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IOT Based Model for Monitoring Datacenters Systems

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Abstract:
As we know the needs to apply the meaning of business continuity of data center in any organization, this paper introduces a newly prototype model for monitoring system based on Internet of Things (IOT). The idea is to design a solution consist of the hardware connected with set of sensors. These devices connected to main monitoring system by Ethernet or Global System for Mobile (GSM).Thisarticle targets securing the data centers from environmental turbulences. By enterprise solution with multi Internet of Things (IoT), the system will send the environmental records to a centralized system which will analyze the data and recommend or take necessary actions. The centralized system will have a portal and contains real time data and historical saved records. These data will be displayed in a graphical dashboard with live charts. The system contains levels of several alerting functions such as (onsite buzzers, portal colored alerts, SMS, emails and customizable alerts based on the admin needs). The portal will be hosted on cloud premises.

***Keywords and Abbreviations**: Internet of Things, Data centers, cloud computing, sensors*

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I. Introduction

The Internet of Things (IoT), is a newly emerging term in the Fourth Industrial Revolution (FIR), refers to the new generation of the Internet (network) that allows understanding between interconnected devices (over IP) address. These devices include tools, sensors, and various artificial intelligent (AI) algorithms, etc., and could be considered as a new customer in the Internet and a new source of data. This definition goes beyond the traditional concept of connecting people with computers and smart phones over a single global network and through the traditional Internet known protocol as shown in **Figure1**

Figure 1 Uses of internet of things

The main advantages of the Internet of Things (IoT) is that it allows users to be free from the place, where the user can control the tools without having to be in a specific place to deal with devices. The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects or humans that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. The data center which is also known as the servers' room where internet servers or data servers are connected and housed. Data Center consists of a set of a high-speed connectivity network that is either used as full servers as platform or divided into (cloud) servers. This study will discuss how the (IoT) can serve the data centers by monitoring and securing the system to ensure the continuity of work over the 24/7. To enhance the quality control of the work in data centers,five (IoT) challenges are examined to explore some of the most pressing challenges related to the technology. These challenges include (security), (privacy), (structures), (standards, legal, regulatory, rights), (emerging economies and development).

II. Literature Review

This section introduces the previous work related to the process of monitoring data center based on IOT systems and discusses the main techniques and methodology for each system.

Design of Data Center Environmental Monitoring System Based on Lower Hardware Cost [1]:

This article showed how the Data Center environmental monitoring represents a step forward towards addressing awareness monitoring of remotely located data centers located by receiving a notification by email. With the proposed monitoring data centers environmental system, organizations can effortlessly install the system with no additional wiring installation or maintenance cost. Additionally, this system can view the system logs andthe status via Internet in real time. Simply, monitoring this data is not enough. As future work in this system they could be expanded in several different aspects. For instance, additional user friend web monitoring portal allowing supervisors to monitor sensor data in real time through charts which can be designed using hypertext markup language(HTML5). This system shows how datacenter environmental monitoring is developed using open-source hardware platforms, Arduino, RaspberryPi, and the Gobetwino to store sensor data to the nearest host server in the datacenter . The sensed data that will be recorded in a file on the host server are temperature, humidity and distance every time an object hitting some object around the datacenter or person walks towards the entrance of the data centersas shown in **Figure 2**.

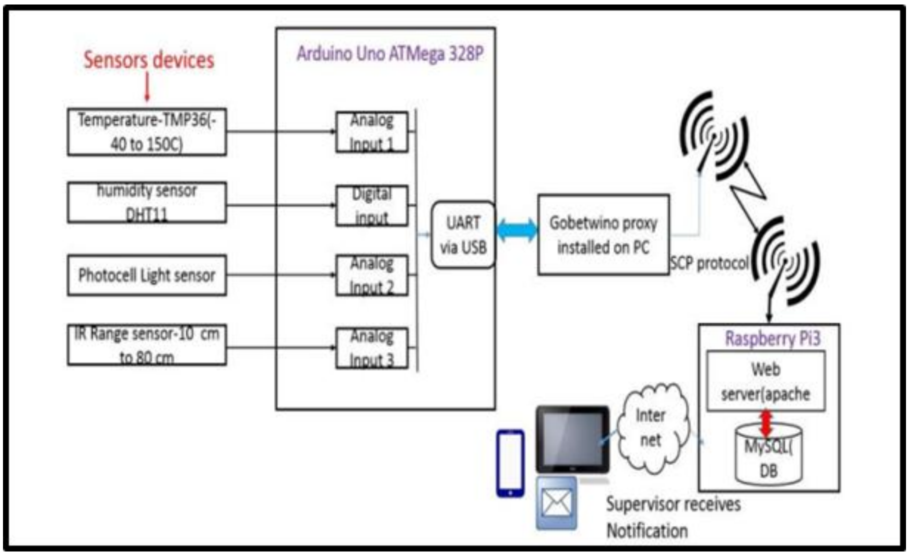


Figure 2 Block diagram for the Environmental Monitoring System

This figure represents the functional architecture of the system. Here temperature-TMP 36, humidity sensor DHT11, photocell light sensor and infrared range sensor are the inputs being used to generate the parameters which are the sensors data for the environmental monitoring system in the data center. Gobetwino is considered as a "generic proxy" for Arduino, that will act on behalf of Arduino and do some of the tasks that Arduino can't do on its own. Using defined command types,they can create commands in Gobetwino that Arduino can request Gobetwino to execute.

IoT Based Weather Monitoring System for Effective Analytics [2]:

This article showed that the implementation of weather monitoring system based on raspberry Pi.The access to this data is available in the intranet with the current level of implementation and it could be made public when the data is made to store in cloud servers or other sources in the internet. This proposed system is the most compact unit for measuring weather parameters in regions suffering from the atmospheric Particulate Matter (PM) that have a diameter of less than 2.5 micrometers (PM 2.5) pollution. This device is composed of multiple nodes that can be connected to the internet from various locations of study. This connectivity will aid the user to monitor the weather metrics corresponding to pollution over a centralized data analytics server asshown in **Figure3.**

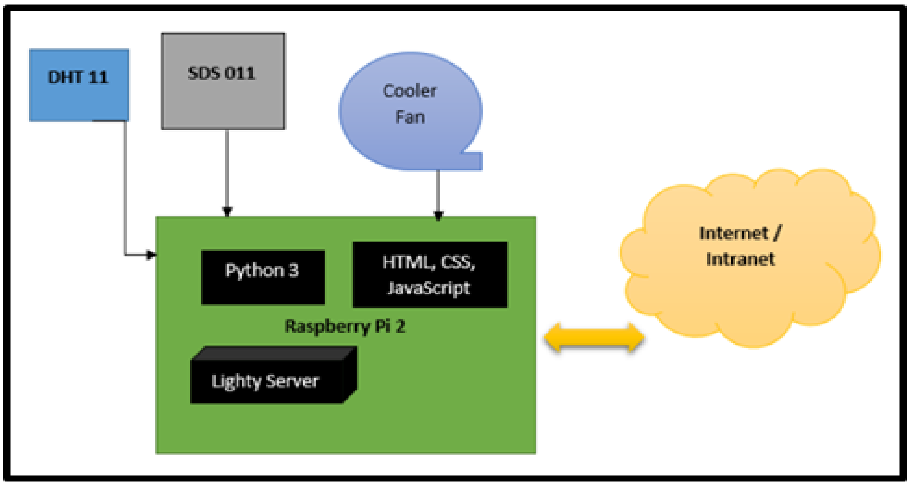


Figure 3: Architecture of System with themeasuredweather parameters

The architecture of the system is given in the diagram. It shows the hardware connected to the raspberry Pi and the software used in managing the data collected using the sensors. The scope of this framework is to store the data in a cloud server but the implementation reports in the availability of data over the intranet of a specified subnet. Data collected is made available to download in comma separated value(CSV) format and the latest weather data in java script object notation (JSON) format is made available to share data online over the network. The software implementation of this system is available in GitHub and it can be accessed from the link http://www.github.com/ferdinjoe.

