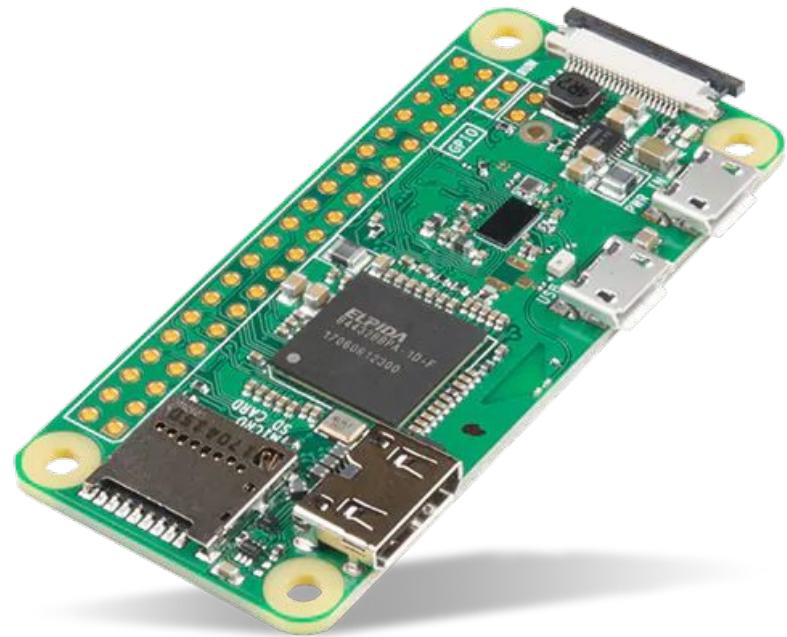
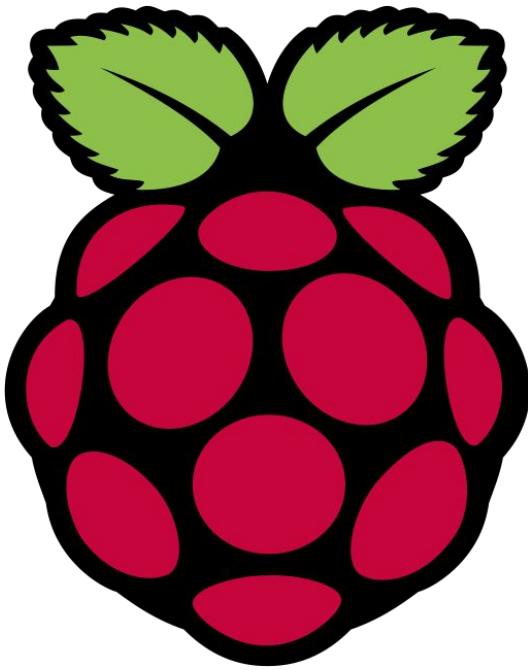


IoT Training with Raspberry Pi Zero W v5



Trainer: Man Guo Chang



Website: www.tertiarycourses.com.sg
Email: enquiry@tertiaryinfotech.com

About the Trainer

Mr. Man Guo Chang graduated from Nanyang Technological University, School of Electrical and Electronic Engineering, major in Computer Engineering.

Mr. Man has more than 25 years of working experience in the Semiconductor field, specialized in IC Testing, Product Engineering, Data Analysis, and Software Development.

Mr. Man is an ACTA certified trainer. His skill set includes Website Development, Digital Marketing, Software Development, Machine Vision, Internet of Things, etc.



Let's Know Each Other...

Say a bit about yourself

- Name
- What Industry you are from?
- Do you have any prior knowledge in IoT
- Why do you want to learn IoT?

Ground Rules

- Set your mobile phone to silent mode
- Participate actively in the class. No question is stupid.
- Mutual respect. Agree to disagree.
- One conversation at one time.
- Be punctual. Back from breaks on time.
- Exit the class silently if you need to step out for phone call, toilet break etc.
- 75% attendance is required

Ground Rules for Virtual Training

- Upon entering, mute your mic and turn on the video. Use a headset if you can
- Use the 'raise hand' function to indicate when you want to speak
- Participant actively. Feel free to ask questions on the chat whenever.
- Facilitators can use breakout rooms for private sessions.



Prerequisite

This is a beginner course. No prerequisite is assumed.

Agenda

Topic 1 Overview of Internet of Things (IoT)

- What is IoT?
- IoT Components
- Sensor and Actuators for IoT
- Wireless Communication Technologies for IoT
- IoT Applications and Use Cases

Topic 2 Raspberry Pi Zero W

- What is Raspberry PI Zero W
- Raspberry Pi Zero W Layout and Pinout
- Setup Raspberry Pi Zero W to VNC Viewer

Topic 3 Introduction to Node-Red

- What is Node-Red?
- Install Node-Red
- Node Operations
- Install Dashboard Nodes

Agenda

Topic 4 Node-Red Raspberry PI GPIO

- Install Raspberry PI GPIO Nodes
- Controlling LEDs with Node-Red
- Sensing Temperature and Humidity Data
- Install Raspberry PI GPIO Nodes
- Controlling LEDs with Node-Red
- Sensing Temperature and Humidity Data

Topic 5 IoT via MQTT

- What is MQTT?
- Test Out MQTT
- Publish/Subscribe Data via MQTT

Prerequisite

Basic knowledge of Raspberry Pi is assumed.

Exercise Files

Please download the exercise files from

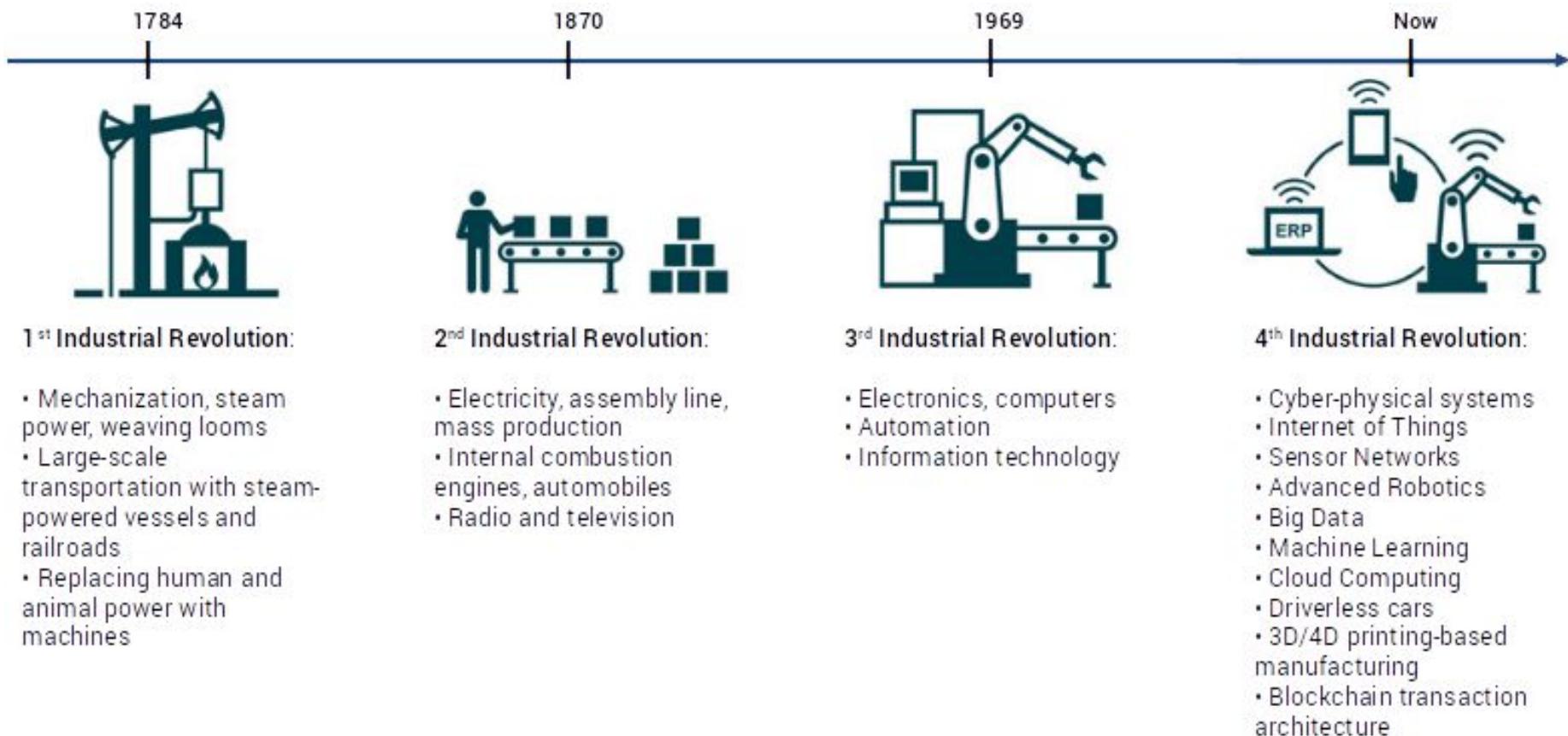
<https://github.com/tertiarycourses/Rpi-IoT-Node-Red>

Topic 1

Overview of Internet of Things (IoT)

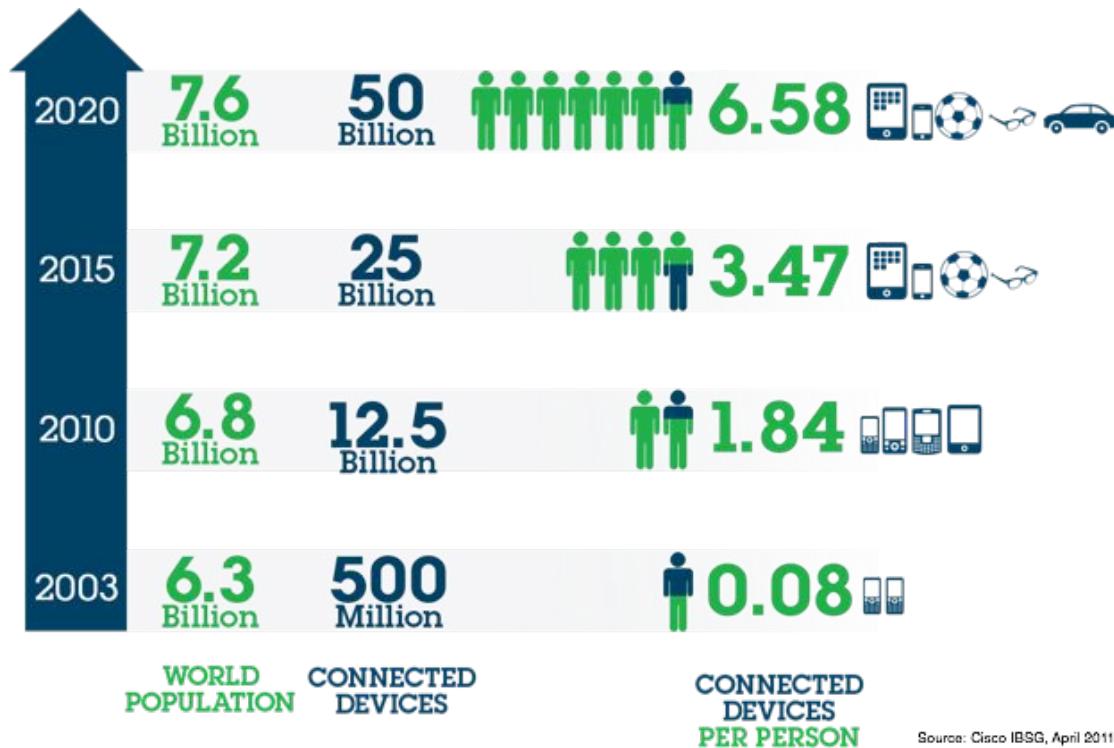
4th Industrial Revolution

- We are at the beginning of 4th industrial revolution
 - AI+IoT+5G+Blockchain+Robots+Cloud Computing



Internet of Things (IoT)

- IoT is simply about connecting objects via the internet in order to optimize operations, reduce costs, boost productivity and improve our everyday life
- IoT market value is estimated to reach \$9 trillion and with 50 billion connected devices by 2020



IoT Components



Sensors

Collecting data



Connectivity

Sending data to cloud



Data Processing

Making data useful



User Interface

Delivering information to user

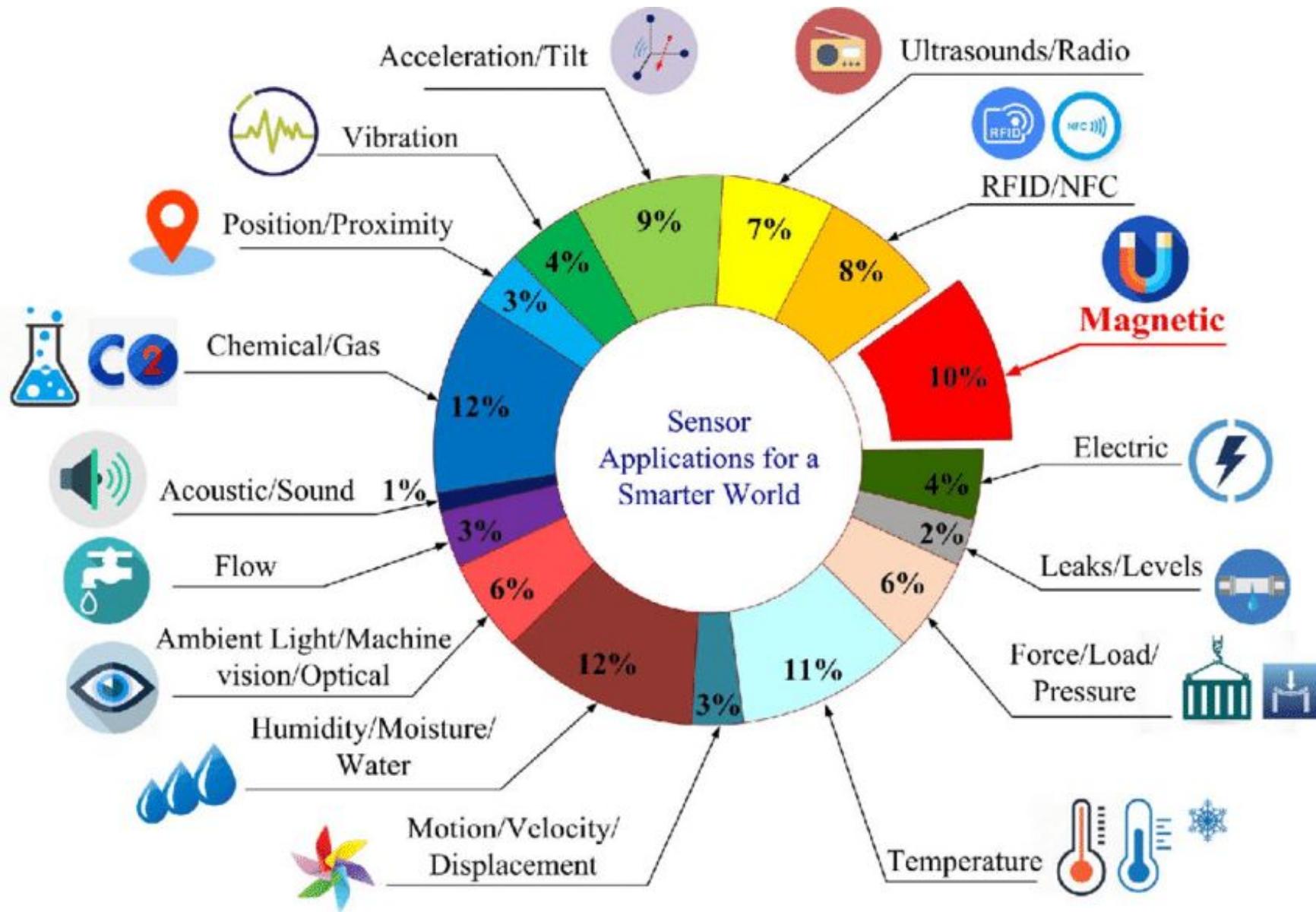
A “thing” is any object with embedded electronics that can transfer data over a network — without any human interaction.

Driving Forces of IoT

- Low cost sensors and long range wireless technology are instrumental to IoT
- 5G will drive IoT to mass adoption.

