

PROJECT REPORT

On

**IOT Analytics Using Predictive Models And Integration With Edge
Devices To Send Commands Based On Prediction Outcomes.**

Submitted in partial fulfillment of requirements for the award of

Bachelor of Technology (B. Tech)



Submitted by:

Twinkle Dey-(ET16BTHEC046)

Ritpan Changmai-(ET16BTHCS033)

Bornali Neog-(ET16BTHCS040)

Trinayan Borah-(ET16BTHCS033)

Under the Supervision and Guidance of

Mr. Yogendra Solanki
(External Mentor)

Ms. Manashee Kalita
(Internal Mentor)

School of Engineering and Technology

The Assam Kaziranga University

Nov 2019



SCHOOL OF ENGINEERING AND TECHNOLOGY
THE ASSAM KAZIRANGA UNIVERSITY
JORHAT-785006 :: ASSAM :: INDIA

CERTIFICATE

This is to certify that the project report entitled '**IOT Analytics Using Predictive Models And Integration With Edge Devices To Send CommandsBased On Prediction Outcomes**' submitted to the Department of Electrical Engineering, Kaziranga University, in partialfulfillment for the award of the degree of **Bachelor of Technology** is a record of bona fide work carried out by **Twinkle Dey-(ET16BTHEC046), Ritpan Changmai-(ET16BTHCS033), Bornali Neog-(ET16BTHCS040), Trinayan Borah-(ET16BTHCS033)** undermy supervision and guidance.

All help received by him from various sources have been duly acknowledged.
 No part of this report has been submitted elsewhere for award of any other degree.

.....

Internal Mentor

.....

External Mentor

CONTENT

Sl. No	Topic	Page no.
1.	Introduction	Iii
2.	Included component details	Iv
3.	Featured Technologies	V
4.	Procedure	Vi
5.	List of diagrams	5 – 9
6.	Trouble shooting	10
7.	Future Scope Of IOT	11
8.	Reference	12

INTRODUCTION

Internet of Things (IoT) Anything that has a sensor attached to it and can transmit data from one object to another or to people with the help of internet .IOT have evolved tremendously in all spheres of our lives like Industrial applications, Social interactions, Remote management of facilities and equipment to name a few. In general application areas, IoT data collected by Sensors can be used for monitoring as well as predicting the outcomes. If any deviation from the norm is detected, corrective action can be prescribed either manually or by an automated process.

IoT has eased the lives of humans. Imagine a hospital connected with all the smart devices. All the data collected from the device stores the information of the patients and then runs the analytics on various machine whichever the doctor or the authority want to check. Makes life so easy and sorted, making the hospital run optimally as possible.

A Predictive model that predicts a faulty condition ahead of time.

1. The Raspberry Pi gets events from the sensors. In the absence of sensors, the sensor events are read from a file.
2. The Node-RED flows are invoked on the Raspberry Pi.
3. The sensor events are sent to the Watson IoT platform.
4. The Watson IoT platform receives the events and sends it to all subscribing applications.
5. The Node-RED flows on IBM Cloud are triggered. The sensor events are recieved and stored into a database.
6. The predictive model on Watson Studio is triggered. The outcome of the model execution is sent back to the Node-RED through websockets.
7. Based on the outcome, the Node-RED flow sends a command with the action to be taken to the edge device(Raspberry Pi) through the Watson IoT platform
8. The Node-RED flow on Raspberry Pi recieve the command

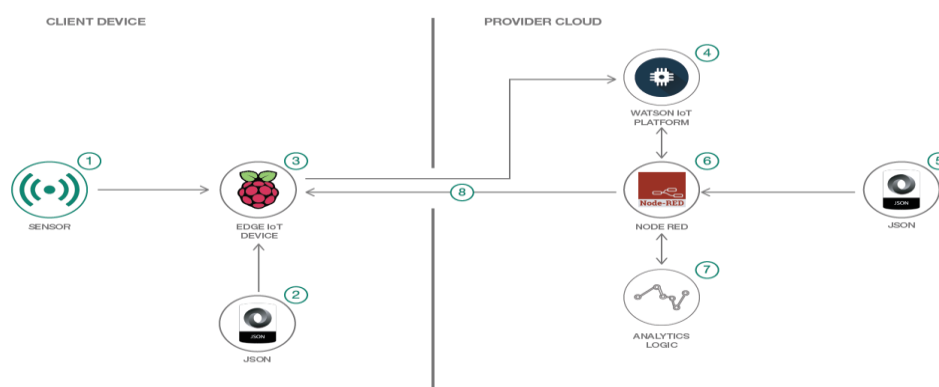


Fig1. Flow diagram of the project

INCLUDED COMPONENT DETAILS

- **IBM Cloud:** IBM's innovative cloud computing platform or IBM Cloud (formerly Bluemix) combines platform as a service (PaaS) with infrastructure as a service (IaaS) and includes a rich catalog of cloud services that can be easily integrated with PaaS and IaaS to build business applications rapidly.

