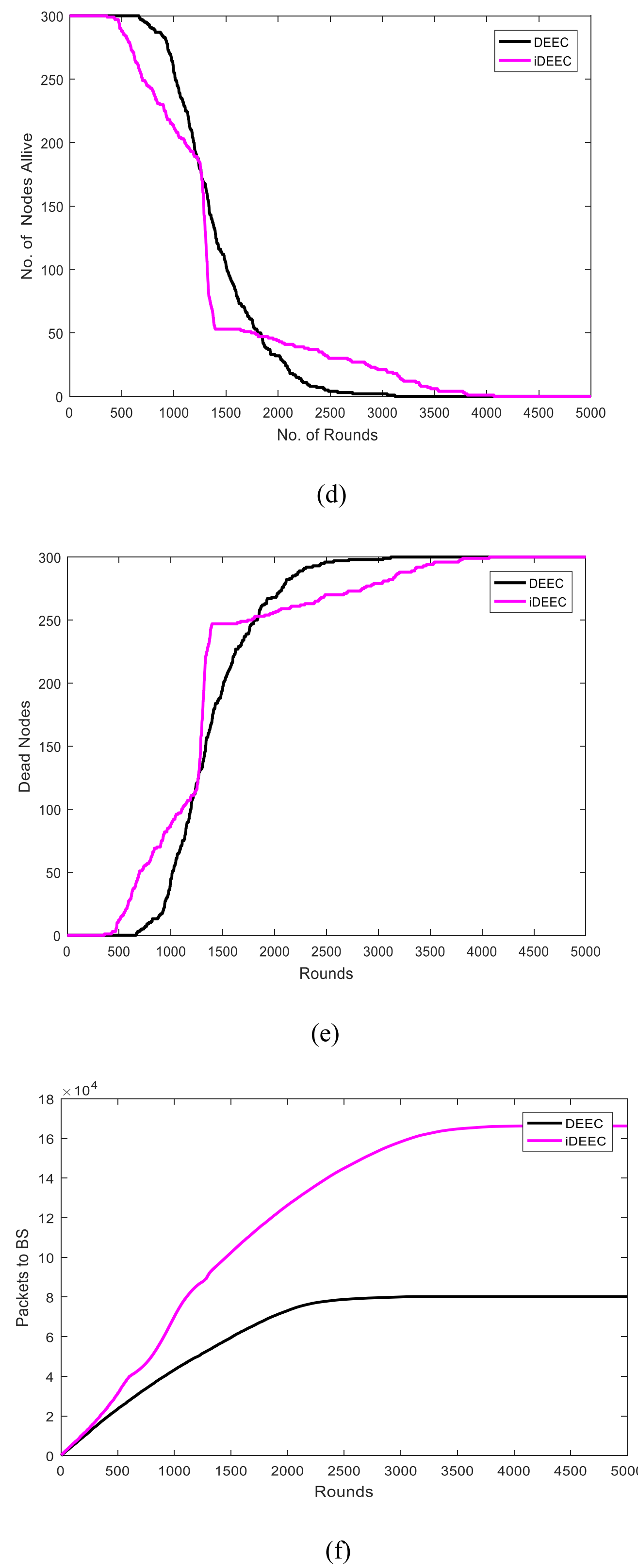


Fig. 3: Comparison of DEEC and iDEEC protocols: (a) the number of live nodes per 5,000 rounds, (b) the number of dead nodes per 5,000 rounds, and (c) the number of data packets to BS per 5,000 rounds.

3.1 Results

Our results are obtained through MATLAB simulation. In our simulations, the sensor network is deployed with a number of homogeneous or heterogeneous sensor nodes that are randomly considered in a square field. Figure 2 shows that the comparison between TEEN as a homogeneous protocol and the awake sleep mechanism iTEEN. It shows that iTEEN is better than TEEN protocol. We compare the number of nodes of a large network with 500 and 1000 nodes number. The first in 500 nodes package number sent to BS increased in iTEEN other than TEEN and alive nodes reached 3000 and 3500 rounds in TEEN and iTEEN respectively.

The number of dead nodes reaches the maximum in the 3500 round of TEEN protocol and iTEEN awake sleep mechanism. Second, for the 1000 nodes, the maximum number of dead nodes is 2,500 rounds and the live nodes reaches 3,000 rounds. it is also clear that the package sent to BS is increasing in iTEEN rather than TEEN.