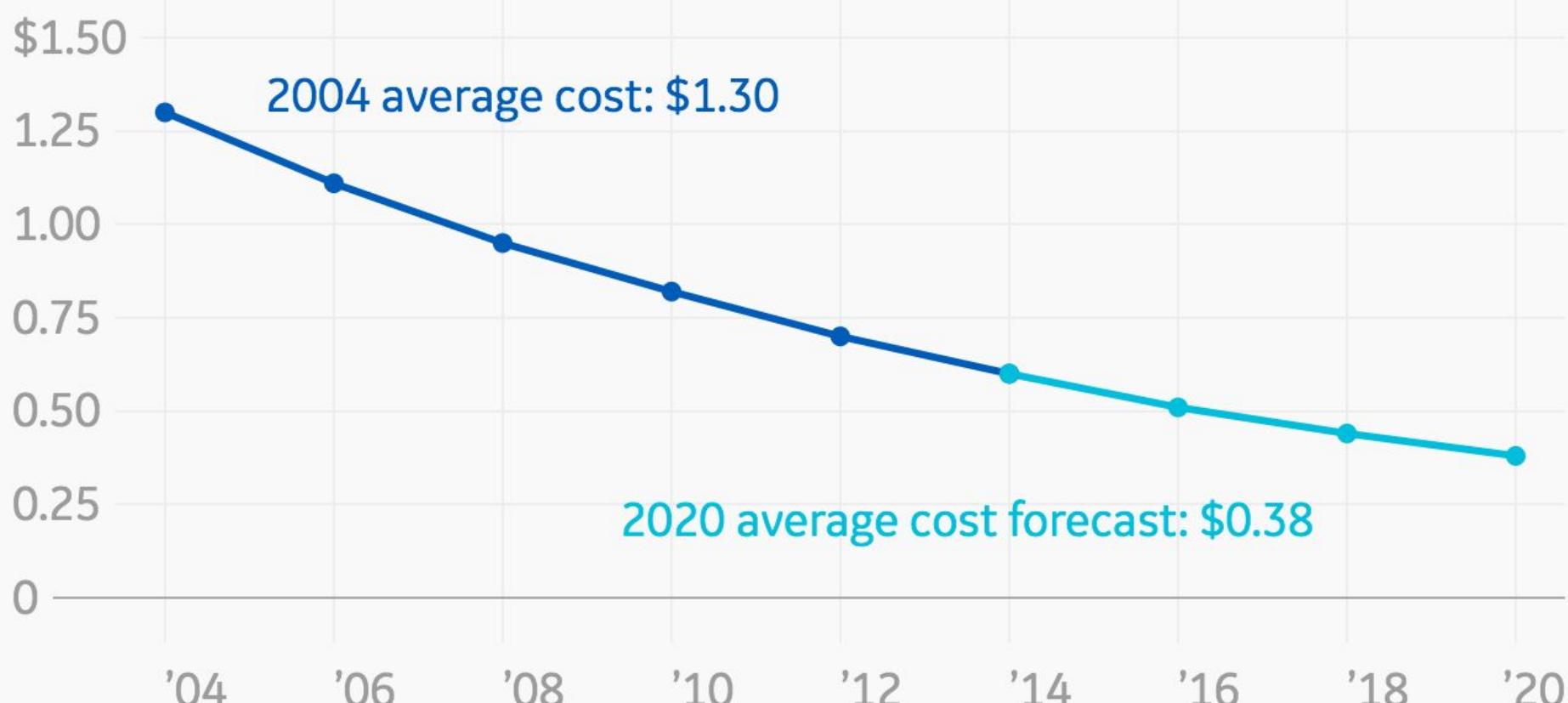


Sensors for IoT

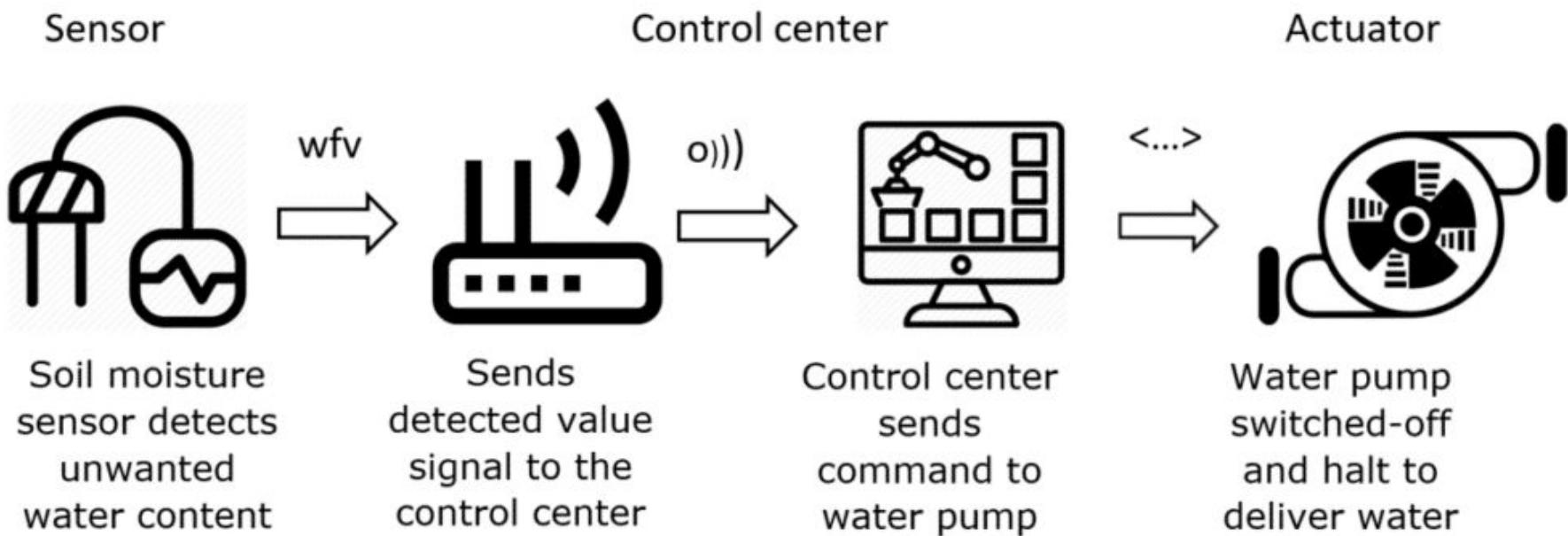


Sensors for IoT

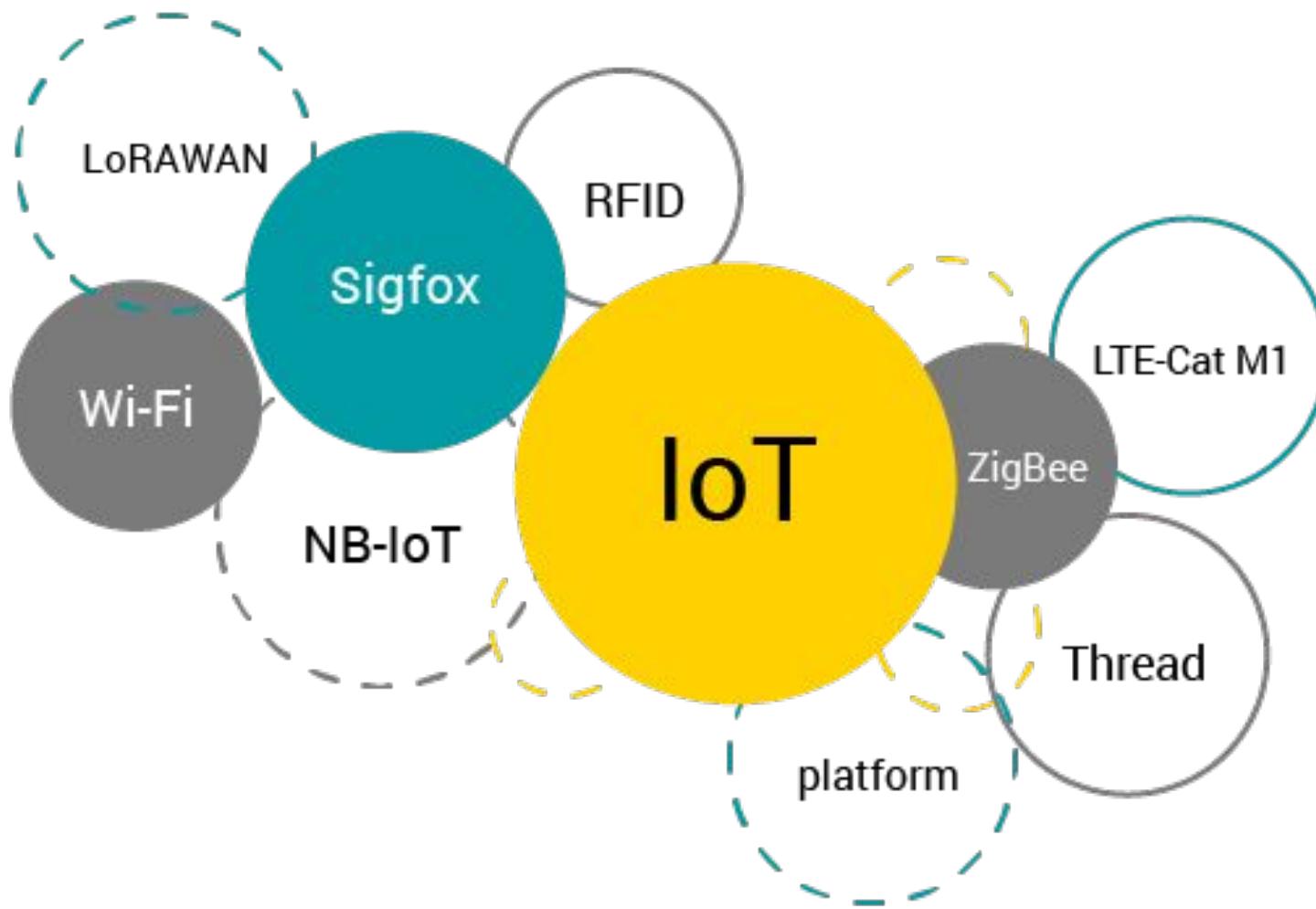
The average cost of IoT sensors is falling



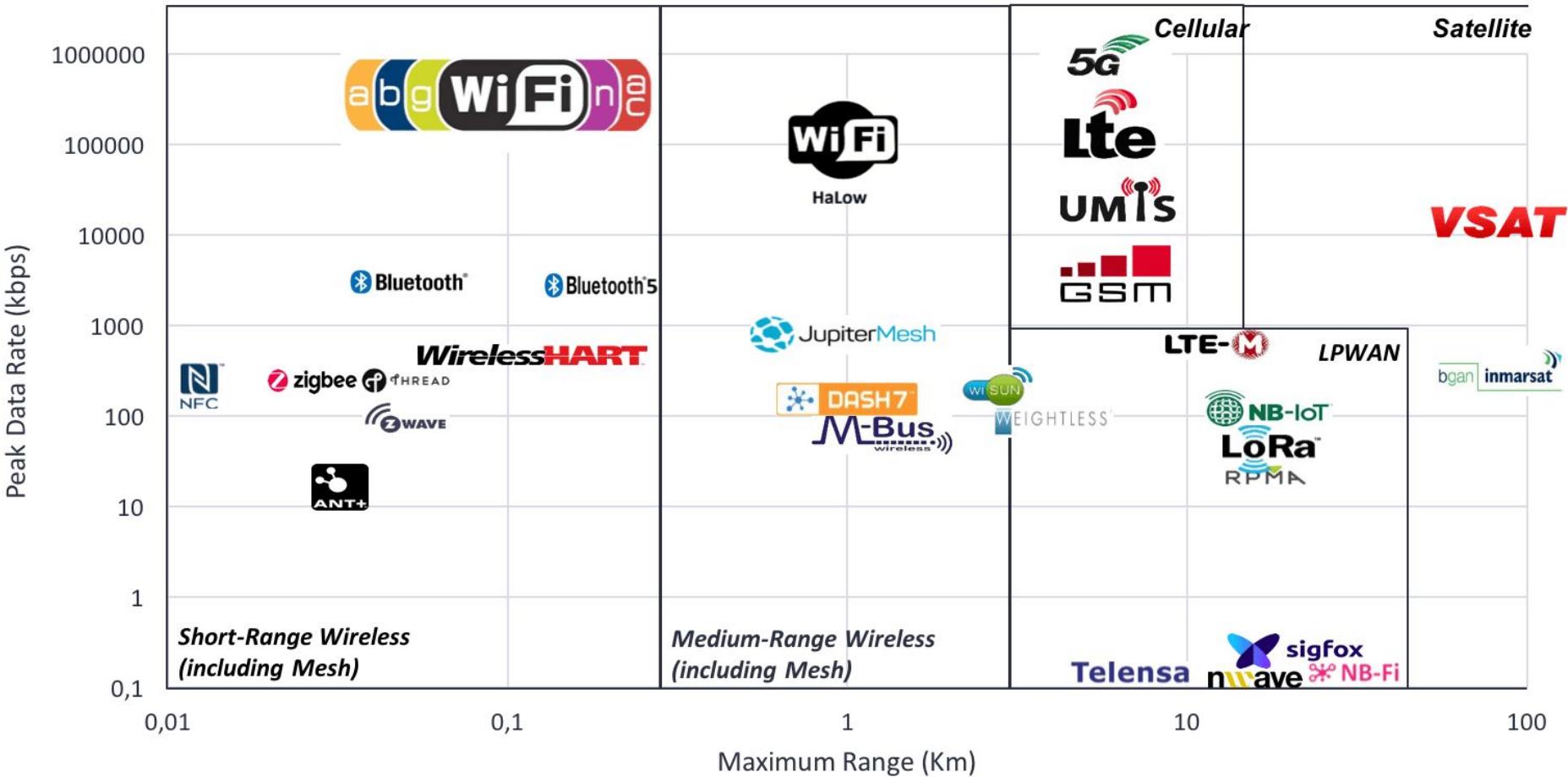
IoT Actuator



Wireless Technologies for IoT



Comparison of Wireless Technologies

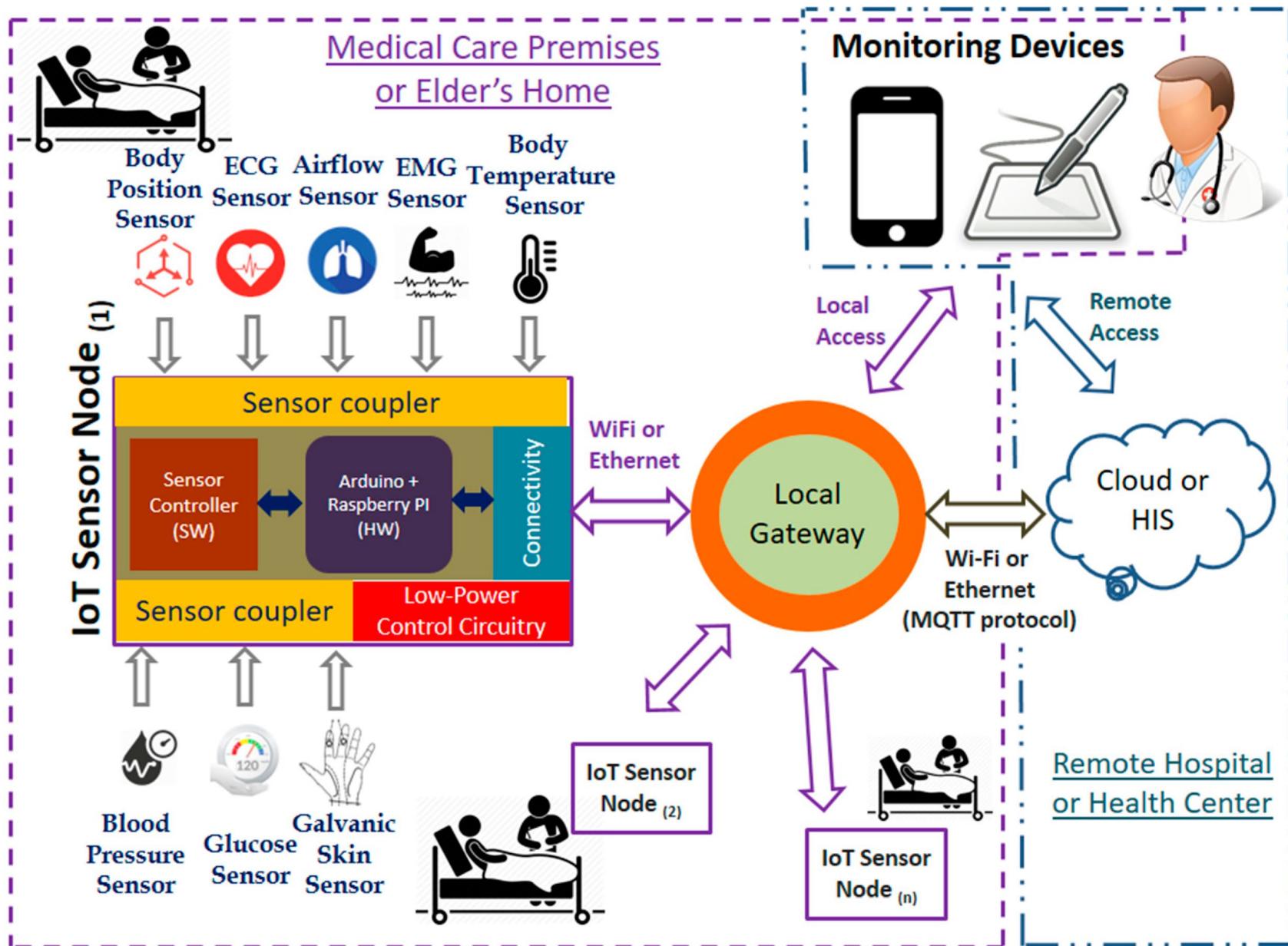


IoT Applications

IoT based application has found its way into every conceivable field, from agriculture to aerospace

Transport & Logistics  Fleet management, Goods tracking	Utilities  Smart metering, Smart grid management	Smart cities  Parking sensors, Waste management, etc.	Smart building  Smoke detector, Home automation
Consumers  Wearables Kids/senior tracker	Industrial  Process monitoring & control, Maintance monitoring	Environment  Food monitoring/alerts, Environmental monitoring	Agriculture  Climate/agriculture monitoring, Livestock tracking

