Design and Implementation of IoT Based SCADA System

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***Abstract*— Development in the IoT (Internet of Things) established appliance has become the state-of-the dexterity technology amid the researcher due to the availability of the Internet all over. To invent the appliance more user convenience, cloud, automation, and IoT-based technologies have acquired their significance in this ‘cutting edge technology. In this paper, the IoT-based Supervisory Control and Data Acquisition (SCADA) system is proposed that can access and control the parameters data from anywhere in the world. This system can overcome the limitations of conventional unidirectional data monitoring and control devices that are currently being used. However, this design will consist of a cloud server, android apps, and a GSM module. The system can operate by cloud server real-time data monitoring and optimizing information using IoT. Thus, the main aim of this work is to construct a security system that is more secure and knowledgeable.**

Keywords*— *Internet of Things (IoT), SCADA systems, Cloud-Server, parameters (sensors) condition monitoring.

I. INTRODUCTION

The IoT-based SCADA system reached the level of excellence in modern days. To come this through, many developments are deployed by the researchers. SCADA technology is used in many ways in the modern world, i.e., control and monitoring systems, distribution systems, networking systems, and many other domains. Internet of things or IoT is a system of reticular computing devices, which is capable to transfer data information through the network while requiring system human-human or human-computer interaction. Moreover, Human-machine interaction (HMI) has become, more realistic and more progress in everyday life due to the development of current technology. [1]-[2]. Merely it’s a networking system that is internet-connected objects able to collect information, monitoring information, stored information, and interchange information.

IoT and SCADA applications are not only restricted in a certain field but also, it has shown the consequential subscription from small scutum appliances to large scutum appliances such as E-commerce [3], Coal Mine [4], Wearable devices [5], Smart Grid [6], Laboratory Monitoring [7], Agriculture [8] and many other domains [9]-[12]. Nonetheless, we have obtained enormous development in the technology, but we still face a lot of limitations on conventional unidirectional data monitoring and control systems as well as an automatic operating device which is one of the substantial problems all over the world.

Consequently, using our IoT-based SCADA device authorized can get the opportunity to optimize 24hours monitoring parameters facility, and most importantly this system operates automatically. Besides, this system is specially designed for the user who wanted to use the network and start secure communication online through the internet and controlling all parameters with the help of a mobile phone. Therefore, providing a sufficient security system is the main concern. Ultimately, the aim of this research to ensure the security of industry/garment workers and goods in case of fire or toxic gas leakage and also providing additional facilities such as measuring current, voltage, and power.

II. LITERATURE REVIEW

As the value for Automation and IoT is enhancing day by day, therefore, SCADA is the next generation area of research to deliver automatic entrance for controlling the home/industrial application with the aid of IoT. This research paper has been started to innovate IoT-based SCADA systems for industrial and commercial purposes. The revolution is the combination of both IoT and SCADA in the same approach.

Research performed on IoT based automation system is reported in [13], [14], [15], [16], [17]. Eventually, many previous systems based on these techniques is either based on Remote control, DTMF or Bluetooth system [13], [18], [19], [20], [21], [22]. Meanwhile, the problem is in the remote-control system requires a physical connection. Besides, the primary issue with the DTMF-based automation system essential devoted PSTN channel for monitoring and controlling devices. Contrariwise, Bluetooth is convenient for small-range connectivity. In this research, an IoT-based monitoring device surely overcomes these limitations. The mechanism of this device operated automatically so that there is no human effort, no remote and no Bluetooth connection required. However, this device can self-regulating which can collect data from sensors and exchange data to cloud-server and also in mobile phones.

On the other hand, the early SCADA system was named DCS which is for Distributed Control system. It had some limitations. Previously SCADA system runs with UNIX, VMS, DOS. But now most running in the Windows operating system, some of which can run in the Linux system. Present SCADA system data gateway supports up to 200,000 server points for large-scale projects and also it can translate between any number of available protocols. The primary SCADA system doesn't support the DNP3 secure authentication. However, our developing SCADA system supports selective logging event data into a real-time-stamped sequence of events (SOE) log file [23], [24].

