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Design of a Microcontroller Based Internet of Things Based Weather Station

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ABSTRACT
Information about environmental conditions around us is usually obtained either from television or radio broadcasting. The world has changed, people are nowadays too occupied to find time to listen to or watch a weather channel. This paper proposes an Internet of Things(IOT) based solution which can convey real time informationabout environmental conditions to users with an internet connection either via a personal computer or a smart phone. The system proposed in this paper uploads data from environmental sensors to a cloud based IoT platform known asThingspeak. Thingspeak has two primary functions: plotting of data and storage of data. The main reason for sending information to a server is to enable the information to be accessed anywhere in the world at any time of the day. The system consists of sensors and circuitry to compile as well as display environmental conditions like temperature, relative humidity, light intensity and carbon monoxide levels. The core of the project is the Arduino Uno R3 microcontroller and the ESP8266-01 Wi-Fi module of which all devices/sensors are connected. The code is written using the Arduino IDE before it is uploaded onto the board. Once the code is uploaded, the system is connected to Wi-Fi through the ESP8266-01 board. Though the proposed system only monitors temperature, humidity, light intensity and carbon monoxide levels in the atmosphere, it can be made scalable to accommodate more sensors. This project also lays down concepts on how an organization can implement their own IOT based weather station that is suitable for their needs such as for weather monitoring or farm production.

Keywords: Arduino Microcontroller,ESP8266-01 Wifi module, Internet of Things, Thingspeak, Weather Station

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I. INTRODUCTION

A weather station can be described as a systemor plant which provides information about weather in a specified geographical area. An automated weather station is a system that measures and records atmospheric parameters using sensors without human intervention. Parameters such as pressure, humidity, wind and temperature are those that can be compiled to give an overview/forecast of weather conditions. Monitoring conditions using sensors provides results which are accurate, also making the system to be faster and more reliable. The internet is a network of networks consisting of private, public, academic, business and government networks that are linked by a broad array of communications and network technology, all using a standard internet protocol suite (TCP/IP). Internet of Things is a new technology that connects things or devices to the internet (integrated seamlessly) for which data provided by these devices may be used for various purposes i.e, weather forecast of a particular place [1]. IOT technology enables for human to human interaction, human to device as well as device to device interaction [2]. The applications for this technology are somewhat limitless. With respect to homes, IOT is used in the development of smart homes enabling users to have access and control over equipment within the home anywhere in the world, e.g, the gate, doors, lights as well as water heating system [2]. Industrially, specifically the energy sector, IOT is applied to create smart grids which detect and respond to changes in energy consumption of a particular place [3]. Furthermore, IOT is now being applied in the health sector [4]. That is, smart watches which are incorporated with sensors to give out data such as heart rate and body temperature [4]. This data is then accessed by doctors as a means of monitoring a patient’s health in the comfort of their home anywhere in the world [5]. Many companies such as Hitachi, Cisco, Bosch, Amazon and others have already invested heavily on IOT technology. With reference to the economic aspects of the technology, it is expected that by the year 2020 IOT would be worth trillions of dollars[6]. Individuals who are working in offices or busy with household chores have no idea about the environmental parameters outside their home or office. More and more people have less time to tune into the radio or watch television (traditional methods of conveying information) in-order to obtain information. Global warming has led to rapid changes in weather. More floods occurring, extreme variations in temperature, wind speed as well as pressure. Places which did not previously experience these conditions on extreme levels are now doing so. Through IOT technology, an economically feasible solution can be provided for these individuals. Weather monitoring for farm production is also very important. This paper presents a low cost system to implement an efficient Internet of Things based weather station. The system presented is scalable but the paper only focuses on monitoring temperature, humidity, Carbon monoxide levels as well as light intensity.

II. LITERATURE SURVEY

There are various models/ways by which an IOT based weather station might be developed. Figure 1 below shows models that might be used . These models or monitoring systems are Sensors, Zigbee, RFID Tags, Mobile phone sensing and WSN measurement nodes.

