DEVELOPMENT OF SMART REAL TIME EMBEDDED SYSTEM FOR WEATHER MONITORING

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Abstract: Now days, IoT is novel paradigm which is adding value to products and applications. IoT systems are combining telecommunications and any kind of devices that facilitates communication between them and the cloud as well as between the devices themselves. The IoT devices produce widely connectivity in network which helpful for connectivity to access data over the network in real time domain; reduce the power consumption and robustness. In this paper, a new approach to practical and meaningful utilization of advanced technology within a smart weather monitoring system in real time domain is presented. Environmental weather monitoring station gives high efficiency with precise instruments as well as equipment for measuring atmospheric data about the weather forecast conditions. Weather checking of the environment is essential for various applications in daily life because changes uncertainly every day to day for atmospheric changes. Weather also plays a vital role in human psychological and physical health as well as for automobile, agriculture chemical and various fields. Considering these facts into account, we present the system which provides advanced solution for Automatic Weather Monitoring (AWM) conditions at our college campus and making the information visible anywhere in the world in real time. A new weather monitoring system is developed using various sensors connected to ESP8266 based Wi-Fi module NodeMCU(12E). The sensors like humidity, CO_2, Light intensity and temperature are linked to the NodeMCU. The values are displayed on a OLED Display and sends the information to the web page and then plots the sensor data as graphical statistics. The received data from implemented system can be accessible in the internet from anywhere in the world because of IoT.
Keywords: Internet of Things (IoT), Power Optimization, ESP8266, Weather Station, real time system, NodeMCU

INTRODUCTION:

In recent years, due to advancement in electronics technology, the demand for efficient and accurate weather monitoring systems are increased due to the increasing need for real-time weather data in various sectors such as agriculture, medical, industry, transportation and disaster management etc.[1]. In traditional methods environmental weather monitoring system involves manual data collection which can be time-consuming, labor-intensive and prone to errors. To address these challenges, smart embedded systems have emerged as a solution, revolutionizing the way weather data is collected, analyzed and utilized[2,3]. A smart embedded system means to a compact, integrated electronic system comprised of sensors, signal conditioner, microcontrollers, communication modules, display devices and software algorithms designed to perform specific tasks autonomously or semi-autonomously. When applied to environmental weather monitoring, these systems offer several advantages over traditional methods: such as smart embedded systems continuously collect weather data in real-time which provides information on temperature, humidity, concentration of environmental gases, light intensity, wind speed, rainfall and other meteorological parameters[4,5]. This real-time data is valuable for making decisions in various applications. Advanced sensors and calibration techniques are used for smart embedded systems to ensure accuracy and reliability in weather data collection. Once deployed a smart real time embedded systems operate autonomously, requiring minimal human intervention. This autonomy reduces the need for manual labor and enables remote monitoring of weather conditions in inaccessible or hazardous locations. Many smart embedded systems are designed to be energy-efficient, utilizing low-power components and sleep modes to conserve energy[6,7]. Such system is also beneficial for precision agriculture were crops are cultivated in controlled environment [7]. The systems also reliable for paper industry, food processing and preserving, chemical, textile, automobile sector were the environmental parameters plays vital role. This feature is particularly important for remote installations powered by solar panels or batteries.

Data Integration and Analysis: Smart embedded systems often include data logging and analysis capabilities, processing, allowing for the storage and visualization of weather data over continuous time. These insights enable better understanding of weather patterns and trends, aiding in decision-making and resource planning. With built-in communication modules such as Wi-Fi[8], satellite connectivity, cellular or smart embedded systems can transmit weather data to central servers or cloud platforms for remote access and analysis. This accessibility ensures that stakeholders can monitor weather conditions from anywhere at any time[9].

On extensive investigation of literature, it is reported the importance of IoT for various other applications such as natural disaster relief, military target tacking, biomedical, transport system and industry monitoring etc. Therefore, it is decide to design portable, low power consumable system based on Node MCU microcontroller embedded system designed for measurement of Weather. The deployment of smart embedded systems[10] for automatic weather monitoring holds immense potential to monitor weather, agriculture industries by providing timely, accurate and actionable weather information. As technology continues to advance, these systems will play an vital role in mitigating the impact of weather-related risks and optimizing resource management in a changing climate.

