IoT BASED MODEL FOR SMART MONITORING OF NETWORK RELATED INFRASTRUCTURE USING INTEGRATED IoT PLATFORM (BOLTIOT)

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Abstract - *IoT (Internet of Things) is poised to transform the real world objects into intelligent virtual objects in the near future. As sensing, communication, and control become ever more complex today, this technology is applied in transforming the Internet into a fully integrated ecosystem. IoT is the next revolutionary technology in transforming the Internet into a fully integrated future ready Internet. IoT allows people and things to be connected at any time, any place, with anything and anyone, by using any path/network and any service. The advances in computer hardware, embedded system devices, networking devices, display devices, control devices, software enhancements, etc. have hugely supported IoT to grow rapidly. The main objective of this paper discusses actual implementation of IoT based monitoring of network infrastructure and its associated peripheral devices/equipment's for parameters like temperature and power supply etc. using appropriate sensors. The main utility of the work presented, is in 24x7 monitoring of remotely located devices where it is impractical to monitor manually with direct physical presence. The implementation has been done using an integrated IoT device BOLTIoT.*

Key words: Internet of Things, BoltIoT, Sensors, Cloud, Network Monitor, etc.

1. INTRODUCTION

[1] Internet of Things (IoT) is a small electronic device which senses and collects data from around the world and shares this data with backend applications. It communicates with any object, environment, and infrastructure. Nowadays every person is connected with many social media communication networks like Facebook, Whatsapp, Twitter, YouTube, Google+, LinkedIn, Google class, classmates, messenger, Wechat, Qchat, Viber, Snapchat, etc. Communication is a very important part of IoT. The idea of IoT is quite useful for real-world applications and services. A few examples of the application of IoT technology are: Putting on the lights automatically on sensing the human activity, Similarly AC and all other devices need to run in an environment and be switched off based on certain event or trigger. Thus an IoT is basically a framework where the devices are connected to the internet for the purpose of monitoring and control.

[2] The First time IoT became popular and made its mark was in the year 1999 when Kevin Ashton applied it for auto-ID. This was a big year for IoT. In 2005 the IoT, combined with ICT technologies, was applied to virtually connect any object at any time and place. IoT applications picked up during 2008 – 2009 with the growth of smart tablet, mobile, PC and other devices connected through the internet. The development of IPv6 helped to reduce the scarcity of public IP address space which was essentially required for the growth of IoT.

2. HOW DOES IOT WORK?

[3] The IoT comprises of a system of connected computational, mechanical and digital devices/machines, object, animal or people that are provided a unique ID and ability to transfer the data over a network without any human interaction. An IoT system has four major components i.e. sensor, connectivity, data processing, and user interface.

1) Sensors/Devices- collect data from their environment. Many IoT applications make use of multiple sensors bundled together. It could be standard sensors or a fully customized device. Different sensors in use for IoT applications are a sensor for

Light detection – LDR
Temperature - LM35
Motion – PIR Sensor
Fire Sensor - IC: LM393
Touch Sensor- TTP223B Digital Touch Sensor Capacitive Touch.

2) Connectivity: - The IoT devices share the collected data using cloud infrastructure. The sensors devices get their connectivity using technologies like cellular, satellite, Wi-Fi, Bluetooth, and low-power wide-area networks, etc.

3) Data Processing: - The data obtained from the cloud is processed further through software as per the requirement of the application.

4) User Interface: - The processed information is presented to the end-user in a useful manner. IoT application may also make use of email, text notification, etc. for communicating with the user.

Thus IoT system consists of sensors/devices which "talk" to the cloud through some kind of connectivity. The data found to the cloud, use by software processes it and then it decided to perform an action, such as sending an alert for SMS and Email or automatically adjusting the sensors/devices without the need for inputs from the user.

3. ARCHITECTURE

[4] IoT systems may be built using varied architectures. Generically, a Six layered architecture is followed, as discussed below :

1- **Coding layer-** It provides identification to object which is given a unique ID.
2- **Perception layer-** It is the physical layer. It senses the environment through the sensor and gathers

information of physical parameters of the device/system under observation.

3- **Network layer-** It is responsible for transmitting the collected information to the processing sub-system.

4- **Middleware Layer-** This layer processes the information received from the sensor devices as communicated by the intervening network.

5- Application layer- It gives the service for a specific application based on processed data.

6- **Business Layer:-** This layer manages the applications and services of IoT and is responsible for all the business and research related to IoT.