2.1 The Zigbee Model

The first model uses zigbee based wireless sensor networks to monitor environmental conditions. Zigbee technology was created by the Zigbee Alliance which was founded in the year 2001 [8]. Zigbee is characterized by low cost, low data rate, relatively short transmission range, scalability, reliability, flexible protocol design.. It is a low power wireless network protocol based on the IEEE 802.15.4 standard [9].Zigbee has a range of around 100 meters and a bandwidth of about 250 kbps [8].

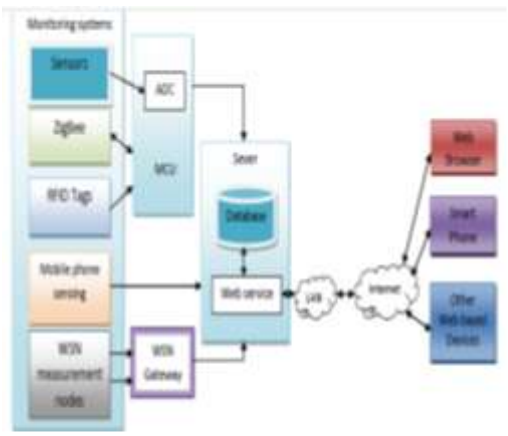

Figure 1: Existing models [9].

Zigbee has two operating modes; the beacon mode and the non-beacon mode. In the beacon mode, zigbeecoordinators/modules and routers continuously monitor the state of end devices by always checking for incoming data. Coordinators and routers in this mode do not sleep hence leading to more power consumption. In the non-beacon mode, when there is no transmission of information from the end devices after a set period of time, routers and coordinators enter into sleep mode. This type of mode is less power consumptive compared to the beacon mode. Moreover, zigbee has three topologies; star, cluster tree and mesh [9]. Any topology consists of one or more zigbee modules. Star topology is set up such that the zigbee module is at the centre of the end devices. Communication is directly via the module. The network range of this type of topology is usually shorter. Cluster and mesh topologies consist of zigbee modules as well as several routers. The difference between the two is how routers are placed to create the network. Both cluster and mesh topologies have a wider network coverage because of the introduction of wireless routers. Figure 2 shows these logical topologies.Zigbee technology, due to its characteristics, is widely used in home automation, agriculture, industrial controls, medical monitoring as well as power systems.

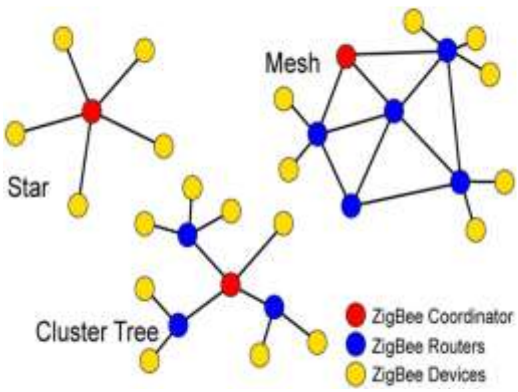

Figure 2: Zigbee logical topologies [8]

2.2 Rfid Model

The second model in figure 1 uses the Radio Frequency Identification(RFID) technology to provide a means for monitoring. RFID is a system that transmits the identity of an object wirelessly using radio waves [7]. The system's components include tags, reader, software, antenna, access controller and a server with the main components being the reader and tags. A tag has an identification number and a memory that keeps additional information such as type of product, manufacturer as well as environmental conditions. The reader is able to read and/write data to tags wirelessly [7]. In an RFID application, tags are attached to objects that are in need of identification.

