# A COMBINED APPROACH FOR BILSTM MODE DUTY-CYCLE SCHEDULING AND SELF CONFIGURATION, A SELF-HEALING FRAMEWORK USING XGBOOST CLASSIFIER FOR IOT-WSN

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**ABSTRACT** : Internet of Things (IoT) is a group of interconnected devices which contain sensors to collect useful data. Artificial Intelligence (AI) techniques like Machine learning (ML) and Deep Learning (DL) are very much popular in many applications including IoT. In this paper, an adaptive duty-cycle scheduling using Bi- Directional Long Short-Term Memory (BiLSTM) algorithm and Self Configuration and Self- healing Framework Using XGBoost Classifier is proposed for IoT-WSN networks. In this algorithm, initially, the Jaccard Similarity Index (JSI) between two sensors are estimated. Then sensors with highest similarity (ie highest JSI values) are selected for sleep scheduling. Once the eligible sensors for sleep scheduling are selected based on the JSI values, their traffic loads and Energy levels are estimated from the previous traffic patterns using BiLSTM. The duty cycle of sensors are by estimated by adjusting the length of sleep duration according to the estimated traffic load and energy levels of the selected sensors. Then the IoT traffic classes are classified into various categories using XGBoost classifier. In the self- configuring phase, the IoT devices are self configured by allocating different transmission slots, contention access period (CAPs) depending on their categories and priorities. In self-healing phase, if either the remaining power of in-between node is truncated or the node has dislocated far-off, a confined route retrieval method is established by the source node cardinally. By experimental results, we show that the proposed BiLSTM-ADS and XGBoost classifier technique achieves higher prediction accuracy and residual energy with lesser computational cost.

**Keywords – IoT, Artificial Intelligence, AIoT, BiLSTM, JSI, XGBoost, contention access period.**

## I. INTRODUCTION

Internet The Internet of Things (IoT) is progressively being used by modern wireless technologies. Pervasive smart devices like RFID tags, sensors, actuators, and smart mobile phones can communicate with one other and work together to achieve common goals in an intelligent fashion. This is the core principle behind the concept of "smart things." The amount of data generated each day has increased considerably as a result of the Internet of Things (IoT) [1].

Recently AI techniques like ML and DL are become familiar in many science disciplines, including IoT [2]. AI based devices are more intellectual and can perform any kind of tasks thus minimizing the resources and time [3]. While the IoT provides an infrastructure for intercommunication between devices and data collection, the AI gives a "brain" to the entire system, which enhances the capability to process the available data [4].

Murat Kuzlu et al [6] have introduced several AI algorithms and investigated their applications in cyber security. Reliability of the systems is critical for their acceptability. Furthermore, trust is essential, since inconsistent conduct may have serious ramifications for the environment as well as individuals. For big systems made up of numerous diverse, resource-constrained (e.g. energy, power and memory) and often inexpensive but unreliable components (e.g. micro controllers), reliability is difficult to achieve. [7].

In IoT-WSNs, self-management can take place on either on network- or mote-level. The monitoring and adaptation to changes will require both hardware and software support to be built in the system. The most important self-management objectives are

- Self-arrangement
- Self-development
- Self-relieve
- Self-shielding
- Self-management in wireless sensor networks

In most IoT systems, the quality of service (QoS) must be ensured in accordance to the necessity of the implementation domain. Measures to quantify the quality of service provided by IoT systems are numerous. The vigorous character of the territory around the IoT structure makes it difficult to fulfill these commitments. The QoS may be endangered by a wide range of unanticipated circumstances. Self-adaptive systems can deal with the system's unpredictable conduct during execution. When the system or its environment changes, a self- adaptive system adjusts its conduct in order to maintain a specified quality level [8].

Self-relieving On the basis of unacknowledged routing, self- healing is achieved. The following two requirements must be met for a routing algorithm to be called "self-healing.":

## 2. Problem statement and Objectives

AI techniques can be applied in duty cycling of nodes such that the nodes can adjust their duty cycling factors based on their available energy. But IEEE 802.15.4 networks possess serious issues like packet drop, resource availability and synchronization. If the duty cycle length is kept small, the energy consumption becomes less. But this will lead to buffer overflows and increase in latency. If the duty cycle length is kept high, a greater number of data packets can be transmitted. However, this will lead to increase in idle listening time of the coordinator. Hence adjusting the duty cycle length suitably in IEEE 802.15.4 networks is a challenging issue. The primary goal of this paper is to develop an AI based duty cycling technique in next generation IoT system to minimize the power consumption involved in data reception, data transmission, sleep and idle states.

