To analysis the energy efficiency with optimized data using the AI-Based Resource Allocation Techniques in Wireless Sensor IoT Networks

DR SOURABH PATHAK

Assistant Professor, FET, ECE Department, M J P Rohilkhand University, Bareilly.

Abstract

Over the past few years, the use of IoT-based restricted wireless sensor networks has gained significant attention and has led to notable advancements aimed at improving resource usage and service delivery. To enable data exchange between different types of devices, IoT relies on a more robust communication network and an efficiently designed wireless sensor network that consumes less energy. This research introduces a novel method for resource allocation in wireless sensor IoT networks, focusing on energy efficiency and data optimization through the use of deep learning techniques. In this context, energy efficiency (EE) and spectral efficiency (SE) are two conflicting objectives that need to be balanced. The network's energy efficiency has been enhanced by employing a deep neural network optimized using the whale optimization algorithm. A heuristic-based multi-objective firefly algorithm was also used to optimize data transmission. This method is applied to optimal power allocation and relay selection in a cooperative multi-hop network structure. The best resource allocation is achieved by minimizing the overall transmit power, while the optimal relay selection is determined by meeting Quality of Service (QoS) requirements. As a result, an energy-efficient protocol has been developed. Simulation results show that the proposed model performs competitively compared to traditional models, achieving a throughput of 96%, energy efficiency of 95%, QoS of 75%, spectrum efficiency of 85%, and a network lifetime of 91%.

Introduction

One of the most important areas of study in the cloud is resource allocation. This area focuses on increasing the profitability of service providers and ensuring customer satisfaction by meeting the requirements set out in Service Level Agreements (SLA). SLA refers to the agreements between service providers and cloud users that ensure a certain level of service quality. Resource allocation is a key topic when dealing with SLA-related issues. Since the workload on physical servers changes over time, resource allocation needs to be handled dynamically. Dynamic resource allocation becomes especially difficult when service quality needs change over time, while also considering processor availability and minimizing idle time. A Wireless Sensor Network (WSN) includes multiple sensor nodes placed in remote areas to monitor environmental conditions. These nodes are equipped with various types of sensors, such as acoustic, pressure, motion, image, chemical, weather, temperature, and optical sensors. WSNs have a wide range of applications, from healthcare to military, defense, agriculture, and daily life. Despite their broad use, WSNs face several common challenges, including limited energy sources, processing speed, memory, and communication bandwidth, which can lead to reduced performance and a shorter network lifetime. Designing separate algorithms for different purposes is a complex task. WSN designers must carefully address issues such as data aggregation, clustering, routing, localization, fault detection, task scheduling, and event tracking.

Wireless sensor nodes are small devices that detect atmospheric conditions such as pressure, temperature, and humidity.

They have memory for storing data and a communication channel for sending it to a base station and other devices. The distribution of these nodes varies based on the number needed to collect data. Many studies have previously focused on these challenges by applying methods from signal communication theory used in telephony, aiming to ensure reliable data delivery without interference. Since it is not possible to provide continuous power to sensors using batteries, researchers must focus on making systems more energy-efficient. Due to the limited power sources, sensor nodes have a short lifespan, which reduces the overall network lifetime. Machine learning (ML) methods are known for their ability to self-learn and operate without requiring reprogramming. ML is a valuable approach that enables efficient, reliable, and cost-effective computing. Machine learning has following three types supervised learning, unsupervised learning and reinforcement learning. It has been found that machine learning technologies are effective in addressing key challenges in WSNs. In the areas of IoT, M2M, and CPS, these approaches have shown benefits. ML can learn from a generalized structure and suggest a general solution to improve system performance. Due to its wide application, ML is used in various fields such as medicine, engineering, and computing for tasks like manual data entry, automatic spam detection, medical diagnosis, image recognition, data cleaning, and noise reduction. Recent research indicates that machine learning has been applied to solve various problems in WSNs. Using ML in WSNs enhances system performance and reduces complex tasks such as reprogramming, manually accessing large data sets, and extracting useful information from data. As a result, ML methods are very beneficial for working with large volumes of data and extracting meaningful insights.