4. PROPOSED WORK

A network infrastructure comprises of varied devices like switches, routers, wireless access points, IP cameras, IP Phones, UPSs, etc. These devices need to be continuously monitored for their activity status whether a device is functional or not. The faults could be on various counts like unavailability of power, fault in cabling or problem with the device itself. Moreover certain environmental parameters also need to be monitored to avoid situations like excessive heating, etc. The presence or absence of a device can also be checked and monitored with the use of RFID tags and their sensors. These devices could be located at a remote location and therefore difficult to be monitored physically on a frequent basis. This paper presents a framework to actively monitor these aspects for the upkeep of a LAN infrastructure and its associated devices from a holistic point of view assuring high uptime and preemptive troubleshooting.

5. IMPLEMENTATION

A) Devices and Parameters for proposed monitoring

The sample devices taken for discussing the framework of implementation are

1. Network Switch
2. UPS
3. Wireless Access Points

The parameters to be monitored for a network switch could be categorized as:

1. Functional
   a) Fan Status
   b) Power
   c) Status of Backbone (uplink) etc.
2. Environment - related
   d) Temperature
   e) Humidity
   f) Water leakage
3. Safety etc.
   g) Theft
   h) Presence of rodents etc

These parameters could be monitored through

1. Motion sensor for sensing the fan movement
2. Sensor for detecting the presence of power
3. An intermediate device in-between uplink and switch for detecting the functioning of backbone
4. Temperature & Humidity sensors
5. Water leakage detector
6. Motion detectors for presence of rodents
7. Sensors attached to hinges of the rack for detecting the unwarranted opening of the rack housing.

The parameters and sensors proposed for UPS devices are:

1. Status of input mains
2. Fan status
3. Battery status to be picked through UPS Management port(RS232) interfaced with a microcontroller based device
4. Output status
5. Temperature etc.

The parameters and sensors proposed for WAP (Wireless Access Point) devices are:

1. Temperature
2. EMI Interference detected due to nearby devices
3. Uplink Status
4. Power Status

Similarly, a number of other monitoring parameters and corresponding sensors can be thought of for comprehensive monitoring.

A layout of the proposed setup is depicted below:

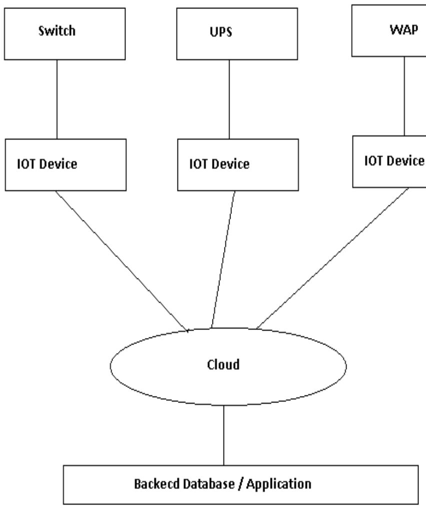


Fig -1: Proposed Setup

B) The Setup and Information Flow:

The setup comprises of:

1) The sensing stage
2) Local processing, logging, and storage
3) Transmission of useful information to the cloud

It is proposed to make extensive use of microcontrollers for local processing of the collected data for detection of threshold breaches and generation of alerts thereof on detecting critical events. SD memory cards are proposed for local storage of data/logs.

Sample layout of the proposed IoT device is shown in the diagram below:

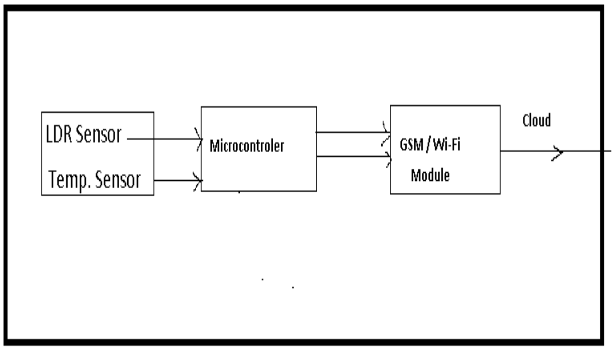


Fig -2: Proposed IoT Device

The diagram below depicts the information flow:

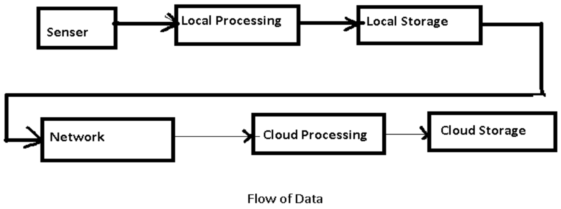


Fig -3: Flow of data Process

The processed data is pushed to the cloud which is then pulled by the backend application for reporting and generation of alerts. The backend application shall also have the feature to sync directly with the IoT devices fetch the entire logs for archival purpose if required.

