Design and Development of IoT based Computer Network Room Environment Monitoring System

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Keyword: IoT, Internet of Things, NRMS, Network Room, Power, Temperature, Humidity.

Abstract: This paper discusses design and development of internet of thing (IoT) based computer network room monitoring system (NRMS) for twenty five rooms of college campus. Furthermore, it also discusses the benefits of Internet of things offer as compare to traditional method of monitoring which does not cope with rising demand of dynamic power used by servers and networking devices. The NRMS deals with monitoring network room environmental conditions like power, temperature, and relative humidity. The system then sends this information to the IoT cloud and displays the live data on the dashboard. It also sends alert to the authorized persons; records the previous data to find any root cause of the problem if needed. The data updated periodically from the implemented system can be accessible through internet from anywhere in the world.

1 INTRODUCTION

The Internet of Things (IoT) is a new growing area that is gaining ground at very fast pace with virtue of sophisticated communications technologies. The basic idea of this concept is the ubiquitous presence around us of a variety of things or objects various sensors, actuators, cell phones by using different protocols and schemes, are able to cooperate with each other and work together with their neighbors to reach common goals (Ashrae, 2011). IoT based NRMS take the benefits of IoT to solve problem and protect the network to go down. Every network room is monitored by one NRMS box for multi parameters, if something goes wrong it take suitable action to resolve the problem. Thing Speak API is used IoT base for data recording and root cause analyses of the problem and serves as an interface between devices such as temperature, humidity and power sensors to collect data and analysis software to analyze data to generate alerts and alarms as required.

2 PROBLEM DEFINATION

The network is room environment is most critical factor for the efficient working and operating life of servers and networking switches and other devices, not proper monitoring can not only damage the equipment but also halt major work in the organization. The impact of downtime ranges from direct loss of revenue to the decreased performance of the organization and spoil reputation. Problem faced by IT networking devices are listed below.

2.1 High Network Room Temperature

High network room temperature can damage the hardware of IT equipment present in the room, even short time rise in the temperature can have worse consequence. It can create intermittent failure of equipment as well as permanent data loss. High temperature can be potential risk for the installation to catch fire (Stanford University, 2011).

2.2 Low Network Room Temperature

Keeping temperature below the specified limited by the manufacturer is energy waster, because it require cooling system to run continuously to maintain the temperature it can also create health related issues for the IT personal working in the room. Furthermore it is heavy on the company budget (ASHRAE, 2008).

2.3 Low Network Room Humidity

Dry climate increases the probability of electrostatic discharge. Which can cause intermittent or

Banakhr, F.
Design and Development of IoT based Computer Network Room Environment Monitoring System.
DOI: 10.5220/0008925201530160
In *Proceedings of the 5th International Conference on Internet of Things, Big Data and Security (IoTBDS 2020)*, pages 153-160
ISBN: 978-989-758-426-8

permanent failure of electronic components. Repairing damaged components can be expensive and time consuming (Swenson, D., & J.T. Kinnear, 2009).

2.4 High Network Room Humidity

High humidity level in network rooms can cause internal components of IT equipment to rust and change their electrical properties, such as resistance and capacitance or thermal conductivity. Short-circuit can be one critical outcome of high humidity, fire, data storage devices failure and financial loss to company is consequence (TIA, 2005).

2.5 High Network Room Sound Level

High Sound level in network room is used to monitor the working of fans of IT equipment, very high sound level indicate that fan of IT equipment malfunctioning and to be fixed early as possible to prevent catastrophic failure. Very High sound in the server rooms can also cause hearing impairment to IT personal working or sitting in the room (Dubravko, 2016).

2.6 Low Network Room Sound Level

Low sound level indicate that fan of equipment not working or running at low speed. Observing sound levels allows IT personnel to identify a problem as early as possible.

2.7 Network Room Power Failure

In normal circumstances, Network room power is backed up by uninterruptable power supply UPS system some time UPS and main Power failure occur at same time which halt the communication process in organization (UPS, 2018).

2.8 Remote Connectivity and Alert

Network room are usually located at isolated place in the organization, remote monitoring is essential for these type of system to send alert to IT personal to take require action.

