AN ENERGY-EFFICIENT MODEL FOR INTERNET OF THINGS USING COMPRESSIVE SENSING

Jay Kumar Jain, Sagar Institute of Research and Technology, India
Dipti Chauhan, Prestige Institute of Engineering Management & Research Indore, India

ABSTRACT

The Internet of Things is one of the most important and promising technologies today. Some researchers estimate that there are more than 20 billion connected devices and counting. Around us, there are smartphones, wearables, and other devices, all of which use sensors. Nowadays, sensors play an important role in our everyday life and in IoT. The sensor network provides service of IoTs applications on the user's side. In the sensor network, the utilization of energy is a major issue. The maximum utilization of energy enhances the IoTs application. The main aim of this paper was to the development of an efficient model to minimize the energy for wireless sensor networks. In this paper, we proposed the dual probability-based energy estimation model in the wireless sensor network. The dual probability-based function measures the expected value of energy for the transmission of data. This function creates a subgroup of networks based on energy function and carries out the operation of energy management in the context of sensor node data processing. This function also integrates cloud-based services with sensor networks. The benefit of this function is that it increases the throughput of the network and the quality of service. The proposed model was simulated in the MATLAB R-2014a environment and the results were obtained using different scenarios of network density. Finally, we analyzed the performance of our proposed work with respect to the following metrics: data utility, energy consumptions, and data reconstruction error.

INTRODUCTION

The concept of the internet of things integrates all devices with the internet. It includes sensors, actuators, and edge devices. The life of network devices depends on the consumption and utility of energy in the sensor node or network. The wire-less sensor network in cooperative technology is a challenge in IoTs. The applica-tion of IoTs is linked with the edge network (Zhou, Y., 2013). The edge network supports the concept of the dynamic nature of cloud-based services. The edge-based compo-nent has a problem with bandwidth and energy. Energy is a major factor in the sensor node for data transmission and data receiving. Due to the mobile nature of the sensors node, the consumption of energy is very high and the life of IoT devices (Bijarbooneh, F. H., 2015; Kaur, K., 2017). In the current decade, the minimization of energy in a wireless sensors network is a big issue. For the minimization of energy, various low-cost based energy protocols are designed. The success story of wireless sensor networks deals with the success of IoT based services over cloud environments. The minimization of energy in wireless sensor networks is possible to use various routing and MAC layer based protocols. The duty cycle based routing protocol also reduces energy consumption during the transmission of data over the sink node. Some authors also suggested the cluster-based routing protocol for the minimization of energy in wireless sensors networks.

1532-5806-24-S3-106

Citation Information: Jain, J. K., & Chauhan, D. (2021). An Energy-Efficient Model for Internet of Things Using Compressive Sensing. *Journal of Management Information and Decision Sciences*, *24*(S3), 1–15.

The current trends of research focus on the minimization of energy in terms of data transmission and data receiving in a wireless sensor network for IoTs. The re-searchers proposed the techniques based on clustering, low route cost, and heuris-tic-based optimization to improve the energy efficiency of sensor nodes (Huang, J., 2014; Nguyen, T.D., 2017). The sensor nodes when left in idle mode for a long time, causes the waste of energy in WSNs.

Now the concept of active and sleep node based on duty cycle. The active and sleep mode increases the use of energy but degrades the performance of the net-work in terms of quality of services, delay and loss of data packet. This paper proposes the dual probability-based energy estimation function for the reduction of energy during the transmission of data to the sink node. The dual probability-based energy function works on the concept of dynamic optimization of route cost and energy. The energy function works on different layers of energy in terms of high energy, middle energy, and low energy. The grouping of energy layers deals with subgroups of sensornodes. The reduction in energy cost increases the life of the sensor nodes and networks (Li S, 2012). The life of the network determines the reliability of IoTs based services over cloud computing. Apart from dual probability-based energy function, it also use some compressed sensing techniques for the minimization of energy in IoTs based services over the cloud networks.