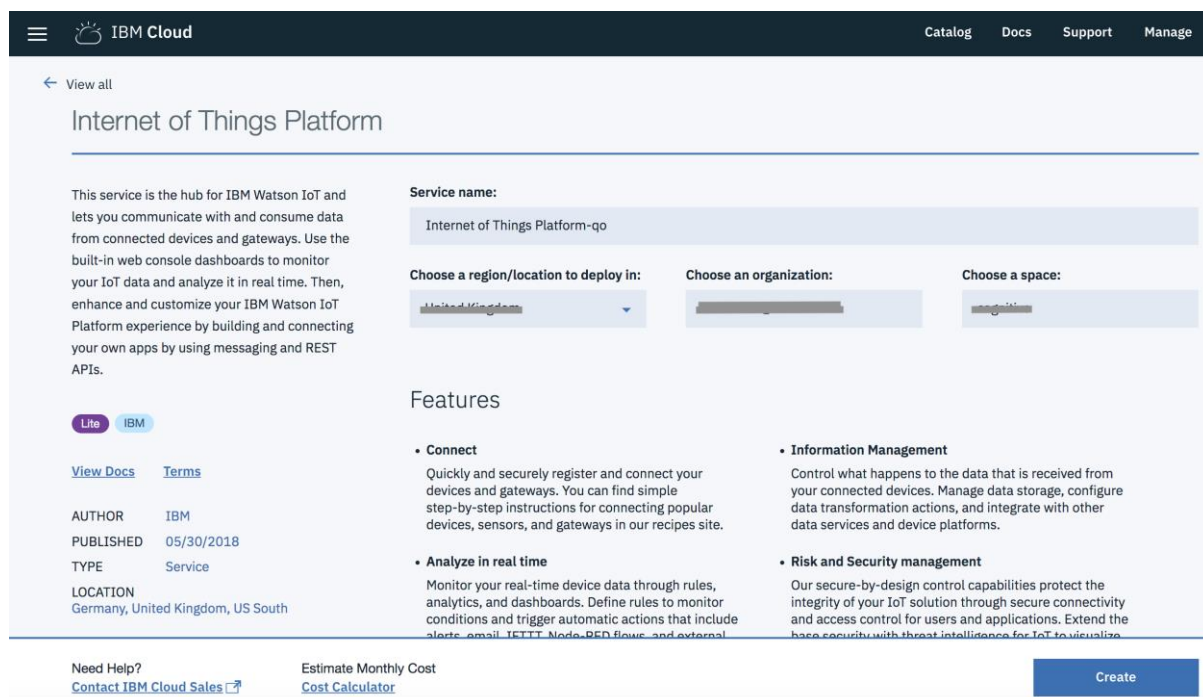


Fig2- IOT Platform

- **IBM Watson IoT Platform:** IBM Watson™ IoT Platform for IBM Cloud gives you a versatile toolkit that includes gateway devices, device management, and powerful application access. By using Watson IoT Platform, you can collect connected device data and perform analytics on real-time data from your organization.
- **IBM Watson Studio:** Analyze data using Python, Jupyter Notebook and RStudio in a configured, collaborative environment that includes IBM value-adds, such as managed Spark.
- **DB2 Warehouse:** IBM Db2 Warehouse on Cloud is a fully-managed, enterprise-class, cloud data warehouse service.

FEATURED TECHNOLOGIES

- Analytics: Finding patterns in data to derive information.
- Data Science: Systems and scientific methods to analyze structured and unstructured data in order to extract knowledge and insights.
- Internet of Things- Anything that has a sensor attached to it and can transmit data from one object to another or to people with the help of internet

- **JSON**: JavaScript Object Notation is an open-standard file format that uses human-readable text to transmit data objects consisting of attribute–value pairs and array data types (or any other serializable value). It is a very common data format, with a diverse range of applications, such as serving as replacement for XML in AJAX systems. It was derived from JavaScript.

PROCEDURE

- ☐ The Raspberry Pi gets events from the sensors. In the absence of sensors, the sensor events are read from a file.
- ☐ The Node-RED flows are invoked on the Raspberry Pi.
- ☐ The sensor events are sent to the Watson IoT platform.
- ☐ The Watson IoT platform receives the events and sends it to all subscribing applications.
- ☐ The Node-RED flows on IBM Cloud are triggered. The sensor events are received and stored into a database.
- ☐ The predictive model on Watson Studio is triggered. The outcome of the model execution is sent back to the Node-RED through websockets.
- ☐ Based on the outcome, the Node-RED flow sends a command with the action to be taken to the edge device(Raspberry Pi) through the Watson IoT platform
- ☐ The Node-RED flow on Raspberry Pi receive the command



LIST OF DIAGRAMS

1. Create IBM Cloud services and configure

Click on [Internet of Things Platform](#) and create an instance of Internet of Things Platform.

