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IoT Based Base Transceiver Station Health Monitoring for Smart Mobile Communication System

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Abstract - In wireless communication network such as base station, a smooth network function is necessary. The objective is to enable the smart mobile communication system to continuously monitor the smartness of the BTS. The factors include Temperature, Humidity, Fuel, Smoke and Signal strength and these are monitored by using IoT platform. Thus, our aim is to develop a mobile application which is used to detect any uncertain changes of values in these factors and generates an alert immediately. These sensors are used to sense the environment around the BTS. Hadoop Map Reduce is used to reduce the abnormal data which exceed the fixed threshold values are sensed by these sensors and these faults are fed into a remote user device with the help of ThingSpeak IoT platform, mobile application, and web server. These abnormal values are loaded into the ThingSpeak which trigger the web server to send an alert message to the admin mobile application. Thus, our developed method makes use of a mobile app which gives the instant message about each activity happening on the site to admin. If the signal strength is a week, an alert message sends to the mobile user using a web server. The reduced data is displayed as a graph in the mobile app which is easy for the admin to monitor the performance of BTS.

Keywords BTS Shelter, Mobile station, Arduino, WiFi module, Sensors, Thingspeak IoT platform and Hadoop Map Reduce.

1. Introduction

This smart mobile communication monitors and sends an alert to users. The temperature, humidity, fuel, gas, and RSSI sensors are used to sense the environment around the BTS. Hadoop Map Reduce is used to reduce the abnormal data which exceeds the fixed threshold values are sensed by these sensors and these faults are fed into a remote user device with the help of ThingSpeak IoT platform, mobile application, and web server. These abnormal values are loaded into the ThingSpeak which trigger the web server to send an alert message to the admin mobile application. If the signal strength is week due to this type weather changes the admin will send a message to get a strong signal to the mobile user via a web server.

The related works are used for monitoring and management of powering and conditioning systems within a remote mobile telecommunication site is to be proposed by Pizzuti et. al. [1]. Ajosh. K et al proposed power optimizing system for Base Station that enables users to monitor remotely the conditions of base stations. It gives an alert message to the user via GSM SMS controller.

Figure 1. Mobile Communication Base Station

[2]. Paschke et. al. proposed system is based on client-server architecture, providing data to main monitoring centres using controllers located at telecom sites or with technological controllers of supervised power and air conditioning systems. [3]. Marco Sapienza et al proposed an architectural model which exploits the MEC (Mobile Edge Computing) concept. It uses cooperation among the Base Transceiver Stations (BTS) to rapidly notify the users which are close to the critical area. [4] The detail about monitoring of all technical infrastructure equipment on site power system, HVAC, security, access control system, fire alarm system, copper wire protection is possible by one controller gives by Manoel Eustáquio dos Santos et.al. [5]. Yaguang Guo et. al. a portable, lower-cost Air Pollution Monitoring (APM) device reporting data in near-real time at a high-time resolution using Thingspeak IoT platform. [6].

Sadeque Reza Khan et. al. suggested FCU is an electronic instrument that records the temperature data and takes decision according to that data using PIC18F4520 which includes 10 bit ADC for data conditioning. [7]. Sadeque Reza Khan et. al. uses Voltage Temperature Monitoring System or VTMS for synchronization of the operation of Generator and battery with Microcontroller PIC 16F877A.

[8]. Yi xianjun et.al suggested TMS320F28031 DSP chip controller are to measure & calculate various metering parameters such as voltage, current, power, temperature of BTS.

2. Proposed Method

The proposed method gives the solution for maintaining the BTS smartness and provides information about the signal strength to admin via thingSpeak IoT platform and the message will be displayed in the web server. The temperature, humidity, fuel, gas, and RSSI sensors are used to sense the environment around the BTS. Hadoop MapReduce is used to reduce the abnormal data which exceeds the fixed threshold values are sensed by these sensors and these faults are fed into a remote user device with the help of ThingSpeak IoT platform, mobile application, and web server. These abnormal values are loaded into the ThingSpeak which trigger the web server to send an alert message to the admin mobile application. The signal strength is sensed by using multiple mobiles if the signal strength is low due to change in weather conditions like rain, storm etc., which sends information to the mobile user to get better signal strength via a web server. The admin can also visualize the sensed values in the created mobile application in the form of a graph which is easy for the admin to predict the performance of BTS if the admin is not available in the BTS cell site.

3. System Implementation

It consists of Software Unit and Hardware Unit. Software unit includes the compiler to run the program, thingSpeak IoT platform to monitor and store the sensed data and Hadoop MapReduce is used for data aggregation. Hardware unit includes Arduino board, Sensors, WiFi module and Power supply.

