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# IBM i Meets IoT

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IBM Community Lead for Node.js

Agenda Key:

# About Michael Dawson

## IBM Community Lead for Node.js



- Active Node.js community member
    - Collaborator
    - Node.js Technical Steering Committee TSC Chair
    - Community Committee member
    - Working group(s) member/leadership
  - Active OpenJS Foundation member
    - Voting Cross Project Council Member
    - Node.js Community Director 2019-2020
  - Twitter: @mhdawson1
  - GitHub: @mhdawson
  - LinkedIn: <https://www.linkedin.com/in/mich>



# Agenda

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- Intro to IoT and MQTT
- Using MQTT with Node.js and IBM i
- Let's Look at some devices
- Anatomy of a simple MQTT Light and Temperature Sensor
- Consuming MQTT data on IBM i
- Leveraging the Cloud

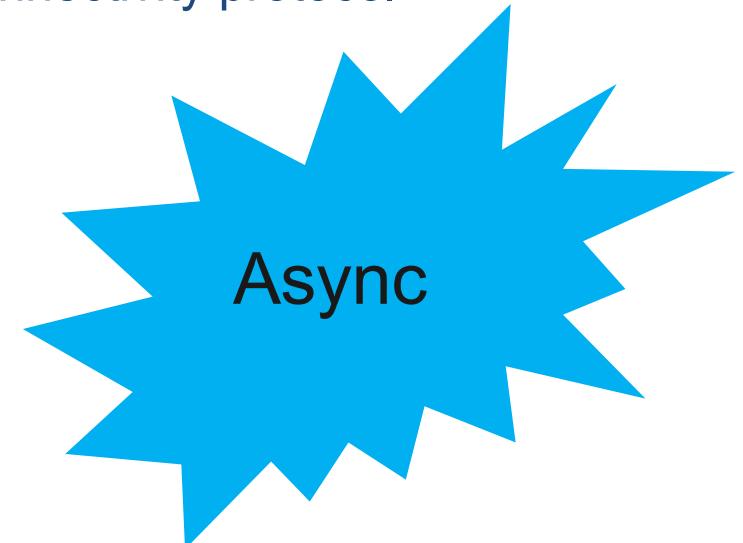
- Internet of Things (IoT)
  - network of physically connected devices (things)
  - devices provide data
  - devices can be controlled
  - [https://en.wikipedia.org/wiki/Internet\\_of\\_Things](https://en.wikipedia.org/wiki/Internet_of_Things)

# MQTT Introduction

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- MQTT (MQ Telemetry Transport)
  - lightweight publish/subscribe
  - small footprint
  - low bandwidth (minimum size is 2 bytes)
  - From <http://mqtt.org/>

“MQTT is a machine-to-machine (M2M)/"Internet of Things" connectivity protocol”



# MQTT - History

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- Invented in 1999
  - Andy Standford-Clark(IBM)
  - Arlen Nipper (Eurotech)
- IBM and Eurotech Donated MQTT to Eclipse Paho project in 2013 - <https://www.eclipse.org/paho/>
  - open-source client implementations
- Mosquitto broker also moved into the Eclipse foundation in 2013 -  
<https://projects.eclipse.org/projects/technology.mosquitto>
  - open-source broker
- Version 3.11 is an OASIS standard
- ISO standard as of 2016 (IOS/IC 20922)
- Version v5.0 official as OASIS standard as of April 2019  
[https://en.wikipedia.org/wiki/Comparison\\_of\\_MQTT\\_implementations](https://en.wikipedia.org/wiki/Comparison_of_MQTT_implementations) – which clients/brokers provide support

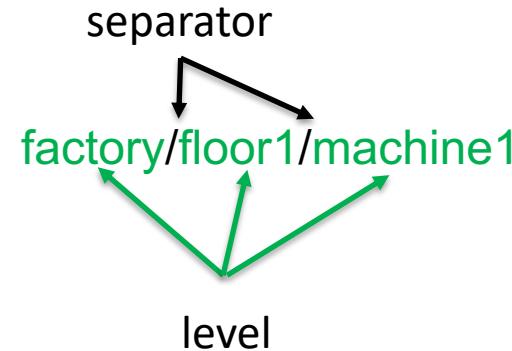
# MQTT – Key terminology

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- Client
  - Publishers and subscribers
  - Paho
  - mqtt.js (MQTT 5 support is experimental)
- Broker
  - Mosquitto
  - ActiveMQ
- Topic
  - Shared id to subscribe or publish on
- Message
  - Free form text
- QoS
  - Quality of Service (0-2)

# MQTT Topics

- **Topics** are one or more **levels** separated by the topic level **separator**



- **Restrictions**

- Must be at least one character
  - Case sensitive

- **Wildcards**

- + Matches one level

factory/+/machine1	factory/floor1/machine1 (yes)	factory/floor1/room1/machine1 (no)
--------------------	-------------------------------	------------------------------------

# matches multiple levels

only allowed at end

factory/#	factory/floor1/machine1 (yes)	factory/floor1/room1/machine1 (yes)
-----------	-------------------------------	-------------------------------------

- 3 Levels
  - 0 – At most once
  - 1 – At least once
  - 2 – Exactly once
- Downgrade of QoS
  - Uses QoS of receiver, so downgrade may occur if sending used higher level
- More overhead for each level
- 0 is generally the default

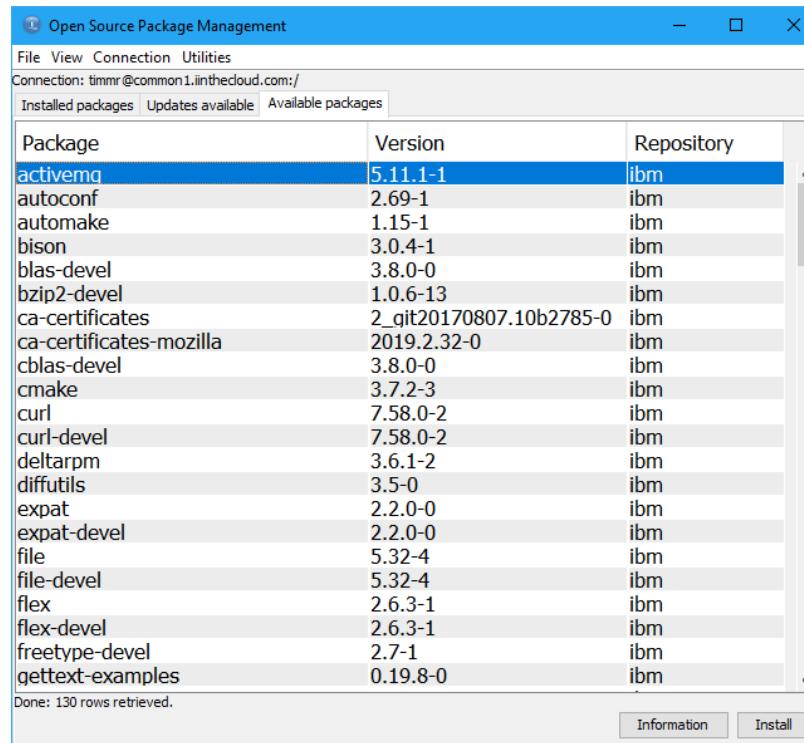
# Why IoT with IBM i?



