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Remote Climate Control in Real Time Using Arduino Microcontroller and Xbee Zigbee

Kadhim Sabah Rahimah [†], Issa Ahmed Abed [‡]

[†]Basrah Engineering Technical College, Southern Technical University, Basrah, Iraq, Email: k.s.sabah@fgs.stu.edu.iq.

[‡] Basrah Engineering Technical College, Southern Technical University, Basrah, Iraq, Email: issaahmedabed@stu.edu.iq.

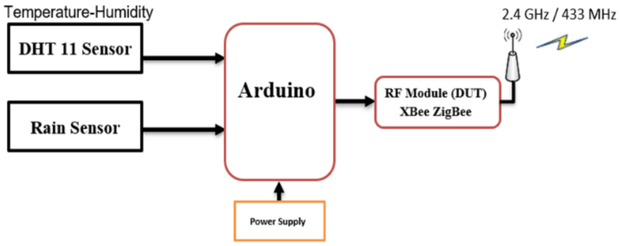
Abstract

Due to the growing demands for security and regulatory compliance, monitoring environmental indicators has become increasingly important nowadays. As a result, it is crucial to measure these factors. The conventional wired systems are unable to perform parameter measurements in remote locations. Therefore, the next generation of technology, like wireless technology, is required. Micro-Electromechanical systems (MEMS) technology has advanced, making small, inexpensive, low-power wireless modules available that function effectively in these settings. An Arduino-based DHT11 sensor-based automatic temperature management system is designed and implemented in this work. Temperature, humidity, a rain sensor to detect environmental occurrences, and Liquid Crystal Display (LCD) indicators to show how weather conditions affect the system under consideration. The results are provided by the DHT11 sensor, which measures the humidity and temperature of the surrounding space. Along with the measured value, the reference value is shown on the liquid crystal display (LCD). The Arduino microcontroller, which controls the system's processing, receives the sensor's measured value and assesses it against the established threshold. What happens is that the microprocessor activates the fan only when the measured room temperature and humidity are below the threshold value's lowest value. The fan is actuated if the detected room temperature exceeds the highest permissible threshold value. If the observed temperature of the room is within the setpoint range, all loads are finally turned off. That suggests that the air is maintained at a consistent temperature and humidity level. The usage of an Arduino microcontroller, Xbee Zigbee, DHT11 sensor, Rain sensor, and Proteus software to monitor temperature, humidity, and rain utilizing wireless sensor network (WSN) technology. As a result, nighttime humidity parameter variation is greater than daytime variation. A wireless system like this will benefit industries like agriculture, healthcare, storage, etc.

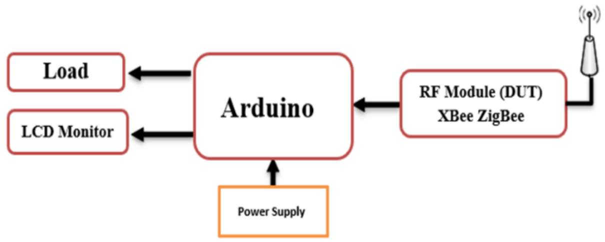
Keywords: A wireless sensor node, Energy Harvesting System, Arduino, Xbee, Environment Monitoring System (EMS)