The internet of things (IoT) is a group of internet enabled things. The internet of things provides services to all societal areas. The things basically deal with elec-tronic communication objects connected through the internet. The acceptability of Compressive Sensing (CS) was an idea starting from the signal processing era. The quality of compressive Sensing is its capacity to remake meager or compress-ible signals from a modest number of estimations without requiring any of the earlier learning about the signal structure. Compressive sensing is beneficial wherever the signals are meager in a known premise, estimations are costly, and calculations at the collector end are shoddy (Candès, E.J., 2008). These qualities totally coordinate WSNs. Contrasted and information pressure, applying compressive sensing in WSNs offers promising enhancements as low power sensor hubs are not for the most part appropriate for actualizing encoding of information pressure systems (Jain, Jay Kumar, 2020) Past survey articles in CS constrain their base recuperation calculations to li-near programming and Greedy calculation (Ji, S., 2008). These strategies experience the ill effects of multifaceted nature, precision and speed issues. Bayesian CS (BCS) is a strategy, which uses a measurable portrayal of the signal to supplement the custo-mary strategies. It can give better execution as far as exact information remaking or a diminished number of estimations. Be that as it may, there are a couple of works in the WSNs field, which take advantage from the Bayesian system to beat their execution. TC-CSBP (Shahrasbi, B., 2011) is a conviction spread (BP) based procedure, which utilizes just a transient connection among sensor readings to remake the signal. Compressive sensing states that meager or compressible signs can be precisely or around recouped from various straight projections. An inadequate signal is a signal, which normally displays sparsity while compressible signal can be all around approximated with meager portrayal through changing to another space, where few the coefficients speak to the vast majority of the energy of the signs (Duarte, M.F., 2011).

The rest of the paper is organized as follows. Section II describes the proposed dual probability-based energy function and the integration model of energy function with IoTs. Section III presents the methodology and experimental results to the proposed algorithm and Section IV concludes the paper.

DUAL PROBABILITY FUNCTION (DPF)

This document, which can be used as a template, has been prepared in the correct format. That is, we defined the “Normal” and the Heading 1, 2, 3, 4, and 5 tabs in the tool bar at the top to

Citation Information: Jain, J. K., & Chauhan, D. (2021). An Energy-Efficient Model for Internet of Things Using Compressive Sensing. *Journal of Management Information and Decision Sciences*, *24*(S3), 1–15.

produce the correct document. If you use this template you will need to copy and paste material into this document to prevent Microsoft Word from keeping the format layouts from your other file (paste by keeping destination format). If you do not use this template, then you will need to modify the defaults in the various tabs in the tool bar. We will describe the changes in the following sections. There should be no headers and no footers in the document. The page size should be set to 8.5 by 11 inches, and the margins should be set at one inch all around. Set the defaults in the Normal tab to be Times New Roman, 12 point typeface, and full justification for the document. You may decide to utilize a first line indent command set to one half inch, but if you do, be sure to remember that the command will also affect contents in your tables and in all layouts for the entire document. Set paragraph spacing to zero, both before and after the paragraph. Set spacing to single. Turn on Widow/Orphan control. We prefer for you to use only one space between sentences, rather than the older approach of double spacing between sentences.Motivated by the use of Probability Density Function by Subir Halder, Amrita Ghosal, Amartya Chaudhuri , and Sipra DasBit Et. al in Energy-Balanced Lifetime-Enhancing Node Deployment in WSN. The dual probability function measures the same level of energy for the grouping of a sensor node to transmit the sensor to the sink node and the IoTs gateway. The dual probability measures the energy level of the same node with a similar probability for measuring the level of energy for communication.

- $P - DP(n)P - DP(n)$: measure the probability of sensor nodes of same energy level
- $sinkprobablity(level - Dp(n))sinkprobablity(level - Dp(n))$of a sensors node nn with respect to another sensors node

$$nlevel - {}_{k}(p,o) = max\{n - probablity(o), n(p,o)\}(1)$$
$$nlevel - {}_{k}(p,o) = max\{n - probablity(o), n(p,o)\}(1)$$

Where $n(p,o)n(p,o)$is the similar probability between pp and oo.