A tag consists of two major things. An integrated circuit for both modulating and demodulating of a radio frequency signal, storing data as well as processing data, it also consists of an antenna for receiving and transmitting a signal. Tags may also be incorporated with sensors as a means of monitoring certain parameters within the region/space in which they are deployed. Furthermore, tags can be classified into three based on the method of power supply; active tags, passive tags and semi passive tags. An active tag is one which has its own power supply (battery) embedded within its circuitry. This type of tag continuously sends data to the reader without having to be prompted by the reader. A passive tag is one which is activated by the reader. It does not have its own power supply. The electromagnetic wave sent by the reader via the antenna is the one responsible for providing a voltage to the tag. RFID technology has a much wider range (kilometres) but the technology is expensive. RFID technology is usually used in military apps, patient monitoring, labelling and tracking of items in supermarkets and factories.

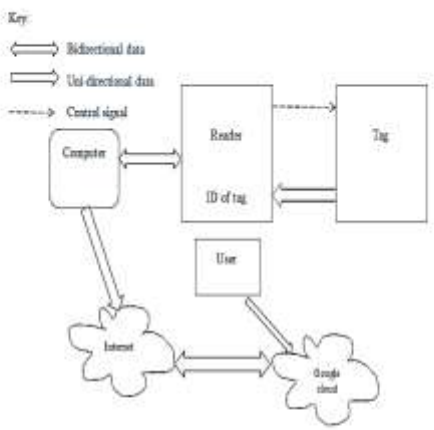

Figure 3: Block diagram of RFID model.

The block diagram of the model is shown in figure 3 above. The system comprises offfour blocks. The first block is the tag. The tag comprises of an antenna as well as circuitry which incorporates sensors. Furthermore, circuitry for modulating and demodulating out-coming and incoming signals respectively is housed within a tag. The second block comprise of the reader. The reader readssensor data from the tag. Since the tag that is being used in this case is a passive tag, the reader prompts and energizes the tag circuitry through radio waves transmitted. Therefore, there is a period of time forwhich the tag is transmitting data and one at which there is no transmission of data making the system to be periodic. The third block comprises of a computer for which data received by the reader is sent to it through special reader software. The received data is then sent to a Google cloud where it can be processed into a meaningful value such as a temperature value which can be viewed by the end user. Also, at the cloud, data is also stored for future references.

2.21. Flow Chart Of The Rfid Model

Figure 4 below shows the flow chart of the model. The scanner scans RFID embedded tags using radio frequencies. The incoming radio waves from the tags are evaluated for validity by checking the ID component of the signal (demodulation).

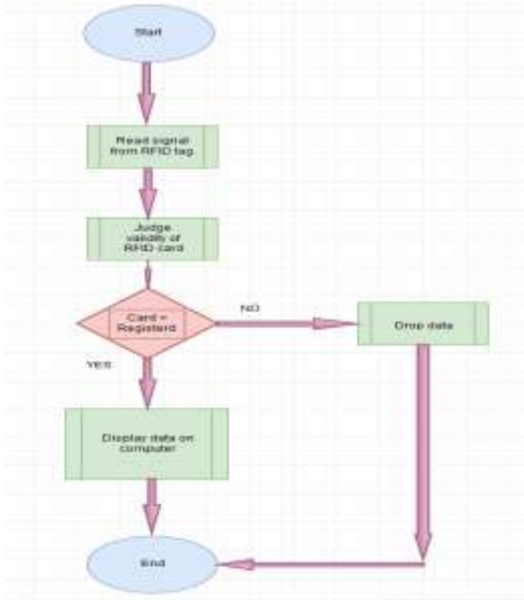

Figure 4: Flow chart of RFID model.

If the ID is valid/registered, the data is displayed on the computer and can be viewed by user else data dropped.

2.3 Wsn Model

The third system depicted by figure 1 makes uses of Wireless Sensor Networking (WSN) for monitoring. WSN is a wireless network consisting of distributed devices using sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants, at various locations [7]. The system consists of a gateway which acts as a network coordinator in charge of node authentication. A wireless sensor network comprises of an end device, gate way node, management monitoring centre and router. An end device collects wireless sensor data, sends the data to parent nodes, then that data is sent to the gateway node from parent node directly or through the router. After receiving information from the sensor network, the gateway node extracts data after packages and analysing then into Ethernet format data, sends them to server. This system is easy to implement and allows for many devices to be incorporated into the network. The main disadvantage of this system is that it requires for the management monitoring centres of the system to be those which are compatible hence enabling communication with one another.

