Smartphones – The Darkhorse of IOT

Electrical and Computer Engineering Department, Charles W. Davidson College of Engineering
San Jose State University, San Jose, CA 95112

Sagar Shah
San Jose State University, USA
sagar.shah@sjsu.edu
011426818

Swara Gandhi
San Jose State University, USA
swara.gandhi@sjsu.edu
011467690

Vidhan Modi
San Jose State University, USA
vidhan.modi@sjsu.edu
011451362

***Abstract*—**The unprecedented growth in the mobile device adoption and the rapid advancement of Internet of things have created demands for integration of all the devices, electronics, software and network connectivity on a single platform. Smartphones can be considered as simple and ubiquitous device, embedded with variety of sensors together providing internet connectivity and electronics needed for an IOT device. This paper presents a technique through which a smartphone can be turned into an IOT device. The proposed framework supports all the smartphones online to collect the data using the built-in sensors and transmit it online to get monitored and create a system specified alert. The paper presents prototyping solution design as well as its application and certain experimental results.

Keywords— Sensors, Internet of Things, PaaS, IBM, IBM watson, IBM Bluemix™, smartphones, MQTT, IOT starter.

INTRODUCTION [SWARA]

As humanity creates more and more smartphones each year there is an unintended glut of still capable yet less desirable one-year-old or two-year-old smartphones that take the backseat to new models[1].While many of these retired smartphones still work and have usable sensors like cameras, accelerometers, touch screens and bluetooth radios, large swaths of them unused or worse yet, end up in landfills.Research from IDC shows that more than 280 million working smartphones were replaced without being recycled last year[1].

The proposed architecture suggests a method by which smartphone sensors can be utilized for IOT operations thus converting a smartphone into a sensing as well as actuating device with the help of IBM's platform as a service (PaaS) offerings.The reference model considers sending sensor data that is generated by smartphone to the IBM Watson IoT Platform cloud-hosted service by using cloud foundry commands, and then create Bluemix™ applications that process, visualize, and store the data.The Bluemix IoT app is further enhanced by using a Node-RED flow to process messages from the smartphone. Communication between the server and the device (smartphone) are done in the form of MQTT messages.

I. PLATFORM [SWARA]

1. *Access to IBM Bluemix™*

Bluemix™ is a fully managed, cloud-hosted service designed to simplify and derive value from IoT devices [1]. An application is created on this with the key steps:

- Deciding a device/ gateway.
- Creating an application on the Bluemix cloud with the selected device (smartphone) and desired service (Transmit and receive data).
- Downloading an application known as IOT starter app on the smartphone used to activate the sensors when application is turned on.
- Securing the communication messages between the device and the cloud using MQTT messaging protocol or HTTP and data using REST and Real time APIs.
- Connecting it to Node – RED to create flow, monitor and analyze.

2. IBM Watson

Watson on the IBM Cloud is a platform to integrate application with the store, train and manage data being on secure cloud server.

3. Node - RED

Node Red is a programming tool for wiring together hardware devices, API's and online services[2]. The browser based editor is used to deploy nodes in their run time.

4. Smartphone

A device with all the sensors like accelerometer, gyroscope, camera, pulse, proximity, magnetometer, etc. embedded on the same platform to make it easier to run them all together as an IOT device.

5. Command line Interface

The reference model considers cloud foundry as an interface between the device collecting data and the IBM Bluemix for the sole purpose of pushing the data on the cloud Bluemix platform. It is a series of commands implemented in the command window.
To receive alerts on different websites and platforms, a respective account is desired. For example, to tweet on twitter when certain event occurs a twitter account is necessary. Similarly to receive an email notifying an event An email account with SMTP relay capabilities is required.

II. ARCHITECTURE [SWARA]

Figure shows the architecture of the system which includes internet based connections between:

a. IOT starter application on the smartphone and IBM Watson IOT platform.Here the Watson platform acts as a server between the Bluemix application and the smartphone application. All the data and the triggers from the smartphone are exchanged with the watson IOT platform.