- $levelprobablity\, levelprobablity$(SLP) of a sensors node nn

$$slp_k(p) = \left(\frac{1}{k}\sum_{0 \in N_{(p,k)}} level - prob_k(p,o)\right)^{-1}, (2)$$

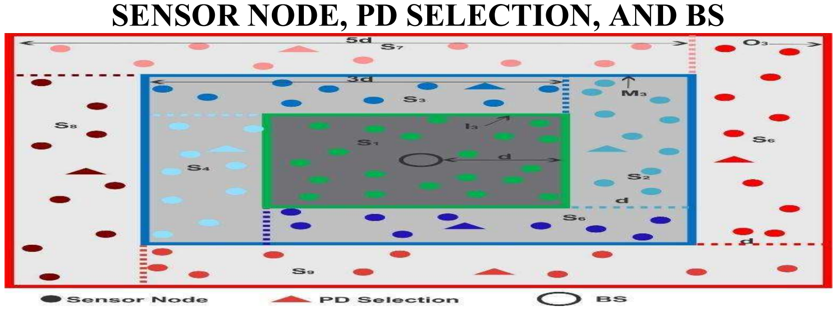
Where $N_{(p,k)}N_{(p,k)}$ is the set of nnnode of the similar probability of energy of nn.

- $sinknodeenergy\, sinknodeenergy$of a sensors node nn

$$DP_{OT_k}(p) = \frac{1}{k}\sum_{0 \in N_{(p,k)}} \frac{slp_k(o)}{slp_k(p)}(3)$$

Here k is a subset group of sensors node for the same level of energy factor and N is total nodesin environments.

FIGURE 1
SENSOR NODE, PD SELECTION, AND BS



Citation Information: Jain, J. K., & Chauhan, D. (2021). An Energy-Efficient Model for Internet of Things Using Compressive Sensing. *Journal of Management Information and Decision Sciences*, *24*(S3), 1–15.

FIGURE 2
DP AND DP_OT

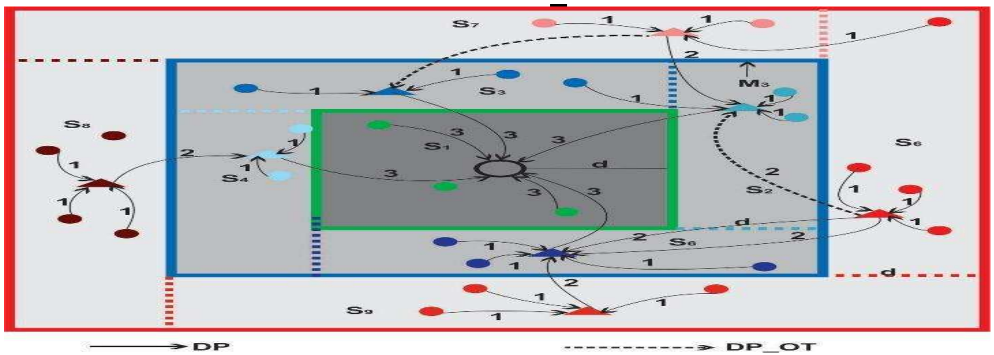


Figure 1 and Figure 2 describe the design layout of the deployment of sensor nodes in IoTs elements. In this scenario, Figure 1 shows the sensor node PD selection and BS (sink node). The sensor node is a normal node and its unit of the data collector. The PD node is a selected node for the transmission of data to the sink node. Figure 2 describes the sensor node connection in terms of subgroups for the level of energy. The levels of energy are different in two decision parameters, one is DP and the other is DP_OT (Jain, 2019)