Implementation of GSM Based Security System with (IOT) Applications [3]:
This system showed how that the Integrated IOT controllers use different communication protocols over the Internet.Thissolution is based on a microcontroller processor (Alf and Vegard AVR-RISC), passive infrared sensor (PIR), a GSM module and a smart phone to start the idea of focusing on the need to design a security system that is moderately tangible. It is a competition of security system through intelligent IP device to access the Internet of things everywhere as shown in **Figure 4.**

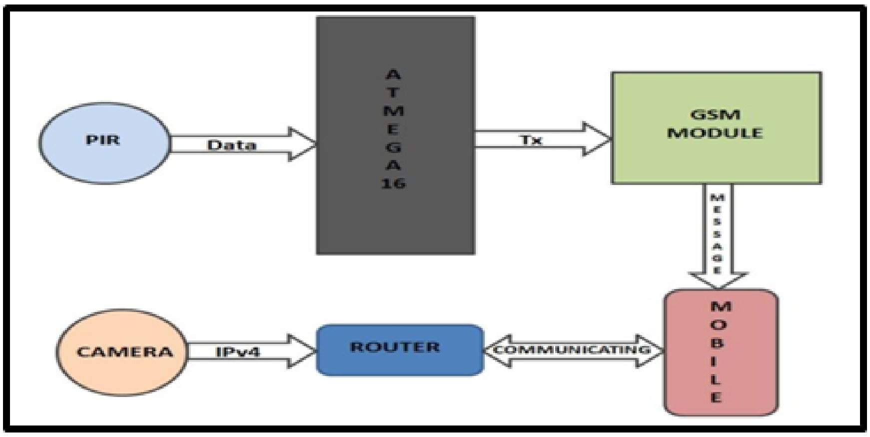


Figure 4: Connectivity of Circuitry Diagram

The first step of this system was to know how many Punches Per Mile put out of service. The output of the Passive Infrared Sensor (PIR) is a number of pulses per mile in a 5-voltsquare wave signal. PIR sensors capture the motionand allow to sense movement, constantly to prove if a human being moved in or out from the sensor area. These sensors are tiny, low power, cheap, uncomplicated to utilize, for this reason, are often found in devices in households and businesses. PIR modules contain 3-pin connector on the surface or undersideas shown in **Figure 5.**

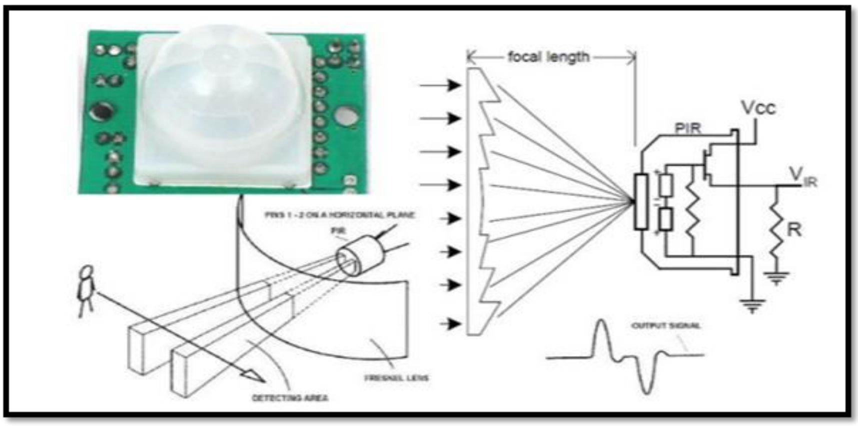


Figure 5: Framework of PIN

Raspberry Pi Based Security System on IoT Platform [4]:

This system is conducted on review surveillance system for motion detection with various aspects. This review assesses the strengths and weaknesses of motion detection algorithms, the communication via push eta and emails will be implemented so that we can upload the images or videos to emails.Live surveillance is also looking to execute if possible so that it can be viewed from anywhere using internet Human Motion Detection.The system includes Raspberry PI (RPi) board with passive infrared (PIR) sensor, vibration Sensor for sensing and the notification will be available on the email or smartphones with buzzer as shown in **Figure 6**.

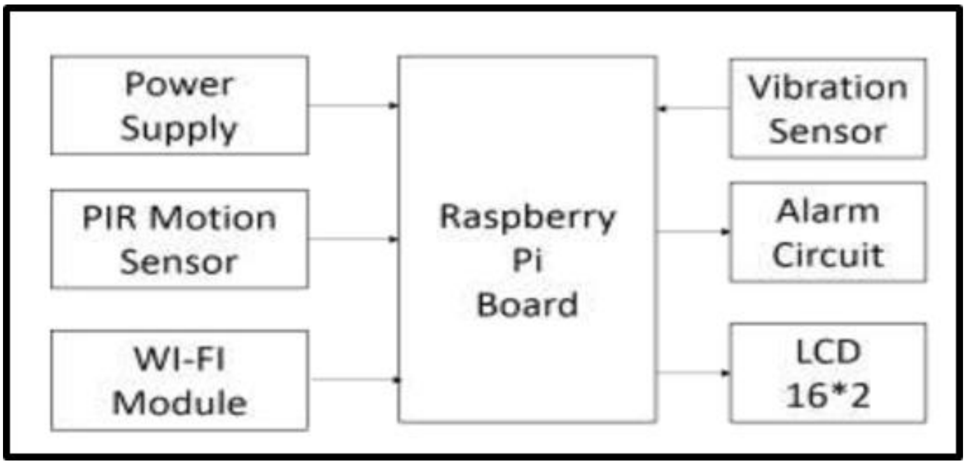


Figure 6: Raspberry pi diagram system

A Remote System for Monitoring Auxiliary Data Center from Environmental threats with Lower Hardware Cost [5]:

This article produces new mechanisms with the objective of saving electrical costs and respecting the business continuity in case of business failure due to inaccessibility of data centers. The objective is achieved by designing and implementing a monitoring system for the environment outside servers. A regular monitoring of temperature and humidity is straightforward because new equipment such as servers can easily cope with energy efficiency by increasing the temperature and decreasing the minimum relative humidity in data centers. The environmental monitoring for outside servers is implemented using open-source hardware platforms, Arduino, Raspberry Pi, and the Gobetwino. Additionally, this system is implemented to view the system logs and status via Internet in real timeand topresent the reads in hypertext markup language HTML.**Figure 7** shows the overall system architecture.

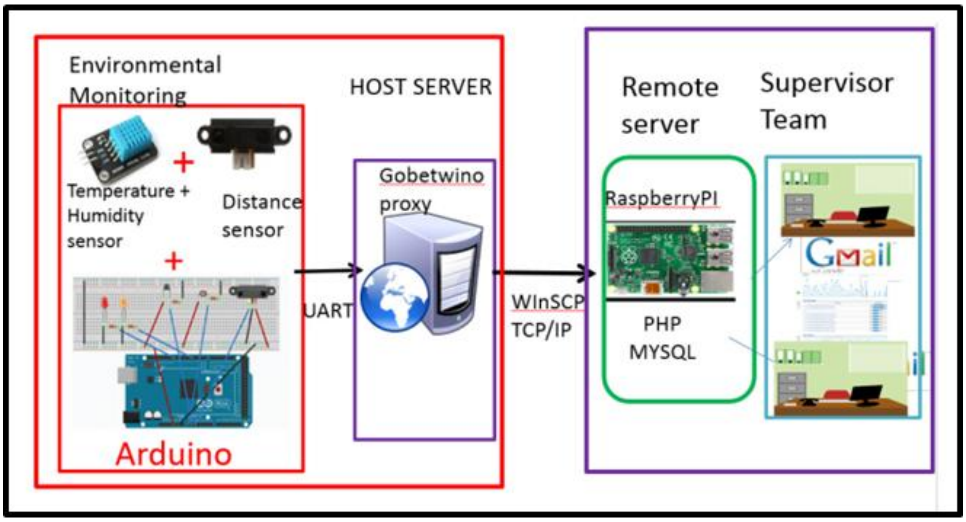


Figure7: Overall system architecture of remote monitoring data center

This system Builds an environmental monitoring requires development and integration of many hardware and software components. (Gobetwino) is listening on the serial port, for "commands" coming from Arduino, and in response it performs something for Arduino and possibly send command to Arduino. Its main function is to safe copying of files between a local and a remote computer. The proposed system developed a script thatperforms a transfer by copying the log sensor file to the remote server on Raspberry Pi. The supervisor team should receive a notification email directly at primary working place. Gobetwino is kind of a "generic proxy" for Arduino. It is a program running on a PC (Windows only), that will act on behalf of Arduino and do some of the things that Arduino can't do on its own. Using the defined command types, commands could be created in Gobetwino as Arduino can request Gobetwino to execute. These commands are used to start a program on the PC, start a program until it finishes, and send data to any windows program from Arduino, like it was typed on the keyboard. Gobetwino is used to send email, optionally with an attached file.

Microcontroller based Real Time WeatherMonitoring Device with Global System for Mobile (GSM)[6]:
The research is about how to develop and implement a simple and low-cost wirelessweather station that get the weather conditions at the remote station and transmit the data to a wireless receiver board connected to the RS-232 port of the PC .The system is based on using GSM model. The system is highly optimized, portable and robust. The system is divided into two main parts: (transmitter) and (receiver) section.

- Transmitter section mainly consists of the sensor circuit, the microcontroller unit, the display unit and GSM module. The sensor circuit contains the temperature sensor, pressure and relative humidity sensor. One sensor provides analog output, which is converted to digital form using Analog-to-Digital Converter (ADC) in the controller and another sensor provides digital output which is further processed to get temperature, humidity and dewpoint temperature. Those measured parameters will be displayed on LCD display. Block diagram of the overall system is shown in **Figure**8.
- Receiver section consists of a GSM unit which is interfaced to laptop or desktop computer. Software collects the data coming from different weather monitoring devices and presents them in a user interface map. Data is also saved for further analysis and possible weather forecast.