The sections below detail a partial implementation of the above-mentioned proposed work.

C) Boltiot: - Bolt is an Internet of Things. It provides the platform (Hardware + Software) makes to connect their devices to the internet through easily and quickly. It contains Wi-Fi/ GSM chip to connect the sensor to the internet. It operates at 2.4 GHz Frequency, 802.11 b/g/n model. It is based on ESP8266 module based 32 Bit RISC processor, Process all the command send into the web execute as per need, this process freq. 80 MHz, ESP Voltage level operates at 3.3V. It can take less than 1 sec boot time, It contains 5 Digital GPIO (General purpose 1/O pins) work with 3.3V output give 1, 0V output gives 0, 1 Analog Input pin work with 1V, 1 Serial UART (Universal Asynchronous Receiver -Transmitter) port. It converts 5V (1A) to 3.3V (1A) so the device is not damaged.

Fig -4(a): Bolt Back Side

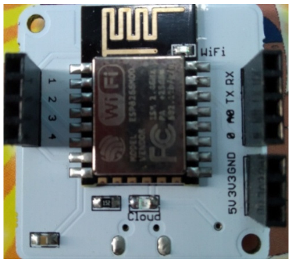


Fig -4(b): Bolt Front Side

D) Temperature Sensor circuit:-

Step-1: Connecting the LM35 sensor to the Bolt

- VCC pin of the LM35 connects to 5v of the Bolt module.
- The Output pin of the LM35 connects to A0 (Analog input pin) of the Bolt module.
- GND pin of the LM35 connects to the GND.

A schematic representation is given in Figure-5 below.

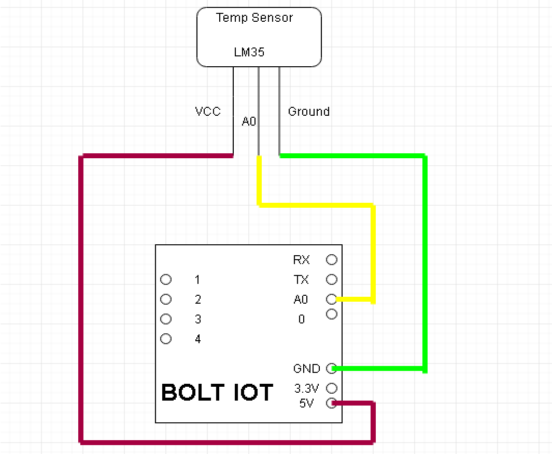
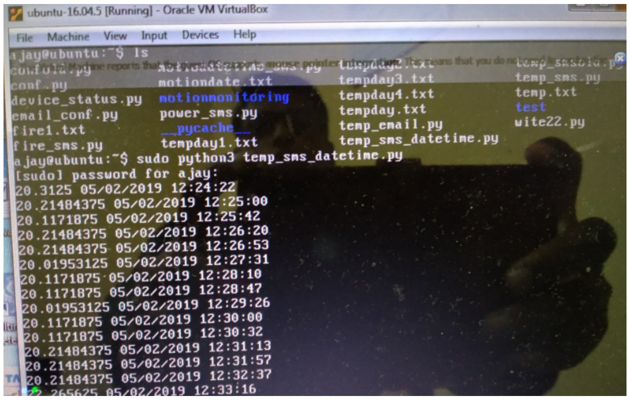


Fig -5: Circuit Design for Temperature Monitoring

Step-2: Run the program temp_sms_datetime.py

A sample output is as shown in Figure-6 below:


ubuntu-16.04.5 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help

```
ajay@ubuntu:~$ ls
conf01a.py        motiondatetime_sms.py  tempday2.txt            temp_sms01d.py
conf.py           motiondate.txt         tempday3.txt            temp_sms.py
device_status.py  motionmonitoring       tempday4.txt            temp.txt
email_conf.py     power_sms.py           tempday.txt             test
fire1.txt         __pycache__            temp_email.py           wite22.py
fire_sms.py       tempday1.txt           temp_sms_datetime.py
ajay@ubuntu:~$ sudo python3 temp_sms_datetime.py
[sudo] password for ajay:
20.3125 05/02/2019 12:24:22
20.21484375 05/02/2019 12:25:00
20.1171875 05/02/2019 12:25:42
20.21484375 05/02/2019 12:26:20
20.21484375 05/02/2019 12:26:53
20.01953125 05/02/2019 12:27:31
20.1171875 05/02/2019 12:28:10
20.1171875 05/02/2019 12:28:47
20.01953125 05/02/2019 12:29:26
20.1171875 05/02/2019 12:30:00
20.1171875 05/02/2019 12:30:32
20.21484375 05/02/2019 12:31:13
20.21484375 05/02/2019 12:31:57
20.21484375 05/02/2019 12:32:37
20.265625 05/02/2019 12:33:16
```