IoT for Healthcare



IoT for Agriculture

Productivity

Crop Yield
Maximization



Preventative maintenance

Disrupting the
mating patterns of
pests



Preservation

Drought response,
minimize waste



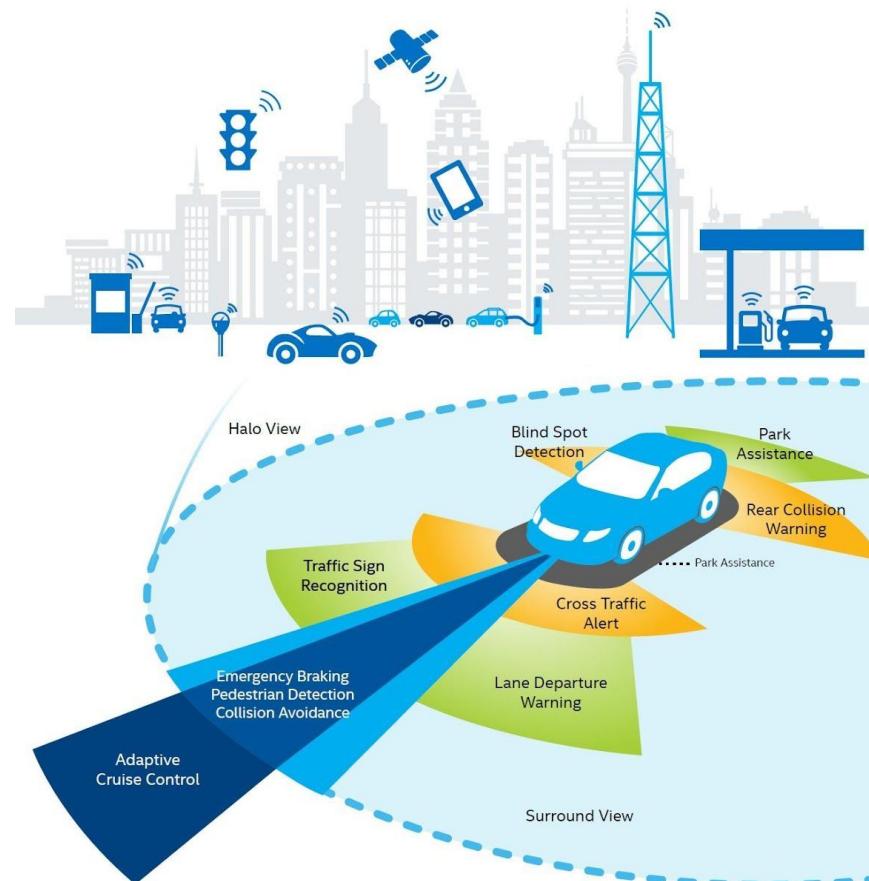
End-to-End lifecycle monitoring

Tracking product
lifecycle in real-time



SMART FARMING

IoT for Autonomous Vehicles



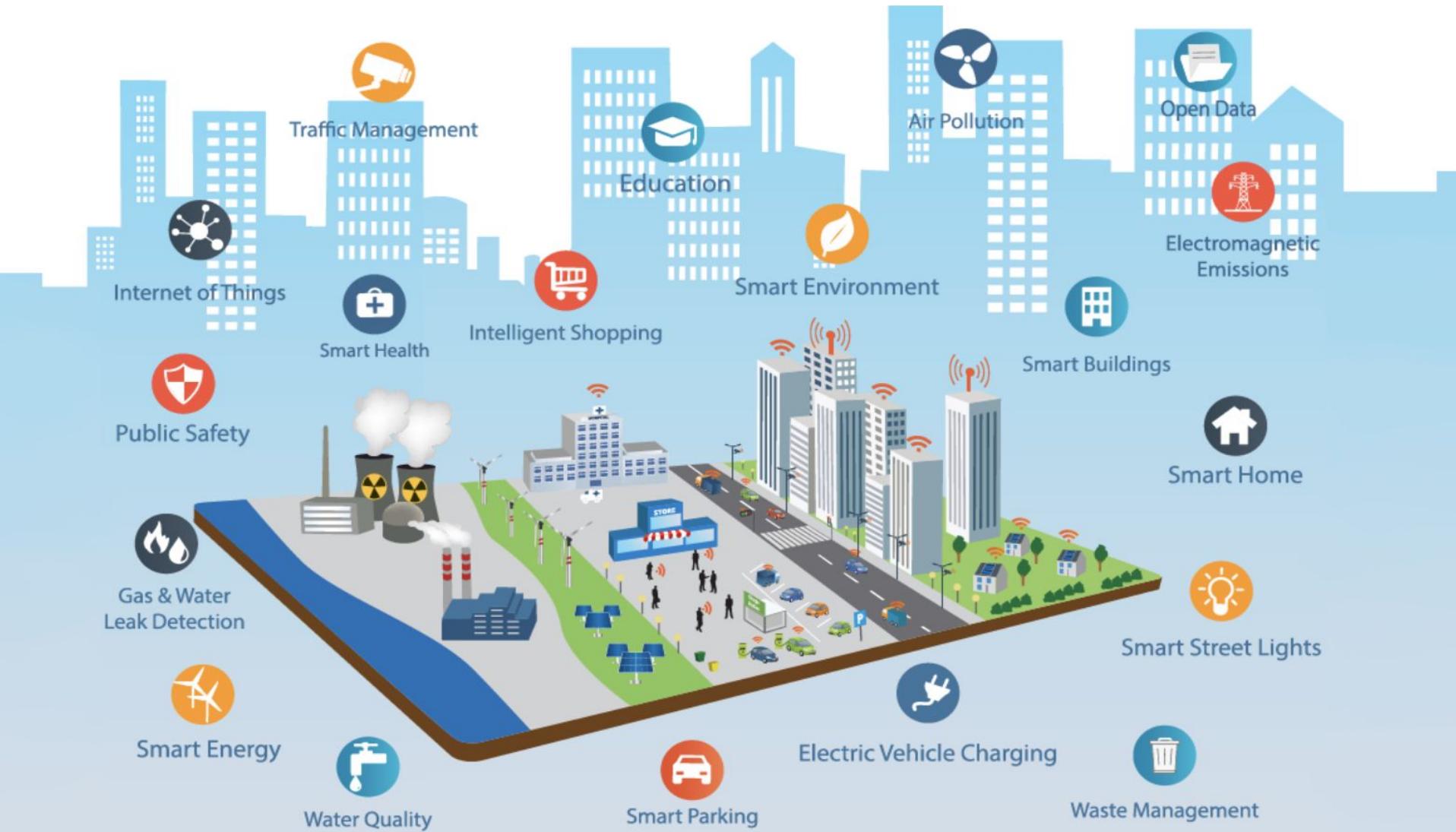
Cars will sense and connect with many things for 360° awareness.

Long Range Radar ~5 @50 mbps each	Lidar ~1 @100 mbps each	Cameras ~5 @100 mbps each	Short/Medium Range Radar ~4 @45 mbps each	Ultrasonics ~15 @30 mbps each

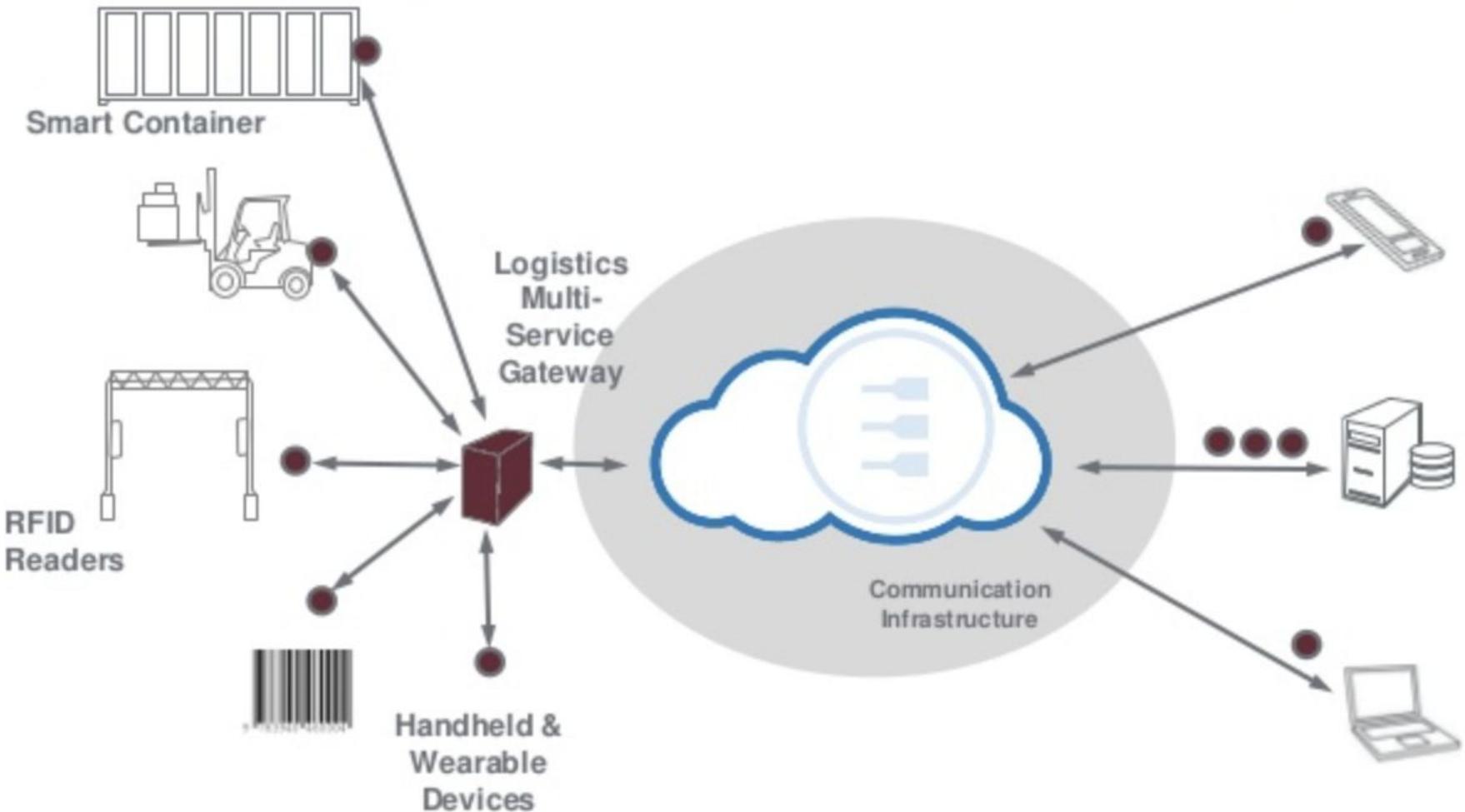
IoT for Smart Home and Building



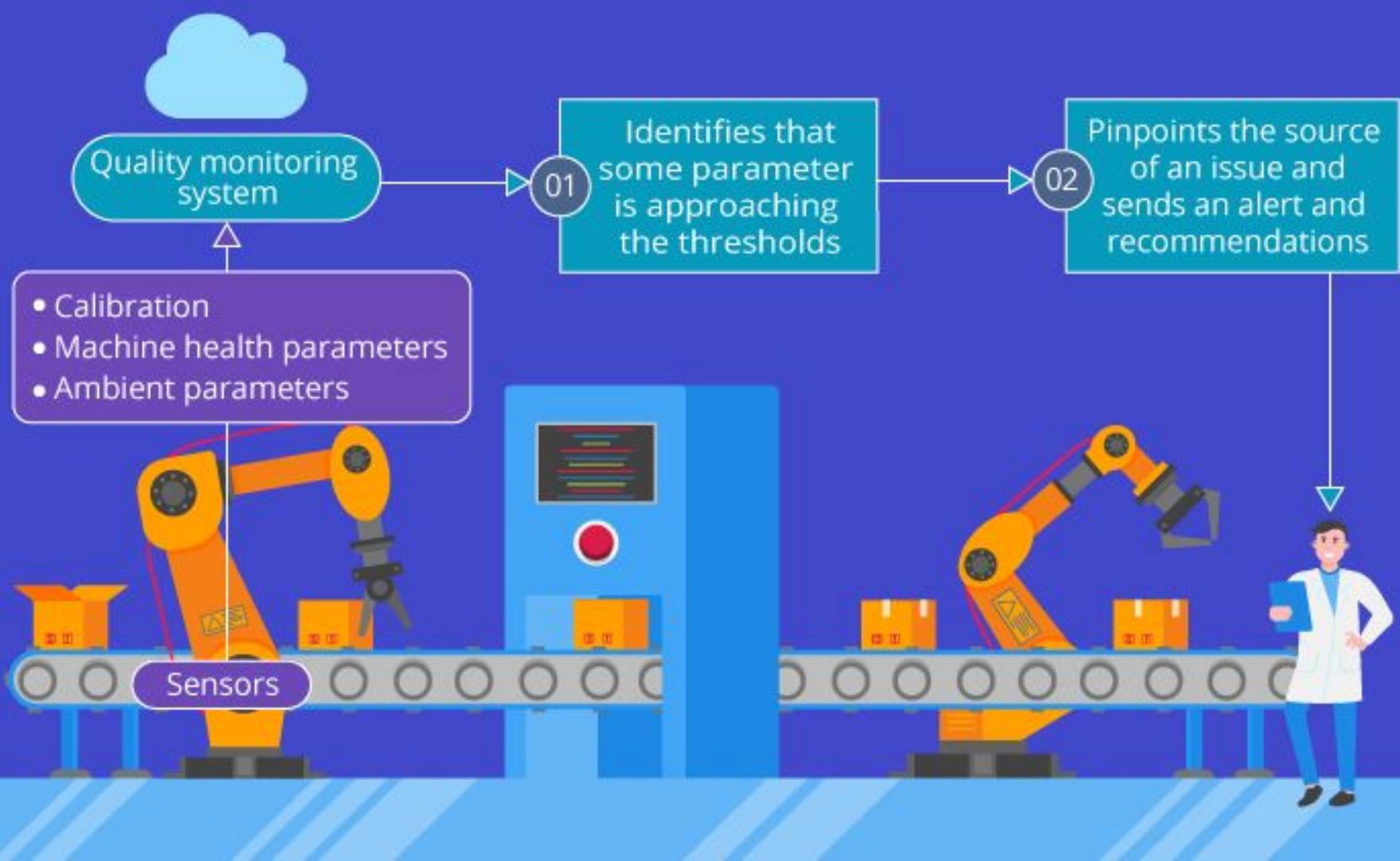
IoT for Smart City



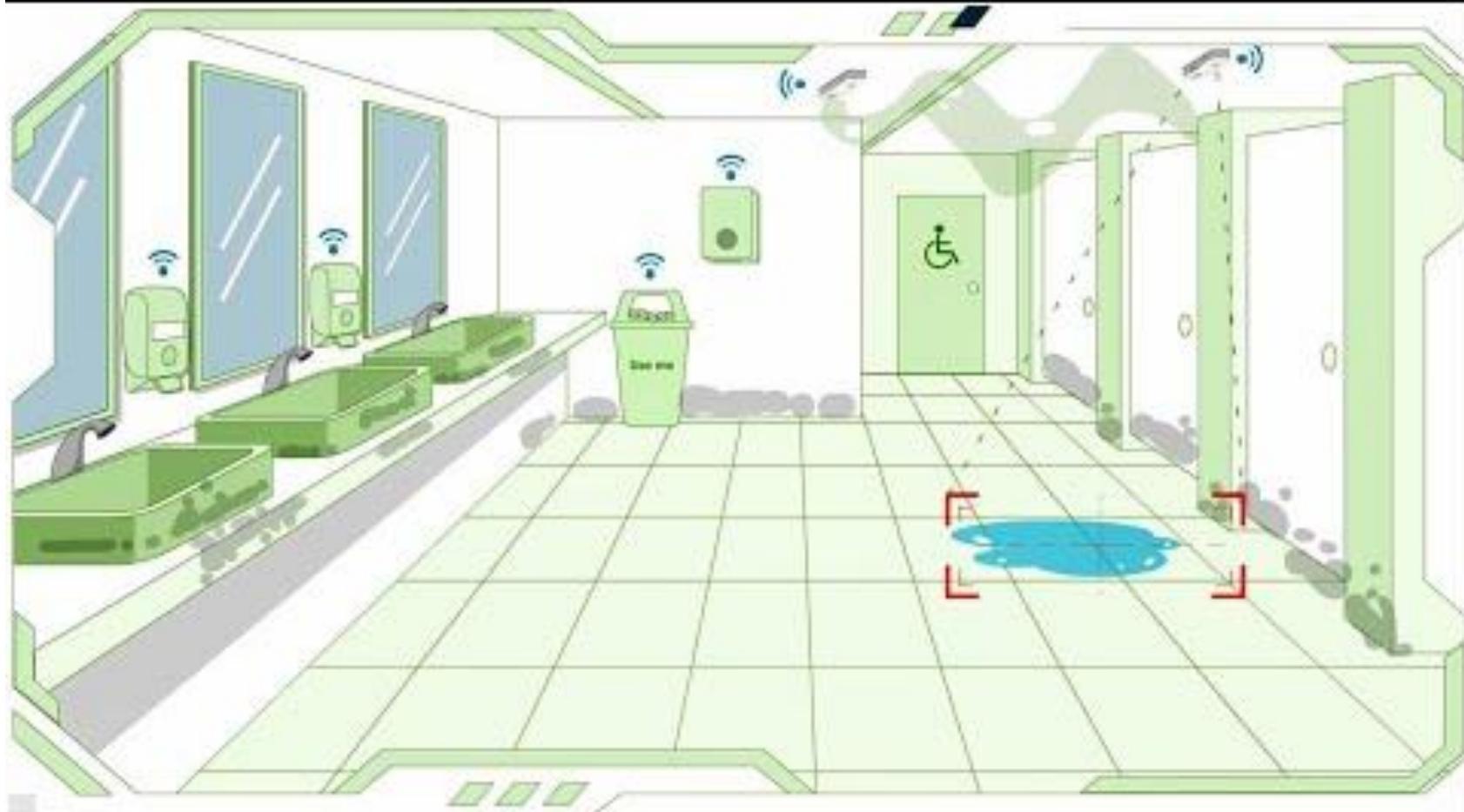
IoT for Logistics



IoT for Manufacturing



IoT Use Case - Smart Toilet



Topic 2

Raspberry Pi Zero W

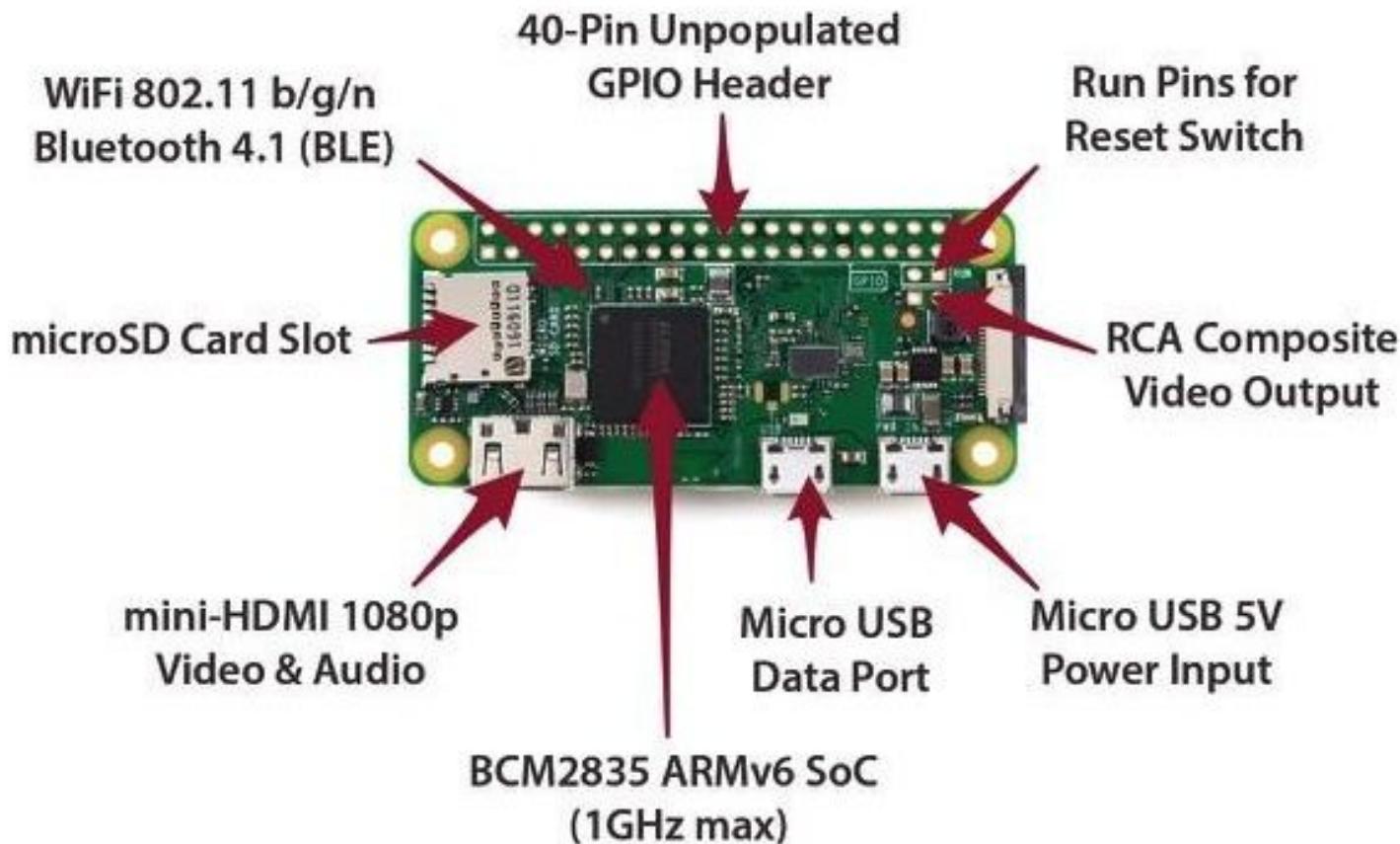
Setup

What is Raspberry Pi Zero W

- Raspberry Pi Zero W is still the Pi you know and love, but at a largely reduced size of only 65mm long by 30mm wide and at a very economical price.
- With the addition of wireless LAN and Bluetooth, the Raspberry Pi Zero W is ideal for making embedded Internet of Things (IoT) projects.