<https://www.ibm.com/it-infrastructure/us-en/resources/power/ibm-i-customer-stories/#/kj-trucking/>

# Using MQTT with IBM i

- ActiveMQ Install



The screenshot shows the 'Package Installation' window. It starts with a message 'Setting up Install Process' followed by 'Resolving Dependencies'. It then lists several dependency resolution steps: '--> Running transaction check', '---> Package activemq.noarch 0:5.11.1-1 will be installed', and '--> Finished Dependency Resolution'. Below this, it says 'Dependencies Resolved'. A table follows with columns 'Package', 'Arch', 'Version', 'Repository', and 'Size'. It shows one package being installed: 'activemq' with version '5.11.1-1' from 'ibm' repository, size '41 M'. The next section is 'Transaction Summary' with 'Install 1 Package'. It then details the download and installation process: 'Total download size: 41 M', 'Installed size: 47 M', 'Is this ok [Y/N]: y', 'Downloading Packages: activemq-5.11.1-1.ibmi7.2.noarch.rpm | 41 MB 00:08', 'Running Transaction Check', 'Running Transaction Test', 'Transaction Test Succeeded', 'Running Transaction', and 'Installing : activemq-5.11.1-1.noarch [#####] 1/1'. The progress bar at the bottom is nearly full.



# Using MQTT with IBM i

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- Start ActiveMQ  
`activemq start`
- Configure
  - <http://activemq.apache.org/mqtt.html>
  - Default config in - /QOpenSys/pkg/lib/activemq/conf/
- Support
  - <http://ibm.biz/ibmi-oss-support>

`npm install mqtt`



# Simple Client (client-local.js)

```
const fs = require('fs');
const path = require('path');
const mqtt = require('mqtt');

// setup mqtt
let mqttOptions;
mqttOptions = {
    key: fs.readFileSync(path.join(__dirname, 'mqttclient', '/client.key')),
    cert: fs.readFileSync(path.join(__dirname, 'mqttclient', '/client.cert')),
    ca: fs.readFileSync(path.join(__dirname, 'mqttclient', '/ca.cert')),
    clientId: 'simple-client',
    checkServerIdentity: function() { return undefined },
    rejectUnauthorized: false,
    username: '',
    password: ''
}

const mqttClient = mqtt.connect('mqtts:common1.iinthecloud.com:8883', mqttOptions);
mqttClient.on('connect', () => {
    console.log('connected');
    mqttClient.subscribe('onibmi/topic');
    mqttClient.on('message', (topic, message) => {
        console.log('message received topic (' + topic + ') message (' + message.toString() + ')');
    });
});
});
```



# Simple Publisher (publisher-local.js)

```
const fs = require('fs');
const path = require('path');
const mqtt = require('mqtt');

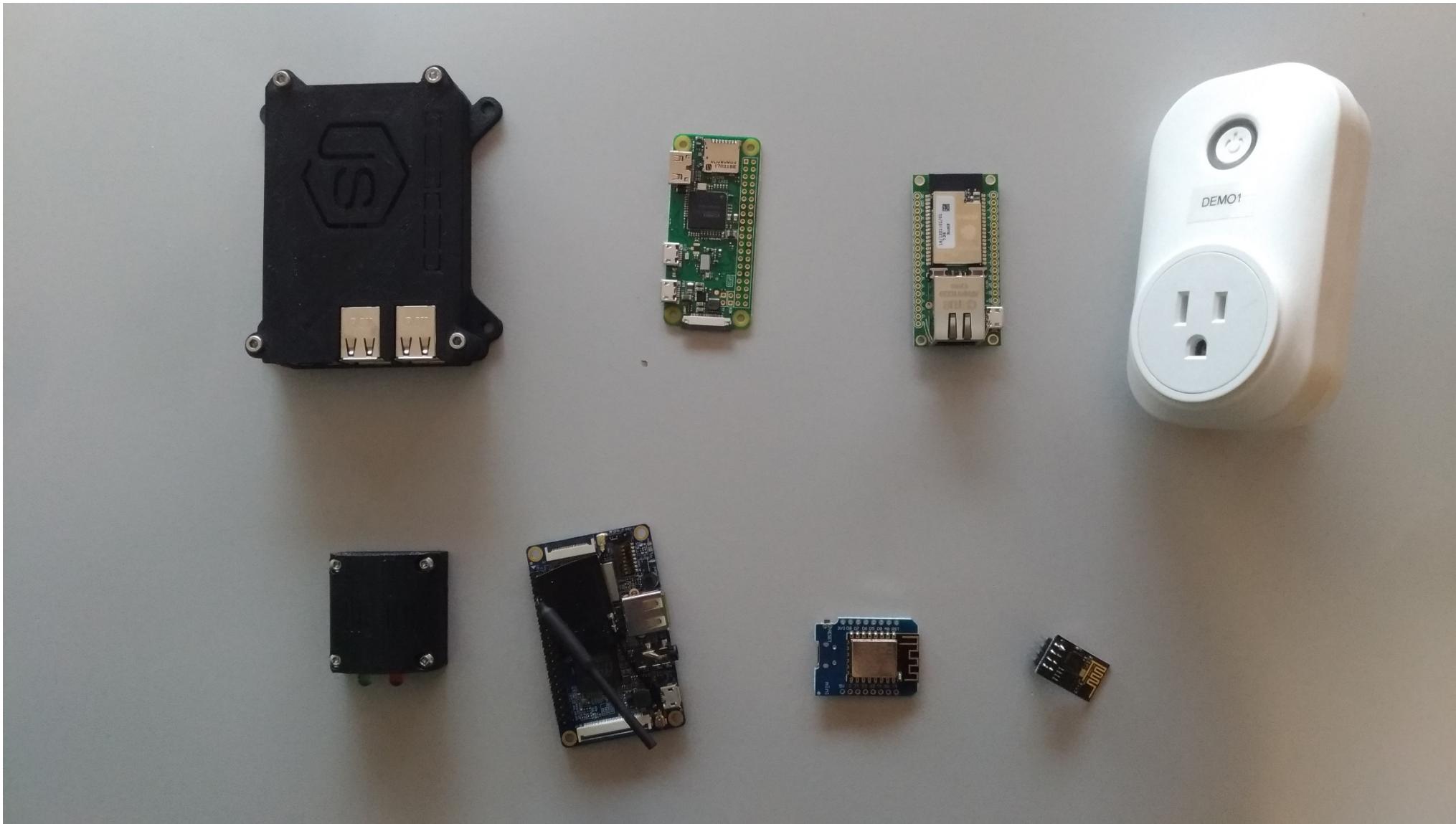
// setup mqtt
let mqttOptions;
mqttOptions = {
    key: fs.readFileSync(path.join(__dirname, 'mqttclient', '/client.key')),
    cert: fs.readFileSync(path.join(__dirname, 'mqttclient', '/client.cert')),
    ca: fs.readFileSync(path.join(__dirname, 'mqttclient', '/ca.cert')),
    clientId: 'simple publish',
    checkServerIdentity: function() { return undefined },
    rejectUnauthorized: false,
    username: '',
    password: ''
}

const mqttClient = mqtt.connect('mqtts:common1.iinthecloud.com:8883', mqttOptions);
mqttClient.on('connect', () => {
    console.log('connected');
    setInterval(() => {
        console.log('publishing');
        mqttClient.publish('onibmi/topic', 'hello world');
    }, 10000 );
});
```