Fig -6: Command Prompt Show temperature

Step-3: Graphical output generated from Step-2, is as shown below (Figure-7):

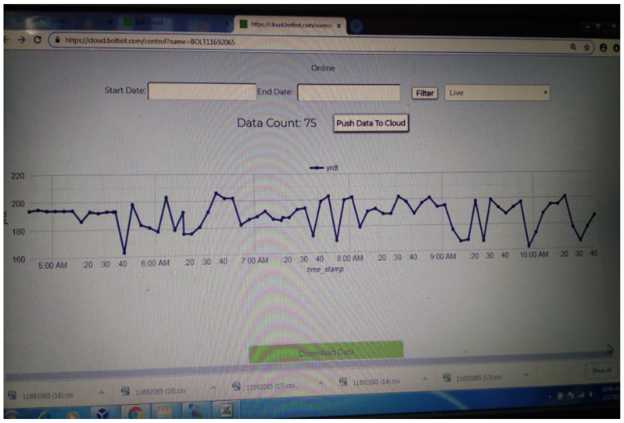
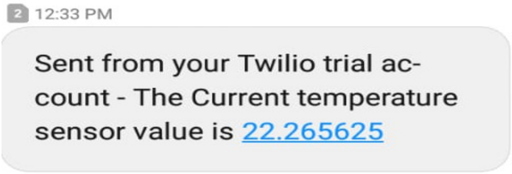


Fig -7: Temperature Graph

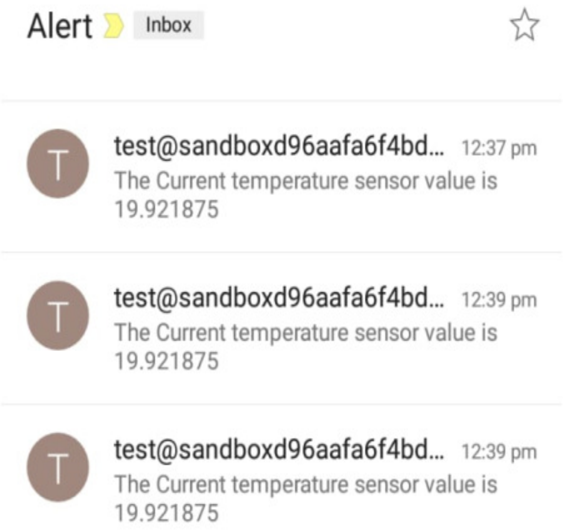
Step-4: when the temperature rises above a threshold then SMS and Email alerts are generated. A sample SMS/Email message generated from the system is as given in Fig.8 & 9.



2 12:33 PM

Sent from your Twilio trial account - The Current temperature sensor value is 22.265625

Fig -8: SMS Message temperature



Alert Inbox

test@sandboxd96aafa6f4bd... 12:37 pm
The Current temperature sensor value is 19.921875

test@sandboxd96aafa6f4bd... 12:39 pm
The Current temperature sensor value is 19.921875

test@sandboxd96aafa6f4bd... 12:39 pm
The Current temperature sensor value is 19.921875

Fig -9: Email Message temperature

E) Motion Sensor Circuit:-

Step-1:- Connecting to a PIR- PIR modules have a 3-pin connection at the bottom. The ground pin is connected to GND, Digital output connected to pin no 2 GPIO pin, VCC connect to 5V of given BoltIoT.

A schematic representation is given in Figure-10 below.

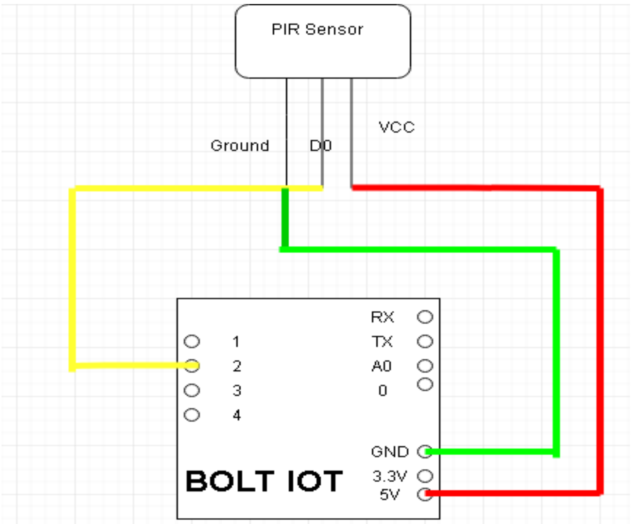
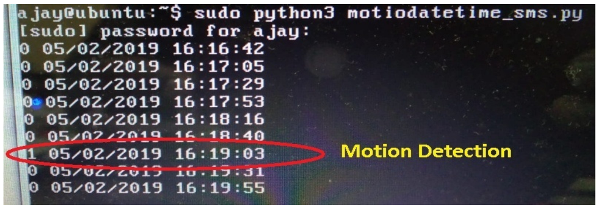


