A Design of Sensing Data Collection Circuits for Wireless Sensor Networks Utilizing WiFi Technology †

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Abstract—Wireless sensor networks (WSNs) facilitate many applications in different fields. And, WiFi technologies have been developed and used widely based on some advantages. Data collection methods in WSNs for monitoring purposes are being exploited to be more effective. In this paper, we design circuits integrating WiFi technology to collect sensing data from WSNs to be sent to online stations. Managing data online is very convenient to be able to monitor and control devices attached with sensor nodes in the networks from everywhere we have the internet available. We also want to control back to the systems to support some applications, such as greenhouse monitoring or remote agriculture. We design circuits and install completely a data collection board to collect and to send data to a server online. We also provide real results collected from the system via server. These could be promising points for collecting data via the Internet of Things (IoTs).

Keywords—Internet of Things (IoT); Wireless sensor networks; Sensing data; WiFi technology; Webserver; Remote control.

I. INTRODUCTION

WIRELESS sensor networks (WSNs), sometimes called wireless sensor and actuator networks (WSANs), are spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to other locations. WSNs support many applications in different fields as follows.

Environmental monitoring: WSNs find multiple applications in environment monitoring including animals tracking, observing soil irrigation, and detecting natural disasters [1, 2]. Health monitoring: small sensors placed across patients' body in a hospital simplify monitoring of their condition and can detect life threatening situations immediately [3]. Military: sensor networks can be used to monitor friendly forces, battlefield surveillance measure loss of resources and people as well as biological and chemical changes to the terrain [4]. Industrial: machine faults can be detected and located quickly assuring uninterrupted work [5]. Smart houses: WSNs can monitor and control over air conditioning, lights, and humidity absorbers to ensure ideal conditions for inhabitants [6]. Smart logistics: WSNs can help track packages and employees, optimize routes of delivery vehicles, and monitor state of packages ensuring fast delivery of intact parcels [7].

WiFi technologies have been exploited widely in many applications [8, 9]. Recently, the Internet of Things (IoT) support all applications online [10, 11]. We are encouraged to design a combination between WSNs and IoTs to collect sensing data. The data could be managed online and then processed to control remotely the sensor systems.

In this paper, we set up a WSN to collect different types of sensing data to be send to a webserver utilizing WiFi technologies. We model and analyze the system, then final install the system. All practical results are shown to verify the system.

The rest of paper is organized as follows: Section II is devoted to the problem formulation. Data collection is described in the Section III. Section IV presents us the results, and finally, the paper is concluded in the last Section.

II. PROBLEM FORMULATION

A. *System Model*

In this model, different kinds of sensors are installed to collect data to be sent to the Arduino circuits for data processing. The data will be transmitted to webserver via the WiFi module. Different types of data will be stored and displayed separately in the webserver for monitoring and controlling purposes.

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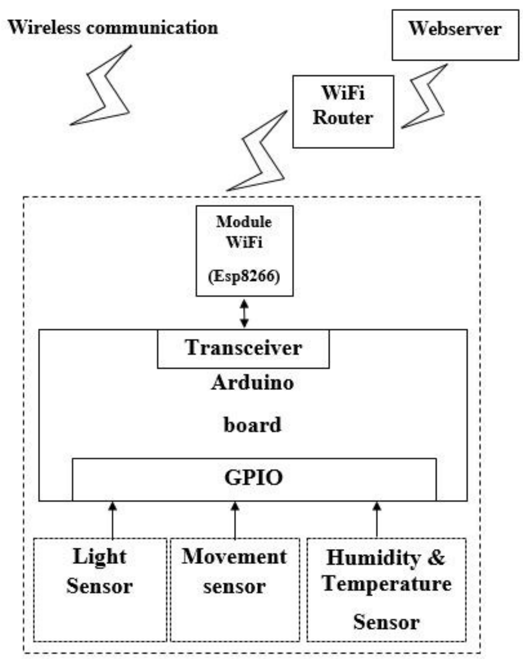

Figure 1. The system is model to be set up

B. *Device Analysis*

Microprocessor Board: The microprocessor board we have chosen for our project is Arduino UNO. Reasons for this decision are as follow. The most important feature is support for UART communication, Analog to Digital converters and GPIO pins. ATmega328p chip is easy and cheap to replace in case of failure as contrary to most other microcontrollers. Its performance to price ratio is also satisfactory.

Figure 2. Arduino Board

Wi-Fi Module: ESP-01 is chosen for communication. It contains an ESP8266 chip as well as PCB antenna and 8 GPIO pins making it ready to use in the project without a need for any additional parts. It has reasonable cost and strong capacity that make it very popular in recent years. In addition, it is very small in size.