BLOCK DIAGRAM:

The hardware part of the system is represented in terms block diagram and depicted in figure 1. Figure 1 provides a basic overview of the key components involved in a smart embedded system for automatic weather monitoring. Depending on specific requirements and applications, the actual implementation may include additional components or functionalities. The design issues discussed in terms of hardware design.

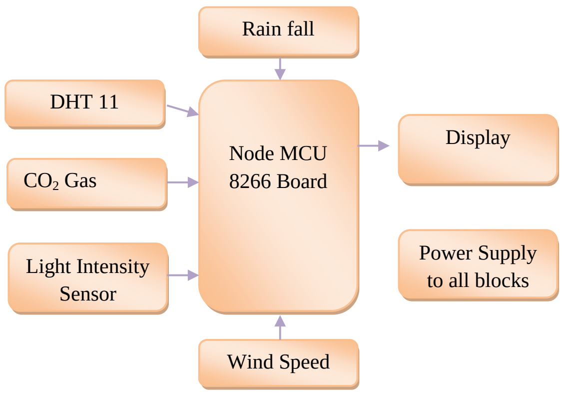

Figure 1: Block diagram smart embedded system for automatic weather monitoring

HARDWARE DESIGN:

Designing issues of hardware for smart real time embedded system for automatic weather monitoring is shown in Figure 2. It consists of NodeMCU DHT11 and display unit. In environmental weather monitoring system consist of various parameters. However, in present trial and testing DHT11 for humidity and temperature monitoring in real time in IoT domain is depicted in figure 2. The details regarding these used components are highlighted through following sub sections.

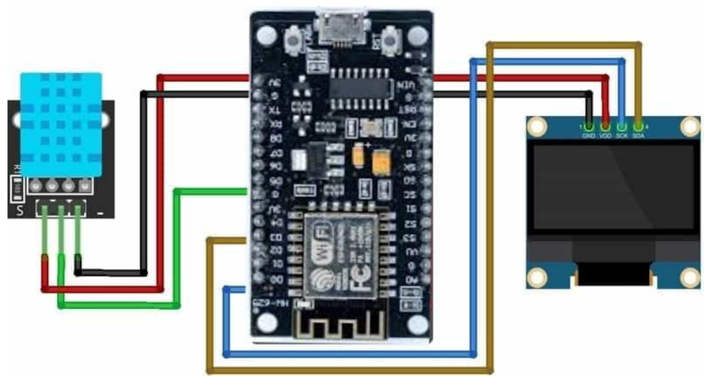

Figure 2 : Circuit diagram smart embedded system for automatic weather monitoring

NodeMCU (EP8266 MOD)

A Node MCU device is a modern advanced microcontroller piece that had been created by Arduino Enterprises. This Node MCU piece works as Arduino with requirements irrespective of AVR microcontroller family[11, 12] that excite Arduino IDE C++ compilers to compile the whole packet. Node MCU consist of on chip ADC with ESP features to reduce the specific sectors that are required to be linked to various roles to be perform. The Node MCU has only one ADC channel, therefore, it create a problem to interface analog sensors more than one. Hence in present work only one analog sensor is deployed. Further the problem is solve by deploying multiplexer for input side and sequentially send by many inputs to single ADC channel. In Node MCU microcontroller programming term ' Core ' has been given to the software group which is needed to debug the Arduino C++ header files using MCU language. The innovation of the ESP8266 wi-fi module contributes to the creation of robust and complete systems design as opposed to the design methodology that developed the Arduino core under the hegemony of the ESP8266 Wi-Fi based on GitHub ESP8266 core website. This module is a basic platform provide for machine learning, incorporating between ESP8266 and NodeMCU microcontroller. The unit shown in figure 3 operates under the control of networks 802.11n and 802.11b. That means it can be used as an access point of AP and Wi-Fi system or both together simultaneously in one platform [13].

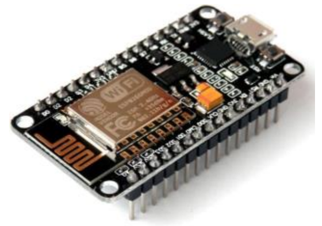

Figure 3: Node MCU

Humidity & Temperature Sensor (DHT11):

DHT11 is a low-cost digital sensor for sensing temperature and humidity easily available sensor shown in figure 4[14,15]. This sensor can be easily interfaced with any micro-controller such as Arduino, Raspberry Pi etc. to measure humidity and temperature instantaneously. DHT11 is available in humidity and temperature sensor as well as a sensor module form. The difference provides between this sensor and module is the pull-up resistor and a power-on LED is present on bord. DHT11 is a relative humidity sensor. To measure the surrounding air this sensor uses a thermistor and a capacitive humidity sensor.