3 SYSTEM ARCHITECTURE

System level diagram is shown below that shows IoT cloud service ThingSpeak is used by our system to display data globally on internet. ThingSpeak is base platform for the Internet of Things applications. ThingSpeak allows to build an application around data collected by sensors on different location. Major advantage of ThingSpeak include: real-time data collection, data processing, visualizations, apps, and plugins. Control room display real time data collected by different sensors from various location. Fig.1 shows network rooms are connected with monitoring systems which is placed in rack or suitable place connected to internet to take fast and effective decisions. Data can be displayed on handheld devices based on android and iPhone. All the data gathered from network rooms is displayed control room screen, which gives alerts to the IT technician if something goes wrong.

Individual sensors do not typically connect individually to the IP network. Instead, the NRMS box interpret the sensor data and send data to the central system by IoT cloud This distributed monitoring architecture dramatically decreases the number of network drops required and reduces the overall system cost and management burden. NRMS box are typically assigned to physical network room within the organization and combine sensors from a limited area in order to limit sensor wiring complexity.

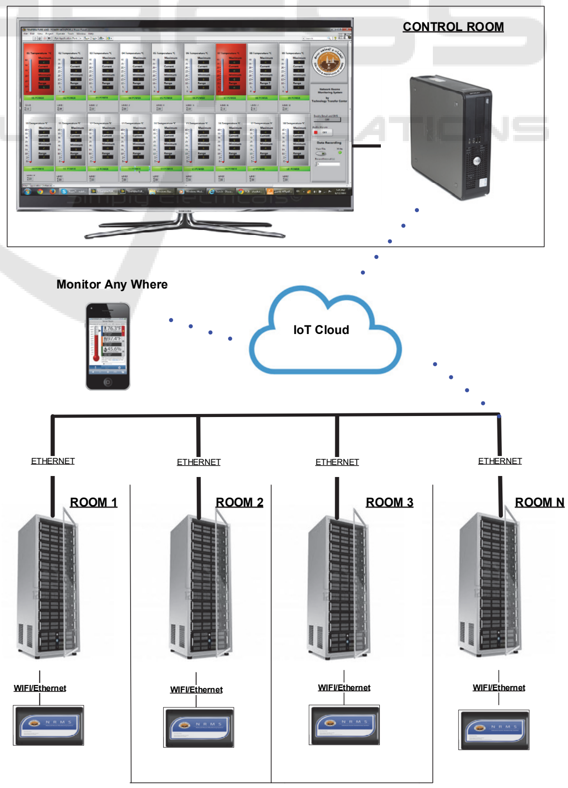

Figure 1: Network rooms are connected with monitoring system.

Figure 2: NRMS box connected to one of the servers.

The heart of the IoT NRMS is microchip PIC32MX360 microcontroller which gives a rich peripheral set at a low cost for a broad range of embedded designs that require complex code and higher feature integration. Block diagram of the system is shown in figure 3.

The major advantage of PIC32 microcontroller is one failure every 16.58 years that make it ideal for monitoring expensive IT equipment. Furthermore, it can operate at over 100 MHz and can operate in temperature range from -40 to 105 centigrade. It has built-in16 channels 10bit ADC that can operate on 1 mega sample per second. Microcontroller has on chip fail-Safe Clock Monitor that allows safe shutdown in case of clock failure (Microchip datasheet, 2011).

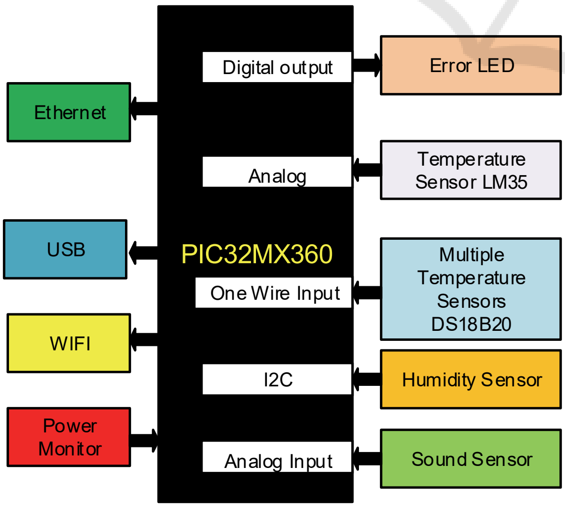

Figure 3: Block diagram of connected system.