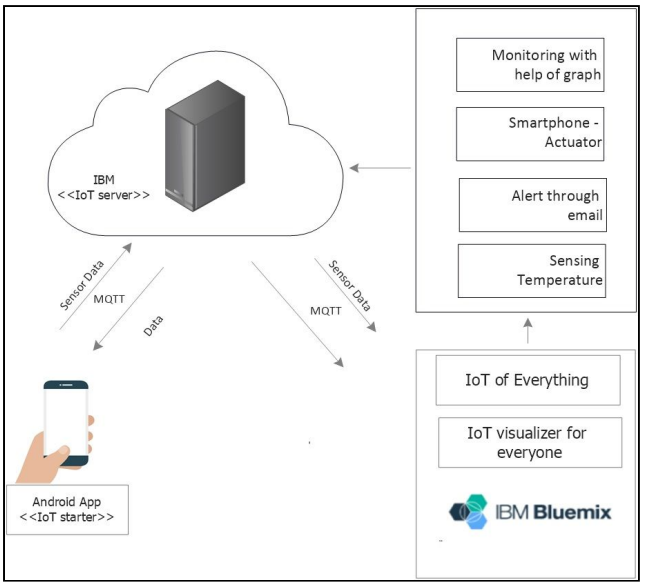

Fig 1: Architecture of the system

b. IBM Watson IOT platform and IBM Bluemix.The platform connects to the application created on the Bluemix to the cloud to store it. Thus, the application created on the phone as well as bluemix connects through watson IOT platform.

c. Bluemix and Alert system.Data captured is analyzed and specific alerts can be generated on email or twitter. Specific alerts for specific data is specified in the application.

III. IMPLEMENTATION [SAGAR]

A. Few Requirements to build IoT apps.

- An IBM Bluemix® account[3].
- A smartphone (an Android or iOS smartphone)[3].
- A twitter or email account to be notified by a tweet or email.
- Download and install the Cloud Foundry command line interface.

B. Creating main IoT app in Bluemix.

The IoT app in Bluemix will be the main backend application in the IoT solution. This backend application will read, receive, and interpret incoming payload messages that contain sensor

data. Additionally, it will define and send IoT commands to actuators based on certain conditions being met. Steps :

1. Log in to Bluemix account[3].

2.In the Bluemix catalog, from the Boilerplates section, select the Internet of Things Platform Starter boilerplate[3].

3. In the right pane, specify a unique name for the app, which is used to create a unique hostname for the app. Then, click CREATE[3]**.**

The Internet of Things Platform Starter boilerplate automatically adds the Internet of Things Platform service and a Cloudant NoSQL Database service to the app. It also includes a Node-RED runtime environment for this app.

C. Registering smartphone in the Watson IoT Platform.

This process starts with registering the smartphone in the Watson IoT Platform before connecting it to the IoT. The Bluemix IoT Platform service automatically allocates an IoT organization to the system. An IoT organization is a space that is used for connecting and managing devices to the IBM Watson IoT Platform so that the applications can access their live and historical data. Steps:

1. On the Bluemix dashboard, select the Internet of Things Platform service. Then, click **Launch dashboard[3]**.
2. The dashboard for IBM Watson IoT Platform opens in a new browser tab. The organization ID is assigned to app created and is displayed in the upper righ[3]t.

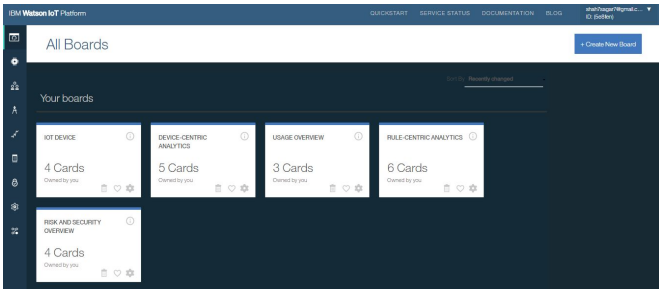

Fig: 2 Snapshot of IBM Bluemix Dashboard

3. On the Boards page, data and devices are managed, from the menu on the left select **Devices**. On the Devices page, click **Add Device**.
4. On the Add Device page, click **Create device type** and register the created device with unique ID[3].

The smartphone is now registered with Watson IoT Platform. Next step is to connect it to the Watson IoT Platform, but before that, install and configure the IoT Starter Mobile app on the smartphone.