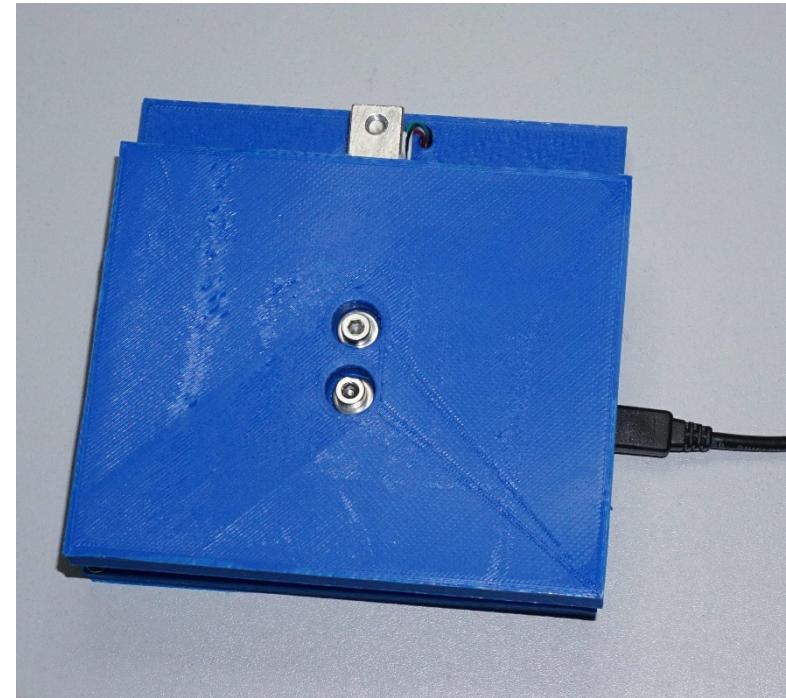
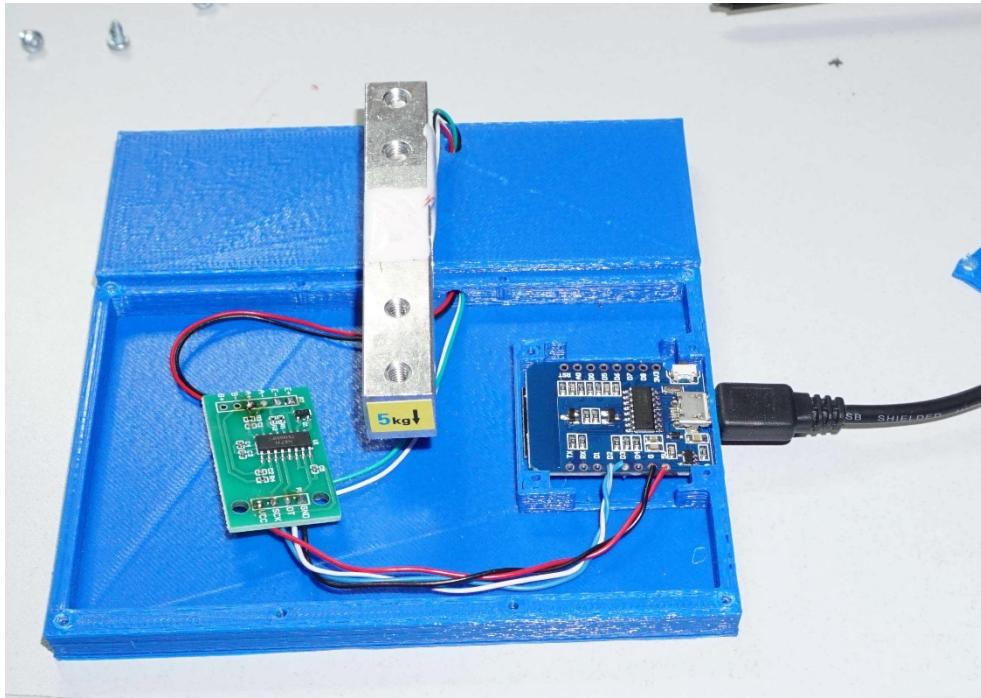
```
driveway@Common1:~/michael/mqttsamples$ node  
publish-local.js  
connected  
publishing  
publishing  
publishing  
publishing  
publishing  
publishing  
publishing  
publishing  
publishing  
publishing
```

```
driveway@Common1:~/michael/mqttsamples$ node client-local.js  
connected  
message received topic (onibmi/topic) message (hello world)  
message received topic (onibmi/topic) message (hello world)
```

