DOI: http://doi.org/10.32792/jeps.v14i4.500

Dynamic Load-Balanced Sink Placement (DLBSP) Algorithm for WSNs in IoT

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Received 18/10/2024, Accepted 6/11/2024, Published 1/12/2024

Abstract

The Wireless Sensor Networks are cost-effective and energy-limited. The need for wireless networks is on the increase because of the important role-play in the Internet of Things (IoT). In traditional Wireless Sensor Networks, the sink is responsible for collecting the data from whole the network, this strategy affects the network performance such as lifetime, congestion, network failure, and energy consumption. That is because the close nodes from the sink will consume more energy and make the network unstable. To solve this problem, it is important to choose an optimal location for the sink to minimize consumed energy and therefore increase network lifetime. This paper presents a new dynamic localization approach for the sink of Wireless Sensor Networks. The sink will be placed in the place where more nodes exist according to distance and energy using the suggested dynamic algorithm, the simulation and comparison are done and the algorithm achieved enhanced performance.

Keywords: WSNs, Energy Consumption, throughput, lifetime.

1. Introduction

Wireless Sensor Networks have developed rapidly and grown widely in recent years [1], because it's a wide range of applications like automatic home operations, military applications, healthcare, transforming artificial and supporting some limited features like discovering some features in the environment. The WSNs considered as most important critical part of the "Internet of Things (IoT)" which is one of the "WSN" applications [2]. The WSNs and IoT networks are designed to collect, share, and manage data efficiently. The basic goal of this corporation is to support data analyzing and automate processes. To make easy operation of decision-making. The security of IoT with WSNs helping requires the execution of protective preventive to conform safety and authentication of the components of IoT and WSNs [3]. Wireless Sensor Networks are composed of many nodes as well as the Base Station, which are known commonly as sinks. Generally, Wireless nodes are very small with a small amount of energy [4]. These nodes are structured commonly to aggregate specific information from one node to another node and lastly to the base station [5]. In Wireless Sensor Networks, a key consideration is determining the optimal position for the base station within the network [6]. The basic feature of Wireless Sensor Networks is most of the evaluation parameters like response time and energy consumption depend on base station localization, which collects, the aggregated data. If the base station is placed in a far location from other nodes this will extend the delay and used energy. On the other side, if it was close to the nodes, this would minimize time and consumed energy [7]. The Wireless Sensor Networks deployment can be randomly or uniformly, so the optimal location of the base station cannot be as other nodes in the network [8].

The contribution of this paper is to specify the optimal location to sink to maximize network lifetime through the suggested algorithm by reducing consumed power. Where the previous information is dependent. Where the sink will placed depending on this information by estimating the stability of the network. This algorithm will improve data collecting and their efficiency by introducing comprehensive approach to manage sink position through dynamic monitoring and make adaptive decisions and focusing on energy efficiency which makes it distinct from previous researches. "The remaining of this paper is structured as follows: section 2 is for related works, section 3" is for the suggested algorithm, section 4 is for simulation and performance evaluation, and lastly section 5 is for the conclusion.

2. Related Works

In [9], in this paper, they follow relating policy to place the base station in the best location. They study problems in previous placemat strategies such as GOSP, ISP, RSP, GSP, and CLHM. They propose new strategies depending on the united center ring guiding. The base station is positioned in place depending on the node's density.

In [10], **in this paper**, they study a random wireless sensor networks regarding the practical role of base station location and its important effect. The simulation results show a reduction in sensing communication average (98.8 to 72.5) when they translate the base station from the center to the surroundings besides the performance parameters. The results show there need for more energy 1.367 times to communicate less than 4% of remote control devices regarding network settings where to increase communication average from 96% to 100% there is a need for more energy 538%.