1. Introduction

Intelligent monitoring techniques are a hot topic in our lives right now [**1].** Automation has permeated human life as a result of the technology's slow but steady growth. Modern technology has contributed a number of improvements that carry out specific tasks automatically in this regard. Among these inventions, the microcontroller is crucial to the electronic world's intelligent systems. A microcontroller is a single-chip control device that enables the automation of the intended system and control process and produces precise results **[2,3].** A monitoring system is, in general, an automated system that continuously and concurrently measures one or more physical parameters, such as temperature, relative humidity, wind speed, light intensity, soil moisture, etc. at one or more specified places. To meet security and legal standards, it is necessary to constantly monitor any sensitive area. A wide range of applications for quality assurance requires the monitoring of temperature, rainfall, and humidity. Monitoring deterioration would provide early notice of imminent problems, enabling the design and timing of maintenance programs and lowering necessary costs. Additionally, the integration of monitoring system data and enhanced service-life prediction models results in additional life cycle cost savings **[4, 5].** In manufacturing facilities, especially those that produce electronic assemblies, it's crucial to keep an eye out for rain, humidity, and temperature. Lack of control over any of these will ultimately result in a decrease in productivity because it will not only influence the process and the comfort of the operators but also the component and equipment **[6].** The survival of bacteria, fungi, and viruses in the air is influenced by temperature and relative humidity. Because infectious diseases can spread by aerosols or airborne infections, environmental control in hospitals is crucial **[7].** Rain, relative humidity, and temperature all have a big impact on the life cycle of plants. When humidity levels are just right, plants flourish because they can breathe deeply without worrying about losing too much water because their pores are fully opened. **[8]** The subject of monitoring and remote sensing has been completely transformed by wireless sensor networks (WSN). Wireless sensor networks, also referred to as wireless sensor & actuator networks (WSAN), are networks of spatially dispersed sensors that cooperate to transmit data to the central location while monitoring physical or environmental conditions like temperature, humidity, fire, etc. **[9].** The sensor node, which manages the information or sensor data, is an important component of this system **[10].** This paper's goal is to create a system that satisfies all the criteria listed above. In this work, the relative humidity and temperature of the environment are measured using a rain sensor and a digital humidity temperature composite (DHT11) sensor, respectively. The parameters are complicatedly calculated using an Arduino microcontroller, The Arduino was chosen by the authors because it is more user-friendly and provides its hardware platform with software coding known as "Sketch." Sketch is a proprietary, free-to-download integrated development environment (IDE) platform from the Arduino franchise. The Arduino IDE has accessible software that can be found in the library, making it an incredibly affordable solution for a variety of applications. The open-source IDE's flexibility, which makes it possible to create sophisticated engineering and electrical systems, along with contributors' online uploads of easily accessible examples and tutorial sketches, has helped the platform gain significant popularity over the years. These qualities make the Arduino open-source IDE appealing to hobbyists, researchers, and system developers looking to use it as a microcontroller-based data-gathering system **[11].** and the data is then wirelessly transmitted to the receiver using an Xbee module. The serial data that is delivered by the transmitter using proteus software is captured at the receiver part using the Xbee module. Fig. 1(a) and 1(b), respectively, display the block diagrams for the transmitter and receiver. Nanoparticles in heat transfer fluids enhance their thermal conductivity**.**



(a)



(b)

Fig.1 Control system: (a) Transmitter Part, (b) Receiver part

2. Description of the system's hardware

2.1 XBee Module

Based on the IEEE 802.15.4 wireless standard, ZIGBEE is a set of technical standards for networking, security, and application software. It is a wireless communications system that is two-way, short-range, low power, low complexity, low cost, and low data transfer rate **[12].** Depending on power output and climatic factors, ZigBee devices can communicate data over distances of up to 10–100 meters by sending data through a mesh network design. 250 Kbit/s is the Zigbee transmission data rate **[13–16**]. It is clear that the XBEE coordinator serves as the data transceiver, or the device responsible for delivering data, and the XBEE router serves as the data signal's receiver. Data sharing between the XBEE coordinator and the router is the goal of this setup, which also attempts to facilitate data transmission **[17].** With the help of this technology, users may swiftly build up networks and set them up in locations where it would be difficult or unpleasant to run cables. Figure 2 depicts the Xbee module's pinout. The network, security, and application layers are referred to as the physical layer and the media access control (MAC) levels of the ZIGBEE Alliance, and these layers continue to use the 802.15.4 standard. ZIGBEE has many applications in a range of industries, including telecommunications, home automation, building automation, industrial and agricultural monitoring, sensor applications, and other control sectors, as a result of its advantages. ZIGBEE has enormous network capacity, great network flexibility, low power consumption, and low latency, as previously mentioned **[18].** The following attributes of home networking communications are also present: a small amount of data transfer without excessive speed; a high network capacity; a variety of devices; good information in real-time; a short delay; and an affordable cost. The technical aspects of ZIGBEE then make it evident that it can be well-positioned to meet the aforementioned needs of the home network **[19].**

The MAX-STREAM XBEE PRO module serves as the wireless communication interface to the home network, enabling data transmission between a microprocessor and home sensors, security systems, and other home appliances. The XBEE- PRO ZIGBEE radio frequency module was created to operate inside the ZIGBEE protocol and meet the unique needs of low-cost, wireless sensor network systems. Data delivery is reliable and the module requires little power. In Figure 3, you can see the ZigBee stack protocol.