## 3. Related Works

A duty cycle learning algorithm (DCLA) has been proposed[9] which adjust the duty cycle period to reduce the power consumption and to ensure successful data transmission. DCLA determines the incoming traffic arrival rate at each active period, based on the collected network traces. For estimating the optimum duty cycle, reinforcement learning (RL) framework is applied at each interval. A quorum-based grid system is developed [10] in which the number of sensors in the quorum is increased to improve the throughput and reduce latency by means of AI technique. By applying weighted load balancing technique, the energy consumption is reduced. A Recurrent Neural network (RNN) based duty cycle adjust method [11] has been proposed. During the training process,the best duty cycle for a specified network constraint is defined using the twin-space analytic solution. The performance comparison of RL based duty cycle methods has been done by Shahzad Sarvar [12]. It consists of the challenges involved in the RL based approaches.

A sensor duty cycling technique which is based on energy and periodical events [13] has been proposed, which predicts the expected events in the forthcoming intervals by applying BiLSTM networks. For predicting the unexpected dynamic events, it deploys monitoring sensor in each cluster using Jaccord Similarity Index (JSI).

For essential and life-saving systems, Rafael Angarita and his collaborators [6] propose that self-healing

Internet of Things applications are necessary. Pure transferrable techniques, where recovery choices are determined automatically based on component transferrable attributes, were shown to have drawbacks. When they came up with this idea, they combined transferrable and self-aware features into the notion of responsible objects. In the context of critical Internet of Entities applications, responsible objects are intelligent objects or things that can make intelligent self-healing choices. A Kalman Filter-deployed forehanded potency assist technique has been recommended by Srinidhi et al. Reduced switching numbers between the attachment points of mobile nodes assist to reduce waving overhead and power consumption by providing seamless connectivity. To anticipate the occurrence of a handoff event, the handoff trigger system takes use of mobility information. The Kalman-Filter is used to anticipate the attachment point and trajectory of mobile nodes. This methodology makes use of the Kalman-Filter predictor- estimator method for movement prediction. Predicting and updating are the first two processes in the Kalman Filtering process.

## 4. Proposed Solution

In this paper, an adaptive duty-cycle scheduling using BiLSTM algorithm is proposed for IoT networks. In this algorithm, initially, the JSI between two sensors are estimated. Then sensors with highest similarity are selected for sleep scheduling. Once the eligible sensors for sleep scheduling are selected based on the JSI values, their traffic loads (TL) and Energy levels (EL) are estimated from the previous traffic patterns using BiLSTM. The duty cycle of sensors are by estimated by adjusting the length of sleep duration according to the estimated TL and EL of the selected sensors. The IoT traffic classes are classified into various categories using XGBoost classifier. In the self-configuring phase, the IoT devices are self-configured by allocating different transmission slots, contention access period (CAPs), depending on their categories and priorities. During the self-healing phase, the source sends a path check that the packet present at time t across the designated path before transferring the data. The successor node immediately sends a rout warning notification to the origin and passes the path check packet to neighbouring nodes toward the destination if either the remaining power or the node has far-off the range. The route recovery method is triggered if the source can get various route alerting messages from the in-between nodes.

### 4.1 Adaptive Duty-cycle Adjustment and Scheduling

The ratio of the active or sensing time to the sleep cycle time is known as the duty cycle. It is assumed that the sensors' duty cycles are random. By modifying $T_{sleep}$ depending on the deduced TL and EL values of the chosen nodes, the duty cycle is modified. A lower duty cycle is indicated by a greater $T_{sleep}$ value. Conversely, a higher duty cycle necessitates more power for functioning. The adaptive duty-cycle adjustment mechanism is described in the following algorithm. Two thresholds, LB and UB, are maintained in duty-cycle (DC) adjustment. The $T_{sleep}$ can be raised by a tiny increment of $\omega_1$ if the device's projected traffic (IL) or energy level (EL) is less than LB. $T_{sleep}$ can increase significantly $\omega_2$ if IL and EL are both simultaneously lower than LB. On the other hand, the $T_{sleep}$ can be reduced with a tiny increase of $\omega_1$ either IL or EL is higher than UB. When IL and EL are both greater than UB at the same time, $T_{sleep}$ is significantly reduced with a huge increment of $\omega_3$.