Besides, other traits can be incorporated in the smart industry for monitoring and controlling. The main purpose is to contain the sensors in real-time information and cameras that can capture entering and outing people in 24h. Moreover, making the device more secure and intelligent, that can have the capability to automatically turn on the motor, light, air-conditioner, and other electrical appliances of the area as well as using sensors it detects the temperature, humidity and also detects any kind of toxic gas leakage.
As a consequence, with this motivation, we conquered to implement an IoT-based SCADA system that can be monitored by mobile phone such as SMS alerts as well as mobile apps. Although, web-based service for controlling and monitoring parameters. In contrast, for security purposes, the user-define command was set which enables the operation of the system as real-time data.

III. DESIGN AND MODELING

A. Working Models

As shown in Figure 1, the working principle of IoT-based SCADA system. Initially, all sensors are measure data automatically and start exchanging data to the SCADA device. Furthermore, the SCADA device is secure and saves all the information of sensors to the cloud-server with help of IoT. To ensure, that the internet connection does not turn off, the main controller is programmed to establish an automatic connection with the available network and connected to the auto power backup. However, if any problems occur in a security system, this device quickly sent that information to the authorized as an SMS alert. Therefore, the authorized can immediately take action on it. Also, this device will collect data continuously 24hour and operates automatically. For security purposes, we have delivered the user access verification code through Gmail that will be asked by the could-sever to verify which will prevent unauthorized smart device access. After successful verification, users will be able to access their web server and start monitoring and controlling all parameters.

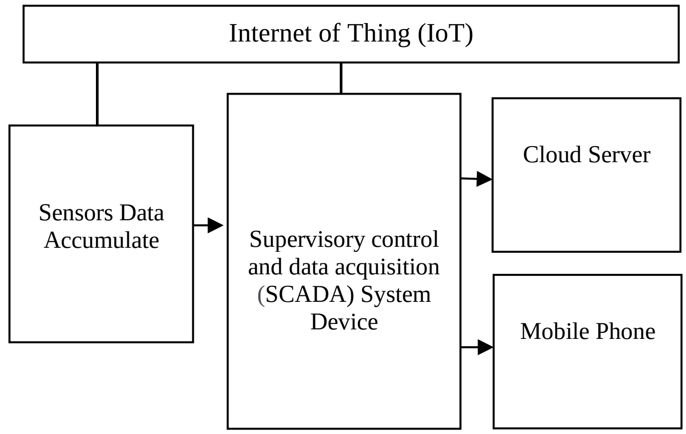

Fig. 1. IoT Based SCADA System architecture.

B. Working Block Diagram of The Device

As shown in Figure 2, the power supply system consisted of two 15 V 5500 mAh Li-Po batteries which were connected to Arduino UNO R3, Node-MCU, and lastly DC motor. The batteries are using to power up all the above-mentioned electrical components such as sensors, LCD, and other particular electrical elements. Contrariwise, the Arduino UNO R3 is using on this device as a microcontroller. Moreover, this microcontroller ATmega328P has 14 input-output digital pins, 16 MHz frequency ratings, 5V operating voltage, and 32KB flash memory. Furthermore, several sensors are used such as the MQ-2 gas sensor, DTH-11 temperature, and humidity sensor, PIR motion sensors, YG1006 flame sensor, LDR sensor. The sensors were sent data to the Arduino UNO and the microcontroller collect data and exchange data through the cloud-server with the help of internet connectivity. The GSM module SIM800L is used for receiving digit commands by SMS from the phone. ESP8266 (Node-MCU) Wi-Fi module used as a chip for connecting microcontrollers to Wi-Fi network communication and make TCP/IP connections through the server and exchange data continuously, IP address link is 192.168.43.32. Node-MCU (ESP8266) is an open-source firmware that provides the flexibility to build the IoT-based application [33]. In addition, the relay is performing as a switch to observe the production lines, and motors, bulbs, DC fans were used as a load of the system. Similarly, the 16x2 LCD was used to observed the condition of the sensor. Besides, to measure current the CT meter were estimated on the device. Finally, the SCADA device monitoring information and keep it in the Thing-Speak™ server. Afterward, it visualizes the information and analyzes live streams in the cloud. The connection diagram of the circuit is shown in Figure 3.

