Remote Data Centre Monitoring System Based On The Arduino Microcontroller.

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Abstract *COVID 19 forced most workers to work from home to stem the tide of infections. Data centers environment requires continuous monitoring by the technical personnel hence the need for system that could allow remote working. Most institutions desire to reduce cost and better management of the available resources including energy that contribute immersely in running data centers. Moreover grid power is not always reliable hence the need to use generators as backup in case of power outages which consume fossil fuels. The aim of the research was to design and implement a sensor based data centre management system using the Arduino microcontroller.. The research methodology adopted was an engineering approach. The output is a prototype of data center monitoring system that enable the data center workers to work from their homes and meet the desired COVID-19 Protocol of social distancing.*
Key Words: Sensors, Arduino Microcontrollers, Data centres, COVID-19. Humidity, temperature

I. INTRODUCTION

In the present COVID_19 pandemic times, it has been a requirement that we maintain social distancing. In working environment, working from home has become the norm. This research project set out to enhance remote working for people working in a Data Centre. Sensor based monitoring system was to play a fundamental role in the management of the data center for it could allow the service providers to provide cloud computing services. plan for their resources , budget and monitor the usage of same resources. Various sensors were incorporated in order to sense the changing environment within the data center environment and the information will be transmitted to other electronic devices such as the Aduino microcontrollers (Elprocus 2020)[1].

Most operators are on the lookout for better ways to reduces cost and have a proper utilization of the resources. Energy may constitute a big margin cost in running various data centers. Therefore, there is a need to have a cooling system to deal with excess heat produced during processing. There is also need to monitor temperature, humidity, purity and density of fossil used generator as a back up. All this monitoring should be done remotely (Tylor 2020)[2]

A: PROBLEM STATEMENT

Servers are mainly fed from grid power which for case of Kenya is usually not that reliable hence the need for having a backup generator in case of power outage thus leading to the consummation of fossil fuel whose quality and cost is important. The temperature found within the server room if left unchecked it can quickly bring down a fully functioning computing system to a halt. Traditionally in data centesr and server room had a predictable heating pattern that was correlated to the workload and work schedule however with our current advancement and expansion of the data center workload has become dynamic thus making it not easy to predict workload and heat generation within the data center[3]. Thus requiring continuous monitoring by personnel on the ground.

Another problem of humidity within the data center, which if not controlled could result in damage of the data centre. High humidity will result to long-term condensation that leads to corrosion and component breakdown yet low humidity will cause electrostatic discharge across crucial components such as CPU, RAM, hard discs and motherboards. This monitoring requires presence personnel on the ground. The COVID-19 protocols requires that personnel work in their homes. Hence, need for this research project

B: OBJECTIVES

The aim is to design and implement a prototype for remote monitoring of environmental variables in data center.

The specific objectives were in Data Centre monitor:
(i)   The purity, pressure and volume of fuel used in the backup generator
(ii)   The temperature and humidity
(iii)   The Current consumption .

II.   RESEARCH METHODOLOGY

For this research since the deliverable is a product, a prototype for remote monitoring of Data Centre then the engineering approach is most suited one and was selected. Figure 1 is graphical representation of the engineering method [4]
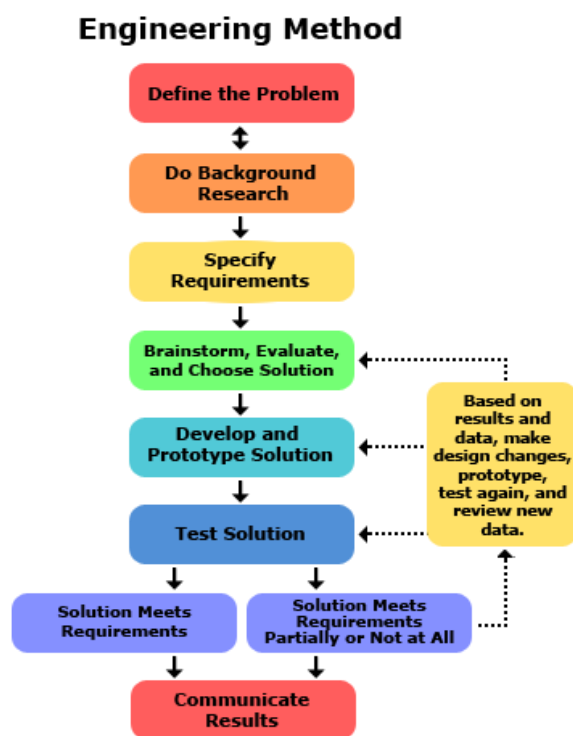
Engineering Method

Figure 1. Engineering Method; Source

The first step in engineering method is defining a problem. This is because engineers look for things that are not working as well as they should or they look for gaps in the needs of the people

The second step is to do background research. The purpose is to find what other people have done, build on their successes or failures. Research also can indicate paths to investigate or to avoid. It can give insight to similar problems that are being investigated. Research can also help prompt brainstorming and more broad ideas.

