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# *Hybrid Machine Learning Algorithm for Energy Efficient in Wireless Sensor Networks*

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***Abstract*—The Wireless Sensor Network (WSN) is a self-infrastructure network with a huge amount of sensor nodes. The distributed sensor nodes communicate with others. In WSN the sensor nodes collect the information and transfer it to the base station. The WSN is deployed in many applications such as healthcare systems, secure military applications, and monitoring applications but the WSN has inherent limitations of energy and storage. Achievement of energy efficiency is essential for WSN. Many researchers have focused on enhancing communication performance and extending the network lifetime. The traditional design of WSN has sensor nodes, cluster head (CH) and base station (BS). The communication of sensor nodes using the traditional design consumes high energy, increases delay and reduces network performance. To address the limitation of the present state of the system, in this research work proposed a Hybrid Machine Learning algorithm for Wireless Sensor Networks (HML). The design of HML-WSN utilizes a hybrid machine learning based optimized path selection algorithm, which improves the network performance in the metrics of throughput, packet delivery ratio and reduces delay and energy consumption. The implementation of proposed methodology made using NS2. The empirical results of the proposed system outperforms with comparison of the existing WSN mechanisms.**

***Keywords— Machine Learning, Energy Efficient, Wireless Sensor Networks.***

## I. INTRODUCTION

The tremendous advancement in wireless communication technology is highly impact on Wireless Sensor Network (WSN)s. The data transmission is essential operation in WSN. From last decade many mechanisms are proposed to improve the performances of data transmission. Efficiently data transmission is essential for both research and industry. The WSN used in wide range of application from military to health care applications and environment monitoring applications to smart city innovations [1]. The WSN have large number of distributed sensor nodes. The traditional WSN have different levels of communication. The network partitions in to many clusters, in each clusters elected one CH. The sensor nodes are deployed in various applications and collected surround information. The sensor node send to the CH and the CH forward to the sensor data to the base station [2].

The WSN sensor nodes have limitations in energy efficiently and data transmission. The sensor nodes have very less computing and communication abilities. The range of sensor nodes very limited and enhancement is needed to improve the communication performance. The deployment of WSN is consider main aspect of load balance. In traditional WSN mainly used Base Station and CHs for data transmission [3]. In Figure 1 observe a model architecture of WSN.

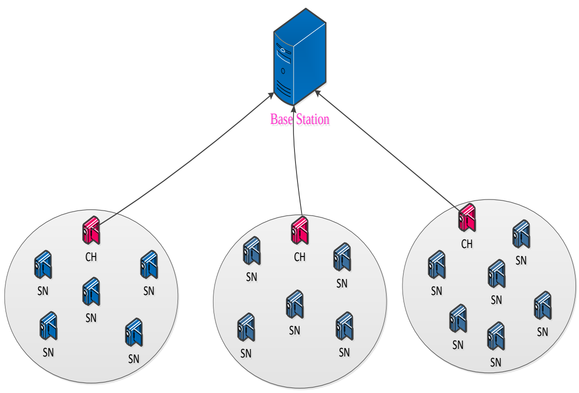



*Fig .1 .A Model Architecture of Wireless Sensor Network*

The WSNs follow the clustering based algorithm, each cluster having a group of sensor nodes. The sensor nodes collect the surrounding information and send it to the CHs. The CHs process collected data and sent it to BS. Each sensor node in the network consumes energy to collect and forward the data. Even though the sensor nodes are shut down due runs out of energy. So it's essential to develop an energy efficient algorithm for WSN. Many clustering algorithms are proposed to balance energy consumption in WSN [4][5]. These algorithms follow the selection of CHs, and also shift CHs position among the sensor nodes in the network. A joint clustering and routing algorithm proposed for reducing energy consumption in large scale WSNs. Design energy efficient mechanism back-off timer and gradient routing to execute the CH selection. In this research work introduced a novel machine learning based PAWAN mechanism, which minimizes the energy consumption, delay and maximizes throughput and PDR [6].

The remaining paper is divided into different sections, each section discussed as follows. Section II provides a comprehensive overview of the state-of-the-art of WSN energy efficient mechanisms. In Section III, discussed the proposed methodology deployed HMLWSN for energy efficiency. In Section IV, discuss the empirical results proposed mechanism and perform comparative analysis of proposed results. In Section V conclude the paper with betterment of proposed mechanism, besides that discuss future outline research work.

