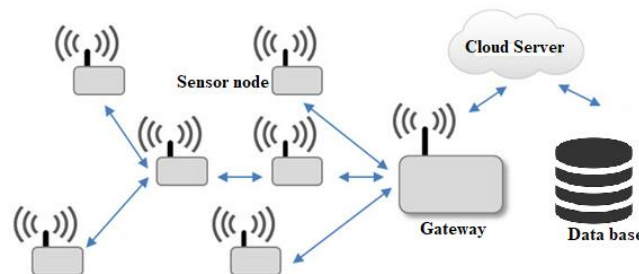# A WSN (wireless sensor network) for controlling long distance actuator control based on Environmental condition using local IP management system.

Abstract: This paper is based on a wireless sensor networking where the data taken from the sensors are sent to a local database using a local server. In this paper, the authors focus on real time environment monitoring system with respect to controlling the actuator system. Two sensors in this project viz DHT 11(Temperature and Humidity sensor) and MQ-6(LPG Gas sensor) are used. A suitable controller needs to be selected which will in effect achieve desired system characteristics, such as high-speed precision and meet high speed requirements in precision control motion. That is why, here ESP-8266 based NodeMCU is used. Moreover, feedback as well as feedforward control system have also been applied. Basing on the data derived from the sensors, actuator system can be turned on and off automatically by the controller and it is highly time efficient. This paper also makes a precise distinction between conventional systems and the system that is used in this research, an IP (internet protocol) based monitoring system where the data collected from the sensors can be monitored even without the internet access. The total system is a solar driven system. Thus, in case of a power shut-down, there will be no hindrances to the functionality of the whole system since it is solar powered.

Introduction: A wireless sensor network is group of distributed and spatially dispersed sensors that can observe environmental and physical condition of a surrounding such as light, temperature, gas concentration and so on which is collected from a central hub. This technique between the hub and network can be flooding or routing. Data, taken from each sensor which are sent through the network that is called a node. [1-3]. At present the sensor-based system is gaining substantial popularity mainly because of the low cost and easy availability. Automation system is taking the whole world by a storm, marking its presence in all entities. Implementing an environmental monitoring system which is automated, takes constant data monitoring and is used for data observation. In this paper, real-time condition, more precisely temperature and humidity are monitored through a local IP that does need any access to the internet. Thus. it can be a highly effective way of monitoring and is very time efficient. For detecting temperature and humidity of the surrounding atmosphere, a type of sensor called DTH-11 is used and it is readily available all around the globe. precise, Arduino is a very befitting hardware that is user friendly and also has an individual IDE named as the same hardware. But using an Arduino here would be costly as well as time consuming. Therefore, we will be using NodeMCU, it consists of an ESP8266 Wi-fi along with a microcontroller with 1 analog and 12 pins. Thus, it is more compatible than an Arduino and for this module the date rate is verily effective and more precise.

(a)A wireless sensor network

Methodology and Materials:

In this article, the ESP-8266 based NodeMCU was used. The various data accomplishment system of Raspberry-pi or Arduino is mother controller but using NodeMCU gives the advantage of using an Arduino together with a 2.4 GHz Wi-Fi module. As this project was a demo project and required far more inquiry in the real practice so, Jumper wires and breadboard were used instead of PCB design to test the tasks. The of materials used for this research is given below along with specifications in Table **1**.