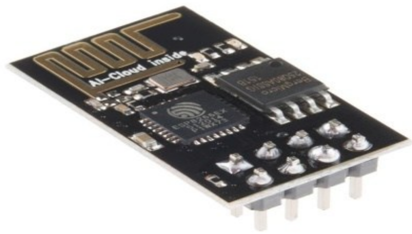

Figure 3. ESP-01 WiFi module with ESP8266

Power: Powering the hardware proved to be a bit trickier than expected. This is because Wi-Fi module draws a lot of current during transmission of data. Using conventional USB port or Arduino pins turned out to be not sufficient for our module - it was resetting because of momentary lack of energy.

Figure 4. LM2596 DC/DC step-down voltage converter

The solution we design to deal with this problem is using 12V AC/DC adapter and a LM2596 DC/DC step-down voltage converter. The output from voltage converter is regulated by resistance potentiometer - we set it to 3.3V in accordance with ESP8266 datasheet.

Arduino is powered using USB type A - USB type B cable from computer's USB-port. All sensors use Arduino's 5V and Ground pins for power.

III. DATA COLLECTION

A. *Sensors*

All our sensors are different thus we use different methods to read as described in detail as follows.

Light sensor: we used very simple and cheap light sensor main part of which is a photo-resistor - it changes resistance according to the amount of light shining at it. Output of the sensor is digital - the only information provided is whether amount of light is below (0) or over (1) a certain level. This level can be adjusted using onboard potentiometer. Output pin of this sensor is connected to GPIO pin of Arduino and information about presence of light is read just before transmission of data.

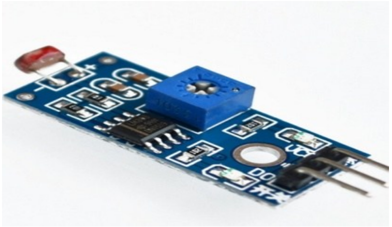

Figure 5. Light sensor

Movement sensor: this low-cost HC-SR501 module has a regulated sensitivity distance and uses digital output to send information about movement detection. When a motion is observed it changes the state of output pin to logical "1" for time chosen by second potentiometer. Output then returns to "0" and sensor is insensitive for any movement for a few seconds.

Figure 6. HC-SR501 movement sensor

Temperature and humidity sensor: DHT22 is used to observe temperatures and humidity. It can measure temperature in range of -40 to 80 degree Celsius with precision of 0.1 degree, error below 0.5 degree and humidity in range of 0 to 100% with precision of 0.1% and error below 2%. It uses just one pin to transmit this data using proprietary producer's protocol. The best way to read it is to use a DHT Arduino library provided by the manufacturer. Important thing to remember about this sensor is that it can only be polled once every 2 seconds - this time however is not a problem because temperature and humidity don't change dynamically enough for sensor to miss any major changes.

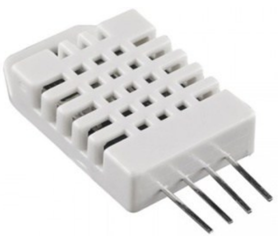

Figure 7. DHT22 sensor

B. Collecting Data from the Sensors

There are many practical applications of this set of sensors. It can act as simple alarm - all one needs to do is leave it in the room and check for movement detection or light presence. It can be used in a greenhouse to monitor temperature, humidity and light what allows to ensure correct growth of plants. Another application is monitoring of animals living conditions, tracking their movements and supervising state of environment around.

Communication between microcontroller board uses Universal Asynchronous Receiver/Transmitter (UART) hardware device incorporated in both modules. Configurable speed is set to 115200 baud/s in compliance with ESP datasheet.

C. Publishing Sensing Data con Webpage

We had developed a webpage to collect and display data from our sensors. Collecting part is written in PHP and the script outputs displaying page in HTML. The developed website allows users to access their sensing data from all over the world. All that is needed is the internet connection. Webpage is also very easy to protect with password for data privacy. Access can be easily shared with friends, family or co-workers.

In order to post data from sensors on our webpage we need to send appropriate commands in correct order to ESP. First of all, we perform a test of communication between WiFi module and Arduino board by sending test command. If everything is correct we try to connect to Access Point with user-defined network's SSID and password. After successful connection and IP acquisition it needs to establish connection with the Internet. We use Transmission Control Protocol (TCP) - main advantage of it is error checking and correction guaranteeing correct transmission of data. Data from sensors is read and put into HTTP header along with specific URL prepared for receiving it. The length of Post request must be measured because it is required by TCP transmission. Next step is executing a command to send a measured amount of bytes. In the end prepared Post request containing sensed data is put in transmitter buffer and send to the server. After successful transmission, TCP connection is automatically closed. Above actions starting from establishing TCP connection are then repeated forever to provide a continuous flow of data.

Created webpage features can be easily enriched by the use of browsers extensions. A good example is auto refreshing extension that can check the website within set time interval for specific text or regex (so in our case specific data) and display notification for user. Very important feature of our project is also ease of adding more sensors. All we need to do is connect it and add small piece of code for reading and transmitting sensed data. It is crucial because Wireless Sensor Networks are still quite undeveloped and open topic for research. Our project is ready for use in technology that is yet to come.