The sensors are used to sense the environment around the base station-. The Arduino board gets the sensed data from sensors and displayed on the serial monitor through USB cable. The Wi-Fi module is connected to Arduino board which is used to send the data's wirelessly to thing speak IoT platform. The sensor will produce a large number of data's continuously but the thing speak is possible to store a limited number of data so before sending the data to thingSpeak it can be reduced by using Hadoop map reducer. The Hadoop map reducer is used to reduce a large number of data into a small number of useful data's. Then the reduced sensor data is stored in thingSpeak and thus database is created. With the help of the database, we will send warning message which is displayed in the web server whenever the data exceeds the threshold value to the admin. Thus we can send a message to the BTS admin the exact information about the fault occurred and the signal strength details send to the mobile users via a web server.

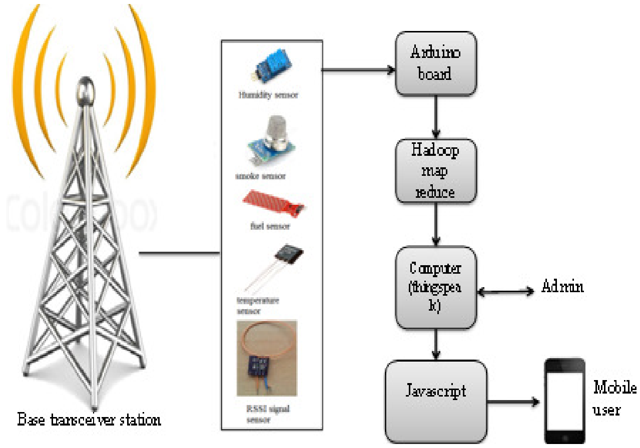

Figure 2. Block diagram of mobile communication BTS

A. System component

1. Arduino Board
2. ESP8266 WiFi module
3. LM35 Temperature sensor
4. DHT11 Humidity sensor
5. Fuel sensor
6. MQ2 Gas sensor
7. Signal strength sensor
8. Thingspeak IoT platform
9. Hadoop Mapreduce

B. Description of Components

a. Arduino UNO board

Arduino is an open source computer hardware and software company, project, and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical world.

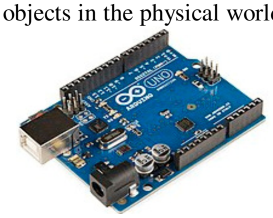

Figure 3. Arduino UNO

Arduino board designs use a variety of microprocessors and controllers. Most Arduino boards consist of an Atmel 8-bit AVR microcontroller (ATmega8, ATmega168, ATmega328, ATmega1280, ATmega2560) with varying amounts of flash memory, pins, and features. The 32-bit Arduino Due, based on the Atmel SAM3X8E was introduced in 2012. Most boards include a 5 V linear regulator and a 16 MHz crystal oscillator or ceramic resonator. Some designs, such as the LilyPad, run at 8

MHz and dispense with the onboard voltage regulator due to specific form-factor restrictions. It is used to monitor the environment of basestation.

b. ESP8266 WiFi module

The ESP8266 WiFi Module is a self contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. This module has a powerful enough on-board processing and storage capability that allows it to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime The ESP8266 supports APSD for VoIP applications and Bluetooth co-existance interfaces, it contains a self-calibrated RF allowing it to work under all operating conditions, and requires no external RF parts.

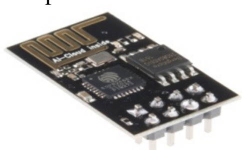

Figure 4. ESP8266 WiFi module

c. LM35 Temperature sensor

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an Advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range .

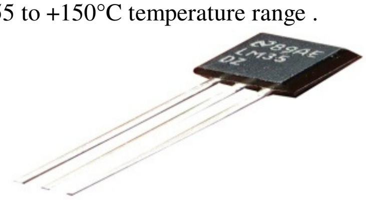

Figure 5. LM35 Temperature sensor

d. DHT11 Humidity sensor

The DHT11 temperature range is from 0 to 50 degrees Celsius with +-2 degrees accuracy. Also the DHT11 humidity range is from 20 to 80% with 5% accuracy. There are two specification where the DHT11 is better than the DHT22. That's the sampling rate which for the DHT11 is 1Hz or one reading every second, while the DHT22 sampling rate is 0,5Hz or one reading every two seconds and also the DHT11 has smaller body size. The operating voltage of both sensors is from 3 to 5 volts, while the max current used when measuring is 2.5mA.