## II. LITERATURE REVIEW

F. Fernando Jurado-Lasso et al [7] proposed an energy-aware routing algorithm with overhead reduction technique. This algorithm facilitates optimized energy consumption along with industrial services in WSN. The software defined multichip WSN implements a function called data packet aggregation, which controls the overhead in WSN. The proposed mechanism extends the network lifetime of WSN with comparison of shortest path algorithms. Also improve the performance in terms of PDR. Even though the performance of the proposed approach is better with comparison of existing algorithms. But to reduce the neighbor advertisement packets and improve the network lifetime a novel innovation algorithm is essential in WSN.

Nelofar Aslam et al [8] proposed a novel algorithm for logical data transmission with clustering and reinforcement algorithm (SARSA). The proposed algorithm is also defined as clustering SARSA(C-SARSA) along with an optimal solution for energy consumption and network stability. The WSN node is designed with the wireless portable charging device (WPCD). With the inspiration of an objective function the proposed method improves the network performance. However the performance improved with implementation C-SARSA in WSN. But the WSN lacks RWSN with respective deployment and recharge schema. Gajendran Malshetty et al [9] proposed a Load Based Self Organize technique for efficient clustering in WSN. The LBSO technique followed three different steps in WSN. In the first step it's followed selection of Cluster Head, in second selection form the clusters with sensor nodes. In the third step it is followed by reselection of cluster head using rotational phase. However, the performance of the network achieved better performance in terms of efficiency and network formation. But the network performance is inefficient in count of different base station deployment and dead nodes.

Muhammad Adil et al [10] proposed an energy efficient load balancing routing schema to maximize lifespan of WSN. A Dynamic Cluster Based Static Routing Protocol (DCBSRP) introduced with an efficient hybrid routing scheme. The proposed protocol is designed with the combination of Ad-hoc On-demand Distance Vector (AODV) Routing Protocol and Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol. In this protocol, establish WSN with different clusters and with selection of CHs. The DCBSRP protocol primarily does not advertise recently selected CH nodes from the initial cycles and its act as normal node. However, the proposed protocol achieved significant improvement in network lifetime.

WSN deployed in different real time applications with a wide range of usage. The WSN operates with self-organization and limited energy resources. To address the limitations of energy efficiency Xinlu Li et al proposed an Energy-Efficient Load Balancing Ant Based Routing Algorithm (EBAR) for WSNs. The EBAR algorithm efficiently reduces energy consumption. An opportunistic broadcast schema utilized for energy efficiency in EBAR utilizes and also controls overhead in WSN. Even though the EBAR achieves energy efficiency, its accuracy is only homogeneous networks only. If the network is heterogeneous the algorithm is unable to support data transmission and leads to high energy consumption [11].

## III. PROPOSED METHODOLOGY

### A. Problem Statement

The WSNs are interconnected with sensor nodes that communicate with each other to gather the information from surrounding environments. The sensor nodes are operated with low energy and decentralized fashion. The WSN is deployed in many emerging applications, such as healthcare systems, industrial applications, environment applications, military applications. The traditional WSN operates with three different levels like base station, cluster head and sensor nodes. The sensor nodes collect the surrounding information and transmit it to the cluster head. But the cluster head receives information for a fixed amount of time and the behavior changes rotationally. The rotational changes of cluster head leads to energy consumption and delay in data transmission. To address the limitations of the present state of the WSN, in this research paper introduced a novel machine learning algorithm with path arbitrary mechanism.

### B. 3.2 HML-WSN

The nature of open resource utility, mobility in sensor nodes and rotational changes in cluster heads leads to high energy consumption, transmission delay. To resolve the problem faced in present art-of-the WSN, in this research work introduced a Hybrid Machine Learning algorithm for Wireless Sensor Networks (HML-WSN).

The WSN has two types of data transmission. First type of data transmission is from sensor node to PA node. Second type data transmission is one cluster sensor node to another cluster sensor node. The sensor node directly links with the path arbitrary node. But in sensor to sensor node communication use another sensor node for intermediate communication. Here the path arbitrary plays a key role in selection of the optimal path from the sender sensor node to destination sensor node. The path arbitrarily defines optimized primary path and alternate paths from source to destination. The path selection from source to destination follows the node distance and energy levels of the link node. If any link/node failure occurs in the primary path. The source node selects the alternate optimized path from source to destination with the help of an arbitrary node. So the path arbitrary mechanism in WSN reduces network delay with implementation of path arbitrary nodes in the networks. Reduce the energy consumption and improve the PDR with the utilization optimize path selection from source to destination.