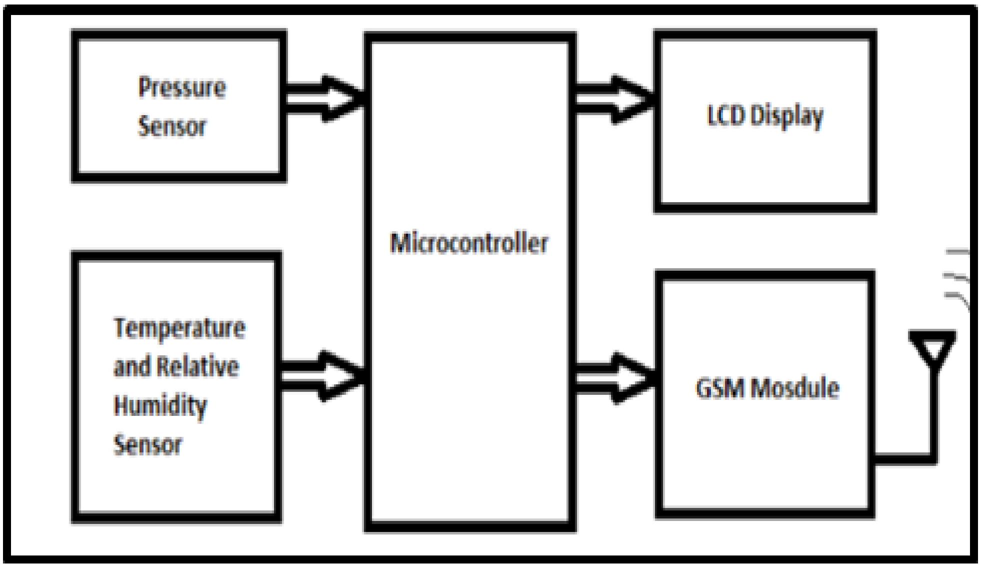


Figure 8: Block diagram of weather monitoring device- transmitting section.

The short Comparison between the Previous Systems and the Proposal System:
Table 1 shows the comparison between the functions of the previous systems and the newly proposed system.

Table 1: Comparison between the previous system and the Newly proposed System

Previous Systems	Proposal system
1. ot enterprise system (local for one place). 2. ot integrated with camera and motion detections. 3. o dashboard for analytics reads and designs makers 4. imitation in system safety as the previous systems host the system in physical hardware located inside the data center. 5. imitation in system fail over.	1. Proposed system is an enterprise system with multiple data center and server room. 2. Add camera sensor and motion detectors 3. Integrated system with access doors system. 4. Apply the encryption technique in the portal 5. Can be integrated with low current system like a air conditions or firefighting system. 6. Use attractive and visualized dashboard to represent the analytics to end user. 7. Provide different channel of alarm system (SMS-EMAIL). 8. No Access limitation on the portal is hosted in public premises over the internet. 9. Apply the business continuity framework and single point of failure. 10. Propose configurable portal to change and save user sittings.

III. The Newly Proposed System- System Overview

The burden of monitoring data center with accurate assessment to apply systems failover is the most important factors for maintenance team in any organization, A newly Data Centers Monitoring System based (IOT) techniques is a full web application system based on internet of things to help the maintenance staff working in datacenter to keep everything organized, and work on their tasks in the most accurate, predictable, and efficient manner. This system is hosted in cloud premises to keep access the services from any time anywhere and more scalable as it could be an enterprise solution for many data centers. Finally, the proposed system undertakesthe task of designing and developing system that satisfies the requirements of user that are easy to use and adaptability for changing requirements, maintainable and has scope for reusability. To do this, it is required to have an effective programming methodology. MVC method The Model-View-Controller (MVC) architectural pattern separates an application into three main groups of components: Models, Views, and Controllers. This pattern helps to achieve the separation of concerns.

MONITORING SYSTEM BASED (IOT) - ANALYSIS AND DESIGN

The system analysis and designsare the main stage in the design of the newly proposed system as it transforms the requirements and needs into a purely programmatic oriented system by defining the architecture, components, modules to proof the concept and to meet the functional requirement.In this section, the authors identify the proposed requirements to define the key application capabilities.The system requirements are divided into:

- Functional requirements.
- Non-functional requirements.

Functional Requirements:
The functional requirements of Data Centers Monitoring System based (IOT) techniques are:

- User shall be able to login/logoff
- User shall be able to change his/her password
- User shall be able to view his dashboard to see all the data center.
- User shall be able to manage tasks and assign them to solve it.
- User shall be able to manage the situation by analytic dashboard based historical data sets.
- User shall be able to print reports for the situation in moment or historical one.
- Admin user shall be able to trace other users' transactions.
- Admin user shall be able to trace system exception logs.

Non-Functional Requirements:
The non-functional requirements of the system are:

- Ease of use
- Effectiveness
- Efficiency
- Easy remember how to use
- Adaptability to changing requirements
- Easy to manage and learn.
- Scalable.
- Easy to maintain.

System block diagram:
Figure 9 shows the block diagram of the newly proposed system. The main parts of the system is the microcontroller Raspberry pi which is connected to a set of sensors to record the environmental conditions and display for monitoring.It takes the actionof alert functions and mentoring the database to record the reads and track the actions.

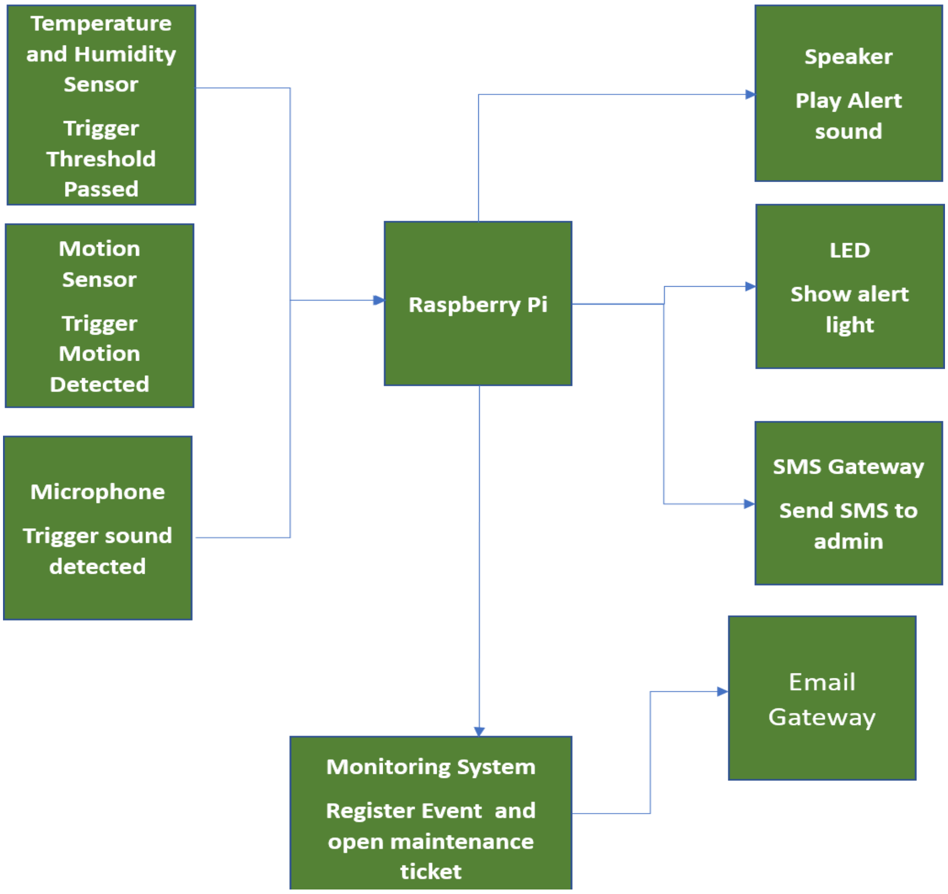


Figure 9: Block Diagram of the proposed system

Tools (Hardwar and Software)

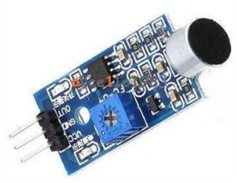
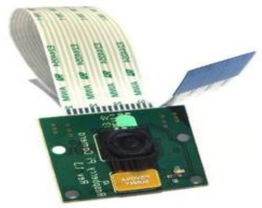
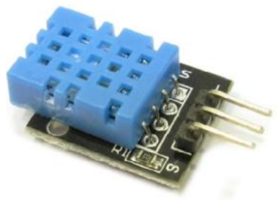
This section describes the hardware and the software components that are used in the proposed system and the purpose for choosing them

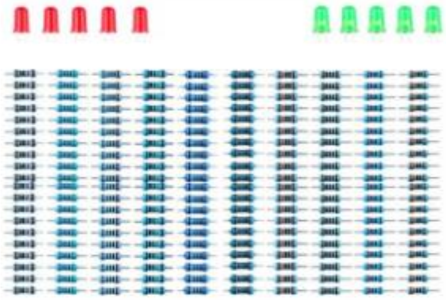
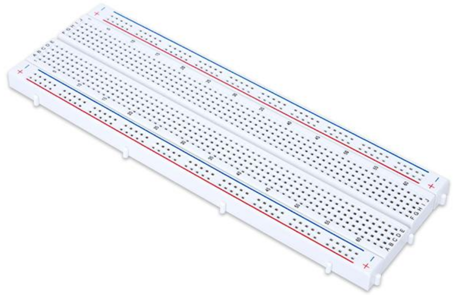
System (hardware):

Table 2 shows the hardware components used in the proposed system.