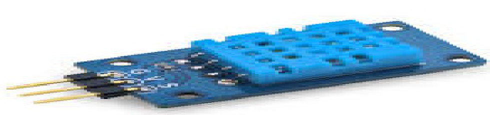

Figure 6. DHT11 Humidity sensor

e. Fuel sensor

Fuel sensors are used to monitor and regulate levels of a particular free-flowing substance within a contained space. These substances are usually liquid, however level sensors can also be used to monitor some solids such as powdered substances. Level sensors are widely used industrially. They can also be found in industrial storage tanks, for slurries, and in household appliances such as coffee machines. Basic level sensors can be used to identify the point at which a liquid falls below a minimum or rises above a maximum level.

Figure 7. Fuel sensor

f. MQ2 Gas sensor

The Grove - Gas Sensor (MQ2) module is useful for gas leakage detection (home and industry). It is suitable for detecting H2, LPG, CH4, CO, Alcohol, Smoke or Propane. Due to its high sensitivity and fast response time, measurement can be taken as soon as possible. The sensitivity of the sensor can be adjusted by potentiometer.

Figure 8. MQ2 Gas sensor

g. Radio Signal Strength Sensor

This Sensor is used to detect any Radio Signals in the frequency Range of 50 MHz to 3 GHz (RF Sniffer). With a simple loop Antenna connected to the board you will be able to catch Bluetooth, WLAN, Cellphone Signals in a building. A Cellphone should be detected in a range of about 50 meters. The Sensor is based on a LT5534 Chip from Linear Technology.

Figure 9. Radio signal strength sensor

h. Thingspeak IoT platform

ThingSpeak is an open source Internet of Things (IoT) application and API to store and retrieve data from things using the HTTP protocol over the Internet or via a Local Area Network. ThingSpeak enables the creation of sensor logging applications, location tracking applications, and a social network of things with status updates. ThingSpeak was originally launched by ioBridge in 2010 as a service in support of IoT applications.

ThingSpeak has integrated support from the numerical computing software MATLAB from Mathworks. Allowing ThingSpeak users to analyze and visualize uploaded data using Matlab without requiring the purchase of a Matlab license from Mathworks.

ThingSpeak has a close relationship with Mathworks, Inc. In fact, all of the ThingSpeak documentation is incorporated into the Mathworks' Matlab documentation site and even enabling registered Mathworks user accounts as valid login credentials on the ThingSpeak website. The terms of service and privacy policy of ThingSpeak.com are between the agreeing user and Mathworks, Inc.

i. Hadoop MapReduce

It is this programming paradigm that allows for massive scalability across hundreds or thousands of servers in a Hadoop cluster. The Map Reduce concept is fairly simple to understand for those who are familiar with clustered scale-out data processing solutions. The term Map Reduce actually refers to two separate and distinct tasks that Hadoop programs perform. The first is the map job, which takes a set of data and converts it into another set of data, where individual elements are broken down into tuples (key/value pairs). The reduce job takes the output from a map as input and combines those data tuples into a smaller set of tuples. As the sequence of the name Map Reduce implies, the reduce job is always performed after the map job.

The Algorithm

MapReduce program executes in three stages, namely map stage, shuffle stage, and reduce stage.

Map stage: The map or mapper's job is to process the input data. Generally the input data is in the form of file or directory and is stored in the Hadoop file system (HDFS). The input file is passed to the mapper function line by line. The mapper processes the data and creates several small chunks of data.

Reduce stage: This stage is the combination of the **Shuffle** stage and the **Reduce** stage. The Reducer's job is to process the data that comes from the mapper. After processing, it produces a new set of output, which will be stored in the HDFS.

During a MapReduce job, Hadoop sends the Map and Reduce tasks to the appropriate servers in the cluster. The framework manages all the details of data-passing such as issuing tasks, verifying task completion, and copying data around the cluster between the nodes.

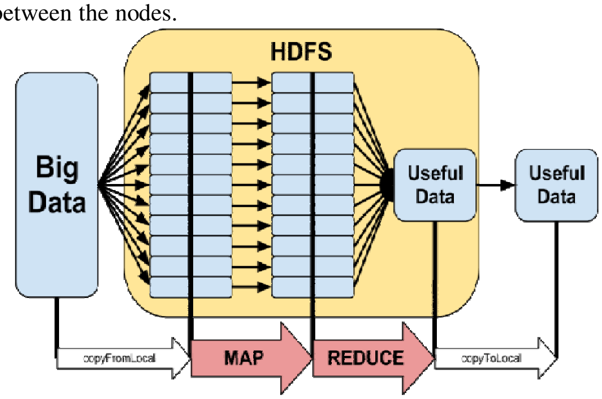

Figure 10. Overall Process of Hadoop Mapreduce

Most of the computing takes place on nodes with data o-n local disks that reduces the network traffic. After completion of the given tasks, the cluster collects and reduces the data to form an appropriate result, and sends it back to the Hadoop server.