In [11], **in this paper**, they search for the “best location to place the source node to maximize” messages receiving “reliability” before receiving and processing them by the base station. The research produces the optimal solution by using the linear programming solution of mixed integer numbers (MILP) for the problem in small-size WSNs. As a result, the maximum path authenticity will give minimum consumed energy to retransmission along the forwarding path. With this in the wide range networks, “the paper produces the Genetic Algorithms (GA) as one of the guided solutions. The fitness function” calculates a negative value for the authenticity path register, and the GA tries to find a base station place with a “minimum value” of fitness to reduce the energy consumed by each sensor when it transmits to the base station. The results of the test set are produced and a comparison is done to measure the efficiency of Genetic Algorithms. Comparison is to find the optimal solution in a reasonable time.

In [12], **in this paper**, they suggest a new enhanced Particle Swarm Optimization (PSO) based algorithm to design an energy-aware protocol. It is give optimal location for the base station in the region of interest. It depends on the number of neighbors for each node, the remaining energy, and how far the node is from the deployment center. The simulation results show the suggested algorithm gives high efficiency for each stage of network building, maintaining, and operating lifetime of the network.

In [13], **in this paper**, they try to add an urban touch to the policy of the new sink in the wireless sensor networks. The researchers have studied the problems within the previous strategies of sink placement such as SOSP, RSP, GOSP, CLHM, GSP, ISP, and CNP. The previously mentioned node placement strategies aren`t inserted in the dynamic of the network. The position information of network nodes is not already available for specified WSNs. On the contrary, the policy of a generalized priorities system is designed for non-specified sensor node positions and it is suggested as standard sink placement policy in networks. So the generalized priorities system is selected to compare their strategy, which decreases energy consumed as well as Overhead expenses. They suggested new enhanced strategies, which work according to unified center ring routing with and without density. In the density status, a new random protocol is used, where the sink node is positioned according to the node's density.

In [14], , **in this paper**, they take the problem of minimizing the number of sinks in improbable topology by increasing links between various wireless sensors and suggests a guided approach for sink node placement in suitable positions in Wireless Sensor Networks.

3. Suggested Algorithm

The Dynamic Load-Balanced Sink Placement (DLBSP) algorithm is designed to dynamically adjust the sink's location in a WSN to balance the load and extend the network's lifetime. This approach involves periodic evaluation of the network's load distribution and adjusting the sink's position accordingly.

Steps

i. **Initial Placement:**

- Place the sink at the geometric center of the network or a pre-defined optimal initial position based on the network topology and expected traffic patterns.

ii. **Load Monitoring:**

- Periodically monitor the data traffic and energy consumption at each sensor node.
- Calculate the load distribution across the network, identifying areas with higher data transmission and higher energy consumption.

iii. **Load Analysis:**

- Divide the network into virtual zones or clusters.
- Compute the average load per zone and identify the zones with the highest and lowest loads.

I. **Sink Movement Decision:**

- Determine if the current sink location leads to imbalanced load distribution. If a significant imbalance is detected (e.g., some zones consistently deplete their energy faster than others do), initiate sink movement.
- Calculate the optimal direction and distance for the sink movement. The new position should be towards the center of the highest load zone but within a boundary that ensures the sink remains accessible to other zones.

II. **Adaptive Movement:**

- Move the sink incrementally rather than in large jumps to avoid drastic changes in network dynamics.
- After each movement, allow a stabilization period where the network adapts to the new sink position, and reassess the load distribution.

III. Continuous Adjustment:

- Repeat the monitoring and adjustment process at regular intervals or based on specific events (e.g., a significant number of nodes reporting low energy levels).
- Ensure the algorithm adapts to changes in network conditions, such as new nodes joining the network or existing nodes failing. Figure 1, represents the algorithm block diagram.