2.4 Mobile Phone Sensing

In another system, mobile phones (smart phones) are the key elements. That is, mobile phones that are enabled with sensors are used to determine conditions within the area of the phone [11]. The data from the phone is then wirelessly sent to a server. The server provides web pages, mobiles phones, PC's as well as other internet enabled devices with access to the uploaded data. Environmental conditions from any location in the world can now be accessed or viewed.

2.5 Wsn Measurement Nodes

In this system which is the proposed system in this paper, sensors are deployed in the environment of interest for computation of parameters of interest. That is, sensors are used together with a microcontroller which converts the analogue values from the sensors into their digital equivalent values. The digital values are then sent to a server where they can be accessed for analysis through the internet. The values sent to the server are raw values, that is, they have no real meaning. Through special programs such as Matlab, these values may be compiled to give out parametric figures which can now be understood clearly.

3.0 .Proposed Model

The proposed model which is microcontroller based is shown in figure 5. The model comprises of four blocks. The first block is the environmental parameters that are to be monitored or measured, in our case these are light intensity, temperature and humidity as well as carbon monoxide levels. The second block, block 2, consists of sensors which are responsible for measuring/detecting the parameters to be monitored. Block 3 consists of the microcontroller device which is the Arduino Uno, which will make decisions based on the values retained from the sensors. That is, it processes the data based on the code uploaded onto it (decision making). Furthermore, the block is characterized by identification of which parameter data it is representing. Block 4 incorporates the Wi-Fi module which will send data to the cloud Thingspeak. At the cloud, data that has been sent via the Wi-Fi module will be processed, stored in the cloud i.e. Thingspeak. End users can access the data using mobile phones or PC's with an internet connection.

3.1 Architecture Of The System

Figure 6shows the block diagram of microcontroller based model. The system to be implemented consists of a microcontroller (Arduino Uno) as the primary/main processing unit for which all devices, sensors, are connected to it.The sensors are operated by the microcontroller which retrieves data from them and processes it.The analysed sensor data and updates retrieved data is transmitted by the Wi-Fi module (ESP8266) connected to the cloud.At the cloud (Thingspeak), uploaded data is processed via Matlab enabling for sensor values to be plotted with respect to time. Trends can be viewed by a user by logging into the platform or via their mobile phones with an android application installed in them or just through an internet browser

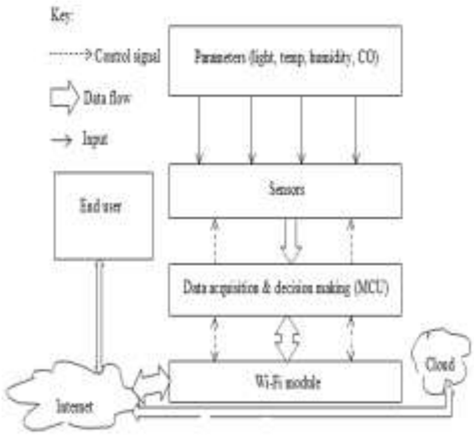

Figure 5: Diagram of sensor network model.

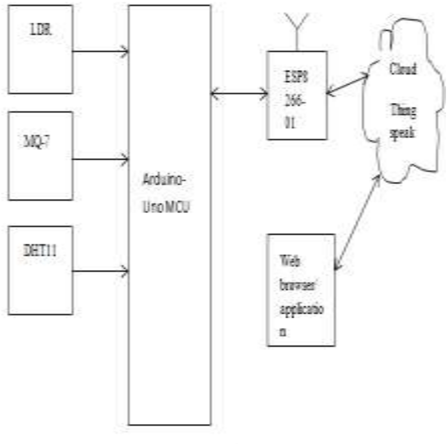

Figure 6: Block diagram of proposed system

3.2. Flow Chart Of System

Figure 7 below shows the flow chart of the entire system to be implemented. The inputs to the system are the environmental parameters to be computed, i.e, temperature, humidity, light and carbon monoxide. When a signal from a sensor corresponding to a specific parameter is detected (connected sensor), it is processed and evaluated by the microcontroller. The sensor data is then sent to the Wi-Fi module via the MCU's transmitter. The internet connected Wi-Fi module then directs the data to the Thingspeak server where the data is stored as well as plotted on the Thingspeak webpage.