The screenshot shows the IBM Cloud interface for the 'Internet of Things Platform' service. The header includes the IBM Cloud logo and navigation links: Catalog, Docs, Support, and Manage. Below the header, there's a 'View all' link and the service title 'Internet of Things Platform'. A descriptive paragraph explains that this service is the hub for IBM Watson IoT, allowing users to communicate with and consume data from connected devices and gateways. It mentions built-in web console dashboards for monitoring IoT data in real time and the ability to enhance and customize the experience by building and connecting apps using messaging and REST APIs.

Below the description, there are tabs for 'Lite' and 'IBM'. A 'View Docs' and 'Terms' link is provided. The 'AUTHOR' is listed as 'IBM', 'PUBLISHED' as '05/30/2018', 'TYPE' as 'Service', and 'LOCATION' as 'Germany, United Kingdom, US South'.

The 'Service name' field is set to 'Internet of Things Platform-qo'. Below this, there are three dropdown menus: 'Choose a region/location to deploy in:' (set to 'United Kingdom'), 'Choose an organization:' (set to 'IBM'), and 'Choose a space:' (set to 'Default').

The 'Features' section lists several capabilities:

- Connect**: Quickly and securely register and connect your devices and gateways. You can find simple step-by-step instructions for connecting popular devices, sensors, and gateways in our recipes site.
- Analyze in real time**: Monitor your real-time device data through rules, analytics, and dashboards. Define rules to monitor conditions and trigger automatic actions that include alerts, email, IFTTT, Node-RED flows, and external actions.
- Information Management**: Control what happens to the data that is received from your connected devices. Manage data storage, configure data transformation actions, and integrate with other data services and device platforms.
- Risk and Security management**: Our secure-by-design control capabilities protect the integrity of your IoT solution through secure connectivity and access control for users and applications. Extend the base security with threat intelligence for IoT to visualize and respond to threats.

At the bottom, there are links for 'Need Help? Contact IBM Cloud Sales' and 'Estimate Monthly Cost Cost Calculator', along with a prominent 'Create' button.

2. DB2 Warehouse

Create a [DB2 Warehouse](#) instance.

The screenshot shows the IBM Cloud interface for the 'Db2 Warehouse' service. The header includes the IBM Cloud logo and navigation links: Catalog, Docs, Support, and Manage. Below the header, there's a 'View all' link and the service title 'Db2 Warehouse'. A descriptive paragraph explains that IBM Db2 Warehouse on Cloud is a fully-managed, enterprise-class, cloud data warehouse service. It is powered by IBM BLU Acceleration and provides unmatched query performance. The service is offered in multiple form factors: SMP for cost-effective cloud data warehousing, and MPP for high-performance parallel query processing and high availability. It also mentions that Db2 Warehouse on Cloud comes packed with a suite of Netezza-like in-database analytics tools and functions, allowing users to run their analytics jobs wherever their data resides. It also states that users can get the most out of their cloud data warehouse by combining it with IBM or third-party data visualization and ETL tools.

Below the description, there are tabs for 'IBM'. A 'View Docs' and 'Terms' link is provided. The 'AUTHOR' is listed as 'IBM', 'PUBLISHED' as '06/05/2018', 'TYPE' as 'Service', and 'LOCATION' as 'Sydney, Germany, United Kingdom, US South'.

The 'Service name' field is set to 'Db2 Warehouse-5a'. Below this, there are three dropdown menus: 'Choose a region/location to deploy in:' (set to 'Sydney'), 'Choose an organization:' (set to 'IBM'), and 'Choose a space:' (set to 'Default').

The 'Features' section lists several capabilities:

- Fully managed, safe, and secure**: Your Db2 Warehouse on Cloud instance is managed, monitored, encrypted and backed-up by IBM, so you can focus on gaining insights from your data instead of administering it.
- Compatible with Netezza and Oracle**: Most of your Netezza and Oracle workloads will migrate seamlessly to Db2 Warehouse on Cloud. For the select few edge cases, we offer free tooling to help you make a smooth transition.
- Built for the hybrid cloud**: Our unified architecture enables a range of hybrid use cases. Easily move data between your on-premises data stores and Db2 Warehouse on Cloud. Access data & run SQL queries across multiple heterogeneous data sources with IBM Fluid Query.
- Highly Available (HA) with MPP**: Your data workloads, queries and dashboards will all continue to run, even during unexpected failure.
- Related Db2 cloud products**: Check out Db2 on Cloud, the enterprise-class, high-performance transactional data store.