The contributions of this research are as follows:

1. Proposing a new technique for resource allocation (RA) in WSN_IoT that improves energy efficiency and data optimization using deep learning architectures;

2. Enhancing network energy efficiency using a whale-optimization-based deep neural network;

3. Optimizing data transmission in the network using a heuristic-based multi-objective firefly algorithm.

Performance Analysis

To analysis this project we have used the MATLAB software. We have to simulate this project to determine the following parameter:

```
num_nodes = 20;          % Number of sensor nodes
num_steps = 4000;        % Simulation steps
init_energy = 2;         % Initial energy per node (Joules)
transmission_cost = 0.01; % Energy cost for data transmission
sleep_cost = 0.001;      % Energy cost for sleeping
data_reward = 1;         % Reward for successful data delivery

%% Q-learning parameters
num_states = 2;          % 1 = enough energy, 2 = low energy
num_actions = 2;         % 1 = transmit, 2 = sleep
alpha = 0.1;             % Learning rate
gamma = 0.9;             % Discount factor
epsilon = 0.1;           % Exploration rate

%% Initialization
energy = init_energy * ones(num_nodes,1);
Q = zeros(num_nodes, num_states, num_actions);
network_lifetime = 0;
total_data_delivered = 0;
```

Result

To optimization of data here we have analyzed the transmitting and remaining energy node to node. Here we see that how to increase the efficiency of the network and lifetime. In the figure 1 is showed the transmitted energy at every node. Figure 2 is showed the remaining energy at each and every stage.