Raspberry Pi Zero W Layout



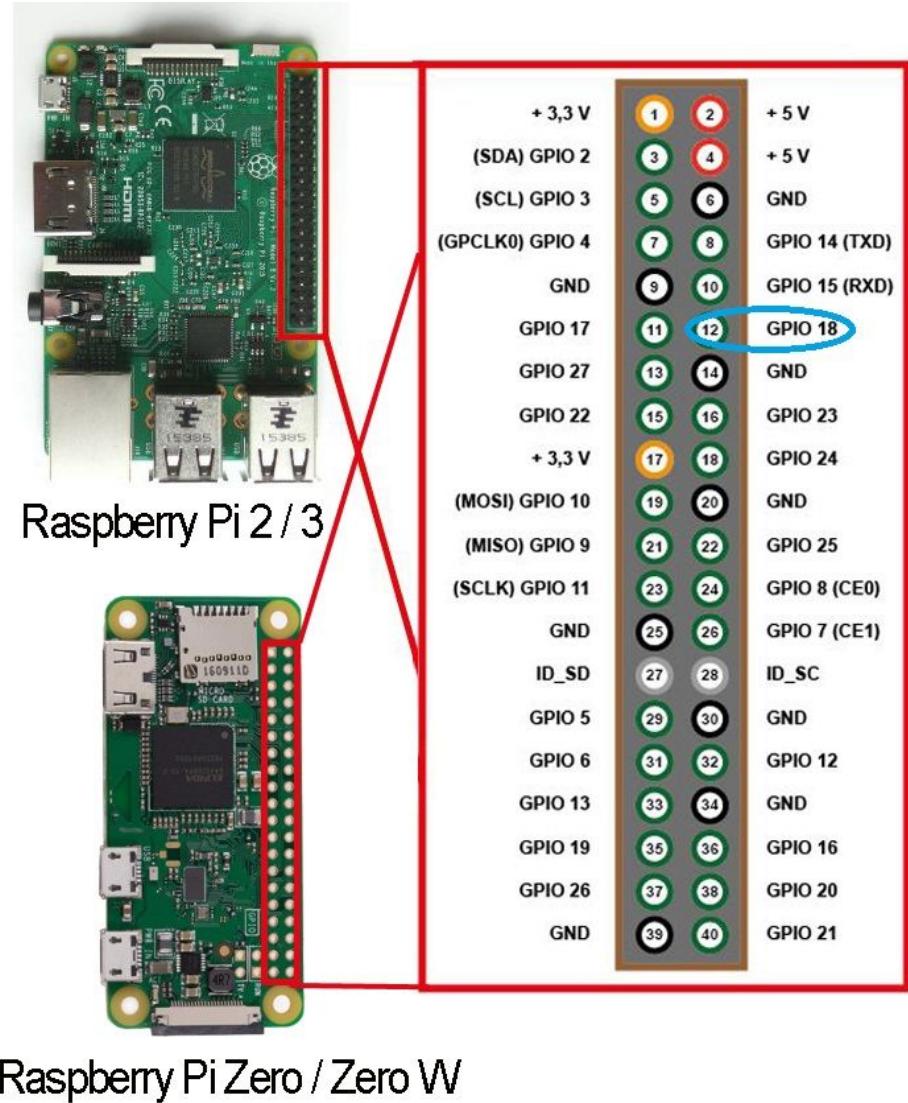
Raspberry Pi Zero W Kit

- 1 x Raspberry Pi Zero W
- 1 x Acrylic Case for Rpi Zero/Zero W to protect the Raspberry Pi Zero W
- 1 x 8GB microSD card with SD card adapter, pre-loaded with NOOBS (New Out of Box Software)
- 1 x 5V 2.5A USB Adapter to power it
- 1 x Raspberry Pi Wire Kit:
- 1 x HDMI mini to standard HDMI adapter/converter
- 1 x USB OTG cable (USB MicroB to to USB Type A receptor)
- 1 x 2x20 Header pin for GPIO



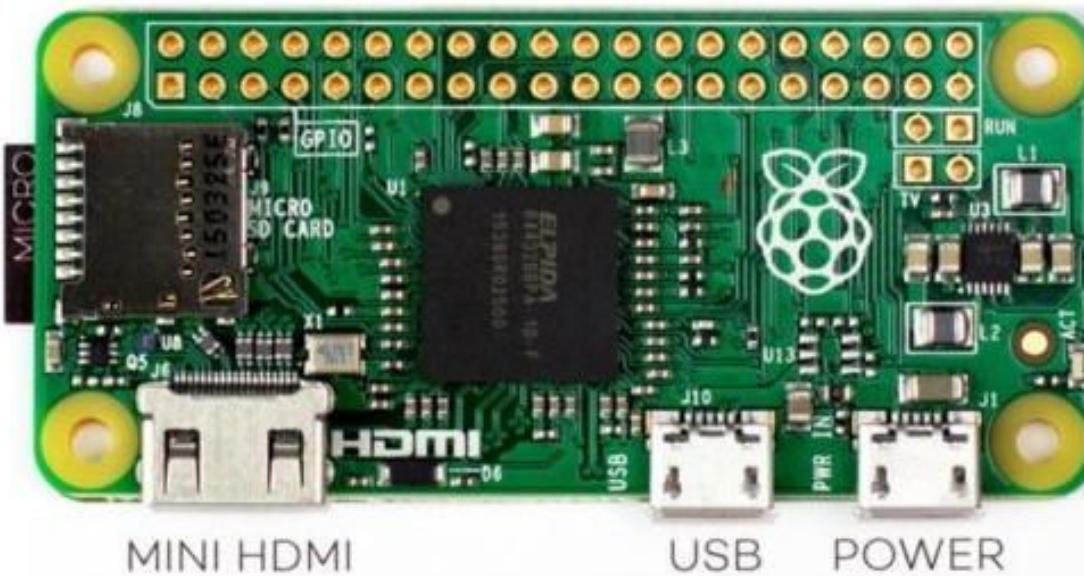
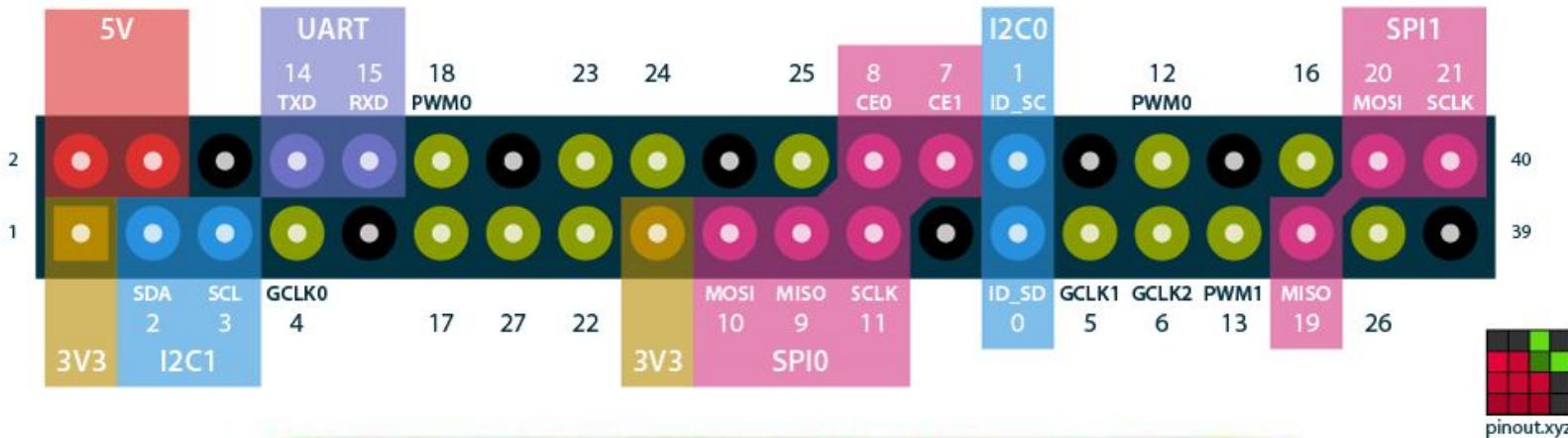
Raspberry Pi Zero W Pinout

- The pinout of Raspberry Pi Zero W and Raspberry Pi are the same.
- So you can use the same program



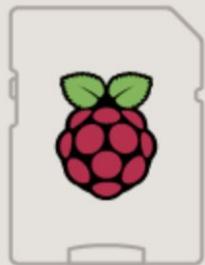
BCM Numbering

Raspberry Pi GPIO BCM numbering



Download Raspberry Pi OS

- Raspberry Pi OS (previously called Raspbian) is the Foundation's official supported operating system. You can install it with NOOBS or download the image
- Raspberry Pi OS comes pre-installed with plenty of software for education, programming and general use. It has Python, Scratch, Sonic Pi, Java and more.
- Goto <https://www.raspberrypi.org/downloads/raspberry-pi-os/>
- Recommend "Raspberry Pi OS (32-bit) with desktop and recommended software"



Raspberry Pi OS (32-bit) with desktop and recommended software

Image with desktop and recommended software based on Debian Buster

Version: May 2020

Release date: 2020-05-27

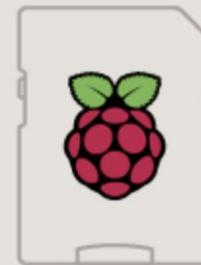
Kernel version: 4.19

Size: 2523 MB

[Release notes](#)

Download Torrent

Download ZIP



Raspberry Pi OS (32-bit) with desktop

Image with desktop based on Debian Buster

Version: May 2020

Release date: 2020-05-27

Kernel version: 4.19

Size: 1128 MB

[Release notes](#)

Download Torrent

Download ZIP

SHA-256: b9a5c5321b3145e605b3bcd297ca9ffc350ecb1844880af8fb75a7
589b7bd04

Download Raspberry Pi OS (Lite)

- Raspberry Pi OS (previously called Raspbian) is the Foundation's official supported operating system. You can install it with NOOBS or download the image
- Raspberry Pi OS comes pre-installed with plenty of software for education, programming and general use. It has Python, Scratch, Sonic Pi, Java and more.
- Goto <https://www.raspberrypi.org/downloads/raspberry-pi-os/>
- Recommend "Raspberry Pi OS LITE (32-bit)"

Raspberry Pi OS Lite

Release date: October 30th 2021

Kernel version: 5.10

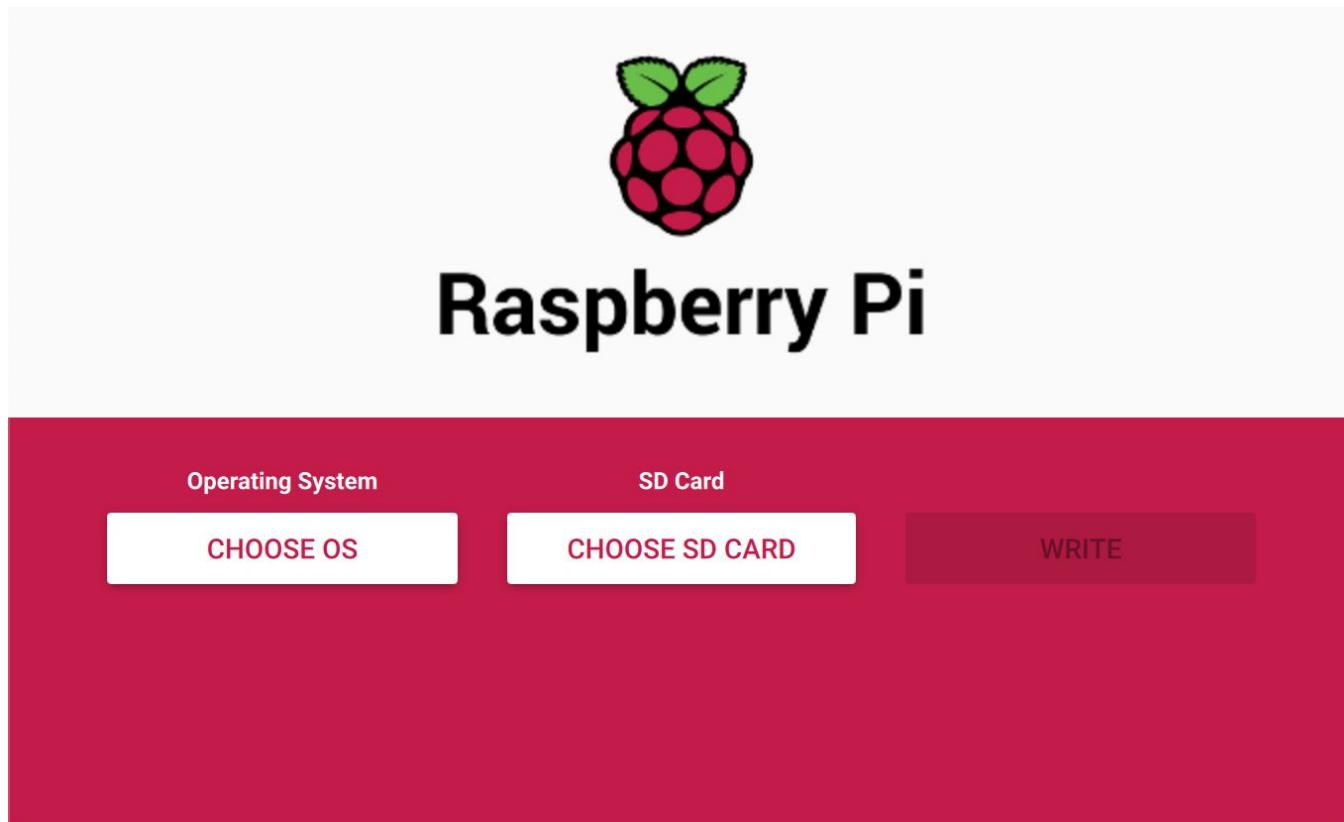
Size: 463MB

[Show SHA256 file integrity hash:](#)

[Release notes](#)

Burn Raspberry Pi Image

- Use Raspberry Pi Imager for an easy way to install Raspberry Pi OS and other operating systems to an SD card ready to use with your Raspberry Pi
- You can get the imager software from
<https://www.raspberrypi.org/downloads/>



Pi Zero W Wi-Fi Setup

1. Create a text file named **wpa_supplicant.conf** with the following text, and place it in the root directory of the microSD card.

```
country=SG
ctrl_interface=DIR=/var/run/wpa_supplicant GROUP=netdev
update_config=1
network={
    ssid="Tertiary infotech"
    psk="Tertiary888"
}
```

2. To enable ssh by default, place an **empty file** named **ssh** (no extension) in the root of the card.
3. Insert microSD card into Pi Zero W and power up using micro-USB cable connected to USB “data” port.
4. Default user and password are pi and raspberry respectively.

Pi Zero W Wi-Fi Setup (Cont'd)

5. Check and record IP address using ifconfig
6. Use Cmd (Win) or Terminal (Mac) to ssh into Pi Zero W with the following command:

```
ssh pi@raspberrypi.local
```
7. Configure the system with raspi-config:

```
sudo raspi-config
```
8. Update System Options > Hostname
9. Change Performance Options > GPU Memory to 16M
10. Update Localisation Options > Locales to en_SG.UTF-8
UTF-8

Pi Zero W Wi-Fi Setup (Cont'd)

11. Update the OS with the following commands:

```
sudo apt update && sudo apt upgrade -y
```

12. Run the following command to ensure npm is able to

```
sudo apt install build-essential git curl -y
```

13. Run the following command to install Node-Red:

```
bash <(curl -sL  
https://raw.githubusercontent.com/node-red/linux-installer/master/deb/update-nodejs-and-nodered)
```

14. Run the following command to enable the service to autostart Node-Red:

```
sudo systemctl enable nodered.service
```

Pi Zero W Wi-Fi Setup (Cont'd)

15. Install DHT Sensor support for Node-Red with the following commands:

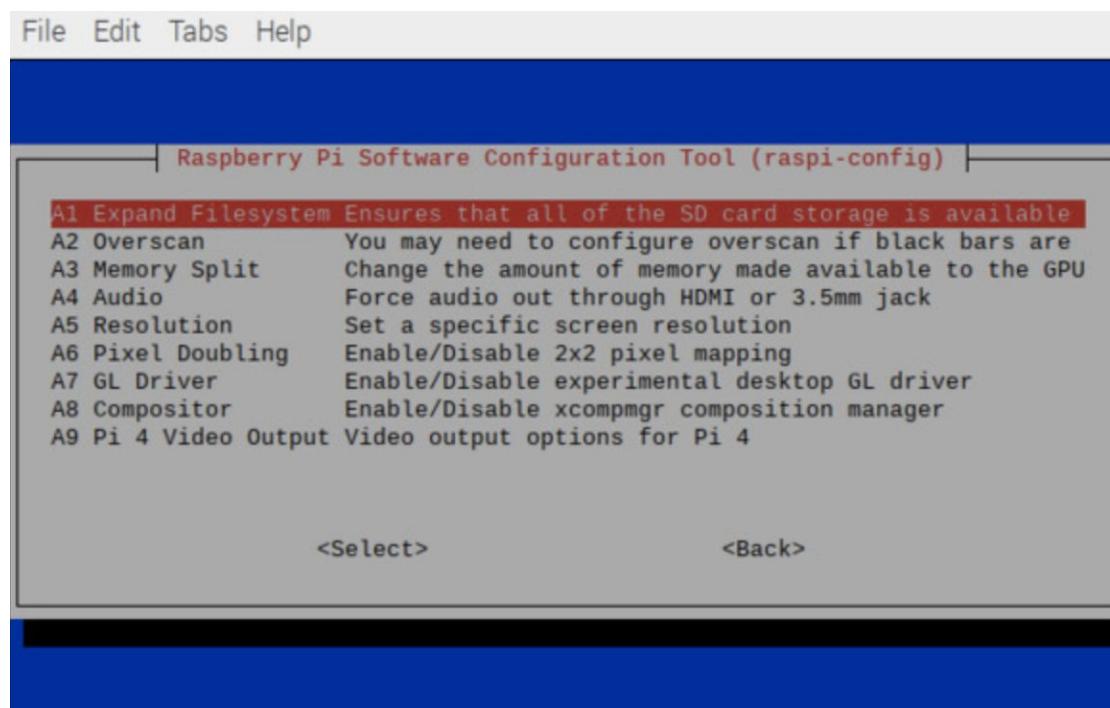
```
sudo npm install --unsafe-perm -g node-dht-sensor  
sudo npm install --unsafe-perm -g node-red-contrib-dht-sensor
```

Boot Your New OS

- You can now insert the SD card into the Raspberry Pi and power it up.
- For the official Raspberry Pi OS, the default user name is pi, with password raspberry. You can change the default password straight away to ensure your Raspberry Pi is secure.
- The default keyboard layout is set to UK. Change to US International
- The default timezone is UK. You can change to Singapore.
- Setup your WiFi credential
- Download and the OS update
- Reboot the OS