Fig -10: Circuit Design for Motion Detection

Step-2: Run the program **motiodatetime_sms.py**

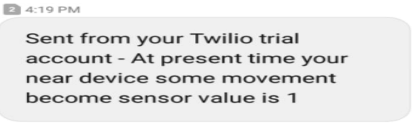
A sample output is as shown in Figure-11 below :



```
ajay@ubuntu:~$ sudo python3 motiodatetime_sms.py
[sudo] password for ajay:
0 05/02/2019 16:16:42
0 05/02/2019 16:17:05
0 05/02/2019 16:17:29
0 05/02/2019 16:17:53
0 05/02/2019 16:18:16
0 05/02/2019 16:18:40
1 05/02/2019 16:19:03
0 05/02/2019 16:19:31
0 05/02/2019 16:19:55
```

Fig -11: Command prompt show Motion Detection

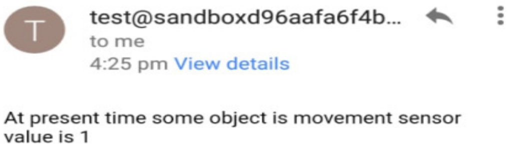
Step-3: When the motion is detected then output value 1 show after SMS and Email alerts are generated. A sample SMS/Email message generated from the system is as given in Fig.11 & 12.



2 4:19 PM

Sent from your Twilio trial account - At present time your near device some movement become sensor value is 1

Fig -12: SMS Message for Motion Detection



test@sandboxd96aafa6f4b...
to me
4:25 pm View details

At present time some object is movement sensor value is 1

Fig -13: Email Message for Motion Detection

F) Fire Sensor Circuit Design: -

Step-1:- Connecting to a Fire Sensor: - Fire sensor modules have a 3-pin connection at the bottom. Middle pin Ground pin is connected to GND, Digital output connected to pin no 2 GPIO pin, VCC connect to 5V of given BoltIoT.

A schematic representation is given in Figure-14 below.

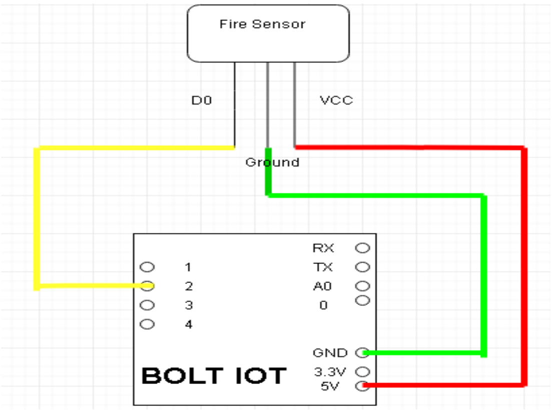
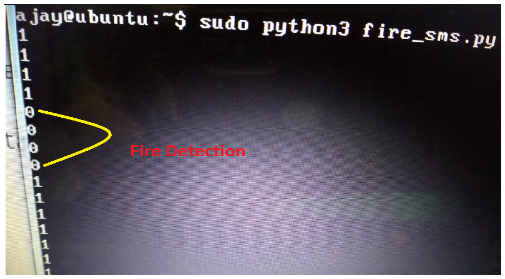


Fig -14: Circuit Design For Fire Detection

Step-2: Run the program **fire_sms.py**

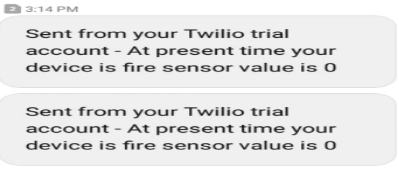
A sample output is as shown in Figure-15 below:



```
ajay@ubuntu:~$ sudo python3 fire_sms.py
1
1
1
1
0
0
0
0
1
1
1
1
1
1
1
```

Fig -15: Command prompt show Fire Detection

Step-3: When the Fire is detected then output value 0 show after SMS and Email alerts are generated. A sample SMS/Email message generated from the system is as given in Fig.16 & 17.