Table **1** : List of materials and their power specification

| Components	Product name	Voltage Rating	Current Rating
Sensors	DHT-11	3.3-5 V (DC)	200 mA
	MQ-6	3.3-5 V (DC)	200-300 mA
Actuator	Pump	12 V(DC)	1 A
	Solenoid valve	12 V(DC)	1 A
Controller	NodeMCU v1.0	5-12 V(DC)	2.1 A
Relay	4 channel 5 V Relay	5 V(DC)/ 250 V(AC)	5-10 A

The methodology section is divided into two section
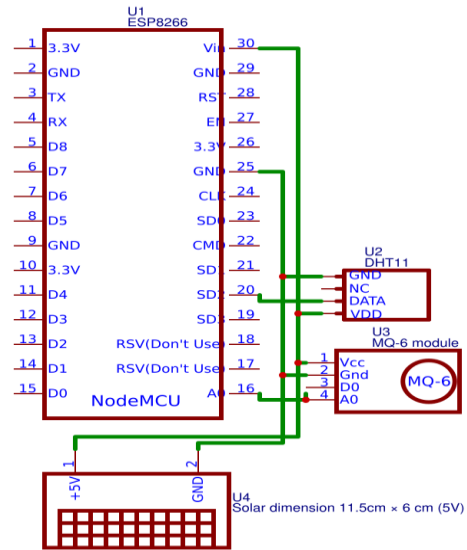
a) Hardware platform:

The hardware platform consists of sensor node and the implementation of solar panel, which is used to supply the power to the controller.

The ESP8266 humidity-temperature sensor node uses the Digital DHT-11 (Humidity and Temperature) sensor, which is connected to the ESP8266 modules GPIO (General Purpose Input Output) pin SD1. DHT11 sensor is used to collect the raw humidity and temperature data. It is a basic temperature and capacitive humidity sensor which works on 3-5 V power. MQ-6 (LPG gas) sensor is connected to the analog pin A0. The sensor node has a wireless connection with a router where the router works as a gateway in the star topology network.

ESP8266 is driven by the 3.7V battery which is plugged in the battery input port to the Solar Lipo Charger. Solar cells are plugged in the PWR in the port, while the ESP8266 Vin and GND port are plugged in to the Solar Lipo Charger port.
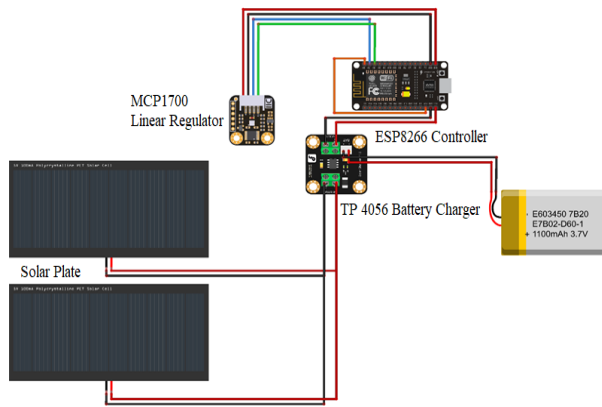
b) Software Platform:

Coding of the project was done by using Arduino IDE. The code was written in C and C++ programming language. Arduino IDE is a free platform for coding.

For storing data to the database MySQL database was used. It is a free database platform for the use of students.

Data Acquisition and Storage:
The software service running on the server performs the following three tasks
(a) acquiring the data and
(b) storing the data.
(c) actuation state control

(a)Web interface of the Server

(b)Home page of the webpage

The webpage hosting the controller is accessible from anywhere in the server, once the controller is driven and linked together. The TCP packet sensor information are stored in a structured manner in a MySQL database. This sensor information is stored in the MySQL database with a designated sensor ID, sensor channel and date and moment to allow the designed webpage to access such data.

(1) Sensor ID
(2) Sensor Channel
(3) Date and time
(4) Sample Data
The data stored in the database can be viewed in the webpage.

(a)Stored Sensor data

(b)The actuator controlling state

Numerical Analysis:

  a) Analysis For MQ-6 data into PPM

MQ-6 is an analog sensor, which provide analog data with respect to voltage. So, the voltage should convert into the ppm (parts per million value) because gas concentration is measured in ppm

As the system focuses on gas concentration-based alerting and control of appliances, thus only MQ-6 gas sensor calibration is considered for the mathematical analysis. DHT-11 sensor is to for checking the conditional Temperature and Relative Humidity.