The third step in engineering method requires one to specify requirements. This is used to make sure that all ideas will be able to fulfill the

problem that exists and   to keep the objective in focus

The fourth step in engineering method, to brainstorm, evaluate, and choose a potential solution. Some things to keep in mind during this step are: no judgement, quantity counts, and wild and crazy are encouraged.

The Fifth step for the engineering method is to design and prototype a solution. This can be a long process to complete but it is a very important step. It is a potential solution to the problem so it must be thought through and carefully executed.

The Sixth step in the engineering process, is testing the prototype,. This step decides the fate of the prototype and the potential solution. In this step data is collected and analyzed. Data must be collected about every aspect of the design and how it preforms.

This seventh step is to decide whether the potential solution will work or whether you have to go back to the drawing board and make a new prototype or scratch the idea entirely.

The eighth and final step is to share the results. Once the information is out there then others, can replicate it, build on it, or try to prove your results wrong. In each case it will further the engineering field which in turn will improve the world[5]

III.   BACKGROUND RESEARCH

The purpose of background research is to identify how similar problem have solved. In our research we came across an open source microcontroller that we found fit for research project. This was the Arduino mega microcontroller whose information got from manufacture website [6] is describe in this section.

A: Arduino Mega Pinout, Pin diagram, Schematic and specifications in detail
The Arduino Mega is an open-source development board that is developed by the Arduino company. It is based on the Microchip ATmega2560P by Atmel. The Atmega3560P is an 8-bit microcontroller that comes with a built-in bootloader, which makes it very convenient to flash the board with code.

Arduino Mega Pinout:
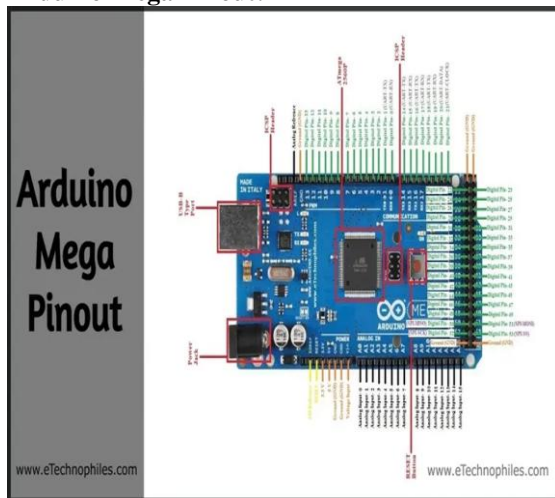
Arduino Mega Pinout

It consists of 54 digital input/output pins, where 16 pins are analog inputs, 14 are PWM pins, and 6 hardware serial ports (UARTs). It has a crystal oscillator-16 MHz, a power jack, an ICSP header, a USB-B port, and a RESET button.The voltage regulator help to convert the input voltage to 5V. The primary use of a voltage regulator is to control the voltage level in the Arduino board. Even if there are any changes in the input voltage of the regulator, the output voltage is constant and steady.

ATmega2560P: It is an 8-bit AVR RISC (Reduced Instruction Set Computer) based microcontroller that executes powerful instructions in a single clock cycle. This allows it to effectively find a balance between power consumption and processing speed. The detail of each pin can found at [7]

Arduino Mega Schematic:
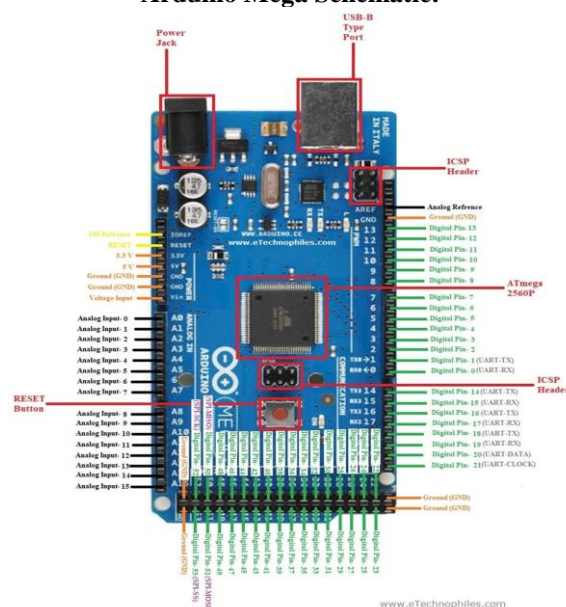
Arduino Mega Schematic, .Source: Arduino Mega official store [8]