Table 2: Hardware component of the proposed system

Raspberry PI 4 B with Display Specifications: **Processor:** BCM2711B0 quad-core ARM processor @ 1.5Ghz **Display Card**: 4K-capable Broadcom Video Core VI video processor. **Display Screen:**320×480 resolution 3.5" TFT LED. **Ethernet:**Gigabit Ethernet-Dual-band. **WIFI:**802.11ac wireless networking **Memory:** 4GB LPDDR4 SDRAM Video out :2 X Micro HDMI Output **Motherboard Chipset**: Cortex **I/O Ports :** 2x USB 2.0 2X USB 3.0 2X Micro HDMI Ports USB-C power port 3.5-millimeter analog audio/video-out port. Casing / Optional Cooling Fan.	  
SENSORS	

Motion Sensor : HC-SR501 Adjustable Infrared IR Pyroelectric PIR Module Motion Sensor Human Body Induction Detector	
Voice Sensor Microphone Sound Sensor (High Sensitivity Sound Detection Module) for Raspberryproducts it work with official Raspberryboards	
Camera **Raspberry Pi V2 Official 8 Megapixel HD Camera Board with IMX219 PQ CMOS Image Sensor**	
Temperature & Humidity Sensor KY-015 DHT11 Temperature Humidity Sensor Module for raspberry products it works with official raspberry boards	
SD Card For OS and Software Storage purposes	
OTHERS	
DC Power Adaptor for Raspberry 5vDC 2.5A-3A Power Adaptor – USB C Type	
Active Buzzer Active Buzzer Module KY-012 raspberry module, it produces a single-tone sound when signal is high KY-012	
GSM Module GSM Module SIM 800L	

Electronic Kit Resistors and LED's (Light Emitting Diode) emits light when an electric current passes through it.	
Electronic Bread Board For circuit prototyping Breadboards Kit Include 2PCS 830 Point 2PCS 400 Point Solderless Breadboards for Connecting Blocks	
DC TO DC regulator module XL6019 DC-DC Step Up Converter DC Step-up Booster 3-35V to 5-40V 4A Adjustable Adapter Module Power Supply Voltage Regular For energizing sensors (optional) when additional power supply is needed. Should be directly connected from a battery source/ dc plug going to breadboard +/- terminals.	
Jumper Wires For Circuit connection EL-CP-004 120pcs Multicolored Dupont Wire 40pin Male to Female, 40pin Male to Male, 40pin Female to Female Breadboard Jumper Wires Ribbon Cables Kit	

Descriptions of solution hardware:

Raspberry PI 4:

Is a microcomputer built-in processor running 1.5-GHz, quad-core Broadcom BCM2711B0 (Cortex A-72), Wi-Fi, 40 Input/output ports, 1 Gigabit ethernet 2 USB 2.0 and 2 USB 3.0 plus 2 micro HDMI display and a USB C port.

Raspberry Pi Camera Module V2 8MP IMX219 Camera Module:

It is a Sony IMX219 8-megapixel sensor. The Camera Module can be used to take high-definition video, as well as photographs which is ideal for the photos that will be taken during motion detection.

HC-SR501 PIR motion detector sensor:

Used as the motion detector sensor for the proposed system. The Author has chosen this sensor because of its capability to detect real-time motions within few meters range.

DHT11 Humidity & Temperature Sensor:

The author has chosen the sensor to provide Humidity and Temperature data to the backend because of its stable sensing capabilities and its cost effectiveness. The sensor is carefully calibrated during its manufacturing process which can make precise data.

KY038 Sound Sensor Module:

The sensor is a microphone sound sensor with a potentiometer that can be adjusted to manipulate its sensitivity which is ideal for the system requirements. It also has 2 data outputs (digital and analog) which are required for the proposed system during both testing and production phase.

MB102 Breadboard Power Supply Module 3.3V - 5V:

A power supply for the sensors is required with 3.3V to power up all sensors which are connected to the USB port of Raspberry using a USB to USB cable.

System (software):

Table 3 shows the software components used in the proposed system.

Table 3: Software components used in the proposed system

Programming language backend, frontend tools And main methodologies	• Raspberry Buster Operating System (Linux Distro) • Google Firebase Platform • React.js v16 Library for Front-end • Yarn • Java script ES6 • Python 3 • Python PIP • Balena Etcher • Methodology of system its MVC method (Model-View-Controller (MVC)).

Raspberry Buster Operating System:

A 64-bit operating system, Debian-base Linux distribution which is standard for all Raspberry PI hardware is used as the operating system for the proposed system. This operating system can interface the sensors with the raspberry mainboard.

Google Firebase Platform:

The platform provides the API (Application programming Interface) for the Backend services which is needed for the proposed system such as Authentication, Database, Storage and hosting services. Firebase is capable of Handling REST (Representational State Transfer) transaction which is needed by the proposed system during transfer of data from the sensors to its Realtime database and from its (No-SQL) database known as Fire Store to the front-end. The (No-SQL) database service or Fire store is utilized for the tickets and messaging features of the proposed system which is provided to the front-end. Google Firebase has another feature which is used to upload files which is known as Firebase Storage, this part of the platform serves as the storage section for the photos that are captured during motion detection. This feature allows the front-end presence of the system to be accessible over the internet.

React.js v16.12.0:

Is a library for building user-interfaces and create the front-end part of the newly proposed system, React is JavaScript base library which is capable of real-time rendering when anything have to be updated and as the sensors provide real-time data. React connects to Firebase directly and utilizes all services provided to display all data in the front-end.

Yarn:

A package manager for React.js which is used to download and install modules for React.js. The proposed system has used a lot of react modules such as react-bootstrap, react-data-table, recompose, etc. The package manager downloads all of these react modules and integrates to the system, it also manages the scripts for building the system and running a local webserver during system testing.

JavaScript ES6: Java script is the de-facto language for the web and React.js .It is used to create the class base and functional components for the front-end. JavaScript is capable of real-time rendering of pages and data.

Python 3:

It is used as the programming language for the data collector programs that resides in the Raspberry Pi 4, the author has chosen this language because of its support with Firebase library and sensor libraries.

PIP:

Is the official package manager for Python, it is used to download and manage libraries such as Firebase and Ad Fruit libraries required by the data collector program.

Balena Etcher :

It is used to install the Raspberry Buster Operating System to the SD Card of the Raspberry Pi 4 Hardware.

Designing with UML notations: The newly proposed system is designed based on using the Use Case Diagram

Use case diagram:

The Use Case Diagram is a kind of visualization to show the interaction between the system and the users. Figure 10 is the Use Case Diagram for the proposed system.

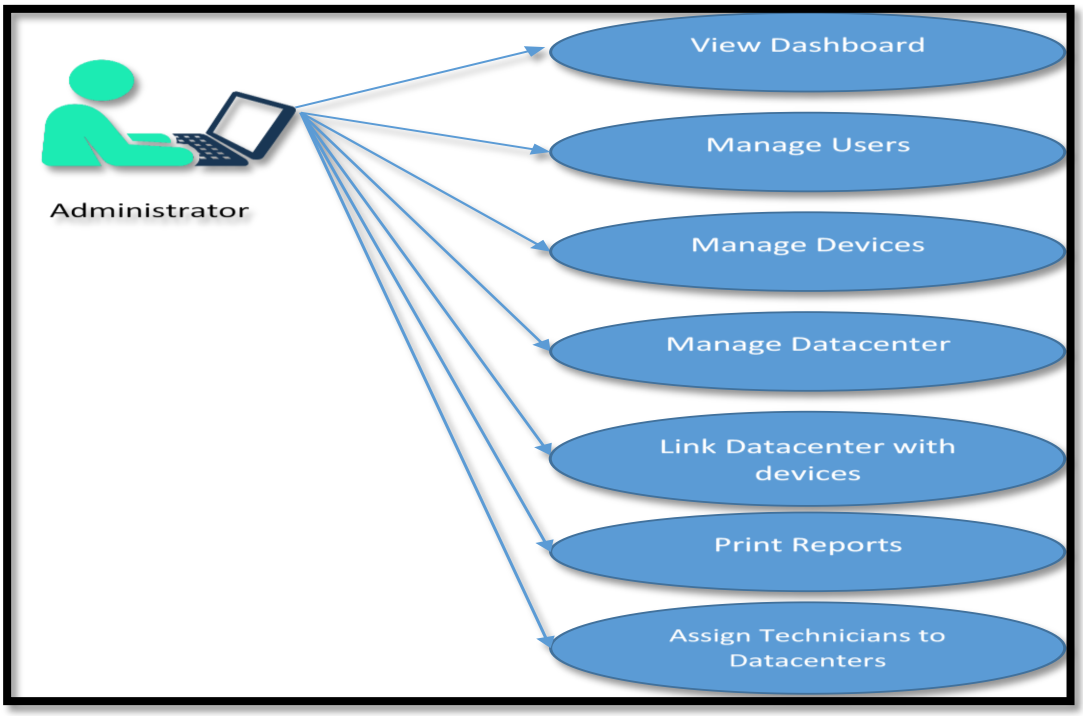


Figure 10: Use case diagram for the proposed system

As shown in Figure 10, the main actor of theproposed systemis the administrator. The administrator is responsible for setting up and managing the whole functions like:

- View dashboard to visualize on time reads of devices with more clarity and usefulness.
- Manage the user "technicians"permeations andalso monitorthe user transactions and reset accounts.
- Manage devices (IOT) parts – setting up and maintaining the sensors according to the maintenance schedules.
- Manage the data center as an enterprise solution that could be scalable to cover many of datacenters.
- Manage and assign technicians to data center.