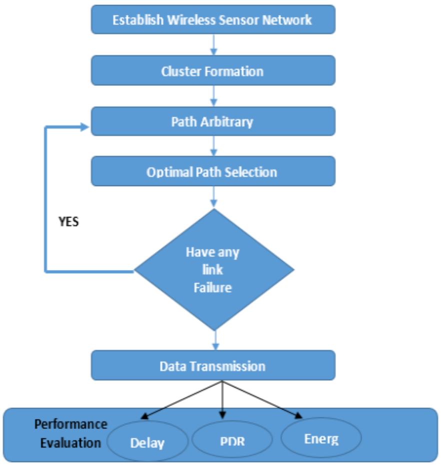



Fig. 1. Path Arbitrary Wireless Sensor Networks

The optimize path selection mechanism follows two different phases in proposed HML-WSN. In first phase applied optimize path selection algorithm, its sends RREQ packet from source node destination node. The RREQ packet broadcast from intermediate nodes and reaches the destination node. The sensor node have the information about the distance and energy values of previous node and next neighbor node in the network. Finally the destination node receives RREQ from multiple nodes with multiple paths.

Algorithm Name : Optimize Path Selection

Input: Network nodes with distance and energy factors

Output: Optimize paths

1. Initialize
2. RREQ packets send from Source Node
3. RREQ packet broadcast by sensor nodes with the information of node distance and energy factor
4. Next sensor node maintain information of node distance and energy factor
5. Calculate total path value
6. Trust value of path = Des + DEn1 +DEn2 +…… + DEnn + DEd
7. Path arbitrary maintain path order based on node DE
8. Primary optimize path selection
9. Send RREP packet.
10. Start Data Transmission from source node.
11. Link failure occurs in primary path
12. Alternate optimize path select
13. Send data transmission from alternate path.
14. End

The summation of node values calculated and ordered all optimized paths. Using the primary optimized path the destination sends an RREP packet to the source node. Also optimized alternate paths available in the network. If any link/node failure occurs in the network utilize the alternate paths for data transmission. To optimize path selection algorithm given detailed implementation steps in HML-WSN.

$$\text{Packet Delivery Ratio}= \frac{\sum_{i=1}^{n} RPi}{\sum_{i=1}^{n} SPi} \text{.................................(1)}$$

## IV. RESULT AND DISCUSSION

The proposed hybrid machine learning based algorithm HML-WSN mechanism is implemented using Network Simulation (NS) version 2.35. The empirical simulation results show the performance of PA-WSN with data transmission. The comparative results discussed in below sub sections.

*A. SIMULATION ENVIROMENT*

TABLE I. SIMULATION ENVIRONMENT

Table 1 gives detailed network parameters, which are used in the design of PA-WSN simulation.

The two ray ground radio propagation is used for deployment of WSN. Different performance metrics are compared for evaluation of proposed mechanisms. The improved performance is measured in terms of delay, throughput, and packet delivery ratio and energy consumption. The different previous mechanisms such as Load Based Self Organize(LBSO) technique for efficient clustering in WSN, efficient hybrid routing scheme using a dynamic cluster-based static routing protocol (DCBSRP) and Energy-Efficient Load Balancing Ant Based Routing Algorithm(EBAR) for WSNs is compared with the PA-WSN[9][10][11]. The definition performance metrics are given in the section below.

*B. Metric Comparative Analysis*

The proposed mechanism simulation results compare with performance metrics. The definition and equations discussions is given below.

*1) Packet Delivery Ratio*

The ratio between the number of packets sent and number packets received at destination node. The formula given in Eq(1).