D. Installing and configuring the IoT Starter Mobile app on the smartphone.

The IoT Starter Mobile app is used for both, read and send sensor data that comes from smartphone and also transform smartphone to be an actuator that can receive and run commands. This application has been developed with native languages on both iOS and Android platforms. With this mobile app, following events can be:

- Accelerometer X, Y, Z event of the smartphone.
- Touch Move event
- Text event

i. Installing the IoT Starter Mobile app on the iOS smartphone.

1. Download the IoT Starter Mobile app for iOS demo application from the iot-starter-for-ios GitHub project[3].
2. Import it into Xcode development environment[3].
3. Build the. ipa package file[3].
4. Deploy the. ipa package file onto iOS smartphone.
5. Once the demo app is installed on the smartphone, open the IoT Starter Mobile app. Its icon looks like this.

Fig:3 IOT starter application icon

Depending on the version of the iOS on the smartphone,a prompted to trust the International Business Machines developer pops up. In the General Settings for iOS smartphone, scroll down and select **Device Management**. Select **International Business Machines**, and then click the **Trust "International Business Machines"** link[3].IoT Starter can be seen in the list of apps and can be verified.

ii. Installing the IoT Starter Mobile app on Android smartphone.

1. Download the IoT Starter Mobile app for Android demo application from the iot-starter-for-android GitHub project[3].
2. Import it into Android development environment.
3. Build the .apk package file[3].
4. Deploy the .apk package file onto Android smartphone[3].

5.Once the demo app is installed on the smartphone, open the IoT Starter Mobile app.

E. Verifying that smartphone messages are being sent to the Watson IoT Platform.

After installing the IoT Starter Mobile app on the smartphone, further configure it with the IoT credentials and connect the app to the Watson IoT Platform.

1. Open the IoT Starter app on the smartphone, and specify the organization and smartphone credentials.
2. Open the profile for the app. For Android devices, select the menu in the upper right, and select **Open profiles[3]**.
3. Click **Activate Sensor**, which causes the app to send messages to the Watson IoT platform.
4. In the Watson IoT Platform dashboard (in Bluemix), in the menu on the left, select **Devices[3]**. Select the smartphone in the list. Verify that accelerometer events are displayed in the **Recent Events** section.
5. A card can also be added to the dashboard to visualize the smartphone data (also in real-time).

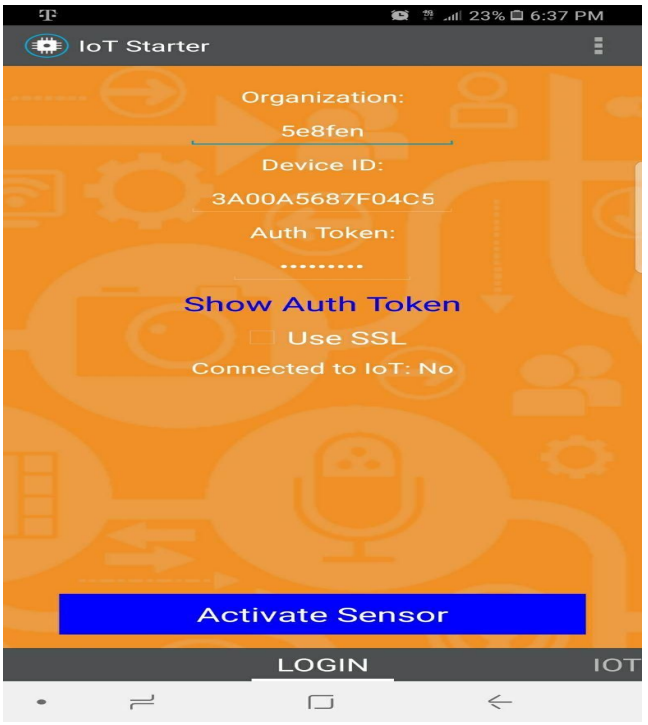

Fig: 4 Snapshot of IOT starter application login

F. Processing messages from the IoT sensor application.

Now that the smartphone is registered, and verified that it is sending its accelerometer data to the Watson IoT Platform,connect the IoT app to the Watson IoT platform by using the IoT service. After which usage of smartphone data in our IoT solution is initialized. Steps:

1. In the Bluemix dashboard, go to application and click application route to access application.

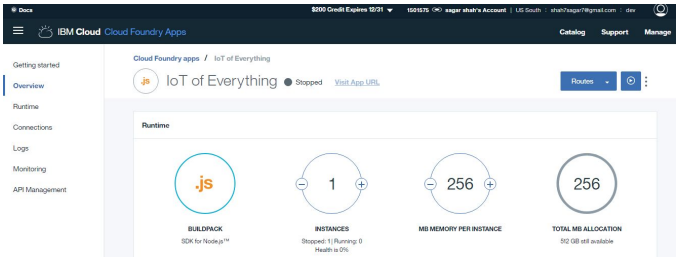

Fig: 5 Application page on IBM Bluemix

2. Open Node-RED flow editor[3].
3. In the Node-RED editor, which opens and contains a sample flow, select all existing nodes and delete them[3].

4. Create a new flow by dragging an ibm iot node from the input section onto your workspace and also dragging a debug node from the output section onto your workspace[3]. Connect the two nodes together.
5. Every program for different application can be developed here and thus developed are the three different flows for the reference applications[3].
6. In function part of flow diagram develop the necessary code for proposed application.
7. Click the **Deploy** button in the upper right of the Node-RED flow editor. The button turns gray when the flow is deployed[3].

H. Sending an alert when the smartphone falls down.

Updating Node-RED flow to use the sensor data.
Steps:

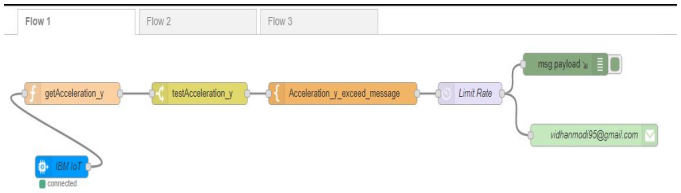

Fig: 6 Flowchart of first application on Nod RED

- Extract the "acceleration_y" value from the JSON payload message[3].
- Trigger a value against an acceleration value[3].
- Debug the notification message[3].
- Either post a tweet or send an email.

With the help of basic settings for email account and the phone in use, all the necessary settings are done for Insurance company application.

I. Displaying Real time data of sensor on Web Application.

The only relevant parameter is the Device ID to connect to the web app.
1. Double-click the node IBM IoT App out. In the pop-up window, enter the Device ID used earlier (for example, 112233445566), and click OK[3].
2. Click Deploy in the flow editor. The flow is deployed and should be active immediately.

3. Move smartphone around; flip and tilt it. The background color of the app on phone should now change colors, depending on the orientation of the z-axis[3].

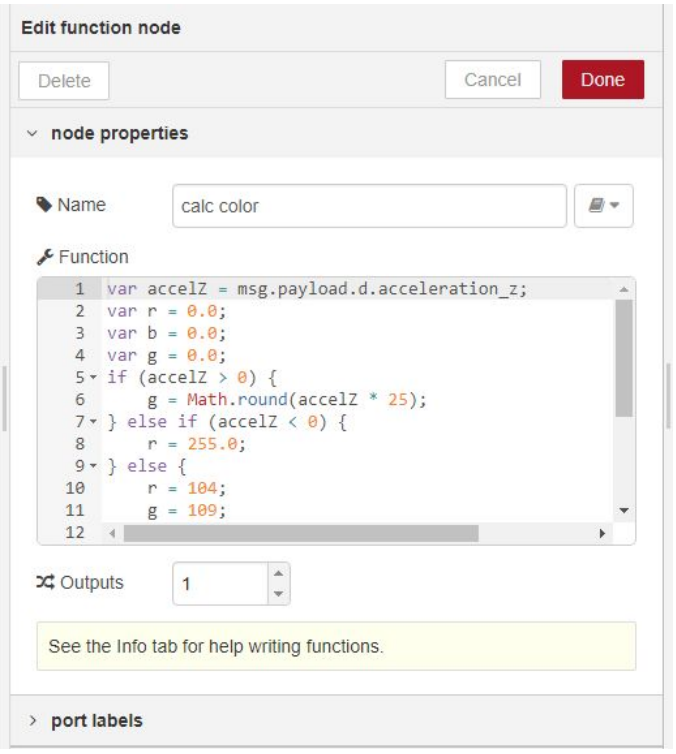

Fig: 7 Code to change the color of the phone screen by axes orientation

4. In the Node-RED editor, click the rectangle next to the msg.payload node, and click the debug tab to enable debugging[3]. Messages sent from phone in the JSON format can be seen.