METHODOLOGY & EXPERIMENTAL RESULT

The minimization of the utilization of energy in data transmission and receiving derived novel energy estimation function is called dual probability (DP). The pro-posed DP approach is compared with the CP method. The dual probability-based function works in the mode of an energy level of the subgroup of the sensor node. The subgroup of sensors node drives three-level energy factors high, low and av-erage. The level of energy factor decides two decision parameters one is DP and the other is DP_OT. The DP decision parameter decides the subgroup of sensor-nodes for the communication of sink nodes. The DP_OT takes the decision of data connection with sink nodes to IoTs. The dual probability-based function also measures the quality of data in terms of data utility of sensors nodes and IoTs elements. For the validation of the design model, we have used MATLAB R-2014a software and created four different network scenarios of a number of sensors nodes 100. For the transmission of data, it uses the CBR data packet and measures the performance in terms of small and combinations of large sensors network scenarios and measures three parameters: data utility, energy efficiency, and data reconstruction error. These three parameters are taken for the evaluation result and compared with the compressive sensing technique. Instead of a compressive sensing technique, the design model increases the utilization of energy and enhances the life of sensor networks. The efficiency of energy increased in terms of transmission of data to the sensors node to the sink node. The increased efficiency of energy depends on the proper integration of the probability factor and sink node energy level. The dual probability function measures the level of energy and groups the sensor node for communication. Despite the utilization of energy it also increases the data utility factor of sensors to the integration gateway for IoTs. The utility of data increases the performance of the network and life of sensors nodes. The data reconstruction of low energy nodes is also good in compression of CP model error reconstruction. The model goes in the dense network and increases the number of sensors node some little bit performance coincides with CP mode in terms of data utility, energy efficiency, and error reconstruction.

We evaluate the performance of our algorithm via simulations in MATLAB R-2014a. The simulation environment setup with the simulation parameters listed in Table 1. The simulated

1532-5806-24-S3-106

Citation Information: Jain, J. K., & Chauhan, D. (2021). An Energy-Efficient Model for Internet of Things Using Compressive Sensing. *Journal of Management Information and Decision Sciences*, *24*(S3), 1–15.

network is a We assume that all the sensor nodes and the sink node are randomly deployed in a circular sensing area. The initial energy of each sensor node is Joule.

TABLE 1 SIMULATION PARAMETER SETTINGS	
Size of the sensor network (n ××m)	400 * 400
Number of sensor nodes	100
Number of gateways	1
Number of the sink node	1
The initial energy of each sensor node	50 Joule
Deployment distribution	Random
Energy of gateway	50 Joule
Sensor communication radius (r)	200
Simulation Time	600 Seconds
Size of sensing data (bytes)	4000 Bytes
Location of the sink node	X= 200 Y=200

The performance metrics considered during simulation have their own signific-ance for better network performance. The important definitions of parameters in-volving in this simulation are:

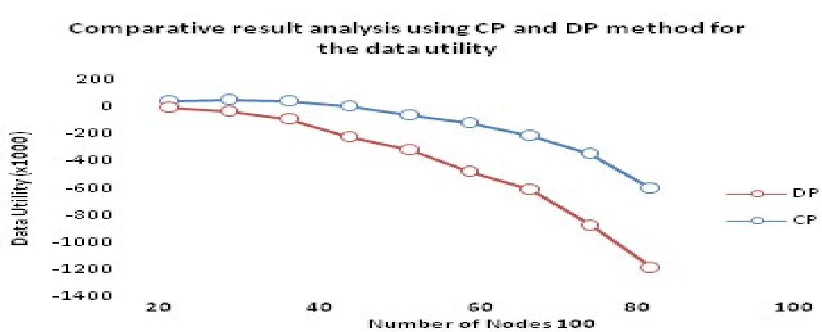
1. Data Utility: Network utilization is the amount of traffic on the network com-pared to the peak amount that the network can support. This is generally specified as a percentage.

2. Energy Consumptions: A useful measure of the efficiency of the network is the energy consumed per bit of data transferred.

3. Data Reconstruction Error: Data reconstruction is the rebuilding of a virtual en-vironment such as the dynamic temperature, light, humidity, gas concentration and is based on the sensory data.

The design model is simulated in MATLAB R-2014a software. For the validation of methods, we have generated four network scenarios of 50, 75, 100 and 500 nodes. The data traffic used is a constant bit rate of 512. The process of energy function defines the value of energy as 12-14 joule. The energy distribution is uni-form. The data is collected from the sink node every 120 seconds. The transmis-sion interval of data is 10 seconds. The total simulation time is 600 seconds. For the validation of models, we have used data utility, energy utilization parameters, and data error correction during the transmission. The results of DP based me-thods compare with the compressive sensing technique (CP) (Bijarbooneh, F.H., 2015).

FIGURE 3
DATA UTILITY WITH 100 NODES



Citation Information: Jain, J. K., & Chauhan, D. (2021). An Energy-Efficient Model for Internet of Things Using Compressive Sensing. *Journal of Management Information and Decision Sciences*, *24*(S3), 1–15.