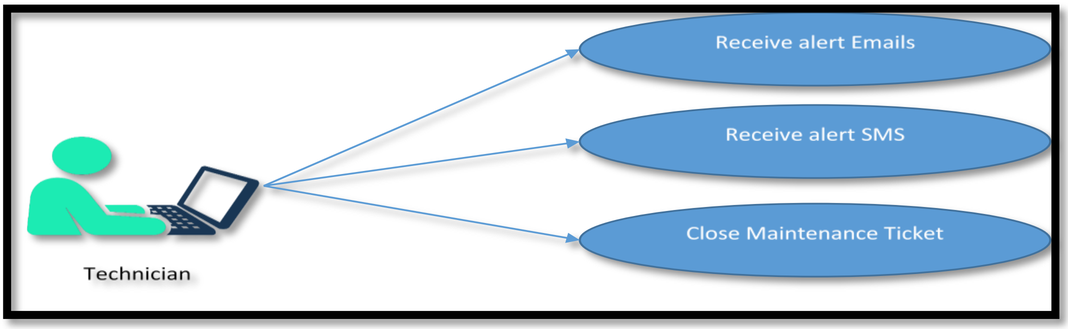


Figure 11: Second actor of the proposed system

Figure 11 shows the second actor of system are the technicians as theyreceive the tickets that are opened automatically by the system and solve the problemsby taking the actions according to the event that happened.

Flow chart ofthe proposalsystem:

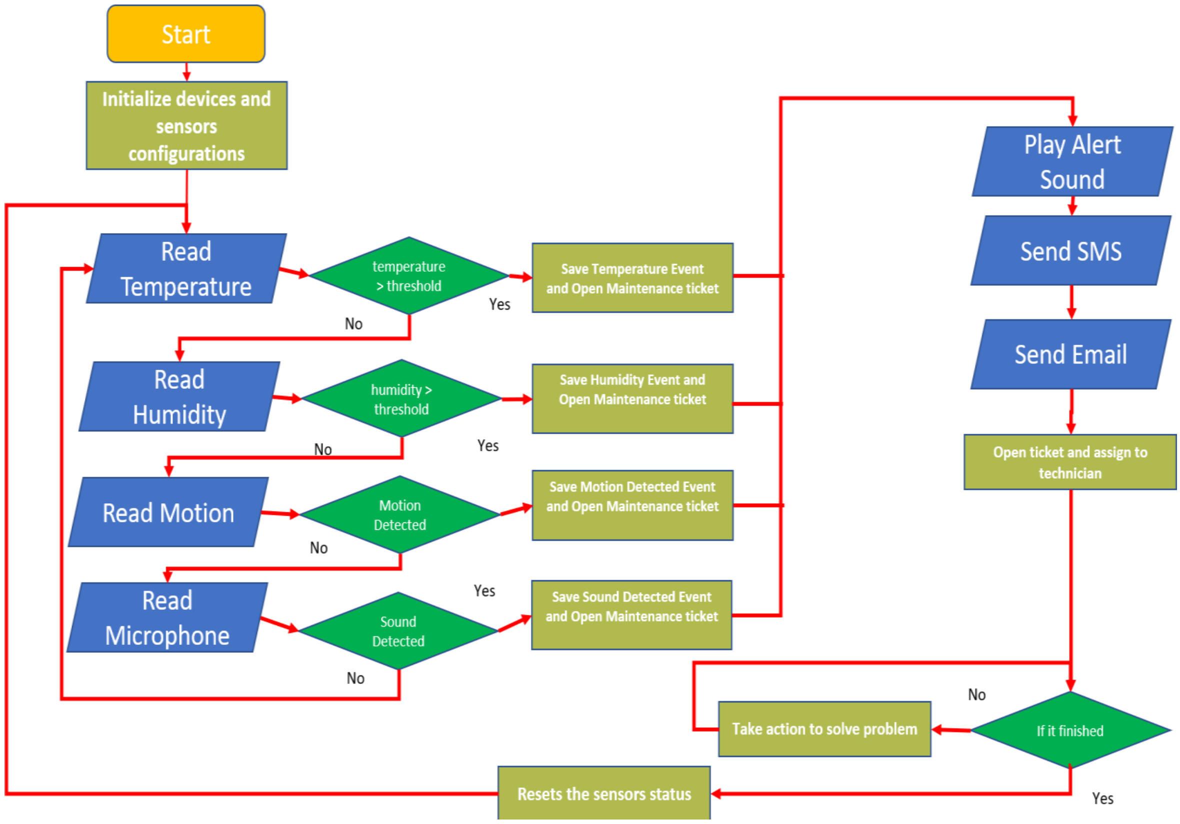


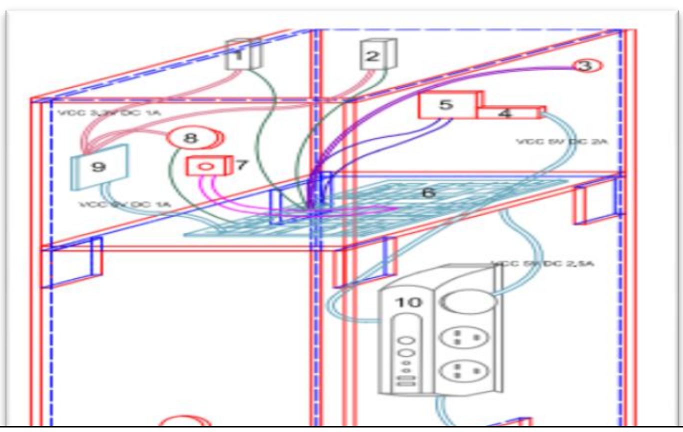
Figure 12: Flow chart of the proposed system

Figure 12 shows the flow chart of the proposed system. The flow chart of system starts by initiating the devices and sensors configurations then reading and recording the IOT devices (signals) (temperature – humidity – motion – microphone). If the reading is crossing the threshold limits defined by the administrator, automatically a ticket will be sent to the alert system. The alert system will send short messages, emails or even voice messages to start diagnosing and manipulating the system. Every alert will be checked by a technician or specialist to start solving the problem. Once the problem is solved the alert resetting process will be activated and the system starts once again keeping the status of the environmental records.

IV. System Implementation And Testing

This section shows the implementation and testing phase of the newly proposed system as shown in figure 13

- **Module design of system hardware:**



Component descriptions	index
DH 11 temperature /humidity sensor	1
Ky 038 sound sensor	2
Buzzer	3
Power convertor	4
GSM module	5
Raspberry bi	6
Camera module	7

	Motion detection	8
	Bread bored power supply	9
	Power extension	10

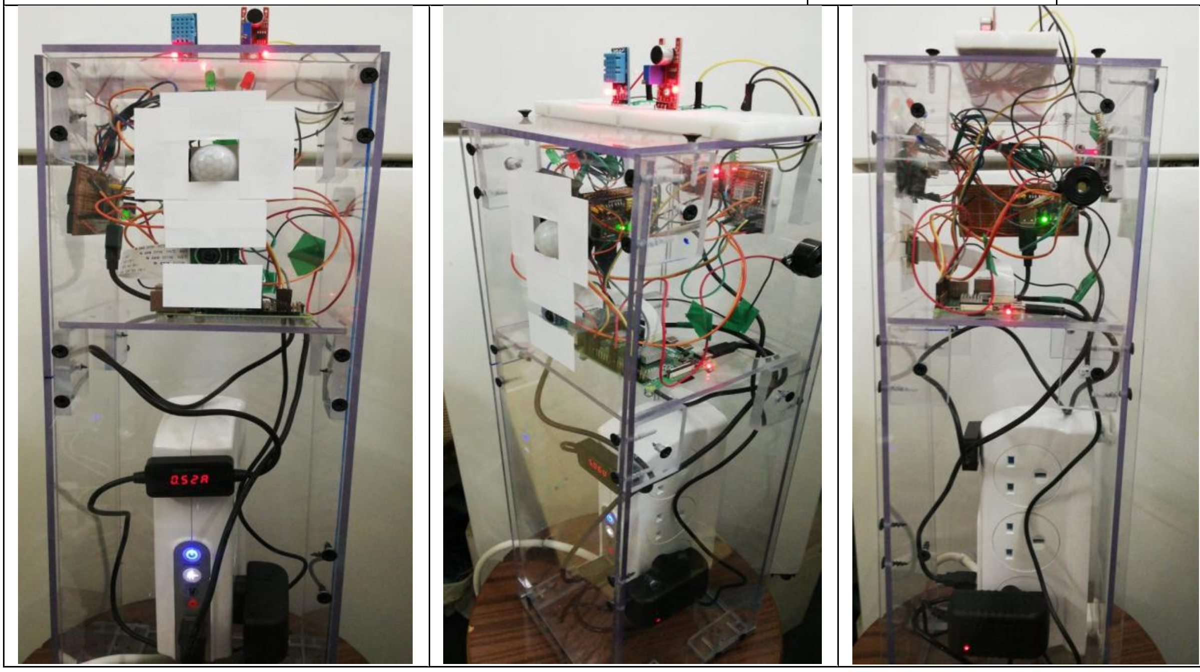


Figure 13 Module design

- **Proposed system screen shot with functions:**

➢ **System domain in internet system (website) :**

Figure 14 shows the main page of system with URLhttps://iot-dtms.web.app/which is hosted in the internet .