3.1 Air Temperature Monitor

LM35 is used to check the air temperature of the network room The LM35 is low temperature sensor with an output voltage linearly proportional to the Centigrade temperature. The LM35 device does need any external calibration or trimming to provide typical accuracies of ±0.25°C at room temperature and 0.75°cover a full −55°C to 150°C temperature range (Texas instrument datasheet, 2017).

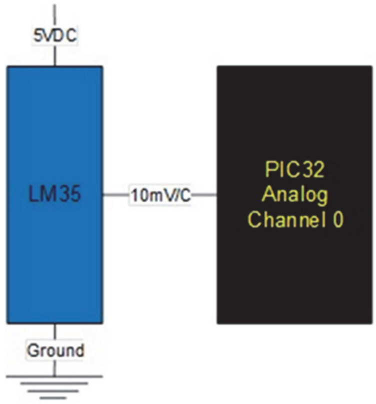

Figure 4: LM35 sensor connected to PIC32 to check the temperature of the network room.

By using this simple circuit to monitor air temperature of the network give benefits as written,

- Monitor the room for high temperature due to cooling system malfunction or total failure to protect and extent life of equipment.
- Monitor for very low temperature save Energy by keeping the temperature at desired level as consequence save energy and money.
- Monitor sudden rise of temperature in the room to protect critical data storage system from damage. Following equations are used to calculate the temperature in the software application.

$$\textit{Temperature in Centigrade} = \frac{\text{LM35 Voltage}}{10\ \text{mV/C}}$$

$$\text{LM35 Voltage} = \text{ADC reading} * \text{ADC resolution (mV/ bit)}$$

$$\text{ADC resolution}\left(\frac{\text{mV}}{\text{bit}}\right) = 3.3\text{mV/bit}$$

$$\textit{Temperature in Centigrade} = \frac{3.3 * \text{ADC reading}}{10}$$

3.2 Network Room Rack Temperature Monitor

Network Room rack is monitored by using DS18B20 single wire temperature sensors. these sensors can be network together on singe input pin of microcontroller with cable length up to 3 meters. The measurement ranges of these sensor are -50 to +125ºC. Each DS18B20 has a unique 64-bit serial address, which allows multiple DS18B20s to function on the same1-Wire bus. One digital input is of pic32 microcontroller is used to control many DS18B20s distributed over IT equipment rack (Maxim integrated datasheet, 2015). While measuring room air temperature in the essential, the real. concern is the temperature inside the racks. There are many variables that affect how rack temperature varies from network room temperature The only way to monitor for sure that equipment is operating in a safe temperature is to note the temperature inside the rack itself. This will save time in troubleshooting as well as save other equipment from overheating and extent the overall life.

DS18B20 Temperature = (Temperature High Byte 8 + Temperature Low Byte) *0.0625

Figure 5 shows single wire connection of four temperatures sensor placed at different location in the network room. Figure 6 shows the placement on temperature sensor at different response (Maxim integrated, 2015).

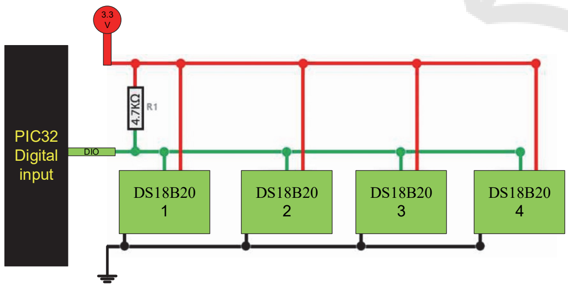

Figure 5: Single wire connection.