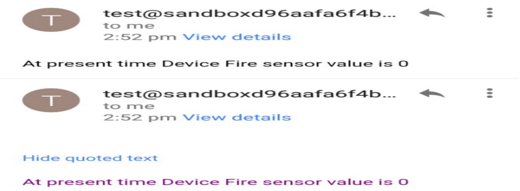


2 3:14 PM

Sent from your Twilio trial account - At present time your device is fire sensor value is 0

Sent from your Twilio trial account - At present time your device is fire sensor value is 0

Fig -16: SMS Message for Fire Detection



test@sandboxd96aafa6f4b...
to me
2:52 pm View details

At present time Device Fire sensor value is 0

test@sandboxd96aafa6f4b...
to me
2:52 pm View details

Hide quoted text

At present time Device Fire sensor value is 0

Fig -17: Email Message for Fire Detection

F) Security Sensor Circuit: -

Step-1:- Connecting to a Touch sensor - Touch sensor modules have a 3-pin connection at the bottom. The ground pin is connected to GND, Digital output connected to pin no 2 GPIO pin, VCC connect to 5V of given BoltIoT.

A sample output is as shown in Figure-18 below :

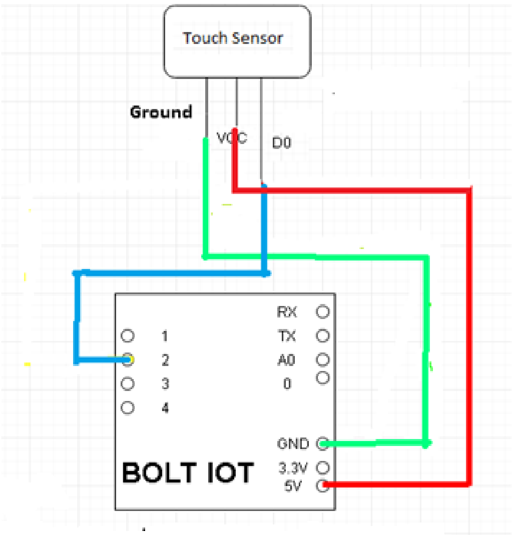
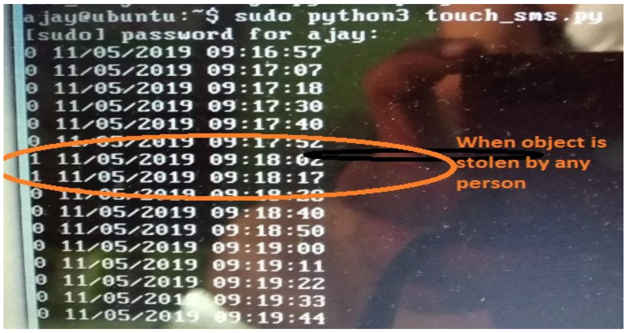


Fig -18 Circuit Design for Security Detection

Step-2: Run the program **touch_sms.py**

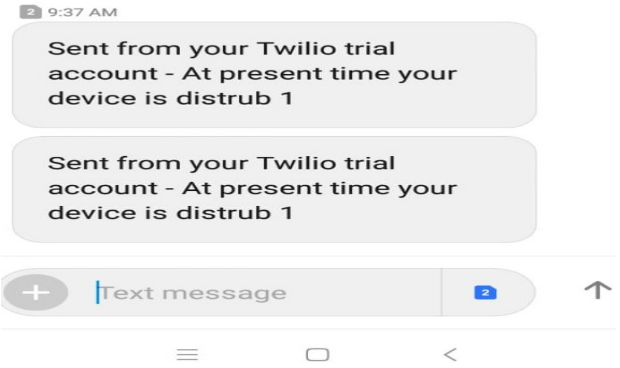
A sample output is as shown in Figure-19 below:



```
ajay@ubuntu:~$ sudo python3 touch_sms.py
[sudo] password for ajay:
0 11/05/2019 09:16:57
0 11/05/2019 09:17:07
0 11/05/2019 09:17:18
0 11/05/2019 09:17:30
0 11/05/2019 09:17:40
0 11/05/2019 09:17:52
1 11/05/2019 09:18:02
1 11/05/2019 09:18:17
0 11/05/2019 09:18:28
0 11/05/2019 09:18:40
0 11/05/2019 09:18:50
0 11/05/2019 09:19:00
0 11/05/2019 09:19:11
0 11/05/2019 09:19:22
0 11/05/2019 09:19:33
0 11/05/2019 09:19:44
```

Fig -19: Command prompt show Security Detection

Step-3: When the detected device is stolen then output value 1 show after SMS and Email alerts are generated. A sample SMS/Email message generated from the system is as given in Fig.20 & 21.