C. Obtaining the sensor readings and storage in Thingspeak IoT platform

Our proposed system obtains five analog signals at float sensor readings from the diesel fuel tank, the temperature reading from the sensor LM35, smoke reading from the sensor MQ2, humidity reading from the sensor DHT11 and signal strength reading from the sensor. Hadoop Map Reduce is used to reduce the abnormal data which exceeds the fixed threshold values are sensed by these sensors. Then the sensor readings are stored in ThingSpeak via wifi module and used for comparison. The values are compared against the value which is already stored in thingSpeak, the values cross beyond the threshold, the system generates an alert message is displayed in the web server for authorized supervisor and this message is sent to the mobile user. The admin can also visualize the sensed values in the created mobile application in the form of a graph which is easy for the admin to predict the performance of BTS if the admin is not available in the BTS cell site.

By this way, admin gets details about BTS performance and send signal strength information to the mobile user to get better signal strength. This information's are sending to the BTS admin which is displayed on the web server. The web server is making use of HTML and JavaScript. In a web server, the alert message is sent whenever the sensed data exceeds the threshold. The threshold is set by using a Hadoop map reduced value which is explained above in the architecture of smart BTS. After getting an alert message, the admin will get the performance of BTS and send a message to the mobile user about the signal strength and direction for getting better signal strength.

Figure 12. Experimental Setup

4. Simulation Results

The room temperature is measured using the LM35 sensor, humidity is measured using the DHT11 sensor, gas level is measured using MQ2 sensor and also the fuel level in the tank using fuel sensor based on the distance it will indicate fuel level. These all results are displayed the in the atmega2560 Aurdino Software and we can store the result in Thingspeak IoT platform. From the result observation, it is cleared that all the modules are working as expected in objectives. Working model of the system is shown in below figures.

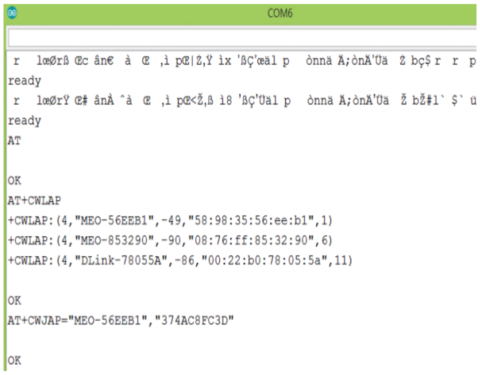

Figure 13. WiFi configuration

Fig 13 shows that the Wi-Fi configuration setup to connect to the internet. First, an empty program is loaded into the Arduino board then in serial monitor enter the AT commands. AT means Wi-Fi module is ready to connect, AT+CWLAP means its list of access point available for connections and AT+CWJAP means to do the joint connection between Wi-Fi module and our network router then it shows Wi-Fi is connected.

Fig 14 shows after the connection setup is made, the sensor readings are sent wirelessly to ThingSpeak via Arduino Wi-Fi module. It starts the TCP connection port 80. It shows API key where my data are stored lively in the channel in which the fields are assigned for storing sensor reading (i.e., field1 store humidity, field2 stores temperature, field3 stores fuel level,field4 stores smoke level, field5 stores received signal strength). Finally, it creates a database in ThingSpeak for further processing.

Figure 14. Serial monitor output

The Hadoop Map Reduce output is shown below:

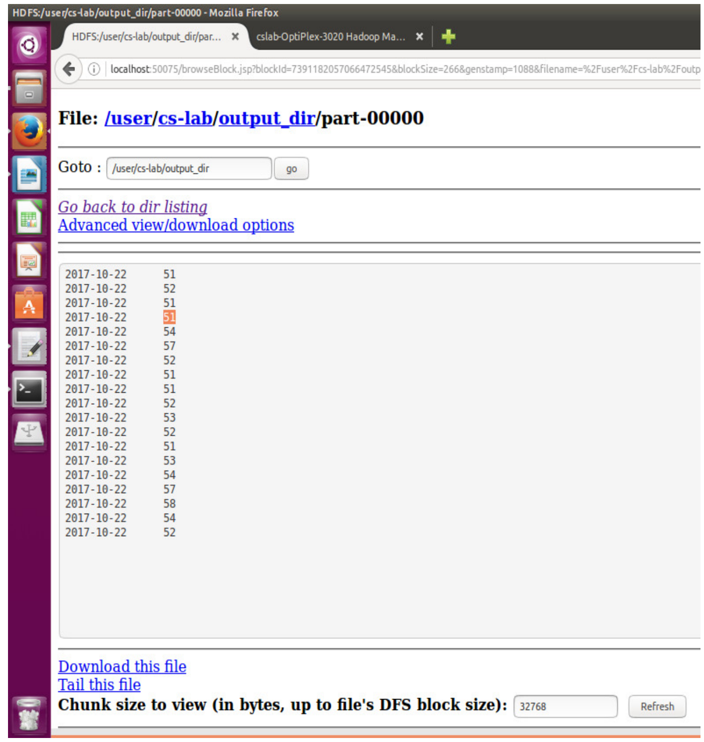

Figure 15. Reduced temperature data

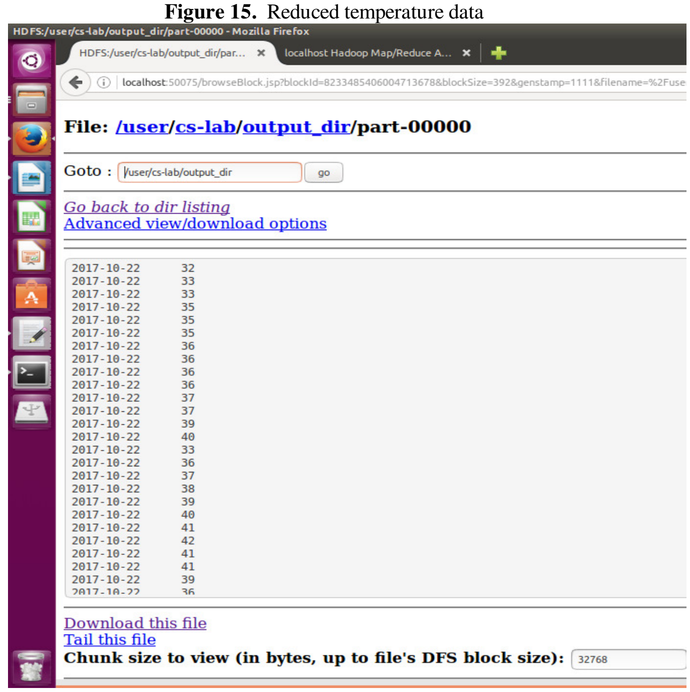

Figure 16. Reduced humidity data

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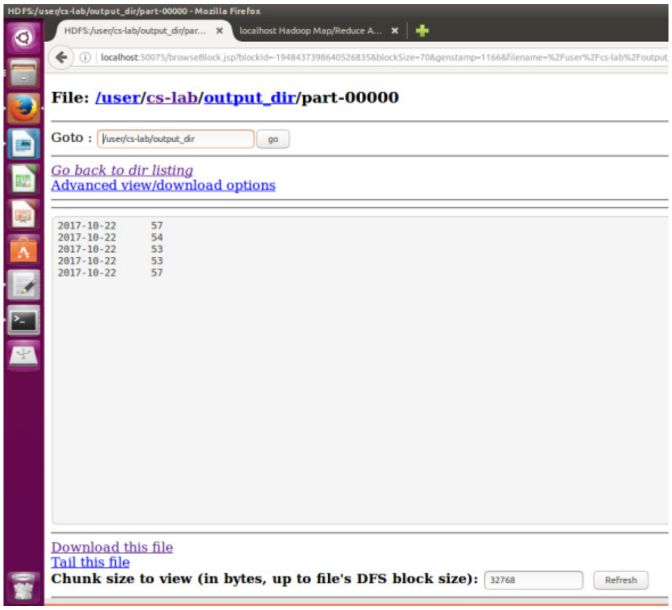