# Lets look at some Devices

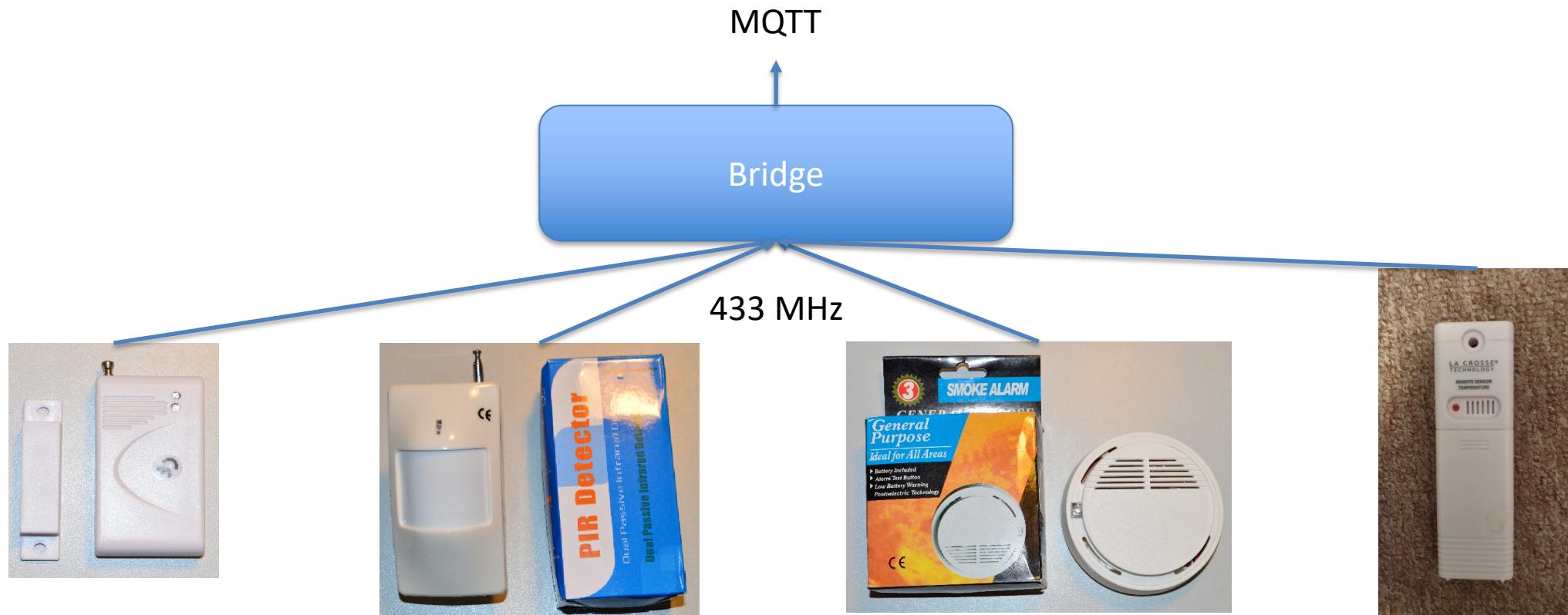


# Lets look at some Devices



# Other/Existing Devices

- Common approach is gateway or bridge
- As an example 433MHz to MQTT bridge  
<https://github.com/mhdawson/arduino-esp8266/tree/master/Mqtt433Bridge>

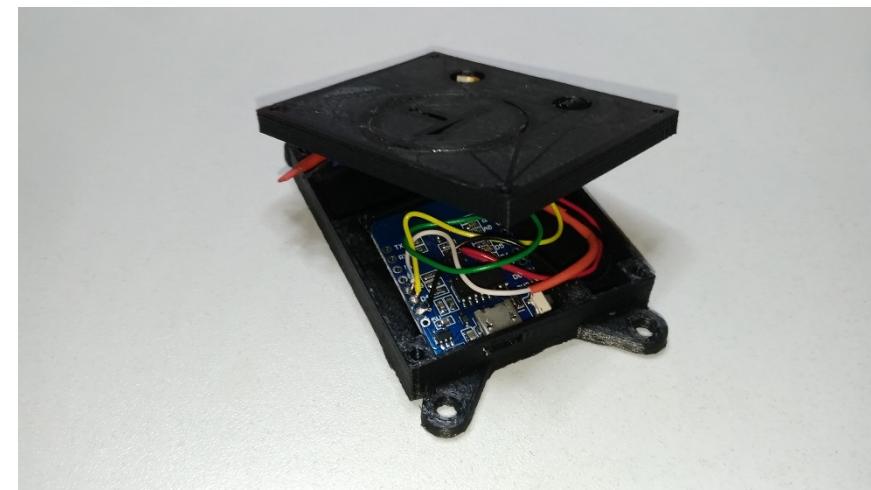
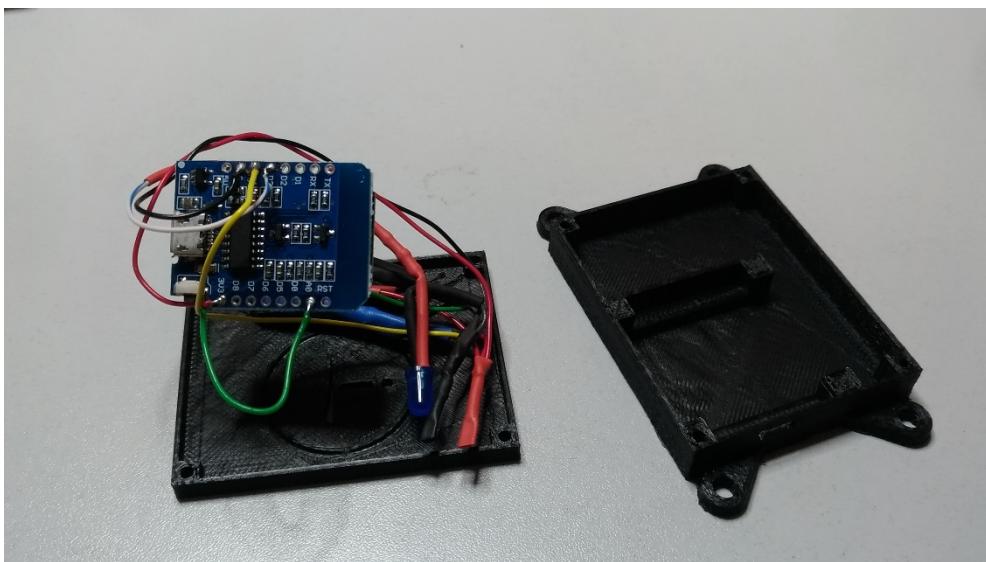