**Results**

The suggested Reinforcement Learning Based Adaptive Duty Cycling (RL-ADC) and BiLSTM based Adaptive Duty-cycle Scheduling (BiLSTM-ADS) are compared and implemented in NS2 [13]. Prediction accuracy, packet loss, computation cost, and average residual energy are used to assess performance. The results are shown in this section with nodes ranging from 20 to 100.

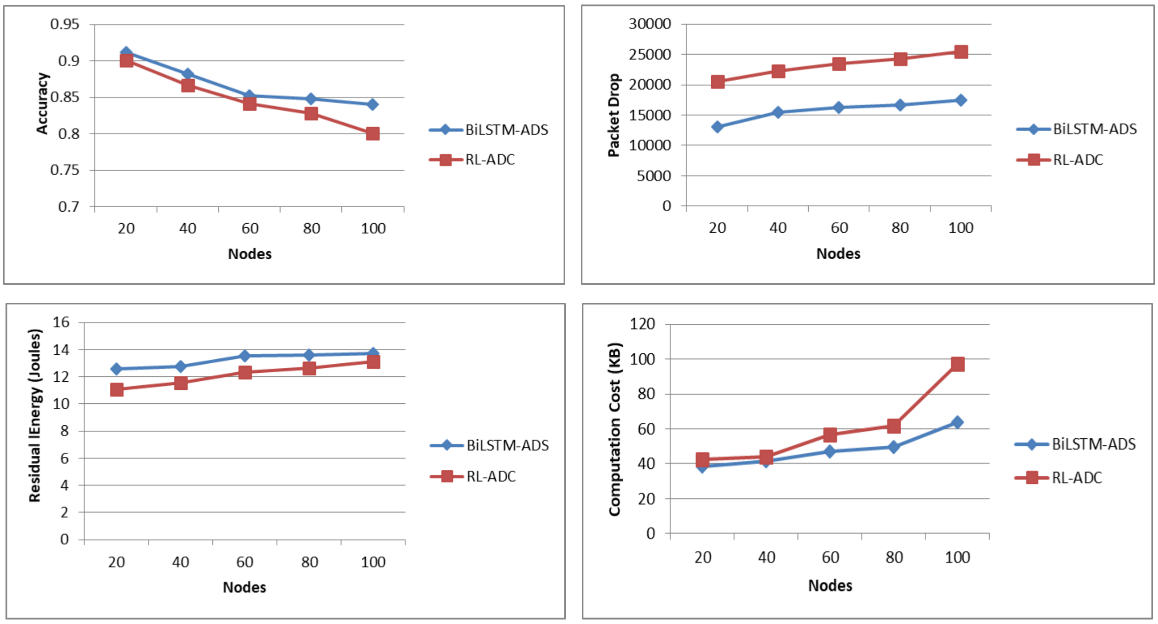


Figure 1 Results Graph

Compared to RL-ADC, BiLSTM-ADS has a 2% greater delivery ratio. BiLSTM-ADS has a 32% lower packet drop rate than RL-ADC. BiLSTM-ADS has a residual energy that is 8% higher than RL-ADC. Compared to RL-ADC, BiLSTM-ADS is 17% less expensive.

**4.2 Self-configuration and Self-healing**

The simulation of XGBoost Classifier-based framework for self-configuration and self-healing is proposed.

**Self-Configuration Process**

The choice of BO, SO, and slot configurations of QoS CAPs is influenced by network traffic. The various QoS CAPs are configured in respect to the different types of traffic in an IoT environment, and there is a clear correlation between these two factors. Based on the existence of various forms of traffic, the appropriate slots configuration, and BO/SO values, the XGBoost classifier divides IoT traffic into 5 classes. There is a priority allocated to each class. The amount of slots and BO/SO are distributed according to the priority of the classes.