Figure 17. Reduced RSSI data

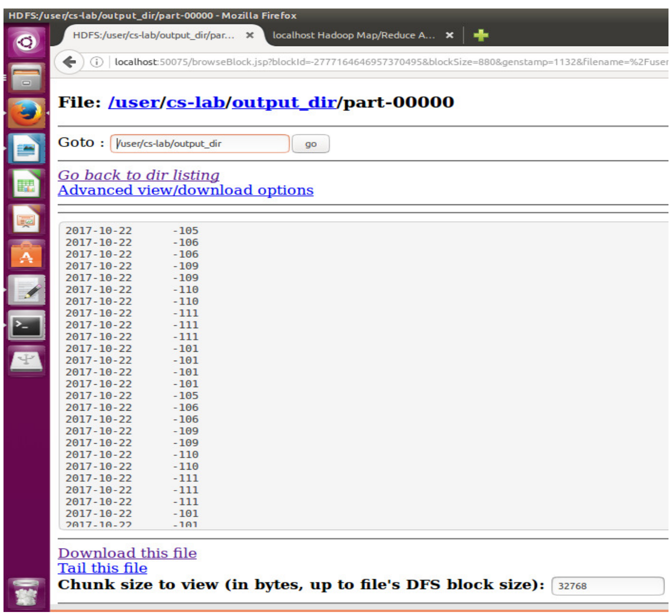
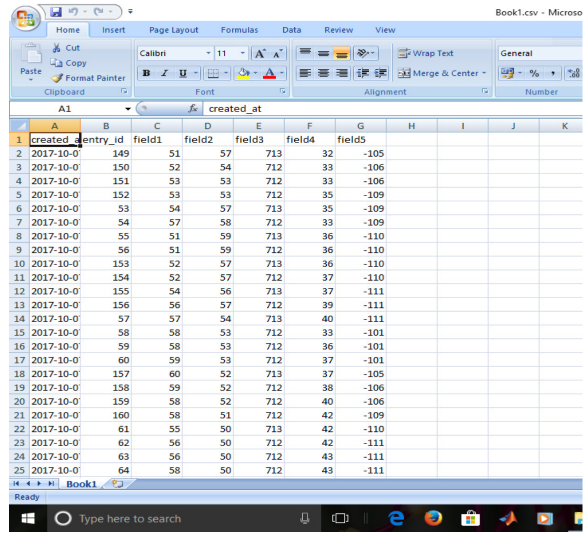


Figure 18.Reduced smoke data

The below output is the database created in the thingspeak after map reducer Fig 19 shows that the sensed is store in the thingspeak in excel sheet format. The excel sheet consist of date and time, entry id, field1(humidity), field2(temperature), field3(fuel), field4(smoke) and field5(received signal strength).



	A	B	C	D	E	F	G
1	created_a	entry_id	field1	field2	field3	field4	field5
2	2017-10-0	149	51	57	713	32	-105
3	2017-10-0	150	52	54	712	33	-106
4	2017-10-0	151	53	53	712	33	-106
5	2017-10-0	152	53	53	712	35	-109
6	2017-10-0	53	54	57	713	35	-109
7	2017-10-0	54	57	58	712	33	-109
8	2017-10-0	55	51	59	713	36	-110
9	2017-10-0	56	51	59	712	36	-110
10	2017-10-0	153	52	57	713	36	-110
11	2017-10-0	154	52	57	712	37	-110
12	2017-10-0	155	54	56	713	37	-111
13	2017-10-0	156	56	57	712	39	-111
14	2017-10-0	57	57	54	713	40	-111
15	2017-10-0	58	58	53	712	33	-101
16	2017-10-0	59	58	53	712	36	-101
17	2017-10-0	60	59	53	712	37	-101
18	2017-10-0	157	60	52	713	37	-105
19	2017-10-0	158	59	52	712	38	-106
20	2017-10-0	159	58	52	712	40	-106
21	2017-10-0	160	58	51	712	42	-109
22	2017-10-0	61	55	50	713	42	-110
23	2017-10-0	62	56	50	712	42	-111
24	2017-10-0	63	56	50	712	43	-111
25	2017-10-0	64	58	50	712	43	-111

Figure 19. ThingSpeak Database

A. Mobile Application Results

In the mobile app, the graph of the sensed data is displayed which useful for the admin to accurately predict changes in the BTS performance. The following figures are shown the mobile app results. Fig 20 shows live data which is visualized as a graph in a mobile application, shows humidity reading and temperature reading with respect to time, shows fuel reading and received signal strength reading with respect to time and shows smoke reading with respect to time and the location of the mobile user.