Below the features, there's an 'Images' section with a caption: 'Click an image to enlarge and view screen captures, slides, or videos. Screen caps show the user interface for the service after it has been provisioned.' There are several thumbnail images showing the Db2 Warehouse user interface.

At the bottom, there are links for 'Need Help? Contact IBM Cloud Sales' and 'Estimate Monthly Cost Cost Calculator', along with a prominent 'Create' button.

- Click on Service Credentials. Click on New Credential. Click on View Credentials.

Manage

Service credentials

Connections

Data & Analytics / Db2

Location: US South Org: Space:

Service credentials

Credentials are provided in JSON format. The JSON snippet lists credentials, such as the API key and secret, as well as connection information for the service. [Learn More](#)

New credential

10 Items per page | 1-1 of 1 items

1 of 1 pages < 1 >

KEY NAME	DATE CREATED	ACTIONS
<input type="checkbox"/> Credentials-1	Jun 6, 2018 - 11:42:43	View credentials

```
{
  "hostname": "XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX",
  "password": "XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX",
  "https_uri": "XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX",
  "port": 50000,
  "ssldsn": "DATABASE=BLUDB;HOSTNAME=XXXXXXXXXXXXXXXXXXXX;PORT=50001;PROTOCOL=TCP/IP;UID=XXXXXXXXXXXX;PWD=XXXXXXXXXXXX;Security=SSL",
  "host": "XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX"
}
```

- Click on Manage
- Click on Open to launch the Dashboard
- Click on Explore.

Click on the schema starting with DASH

IBM Db2 Warehouse on Cloud

Load **Explore** Run SQL Analyze

Database tables

Schema

Find a schema

DASH

ERRORSCHEMA

GOSALES *Sample*

GOSALESBW *Sample*

GOSALESBW *Sample*

3. Node-RED on IBM Cloud

- Create the [Node-RED Starter application](#).
- Choose an appropriate name for the Node-RED application - App name:.
- Click on Create.

IBM Bluemix Catalog

Catalog Support Manage

View all

Create a Cloud Foundry App

Node-RED Starter

This application demonstrates how to run the Node-RED open-source project within IBM Bluemix.

Community

View Docs

VERSION 0.6.0

TYPE Boilerplate

REGION United Kingdom, Germany, Sydney, US South

App name:

Host name:

Domain: eu-gb.mybluemix.net

Select region to deploy in: United Kingdom

Choose an organization:

Choose a space:

Selected Plan:

SDK for Node.js™ Default

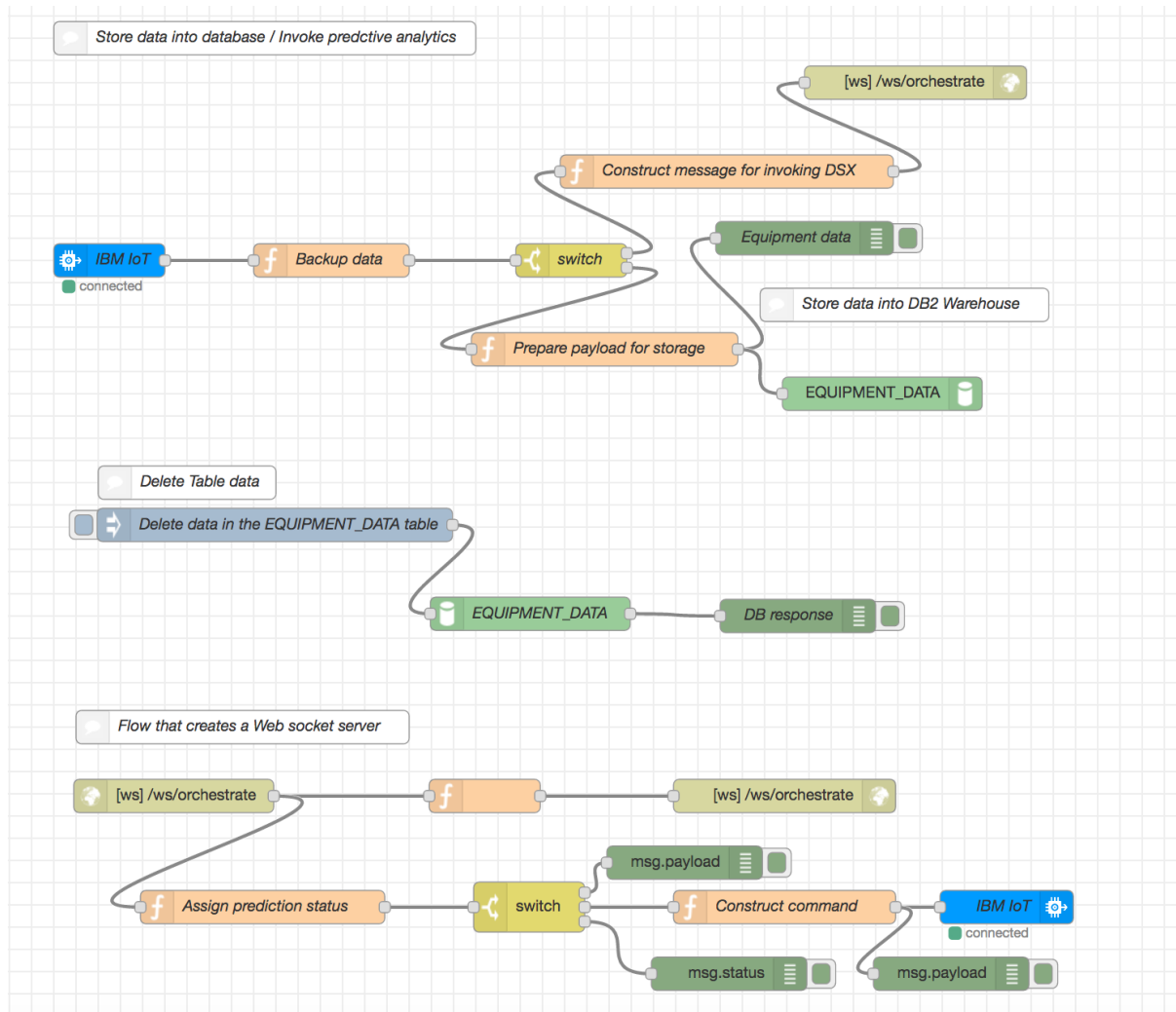
Cloudant NoSQL DB Lite

Need Help? Contact Bluemix Sales

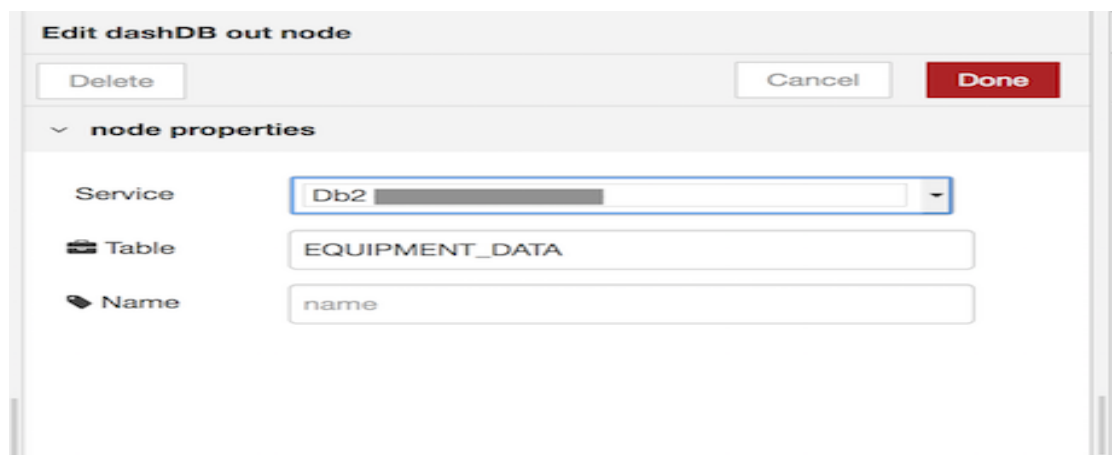
Estimate Monthly Cost [Cost Calculator](#)

Create

4.Import the Node-RED flow



- On the two DB2 nodes named EQUIPMENT_DATA. Select the DB2 Warehouse service.



5. Watson Studio

- Sign up for IBM's [Watson Studio](#).
- Create a project if necessary, provisioning an object storage service if required.
- In the Assets tab, select the Create notebook option.
- Select the From URL tab.
- Enter a name for the notebook.
- Optionally, enter a description for the notebook.
- Enter this Notebook URL: https://github.com/IBM/iot-edge-predictive-models-dsx/blob/master/notebooks/watson_iotfailure_prediction_integrated.ipynb
- Select the free runtime.
- Click the Create button.