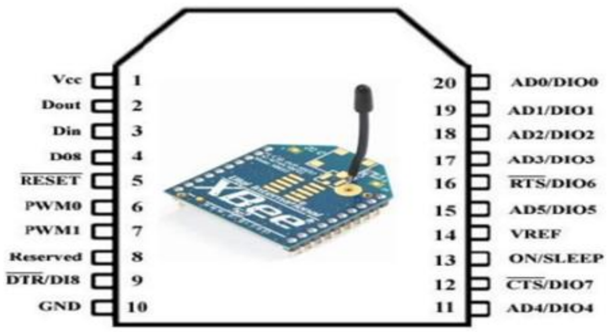


Fig.2 XBee Transceiver Pin Diagram

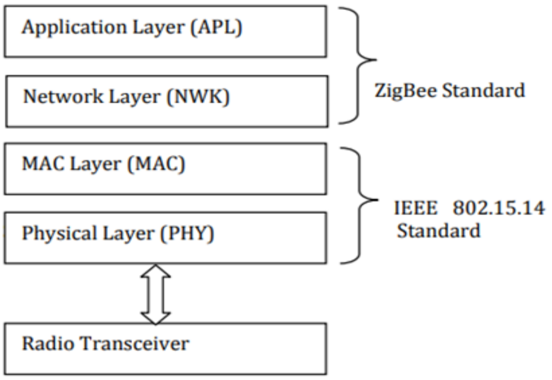


Fig.3 a stack protocol for ZigBee

2.2 Temperature and Humidity Sensor

Humidity is one of the factors that have the biggest impact on battery quality. Due to the nation's rising energy costs and consumption, it is challenging to employ matching equipment generally. Investigating both cheaper and pricier options is essential as result. The two most common types of moisture-sensitive components are resistance and capacitance [20], both of which are protected by a humidity layer constructed of a moisture-sensitive substance. Materials that are sensitive to humidity change substantially in terms of impedance and dielectric properties when they take in vapor from the environment. A low-cost digital sensor called DHT11 can measure humidity and temperature. To instantly share humidity and temperature, this sensor may be easily interfaced with any microcontroller, including Arduino, Raspberry Pi, etc. [21] The DHT11 sensor is used to calculate humidity and temperature. DHT11 is a capacitive digital sensor with high-precision calibration. shows how it is small and energy-efficient [22].

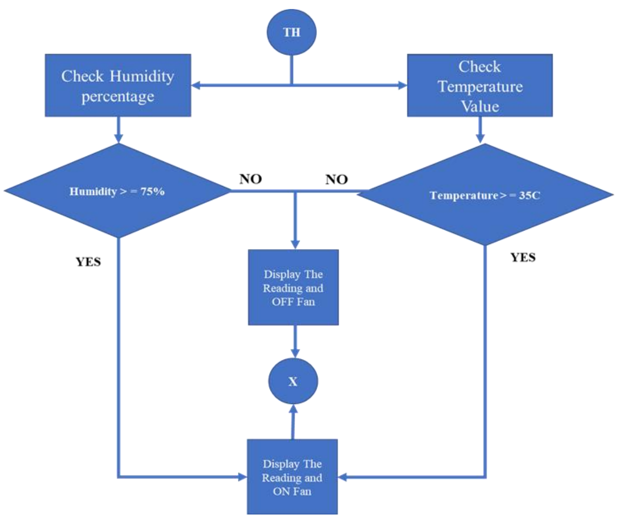


Fig.4 Temperature and Humidity Flow Chart

TH which stands for Temperature and Humidity, X is stated and used to represent XBEE ZIGBEE. platform as Each of the connection nodes specified above will be directed to sub flaws as shown in Figure 7. The signal is sent to be further checked by ZIGBEE and/or Arduino if it is humidity and greater than or equal to 75%. In addition, if the temperature exceeds 35 C FAN on the Battery will be triggered and the LCD will be updated with the reading and sent to XBee Zigbee on another side as shown in Figure.4.