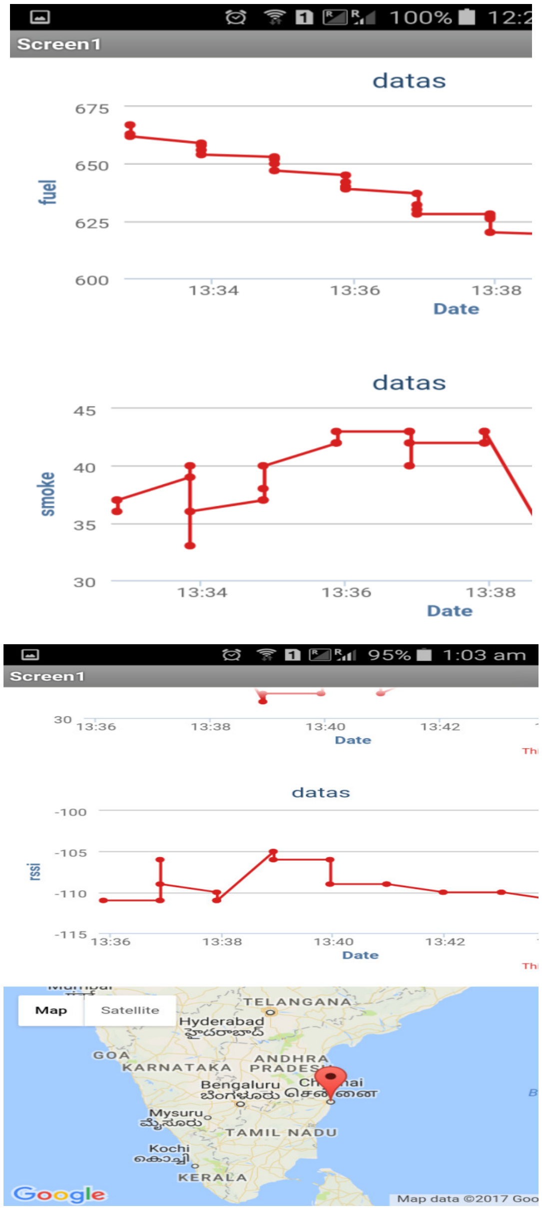


Figure 20. Mobile app display

B. Web Application Results

The below outputs are explaining the process of web server how it works to display the alert message. Fig 21 shows that web server for monitoring the sensed data's. The first page is user registration to enter into the web server to monitor the BTS. The user can register using their Sim and IME number. This page is accessed by anyone whose wants to get the information about the signal strength of BTS. Fig 22 shows that the live data's which is displayed on the next page. In this page, the live data's which is sensed by the sensor is displayed here which is continuously monitored by the admin. Fig 23 shows that the alert message for the admin. The sensed data is continuously checked with a threshold level which set inside the threshold button using JavaScript. If the sensed data exceeds the threshold level, it will show an alert message to admin. Fig 24 shows that message for the mobile user which is sent by the admin After getting an alert message, the admin sends a message to the mobile user about the week signal strength and provide direction to get better signal strength.