New notebook

BlankFrom fileFrom URL

Name*

watson_iotfailure_prediction_integrated

11 Characters Remaining

Description

Type your Description here

Notebook URL*

dsx/blob/master/notebooks/watson_iotfailure_prediction_integrated.ipynb

Select runtime* Includes notebook environments ⓘ

Default Python 3.5 Free (1 vCPU and 4 GB RAM) ▼

The selected runtime has 1 vCPU and 4 GB RAM and is free.
[Learn more about capacity unit hours and Watson Studio pricing plans.](#)

Cancel

Create Notebook

- In Section 7. of the notebook, enter the websocket URL noted earlier.

```
def start_websocket_listener():
    websocket.enableTrace(True)
    ws = websocket.WebSocketApp("ws://192.168.225.208.mybluemix.net/ws/orchestrate",
                                on_message = on_message,
                                on_error = on_error,
                                on_close = on_close)

    ws.on_open = on_open
    ws.run_forever()
```

4 Read IoT Sensor data from database

```
In [8]: # Read data from DB2 warehouse in RMX
# -----
from ibmdbpy import IdaDataBase, IdaDataFrame

# Call function to read data for specific sensor
# @hidden_cell
# The section below needs to be modified:
#   Insert your credentials to read data from your data sources and replace
#   the idaConnect() section below
# This connection object is used to access your data and contains your credentials.
idadb_d281f6cd34eb4bc98f0183a45598dbb9 = IdaDataBase(dsn="DASHDB;Database=BLUDB;Hostname=<HOST_NAME>;Port=50000;PROTOCOL=TCP/IP;UID=<UID>;PWD=<PASSWORD>")

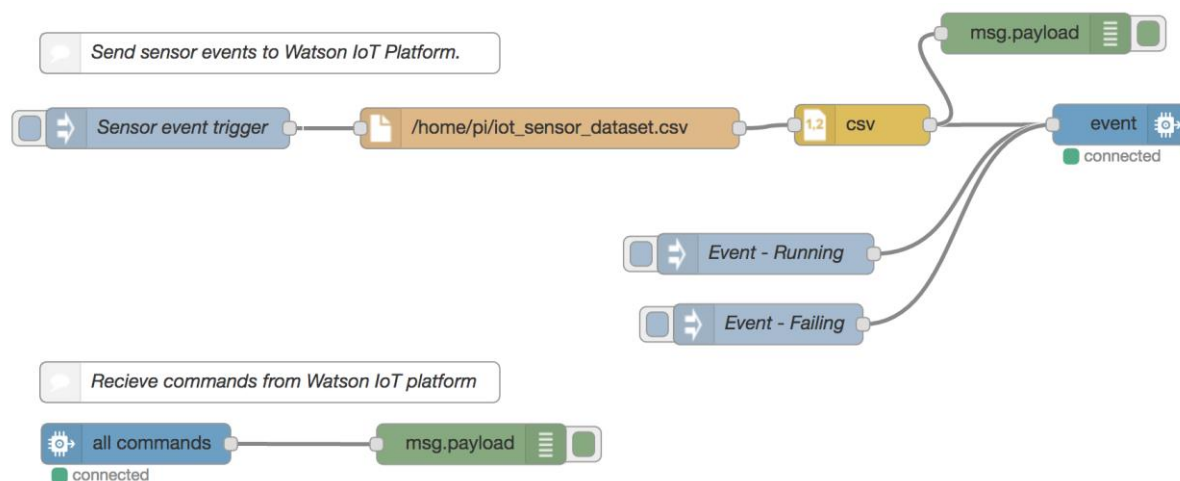
df_iotdata = IdaDataFrame(idadb_d281f6cd34eb4bc98f0183a45598dbb9, <SCHEMA>.EQUIPMENT_DATA').as_dataframe()

# Check Number of observations read for analysis
print ("Number of Observations :", len(df_iotdata))
# Inspect a few observations
df_iotdata.head()
```

6. Configure Raspberry Pi

```
[Balajis-MBP:data bkadambi$ ftp 192.168.225.208 ]
Connected to 192.168.225.208.
220----- Welcome to Pure-FTPd [privsep] [TLS] -----
220-You are user number 1 of 50 allowed.
220-Local time is now 04:57. Server port: 21.
220-This is a private system - No anonymous login
220-IPv6 connections are also welcome on this server.
220 You will be disconnected after 15 minutes of inactivity.
Name (192.168.225.208:bkadambi): pi
331 User pi OK. Password required
[Password: ]
230 OK. Current directory is /home/pi
[ftp> put iot_sensor_dataset.csv ]
200 PORT command successful
150 Connecting to port 55160
226-File successfully transferred
226 0.055 seconds (measured here), 383.40 Kbytes per second
23474 bytes sent in 0.00717 seconds (3.12 Mbytes/s)
[ftp> ls iot_sensor_dataset.csv ]
200 PORT command successful
150 Connecting to port 55162
-rw-r--r-- 1 pi pi 21584 Jun 9 04:57 iot_sensor_dataset
.csv
226-Options: -l
226 1 matches total
[ftp> pwd ]
257 "/home/pi" is your current location
[ftp> bye ]
221-Goodbye. You uploaded 22 and downloaded 0 kbytes.
221 Logout.
Balajis-MBP:data bkadambi$
```

7. Configure Node-RED on the Raspberry Pi



- Click on the event node.