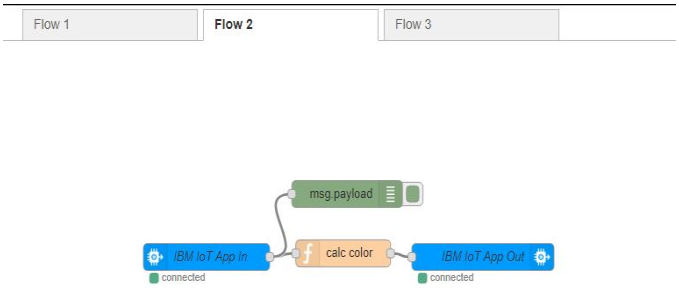

Fig: 8 Flowchart of second application on Node-RED

5. In the Bluemix Dashboard, open the Overview page for web app. Click Bind a service or API.

6. Select the Internet of Things service defined in Create an IoT app in Bluemix[3]. Click Restage to restage the app. Now the app can receive messages from the IBM IoT server.
7. To verify the visualizer app, in a browser, open http://*iotvisualizerforeveryone*.mybluemix.net[3]
8. In the Device drop-down box, select device id.

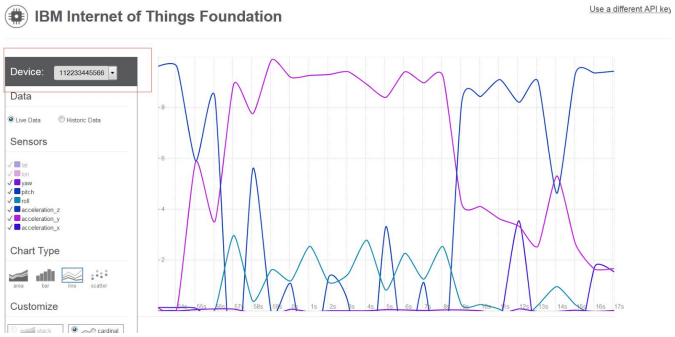

Fig: 9 Real time graph of phones movement on our web application IoT Visualizer for everyone

J. Sending a command to smartphone and phone will work as an actuator.

Until now, smartphone has been acting as a sensor. However,IoT Starter Mobile app can be used to turn smartphone into an actuator by having smartphone receive and act on commands.
The IoT Starter Mobile app can manage three types of events:

- accel events, for the accelerometer.
- touchmove events, for the swipe event on smartphone.
- text events, for text commands.

The app can receive and act on four commands:

- light - This command turns on or off the light on smartphone or in home.
- color - This command changes the background color of the IoT Starter Mobile app or color of light in home.
- alert - This command displays an alert message in the app.
- any text value - This command logs a message in the app.

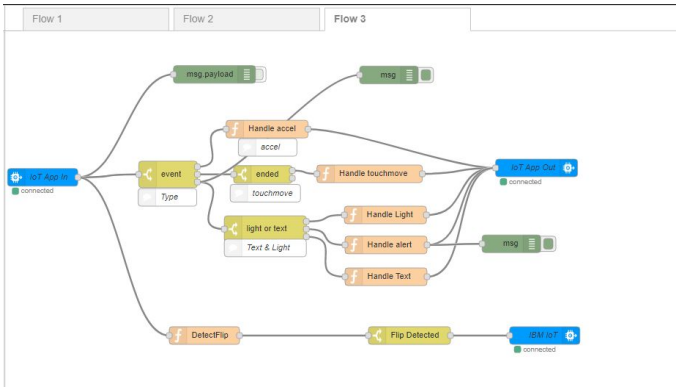

Fig: 10 Flowchart of third application on Nod RED

1. On smartphone, make sure that the IoT Starter Mobile app is running, and click Activate Sensor, if necessary.
2. Move smartphone around; flip it and tilt it. The background color of the app on phone changes colors. Smartphone is receiving the accel event.
3. On mobile smartphone with the IoT Starter Mobile app in the foreground, swipe left and right with one finger on the screen. Check the Log tab in app. Two messages are logged.Smartphone is enabled for receiving the touchmove event.