Let, V_C = Supply Voltage = +5V

R_S = Sensor Resistance

R_L = Load Resistance (Variable)

V_{out} = Sensor output Voltage

From, Current flow and Voltage relationship,

$$V = I \times R \tag{1.1}$$

$$V_{out} = \frac{\text{Analog value} \times 5}{1023}$$

Resistance of the sensor () is defined in datasheet [19] of MQ-6 as:

$$R_S = \left(\frac{V_{cc}}{V_{out}} - 1\right) \times R_L$$

$$= \left(\frac{1023}{\text{Analog value}} - 1\right) \times R_L$$
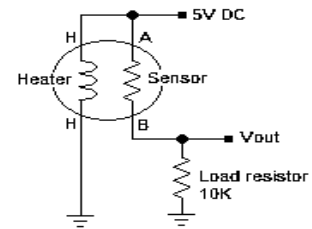
Fresh air resistance ration for gas sensors: [22]
Data analyzing from R_S/R_0 vs ppm graph: From the equations of a straight line,

$$y = mx + b$$

Here, y = value on Y-axis; x = value on X-axis; m = Slope of line; b = Intercept from Y-axis

For log-log plot equation-(5) becomes:

$$\log(y) = m \times \log(x) + b$$

Note: the log is base 10.

Slope (m) Value formula: If (x_0, y_0) and (x, y) are any two points of a line from a log-log plot then the formula for determining m is below:

$$m = \frac{\log_{10}(\frac{y}{y_0})}{\log_{10}(\frac{x}{x_0})} \tag{1.2}$$

Intercept from Y-axis (b) Value formula:

From, equation-(1.2);

$$\log_{10}(y) = m \times \log_{10}(x) + b$$

Or, $b = \log_{10}(y) - m \times \log_{10}(x)$ (1.3)

Using equations-(1) to (8) the gas concentration can be determined directly in ppm (parts per millions)

$$\log_{10}(\text{ppm}) = \frac{\left(\log_{10}\left(\frac{R_s}{R_0}\right) - b\right)}{m} \tag{1.4}$$

    b) Calculation of the solar PV energy output of a photovoltaic cell

A solar panel was constructed which was used for powering the controller. A dimension about 11.5cm × 6 cm rectangular solar plate was used to make the solar panel.

Formula for Solar PV energy output: $E = A \times r \times H \times PR$

E = Energy (kWh)	1 kWh/an
A = Total solar panel Area (m²)	0.0069 m²
r = solar panel yield (%)	15%
H = Annual average irradiation on tilted panel (shadings not included)	1250 kWh/m².an
PR = Performance ratio, coefficient for losses (range between 0.9 and 0.5, default value =0.75)	0.75

Result:

(a)Sensor data calibration
From the MQ-6 datasheet we have obtained the value of m and b

Slope, $m = -0.423$
And $b = 1.276$
And sensor resistance R_0=5.62 kΩ
Using equation (1.4) the further calculation was analyzed.

Table **2** Raw voltage values received through the MQ-6 sensor and corresponding temperature and humidity values:

ID	Time	Temperature (in °C)	Humidity (in %)	Analog value
1	13:19:41	30	61	533.15
2	13:19:36	30	61	533.48
3	13:19:31	30	61	532.48
4	13:19:25	30	61	528.04
5	13:19:20	30	61	532.48

6	13:19:15	30	61	532.48
7	13:19:10	30	61	528.04
8	13:19:05	30	61	528.04
9	13:18:59	30	61	528.04
10	13:18:54	30	61	528.04

Table **3** Raw voltage converted to resistance value and then the corresponding PPM, R_0 was previously calibrated

ID	Time	Resistance (R_s)	PPM
1	13:19:41	9187.764	325
2	13:19:36	9175.828	316
3	13:19:31	9211.781	313
4	13:19:25	9373.252	310
5	13:19:20	9211.781	313
6	13:19:15	9211.781	313
7	13:19:10	9373.252	310
8	13:19:05	9373.252	310
9	13:18:59	9373.252	310
10	13:18:54	9373.252	310