2.3 Blue 8051

The sensor function determines if rain is falling or not and then reports its findings. The use of a rain sensor module creates a switch that is activated by rain. It is constructed of strips of conductive wire that are so far apart from one another that electricity cannot pass between them due to the tremendous resistance between them. The strips are connected by the raindrops that fall on them, completing the circuit. The sensor now generates a high output once the circuit is finished [23]. Conduction-based raindrop detection is discussed in [24]. It makes use of two parallel conductive rods installed in a casing and separated apart. This type of rain-detecting technology has the drawback that, in light rain, there could not be enough precipitation to create a conductive route between the electrodes. As part of the design, the system must be able to detect the presence of rain and transform it into an electrical signal. A rain sensor was used. If it rains, an LED turns on to alert the user, while the LCD displays "it's rain. “The information is sent from the roof of the building to the control center inside the room wirelessly through the XBEE ZIGBEE, and the LED of the rain sensor is turned on or off inside the control room, with the sensor’s status displayed on an LCD screen as illustrated in Figure 5, X is stated and used to represent XBEE ZIGBEE.

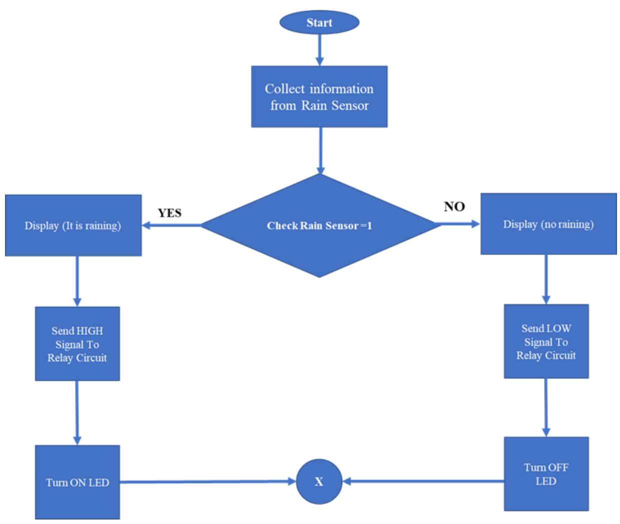


Fig.5 Rain sensor Flow Chart

3. System Implementation

In Figure 6, The data was transmitted wirelessly using XBee ZigBee to two different places from the roof of the building to the Control Centre. The Rain sensor has also been introduced as a detection device. The rain sensor is installed on the building's opposite end roof. It is programmed to look for rain. This sensor is connected to the model's lighting system so that, in the event of rain, the general lighting in the house would be adjusted in order to save energy in the lighting system. Finally, the DHT11 humidity and temperature sensor are configured to detect the corresponding variables and display them on the LCD screen. Additionally, a fan indicating a dehumidifier and temperature would switch on from the batteries when the humidity level reached 75 or the temperature reached 35. Each of the associated push buttons allows the lights and other appliances, like the fan, to be manually turned on or off. To enable communication between the two Arduino boards, two Xbee (S2C variants) are used to establish a wireless Zigbee connection. The Proteus 8 Professional computer that the module is modeled after has an Intel(R) Core (TM) i5-10500H CPU and 8GB of RAM.

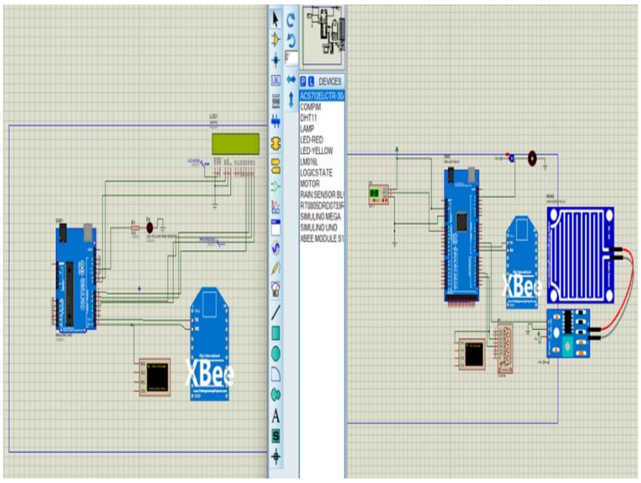


Fig.6 Communication with Xbee

3.1 Transmitter Part

Arduino, DHT11, a rain sensor, and an Xbee module are all components of the transmitter. DHT11 sensor, Rain Sensor, and XBee module are powered by the Arduino microcontroller. The Arduino MEGA's digital pin 13 is linked to the DHT11sensor's pin A1 output. The Arduino UNO's digital pin 11 is linked to the output of the Rain sensor's pin 2. Both the Tx pin and the Rx pin of the Xbee breakout board are connected to the Tx pin of the Arduino, which is connected to the Rx pin of the Arduino. Figure 7 depicts it.