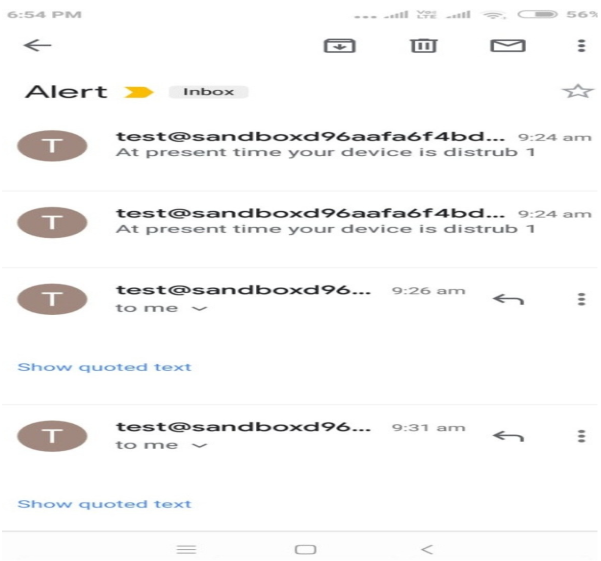


2 9:37 AM

Sent from your Twilio trial account - At present time your device is distrub 1

Sent from your Twilio trial account - At present time your device is distrub 1

Fig -20: SMS Message for Security Detection



test@sandboxd96aafa6f4bd... 9:24 am
At present time your device is distrub 1

test@sandboxd96aafa6f4bd... 9:24 am
At present time your device is distrub 1

test@sandboxd96... 9:26 am
to me

Show quoted text

test@sandboxd96... 9:31 am
to me

Show quoted text

Fig -21: Email Message for Security Detection

G) Uplink Monitor

Step-1:- Connecting to a LDR sensor:- Connect one lead of the LDR into the Bolt Module 3.3V Pin and other lead of the LDR into the A0 Pin. 10K Ohm resistor one leg to ground Pin connect and other leg is resistor into the A0 pin respectively.

A sample output is as shown in Figure-22 below:

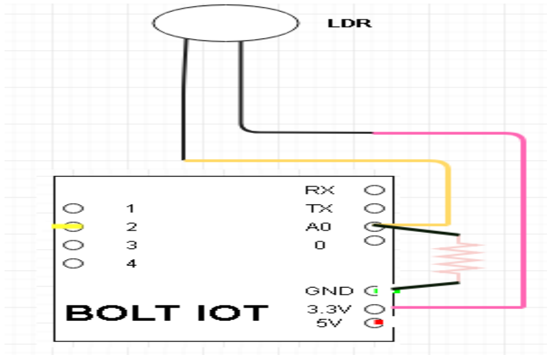
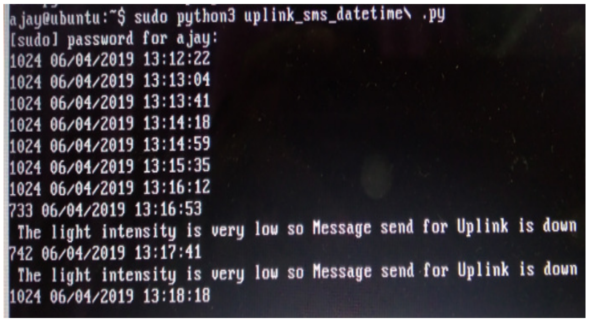


Fig -22: Uplink device circuit

Step-2: Run the program **_sms_datetime.py**

A sample output is as shown in Figure-23 below:

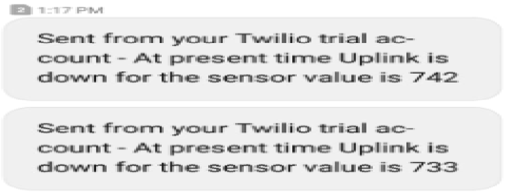


```
ajay@ubuntu:~$ sudo python3 uplink_sms_datetime\ .py
[sudo] password for ajay:
1024 06/04/2019 13:12:22
1024 06/04/2019 13:13:04
1024 06/04/2019 13:13:41
1024 06/04/2019 13:14:18
1024 06/04/2019 13:14:59
1024 06/04/2019 13:15:35
1024 06/04/2019 13:16:12
733 06/04/2019 13:16:53
 The light intensity is very low so Message send for Uplink is down
742 06/04/2019 13:17:41
 The light intensity is very low so Message send for Uplink is down
1024 06/04/2019 13:18:18
```

Fig -23: Command prompts for SMS show Uplink is down

Step-3: When the detected **Uplink is down** then SMS and Email alerts are generated. A sample SMS/Email message generated from the system is as given in Fig.24 & 25.