3.3 Network Room Rack Humidity Monitor

The humidity of the air is a measure of the amount of water vapors content it holds. Relative humidity (RH) is a convenient way of expressing the amount of water vapor contained in a volume of air. It's defined as the ratio expressed in percentage of the mass of water vapor in the air to the mass required to

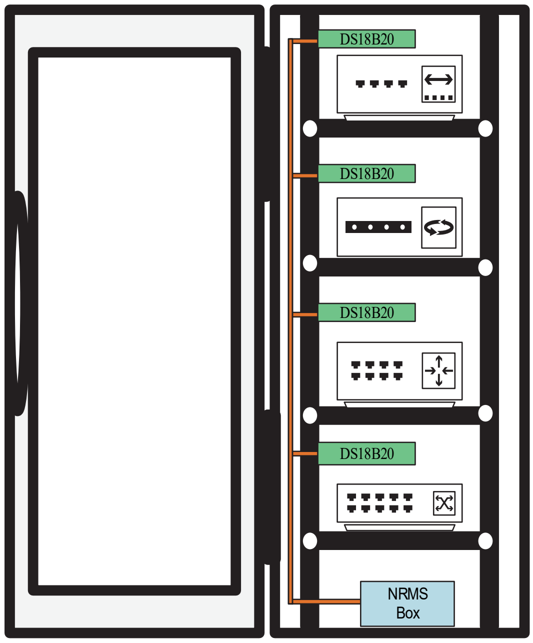

Figure 6: Placement of temperature sensors.

produce saturation at the same temperature. When the air is saturated, therefore, its RH is 100%. For this system low cost Honeywell HIH8120-021-001 humidity sensor is selected, main reason of this selection is, it can operate on high temperature range of -40 to 125 centigrade with accuracy of ±2.0 %RH (Honeywell datasheet, 2015). Moreover, it also eliminates the need to regularly recalibrate the sensor, which can be troublesome and pricey. It has very low power consumption the sensor goes into sleep mode when not taking Measurement, consuming only 1 µA versus 650 µA figure 7 shows hardware interface to humidity sensor with microcontroller by simple I2C protocol. This solution protects equipment failure from static electricity accumulation at low humidity points and condensation formation at high humidity points on the IT equipment. Following formula is used to calculate the humidity (%RH).

$$\text{Humidity (\%RH)} = \frac{\text{Humidity Output Count} * 100}{16383}$$

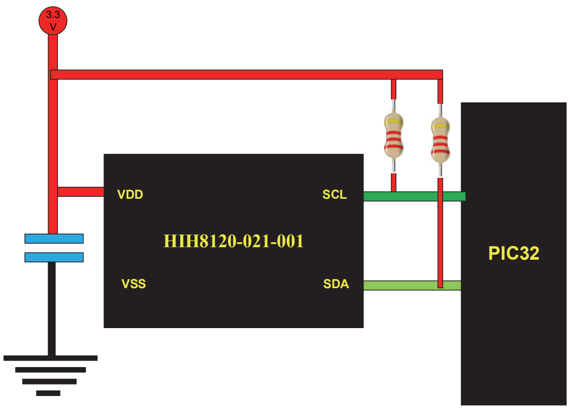

Figure 7: Hardware interface to humidity sensor with microcontroller.

3.4 Network Room Sound Monitor

Sound monitor circuit uses SEN-14262 sound detector based on microphone and audio amplifier (Spark Fun online, 2018). The Sound monitor has three separate outputs. One is amplified audio output from microphone, second is sound envelope and third is pulse output when sound above threshold is detected. Microcontroller analog pin is connected with envelope pin of sound detector to identify audio level which indicate malfunctioning of fans

Sound Detector

Read Analog Value from ADC

If sound level is greater than 30 means very noisy,

may be fans are dusty.

If sound level is less than 10 fan is not working

check the fan

3.5 Network Room Power Monitor

Simple opt coupler is used to detect the power failure from the main socket this simple circuit work on UPS power to detect the condition of main power. If is power for long time it will send alert to concerned maintenance technicians.

Ethernet cable of NRMS is connected with main switch or hub in when power is loss by the switch communication loss error due to power is send to the control room.

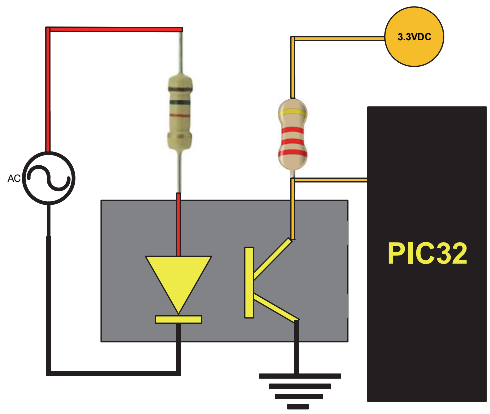

Figure 8: Power failure detection.