B: Sensors

For the microcontroller to function sensors are required detect the changes in data centre environment. These could be then be measured to determine whether there output is within range. Some of the sensor of interest that are compatible to Arduino are:

(i) Humidity and Temperature Measurement using Arduino

Arduino based temperature and humidity are available with LCD screen. A combined temperature and humidity sensor were and there available adopted for this project[9]

In using the sensor, the first step involves sensing. The second step is to read the sensor module's output and extracts temperature and humidity values into a suitable number in percentage and Celsius scale. The third step is to displays humidity and temperature on LCD.

(ii) Ultrasonic level transmitter

Human can hear maximum up to a frequency of 20 KHz. Ultrasonic frequencies are above 20 KHz. Ultrasonic waves are used to measure level of liquids and solid objects in industries. Ultrasonic level measurement uses the contactless principle and suitable for level measurements of hot, corrosive and boiling liquids. The normal frequency range used for ultrasonic level measurements is within a range of 40 200 KHz.

When ultrasonic pulse signal is targeted towards an object, the object reflects it and echo returns to the sender. The time travelled by the ultrasonic pulse is calculated, and the distance of the object can be determined..

An ultrasonic level transmitter is fixed at the top of a tank half filled with liquid. The reference level for all measurements is the bottom of the tank. Level to be detected is marked as "C", and "B" is the distance of the ultrasonic sensor from the liquid level. Ultrasonic pulse signals are transmitted from the transmitter, and it is reflected back to the sensor. Travel time of the ultrasonic pulse from sensor to target and back is calculated. Level "C" can be found by multiplying half of this time with the speed of sound in air. The measuring unit final result can be centimeters, [10].

Level = Speed of sound in air x Time delay / 2

A micro-controller based *Control Circuit* monitors all the activities of the ultrasonic level transmitter. There are two *Pulse Transmission Circuits*, one for transmitter pulse and the other one for receiver pulse. The pulse generated by the transmitter pulse is converted to Ultrasound pulses by the *Ultrasonic Sensor* (Transmitter) and targeted towards the object.

This ultrasound pulse is reflected back as an echo pulse to the Ultrasonic Sensor (Receiver). The receiver converts this Ultrasonic pulse to an electrical signal pulse through the pulse generator. The time elapsed, or the reflection time is measured by the counter. This elapsed time has relation to the level to be measured. This elapsed time is converted to level by the Control Circuit. There is a *Timing Generator Circuit* which is used to synchronize all functions in the ultrasonic level measurement system. The level is finally converted to 4-20mA signal. 4mA is 0% level, and 20mA is the 100% level This 4-20mA output signal carrying the level data can be transmitted to long distance to Process Control Instruments.

(iii) Using the ACS712 Current Sensor

The sensor[11] consists of a linear Hall circuit with a copper conduction path located near the surface of the chip. Applied current flowing through the copper conduction path generates a magnetic field which the sensor converts into a linearly proportional voltage $\pm2.5V$ centered around 2.5V. This voltage is read through the Arduino ADC as a 10 bit number (0-1023), from which the DC or AC current can be calculated.

Sensing DC Current
DC current flows in the same direction over time, so sensing the current is simply a matter of reading the analog value, applying the calibration parameters, and scaling to the obtain the current reading.

Sensing AC Current
Sensing AC current is slightly more complex as the current reverses direction with each sinusoidal cycle. What is measured is the Root Mean Square (RMS) voltage *Vrms*. *Vrms* can be calculated from the peak voltage *Vp* of the sine wave as $Vrms = Vp / \sqrt{2}$.

SIM 800C
This is a complete Quad-band GSM/GPRS solution, which can be embedded in the customer applications. These modules are sub-system of the Internet-of-everything hardware. SIM800C supports Quad-band 850/900/1800/1900MHz, it can transmit Voice, SMS and data information with low power consumption. This is required for remote connection of system reading to a distance computer [12]

C: SYSTEM REQUIREMENT
From the background research, the following were identified as the required sensors and components.