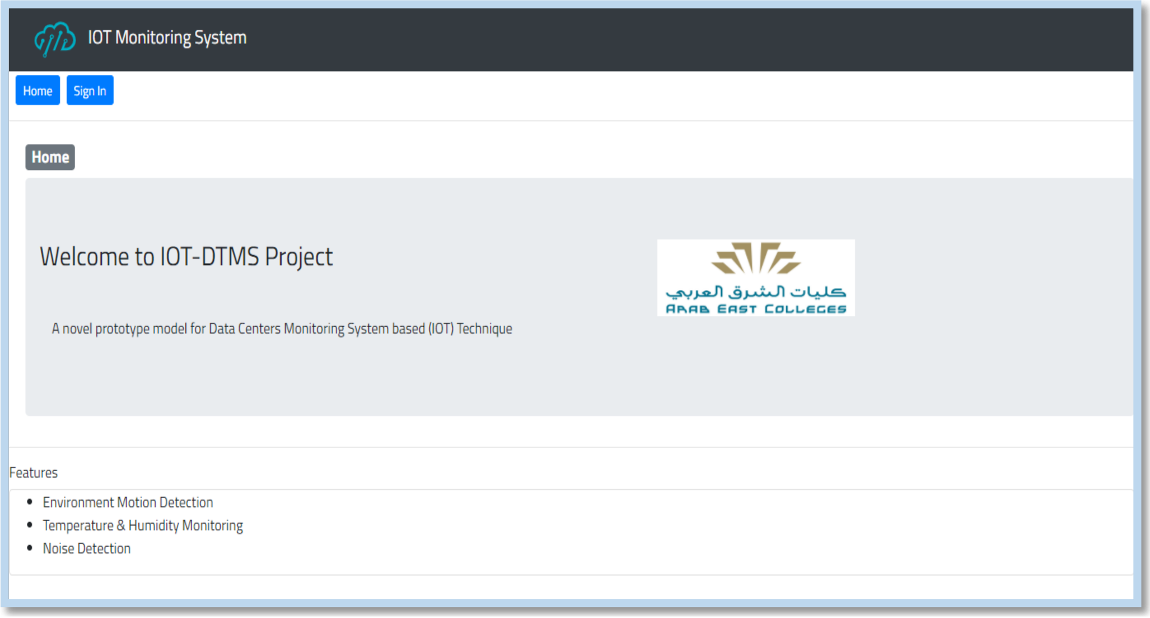


Figure 14 Main page of the proposed system

➢ **Home page descriptions:**

Table 4 Descriptionsof the mainpage

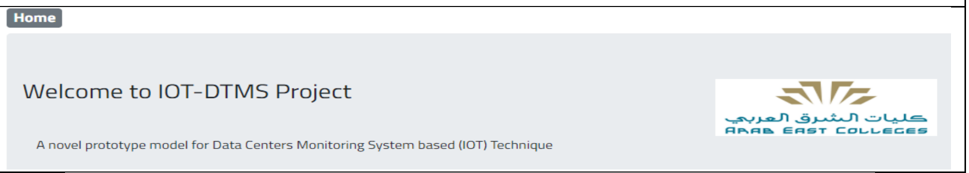
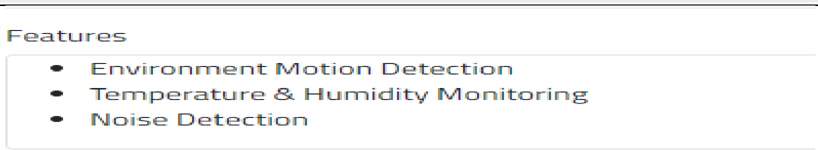
Can be enter to the system according to system permission	
As shown the home page contain the name of system and the college logo	
The system feature	

Table 4 shows simple definition of each component of welcome page.

➢ **Log in page**

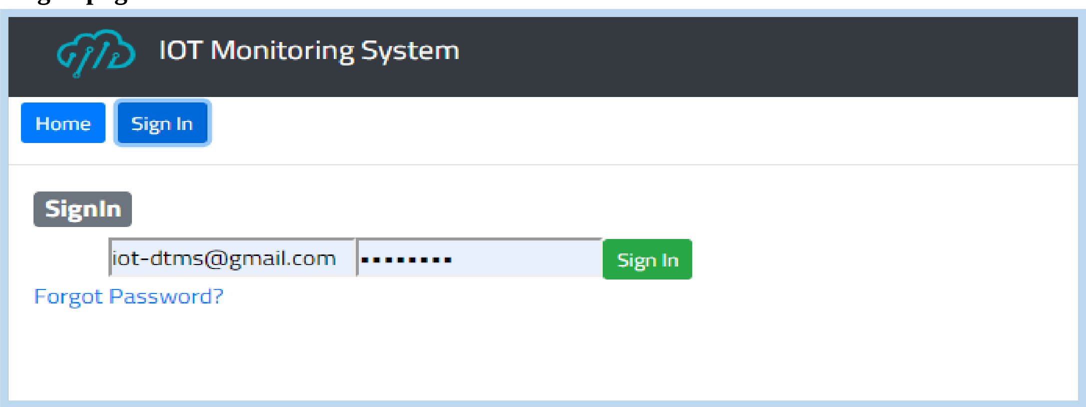


Figure 15 Login page

Figure 15 shows the access to the system with predefined (username and password).

➢ **Main function in the system**

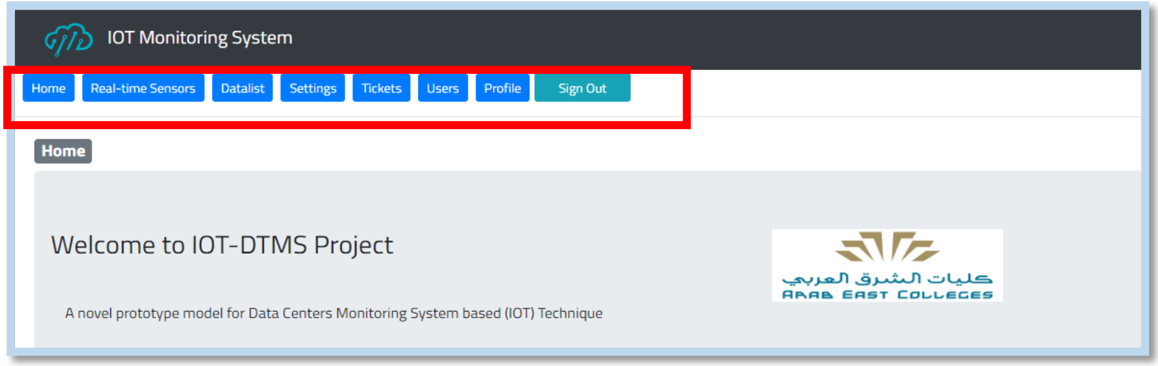


Figure 16 Home page of system

After signing in successfully, the home page with the main functions will be displayed on the screen as shown in figure 16.

➢ **Data list of sensors**

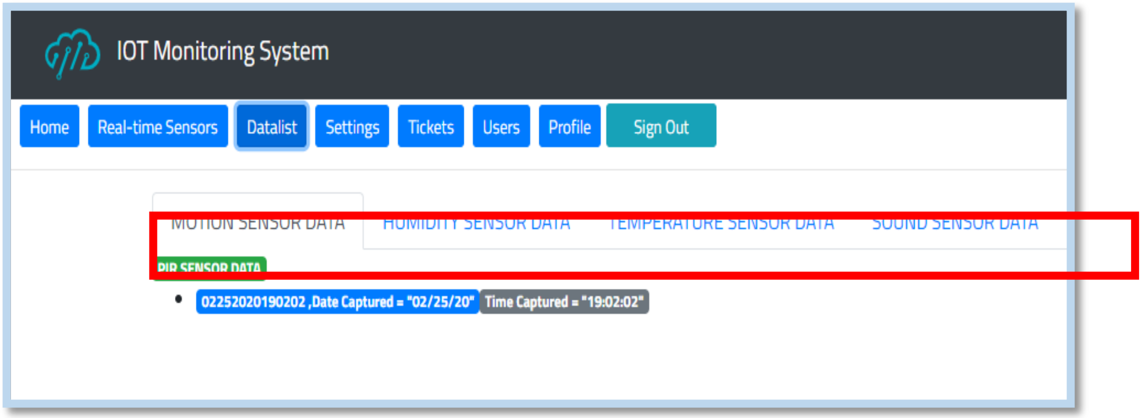
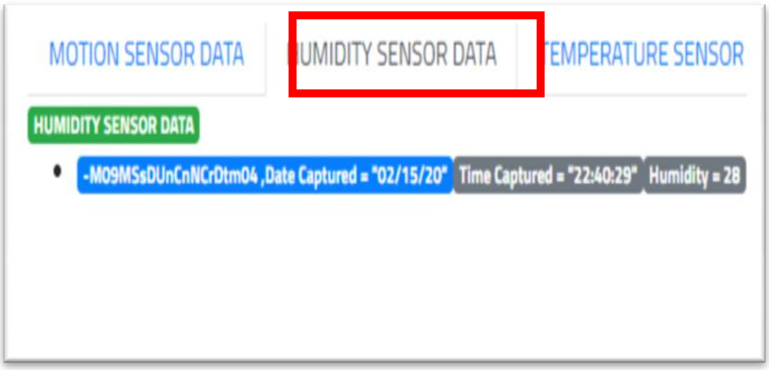
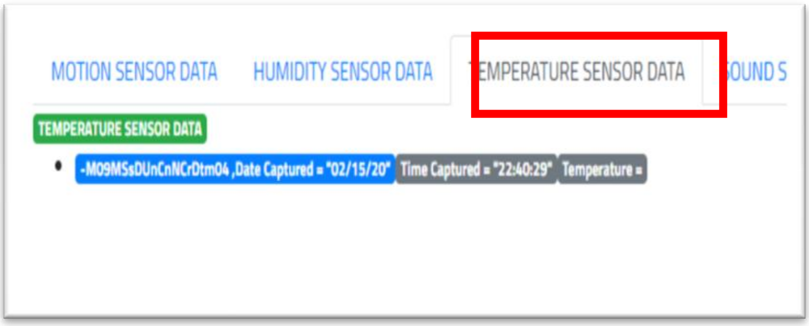
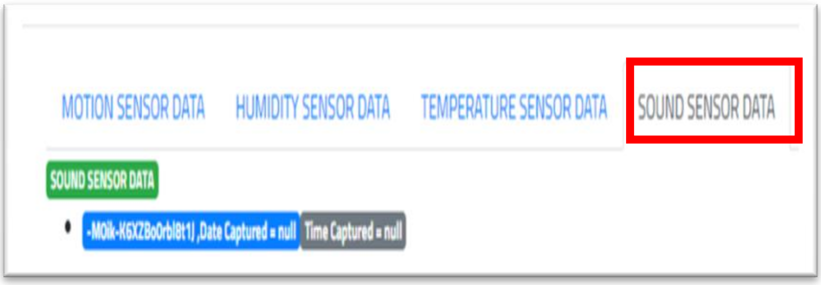