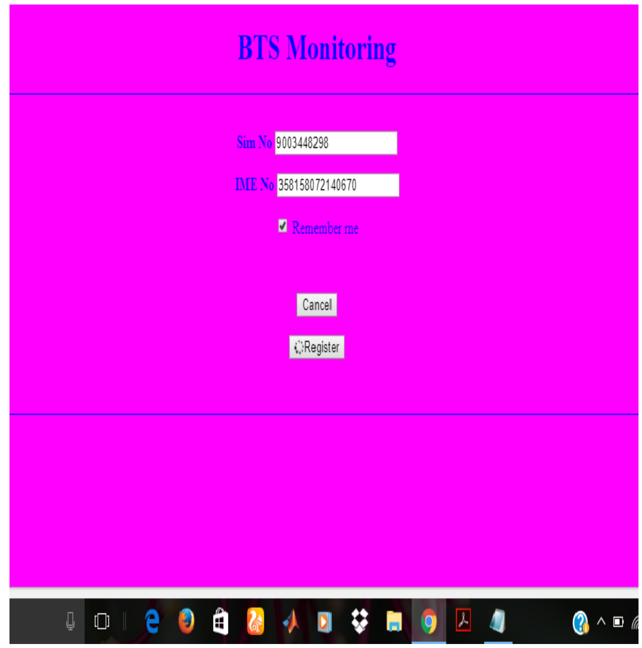


Figure 21. First page

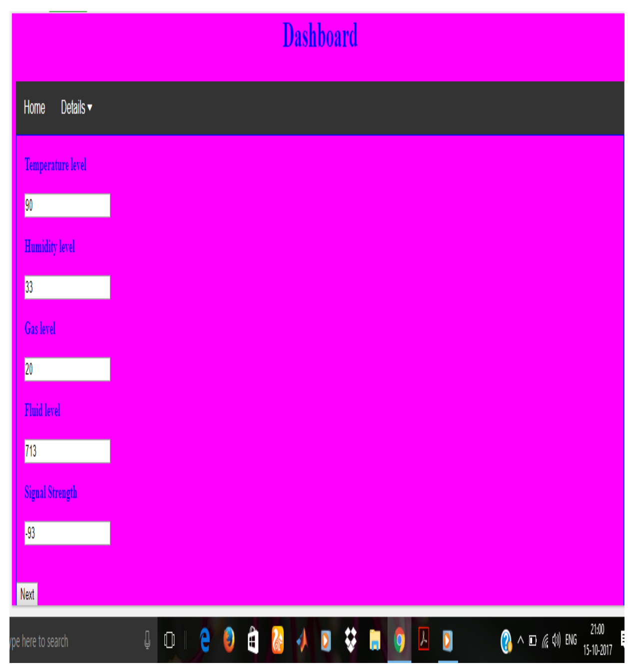


Figure 22. Data display

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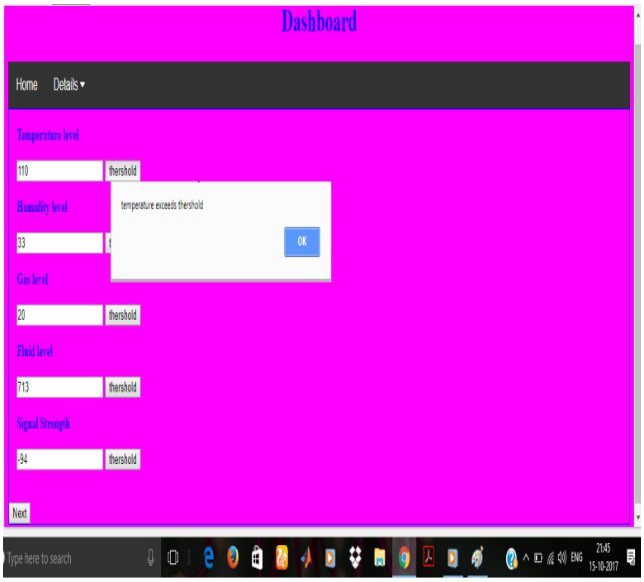

Figure 23. Warning message

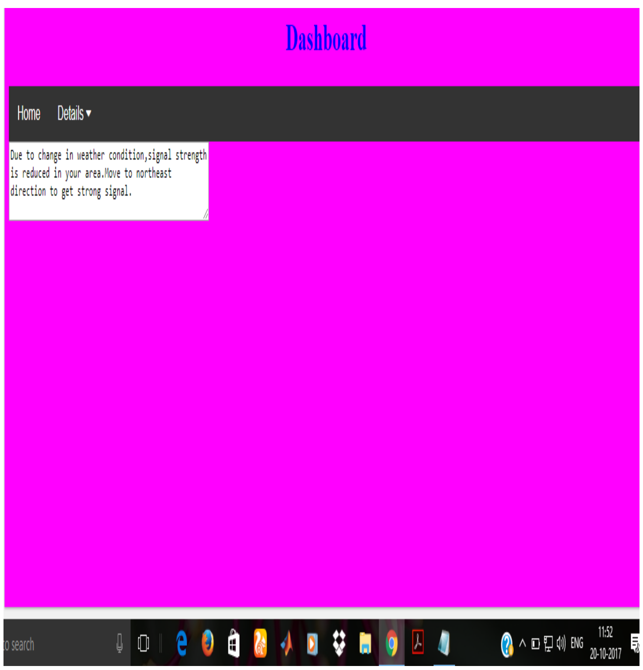

Figure 24. Message about signal strength

5. Conclusion

Thus, we conclude that IoT places a major role to protect the mobile BTS site like, BTS Monitoring. It enables users to monitor remotely the conditions of base transceiver stations (BTS). Sensors are used to monitor the BTS environment and send condition of BTS information to admin. Temperature, humidity, gas, fuel and signal strength sensors are used to sense the BTS environment. Hadoop Map Reduce is used to reduce a large number of sensor data to small useful data's which is uploaded in thing Speak. By the use of these data we can easily predict the signal strength of the BTS. The core of the solution is the web application SMS controller which always monitoring performance features of BTS and also we display the sensed data's in the mobile application as in the form of a graph. This form of results is easy for the admin to predict the changes in the sensed data's and send an alert message to the mobile user like signal strength of the Base station.

It reduces the manual interruption. The system itself efficiently monitors the temperature, humidity, smoke, and fuel controls the Base Station equipment to avoid total power outage and also provide better signal strength for communication. With this proposal, we can develop low cost, a real-time system which can monitor and control the operation of cell sites. We also believe that the described control and information message sending system will be an important tool in our efforts to create a better signal strength and total availability for the power feeding of our different telecommunication systems. This adaptive technique will help to maintain a base transceiver station and signal strength of BTS. Future work is to use an algorithm to fix threshold level and develop a mobile application to send a message about better signal strength to the mobile user.

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