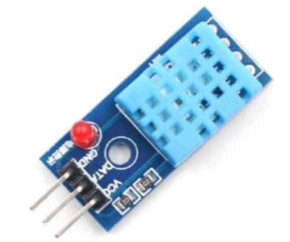

Figure 4: DHT 11 Sensor

The DHT11 sensor module consists of a capacitive type humidity sensing element and a thermistor use for sensing temperature. The humidity sensing capacitor has two electrodes with a moisture holding substrate as a dielectric between them. Change in the capacitance value occurs with the change in humidity levels. The IC measure, process this changed resistance values and convert them into digital form.

In DHT11 sensor measuring temperature uses a Negative Temperature coefficient thermistor, which causes a decrease in its resistance value with increase in temperature. This sensor is usually made up of semiconductor ceramics or polymers to get larger resistance value for the smallest change in temperature, DHT11 sensor has four pins- VCC, GND, Data Pin and a not connected pin[16]. A pull-up resistor of 5k-10k ohms is connected for communication between sensor module and micro-controller.

Features of DHT11

- Ultra low cost
- 3 to 5V power and I/O
- 2.5mA maximum current use during conversion
- Good for 0-50°C temperature readings ±2°C accuracy
- No more than 1 Hz sampling rate is apply for every second.
- 4 pins with 0.1″ spacing
- Good for 20-80% humidity readings with 5% accuracy
- Body size 15.5mm x 12mm x 5.5mm

FIRMWARE:

The required firmware to rely smart embedded system is developed in arduino IDE, as it plays an equally important role. Once developed, this firmware is embedded into the target device using same IDE[17] The Arduino IDE is open source and provides various library resources for interfacing. So it is easy to work out for development of such new things.

RESULTS:

The deployment of smart embedded systems for automatic weather monitoring has yielded significant results across several realms. Real-time monitoring capabilities have enabled timely access to accurate weather data, empowering stakeholders to make informed decisions in industries, transportation, agriculture, renewable energy, disaster management and research. The integration of advanced sensors and microcontrollers has ensured high accuracy and reliability in data collection, leading to improved resource management and risk mitigation strategies. Autonomous operation and remote accessibility features have facilitated continuous monitoring of weather conditions in remote or inaccessible locations, enhancing safety and efficiency in various industries. Furthermore, the data integration and analysis capabilities of smart embedded systems have provided valuable insights into weather patterns and trends, enabling better forecasting and planning for future events. Figure 6 illustrate the developed embedded system for weather monitoring system using Node MCU. The system is implemented in room for monitoring room temperature and humidity and the received data from sensor broadcast to cloud and observe on internet which depicts in figure 6. Further the smart GUI is developing for end user to represent the all environmental data in graphical and numerous forms.

Figure 5: Designed Node MCU Board

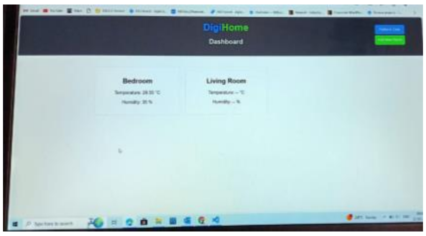

Figure 6: Representation of humidity and temperature online through IoT

CONCLUSION:

Finally in conclusion, smart embedded systems represent a paradigm shift in weather monitoring technology for humidity and temperature, offering unparalleled advantages over traditional methods. By leveraging advanced sensors, microcontrollers, communication modules and software algorithms, these systems have transformed the way weather data is collected, analyzed and utilized. The benefits of real-time monitoring, accuracy, autonomy, and remote accessibility have revolutionized industries dependent on weather information, leading to improved efficiency, productivity and safety. However, challenges such as data security, sensor calibration, cost and integration with existing infrastructure remain to be addressed. Nevertheless, the future of smart embedded systems for automatic weather monitoring looks promising, with ongoing research and innovation focused on enhancing performance, reliability and scalability. As technology continues to advance, these systems will play an increasingly vital role in mitigating the impact of weather-related risks and optimizing resource management in a changing climate. Further system is upgrade for rest environmental parameter monitoring with smart GUI for end user.

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