Figure 17 Data list tap

Table5shows a brief explanation of data sensors.

Table 5 Descriptions of data list

Descriptions	Tap of sensors
Motion sensors data it shows the kind and time stamped As " 02252020190202 ,Date Captured = "02/25/20"Time Captured = "19:02:02""	

Humidity sensor data it shows the kind time stamped As " M09MSsDUnCnNCrDtm04 ,Date Captured = "02/15/20"Time Captured = "22:40:29"Humidity = 28"	
Temperature sensor data shows - M09MSsDUnCnNCrDtm04 ,Date Captured = "02/15/20"Time Captured = "22:40:29"Temperature 25	
Sound sensor data shows as -M0ik-K6XZBo0rbl8t1J ,Date Captured = nullTime Captured =	

➢ **Real time data dashboard (indicator)**

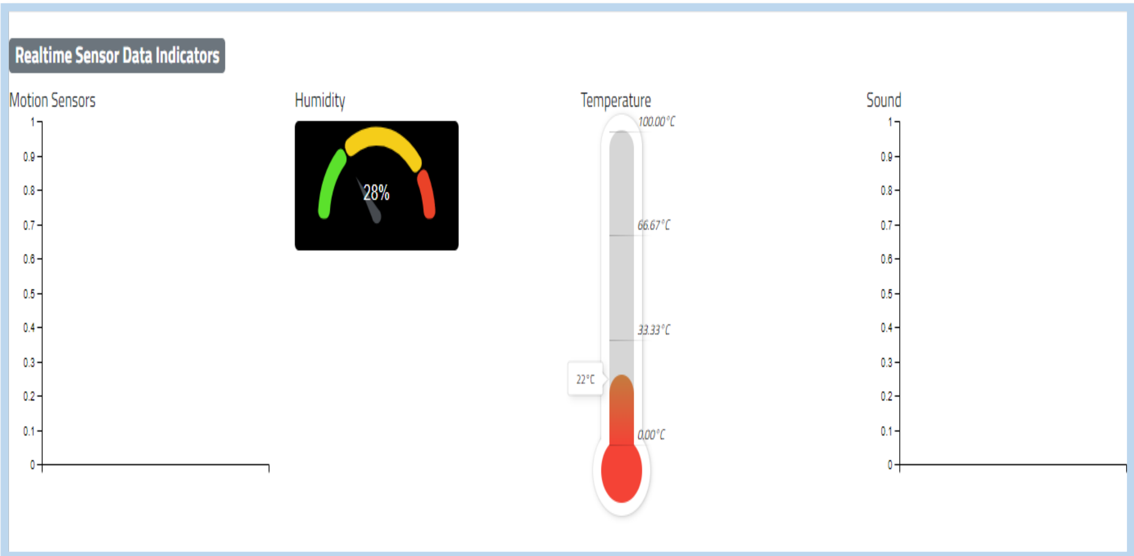
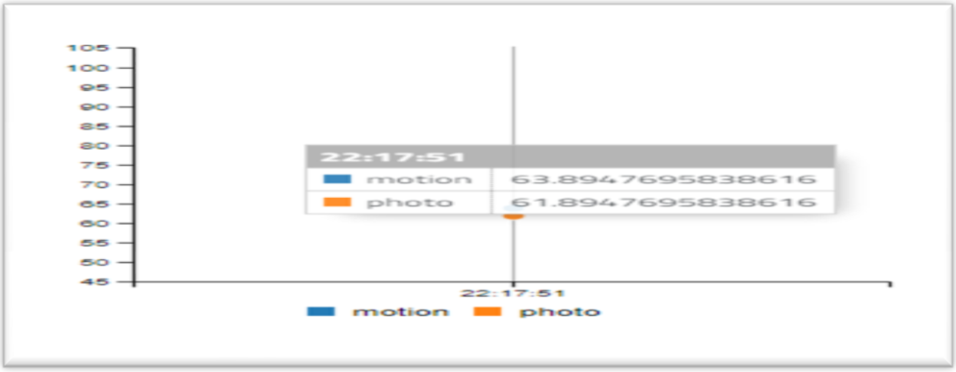
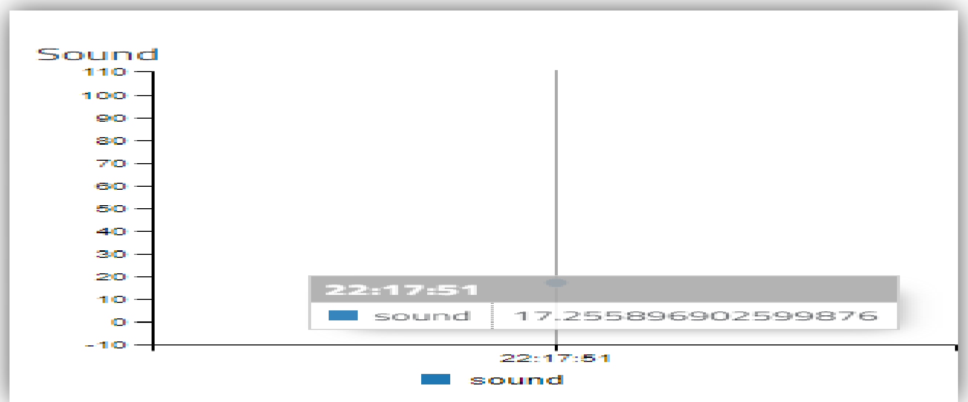
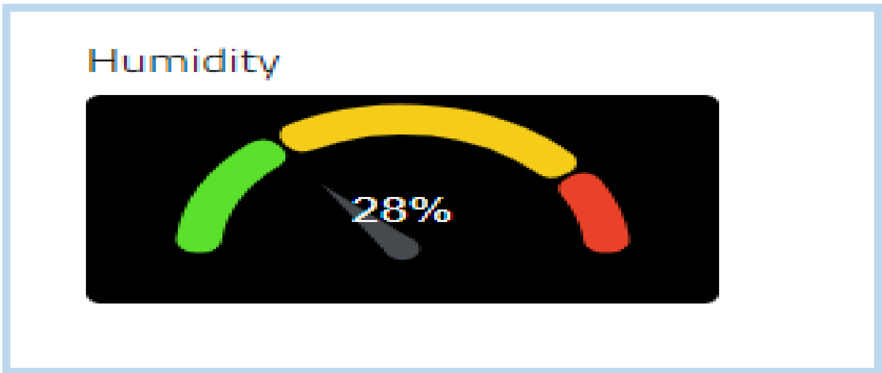
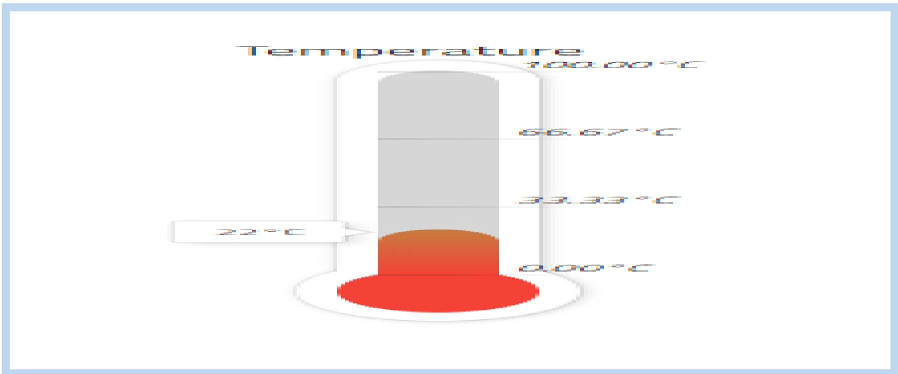


Figure 18 System dashboard

This tap displays system dashboard and it is consists of four chart (motion and photos graph – humidity – temperature –sound) .Itshows real time sensing records while the sensors up and run otherwise it presents last 10 read records.Table 6shows the explanation for each one.