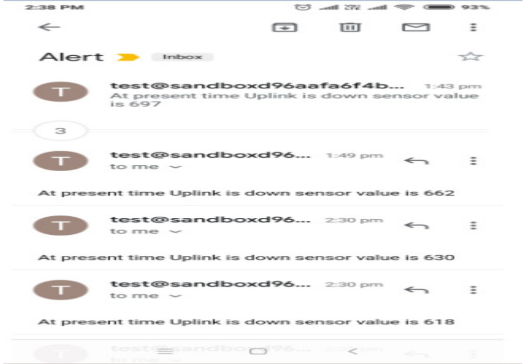
When the Uplink is down then got the message by SMS.



Sent from your Twilio trial account - At present time Uplink is down for the sensor value is 742

Sent from your Twilio trial account - At present time Uplink is down for the sensor value is 733

Fig -24: SMS Message for Uplink is down



test@sandboxd96aafa6f4b... 1:43 pm
At present time Uplink is down sensor value is 697

test@sandboxd96... 1:49 pm
to me

At present time Uplink is down sensor value is 662

test@sandboxd96... 2:30 pm
to me

At present time Uplink is down sensor value is 630

test@sandboxd96... 2:30 pm
to me

At present time Uplink is down sensor value is 618

Fig -25 Email Message for Uplink is down

H)- POWER ON/OFF FEATURE

This feature is required for remotely turning off/on the device. This is achieved by a relay connected to the remote device through BoltIoT.

Connection for controlling ON/OFF state of Switch:-

Step-1:- Connecting to a Relay:-

1- Connect the 5V and Ground of the Boltiot to the 5V and Ground pin of the relay module.
2- Connect the one pin digital of Boltiot i.e. (0) to the IN pin of the relay module.
3- Connect one wire from switch to the common (COM) pin of the relay module.
4- Connect one wire from the normally open (NO) pin of the relay module to the Power Plug in real current (phase).
5- Switch one wire connect to the Power Plug which neutral.

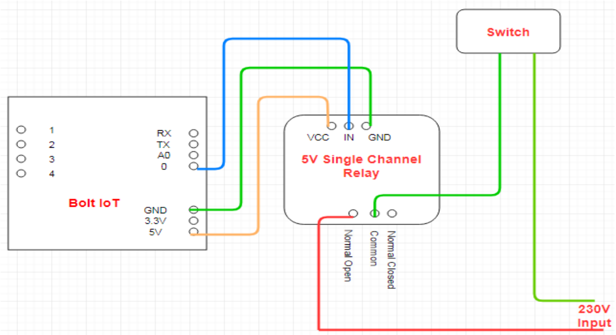


Fig -27: Circuit design for control Switch ON/OFF

6. BACKEND DATABASE/APPLICATION

The backend database stores all the details as collected from the field stationed IoT devices. The data is further processed for statistical reporting and generation of the pattern of events which require attention for the upkeep of the infrastructure. This application is also responsible for the generation of alarms and alerts.

7. CHALLENGES AND LIMITATION

The challenges envisaged for the proposed implementation are:

1. Powering of IoT devices, as replenishment of battery could pose a major challenge. The direct power supply cannot be entirely relied on.
2. The local storage embedded within the IoT device can be a challenging proposition.
3. The connectivity through Wi-Fi or GSM for communicating with the cloud may pose hurdles in achieving 100% efficiency in the regions where signal strength is poor.

8. FURTHER WORK

The proposed work can be further pursued with the actual implementation and further enhancements like storage on the edge and design of interactive IoT devices with remote control from users.

9. CONCLUSIONS

A network is the most critical component of any ICT infrastructure which is live 24x7 and to monitor it through physical human intervention is not feasible when the scale is large. Therefore, the IoT applications for monitoring temperature, motion, fire, uplink status, security can be of great utility for detecting any issue and raising alerts through SMS and email thereby coming to know quickly about the problem occurring on a remote site without delay and then act according to the need. This can also lead to saving in Power by switching off the device remotely when not in use, by Power ON/OFF application. Such solutions are very cost effective and provide 100% redundancy in the effective monitoring of the infrastructure leading to high uptime availability.

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