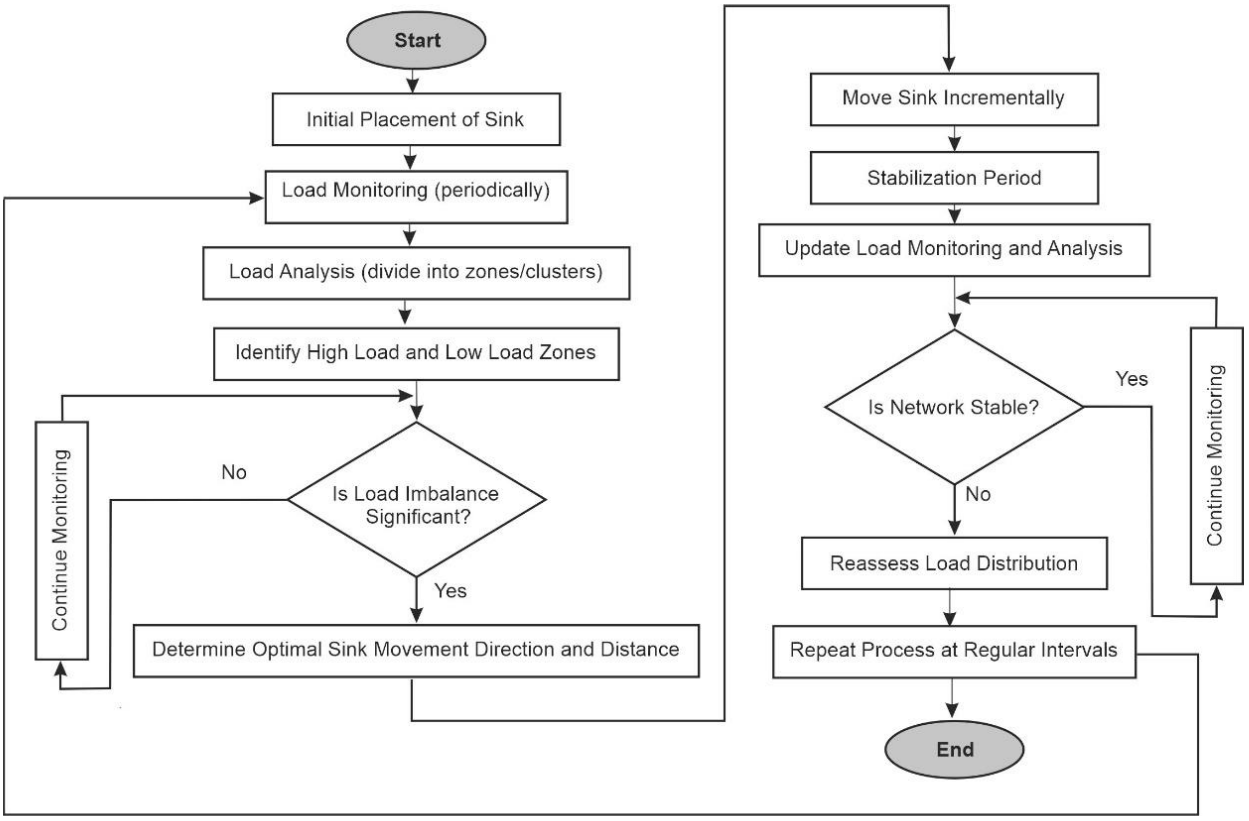

Figure 1: Block diagram for DLBSP algorithm.

4. Simulation and Performance Evaluation

The paper uses simulation to investigate the efficiency of our algorithm, NetLogo is an Agent-Based Modeling (ABM) used in numerous scenarios. In NetLogo, the concept of ticks represents discrete time steps in a simulation. Unlike using seconds, minutes, or hours, which can vary across different models and computers, ticks, are standardized and consistent across all NetLogo models. In the time-stepped simulation, everything happens at every increment of time (tick). The state of all agents is updated with each tick. NetLogo provides a built-in tick mechanism to facilitate this type of simulation. In summary, NetLogo's ticks provide a consistent measure of time, and event-driven simulation can be more efficient for certain scenarios. Using two approaches for comparisons with the new algorithm, Adjacency-based Cell Score and Multi-Objective Particle Swarm Optimization (MOPSO). In each scenario, 100 ordinary sensor nodes for the three approaches under consideration for five numbers of ticks 0, 50, 100, 150, and 200. Four performance measures for our investigation, Distance, Residual Energy, Throughput, and Lifetime with key parameters as suggested in Table 1.