3.6 NRMS Wifi Communication

In this project ESP8266 IoT wifi module is used which is very low cost with a complete AT command library. This allows for stress-free integration with a Wi-Fi network through serial communication. Module has low power consumption at sleep mode (Spark Fun online, 2018).

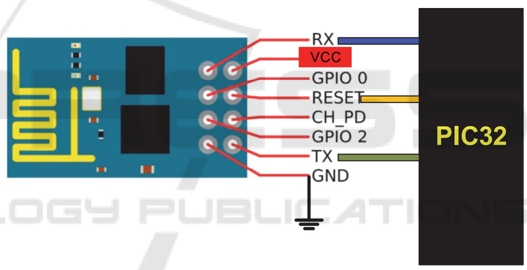

Figure 9: ESP8266 IoT WiFi module.

4 SYSTEM SOFTWARE DESCRIPTION

System software has four major components Application programming interface API and Web Service for the Internet of Things, embedded software for microcontroller, LabVIEW program for main control panel software, and mobile software for remote monitoring. Following paragraphs discuss the implementation.

4.1 API and Web Service for the IoT

For the purpose of connecting an NRMS to the IoT, system uses ThingSpeak API (ThingSpeak, 2018). Fig 10 represents the connections of system
The API provides simple communication capabilities to objects within the IoT environment, as well as

interesting additional feature like tweeter interface. Additionally, ThingSpeak permits to build software applications around data collected by sensors by NRMS Data is stored in. the channel that is primary component of ThingSpeak, which holds data fields, location fields, and a status field. Real-time snapshot of thingspeak is shown in the figure 11.

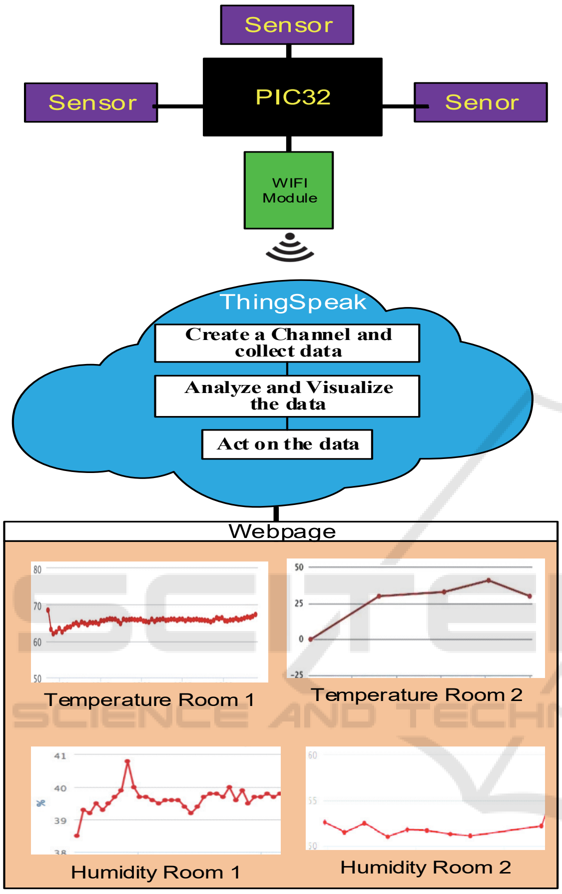

Figure 10: Connection system of NRMS to IoT.

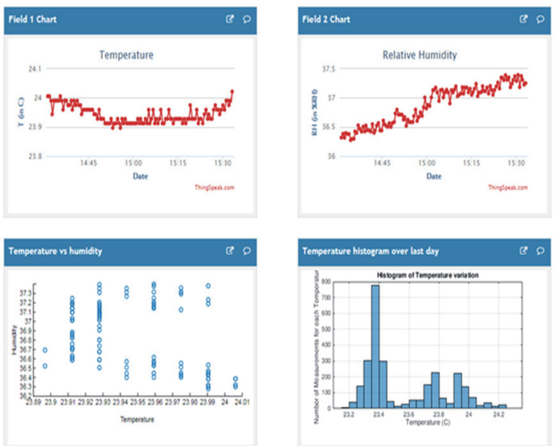

Figure 11: Real-time snapshot of thingspeak.