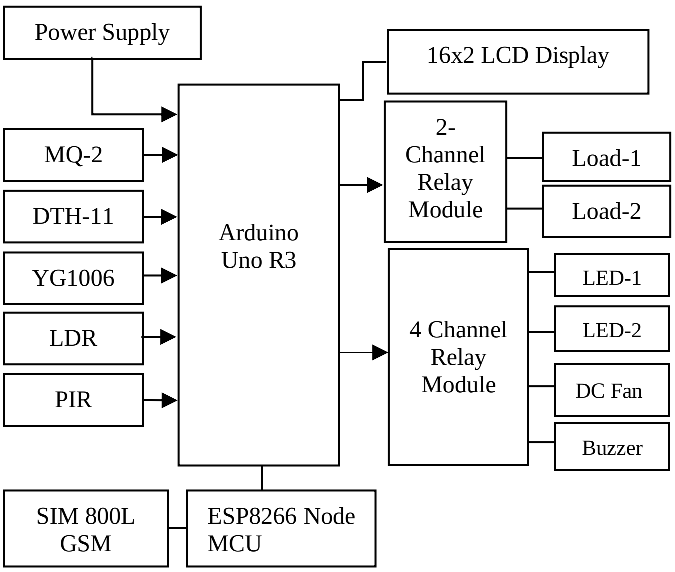

Fig. 2. Block Diagram of IoT Based SCADA System.

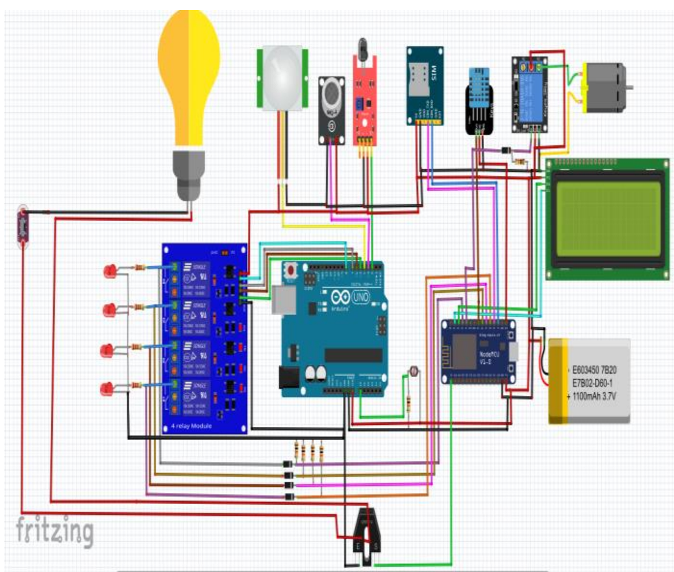

Fig. 3. Schematic Diagram of IoT Based SCADA System.

IV. IMPLEMENTATION & RESULT ANALYSIS

For the hardware implementation mechanism, the sensors will exchange data through the server 24/7h, and deliver the data to the cloud server as well as the mobile application. The authorized can easily detect the condition of the system using his mobile phone because the data is operating in real-time by the server. The supervisory system gathers data on the process and sends the commands control to the process. Most importantly, if there were any unconditional prevent accidents happened in the system (e.g. fire detected) it will automatically send the information to the user phone as an SMS alert as well as get the red signal alert instantly. Here, we used different kinds of sensors (MQ2, flame, DTH-11) controlled by a microcontroller (Arduino UNO) and for the load, we use a DC motor and a blub. The CT meter were able to observe the current of the system as the prototype represent in Figure 4. All in all, this device consists of sufficient security protection.