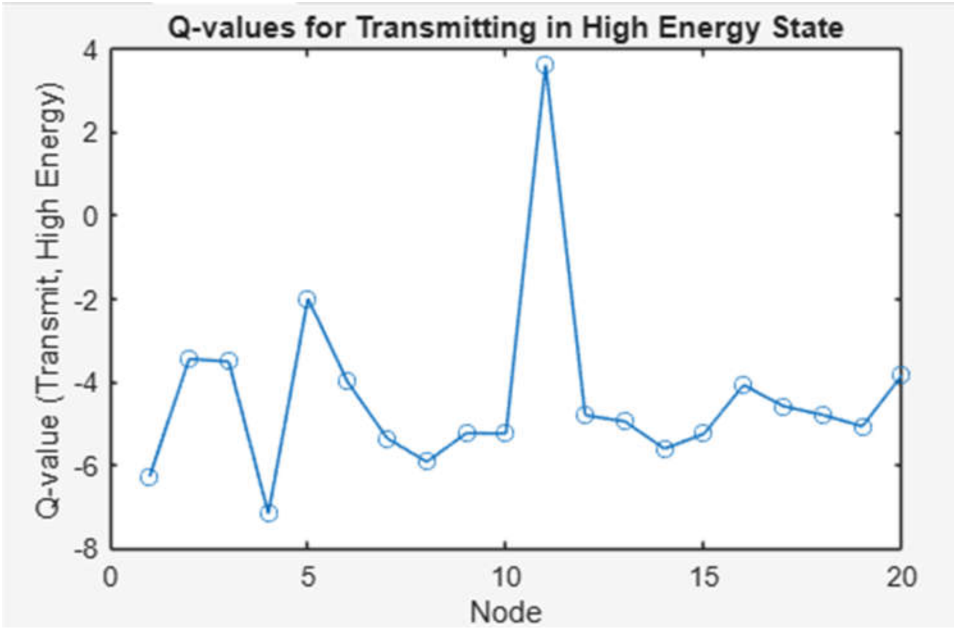

Figure 1: Transmitting energy status

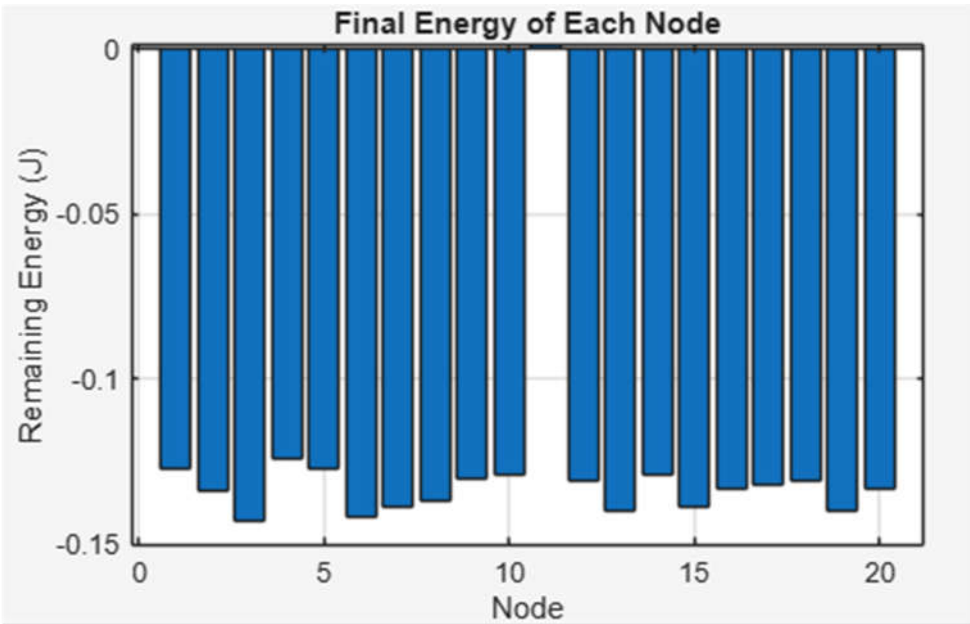

Figure 2: Remaining energy of each node status

Conclusion

This study employs deep learning techniques to offer a distinctive approach for resource allocation in WSN-IoT systems, focusing on improving energy efficiency and data optimization. In this context, energy efficiency and spectral efficiency are two conflicting objectives that need to be balanced. The network's energy efficiency has been enhanced using a deep neural network optimized through whale optimization. A heuristic-based multi-objective firefly algorithm was implemented to optimize data transmission. The proposed method is applied to achieve optimal power allocation and relay selection. The study is based on a cooperative multi-hop network structure. The most effective resource allocation is achieved by minimizing the overall transmit power, while the best relay selection is done by ensuring compliance with quality of service standards. As a result, an energy-efficient communication protocol has been developed. The simulation outcomes show that the suggested model performs competitively compared to conventional models, achieving a throughput of 96%, energy efficiency of 95%, quality of service of 75%, spectrum efficiency of 85%, and a network lifetime of 91%. The future direction of this research could involve applying it to medical applications with improved security in real-time sensor-based systems, which could further enhance the efficiency of the proposed method by integrating machine learning with block-chain technologies.

References

[1] Wang, W.; Guo, H.; Li, X.; Tang, S.; Xia, J.; Lv, Z. Deep learning for assessment of environmental satisfaction using BIM big data in energy efficient building digital twins. Sustain. Energy Technol. Assess. **2022**, 50, 101897. [CrossRef]

[2] Goswami, P.; Mukherjee, A.; Maiti, M.; Tyagi SK, S.; Yang, L. A neural network based optimal resource allocation method for secure IIoT network. IEEE Internet Things J. **2021**, 9, 2538–2544. [CrossRef]

[3] John, N.M.; Joseph, N.; Manuel, N.; Emmanuel, S.; Kurian, S.M. Energy efficient data aggregation and improved prediction in cooperative surveillance system through Machine Learning and Particle Swarm based Optimization. EAI Endorsed Trans. Energy Web **2021**, e40. [CrossRef]

[4] Soni, S. K., Madan Mohan Malaviya University of Technology, North Dakota State University, Institute of Electrical and Electronics Engineers. Uttar Pradesh Section, IEEE Industry Applications Society, & Institute of Electrical and Electronics Engineers. (n.d.). ICE3- 2020: International Conference on Electrical and

Electronics Engineering: February 14-15, 2020.

