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Energy Efficient Communication Technique in WSN

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Abstract— ***Low-power devices are distributed across geographically remote regions to create Wireless Sensor Networks (WSN) utilizing cluster arrangements of sensors. The cluster head (CH), a crucial node defined for each cluster, gathers data from its sensor nodes for transmission to a base station (BS). Sensors utilize non-replaceable batteries, raising concerns about energy consumption in WSNs. In this paper, we propose an intelligent approach to reduce energy consumption and data usage, extending the network lifetime. Unlike studies using a common duty cycle value for synchronization, our approach adapts the duty cycle based on traffic conditions to decrease energy consumption and latency. We receive data from nodes, perform data aggregation at the cluster head, and transmit only the aggregated data to the base station.***

Index Terms— ***Wireless Sensor Networks, cluster head, aggregation, base station, synchronization, latency***.

I. INTRODUCTION

Currently, the innovative design of industrial Wireless Sensor Networks (WSNs) focuses on network deployment, management, and wireless resource management. WSNs, crucial for industries, consist of small wireless sensing nodes with sensing devices, data processing devices, memory, batteries, and communication devices. Research areas in WSNs span energy consumption, lifetime, and network security.

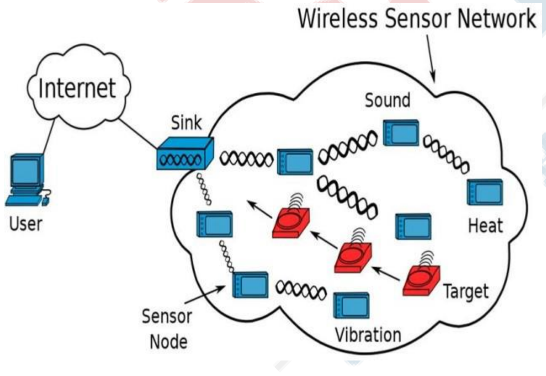

Figure 1 : WSN system

II. LITERATURE REVIEW

According to Haider Mahmood Jawad, Rosdiadee Nordin, and Sadik Kamel Gharghan [1], the use of Power Amplification (PA) allows for the customization of techniques for crops, irrespective of site settings. During the sleep state, sensor nodes conserve energy by abstaining from data exchange. To optimize energy usage, nodes awaken periodically, collect and transmit data, and return to sleep mode. Agricultural applications employ duty cycling, medium-access control (MAC) protocols, and topology control to implement the sleep/wake approach.

From the work of Malek Alrashidi, Nejah Nasri, and Salim [2], the fourth stage of industrialization involves the transition from conventional to digital industry (Industry 4.0) facilitated by Wireless Sensor Networks (WSNs). Primary challenges in WSNs include extending lifespan and reducing power consumption. Addressing these challenges involves maximizing node deployment, implementing energy-efficient routing protocols, and utilizing clustering strategies to optimize battery life.

Guopeng Li, Fufang Li, Tian Wang, Jinsong Gui, and Shaobo Zhang [3] introduce the bi-adjusting duty cycle schedule (BADCS) method for low duty cycle wireless sensor networks. This strategy minimizes event detection latency and data routing delay. Meanwhile, Yang Liu, Jing Xiao, Chaoqun Li, Hu Qin, and Jie Zhou [4] focus on the increasing use of Industrial Wireless Sensor Networks (IWSNs) in factories. They present a unique group intelligence technique based on grey wolf optimization to optimize the sensor duty cycle model (SDCM) for IWSN modeling. Their findings demonstrate the superiority of QCGWO over GA and SA in extending the life of IWSNs.

III. METHODOLOGY

The initial phase involves the deployment of sensor nodes throughout the industrial environment to collect data. These sensor nodes collectively form a cluster within a Wireless Sensor Network (WSN), and a cluster head is designated using a hierarchical clustering algorithm. Each individual sensor node is equipped with components such as an ESP-32, DHT-11 Temperature and Humidity sensor, and a vibration sensor (SW-420). To optimize sensor performance, an ideal duty cycle is established, and the gathered data is transmitted to a Raspberry Pi 4 acting as a cluster head, employing a sleep-awake algorithm.

The interconnection of microcontrollers is facilitated through Wi-Fi technology, with Message Queuing Telemetry Transport Protocol (MQTT) utilized for communication. In the event that the measured data surpasses predetermined thresholds for any sensor, the cluster head transmits the data to the base station via Wi-Fi for further analysis. The proposed system is characterized by its robustness and energy efficiency.