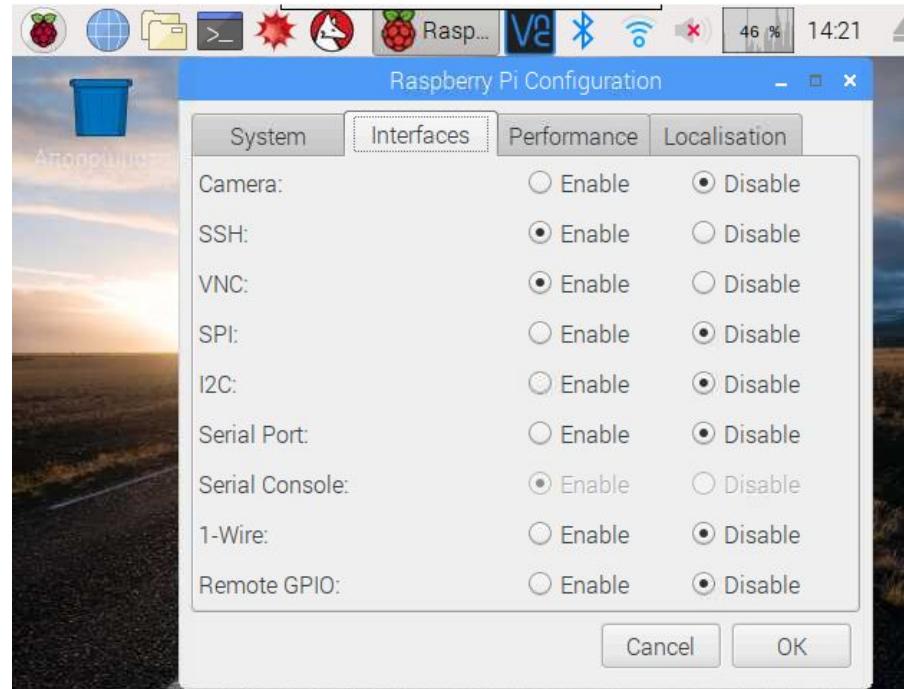
Expand File System

- If you are using larger microSD memory, you can expand the file system to reclaim the space as follows:
 - sudo raspi-config
 - select the “7 Advanced Options” menu item
 - sudo reboot
 - df -h



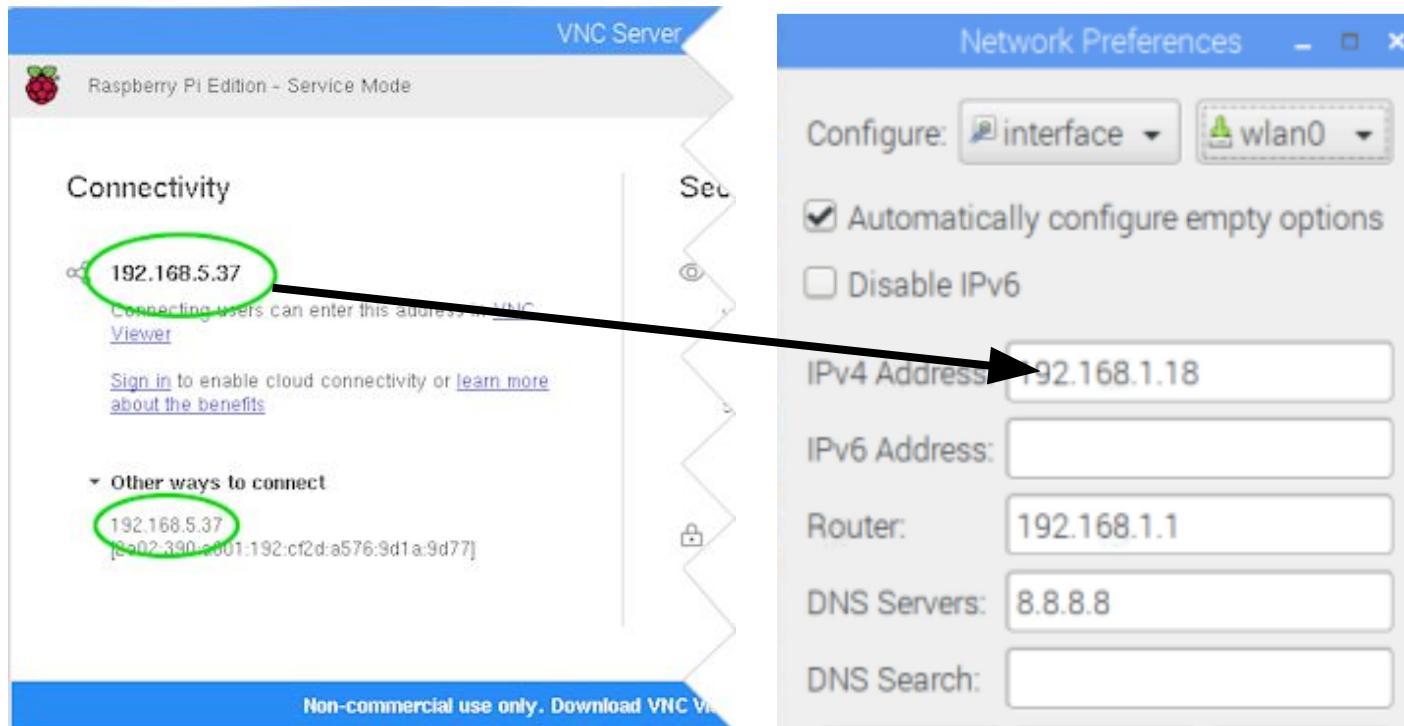
Enable VNC

- If you need to use your Raspberry Pi without connecting it with a monitor (or TV) you need to activate the VNC server service. By using the VNC you will be able to control your RPi from your computer (or laptop)! It's like the TeamViewer but it's only share the desktop of the RPi over a local network.
- The VNC server is already installed in your Raspbian Operating System, you just need to activate it.
- First of all, you need to enable VNC on your Raspberry Pi. Choose Menu-> Preferences-> Raspberry Pi Configuration.



Setup Static IP (Optional)

- Every time that the RPi it's starting (after power on or reboot) it takes a new IP address. For this reason it will be good to set a static IP address. Make a right click on WiFi icon in status bar and select the first choice "Wireless & Wired Network Settings".
- Select wlan0 and write the static IP that you want in "IPv4 Address" field and your router's IP in "Router" field.
- We advise you to use the google dns servers, so in "DNS Servers" field write the address 8.8.8.8.



Download VNC Viewer

Download VNC Viewer on your local laptop

<https://www.realvnc.com/en/connect/download/viewer/>

VNC® Connect consists of VNC® Viewer and VNC® Server

Download VNC® Viewer to the device you want to control from, below. Make sure you've [installed VNC® Server](#) on the computer you want to control.



Windows



macOS



Linux



Raspberry Pi



iOS



Android



Chrome



Solaris



HP-UX

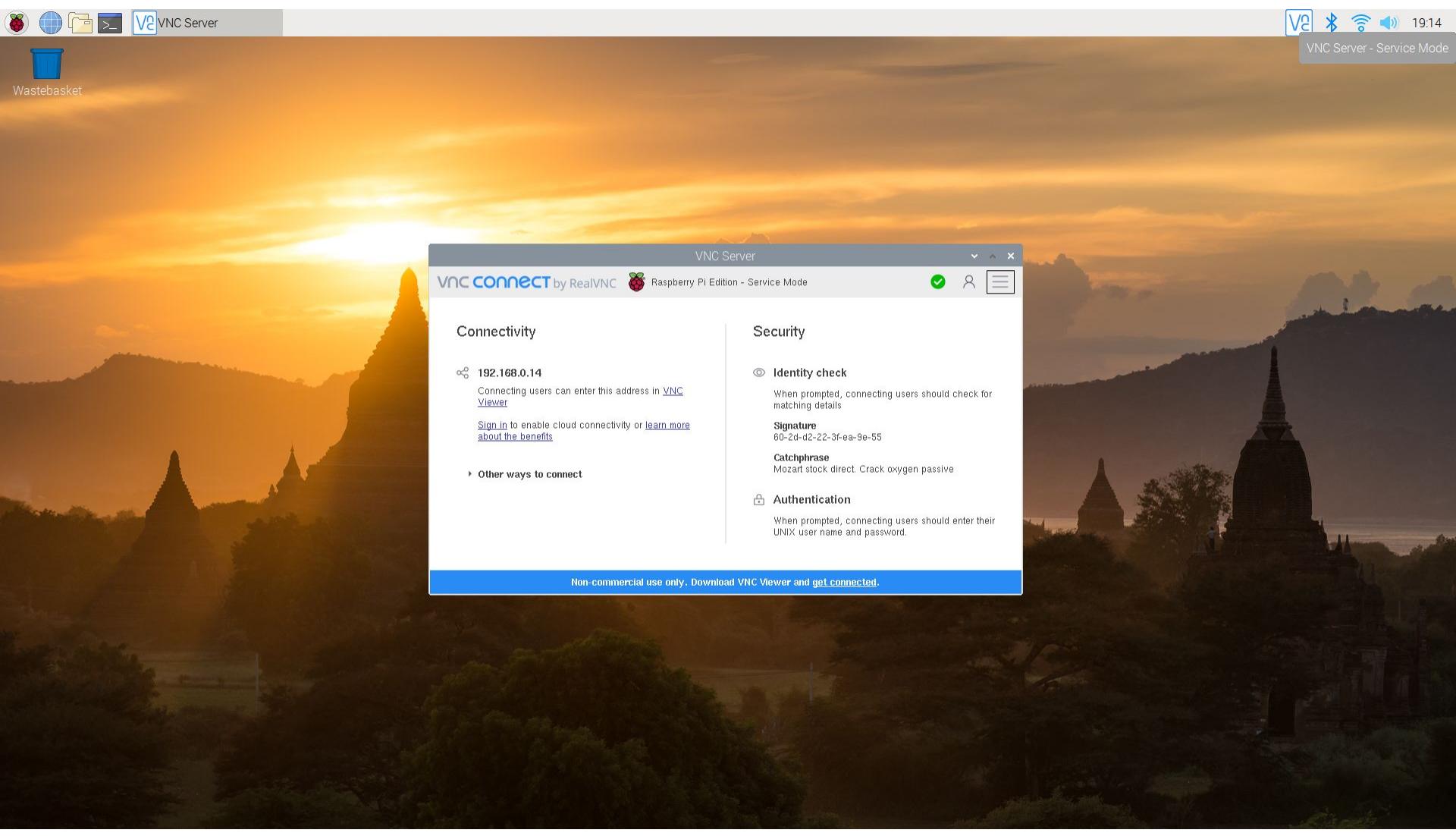


AIX

Download VNC Viewer

Remote Access Raspberry Pi via VNC

Enter the IP address to your VNC viewer and you can now remote access your Raspberry Pi from laptop



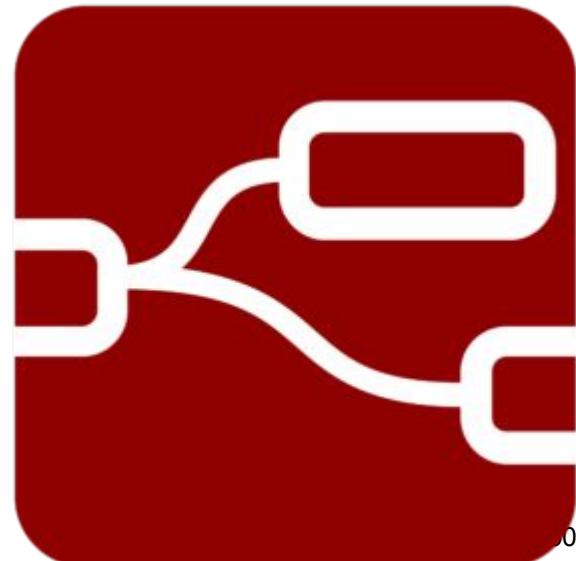
Topic 3

Introduction to

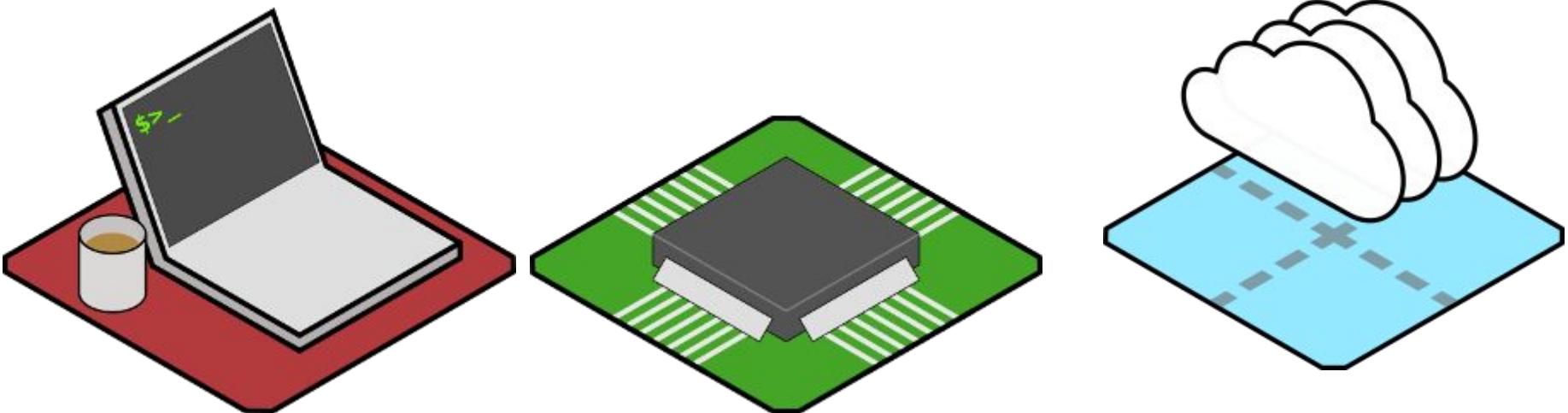
Node-RED

What is Node-RED?

- Node-RED is a visual programming tool for wiring The Internet of Things
- It provides a browser-based editor that makes it easy to wire together flows
- It is based on node.js
- <http://nodered.org/>



Where to run Node-RED?



- Run locally
- Docker
- Raspberry Pi
- Beaglebone
- Arduino
- Android
- IBM Bluemix
- AWS
- Microsoft Azure

Install Node-RED Locally

To install Node-RED on raspberry pi, you can follow the instruction on

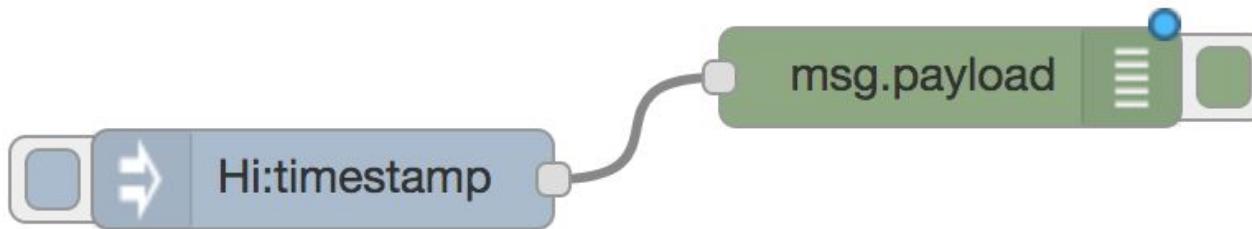
<https://nodered.org/docs/hardware/raspberrypi>

or you can run the following command on the terminal

```
bash <(curl -sL  
https://raw.githubusercontent.com/node-red/raspbian-deb-package/master/resources/update-nodejs-and-nodered)
```

Creating Your First Flow

- Once Node-RED is running, point a local browser at `http://localhost:1880`.
- The Inject node allows you to inject messages into a flow
- The Debug node causes any message to be displayed in the Debug sidebar.
- Connect the Inject and Debug nodes
- Click the Deploy button



Ex: Inject and Debug Nodes

msg.payload refers to the data of the msg object that passes from one node to another node

Change the payload of a inject node to "today is a great day"
and connect to a debug node

Function Node

- The Function node allows JavaScript code to be run against the messages that are passed in
- The message is passed in as an object called msg. By convention it will have a msg.payload property containing the body of the message
- Wire the function node between inject and debug nodes

```
var newMsg = { payload: msg.payload.length };
return newMsg;
```

Function Node - Multiple Outputs

Use array for multiple Outputs:

```
var newMsg = { payload: msg.payload.length };
return [msg, newMsg];
```

Ex: Multiple Outputs

Create a function with 2 outputs for the following messages

Msg1

Msg2

Msg3

Msg4

Msg1,Msg2,Msg3 go to first output

Msg4 goto Second output

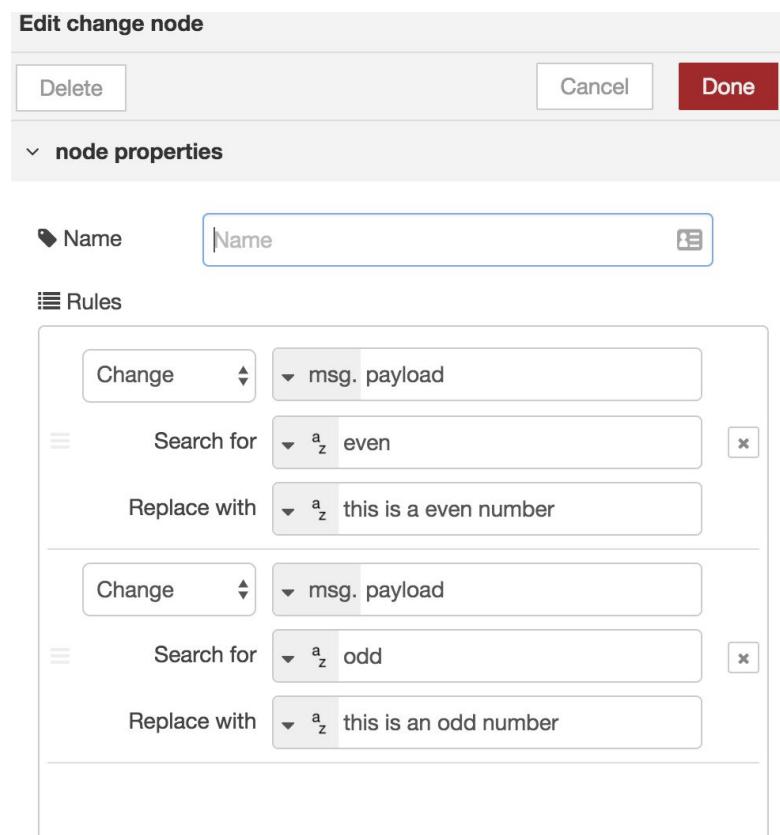
Ex2: Function Node

Write a function to determine if the injected number is even or odd

Change Node

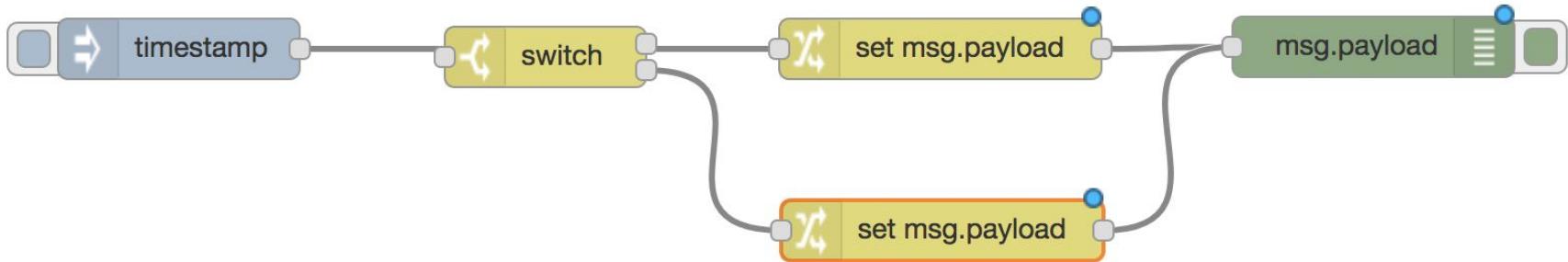
The change node provides four basic operations:

- Set a property to a value,
- Change a String property by performing a search and replace,
- Delete a property,
- Move a property.