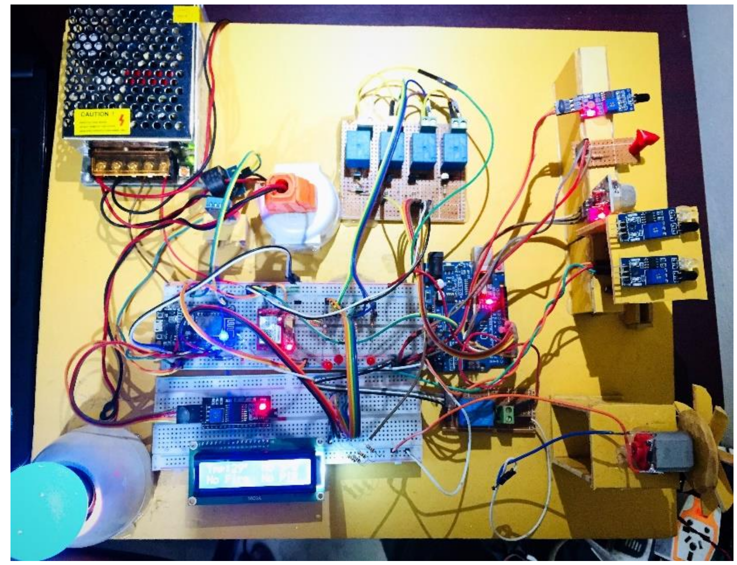

Fig. 4. A prototype model of IoT based SCADA device

A. GSM Module Performance analysis

GSM module is a chip or circuit that is used to establish communication between a mobile or computing machine. At first, it digitizes the data and sends it as an SMS alert. if there any inconveniences occur in the system (e.g., Gas/Smoke detected) it will automatically generate the data to the client's mobile as an SMS alert. Although, the monitoring parameters information generates through the SMS within 1 second. In this paper, we use the GSM module for SMS alerts. However, when any sensor was detected, it will inevitably engender SMS alert to the owner such as fire sensed as show in Figure 5.

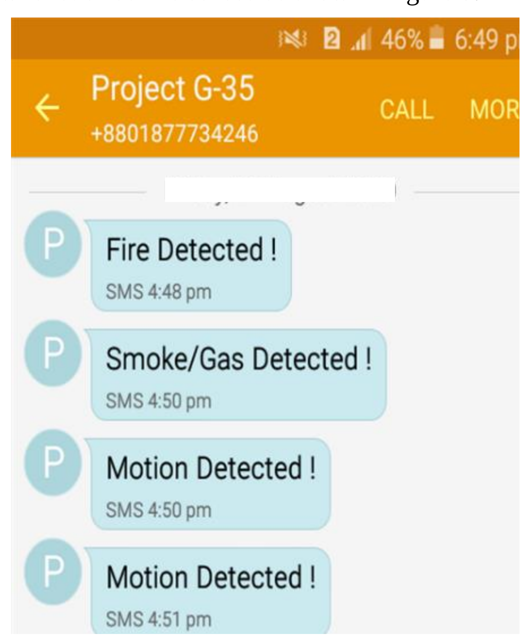

Fig. 5. Performance Analysis by GSM Module.

B. Result Analysis by Cloud-Server (Thing-Speak™)

In this research, we used Thing-Speak™ cloud server for specialist and sensor performance test as well as observation. Thing-Speak™ is an IoT analytics platform service that allows us to aggregate, visualize, and analyze live data streams in the cloud. The mechanism of Thing-Speak™ provides instant visualizations of data posted by device sensor to Thing-Speak. By using, the Gmail address and correct password users can access the information of the system using IoT real-time data to optimize any area of the world as we shown sensor data presentation and result in Figure 6, Figure 7, Figure 8, and Figure 9.

C. Temperature (DTH-11) Sensor Performance Analysis

The DHT11 is a fundamental, ultra-ease advanced temperature and humidity sensor. It utilizes a capacitive moistness sensor and a thermistor to quantify the encompassing air and lets out an advanced sign on the data pin (no analog input pins required). The sensor operating voltage is 5.5V DC and the temperature range is 0°C to 50°C. The graph of figure-6 illustrates to observe the temperature will be changed through the condition of the weather. The temperature (in Celsius) by the vertical axis and the time is represented by the horizontal axis. Most of the temperature remains at 29 ° C it depends on atmospheric conditions. As shown in figure 6, at a certain time when the temperature increasing and reached 33°C then the DC Fan turns on automatically. As the test was performed at different times so that the graph of temperature will fluctuate.