Table **4** The Temperature and Humidity correction factor is used and the Corrected Resistance and subsequently the Corrected PPM is evaluated: [69]

$$R_s\_Scaling\ factor = 1.6979 - 0.012t - 0.00612h$$
$$Corrected\ R_s = \frac{R_s}{R_s\_Scaling\ factor}.$$

ID	Time	Resistance Corrected R_s	Corrected PPM	Correction Factor
1	13:19:41	7177.940	582.55	1.28
2	13:19:36	7168.615	584.34	1.28
3	13:19:31	7196.703	578.96	1.28
4	13:19:25	7338.478	552.87	1.28
5	13:19:20	7196.703	578.96	1.28
6	13:19:15	7196.703	578.96	1.28
7	13:19:10	7338.478	552.87	1.28
8	13:19:05	7338.478	552.87	1.28
9	13:18:59	7338.478	552.87	1.28
10	13:18:54	7338.478	552.87	1.28

(b)System Performance Analysis
A total of 20 tests were done to develop a system performance analysis. The tests have also been researched effectively and no substantial error has been observed. The Table 5 below indicates

the findings of the performance test. The commands were performed in this study using the cloud server followed by actuation observation using the experimental setup mentioned in Fig earlier in this thread for IoT (Internet of things) and also for the Local server. For the feedback control option, the reference value was set at 300 PPM.

Table **5** Comparison between IoT and Local server based Actuator Control time.

No of Obs.	Gas Concentration In PPM	Actuator Response	Elapsed Time in IoT (sec)	Elapsed Time in Local IP System(sec)	Experimentation
1	170	0	0 (start)	0	N/C
2	173	0	15.3	3	N/C
3	211	0	20	2	N/C
4	288	0	11	1.52	N/C
5	316	1	7.5	1.71	Success
6	375	1	N/C	N/C	Success
7	402	1	N/C	2.61	Success
8	287	0	12	1.54	N/C
9	255	0	N/C	N/C	N/C
10	221	0	15.7	1.32	N/C
11	300	1	N/C	1.77	Success
12	300	1	13.4	1.67	Success
13	302	1	N/C	N/C	Success
14	380	1	N/C	1.90	Success
15	293	0	12	1.47	N/C
16	319	1	N/C	1.58	Success
17	327	1	18	1.97	Success
18	289	0	8	N/C	N/C
19	294	0	11	1.89	N/C
20	277	0	5	1.56	N/C

All the analysis indicates that the entire system operates like a program free of errors. Even though the processing time of the records is a bit long (about 13 sec for IoT) beside this the response time for the Local IP based proposed system is less but the behavior of the device seemed good. In case of IoT using manual Api and custom server, this system execution delay can be designed specifically. But in fabricated Local IP based system it doesn't require any third-party server because the web server is designed particularly for the WSN network. This fabricated system can be used to reduce the loss during fire inflation in home and industrial accidents caused by gas leakage. In factories, there are different types of poisonous-hydrocarbon-based gases in the food, chemical and pesticide industries (might be able to ignite fire). Which may cause a threat for huge people. In that case the fabricated system will work properly to reduce the loss immediately.

Conclusion:
The system was fabricated effectively and 20 tests were conducted to evaluate its efficiency. In those 20 experiments, which took about three hours to run, there were no mistakes. When signals from the host server were sent, the control system took almost 1 second (approximately) to execute required commands. From analyzed signals the impulse period and the group delay period seemed quite perfect if the Baud Rate (Sampling Frequency) tuning ranges from 11 to 12.6 kHz. The sample frequency was 11.52 kHz in this dissertation and the gas sensor energy density range was pretty nice, although the noise signal percentage was slightly high. The 20-pF ceramic unit condenser can overcome that.

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