Delete
Cancel
Done

Connect as
Device

☐ Quickstart
☒ Registered

Credentials
Add new wiotp-credentials...

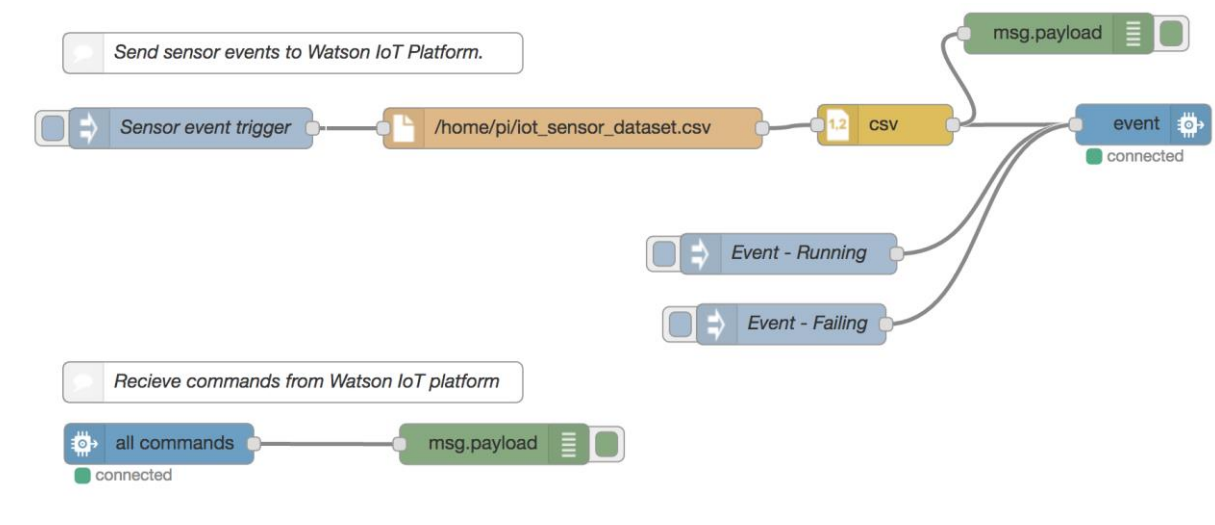
Event type
event

Format
json

QoS

Name

9. Trigger the Node-RED flow on Raspberry Pi

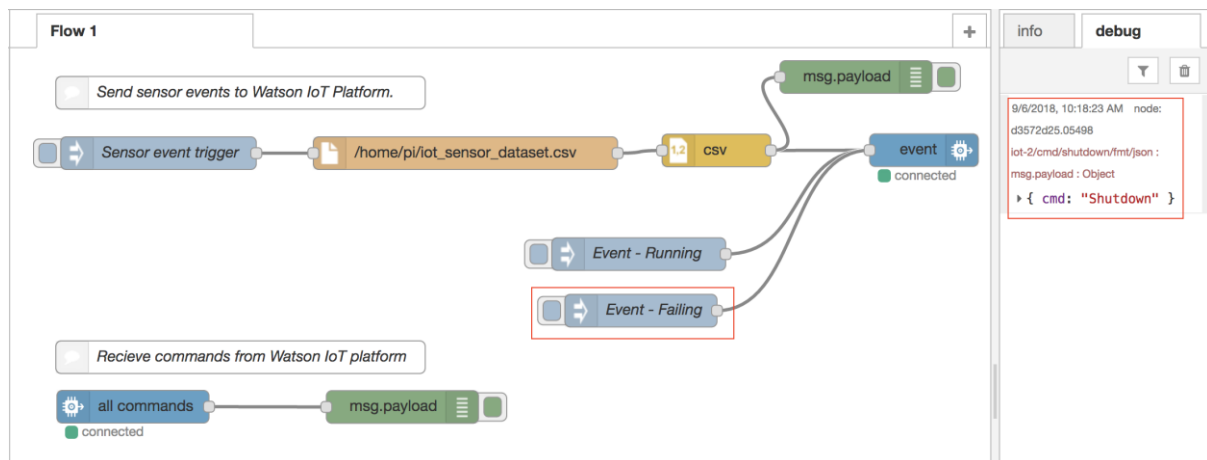


10. Run the notebook

There are several ways to execute the code cells in your notebook:

- One cell at a time.
 - Select the cell, and then press the Play button in the toolbar.
- Batch mode, in sequential order.
 - From the Cell menu bar, there are several options available. For example, you can Run All cells in your notebook, or you can Run All Below, that will start executing from the first cell under the currently selected cell, and then continue executing all cells that follow.
- At a scheduled time.
 - Press the Schedule button located in the top right section of your notebook panel. Here you can schedule your notebook to be executed once at some future time, or repeatedly at your specified interval.