[5] Akkaş, M. A., SOKULLU, R., & Ertürk Çetin, H. (2020). Healthcare and patient monitoring using IoT. Internet of Things (Netherlands), 11. https://doi.org/10.1016/j.iot.2020.100173

[6] Souza, L. C., Neto, E. R., Lima, E. S., & Junior, A. C. S. (2022). Optically-powered wireless sensor nodes towards industrial internet of things. Sensors, 22(1). https://doi.org/10.3390/s22010057

[7] Pundir, S., Wazid, M., Singh, D. P., Das, A. K., Rodrigues, J. J. P. C., & Park, Y. (2020). Intrusion Detection Protocols in Wireless Sensor Networks Integrated to the Internet of Things Deployment: Survey and Future Challenges. In IEEE Access (Vol. 8, pp. 3343– 3363). Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/ACCESS.2019.2962829

[8] K. H. K. Reddy, A. K. Luhach, B. Pradhan, J. K. Dash, and D. S. Roy, "A genetic algorithm for energy efficient fog layer resource management in context-aware smart cities," Sustainable Cities and Society, vol. 63, p. 102428, 2020.

[9] S. N. Mohanty, E. L. Lydia, M. Elhoseny, M. M. G. Al Otaibi, and K. Shankar, "Deep learning with lstm based distributed data mining model for energy efficient wireless sensor networks," Physical Commu nication, vol. 40, p. 101097, 2020.

[10] S. Radhika and P. Rangarajan, "Fuzzy based sleep scheduling algorithm with machine learning techniques to enhance energy efficiency in wireless sensor networks," Wireless Personal Communications, vol. 118, pp. 3025–3044, 2021.

[11] G. Kaur, P. Chanak, and M. Bhattacharya, "Energy-efficient intelligent routing scheme for iot-enabled wsns," IEEE Internet of Things Journal, vol. 8, no. 14, pp. 11 440–11 449, 2021.

[12] B. Xu, J. Wang, Z. Zhao, H. Lin, and F. Xia, "Unsupervised anomaly detection on attributed networks with graph contrastive learning for consumer electronics security," IEEE Transactions on Consumer Electronics, vol. 70, no. 1, pp. 4062–4072, 2024.

[13] M. Shahid, M. Tariq, Z. Iqbal, H. M. Albarakati, N. Fatima, M. A. Khan, and M. Shabaz, "Link-quality based energy-efficient routing protocol for wsn in iot," IEEE Transactions on Consumer Electronics, vol. 70, no. 1, pp. 4645–4653, 2024.

[14] X. Huang, Y. Zhang, Y. Qi, C. Huang, and M. S. Hossain, "Energy efficient uav scheduling and probabilistic task offloading for digital twin-empowered consumer electronics industry," IEEE Transactions on Consumer Electronics, vol. 70, no. 1, pp. 2145–2154, 2024.

[15] A. Taneja and S. Rani, "A novel energy conservation scheme for iot based wireless networks: A use case of e-commerce systems for consumer electronics," IEEE Transactions on Consumer Electronics, vol. 70, no. 1, pp. 1648–1655, 2024.

[16] Achour, M., & Boufaied, A. (2023). Check for updates multi-objective optimization for sensor networks based smart parking systems. Intelligent systems design and applications: 22nd international conference on intelligent systems design and applications (ISDA 2022) (Vol. 646, p. 230). Springer Nature.

[17] Vishal Sharad, H., Desai, S. R., & Krishnrao, K. Y. (2022). Fault-tolerant multi-path data communication mechanism in WSN Based on optimization enabled routing. Wireless personal communications, 125(1), 841–859. DOI: 10.1007/s11277-022-09580-7

[18] Yadav, A., Noori, M. T., Biswas, A., & Min, B. (2023). A concise review on the recent developments in the internet of things (IoT)-based smart aquaculture practices. Reviews in fisheries science & aquaculture, 31(1), 103–118.

[19] Samyoun, S.; Shubha, S.S.; Sayeed Mondol, M.A.; Stankovic, J.A. IWash: A Smartwatch Handwashing Quality Assessment and Reminder System with Real-Time Feedback in the Context of Infectious Disease. Smart Health **2021**, 19, 100171. [CrossRef] [PubMed]

[20] Alharbi, M.; Karimi, H.A. Context-Aware Sensor Uncertainty Estimation for Autonomous Vehicles. Vehicles **2021**, 3, 721–735. [CrossRef]

[21] Mendez, J.; Molina, M.; Rodriguez, N.; Cuellar, M.P.; Morales, D.P. Camera-Lidar Multi-Level Sensor Fusion for Target Detection at the Network Edge. Sensors **2021**, 21, 3992. [CrossRef]