4.2 PIC32 Microcontroller Ethernet Program

The microcontroller uses microchip TCP/IP stack that provide a foundation for embedded IoT network applications by handling most of the interaction required between the physical network port and sensing application. They stack provide for complicated network layers free of cost on embedded microcontroller that include HTTP for serving web pages, SMTP for sending e-mails, SNMP for providing status and control. Microchip's TCP/IP stack uses of cooperative multitasking to implement the various TCP/IP stack functions and collect sensor data, which all cooperate, to share processing time on a single microcontroller. In other words,. This is done by either dividing its job into multiple tasks, or organizing its main job into a Finite State Machine (FSM) and dividing a long job into multiple smaller jobs. Each job has been planned to cooperate by running only a short time so that the other tasks can have their share of the processor. State diagram of microcontroller program is shown in fig. 12.

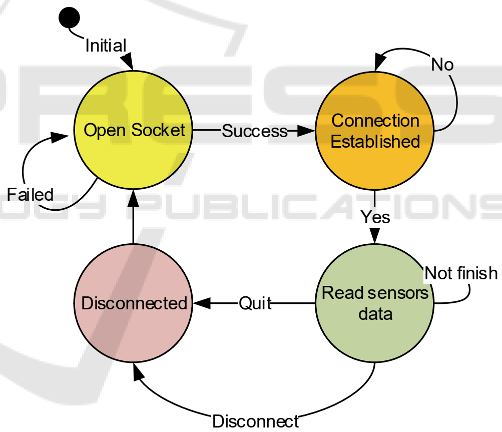

Figure 12: State diagram of microcontroller program.

4.3 PIC32 Microcontroller Wi-Fi Program

The ESP8266 Wi-Fi module has a full TCP/IP stack support. It can effortlessly have configured as a web server or client by use of serial port of microcontroller. The module accepts serial AT commands and responds back with the operation's outcome. Moreover, once the device is connected and is set to accept connections, it will send spontaneous messages whenever a new connection or a new request is issued. Communication algorithm IoT cloud and Wi-Fi module is shown in figure 13.

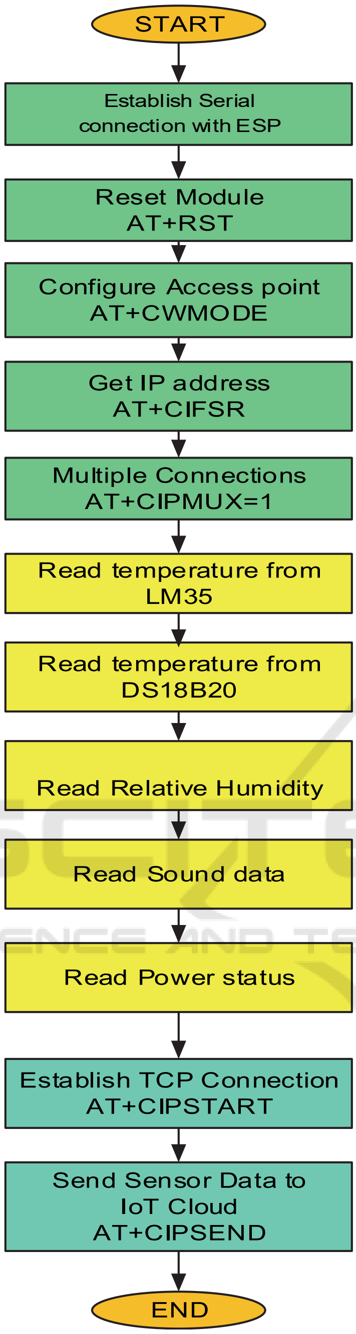

Figure 13: Communication algorithm IoT cloud and Wi-Fi module.

4.4 Main Control Room Software

Main control software display information from the all network rooms in one place developed using LabVIEW (LabVIEW, 2017). Figure 14 shows sensors and power information displayed on main screen on the control room.