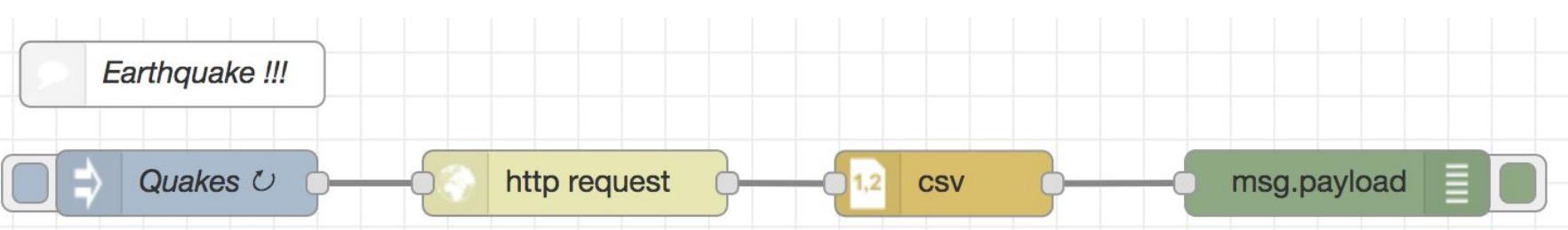
Switch Node

- The Switch node routes message based on property.
- Create even/odd routes



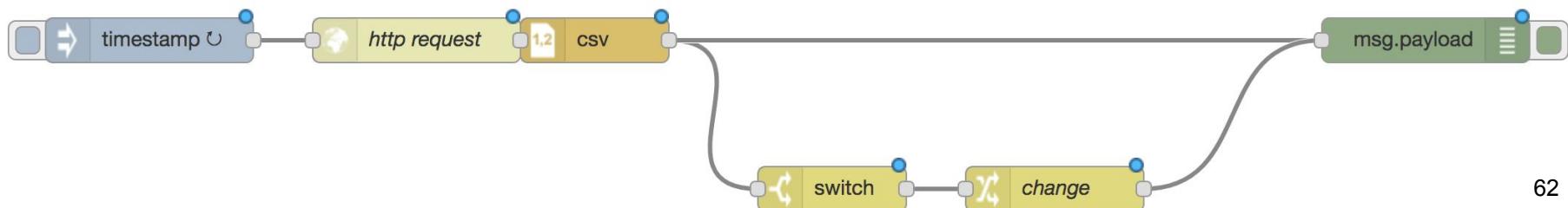
Http Request Node

- The HTTP Request node make a simple GET request to a website and extract useful information.
- Gets the earthquake report from USGS (last day > magnitude 2.5) - and creates one message per quake with time, lat, lon, depth, magnitude and array that detected it.



Ex: A Quake Alert

- Connect the nodes like below
- Set the http request property to
https://earthquake.usgs.gov/earthquakes/feed/v1.0/summary/significant_week.csv
 - CSV node set "First row contains column names"
 - Set the Switch node property to msg.payload.mag and Configure the test to be \geq and the value to be 7
 - Configure the Change node to msg.payload to be PANIC!



Email Node

Configure your email node to send email

Edit e-mail node

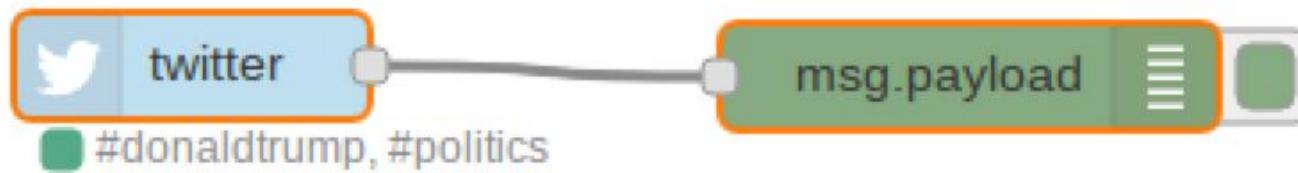
[Delete](#) [Cancel](#) [Done](#)

▼ node properties

To	angch@tertiaryinfotech.com	
Server	smtp.gmail.com	
Port	587	<input type="checkbox"/> Use secure connection.
Userid	angchewhoe@gmail.com	
Password	
Name	email	

Twitter Node

- Enter your twitter ID and search tweets
- Post the tweets on Debug node



Twitter ID: @angchewhoe

Search: all public tweets

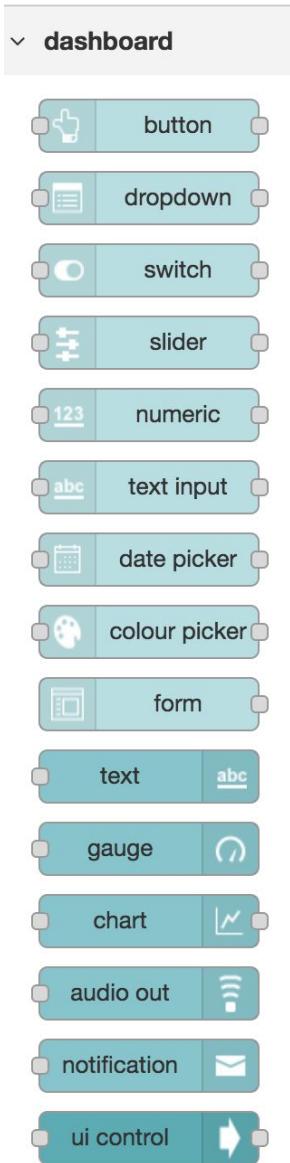
for: #donaldtrump, #politics

Name: Name

Install New Nodes Using Palette

- Setting -> Manage Palette
- Search for the new node to install

Install Dashboard Node



- Setting -> Manage Palette
- Goto Install tab
- Search for Dashboard node and click install
- Alternatively, you can install node-red dashboard from command line:
`npm install node-red-dashboard`

Access UI from Web & Mobile

All a few dashboard nodes to the editor.

You can access the UI from
<http://localhost:1880/ui>

Or you can access from your mobile phone
browser

http://Your_RPi_IP_address:1880/ui

Dashboard UI Tab and Group

- The user interface is organized in tabs and groups.
- Every widget should have an associated group that determines where the widget should appear on the user interface.
- To create a tab and a group
 - Select the dashboard tab on the right
 - Add a tab to the user interface
 - Edit the tab and add groups

Ex: Dashboard

Create a button to send an email when pressed.

Time: 5 mins

Auto Start Node-RED on boot

If you want Node-RED to run when the Pi boots up
you can type the command

```
sudo systemctl enable nodered.service
```

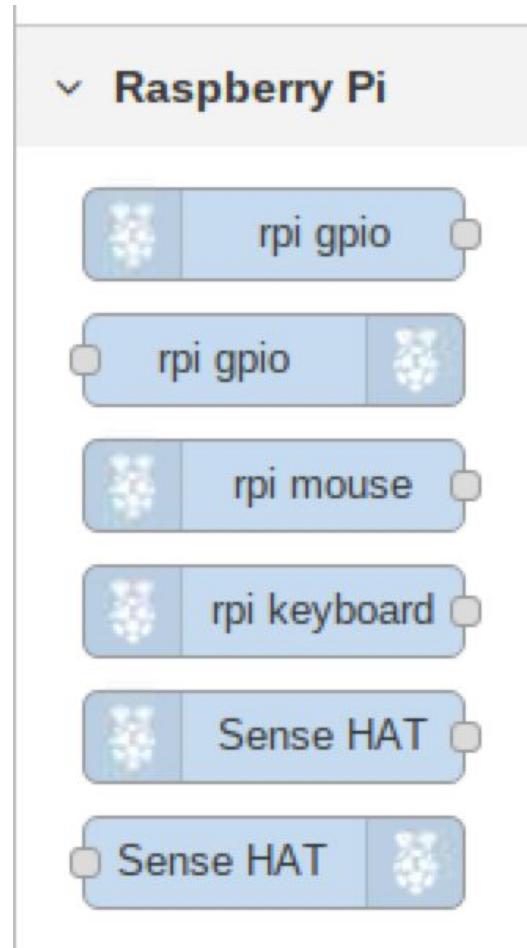
Topic 4

Node-RED Raspberry Pi GPIO

Raspberry Pi GPIO Pin Number

3.3V PWR	1	2	5V PWR
GPIO2 (SDA1 , I2C)	3	4	5V PWR
GPIO3 (SCL1 , I2C)	5	6	GND
GPIO4 (GPIO_GCLK)	7	8	(UART_TXD0) GPIO14
GND	9	10	(UART_RXD0) GPIO15
GPIO17 (GPIO_GEN0)	11	12	(GPIO_GEN1) GPIO18
GPIO27 (GPIO_GEN2)	13	14	GND
GPIO22 (GPIO_GEN3)	15	16	(GPIO_GEN4) GPIO23
3.3V PWR	17	18	(GPIO_GEN\$) GPIO24
GPIO10 (SPI0_MOSI)	19	20	GND
GPIO9 (SPI0_MISO)	21	22	(GPIO_GEN6) GPIO25
GPIO11 (SPI0_CLK)	23	24	(SPI_CE0_N) GPIO8
GND	25	26	(SPI_CE1_N) GPIO7
ID_SD (I2C EEPROM)	27	28	ID_SC (I2C EEPROM)
GPIO5	29	30	GND
GPIO6	31	32	GPIO12
GPIO13	33	34	GND
GPIO19	35	36	GPIO16
GPIO26	37	38	GPIO20
GND	39	40	GPIO21

Raspberry Pi GPIO Node

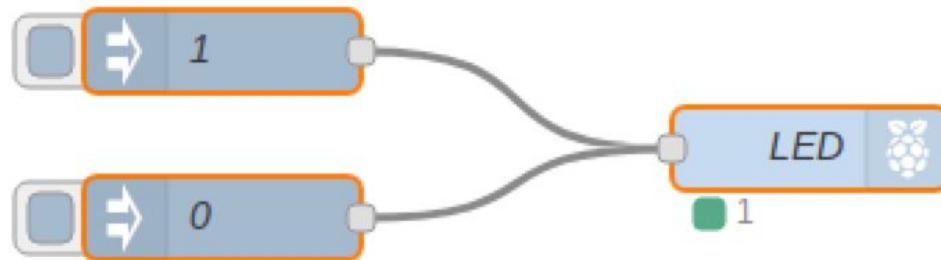


GPIO Input Node

GPIO Output Node

Turn LED On/Off

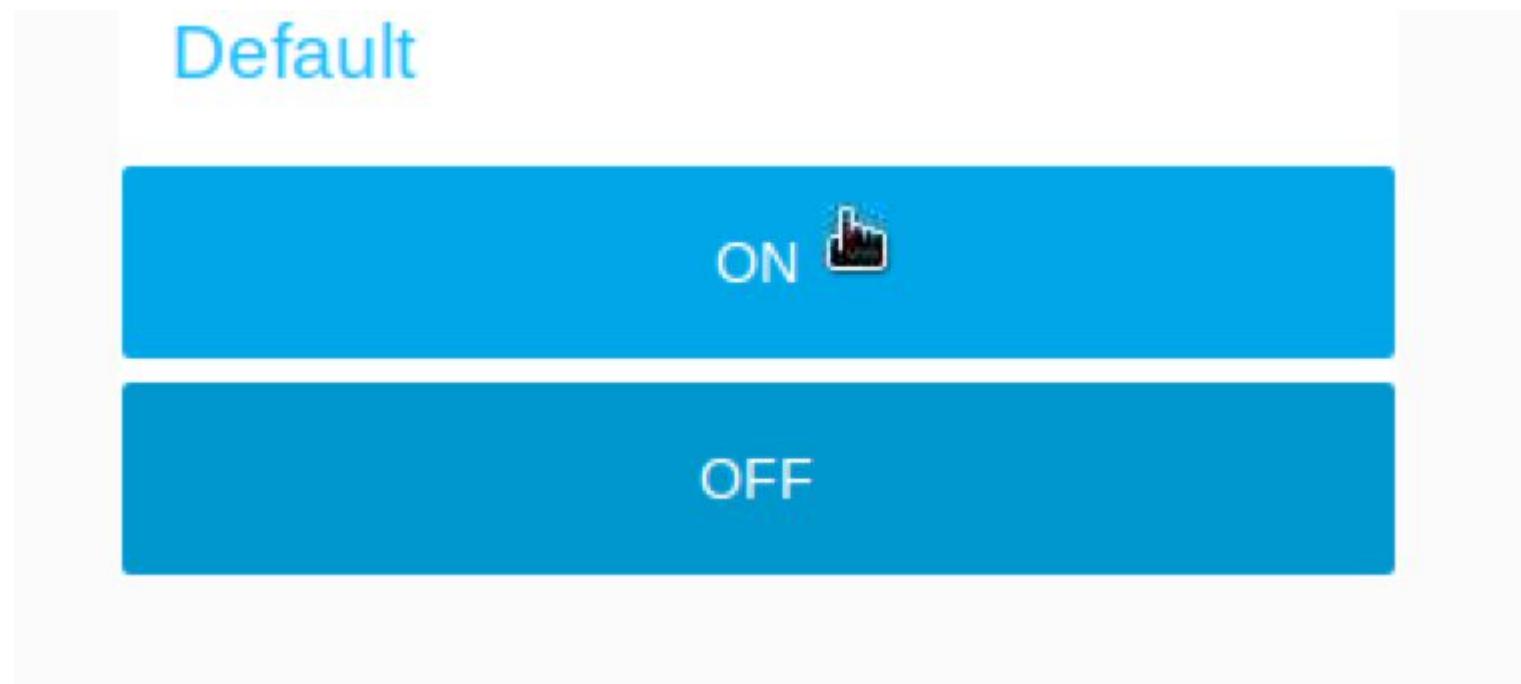
- Connect a LED to RPi GPIO pin 40
- On the node-red, connect a RPI GPIO output node to two Inject nodes
- Set one inject node to "1" and the other inject node to "0"
- Turn on and off the LED with inject nodes.



Ex: ON/OFF Buttons UI

Create a ON/OFF button UI to on/off the LED

Time: 5 mins



Blink LED

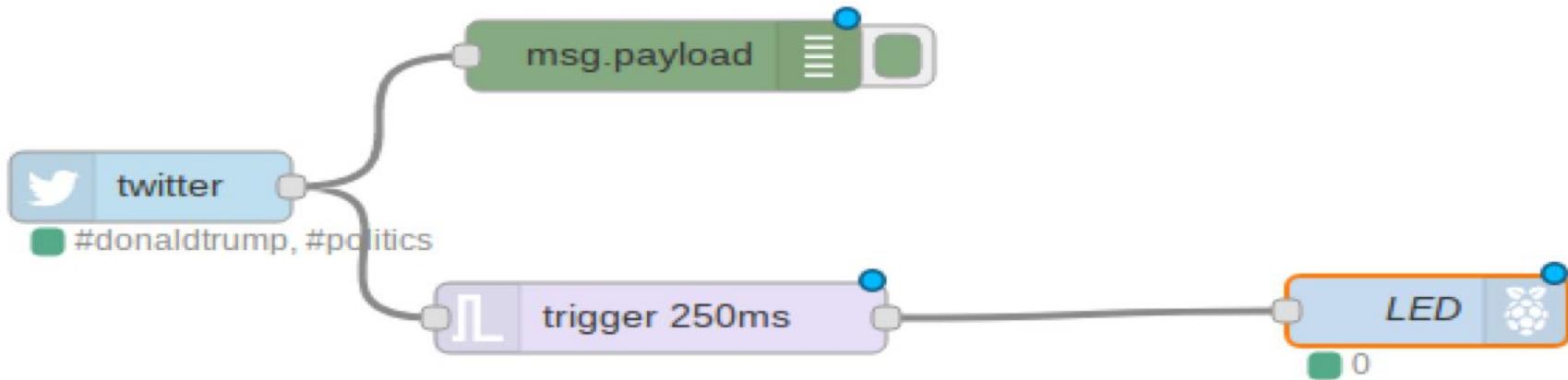
- To create a blink on the LED, add a trigger node between inject and LED node
- Set the inject node to inject repeatedly



Ex: Twitter Alert

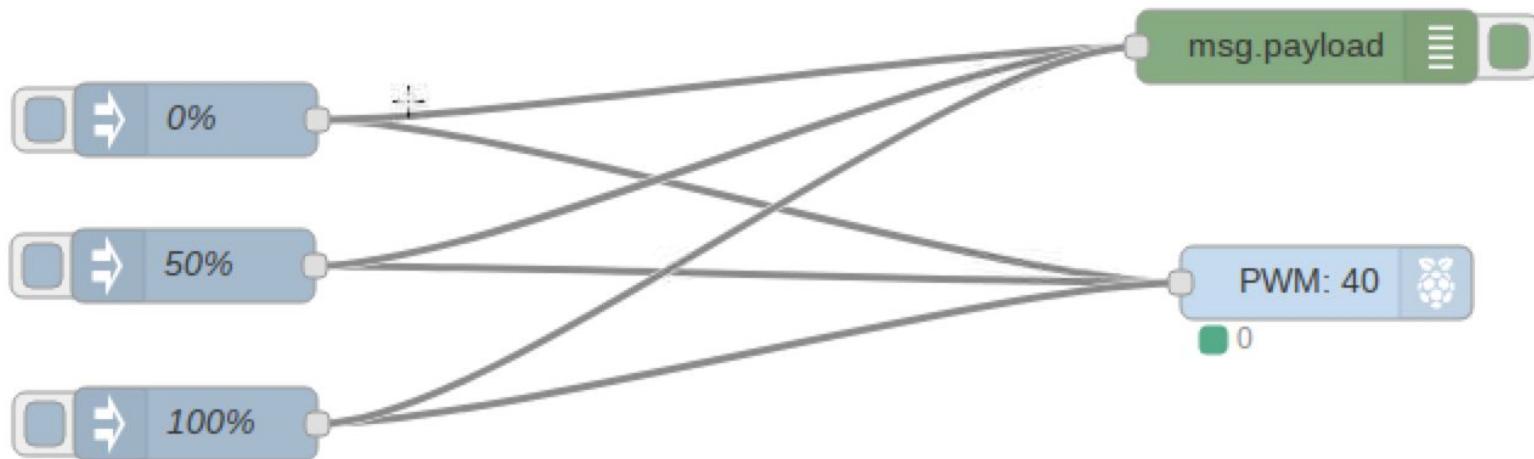
When there is a twitter post on bitcoin, trigger the LED to light up