# Anatomy of a Simple Device

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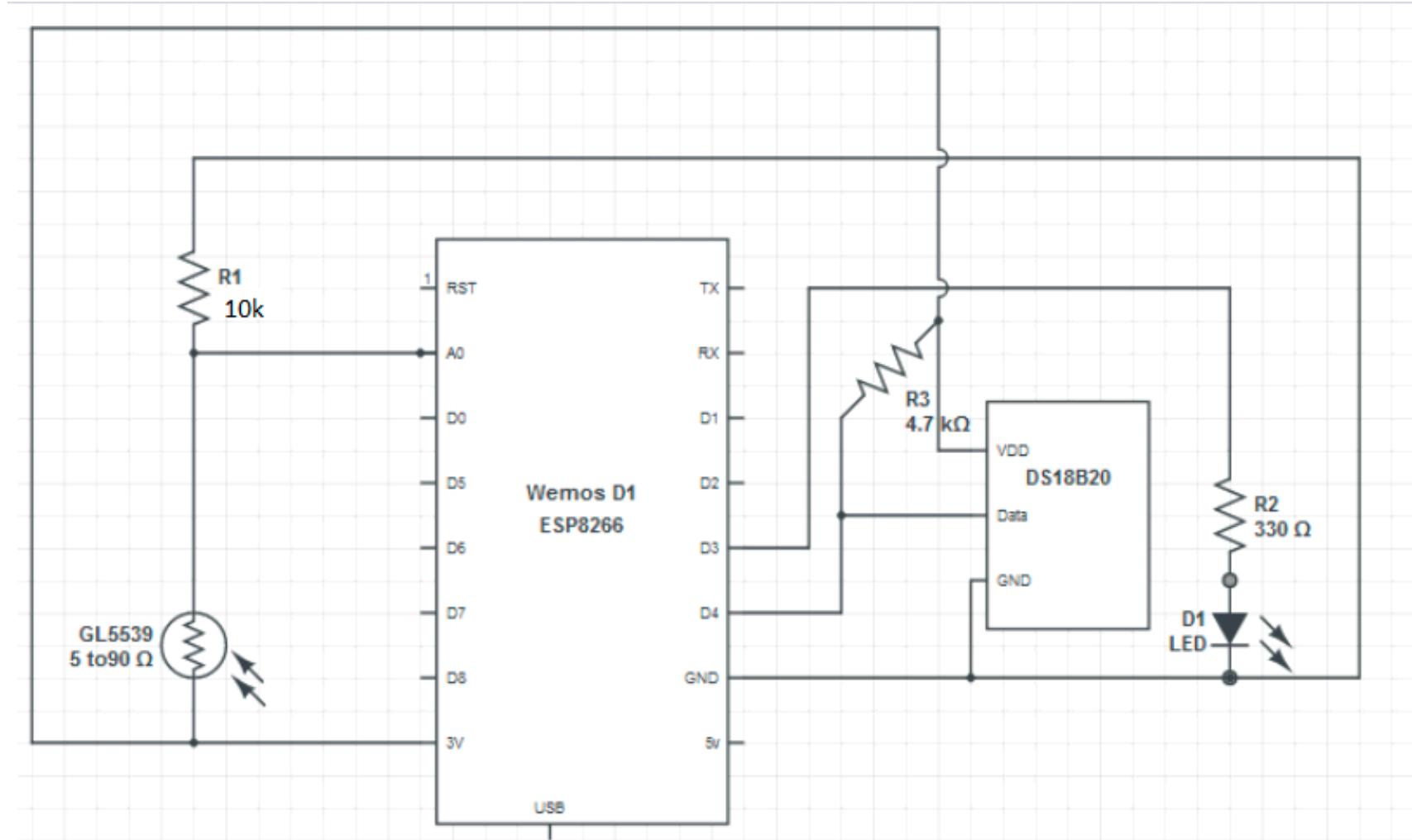
- Maybe your business grows plants?
- **Temperature** and **Light** intensity through the day might be interesting?

# Anatomy of a Simple Device – Temp and Light Sensor



<https://github.com/mhdawson/arduino-esp8266/tree/master/TempAndLightSensor>

# Anatomy of a Simple Device



# Anatomy of a Simple Device



```
5 #ifndef __SENSOR_CONFIG_H__
6 #define __SENSOR_CONFIG_H__
7 #define LIGHT_TOPIC "factory/1/light"
8 #define TEMP_TOPIC "factory/1/temp"
9 #define LED_TOPIC "factory/1/led"
10#endif

1 // wireless setup
2 #ifndef __WIRELESS_H__
3 #define __WIRELESS_H__
4 const char *ssid = "XXXXXXXXXXXX"; // cannot be longer than 32 characters!
5 const char *pass = "XXXXXXXXXX"; //
6 const char* mqttServerString = "XX.XX.XX.XX";
7 const uint16_t mqttServerPort = 8883;
8
9#define USE_CERTS
10unsigned char client_cert[] PROGMEM = {
11    0x30, 0x82, 0x03, 0x92, 0x30, 0x82, 0x02, 0x7a, 0x02, 0x09, 0x00, 0xcb,
12    .....
13};
14 unsigned int client_cert_len = YYYY;
15
16
17 unsigned char client_key[] PROGMEM = {
18    0x30, 0x82, 0x04, 0xa5, 0x02, 0x01, 0x00, 0x02, 0x82, 0x01, 0x01, 0x00,
19    .....
20};
21 unsigned int client_key_len = ZZZZ;
22#endif
```

# Anatomy of a Simple Device



```
5 #include <Arduino.h>
6 #include <ESP8266WiFi.h>
7 #include <WiFiClientSecure.h>
8 #include <PubSubClient.h>
9 #include <OneWire.h>
10 #include <DallasTemperature.h>
11
12 // device specifics
13 #include "WirelessConfig.h"
14 #include "SensorConfig.h"
15
16 #define TRANSMIT_INTERVAL_SECONDS 60
17 #define MILLIS_IN_SECOND 1000
18 #define LOOP_DELAY 100
19
20 #define LED_PIN D3
21 #define LED_BLINK_TIME_SECONDS 2
22
23 #define MAX_MESSAGE_SIZE 100
24
25 #define LIGHT_PIN A0
26
27 #define DS18B20_PIN D4 // don't use D0 or D2 as can interfere with boot
28 OneWire ds(DS18B20_PIN);
29 DallasTemperature tempSensors(&ds);
30
```

# Anatomy of a Simple Device



```
31  bool ledOn = true;
32  void toggleLED() {
33      if (ledOn) {
34          ledOn = false;
35          digitalWrite(LED_PIN, LOW);
36      } else {
37          ledOn = true;
38          digitalWrite(LED_PIN, HIGH);
39      }
40  }
41
42  void callback(char* topic, uint8_t* message, unsigned int length) {
43      if (strncmp((const char*)message,"on", strlen("on")) == 0) {
44          digitalWrite(LED_PIN, HIGH);
45          ledOn = true;
46      } else {
47          digitalWrite(LED_PIN, LOW);
48          ledOn = false;
49      }
50  }
```

# Anatomy of a Simple Device

```
52  WiFiGenericClass wifi;
53
54 #ifdef USE_CERTS
55 // if certs are used the following must be defined in WirelessConfig.h
56 //   unsigned char client_cert[] PROGMEM = {bytes in DER format};
57 //   unsigned int client_cert_len = 918;
58 //   unsigned char client_key[] PROGMEM = {bytes in DER format};
59 //   unsigned int client_key_len = 1193;
60 //
61 //   conversion can be done using
62 //     openssl x509 -in cert -out client.cert -outform DER
63 //     openssl rsa -in key -out client.key -outform DER
64 //   and then using xxd to generate the required array and lengths
65 //   see https://nofurtherquestions.wordpress.com/2016/03/14/making-an-esp8266-web-accessible/
66 //   for more detailed info
67 WiFiClientSecure wclient;
68 #else
69 WiFiClient wclient;
70 #endif
71
72 PubSubClient client(mqttServerString, mqttServerPort, callback, wclient);
73
74 int counter = 0;
75 char macAddress[] = "00:00:00:00:00:00";
```