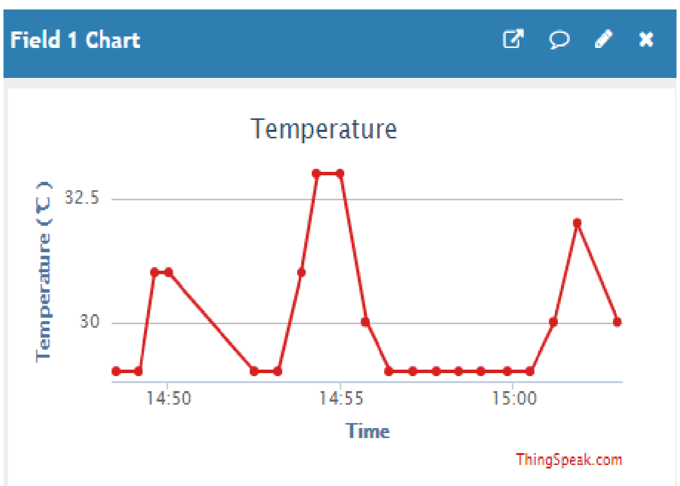

Fig. 6. Temperature (DTH-11) Sensor Performance Analysis

D. MQ-2 (Gas/Smoke) Sensor Performance Analysis

The MQ2 has an electrochemical sensor, which changes its obstruction for various groupings of fluctuated gasses. MQ-2 is a semiconductor type of sensor and the concentration range of the sensor is 300-10000ppm. When the concentration level is 0300ppm then the digital output value of the sensor LOW (0) and if the concentration level increased up to 300ppm then the digital output value becomes HIGH (1). The digital value (0,1) represents the vertical axis and the time represents the horizontal axis. As shown in figure 7, initially, the gas concertation remains at 0ppm, it only performs when gas is detected. If gas/smoke is detected then the digital value gets HIGH as a consequence, the graph has risen 0 to 1 as shown in figure 10. Afterward, the power will automatically turn off and also sent the information instantly to the users as an SMS alert.

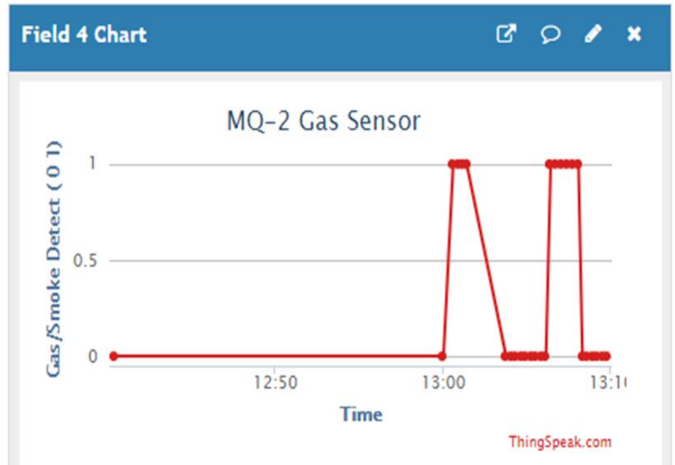

Fig. 7. MQ-2 (Gas/Smoke) Sensor Performance Analysis

E. Flame (Fire) Sensor Performance Analysis

The flame sensor can observe fire and infrared light origins with wavelengths scale from 760 nm to 1100 nm. It operates the LM393 comparator chip, which provides a digital output indicator e.g. High (1) or Low (0), and a driving capacity of 15 mA. In this project, the flame detector is used in fire alarms and other fire detecting devices. The digital value (0,1) represents the vertical axis and the time represents the horizontal axis. The graph is grown LOW (0) to HIGH (1) only when the fire is detected and the indicator red signal turns ON as shown in the given figure 8.