Again we compare DEEC performance and iDEEC protocols. For the best performance rating, we ignore signal collision disturbances and interference with a wireless medium. It has been clear that the network lifetime of awake sleep mechanism iDEEC is greater than DEEC protocol. There is a small time in the stability period of DEEC and iDEEC ,but the lifetime of iDEEC is better. From the awake sleep mechanism, we can use energy looking at each area to remove energy holes.

Figure 3 shows a DEEC comparison as a heterogeneous protocol and iDEEC awake sleep mechanism. The package sent to the BS and the number of dead nodes decreased per round simulation. In a small network with the 100 nodes the lifetime of iDEEC increased other than the DEEC protocol but the package sent to BS and dead node also decreased. Again we simulate in a large network with 500 and 1000 nodes respectively the same result that was obtained as a small network. Hear, lifetime increases in a large network of WSN as an application of IoT.

Rasheedl et al. 6] conducted a similar experiment called EHORM to compare the number of live nodes with a network of only 100 nodes for protocols, such as LEACH, DEEC, TEEN and SEP. Trumpti M.Behera and Sushanta K. Mohapatra [3] gave better results than the EHORM approach to TEEN protocol and DEEC that extended to another 3,500 rounds of becoming dead by 2,500 and 3,000 respectively. In our dead results it extended to 4,000 shots and 5,000 rounds for DEEC and TEEN respectively. Thus, we can say that the lifetime of the network is enhanced by our implementation of both heterogeneous and homogeneous protocols.

3.2 Overhead

Both TEEN and iTEEN protocols reduce overhead while increasing the number of nodes or network size. We can define the overhead as follows: Routing and data packets must share the same network bandwidth most of the time, so routing packages are considered to be overhead in the network'. Hence, a good routing protocol has less overhead [9,10,11]. Table 2 contains TEEN protocol carrying less than iTEEN protocols.

Also, for all DEEC and iDEEC protocols, overhead increases with the number of nodes. Table 3, show that iDEEC has less load than deec protocol.

Table2: overhead of TEEN and iTEEN protocols

N. of nodes	teen	iteen
	overhead	overhead
100	1.0398	2.0381
300	1.0386	1.0389
500	0.0339	1.0349
1000	0.0312	0.0313

Table3: overhead of DEEC and iDEEC protocols.

N. of nodes	DEEC	iDEEC
	overhead	overhead
100	0.0023	0.0014
300	0.0036	0.0018
500	0.0047	0.0020
1000	0.0062	0.0022

3.3 End to end Delay

TEEN, iTEEN, DEEC and iDEEC protocols increase delays as the number of nodes in the network increases end-to-end delays this means that the time it takes for a package to travel from source to destination depends on the number of hops and congestion on the network [9].

By increasing the number of node hops and congestion increase which means increased delay that the package takes many times to reach the destination this is shown in table 4,5 for TEEN, iTEEN, DEEC and iDEEC protocols respectively [12,13,14].

Table 4: End-to-end delay of TEEN and iTEEN protocols.

N. of nodes	teen	iteen
	End-to-end delay	End-to-end delay
100	2.49E+05	2.57E+05
300	7.74E+05	7.68E+05
500	1473600	1.43E+06
1000	3.20E+06	3192000

Table 5: End-to-end delay of DEEC and iDEEC protocols.

N. of nodes	DEEC	iDEEC
	End-to-end delay	End-to-end delay
100	4407400	6978500
300	8250000	16228800
500	10530200	24739300
1000	16180100	46381300

4 Conclusion

In this paper, we addressed the problem of energy hole and network lifetime in WSN for the IoT application. We use TEEN and DEEC as an example of homogeneous and heterogeneous protocols respectively. We also discussed the creation of energy holes in homogeneous and heterogeneous routing protocols.

We have implemented TEEN and DEEC routing protocol to study network behavior under different scenarios to remove any energy hole and extend network lifetime. We note that less energy in iTEEN and iDEEC means nodes lives longer than TEEN and DEEC. Our results lead to extended to 4,000 rounds and 5,000 rounds for DEEC and TEEN respectively and an awake sleep mechanism each.