It is another important factor that sensor nodes are supposed to work without human supervision. Our program is prepared to automatically recover from power cuts or connection to access point breaks.

IV. PRACTICAL RESULTS

This paper only concentrates on following data of environmental factors: humidity, temperature, light and movement.

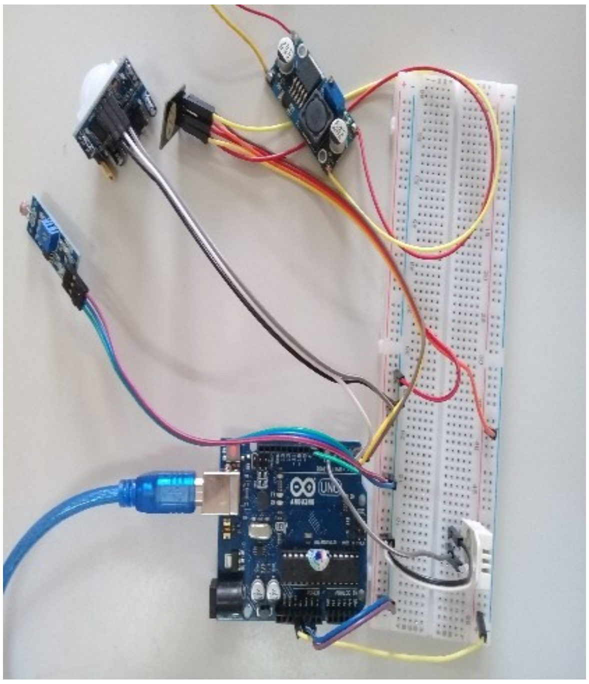

Figure 8. The real system is ready for testing

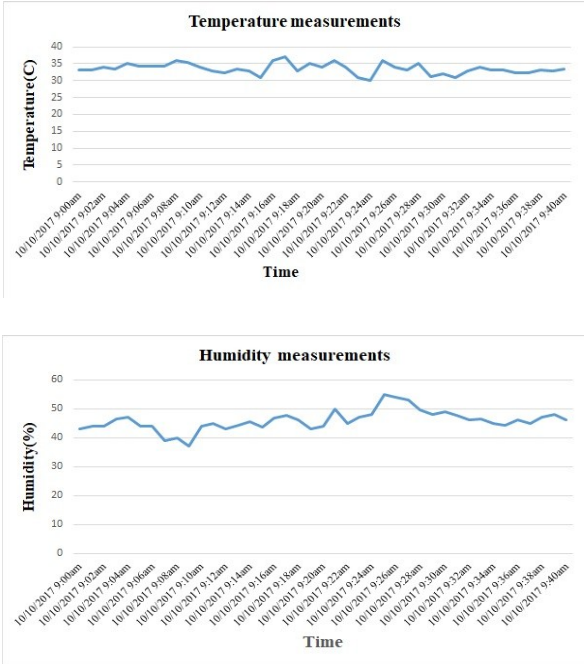

Figure 9. Real temperatures and Humidity collected showing on the webpage

The problems that needed to be solved in order to develop our project can be divided into a few different categories - choosing appropriate devices, delivering power to them, connecting and establishing communication between them as well as creating a webpage that is able to receive the data over WiFi and display it in user-friendly way. Details of steps taken in each of these categories can be found below.

To display incoming data, we created 2 different website files. One of them is responsible for receiving data and second is responsible for displaying it in user-friendly way.

Data collector part is a script written in PHP. It utilizes PHP Request function to read data received in URL. Data is then parsed and processed into HTML webpage. As an addition PHP date function is used to add timestamp to the website - it informs user when the last data was received and how up-to-date it is.

Data displayer part is a webpage HTML code generated by data collector. It is final visible result for end user. Sensed data as well as timestamp can be seen here, for easier readability variable values are displayed in bold font.

A lot of tests have been performed during whole development process following a bottom-up approach. Every piece has been tested before using it in more complex system: Arduino itself, WiFi module and communication with it (also direct communication with computer utilizing PL2303 USB-UART converter), each of sensors and power delivery devices.

V. CONCLUSIONS AND FUTURE WORK

A design of circuits for data collection in WSNs utilizing WiFi has been installed and tested successfully. We made all electrical circuits and connections between individual pieces to ensure smooth communication. Furthermore, as a main part of practical engineering work both a website and a microcontroller application were created. Eventually final tests have been conducted to ensure compliance with initial requirements. There has been many minor tests and problems in the process that have been dealt with as well. Our project takes advantage of increasingly popular technologies like WiFi and wireless transmission of sensors data that are the cutting edge of future smart devices.

In future work, controlling objects would be considered to not only monitor but also control back the system to support the environment that needs to be monitored. The project can be installed more sensor nodes to be connected as a network. Mobile sensors could also be considered for sensing data in a vast area.

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