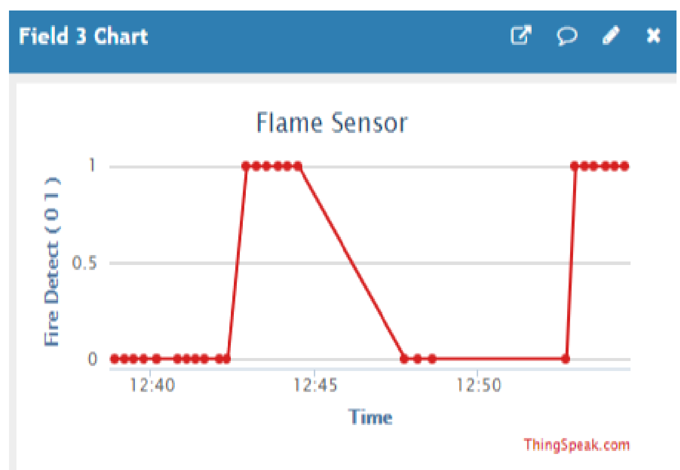

Fig. 8. Flame (Fire) Sensor Performance Analysis

F. CT Meter Performance Analysis

A CT meter only measures a fraction of the current passing through the connection and a multiplier is applied to this reading to reflect the actual current. In this research, the use of a CT meter for observing the total amount of current of the load (e.g. bulb, fan, motor). Representation of the graph for observing that the current will be changed through the condition of the load. The current (in milliamperes) by the vertical axis and the time represented by the horizontal axis. The value of the current depends on the load, if the loads were increase then the current will be increased. Initially, the current is in 0mA but when the power supply is turned on, it increases up to 110mA as shown in figure 9. After some time, when the DC fan is turned on, the current grow slightly from 100mA to 165mA. But when the device is turned off then instantly the current falls into 0mA. However, when the device again turns on and the load power is increased consequently, the current has risen from 0mA to 207.12mA as shown in figure 9.

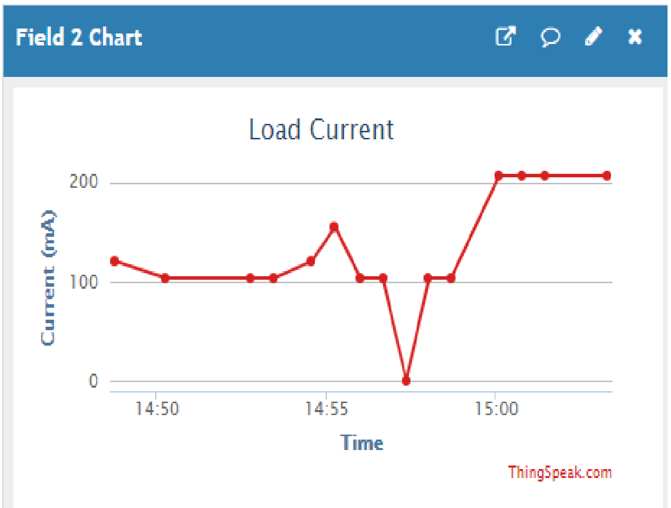

Fig. 9. CT Meter Performance Analysis

In this paper, we have shown the example of the monitor and control system of sensor data that we have designed for the smart security device. Figure 11 shows the prototype model of IoT based SCADA device. For continuous operation of the circuit, all data are continuously monitored in real-time data and save in the cloud server as shown in Figure 6, Figure 7, Figure 8, and Figure 9.

V. CONCLUSION & FUTURE WORK

In this research, the unique method of using IoT and SCADA systems in equivalent tactics for the secure and more effective security system is researched. With the help of this device, any safety and control system can be converted into a smart and intelligent device. The working of the projected prototype was experimentally revealed with the assistance of connecting several sensors as well as internet connectivity. A planned system has two advantages. First, using IoT connectivity, we can display and admittance our smart appliances simply from anyplace, which will undeniably demonstrate be more user suitability, competence, and protection. Secondly, all data are recorded in the cloud-server accordingly the sensor's information as a real-time monitoring system, therefore the user can evaluate all evidence. In the future, this device can be improved with many features and components as using this technology we can develop not only an industrial and home automation but also innovation a whole city where all the guide automatic and control by the webserver. As a consequence, we can provide a protected, more intellectual, and more advanced human life. This paper provides an exceptional and reliable mechanism design of a SCADA device with IoT support.

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