In light of the numerous probable scenarios, the IoT gateway (IoT-GW) gets the Superframe's corresponding slots configuration. Any unused slots can be transferred to another QoS CAP that desperately needs them according to the self-optimizing method, but the higher priority classes are still given priority. The settings for BO and SO values and slots must be changed if there are any changes to the QoS classes' existence. The modified beacon at the BI is delivered to all IoT nodes, and the IoT-GW is informed of the new BO, SO, and slots configuration settings.

Our suggested IoT architecture's GW1 and GW2 carry out a self-configuring IoT procedure. The knowledge base (GW1) is one of the four tasks that the AM (autonomous manager) can carry out. The GW2 has a functional interface to receive configurations sent from the GW1 in order to update the beacon information.

**Self-Healing Process**

The steps that make up the procedure are listed below. In this self-healing routing system, Source S first sends a route check packet over the designated route at time t before sending the data. Each intermediate node Ni+1 receives a packet including a routing check, and if the node is out of range or has lost power, Ni+1 checks the next node Ni+1. Node Ni+1 instantly sends a route check packet to other nodes in the direction of destination D if the route warning message is received. If S receives several route warning messages from the intermediate nodes, the route recovery procedure is started. During the route recovery phase, S will examine any intermediate nodes for a quicker alternative path. sends a packet with a route repair request to the node where a new route can be created. If not, S will pick another option from the list of options.

**Results**

The SCSH-XGboost simulation is run in NS2 and compared to FarpScusn [14]. Regarding packet delivery ratio, packet drop, computational cost, and residual energy, performance is assessed.

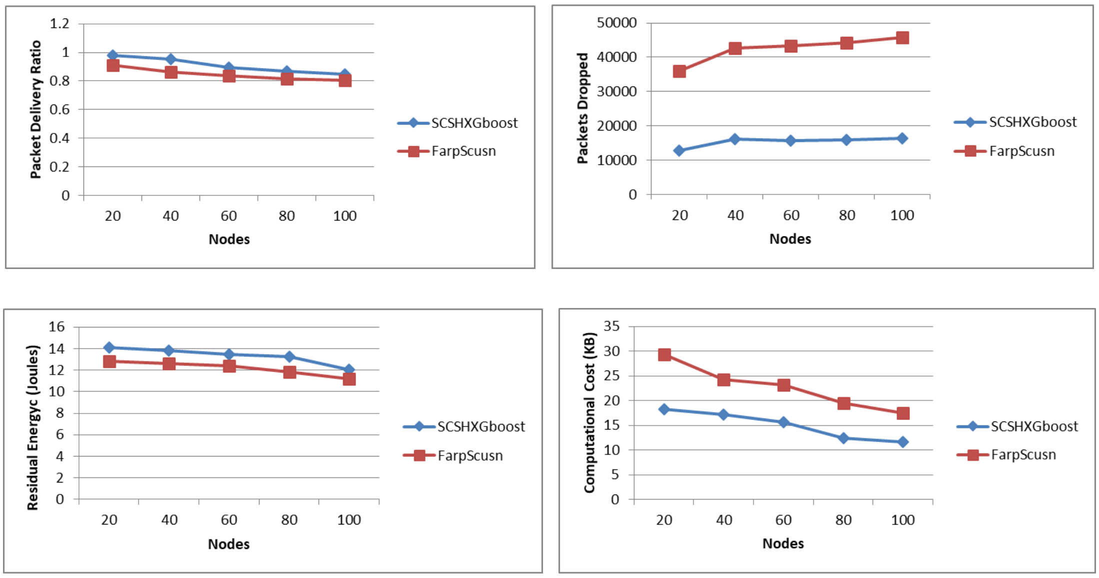


Figure 2 Results Graph

SCSH-XGboost has a packet delivery ratio that is 6% higher than FARPSCUSN. SCSHXGboost's packet Drop is 63% lower than FARPSCUSN's. SCSHXGboost has a residual energy that is 8.6% greater than FARPSCUSN. SCSHXGboost is 33% cheaper than FARPSCUSN in terms of price.