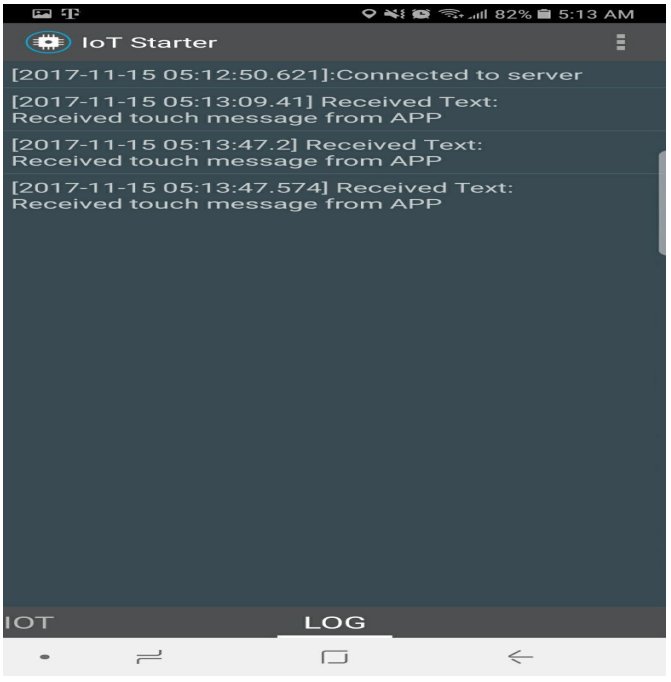

Fig: 11 Touch movement on screen is displayed on app log

4. On smartphone, go back to the IoT tab. Click the Send Text button. Type any text value, and click the Submit button.

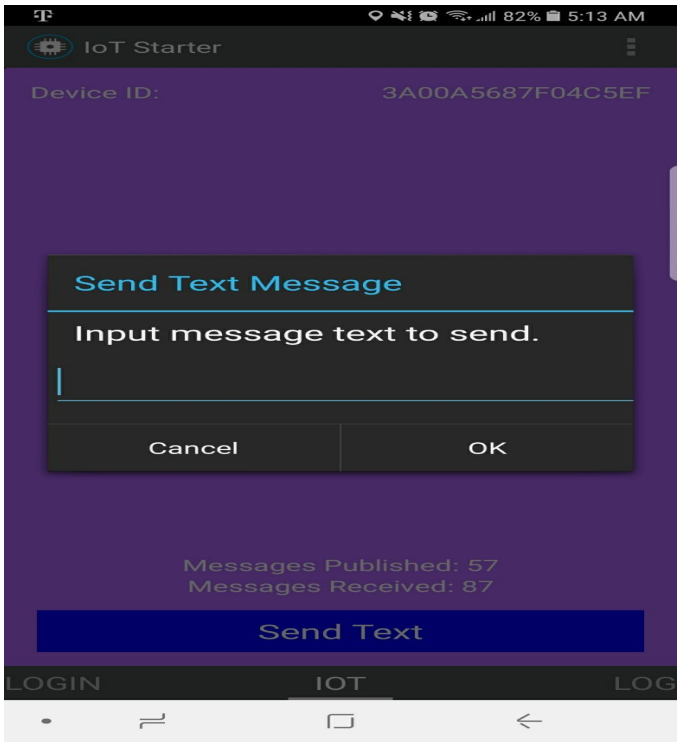

Fig: 12 Application window to send command

5. On smartphone, go back to the IoT tab. Click the Send Text button. Type light in the field, and click the Submit button[3]. The light on smartphone is turned on.Click Send Text again, type light, and the light will be turned off.