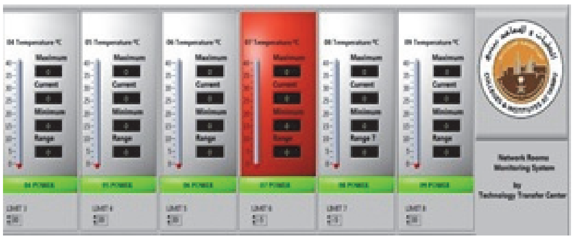

Figure 14: Sensors and power information displayed on main screen on the control room.

User can set the desired threshold of sensors for generating alerts and alarm from main control panel software for IT Staff. Based on the severity level of an alert system decide the action to be taken These automated actions could be personnel email or cell phone text message notification, or they could be corrective actions such as triggering back up cooling fans or dryer

Historical recoding of sensors data is implemented in the program Data can be used to predict future behavior as more and more equipment are aggregated in the room, and could help forecast when the data room will reach to the limit. Long term historical data analysis can be used at the rack level to compare how equipment from different manufacturers in different racks, which may guide future purchases recording.

5 RESULTS

Table 1 shows the result of Implementing the NRMS in different locations in the campus.

Table 1: RCYCI Communication Room Temperature.

Location	MAC Address	BOX	Mean Temp	Mean Relt. Humidity	Power Status	Sound Level
YIC Main Data Center	00-04-A3-F4-C0-06	NRMS09	20	62	OK	OK
YIC ACX Comm room	00-04-A3-F4-BB-04	NRMS03	22	60	OK	OK
YIC AC Server Room	00-04-A3-F4-C0-1B	NRMS07	21	61	OK	OK
YIC New Dorm B#1	00-04-A3-F4-BB-46	NRMS14	25	60	OK	OK
YIC New Dorm B#7	00-04-A3-F4-B7-F0	NRMS01	24	63	OK	OK
YTI Main Server Room	00-04-A3-F4-BC-97	NRMS06	20	62	OK	OK

Table 1: RCYCI Communication Room Temperature (cont.).

Location	MAC Address	BOX	Mean Temp	Mean Relt. Humidity	Power Status	Sound Level
YTI B2 Comm Room	00-04-A3-F4-BE-F5	NRMS18	21	60	OK	OK
YTI B4 Comm Room	00-04-A3-F4-BE-99	NRMS12	26	59	OK	OK
YTI B5 Comm Room	00-04-A3-F4-C8-18	NRMS05	**28**	58	OK	OK
YUCM J1 Server room	00-04-A3-F4-B7-20	NRMS11	20	60	OK	OK
YUCM J2 Server room	00-04-A3-F4-BF-A9	NRMS02	23	61	OK	OK
YUCM J1 Comm room	00-04-A3-F4-BB-65	NRMS15	24	62	OK	OK
YUCF Buildg A	00-04-A3-F4-C0-4C	NRMS16	**27**	61	OK	OK
YUCF Buildg B	00-04-A3-F4-A5-04	NRMS08	20	60	OK	OK
YUCF Buildg C	00-04-A3-F4-C2-40	NRMS10	22	62	OK	OK
YUCF Buildg D	00-04-A3-F4-BB-0D	NRMS17	21	63	OK	OK
YUCF Buildg E	00-04-A3-F4-C0-45	NRMS13	23	64	OK	OK

Monitoring system

*YIC, refers to Yanbu Industrial College.

*YUCM, refers to Yanbu University College Male Campus.

*YUCF, refers to Yanbu University College Female campus.

*YTI, refers to Yanbu Technology Institute.

6 CONCLUSION

IoT based NMRS provide protection against environmental threats that is critical to a comprehensive network equipment safety strategy. Location and procedure of temperature, humidity, and sound sensing equipment requires assessment, choice, and design, best practices and design tools are available to support for efficient and effective deployment. IoT software and control program manage the collected data and provide recording, analysis, smart alerts and automated corrective and preventive action as desired. By utilizing IoT for monitoring dispersed physical threats in different network room enables the IT administrator to fill critical cracks in overall network safety to achieve the required goals.

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