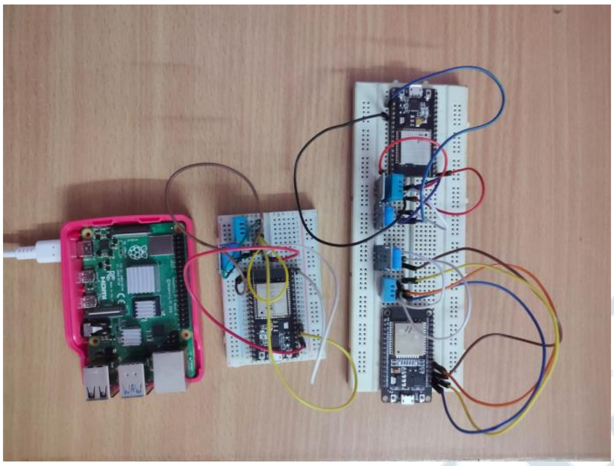

Figure 2: The proposed system

1. ESP32

The cost-effective ESP32 device features a microcontroller and two connection chips integrated into its main board. Its Bluetooth and Wi-Fi capabilities enable the development of a wide range of Internet of Things (IoT) applications. Additionally, the ESP32 provides support for various legacy connections, including Bluetooth Low Energy (BLE), Service Discovery Protocol (SDP), and Generic Access Profile (GAP).

Figure 3 : ESP 32

2. Raspberry pi

The Raspberry Pi is a compact and affordable computer, comparable in size to a credit card, suitable for use as a standard PC. It employs a system-on-chip (SoC) known as the BCM28351, commonly found in mobile phones. The advantages of utilizing a Raspberry Pi encompass its budget-friendly pricing, reliable computational capabilities, and energy efficiency. Its cost-effectiveness and robust performance make it a favored option for various applications. Additionally, the Raspberry Pi relies on free and open-source software, enabling students to integrate multiple software types for the creation of personalized learning experiences.

Figure 4 : Raspberry Pi 4

3. DHT11 SENSOR

The DHT11 sensor module serves as a humidity and temperature sensor, producing a calibrated digital output signal. It includes a humidity and temperature complex, resulting in a precise digital signal output. The DHT11 ensures accurate measurements of humidity and temperature, guaranteeing reliability and long-term stability. Communication with the DHT11 module occurs serially, and its design features a compact size with low power consumption.

Figure 5 : DHT11

4. SW-420 Vibration Sensor module

The SW-420 sensor module is a vibration sensor. When the sensor module experiences vibration or shock, one metal float will vibrate in a savings containing two electrodes. There are two outputs: an analogue output and a digital output (0 and 1). (voltage).

Figure 6 : SW-420

5. Message Queue Telemetry Transport (MQTT)

operates on the TCP/IP protocol, functioning as a lightweight messaging protocol suitable for high-latency, low-bandwidth, or unreliable networks. The use of MQTT involves (publish-subscribe) topics. The protocol's design incorporates compression to reduce network bandwidth while preserving message accuracy and reliability. MQTT finds application in machine-to-machine and Internet of Things communication, especially when bandwidth and power consumption are critical considerations. In the described setup, sensor node data is transmitted to the Raspberry Pi via the MQTT protocol, facilitating data aggregation on the Raspberry Pi. If the sensor data exceeds a predefined threshold value, a message is then sent to the base station using MQTT