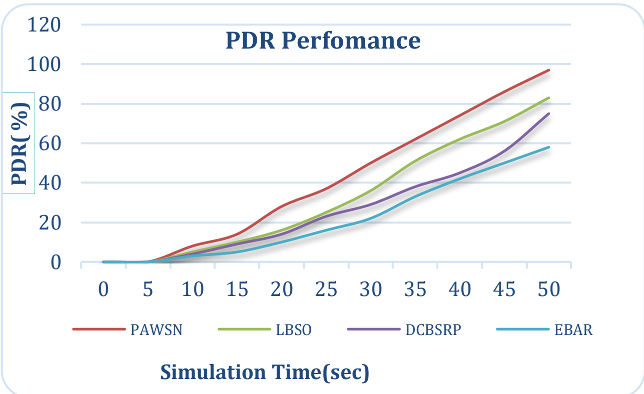



Fig. 3. PDR Performance Comparison

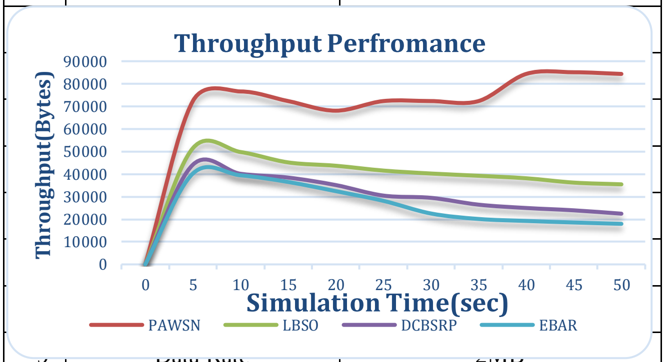
Figure.3. shows the empirical results of proposed mechanism HMLWSN and existing mechanisms of LBSO, DCBSRP, and EBAR. The X-Axis took simulation time from 0 seconds to 50 seconds. The Y-axis is the percentage of PDR. The PDR of the proposed HMLWSN network increases with a respective increase in simulation time. The same kind of fashion is observed in existing mechanisms, but the performance results stated that HMLWSN mechanism outperforms with comparison of LBSO, DCBSRP, and EBAR.

*2) Throughput*

The number of bytes received at destination node with respective simulation time. The formula given in Eq(2).

$$\text{Throughput} = \sum_{i=1}^{n} \frac{Pi}{Time} \times 8 \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

| S.N | Network Parameter | Network Value |
|---|---|---|
| 1 | Type of Channel | Wireless Channel |
| 9 | Data Rate | 2MB |
| 10 | Basic Rate | 1MB |
| 11 | Total Simulation Time | 50 |




The throughput performance of proposed mechanism with respective simulation time.

Fig. 4. Throughput Performance

Figure 4 represents the throughput performance proposed HMLWSN mechanism. The simulation time recorded from 0 to 50 seconds on the X-axis. The number of bytes received at the destination node is taken on the Y-axis. The proposed HMLWSN mechanism showed significant performance improvement in terms of throughput. The proposed HMLWSN mechanism received 85120 bytes with comparison of existing mechanism LBSO, DCBSRP and EBAR received 51456, 44158, and 40256 respectively.

*3) Delay*

The difference between the packets received time and packet sent time. The formula given in Eq(3).

$$\text{Delay} = \sum_{i=1}^{n} PSTi - PRTi \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

The delay performance of proposed mechanism with respective simulation time. The results proposed mechanism is compare with the present state-of-art-of the system.

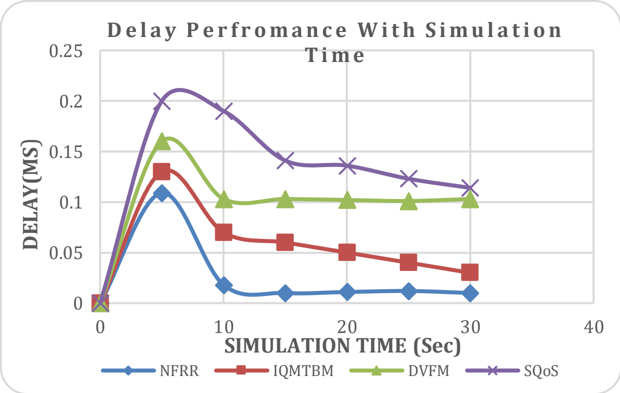



Fig.5. Delay Performance Comparison Results

Figure 5 shows the performance comparative results of network delay of the proposed mechanism. The simulation time is taken on X-axis, which is measured seconds, and network delay is taken on Y-axis, which is measured in milliseconds value. The empirical results proved that the proposed mechanism achieved better performance with comparison of the present state of the system. The proposed mechanism showed significant performance improvement results recorded from 0 to 50 seconds. Even though initially have high network delay, the proposed mechanism gradually reduces and minimizes.

#### *4) Energy Consumption*

It represents total energy utilized by the sensor nodes for data transmission and other activities in the network. The formula given in Eq (4).

$$\text{Energy} = \sum_{i=1}^{n} NEi \text{ ..........................................(4)}$$

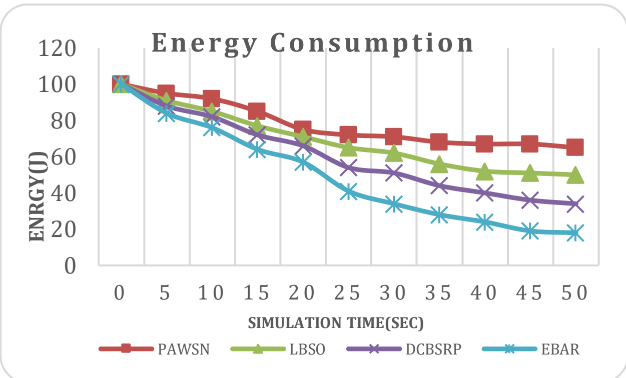



Fig. 6. Energy Consumption

Figure 6 shows the energy consumption with respective simulation time. This graph showed total consumed energy for each interval time. The simulation is taken from 0 seconds and 50 seconds. In the HMLWSN network each sensor node allocated 100 Joules energy. When simulation time.