Overheads also increased and end-to-end delayed as the node density of these protocols increased. Thus, we can say that the lifetime of the network is reinforced by our implementation of both heterogeneous and homogeneous protocols. The lifetime of the sensor network will be increased after the implementation of the wake sleep mechanism. The result showed improved stability and increased data packets sent to the sink in the network. The best power performance can be achieved when implemented in IoT in an application. As a future work, our analysis protocol can be applicable to IoT in LEACH extensions, and its modifications. Tests for AODV and DSR as well as their extensions can also work.

References

[1] INFSO D.4 Networked Enterprise RFID INFSO G.2 Micro Nanosystems in Co-operation with the Working Group RFID of the ETP EPOSS, “Internet of Things in 2020, Roadmap for the Future, Version 1.1,” *European Commission, Information Society and Media, Tech. Rep*., May 2008.

[2] Zhikui Chen, Haozhe Wang “A Context-Aware Routing Protocol on Internet of Things Based on Sea Computing Model”, *Journal of computers., **7(1)**,* 96-105(2012).

[3] Trumpti M.Behera and Sushanta K. Mohapatra:” improving network lifetime by minimizing energy hole problem in WSN for the application of IoT”, *FACTA UNIVERSITES, Series: Electronica and Engrgetics*., **31(2)**, 267-277(2018).

[4] M. Jiang, J. Li, and Y. C. Tay. Cluster Based Routing Protocol. *Internet Draft*, 1999.

[5] M. B. Rasheedl, N. Javaid, A. Javaid, M. A. Khan, S. H. Bouk, and Z. A. Khan,“Improving Network Efficiency by Removing Energy Holes in WSNs,” *arXiv Prepr. arXiv1303.5365*., 2013.

[6] M. B. Rasheed, N. Javaid, Z. A. Khan, U. Qasim, M. Ishfaq:” E-HORM: AN ENERGY-EFFICIENT HOLE REMOVING MECHANISMIN WIRELESS

SENSOR NETWORKS", *arXiv:1303.6260v1 [cs.NI]* 25 Mar 2013.

[7] A. Manjeshwar and D. P. Agrawal, "TEEN: A Routing Protocol for Enhanced Efficiency in Wireless Sensor Networks.," *in ipdps.,* **1**, 189(2001).

[8] L. Qing, Q. Zhu, and M. Wang, "Design of a distributed energy-efficient clustering algorithm for heterogeneous wireless sensor networks," *Comput. Commun*., **29(12)**, 2230–2237(2006).

[9] Hamdy H. El-Sayed:" Performance comparison of LEACH, SEP and Z-SEP Protocols in WSN", *International Journal of Computer Applications (0975 – 8887)* Volume 180 – No.30, April 2018.

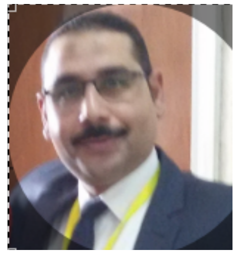
[10] -Mariam Benmoussa, Mariyam Ouaissa et.al., *,'QoS Analysis of Hierarchical Routing Protocols for Wireless Sensor Networks'*, In the Proceedings of the Second International Conference on Internet of Things, Data and Cloud Computing, ACM Digital Library, A.No.89, 2017.

[11] -Hamdy H. El-sayed: " Some WSN Characteristics Effects on the Performance of LEACH and MODLEACH Protocols", *Applied Mathematics & Information Sciences, Appl. Math. Inf. Sci*., **13(3)** , 1-8 (2019).

[12]- Hamdy H. El-sayed:" Effects of Number of Nodes and Network Area Size Parameters on WSN Protocols Performances", *Int. J. Advanced Networking and Applications.,* **11(2)**, 4244-4251(2019).

[13]- Hamdy H. El-sayed and Hassan Shaban Hassan:" Performance Comparison of Various Hierarchical WSN Routing Protocols ", *Int. J. Advanced Networking and Applications.,* **11(2)**,4218-4223(2019).

[14]- Mahmoud A. Mofaddel, A. Younes and Hamdy H. El-Sayed:" Multi-Objective Multicast Routing Based on Ant Colony Optimization in Mobile Ad-Hoc Networks ", *Journal of Statistics Applications and Probability* Acceptance, Ref. No: 202062 2, Jun2 2020.



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