A. Block Diagram

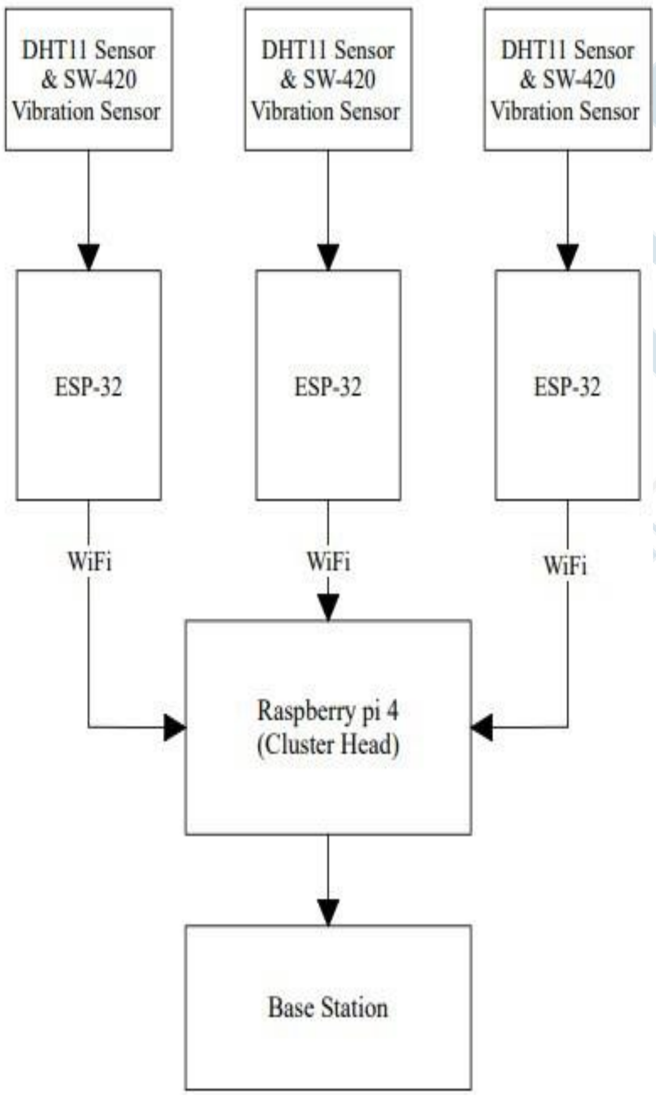

Figure 7 : Block Diagram

Flow Chart

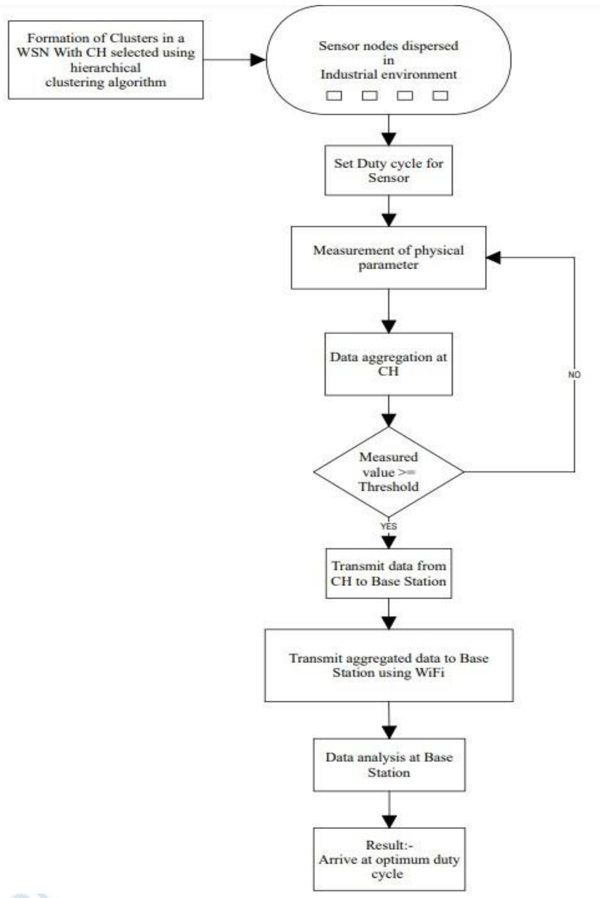

Figure 8 : Flow Chart

IV. CONCLUSION AND RESULT

A. Results

The Sensor nodes are successfully connected to the Raspberry Pi 4 via Wi-Fi and transmitting Temperature, Humidity and Vibration values to Raspberry Pi through MQTT protocol with a duty cycle of 33.33%. After receiving raw data from the nodes, the Cluster Head aggregates the data and sends it to the Base Station over Wi-Fi. Thus, the power is conserved due to sleep-awake of the nodes and data is reduced as only the aggregated data is being transmitted. The proposed method is energy efficient mode of Wireless Sensor Network compared to the existing model. In this method energy is conserved in two stages, in first stage setting duty cycle to nodes rather than making it on all the time, and in second stage data transmission is done if sensor value is above threshold. By these two stages power is conserved in data transmission ,whereas in existing model use either one method for reducing power consumption.