## 5. Conclusion

In this paper, an BiLSTM based adaptive duty-cycle scheduling (BiLSTM-ADS) algorithm and Self Configuration and Self-healing Framework Using XGBoost Classifier is proposed for IoT networks. In this algorithm, THE sensors with highest similarity are selected for sleep scheduling. Once the eligible sensors for sleep scheduling are selected based on the JSI values, their traffic loads (TL) and Energy levels (EL) are estimated from the previous traffic patterns using BiLSTM. The duty cycle of sensors are then estimated by adjusting the length of sleep duration according to the estimated TL and EL of the selected sensors. Then the IoT traffic classes are classified into various categories using XGBoost classifier. In the self-configuring phase, the IoT devices are self configured by allocating different transmission slots, contention access period (CAPs) depending on their categories and priorities. In self-healing phase, if either the remaining power of in-between node is truncated or the node has dislocated far-off, a confined route retrieval method is established by the source node cardinally. The proposed BiLSTM-ADS is implemented in NS2 and it is compared with RL-ADC algorithm. By experimental results, we show that the proposed BiLSTM-ADS technique achieves higher prediction accuracy and residual energy with lesser computational cost, when compared to RL-ADC.

## 6. References


1. Venkatesh K. Pappakrishnan, R. Mythili, V. Kavitha and N. Parthiban, "Role of Artificial Intelligence of Things (AIoT) in Covid-19 Pandemic: A Brief 79 Authorized licensed use limited to: National Taiwan Univ of Science and Technology. Downloaded on June 19,2022 at 05:57:33 UTC from IEEE Xplore. Restrictions apply. Survey", In Proceedings of the 6th International Conference on Internet of Things, Big Data and Security (IoTBDS 2021), pages 229-236.
2. Tao Lin, "Deep Learning for IoT", Machine Learning. arXiv:2104.05569 (cs)., 2021.
3. Hao Qinxia ,Shah Nazir ,Ma Li,Habib Ullah Khan ,Wang Lianlian and Sultan Ahmad, "AI-Enabled Sensing and Decision-Making for IoT Systems", Hindawi,Complexity,Volume 2021, Article ID 6616279, 9 pages.
4. Guoping Rong, Yangchen Xu, Xinxin Tong and Haojun Fan, "An edge-cloud collaborative computing platform for building AIoT applications efficiently", DOI:10.21203/rs.3.rs-218949/v1, 2021.
5. Subhas Chandra Mukhopadhyay,Sumarga Kumar Sah Tyagi,Nagender Kumar Suryadevara,Vincenzo Piuri and Sherali Zeadally, "Artificial Intelligence-Based Sensors for Next Generation IoT Applications: A Review", IEEE SENSORS JOURNAL, 2021.
6. Murat Kuzlu, Corinne Fair and Ozgur Guler, "Role of Artificial Intelligence in the Internet of Things (IoT) cybersecurity", Discover Internet of Things, Vol-1, No-7, 2021.
7. Hamidreza Bolhasani, Maryam Mohseni and Amir Masoud Rahmani, "Deep learning applications for IoT in health care: A systematic review", Elsevier,Informatics in Medicine Unlocked 23, 2021.
8. Timo Toyry, "Self-management in Internet of Things", IEEE, 2017.
9. Iván Alfons , Kelly Garces, Harold Castro and Jordi Cabot, "Self-adaptive architectures in IoT systems: a systematic literature review", Journal of Internet Services and Applications, 2021.
10. Fengyin Li, Ying Wang , Hongwei Ju, Yanli Wang, Zhaojie Wang and Huiyu Zhou, "FarpScusn: Fully Anonymous Routing Protocol with Self-Healing Capability in Unstable Sensor Networks",

Sensors, 2020.

**11.** Rafael Angarita, "Responsible Objects: Towards Self-healing Internet of Things Applications", IEEE, 2021.

**12.** Ahmad Khalil, Nader Mbarek and Olivier Togni, "Self-Configuring IoT Service QoS Guarantee Using QBAIoT", Computers, 2018.

**13.** Abouzar Estebsari, Matteo Orlando, Enrico Pons, Andrea Acquaviva and Edoardo Patti, "A Novel Internet-of-Things Infrastructure to Support Self-Healing Distribution Systems", IEEE, 2018.

**14.** Ganesh Raja. M, "Adaptive Duty-Cycle Scheduling using Bi-Directional Long Short-Term Memory (BiLSTM) for Next Generation IoT Applications" International Conference on Computing, Communication and Power Technology (IC3P), 978-1-6654-2525-4/22, IEEE Xplore | DOI: 10.1109/IC3P52835.2022.00024,2022.