Table 1: key parameters.

Parameter	**Description**
Network Topology	Hybrid(Mesh+Star)
Initial sink position	geometric center
Clustering method	**Zone-Based**

A. Distance

If the base station is placed far from sensors then the distance will lead to extended delay time and consume more energy. Otherwise, if the base stations are placed close to the sensors, this leads to reduced delay time and energy consuming [15]. The main problem of the network under consideration is the placing of one sink inside the network [16]. The movement of the sink node is clarified into two types, randomly and uniform [17]. Taking into consideration the load to place the sink in an optimal location with minimum distance from adjacent nodes where placed our sink in the epicenter of sensors using DLBSP. Table 2; gives us the calculated values in each number of ticks for the three approaches under consideration and represents distance versus ticks for the simulation results.

Table 2: Distance metric for the three approaches with various numbers of Ticks.

Number of Ticks	**DLBSP**	**Adjacency-based Cell Score**	**MOPSO**
0	**0**	**0**	**0**
50	**25**	**30**	**33**
100	**63**	**68**	**73**
150	**101**	**111**	**117**
200	**125**	**137**	**146**

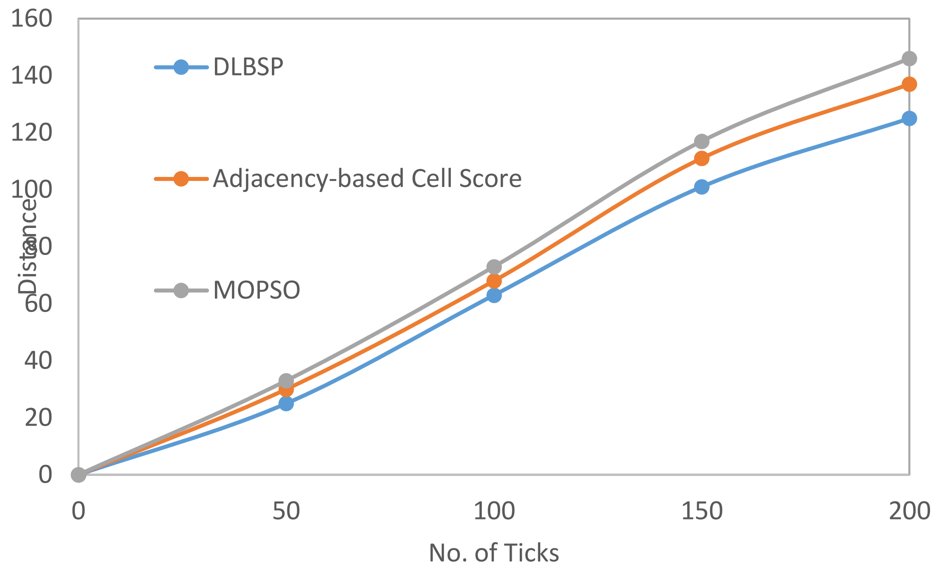

Figure 2: represents distance versus ticks.

The investigation found the DLBSP gives slightly more reduction in terms of distance. In the 50 ticks, obtained a 25m distance while Adjacency-based Cell Score and Multi-Objective Particle Swarm Optimization gave us 30 and 33m respectively. This slight reduction in distance will make the network more stable and therefore the extension in terms of lifetime will occur while consuming less energy because the other nodes will be affordable. As well as another number of ticks, finding more reduction in the distance as the number of tricks increased as mentioned in Table 2 and Figure 2.