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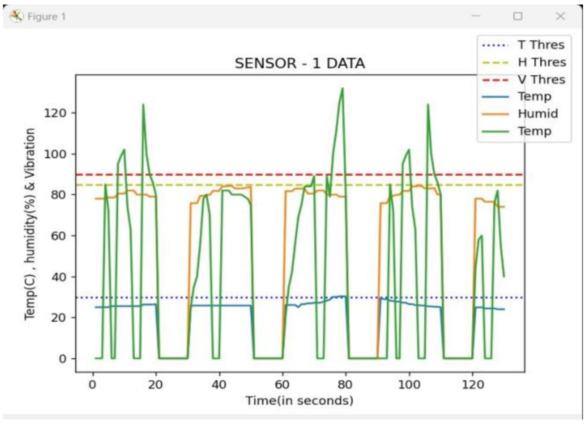

Figure 9 : Sensor Data from node 1

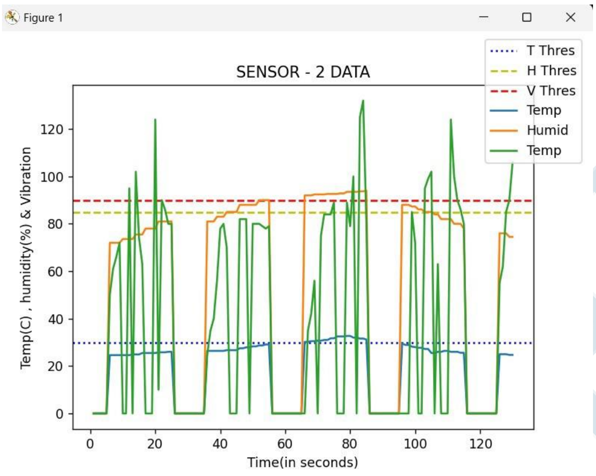

Figure 10 : Sensor Data from node 2

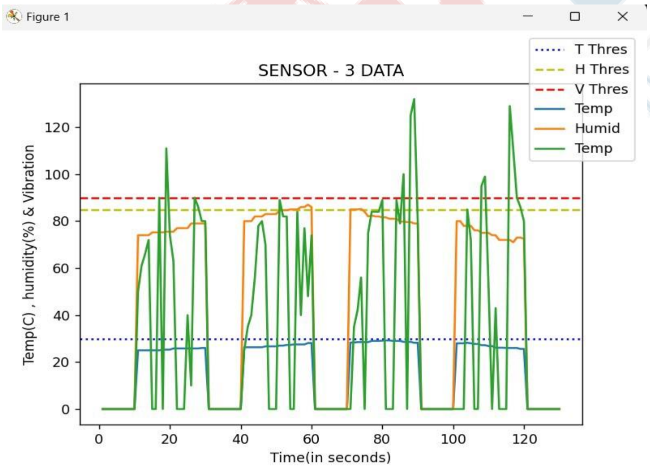

Figure 11 : Sensor Data from node 3

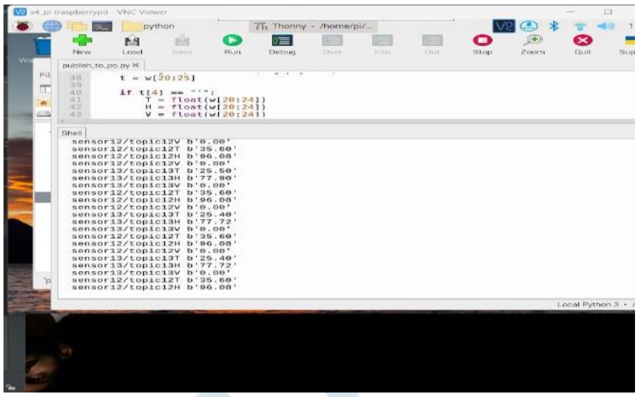

Figure 12 : Raw Data at pi (from sensor nodes)

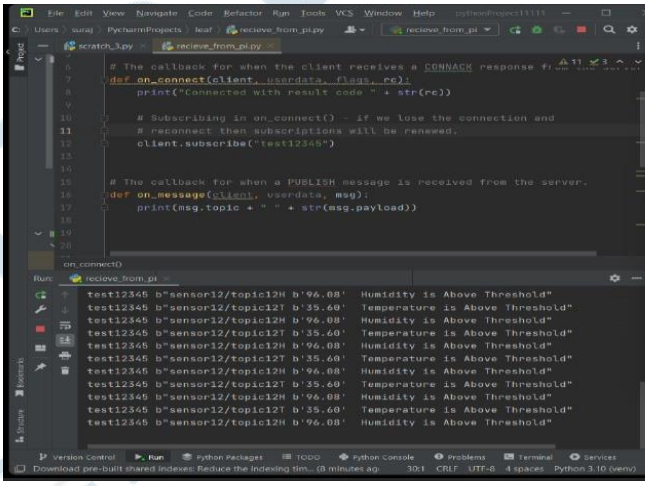

Figure 13 : Aggregated Data at Base station

Future Work

This has a potential for future work it includes using more efficient sensor nodes, and making the sensor smarter i.e. performing data aggregation at nodes rather than in cluster head.

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