11. Analyze results



Troubleshooting

Node-RED

- This Code Pattern uses [Raspberry Pi 3 Model B](#)
- While installing Raspbian on Raspberry Pi make sure you installed the correct version. The version used in this IBMCode pattern can be found [here](#)
- You can refer to a complete list of Raspberry Pi OS archives [here](#)
- Make sure the import of Node-RED ran correctly. Ensure each flow works correctly in the sequence of data flow before moving on to the next.
- All the flows depend on the outputs from previous flows and also the connectivity. If there is an issue in any stage stop and resolve the issue before moving further. Start from the beginning when troubleshooting. Examine the outputs in the debug window in Node-RED editor thoroughly at each stage.
- The flow relies on service credentials from IBM Cloud. Make sure to add your service credentials correctly.

IBM IoT Platform

- Make sure data is received and transmitted correctly between Raspberry Pi and IBM IoT Platform on the cloud.
- Specifically ensure the Region in which your Service is created in IBM Cloud is consistent
- Also pay special attention to the unique Device ID you set on the Raspberry Pi Node-RED flow as well as the Node-RED flow in IBM Cloud. These must be same and unique to ensure seamless data transfer.

FUTURE SCOPE OF USING IOT

- IoT or internet of thing these days we quite often listen to this word. The words such as the cyber-attack, hacking we can hear these too jointly with IoT. Despite, of the fear of piracy and cyberattack the internet of things and IoT applications will grow much more faster in the coming years. Ultimately we can say the IoT future scope or the future of IoT is very bright. There will a lot of IoT devices which will be coming shortly.
- IoT or Internet of Things is primarily a full system of all the interconnected computing devices, having all the mechanical and digital machines. When the objects or the living beings have the UIDs or the Unique Identification, Iot and IoT application can transfer the data automatically without including the human to human interaction and human to computer interaction in between.
- The Internet Of Things or IoT objects can be anything like an artificial heart in a human or a biochip transponder in the farm animals or the automobile containing the sensors. All these things are essential for human survival. As the organizations are increasing so as the need of the organization that can make the work go easier in an efficient way.



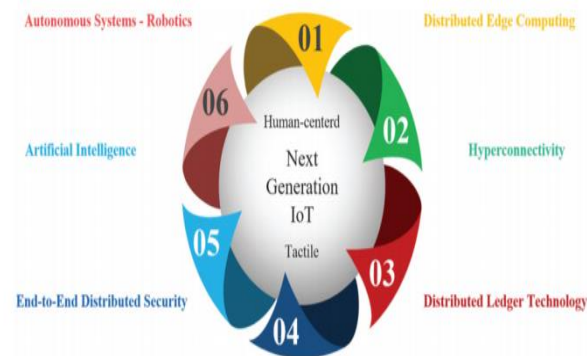


Fig-Next Generation IOT Convergence

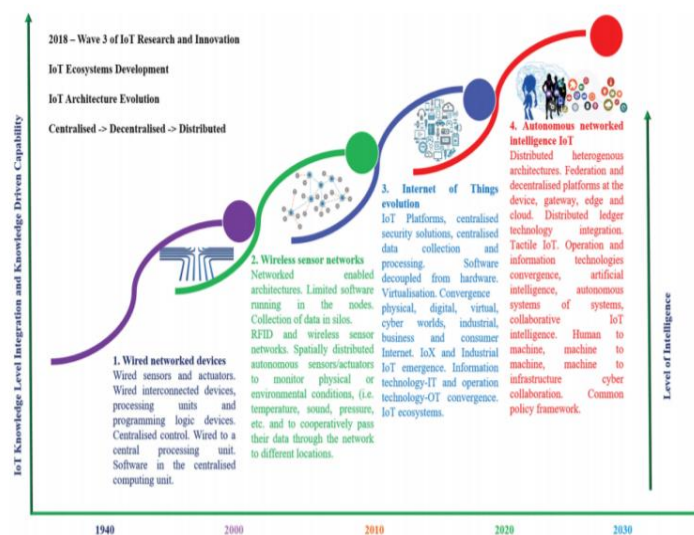


Fig-Next Generation IOT evolution

CONCLUSION

From this IOT project we will be able to analyze the prediction of any data such as temperature, humidity, etc outcomes. It can be used to identify patterns, trends or even predict certain outcomes. It will help in businesses purpose such as in large scale industries. IOT devices are going to send truckloads of data for analysis to Big Data organizations.

Right now Big Data companies are only just becoming capable of handling this immense amount of data in a highly secure manner. The change we are expecting on the Big Data front would be the adoption of flexible and scalable solutions to enhance security, data storing, and data analysis capabilities.

Bibliography

Project site:- <https://github.com/IBM/iot-edge-predictive-models-dsx/blob/master/README.md>