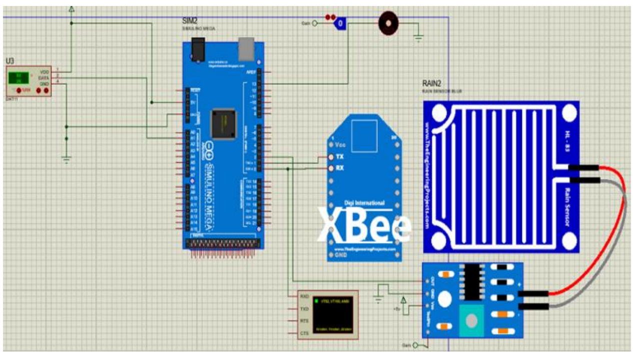


Fig.7 Circuit Diagram of Transmitter

3.2 Receiver Part

An Xbee S2 module serving as a coordinator, an Arduino UNO, and an LCD screen make up the reception component. The Xbee S2 module will wirelessly receive serial data from the transmitter. Figure 8 depicts the implementation.

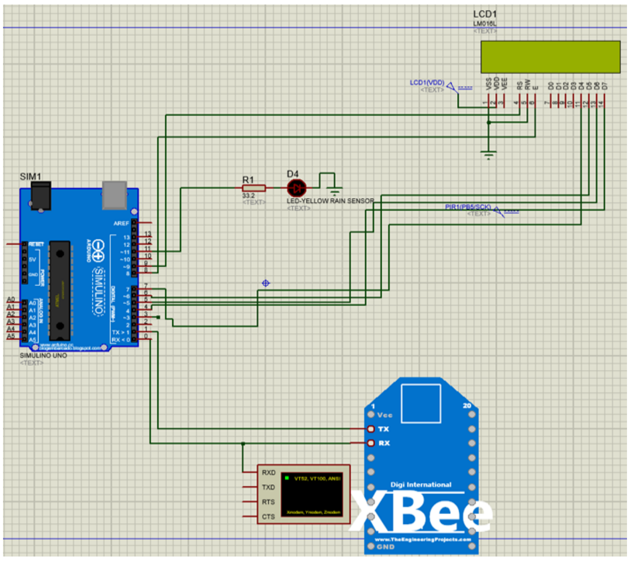


Fig.8 Implementation of Receiving

4. Results and Discussion

Figure 9 displays the Proteus software's Virtual Terminal output that was sent by the transmitter part.

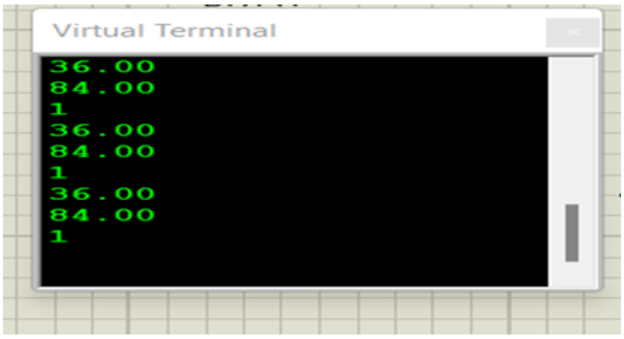


Fig.9 Output in Virtual terminal

As can be seen in Figure 10, Receiving data from the transmitter, implementing it, and displaying it on the LCD screen, the LED turns on and off, indicating whether it is raining