Time: 5 mins



Adjust LED Brightness

- Set the GPIO output as PWM
- Add 3 inject nodes with values of 0, 5 and 10



Ex: Adjust LED Brightness

- Adjust the LED brightness with a slider UI
- Add a gauge UI to show LED brightness
- Show the UI at localhost:1880/ui

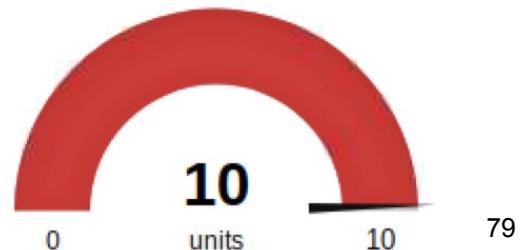


Default

slider

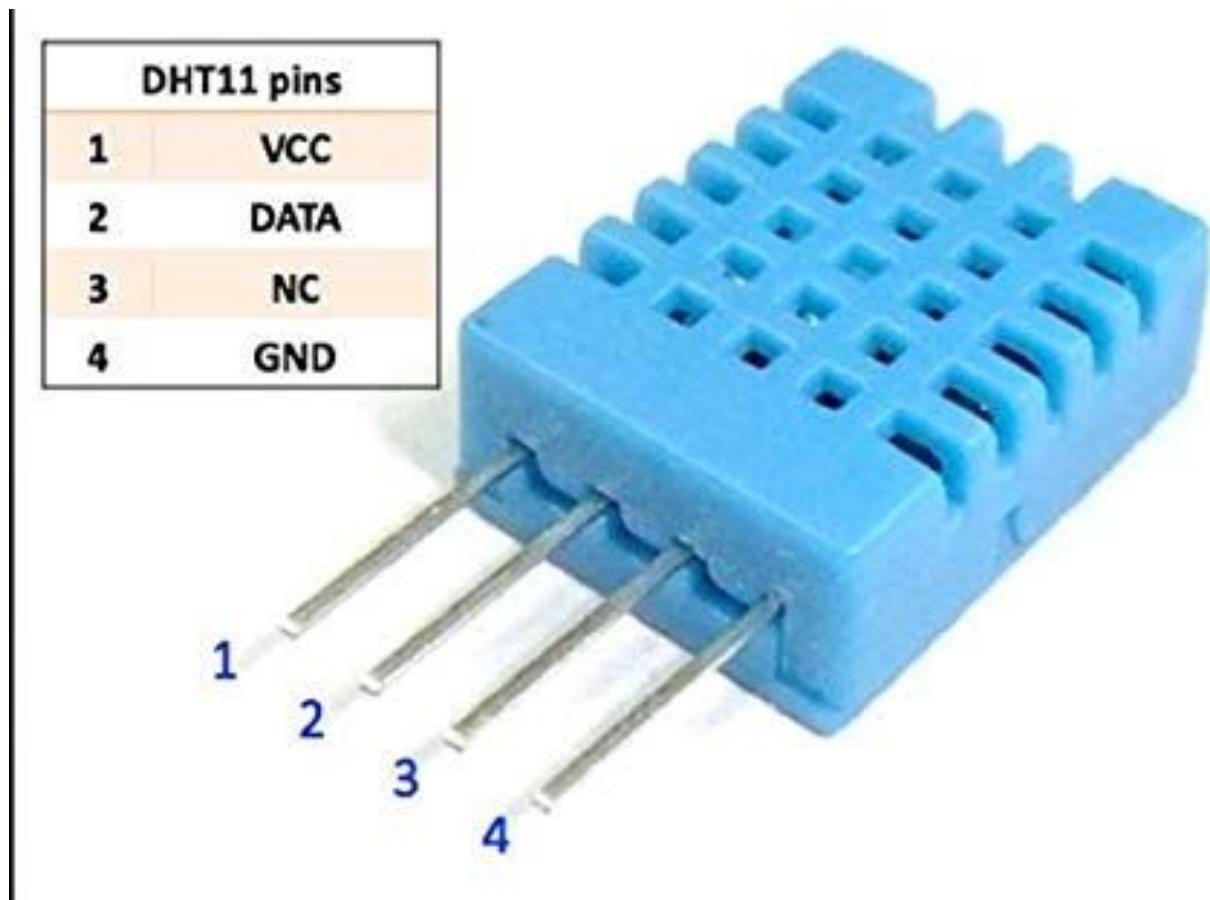


Gauge



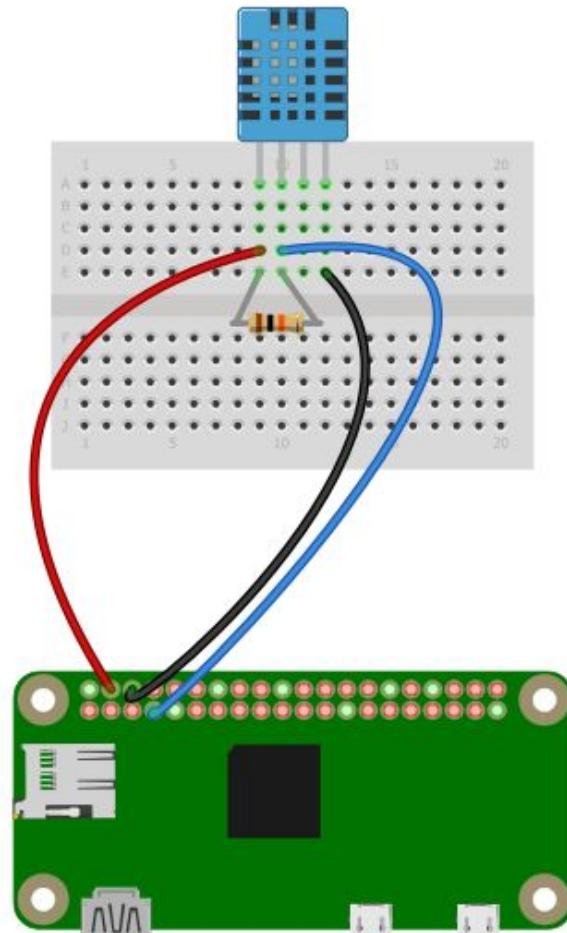
DHT Sensor

Connect the DHT Pin2 to Arduino UNO D2, Pin 1 to 5V and Pin 4 to GND.



Sense Temperature & Humidity

- Connect a DHT11 /DHT22 sensor with the Raspberry Pi Zero W as shown on the right



DHT11 Sensor

- To read the DHT11/DHT22 sensor from node-red install the node-dht-sensor library.
- Configure the node

Edit rpi-dht22 node

Delete	Cancel	Done
Properties		
Topic	rpi-dht22	
Sensor model	DHT22	
Pin numbering	WiringPi (rev. 2)	
Pin number	7	
Name	Name	

Edit rpi-dht22 node

Delete	Cancel	Done
Properties		
Topic	rpi-dht22	
Sensor model	DHT22	
Pin numbering	BCM GPIO	
Pin number	4	
Name	Name	

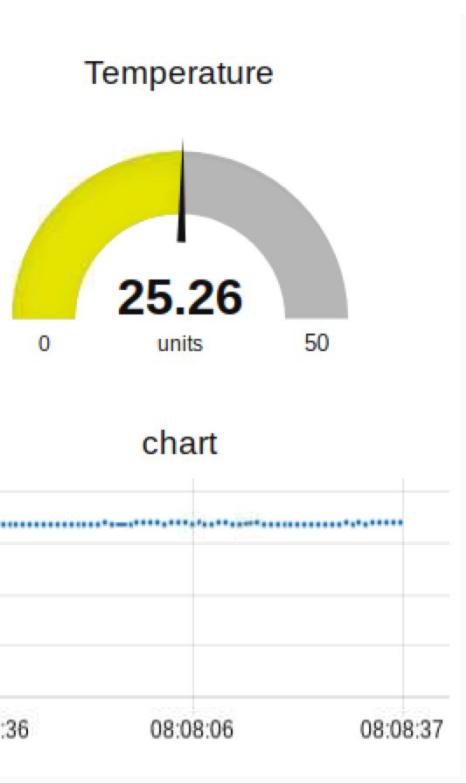
Sensing Environment Data

- Display the temperature humidity and pressure
- The message returned includes the temperature as the payload, and the humidity and the device ID as part of the message itself:



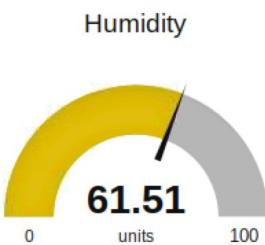
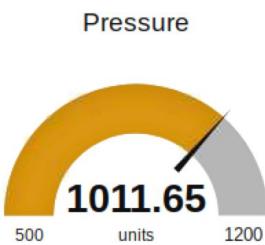
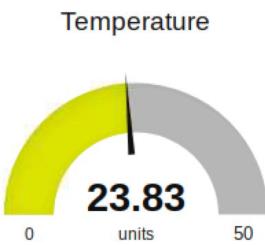
Display Temperature Data

Add a gauge and chart to show the temperature data



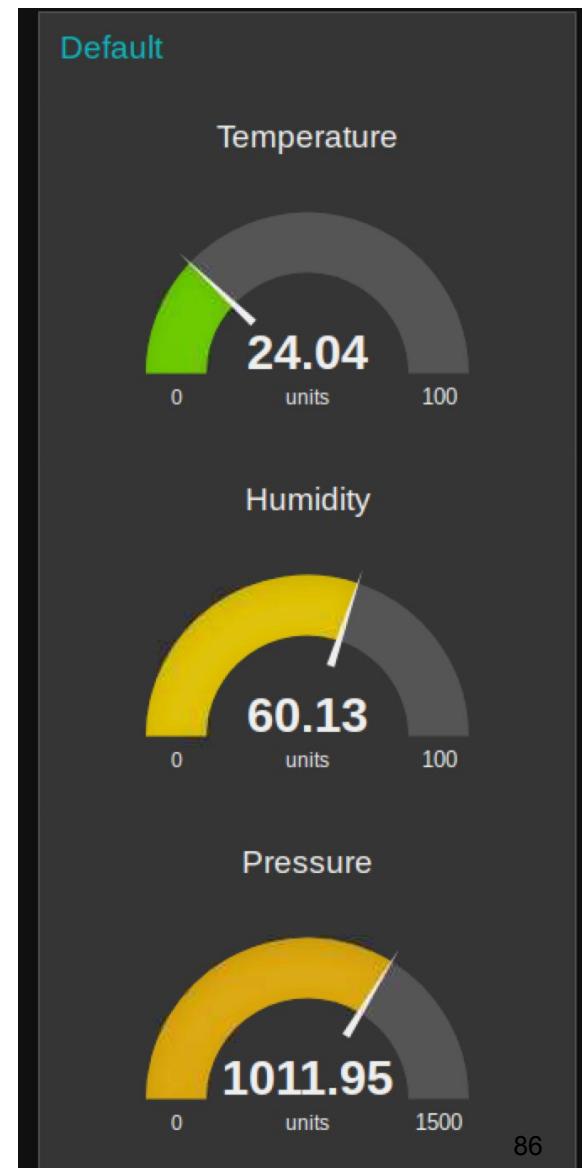
Ex: Display Environmental Data

Add 3 gauges to show all the environmental data



Ex: Display Environmental Data

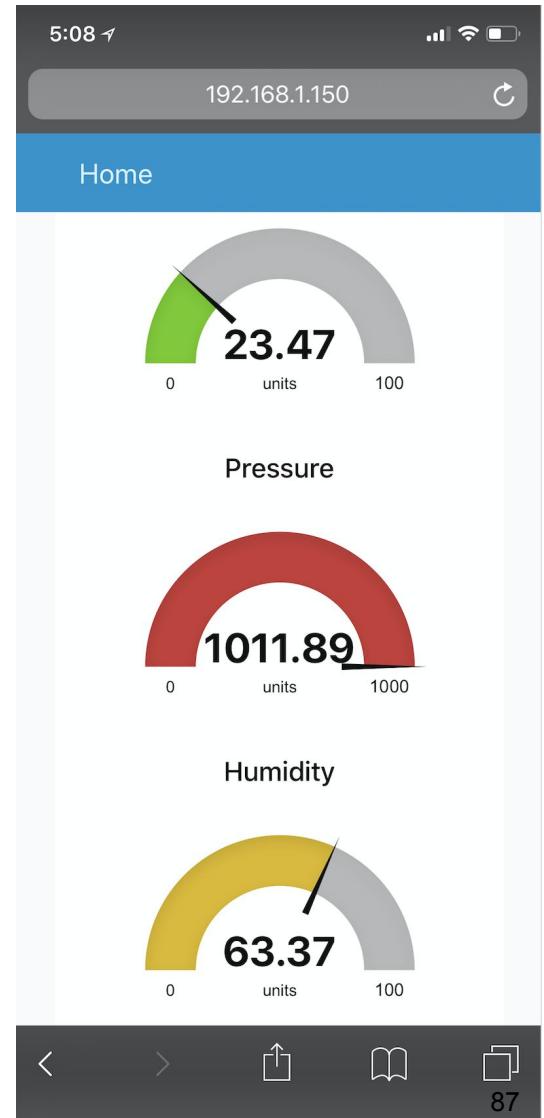
- Add 3 gauges to show all the environmental data.
- You can change to theme color from the dashboard tab on the right.



Display on Mobile Phone

You can see the data display on your mobile phone browser

`http://<your rpi IP>:1880/ui`



Topic 5

IoT via MQTT

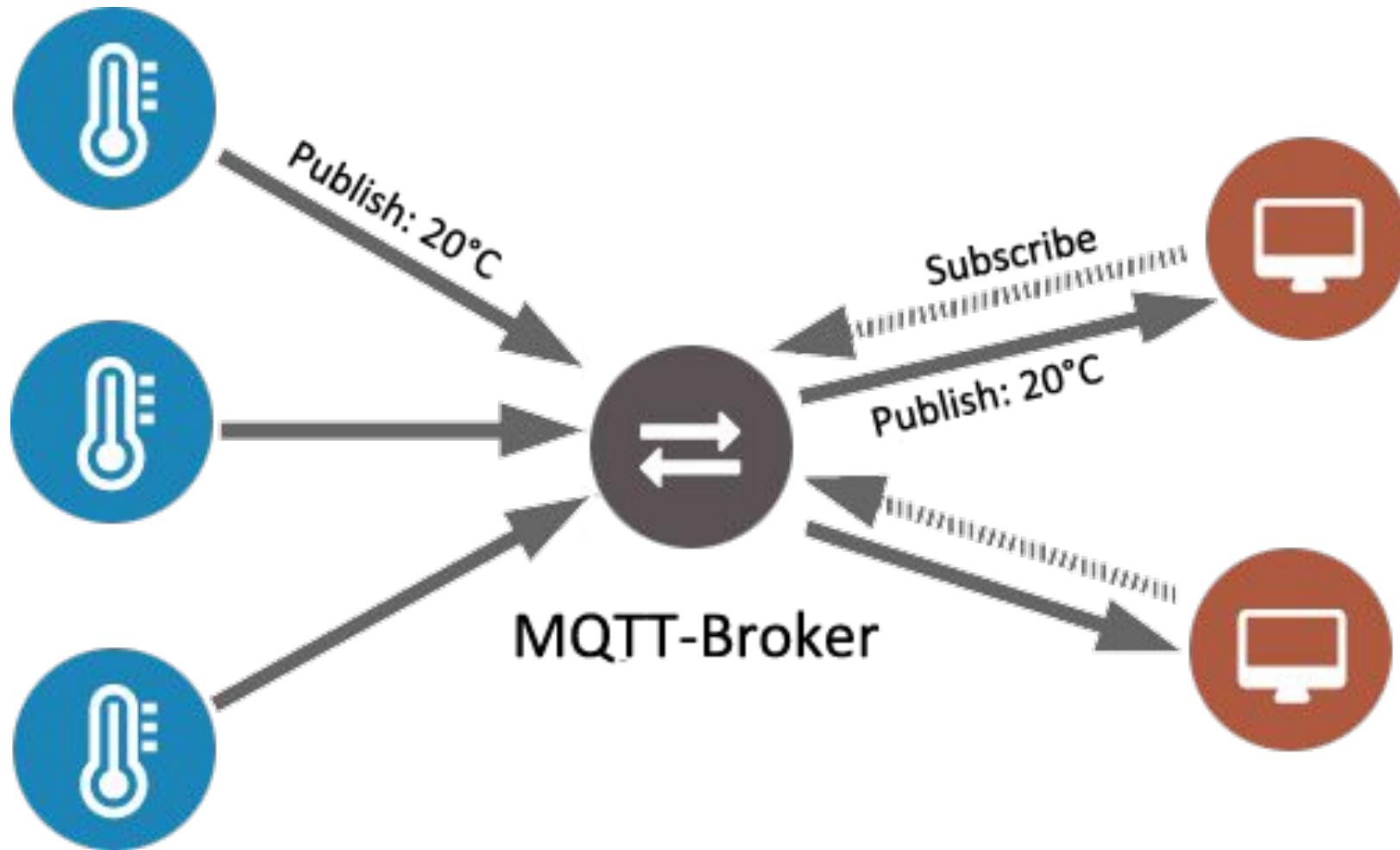
What is MQTT?