Runs when MQTT message received



# Anatomy of a Simple Device



```
77 void setup() {
78     delay(1000);
79
80     // Setup console
81     Serial.begin(115200);
82     delay(10);
83     Serial.println();
84     Serial.println("Started");
85
86     pinMode(LED_PIN, OUTPUT);
87     digitalWrite(LED_PIN, HIGH);
88
89 #ifdef USE_CERTS
90     wclient.setCertificate_P(client_cert, client_cert_len);
91     wclient.setPrivateKey_P(client_key, client_key_len);
92 #endif
93
94     // turn off the Access Point as we are not using it
95     wifi.mode(WIFI_STA);
96     WiFi.begin(ssid, pass);
97
98     // first reading always seems to be wrong, read it early and
99     // throw it away
100    tempSensors.requestTemperatures();
101
102    // get the mac address to be used as a unique id for connecting to the mqtt server
103    byte macRaw[6];
104    WiFi.macAddress(macRaw);
105    sprintf(macAddress,
106            "%02.2X:%02.2X:%02.2X:%02.2X:%02.2X:%02.2X",
107            macRaw[0],
108            macRaw[1],
109            macRaw[2],
110            macRaw[3],
111            macRaw[4],
112            macRaw[5]);
113 }
```

# Anatomy of a Simple Device



```
115 void loop() {  
116     client.loop();  
117     delay(LOOP_DELAY);  
118  
119     // make sure we are good for wifi  
120     if (WiFi.status() != WL_CONNECTED) {  
121         Serial.print("Connecting to ");  
122         Serial.println(ssid);  
123         WiFi.reconnect();  
124  
125         if (WiFi.waitForConnectResult() != WL_CONNECTED) {  
126             Serial.println("Failed to reconnect WIFI");  
127             Serial.println(WiFi.waitForConnectResult());  
128             delay(1000);  
129             return;  
130         }  
131     }  
132  
133  
134     if (!client.connected()) {  
135         if (client.connect(macAddress)) { ← Make sure ID is Unique !  
136             Serial.println("mqtt connected:");  
137             Serial.println(macAddress);  
138             Serial.println("\n");  
139             client.subscribe(LED_TOPIC); ← Subscribe to topics of interest  
140         }  
141     }
```

# Anatomy of a Simple Device



```
143     counter++;
144     if (counter == (TRANSMIT_INTERVAL_SECONDS * (MILLIS_IN_SECOND/LOOP_DELAY))) {
145         Serial.println("Sending");
146
147         // don't send out temperature too often as we'll get
148         // incorrect values if we sample too often
149         char tempMessage[MAX_MESSAGE_SIZE];
150         char floatBuffer[10];
151         tempSensors.requestTemperatures();
152         float currentTemp = tempSensors.getTempCByIndex(0);
153         sprintf(tempMessage, MAX_MESSAGE_SIZE, "0, 0 - temp: %s",
154                 dtostrf(currentTemp, 4, 2, floatBuffer));
155         client.publish(TEMP_TOPIC, tempMessage);
156
157         char lightMessage[MAX_MESSAGE_SIZE];
158         int lightValue = analogRead(LIGHT_PIN);
159         sprintf(lightMessage, MAX_MESSAGE_SIZE, "0, 0 - light: %d", lightValue);
160         client.publish(LIGHT_TOPIC, lightMessage);
161
162         toggleLED();
163         counter = 0;
164     } else if (counter == (LED_BLINK_TIME_SECONDS * (MILLIS_IN_SECOND/LOOP_DELAY))) {
165         toggleLED();
166     }
167 }
```

Publish data

# Anatomy of Simple Device

- Don't like C++? Can use JavaScript as well
  - <https://github.com/mhdawson/espruino-stuff/blob/master/SmartPlug.js>

```
54 client.on('publish', function(message) {  
55   console.log(message);  
56   if (message.topic === (devicePrefix + '/power')) {  
57     if (message.message === 'on') {  
58       powerState = 1;  
59     } else if (message.message === 'off') {  
60       powerState = 0;  
61     }  
62     digitalWrite(powerPin, powerState);  
63     console.log('Power state:' + powerState);  
64   } else if (message.topic === (devicePrefix + '/led')) {  
65     clearLedFlashTimer();  
66     if (message.message === 'on') {  
67       ledState = 1;  
68     } else if (message.message === 'off') {  
69       ledState = 0;  
70     } else if (message.message.substr(0, 'flash'.length) === 'flash') {  
71       try {  
72         timeout = message.message.split(':')[1];  
73         startFlashTimer(timeout);  
74       } catch (err) {  
75         console.log(err);  
76       }  
77     }  
78     digitalWrite(ledPin, (ledState + 1) % 2);  
79     console.log('Led state:' + ledState);  
80   } else if (message.topic === (devicePrefix + '/query_state')) {  
81     client.publish(devicePrefix + '/state/power', powerState);  
82     client.publish(devicePrefix + '/state/led', ledState);  
83   }  
84 });
```





# Consuming Sensor Data on IBM i (client-sensor.js)

```
const fs = require('fs');
const path = require('path');
const mqtt = require('mqtt');

// setup mqtt
let mqttOptions;
mqttOptions = {
    key: fs.readFileSync(path.join(__dirname, 'mqttclient', '/client.key')),
    cert: fs.readFileSync(path.join(__dirname, 'mqttclient', '/client.cert')),
    ca: fs.readFileSync(path.join(__dirname, 'mqttclient', '/ca.cert')),
    clientId: 'simple-client',
    checkServerIdentity: function() { return undefined },
    rejectUnauthorized: false,
    username: '',
    password: ''
}

const mqttClient = mqtt.connect('mqtts:common1.iinthecloud.com:8883', mqttOptions);
mqttClient.on('connect', () => {
    console.log('connected');
    mqttClient.subscribe('factory/1/light');
    mqttClient.subscribe('factory/1/temp');
    mqttClient.on('message', (topic, message) => {
        console.log('message received topic (' + topic + ') message (' + message.toString() + ')');
    });
});
```