Table 6 Descriptions of each graphs

This graph shows the motion and photos with initial time stamped as reference number	
This graph shows the sound sensor with sensitivity measurement	
This graph shows the humidity sensor with sensitivity measurement and color-based indicator	
This graph shows the temperature sensor with measurement and color-based indicator	

➢ **Tickets**

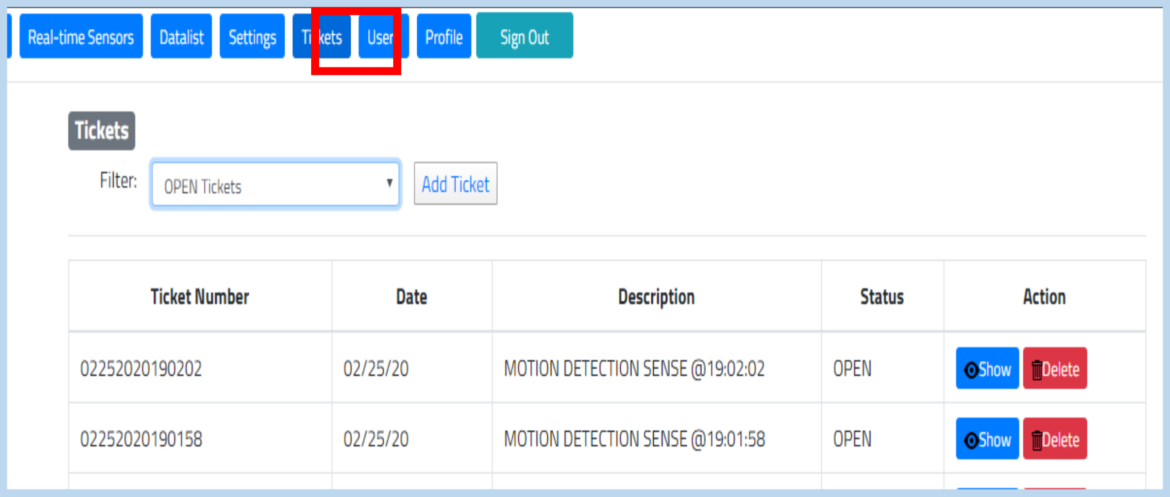
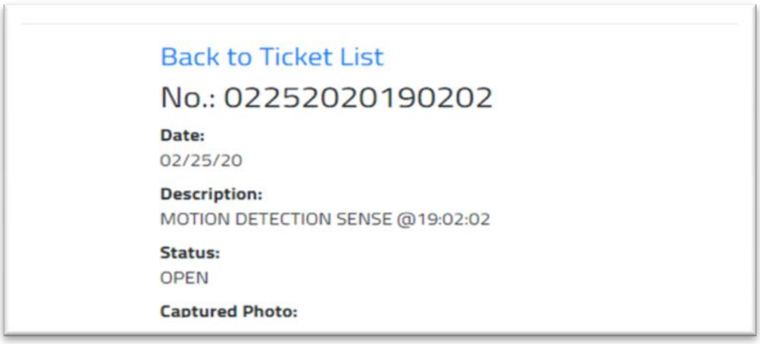


Figure 19 Tickets descriptions

Figure 19 shows the operation ticket that opened automatically when the system threshold is happened and assign it immediately to the technician with the list of metadata as shown in table 7.

Table 7 Tickets metadata

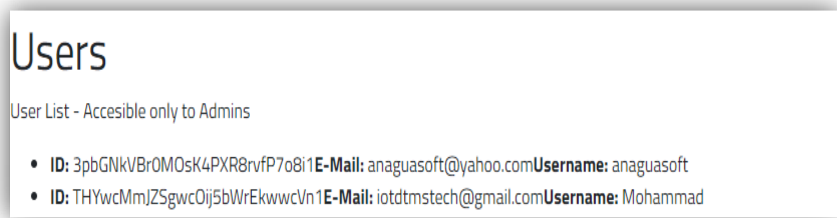
Ticket no	Reference no unique	
Date	Date that the ticket initial	
Description	Contain the threshold and sensor with exact time	
Status	Open – closed	

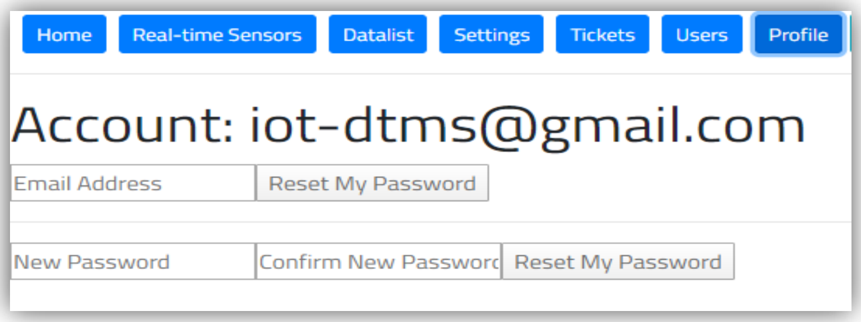
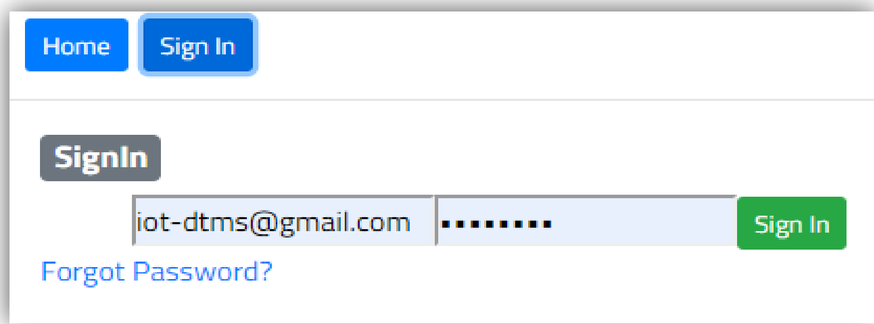
➢ **Users – profile – sign out**:Figure 20 shows the tap contains of (users – profile – sign out) of system.

Figure 20 Users' privilege

Table8showsthe descriptionsof users' privilege.

Table 8 SystemDescriptions

The user shows the list of system	

Profile shows change password	
Sign-out Logout from system	

➢ **System settings:**

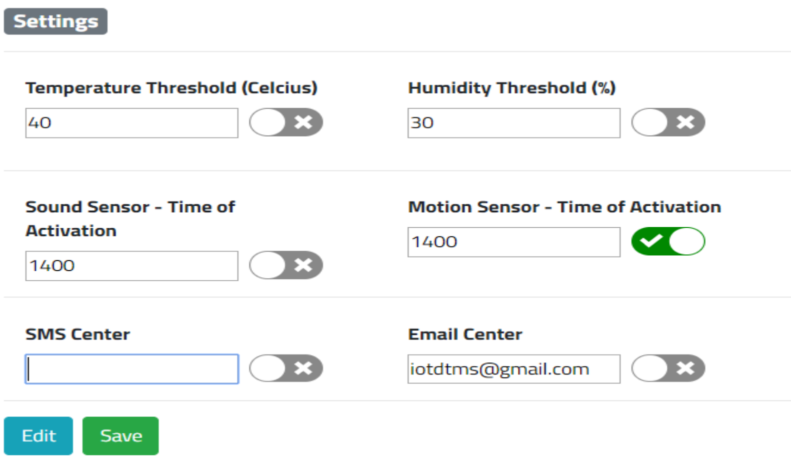


Figure 21 System Settings

Figure 21 shows howthe system admin can configure the sensors threshold according the business need.

V. Cost Analysis

Table 9 shows the cost analysis of the proposed system

Table 9 Cost analysis of the proposal system

Item Description	Qty	Unit	Unit Price in dollar	Total Price in $
Raspberry PI 4b	1	pc	100.00	100.00
Humidity and Temp Sensor (DHT11)	1	pc	4.00	4.00
PIR Sensor (HC-SR501)	1	pc	8.00	8.00
Sound Sensor (KY-038)	1	pc	9.33	9.33

Toshiba SD Card 32 GB	1	pc	10.67	10.67
Breadboard Power Supply	1	pc	4.00	4.00
Dupont Wires	3	set	4.00	16.00
Prototype PCB	1	pc	4.00	4.00
Power Adapter	1	pc	15.73	15.73
USB Micro to USB-C Adapter	1	pc	2.40	2.40
SIM 800l Module	1	pc	39.73	39.73
Active Buzzer Module	1	pc	4.00	4.00
Bread Board	1	pc	5.33	5.33
LED and Resistors	1	set	5.07	5.07
Raspberry LED Display	1	pc	42.67	42.67
Raspberry Camera	1	pc	34.67	34.67
Digital Multi-Tester	1	pc	17.33	17.33
Soldering Iron	1	pc	9.33	9.33
Soldering Lead	1	roll	5.33	5.33
Total Cost				337.59

VI. Conclusion and future work

In this paper authors aimed at providing an integrated solution for monitoring the environmental turbulences in data centers to achieve the concept of business continuity 24/7 based on one of a newest technology that is used in Fourth Industrial Revolution called Internet of things IOT. In addition to that some of the latest articles of IOT especially in monitoring and protecting data centers are introduced. Design ,implementation and testing of a newly proposed IoT based system had been detailed .Future work will be dedicated for deploying this prototype model in real environment and evaluate it with global metrics . In addition to that extending the feature of system and integrate it with some system in security domain like: Access control -Low current systems (firefighting – air conditions – video management systems VMS) and SCADA systems.

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