3.3 Thingspeak Cloud

Thingspeakis an open source Internet of things application and API to store and retrieve data from things using the HTTPS protocol over the Internet [12]. Thingspeak enables the creation of sensor logging applications, location tracking applications, and a social network of things with status updates. Thingspeak has integrated support from the numerical computing software MATLAB from Math Works enabling users to analyze and visualize uploaded data using Matlab.

III. COMPARISON OF THE SENSOR NETWORK MODEL AND RFID MODEL

Compared to the other models the Microcontroller based model is desirable because it can be easily implemented with low cost components. The system is also easy to operate as well as troubleshoot. The cost associated with proposed system or model is low when compared to other models. However, theRFID model offers for deployment of sensor devices over a much wider area thereby enablingresults obtained from analysis to be more accurate. Also, since the tags are passive, enormous amount of energy can be saved by this implementation also enabling for a longer lifespan of the device.However, the model is expensive since it will require nano circuit implementation at the tags.The reader and its software are also expensive. Microcontroller based model offers for a system that can be implemented easily. The components associated with the system are relatively low cost and the system itself is uncomplicated. However, the system does not cover a wider area, data retrieved from sensors is of a specific small location. Therefore, redundancy has to be employed for a much wider area.Basing on the above information, it is quite clear that microcontroller based model is much more suitable since it can be implemented easily and can be affordable to the majority of individuals.

IV. RESULTS AND ANALYSIS

Figure 8 below shows the results that were obtained from Thingspeak. The figure shows that there are four field charts of which are relative humidity, temperature, light intensity and CO level.Each chart contains data on the environmental parameter that was measured by a corresponding sensor. Data on field 1 and 2 charts are from the DHT11 sensor.Data on field 3 and 4 are from MQ-7 and LDR respectively. For each plotted data, there is a time stamp showing the exact time for which the data was received.The location at which data was obtained as also shown on the channel location chart provided by google maps. The location in this case is pin pointed to be Gaborone, University of Botswana block 251.

Figure 7: Flow chart of microcontroller based model.

The maximum and minimum relative humidity between 16:54:30 and 17:06:00 was 32% and 29% indicating dry air. Max and min intensity of light was 28 and 18 lumens respectively. The graphs also indicates that every environmental parameter is fluctuating between a certain maximum and minimum value. There is no constant value.

Figure 3: Plotted sensor data on Thingspeak.

V. CONCLUSION AND FUTURE SCOPE

The implemented model can be used as a way of providing information about weather conditions of a particular place of interest to individuals in a manner that is very cost efficient and yet highly effective as shown by the results. By deploying sensor devices in the environment, the environment is brought to real life. That is, it can interact with other devices through the network. Furthermore, data can be stored of which will be helpful for future analysis.

However, the system is not 100% flawless. By making data received at the server to be reliable, a tradeoff was created between reliable data and time to upload ready sensor data. This was due to the fact that the system always tries to start a TCP connection with the server before sending any data. Therefore, data from some the sensors would be dropped at the microcontroller side of the system since the Wi-Fi module would not be ready to accept and send any data. Inconsistencies in period of data upload created by system.

The primary objective was send to sensor data to the server of which the implemented system archived. The implemented solution can be further improved by implementing a mobile application which directly obtain the data from the Thingspeak cloud service. Therefore, information can checked anywhere at any time by using the internet. This will be more beneficial for everyone as in every home there is at least one smart phone these days.

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