B. Residual Energy

Precise enhancement is inevitable for data transmission protocols in wireless nodes to maximize network lifetime and minimize energy [18]. To maximize network lifetime, there is a need for different strategies to control energy consumption in the wireless sensors, at the same time, it is must use energy-efficient techniques in the whole network layers [19]. The DLBSP divides the deployed sensors into zones or clusters and investigates if there is unbalancing in load, in this state, the sink to another zone is moved to balance the load around the network and check the load again to serve the residual energy. Table 3, gives the calculated residual energy

values in each number of ticks for the three approaches under consideration. . Figure 3 represents residual energy versus ticks for the simulation results.

Table 3: Residual Energy for the three approaches with various numbers of Ticks.

Number of Ticks	DLBSP	Adjacency-based Cell Score	MOPSO
0	100	100	100
50	94	92	89
100	75	71	69
150	54	48	45
200	29	21	15

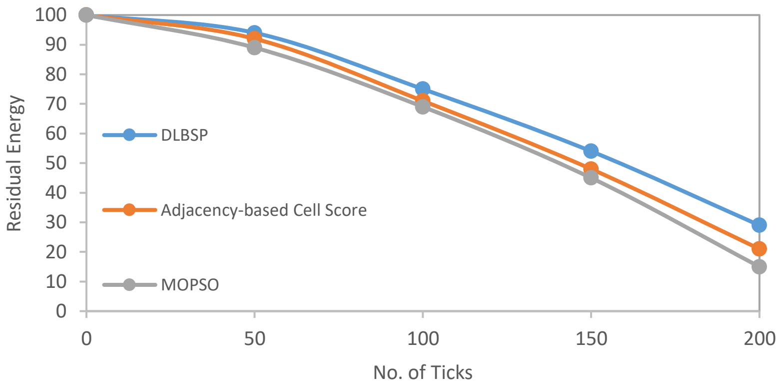

Figure 3: Residual Energy versus Ticks.

The investigation found that the DLBSP gives a slightly more extension in terms of residual energy. In the 50 ticks, obtaining 94% battery percentage while Adjacency-based Cell Score and Multi-Objective Particle Swarm Optimization gave us 92% and 89% respectively. This slight extension in power will make the network more authenticated and therefore the extension in terms of lifetime will occur while consuming less energy because the other nodes will be affordable. As well as another number of ticks, the finding is, more extending in residual energy as increase the number of tricks as mentioned in Table 3 and Figure 3.

C. Throughput

Indicates to rate of data transmitted from the source successfully from the sensor node to the destination (ordinary node or Base Station). In WSNs, it is necessary to achieve high throughput for efficient connectivity, especially for monitoring operations, where collecting data and delivering it at a suitable time are most important [20], [21]. Table 4; gives us the calculated values in each number of ticks for the three approaches under consideration. Figure 4 represents throughput versus ticks for the simulation results. Throughput mathematically can be represented as:

$$\text{Throughput} = \frac{Total\ data\ successfully\ delivered}{Time\ taken\ to\ deliver\ data}$$

Table 4 : Throughput for the three approaches with various numbers of Ticks.

Number of Ticks	DLBSP	Adjacency-based Cell Score	MOPSO
0	100	100	100
50	88	87	86
100	83	78	75
150	72	65	61
200	57	50	45

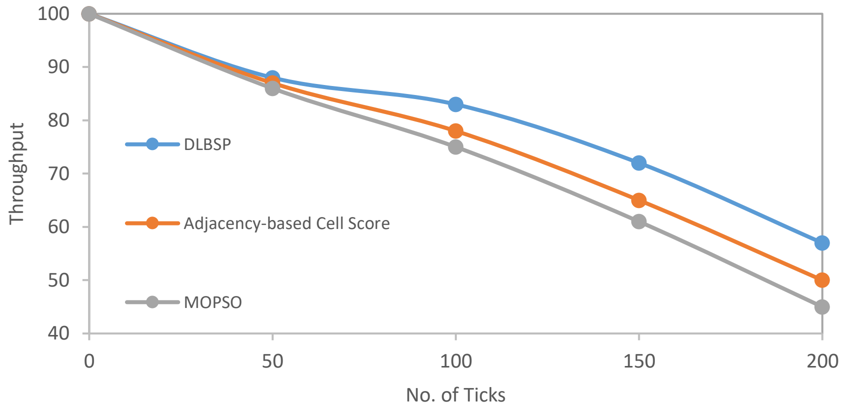

Figure 4: Throughput versus Ticks.