K. Use of Temperature sensor on various applications.

1. Open Watson IOT platform based sensor simulator.This is a simulated sensor that is capable of sending temperature, humidity, and object temperature data.The value being sent can be changed by interacting with the web UI of the simulator.This sensor connects to the IoT Platform and sends an 'iot sensor' event every 2 seconds while active[3].Keep a tab or window open with the sensor to continue sending data.
2. Device is connected by using token.Change in temperature can be visualize in real time on our IBM bluemix application.
3.This application can be used in many smart cities and smart home development and can produce large number of real time data for future machine learning and AI applications of IoT.

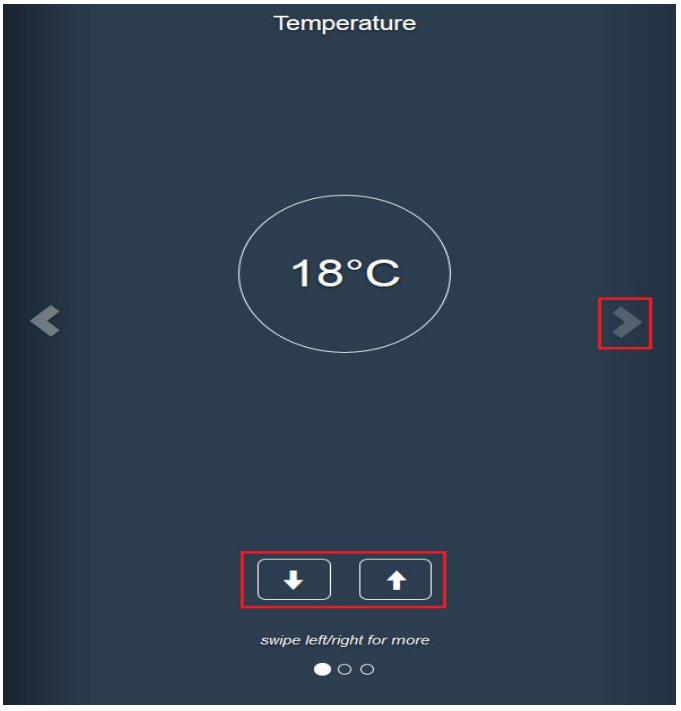

Fig: 13 Application window to display different temperature and humidity

4.The ability to change the temperature can be helpful to change the temperature of thermostat and heater and home and offices.

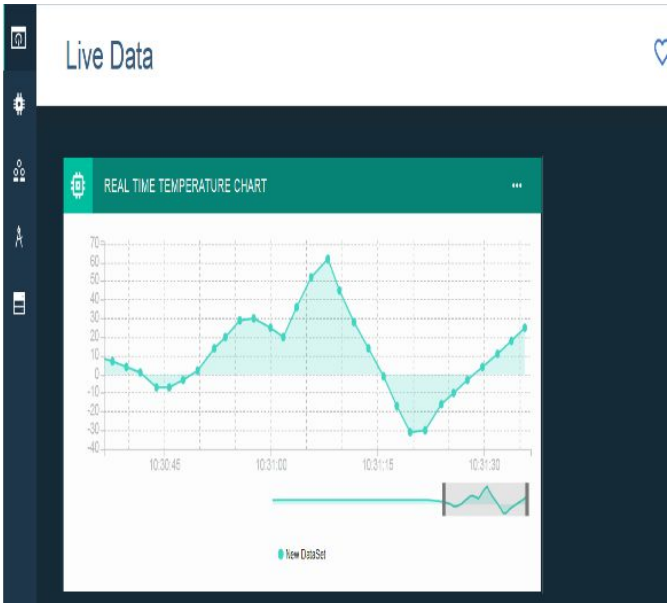

Fig: 14 Real time visualization of temperature

IV. TECHNICAL CHALLENGES [SAGAR]

The technical challenges involved in this project are both software and hardware in nature. On the hardware side we interfaced the smartphone device to the server. The challenge to select the Accel value to generate the email for phone falling. On the software side setting up the IBM Watson, IBM Bluemix and Node RED environment was the main challenge. Also the other challenge was to configure the device and control sensors properly to ensure smooth connection and communication. Establishing link between the application and server was a challenge

V. RESULTS

With these many creative and different applications, we have tried to take more attention towards the scope of smartphone as an IoT device. Result of each application is showed in many images throughout the paper. Here we have used just two sensors of our phone but we can interface each and every sensor of our phone to use the whole set of functions and future applications in the new era of IoT. Our phones can be used in medical, aerospace, smart cities, smart homes, machine learning, augmented reality and artificial intelligence in near future. By using phones as an IoT device, we can cover the large audience and create a big market of IoT in near future.