# Controlling Sensor on IBMi (control.js)

```
const fs = require('fs');
const path = require('path');
const mqtt = require('mqtt');

// setup mqtt
let mqttOptions;
mqttOptions = {
    key: fs.readFileSync(path.join(__dirname, 'mqttclient', '/client.key')),
    cert: fs.readFileSync(path.join(__dirname, 'mqttclient', '/client.cert')),
    ca: fs.readFileSync(path.join(__dirname, 'mqttclient', '/ca.cert')),
    clientId: 'control client',
    checkServerIdentity: function() { return undefined },
    rejectUnauthorized: false,
    username: '',
    password: ''
}

const mqttClient = mqtt.connect('mqtts:common1.iinthecloud.com:8883', mqttOptions);
mqttClient.on('connect', () => {
    console.log('connected');
    mqttClient.publish('factory/1/led', process.argv[2], () => {
        setTimeout( () => {
            process.exit(0);
        }, 2000);
    });
});
```

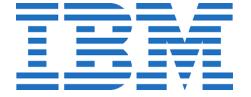


# Consuming Sensor Data on IBM i – Store to DB

```
const { DBPool } = require('idb-pconnector');
const pool = new DBPool();

async function setupDb() {
  try {
    await pool.prepareExecute('CREATE SCHEMA JESSEGIOT');
  }catch(err) {
    if(err.stack.includes('SQLSTATE=42710')) {
      console.log('schema already exists');
    } else {
      console.log('error: '+err.stack);
    }
  }
  try {
    await pool.prepareExecute(`CREATE OR REPLACE TABLE JESSEGIOT.IOT_RECORDS (
      DEVICE VARCHAR(80) ALLOCATE (10) CCSID 1208 NOT NORMALIZED NOT NULL NOT HIDDEN,
      SENSORVALUE DECIMAL(7, 2) NOT NULL NOT HIDDEN,
      SENSORTIME TIMESTAMP(6) GENERATED ALWAYS FOR EACH ROW ON UPDATE AS ROW CHANGE TIMESTAMP
      NOT NULL NOT HIDDEN
    )
    NOT VOLATILE UNIT ANY KEEP IN MEMORY NO`);

  }catch(err) {
    console.log('error: '+err.stack);
  }
  console.log('Database setup complete!');
}
```



# Consuming Sensor Data on IBM i – Store to DB

```
const mqttClient = mqtt.connect('mqtts:common1.iinthecloud.com:8883', mqttOptions); mqttClient.on('connect', () => {
  console.log('connected');
  mqttClient.subscribe('factory/1/light');
  mqttClient.subscribe('factory/1/temp');
  mqttClient.on('message', (topic, message) => {
    let value = message.toString().replace(/\.*:/g, '').replace(/[^0-9.]+/g, '');
    pool.prepareExecute('insert into JESSEGIOT.IOT_RECORDS(device, sensorvalue) values(?, ?)', [topic, value]);
    console.log('message received topic (' + topic + ') message (' + message.toString() + ')');
  });
});
```

# Controlling Sensor on IBM i (control.js)

The screenshot shows the IBM i Access SQL Scripts interface. At the top, the title bar reads "C:\Users\jgorzins\Desktop\iot.sql\* - Run SQL Scripts - common1.iinthecloud.com(lhost)". The menu bar includes File, Edit, View, Run, VisualExplain, Monitor, Options, Connection, Tools, and Help. Below the menu is a toolbar with various icons. The main area contains two SQL scripts:

```
1 -- description: Temperature
2 SELECT *
3   FROM JESSEGIOT.IOT_RECORDS
4  WHERE DEVICE LIKE '%temp'
5  ORDER BY SENSORTIME DESC
6  LIMIT 50;
7
8 -- description: Light
9 SELECT *
10  FROM JESSEGIOT.IOT_RECORDS
11 WHERE DEVICE LIKE '%light'
12 ORDER BY SENSORTIME DESC
13 LIMIT 50;
14
```

Below the scripts is a table displaying the results of the second query:

DEVICE	SENSORVALUE	SENSORTIME
factory/1/temp	24.75	2019-04-12 16:07:05.510507
factory/1/temp	24.75	2019-04-12 16:06:35.337323
factory/1/temp	24.75	2019-04-12 16:06:05.127732
factory/1/temp	24.75	2019-04-12 16:05:34.939690
factory/1/temp	24.75	2019-04-12 16:05:04.754581
factory/1/temp	24.75	2019-04-12 16:04:34.556798
factory/1/temp	24.75	2019-04-12 16:04:04.355322

At the bottom of the table, it says "Done: 43 rows retrieved."

Below the table are tabs for "Temperature", "Light", "Messages", and "Global Variables and Special Registers".

At the very bottom, a status bar indicates: "Connected to relational database lhost on common1.iinthecloud.com as TIMMR - 060877/QUSER/QZDASOINIT using JDBC configuration 'Common'".

# Demo

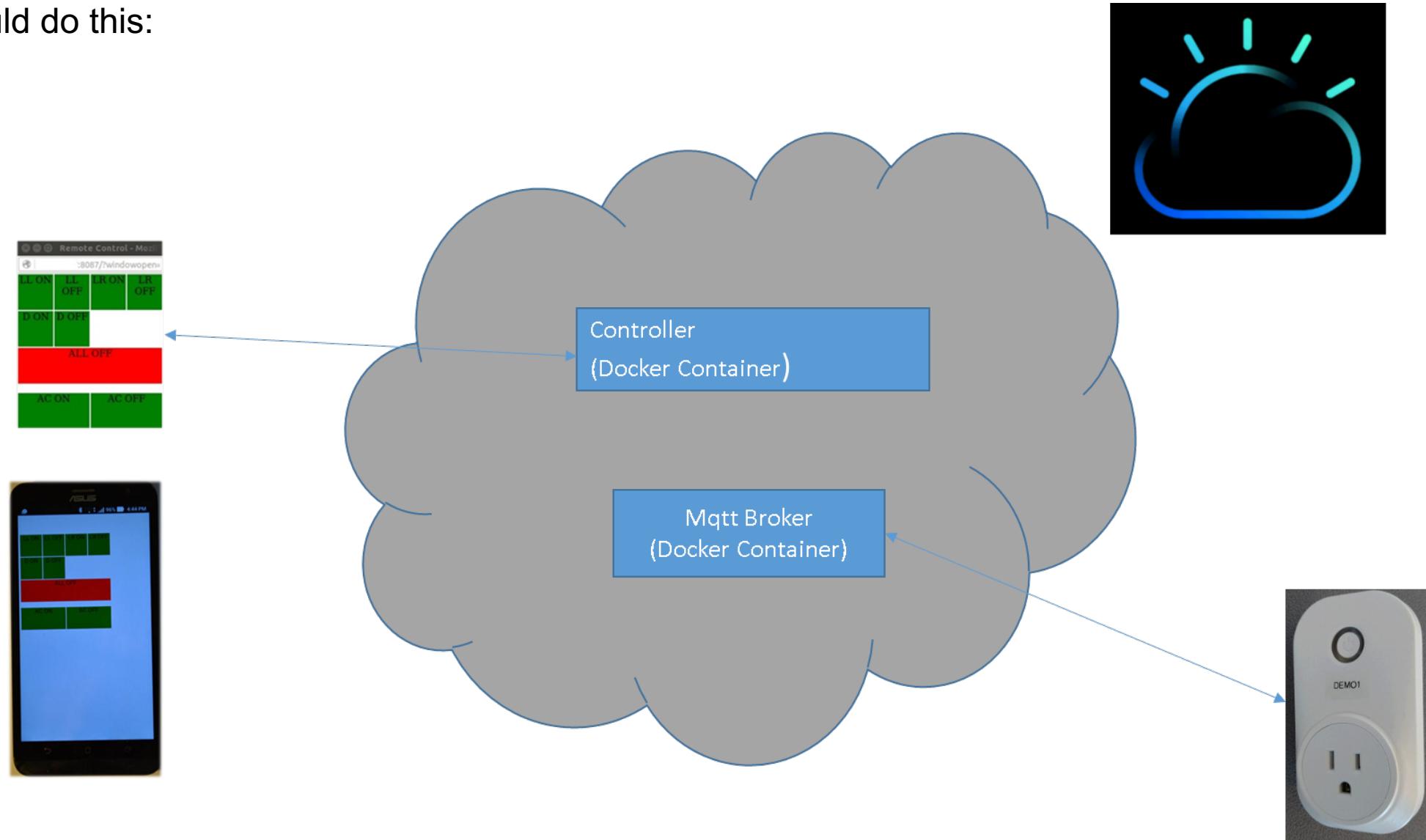
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- Live Device data flow