Figure 3 shows the comparative result analysis between CP and DP method with the data utility and the number of nodes is 100 used in this simulation work. Due to entering the selection of path to data transfer to lower level interrogation to sink node data utility is increasing in comparison to CP. DP method gets the increasing percentage compared to CP method in data utility, when the number of nodes is 20, 40, 60, 80, 100 sequentially increased, percentage 0.5%, 4%, 25%, 35% and 50%. Here this proposed work as a DP method gives better performance compared to the CP method.

FIGURE 4
ENERGY CONSUMPTION WITH 100 NODES

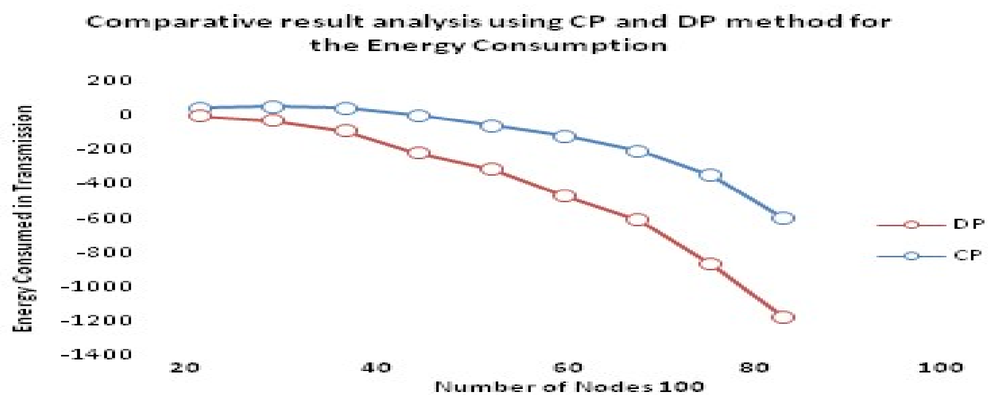


Figure 4 shows the comparative result analysis between CP and DP method with the energy consumption in transmission and the number of nodes is 100 used in this simulation work. Due to the level selection of sensor nodes that give the fare path for the transmission of data now, the consumption of energy decreases in the method of DP. DP method gets the decreasing percentage compared to CP method in energy consumption, when the number of nodes is 20, 40, 60, 80, 100 sequentially decreased, percentage 0.2%, 0.5%, 25%, 34% and 50%. Here this proposed work as a DP method gives better performance compared to the CP method.

FIGURE 5
DATA RECONSTRUCTION ERROR WITH 100 NODES

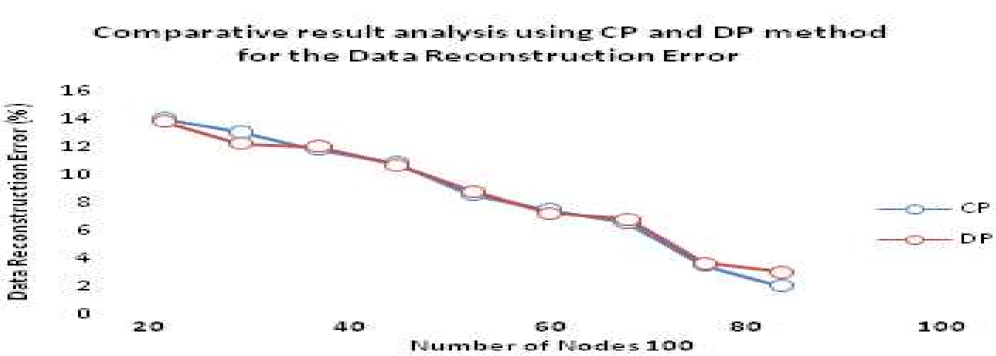


Figure 5 shows the comparative result analysis between CP and DP method with the data reconstruction error and the number of nodes is 100 used in this simulation work. The value of

1532-5806-24-S3-106

Citation Information: Jain, J. K., & Chauhan, D. (2021). An Energy-Efficient Model for Internet of Things Using Compressive Sensing. *Journal of Management Information and Decision Sciences*, *24*(S3), 1–15.