The finding is the DLBSP gives us slight enhancement in terms of throughput. In the 50 ticks, obtained 88% percentage while Adjacency-based Cell Score and Multi Objective Particle Swarm Optimization gave us 87% and 86% respectively. This slight enhancement in throughput will make the network more dependent and authenticated. Therefore extending in terms of lifetime will occur by consuming less energy because the other nodes will be affordable and have less lost in data packets. As well as another number of ticks, so more extension in throughput percentage as the increasing in the number of tricks as mentioned in Table 4 and Figure 4.

D. Lifetime

The lifetime is considered a crucial issue must take into consideration while designing the networks. When losing the energy of the wireless sensor, this will lead to disconnecting it from the network so must save energy. For example, if the sensor senses important information such as medical values in a living body this may lead to death, so the WSNs must have a max lifetime to serve continuous data flow [22], [23]. Table 5 ; gives the calculated values in each number of ticks for the three approaches under consideration. Figure 5 represents lifetime versus ticks for the simulation results.

Table 5 : Lifetime for the three approaches with various numbers of Ticks.

Number of Ticks	DLBSP	Adjacency-based Cell Score	MOPSO
0	50	50	50
50	44	41	38
100	36	33	29
150	27	24	21
200	19	16	15

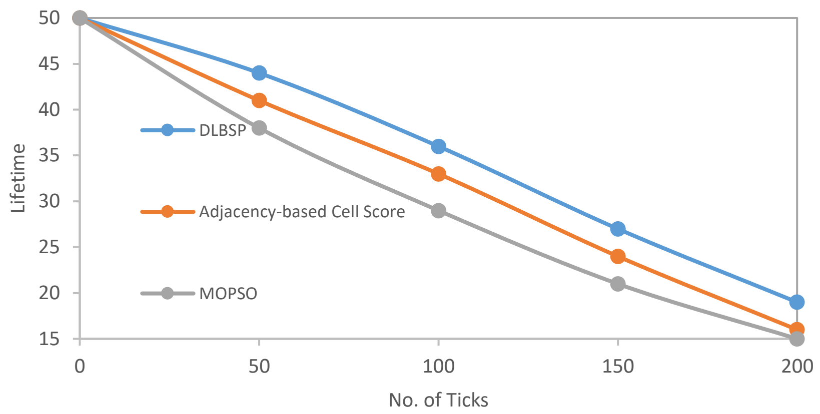

Figure 5: Lifetime versus Ticks.

The investigation found the DLBSP gives a slightly more extension in a lifetime. In the 50 ticks, obtaining 44 units while Adjacency-based Cell Score and Multi-Objective Particle Swarm Optimization give a 41 units and 38unit respectively. This slight extension in the lifetime will make the network more stable and therefore an enhancement in residual energy will occur while consuming less energy because the other nodes will be affordable. As well as another number of ticks, the fining is less extending in lifetime as increase the number of tricks as mentioned in Table 5 and Figure 5.

5. Conclusion

By dynamically adjusting the sink's position, the algorithm ensures a more uniform energy consumption across the network, preventing early depletion of any single node or zone. With balanced load distribution, the overall network lifetime is extended, as the nodes do not deplete their energy resources prematurely. The algorithm is scalable and can be adapted to networks of varying sizes and densities. And it is can respond to changes in network conditions, making it robust in dynamic environments. Furthermore, the simulation results indicates to regarded improvements in wireless networks, like increasing of remaining energy rate and improve the data transmission rate. The results can open new horizons in wireless networks performance improvement research, which contributes to develop more efficient applications in numerous fields like health care and environmental monitoring. Adopting this algorithm can lead to achieving more sustainability in wireless networks, which support future innovations in the IoT field.

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