* Arduino MEGA-PROCESSING UNIT
* Ultrasonic Level sensor—HCSR04
* Temperature/Humidity sensor-SHT21
* Current Sensor-AC5712
* VOLTAGE Transformer (9-240v)
* Sim 800cDesign

IV. SYSTEM DESIGN
The design consist of high-level and low-level

(i) High Level Design
The diagram below shows the high level design for the system. Once the devices have been identified the next is to have high design of the system showing how the various block diagram are connected as shown in figure 4.1

The Arduino mega is the microcontroller which shall been used for processing all signals received by the various sensors namely:

i. Pressure sensor – this together with the ultrasonic level is used to measure density of fuel to detect adulterated fuel.

ii. Ultrasonic Level- used to measure depth of fuel in generator fuel tank

iii. Temperature/humidity sensor-used to take temperature and humidity of the data centre

iv. Current sensor-used to measure current used by the data centre which in turn can allow us calculate the power consumption.

v. Voltage Transformer-this will enable step up and step down voltage.

vi. SIM 800c used to relay the data collected to a server

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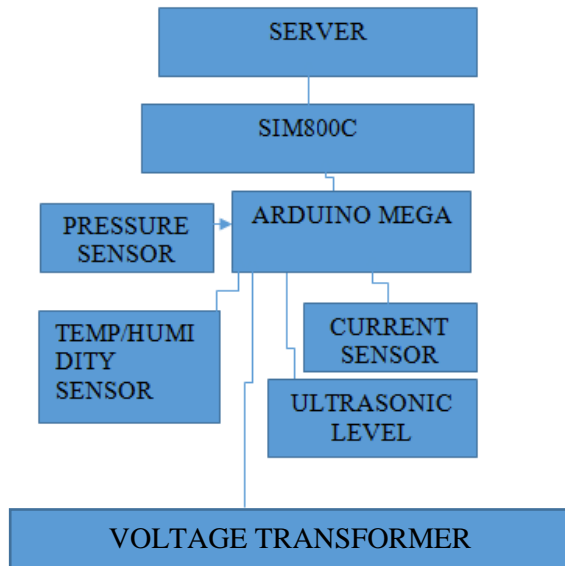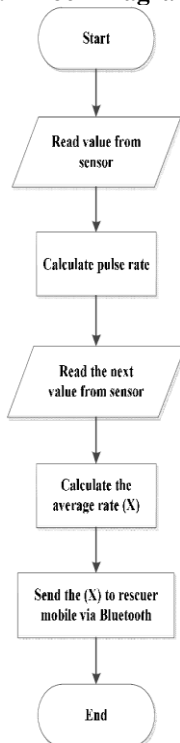that can be queried to give an output on an android application.

Fig 4.1 Block Diagram of Proposed system

(ii) Low level design
In this aspect flow chart for reading sensor reading was design and typical flow chart is show below
The block diagram fig 4.1 in design was implemented as shown by the picture attached

4.2 Low level design

V. IMPLEMENTATION
Figure 5. This illustrate the physical construction of implementation. We have attached typical program for the software implementation that is coding'
In the photograph (fig 5) was taken of the prototype with various sections being identified by paper label and attached with a masking tape.

Figure 5. A picture/Photo of physical construction of the prototype.

VI. Testing
After implementation testing was the carry out. The results are presented in in section , basic analysis was done and conclusion made.
(a)   Volume of in fuel tank and Purity of fuel
To carry out this test a plastic container was used to represent the generator fuel talk and water was used to simulate the fuel. The container was measured with no water and then water was added in 0.5

Litres amount to maximum of two litres. The leading was what prototype was reading for maximum and also indicating that fuel quality was poor. There was difference in volume reading between actual and amount in container. This was attributed to calibration. The result are as tabulated in table 6.1

Table 6.1

Actual measurement In litres	Sensor Reading 1st	Sensor reading 2nd	Average sensor reading
Empty (0 litres)	5.54	4.79	5.51
0.5	6.57	6.52	6.55
1.0	7.06	7.20	7.13
1.5	8.20	8.20	8.20
2.0	9.23	9.23	9.23

From there appears to be linear relationship of the form y=Mx +C

$M = (9.23 – 5.51)/(2.0 -0)= 1.86$

Therefore $Y = 1.86X + 5.51$

There is sensor apart of calibration was displaying as expected.