data rejection is minimized due to rejection of lower energy sensor nodes packets are not captured to the sink node so the value of reconstruction error is minimized. DP method gets the decreasing percentage compared method in data utility, when the number of nodes is 20, 40, 60, 80, 100 sequentially increased, percentage 0.5%, 4%, 25%, 35% and 50%. Here this proposed work as a DP method gives better performance compared to the CP method. to CP method in energy consumption, when the number of nodes is 20, 40, 60, 80, 100 sequentially decreased percentage 0.3%, 0.1%, 0.6%, 0.8% and 1.5%. Here this proposed work as a DP method gives better performance compared to the CP method.

CONCLUSION

Enriched by the services of cloud environments with IoTs, we have designed a novel integration function of the sensor node with IoTs elements. The integration of sensor nodes with IoTs requires more energy and life of the sensor node expires. In a dense network, the level of grouping of sensor nodes is very high due to the estimation of multiple functions of dual probability and the performance of the network decreases. But the level of energy is minimized in terms of the level of impact of sensor nodes, the performance of the network again boosts. The dual probability-based function reduces the level value of sensors node grouping of data according to their design model. So the overall performance of the proposed model is better instead of the CP model. The design model works only for a single sink node communication pattern, in future work with multiple sink nodes and also integrates the dual probability function with a compressive sensing technique.

REFERENCES

Zhou Y, Huang C, Jiang T, Cui S. *Wireless sensor networks and the internet of things: Optimal estimation with non uniform quantization and bandwidth allocation*. IEEE Sensors Journal. 2013 May 23; 13(10):3568-74.

Bijarbooneh FH, Du W, Ngai EC, Fu X, Liu J. *Cloud-assisted data fusion and sensor selection for internet of things.* IEEE Internet of Things Journal. 2015 Nov 19; 3(3):257-68.

Kaur K, Dhand T, Kumar N, Zeadally S. *Container-as-a-service at the edge: Trade-off between energy efficiency and service availability at fog nano data centers*. IEEE wireless communications. 2017 Jun 22; 24(3):48-56.

Huang J, Meng Y, Gong X, Liu Y, Duan Q. *A novel deployment scheme for green internet of things*. IEEE Internet of Things Journal. 2014 Jan 21;1(2):196-205.

Nguyen TD, Khan JY, Ngo DT. *Energy harvested roadside IEEE 802.15. 4 wireless sensor networks for IoT applications.* Ad Hoc Networks. 2017 Mar 1; 56:109-21.

Li S, Da Xu L, Wang X. *Compressed sensing signal and data acquisition in wireless sensor networks and internet of things. IEEE Transactions on Industrial Informatics*. 2012 Feb 28;9(4):2177-86.

Candès EJ, Wakin MB. *An introduction to compressive sampling: a sensing/sampling paradigm that goes against the common knowledge in data acquisition*. IEEE signal processing magazine. 2008;25(2):21-30.

Jain, Jay Kumar. "*A Coherent Approach for Dynamic Cluster-Based Routing and Coverage Hole Detection and Recovery in Bi-layered WSN-IoT*." Wireless Personal Communications 114.1 (2020): 519-543.

Ji S, Xue Y, Carin L. *Bayesian compressive sensing. IEEE Transactions on signal processing*. 2008 Jun 1;56(6):2346.

Shahrasbi B, Talari A, Rahnavard N. TC-CSBP: *Compressive sensing for time-correlated data based on belief propagation*. In2011 45th Annual Conference on Information Sciences and Systems 2011 Mar 23 (pp. 1-6). IEEE.

Duarte MF, Eldar YC. *Structured compressed sensing: From theory to applications. IEEE Transactions on signal processing.* 2011 Jul 14;59(9):4053-85.

Jain, Jay Kumar. "*Secure and energy-efficient route adjustment model for internet of things*." Wireless Personal Communications 108.1 (2019): 633-657.

1532-5806-24-S3-106

Citation Information: Jain, J. K., & Chauhan, D. (2021). An Energy-Efficient Model for Internet of Things Using Compressive Sensing. *Journal of Management Information and Decision Sciences*, *24*(S3), 1–15.