- MQTT (Message Queue Telemetry Transport) is a publish-subscribe messaging protocol widely used in IoT applications.
- This protocol is designed for data transfer between devices with limited network bandwidth and power. Thus, it is highly recommended for microcontroller projects that sends data over the internet.
- More info on MQTT is available on <http://mqtt.org/>

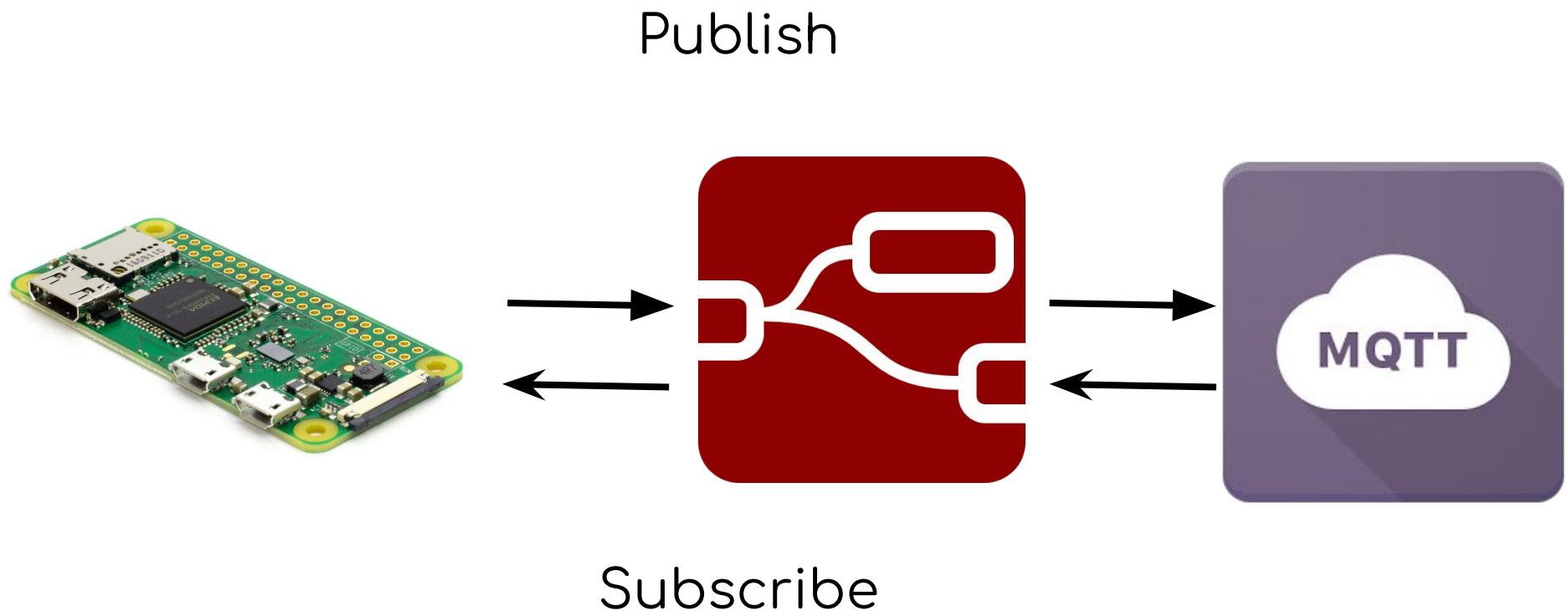
MQTT vs HTTP

- We can also send data to web servers thru HTTP which is the de facto standard of how web pages are acquired by web browsers. However, HTTP is document-centric which consumes a lot of network bandwidth.
- MQTT, in contrast, transfers data as a byte array which is more lightweight. HTTP is also a more sophisticated protocol that can drain more power from microcontrollers and embedded computers.

How MQTT Work?



Raspberry IoT via MQTT



MQTT Broker Available

- Eclipse:
 - Website: <https://iot.eclipse.org/>
 - host: iot.eclipse.org
 - port: 1883
- hiveMQ
 - Website: <https://www.hivemq.com/>
 - host: broker.hivemq.com
 - port: 1883
- MQTT-Dashboard
 - Website: <http://www.mqtt-dashboard.com/>
 - host: broker.mqtt-dashboard.com
 - port: 1883
- Adafruit IO
 - Website: <https://learn.adafruit.com/adafruit-io/mqtt-api>
 - host: io.adafruit.com
 - port: 1883
- shiftr.io
 - Website: <https://docs.shiftr.io/interfaces/mqtt/>
 - host: broker.shiftr.io
 - port: 1883

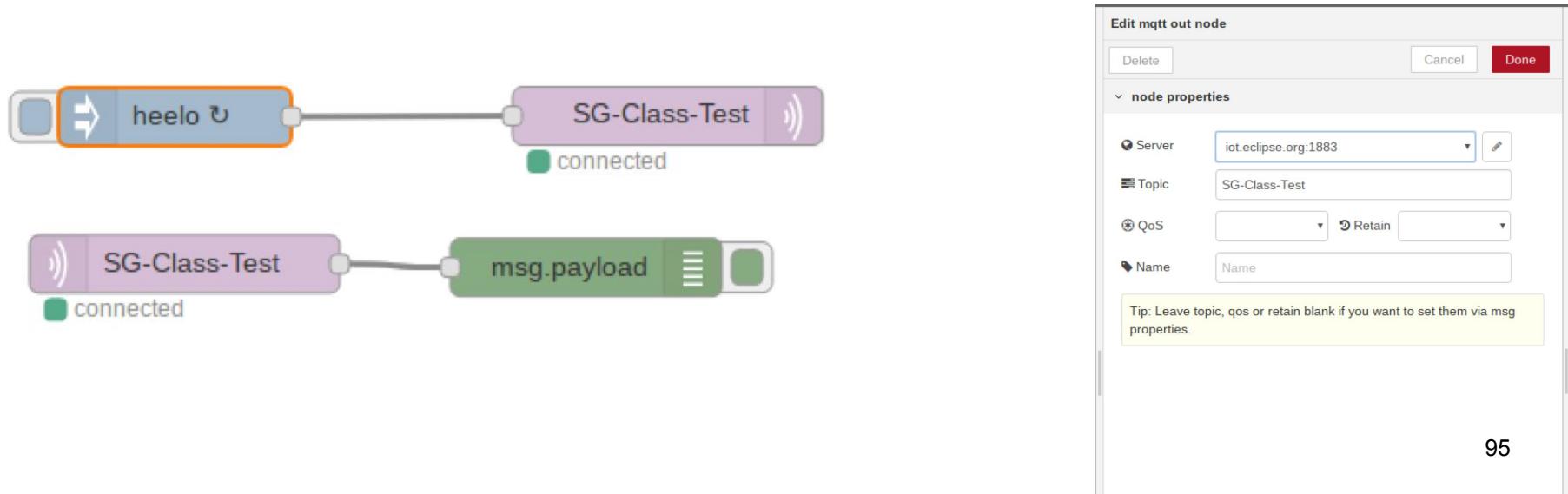
Install Your Own MQTT Broker

- You can also install your own MQTT Broker using Eclipse Mosquito
- Eclipse Mosquitto is an open source message broker that implements the MQTT protocol versions 3.1 and 3.1.1.
- Mosquitto is lightweight and is suitable for use on all devices from low power single board computers to full servers
- Download and install mosquito from ⁹⁴
<https://mosquitto.org/download/>



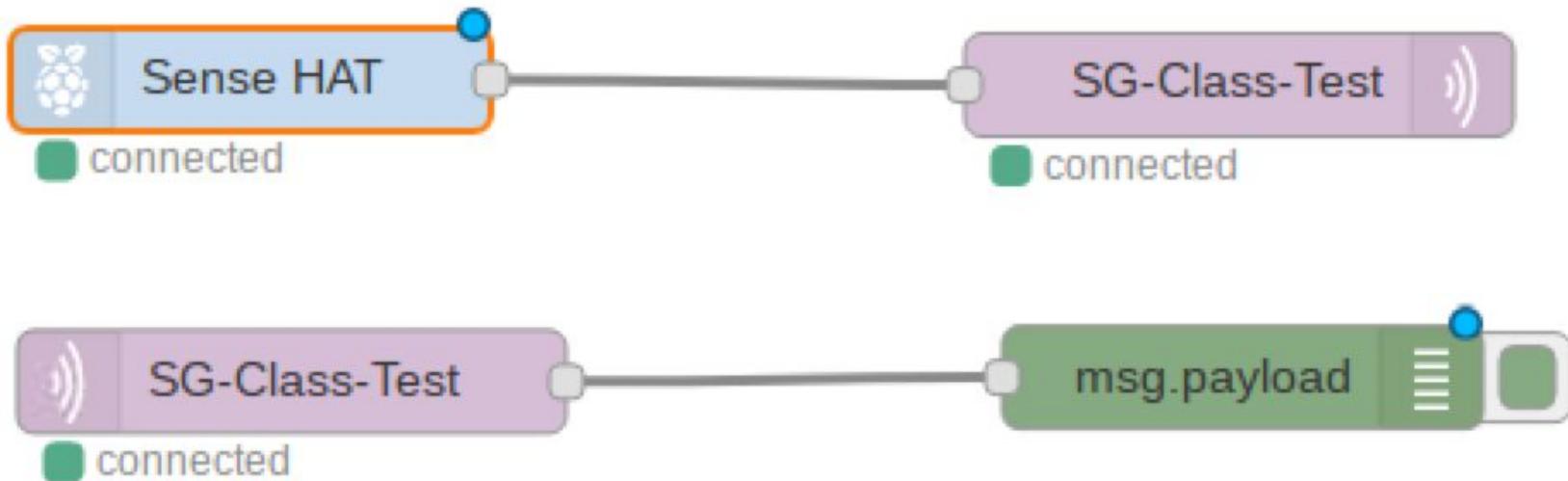
Test Out MQTT

- Use the free MQTT from Eclipse IoT (<https://iot.eclipse.org>)
- Access the server using the hostname `iot.eclipse.org` and port 1883.



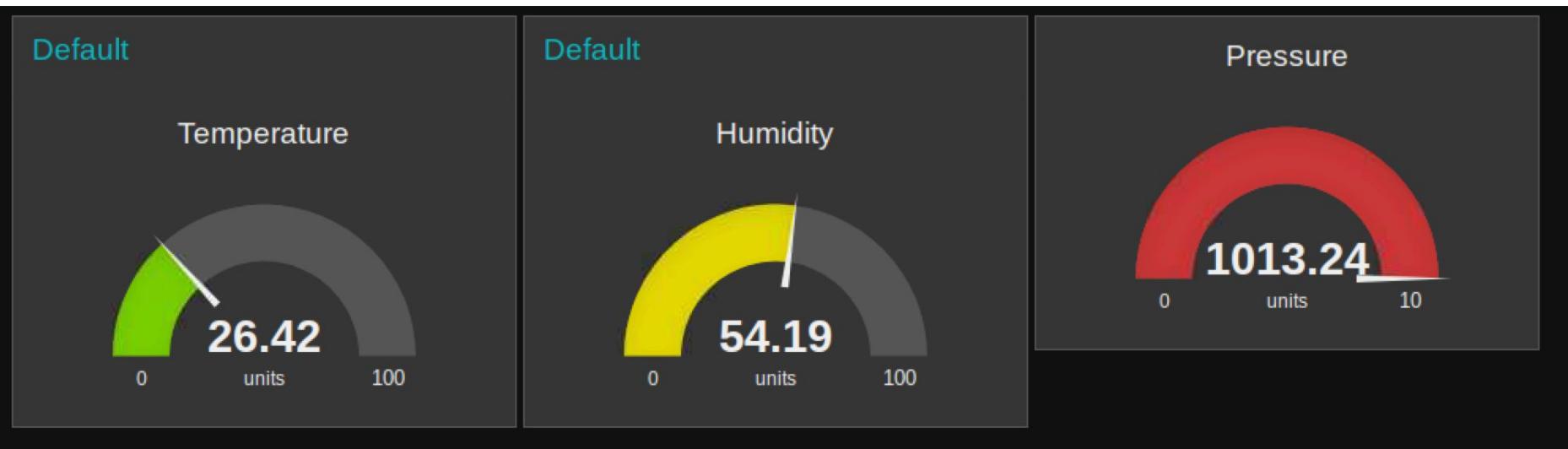
Sense HAT Data Via MQTT

Publish Sense HAT data to the Internet via MQTT

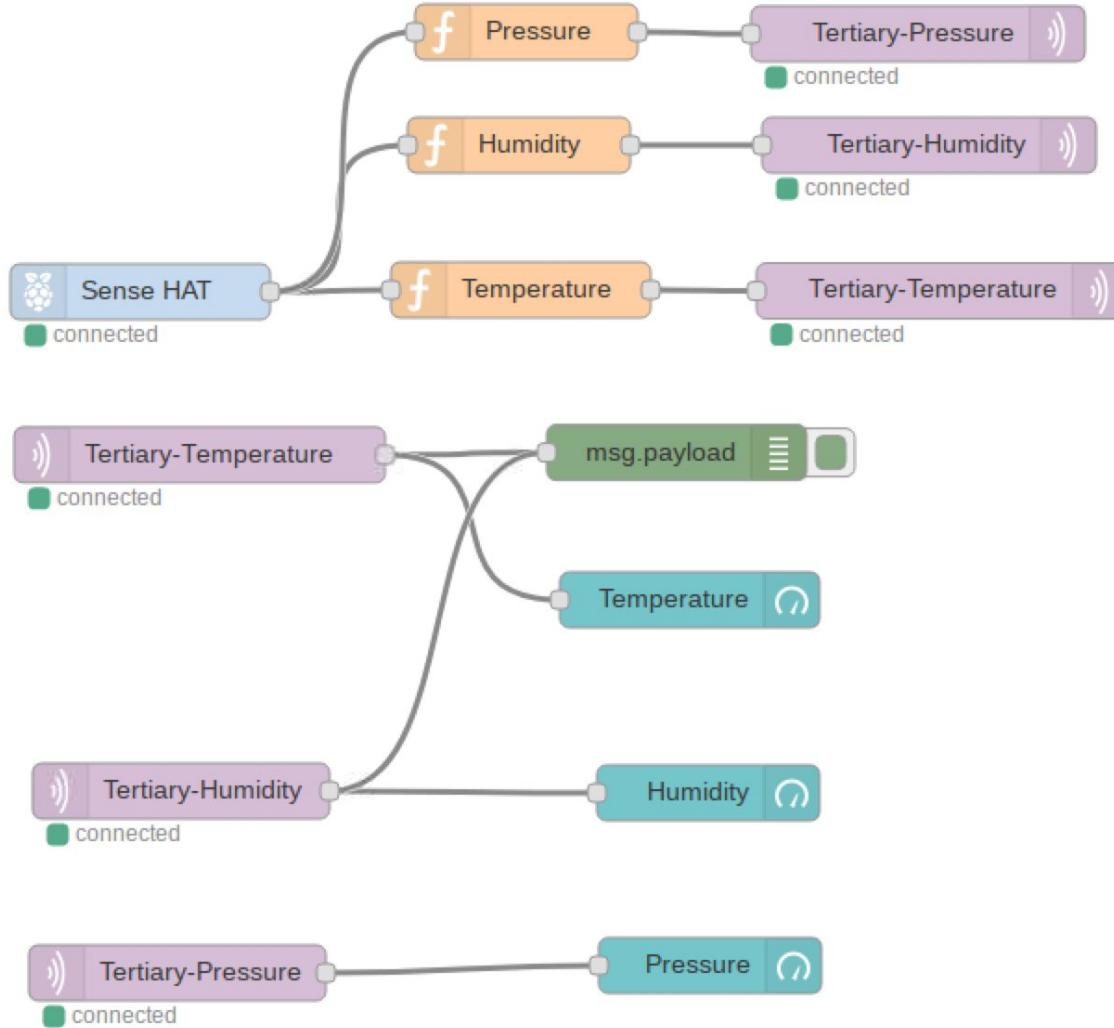


Ex: Transmit Sense HAT Data Via MQTT

Publish the temperature, humidity and pressure data to the internet via MQTT and display them on the gauges

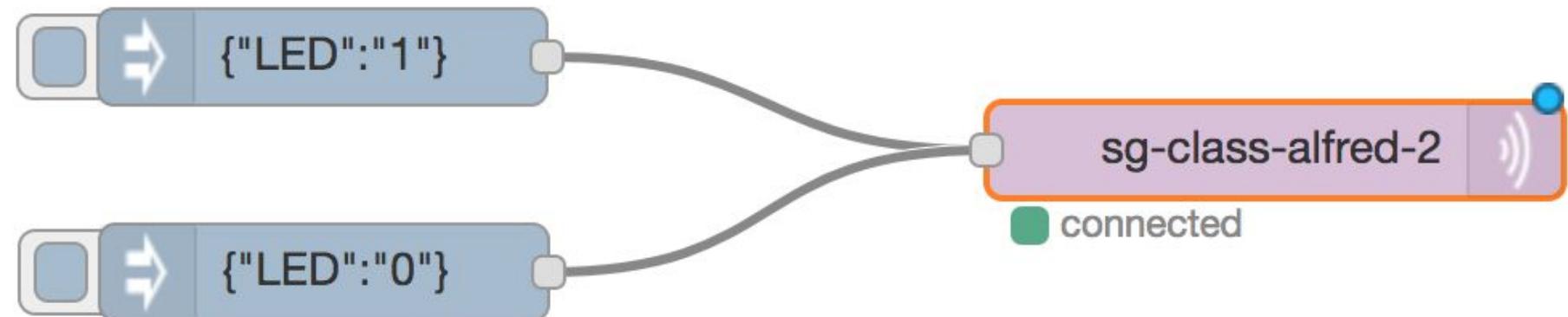


Hint to Exercise



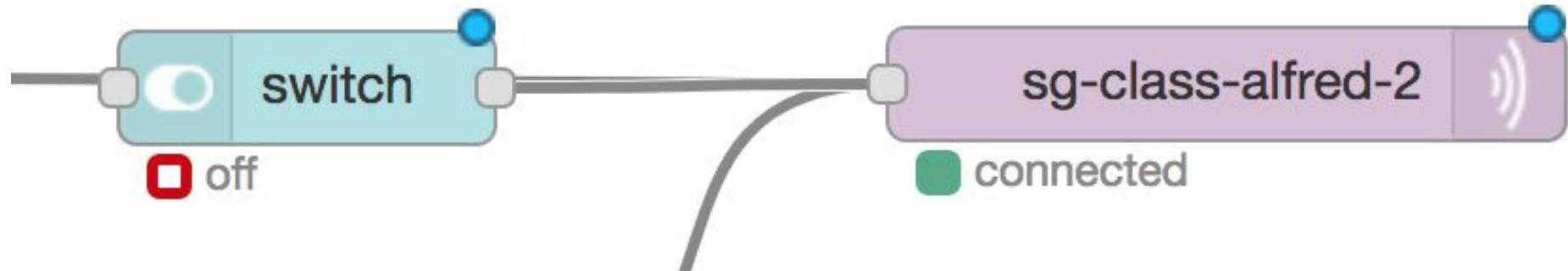
Turn On/Off LED via MQTT

- Add a MQTT Input node and connect to two inject node as follows
- Config the MQTT server setting to
- iot.eclipse.org and the port to 1883
- Deploy and check the GPIO by injecting 1 and 0



Ex: Switch LED via MQTT

Add a switch to the dashboard to switch on and off the LED



Hint

Change the switch output to json and configure as follows:

On Payload

▼ {} {"LED":"1"}

...

Off Payload

▼ {} {"LED":"0"}

...

Summary

Q&A



Feedback

<https://goo.gl/R2eumq>





CERTIFICATE *of ACCOMPLISHMENT*

You will receive a digital certificate in your email
after the completion of the class

If you did not receive the digital certificate,
please send your request to
enquiry@tertiaryinfotech.com

Thank You!

Man Guo Chang
gc.man.sg@gmail.com