6.2 Liquid pressure KPA

Pressure of the simulated fuel tank was measured and tabulated table 6.2

Actual measurement in litres	First sensor reading	Second sensor reading	Average sensor reading
Empty(0 litre)	-0.33	-0.33	-0.33
0.5	0.33	0.28	0.31
1.0	0.71	0.71	0.71
1.5	1.14	1.14	1.14
2.0.	1.36	1.26	1.31
2.5			

Table 6.2

From table there appears to be linear relation of form
Y=MX +C
$M = (1.31 –(-0.33))/(2.0 -0) =0.82$
$Y = 0.82X- 0.33$

6.3. Voltage Measurement

At time of carrying out the test voltage measurement was 222. 66 V rms


6.4 Current Measurement

Bulbs were used as loading. Measurement was done with no load (no bulb) and as bulbs were increased from one to four. The results were also tabulated in table   6.4

Table 6.4

Actual measurement different load	First sensor reading (current reading amps rms	Second sensor reading	Average sensor reading
No load(bulb)	0.30	0.30	0.30
I bulb (5w)	0.33	0.33	0.31
2bulbs (10w)	0.35	0.36	0.355
3bulbs(15w)	0.40	0.41	0.405
4bulbs(20w).	0.46	0.44	0.45
2.5			

The equation of current in circuit was increasing as per loading and is of form Y=MX+ C

$M = (0.45 - 0.3)/(20 - 0) = 0.15/ 20 = 0.0075$

$Y = 0.0075X + 0.3$. Figure below indicated when all the bulbs were on full load.
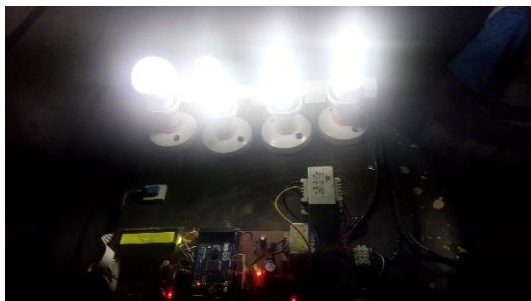
6.5TEMPERATURE and HUMIDITY

These tests were done by measuring temperature and humidity in different rooms

Room	Temperature	Humidity
1	24	62.00
2	24	64.00
3	23	66.00
4	21	70.00

It was observed the temperature and humidity reading were in tandem with state of rooms.

VII.   Conclusion

After carry out the test we can conclude that the prototype proved the concept. The aim which was to design the prototype was achieved. However the prototype requires calibration and validation against other meters.

REFERENCE

[1].   Elprocus 2020 Arduino sensors and application https://www.elprocus.com/arduino-sensor-types-and-applications/

[2].   Tylor 2020 why server room environmental monitoring is important :https://colohouse.com/environmental-monitoring-in-the-data-center/

[3].   CentersRatnesh K. Sharma, Cullen E. Bash, Chandrakant D. Patel,Richard J. Friedrich, Jeffrey S. Chase {2003) Balance of Power: Dynamic ThermalManagement for Internet Data Systems and Storage Laboratory HP Laboratories Palo AltoHPL-2003-5February 18th , 2003 *(3) (PDF) Balance of Power: Dynamic Thermal Management for Internet Data Centers*. Available from: https://www.researchgate.net/publication/220490841_Balance_of_Power_Dynamic_Thermal_Management_for_Internet_Data_Centers [accessed Jun 18 2022].

[4].   Krishnan Nallaperuma 2017: A Computer Science and Engineering and Information and Communication Technologies Perspective. Engineering https://www.academia.edu/37834736/Engineering_Research_Methodology

[5].   Engineering Research Methodology https://www.gsdsef.org/sites/default/files/comparing_the_scientific_method_to_the_engineering_design_method.pdf

[6].   www.eTechnologies.com

[7].   https://store.arduino.cc/usa/mega-2560

[8].   Arduino Mega 2560 Rev3 | Arduino Official Store(https://store.arduino.cc/usa/mega-2560)

[9].   Abdullah Al Mamun, Mohammad Alamgir Hossain, Muntasir Rahman, Ibrahim Abdullah, Shamim Hossain; 2020 Design and Development of Arduino Based Contactless Thermometer (researchgate.net) https://www.researchgate.net/publication/ Volume 11, Issue 1 ·January-June 2020

[10].   Prisma Megantoro, Andrei Widjanarko, Robbi Rahim , Kunal Kunal, Afif Zuhri Arfianto The Design of Digital Liquid Density Meter Based on Arduino Journal of Robotics and Control (JRC) Volume 1, Issue 1, 2020 ISSN: - DOI https://www.researchgate.net/publication/

[11].   Sensor projects: https://how2electronics.com/sensor-projects-for-arduino-beginners/

[12].   Sim800. https://www.rhydolabz.com/wireless-gsm-gprs-c-130_185/sim-800c-module-p-2290.html