VI. ADVANTAGES [VIDHAN]

- One can know whether your phone is falling whenever you are away from it.
- The movement of phone can be detected or visualized with help of the real time graph.
- In an emergency one can send alert message to anyone's mobile within his/her network without calling, all you need is an internet access.
- One can communicate to different devices connected to through API's, can also be called as IoT Chat.
- Smartphone can also be converted for a fun application with help of the accelerometer sensors.
- Smartphone application provides a single device to do the same task as multiple devices, which makes management and data transfer easier and faster.

VII. DISADVANTAGES [VIDHAN]

- Without internet connectivity you cannot communicate through your cloud based server.
- The gateway from device to the cloud based server is vulnerable place where data can be hacked.
- A less probability for the chances of the data to get online on the cloud.
- If the threshold is set wrong, bulk of emails received on your email.
- Smartphone battery life would be compromised.
- Reliability on the this would be a problem.

VIII. FUTURE SCOPE [VIDHAN]

- ***Exploration of Unused Sensors***. There are many built-in sensors in smartphones which have yet to be explored.
- ***Improvement of Algorithms to Process Sensing Data.*** In addition to using accelerometer data to detect various types of activities, researches can further improve the algorithms to detect whether the activity that is performed is done in an appropriate manner or no[4]t.
- ***Smartphone Battery Usage Reduction***. We noticed that most of the papers reviewed here did not consider battery efficient aspect in the design and development process of their applications[4] Because, every time one doesn't carry charger every time. Therefore, design and development of a battery efficient application is crucial for the practicality of any smartphone application and could be another future direction for research in this area.
- ***Appropriate User Interface Design for Target Users.*** This project aims on making a Intuitive interfaces for respective user groups are important for the success of

smartphone applications[4]. Level of literacy and familiarity with gadgets are two of the key factors to consider in smartphone application design.

- ***Solutions for External Factors Affecting the Effectiveness of Smartphone Applications***. Multiple problems have been reported in using smartphone applications, for example poor mobile network coverage[4]. While it is expected that network coverage will be continually improved, providing a solution that adapts to network coverage would be beneficial.
- ***Enhanced Accelerometer Usage***. Smartphones have a three-axis accelerometer is all that is needed to determine the context of a phone: in a pocket, on a table, in a moving vehicle, etc[4]. The next major step is in indoor navigation, where GPS tracking isn't available and where GPS would not be not effective determining location in a multi-story building.

IX. CONCLUSION

From this project, easy transformation of smartphone into a sensor and an actuator device was done to use it as an IOT device connecting it to the IBM Watson IoT Platform, sending and receiving data from smartphone. Thus, smartphones can contribute to the future of IOT providing inbuilt circuit with all the mobile functions.

X. ACKNOWLEDGMENT

The work described in this paper was made possible and achieved by the contribution of **Dr. Ammar Rayes** and platform of IBM Watson and Bluemix. The cloud storage and services were purchased from IBM and smartphone used in this project was of SAMSUNG Galaxy series Note8. Application for phone was possible due to help of github and IBM Watson.

XI. REFERENCES

[1] Phonvert has a plan to convert old smartphones into IoT nodes by Jay Donovan. https://techcrunch.com/2016/03/14/phonvert-has-a-plan-to-convert-old-smartphones-into-iot-nodes.

[2] Node RED https://nodered.org.

[3] Turn your smartphone into an IoT device by Daniel Beguelin. https://www.ibm.com/developerworks/library/iot-mobile-phone-iot-device-bluemix-apps-trs.

[4] How the smartphone is driving the Internet of things by Jonah McLeod, Kilopass Technology Inc. http://www.kilopass.com/how-the-smart-phone-is-driving-the-internet-of-things.

[5] Bluemix login https://console.bluemix.net/registration.

[6] IBM watson https://github.com/ibm-watson-iot/iot-starter-for-android