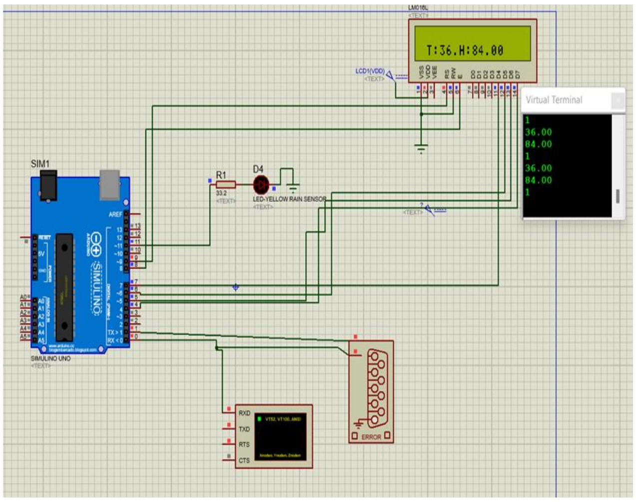


Fig.10 Output in DHT11 and Rain sensor

Figure 11. It appears that the LED is turned on, indicating that it is raining. The data was received from the other Arduino and was transmitted wirelessly using XBee Zigbee

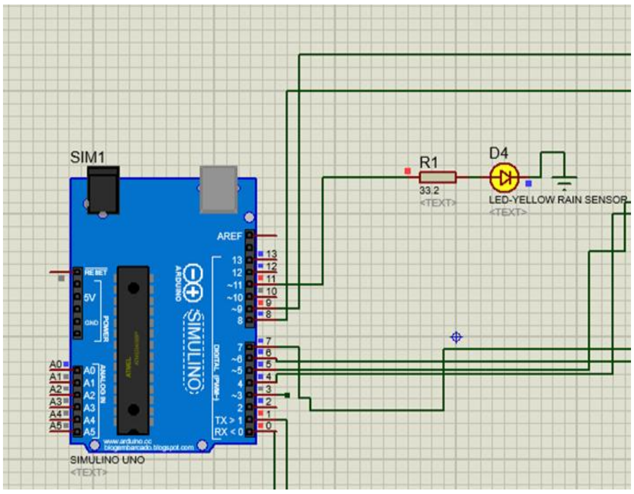


Fig.11 Output in Rain sensor

Figure 12. The actual humidity and temperature ratio of the humidity and temperature sensor was exceeded. the fan was turned on to withdraw moisture and reduce the temperature, and the data was sent to the other Arduino in the control room to know the actual results and the effect of the atmosphere on the devices

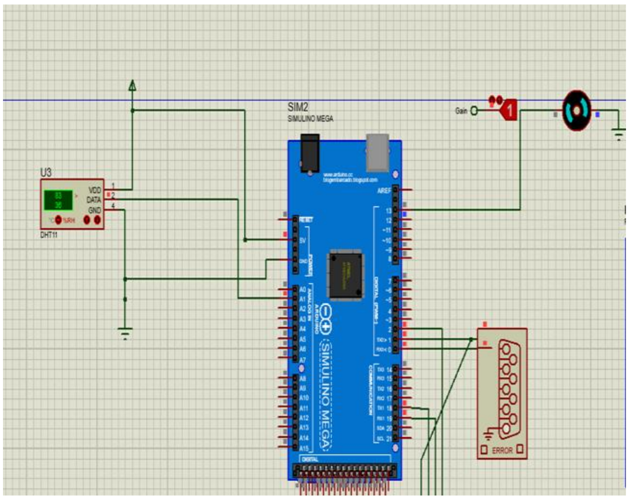


Fig.12 Output in Transmitter

Conclusions

Through a wireless sensor node, the Xbee module is utilized to collect and transfer data. Real-time data was collected, stored, and displayed using Xbee to track the temperature, humidity, and rainfall. The findings of the temperature and humidity monitoring indicated that throughout the summer nights, the two parameters changed over time. In light of this, we can say that nighttime humidity variations are greater than daytime variations. With the fewest components and the least amount of complexity, a streamlined temperature, humidity, and rain monitoring system has been created. When compared to the costs of the devices used to measure the parameters, the system is affordable and compact. The proposed system was evaluated and found to be stable, extremely dependable for transmitting data, and user-friendly. It may be applied broadly in a variety of contexts for automatic environmental parameter monitoring. This system's primary benefit is that it requires only a single investment and is less expensive. Effective applications include healthcare, agriculture, storage facilities, etc. In order to further extend the battery's lifespan, future studies will examine how to develop a low-power sensor and how to reduce the power consumption in the circuits used for energy harvesting. can utilize ESP32 or a Raspberry Pi to perform IoT analytics, evaluate the data, and forecast future events.

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