## V. CONCLUSION

The advancement in WSNs is utilized in many real time applications such as military, healthcare, agriculture, smart cities, etc. The WSN is highly efficiently used for data transmission. The operational capabilities of sensor nodes are based on the real time environments. The sensor nodes are highly resource constrained due to the nature of WSN. The present WSN has many problems to solve, but the performance efficiently and network delay is essential. To address the issues in WSN, in this research paper proposed a novel machine learning based HMLWSN. The path arbitrarily plays a key role in data transmission and selection of optimized paths between the sensor communications. The optimize path selection mechanism also maintains the alternate optimize paths. Which can be utilized if any link failure occurs in the primary path. The proposed schema improved performance in terms of delay, throughput, and PDR and energy consumption. However, the proposed HMLWSN achieved outperforms with the comparison of different energy efficient WSN mechanisms. In other words, the HMLWSN is optimized in order to enhance data transmission in WSN. The implementation is done using NS2 simulations. The empirical results revealed that the proposed approach has significant performance improvement over standard system. This research is further extended in future to overcome link failure problem by enhance HMLWSN continue the data transmission with stipulated amount of in WSN.

## REFERENCES

[1] Singh, J., Yadav, S.S., Kanungo, V. and Pal, V, “A node overhaul scheme for energy efficient clustering in wireless sensor networks”. IEEE Sensors Letters ( Volume: 5, Issue: 4, April 20211.

[2] Raj, J.S., 2020. Machine learning based resourceful clustering with load optimization for wireless sensor networks. Journal of Ubiquitous Computing and Communication Technologies (UCCT), 2(01), pp.29-38.

[3] Kobo, H.I., Abu-Mahfouz, A.M. and Hancke, G.P., 2018. Fragmentation-based distributed control system for software-defined wireless sensor networks. IEEE transactions on industrial informatics, 15(2), pp.901-910.

[4] Prajapati, J. and Jain, S.C., 2018, April. Machine learning techniques and challenges in wireless sensor networks. In 2018 Second International Conference on Inventive Communication and Computational Technologies (ICICCT) (pp. 233-238). IEEE.

[5] Yang, L., Lu, Y., Xiong, L., Tao, Y. and Zhong, Y., 2017. A game theoretic approach for balancing energy consumption in clustered wireless sensor networks. Sensors, 17(11), p.2654.

[6] Raj, J.S., 2020. Machine learning based resourceful clustering with load optimization for wireless sensor networks. Journal of Ubiquitous Computing and Communication Technologies (UCCT), 2(01), pp.29-38.

[7] Jurado-Lasso, F.F., Clarke, K., Cadavid, A.N. and Nirmalathas, A., 2021. Energy-aware routing for software-defined multihop wireless sensor networks. IEEE Sensors Journal, 21(8), pp.10174-10182.

[8] Aslam, N., Xia, K. and Hadi, M.U., 2019. Optimal wireless charging inclusive of intellectual routing based on SARSA learning in renewable wireless sensor networks. IEEE Sensors Journal, 19(18), pp.8340-8351.

[9] Malshetty, G. and Mathapati, B., 2019, April. Efficient Clustering in WSN-Cloud using LBSO (Load Based Self-Organized) Technique.

In 2019 3rd International Conference on Trends in Electronics and Informatics (ICOEI) (pp. 1243-1247). IEEE.

[10] Adil, M., Khan, R., Ali, J., Roh, B.H., Ta, Q.T.H. and Almaiah, M.A., 2020. An energy proficient load balancing routing scheme for wireless sensor networks to maximize their lifespan in an operational environment. IEEE Access, 8, pp.163209-163224.

[11] Li, X., Keegan, B., Mtenzi, F., Weise, T. and Tan, M., 2019. Energy-efficient load balancing ant based routing algorithm for wireless sensor networks. IEEE Access, 7, pp.113182-113196.

[12] Kotari Sridevi, Srinivas Rao Dhanikonda, D Vara Prasad, Chandragiri Tirupati, "WSNS Security Enhancement Based On a Game Theory", JSR Journal, ISSN: 1781-7383, pp. 16-25, Volume XIII, Issue 1, January-2021.

[13] Mohammad, G.B. and Shitharth, S., 2021. Wireless sensor network and IoT based systems for healthcare application. Materials Today: Proceedings.

[14]

[15]