# Leveraging the Cloud

- Could do this:



# Leveraging the Cloud – Even Better

- Cloud Based Service
  - Don't worry about infrastructure
  - Get started fast
  - Easy visualization

## Internet of Things



### Internet of Things Platform

Lite • IBM

This service is the hub of all things IBM IoT, it is where you can set up and manage your connected devices so that your apps can access their live a...



### AT&T Flow Designer

Third Party

Design, Build and Deploy IoT Solutions in Minutes



### AT&T IoT Data Plans

Third Party

Launch your IoT product fast with IoT data plans



### Bosch IoT Rollouts

Third Party

Rollout software and firmware updates to devices

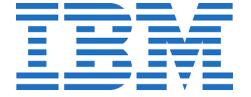


### UnificationEngine

Third Party

Intelligent IoT messaging for all H2M communications.

# Leveraging the Cloud



```
diff --git a/TempAndLightSensor/SensorConfig.h b/TempAndLightSensor/SensorConfig.h
index 4459876..b33e08d 100644
--- a/TempAndLightSensor/SensorConfig.h
+++ b/TempAndLightSensor/SensorConfig.h
@@ -4,7 +4,7 @@
#ifndef __SENSOR_CONFIG_H__
#define __SENSOR_CONFIG_H__
-#define LIGHT_TOPIC "factory/1/light"
-#define TEMP_TOPIC "factory/1/temp"
-#define LED_TOPIC "factory/1/led"
+#define LIGHT_TOPIC "iot-2/evt/light/fmt/json"
+#define TEMP_TOPIC "iot-2/evt/temp/fmt/json"
+#define LED_TOPIC "iot-2/cmd/led/fmt/txt"
#endif
diff --git a/TempAndLightSensor/TempAndLightSensor.ino b/TempAndLightSensor/TempAndLightSensor.ino
index 8acbba..3185175 100644
--- a/TempAndLightSensor/TempAndLightSensor.ino
+++ b/TempAndLightSensor/TempAndLightSensor.ino
@@ -13,7 +13,7 @@
#include "WirelessConfig.h"
#include "SensorConfig.h"

#define TRANSMIT_INTERVAL_SECONDS 60
#define TRANSMIT_INTERVAL_SECONDS 30
#define MILLIS_IN_SECOND 1000
#define LOOP_DELAY 100

@@ -132,11 +132,12 @@
void loop() {

    if (!client.connected()) {
        if (client.connect(macAddress)) {
+       if (client.connect("d:a13kr9:TempAndLightSensor:device2", MQTT_USERNAME, MQTT_PASSWORD)) {
            Serial.println("mqtt connected:");
            Serial.println(macAddress);
            Serial.println("\n");
            client.subscribe(LED_TOPIC);
+       } else {
+           Serial.println("Failed to connect to mqtt server\n");
        }
    }

@@ -150,13 +151,13 @@
void loop() {
    char floatBuffer[10];
    tempSensors.requestTemperatures();
    float currentTemp = tempSensors.getTempCByIndex(0);
-   sprintf(tempMessage, MAX_MESSAGE_SIZE, "0, 0 - temp: %s",
+   sprintf(tempMessage, MAX_MESSAGE_SIZE, "{ \"temp\": %s }",
           dtostrf(currentTemp, 4, 2, floatBuffer));
    client.publish(TEMP_TOPIC, tempMessage);

    char lightMessage[MAX_MESSAGE_SIZE];
    int lightValue = analogRead(LIGHT_PIN);
-   sprintf(lightMessage, MAX_MESSAGE_SIZE, "0, 0 - light: %d", lightValue);
+   sprintf(lightMessage, MAX_MESSAGE_SIZE, "{ \"light\": %d }", lightValue);
    client.publish(LIGHT_TOPIC, lightMessage);

    toggleLED();
}
```

[https://cloud.ibm.com/docs/services/IoT/reference/security?topic=iot-platform-connect\\_devices\\_apps\\_gw](https://cloud.ibm.com/docs/services/IoT/reference/security?topic=iot-platform-connect_devices_apps_gw#connect_devices_apps_gw)

```
-#define LIGHT_TOPIC "factory/1/light"
-#define TEMP_TOPIC "factory/1/temp"
-#define LED_TOPIC "factory/1/led"
+#define LIGHT_TOPIC "iot-2/evt/light/fmt/json"
+#define TEMP_TOPIC "iot-2/evt/temp/fmt/json"
+#define LED_TOPIC "iot-2/cmd/led/fmt/txt"

-    sprintf(lightMessage, MAX_MESSAGE_SIZE, "0,
0 - light: %d", lightValue);
+    sprintf(lightMessage, MAX_MESSAGE_SIZE, "{\n\"light\": %d }\", lightValue);
```

# Leveraging the Cloud



IBM Watson IoT Platform

Browse Action Device Types

This table shows a summary of all devices that have been added. It can be filtered, organized, and searched on using different criteria. To get started, you can add devices by using the Add Device button, or by using API.

<input type="checkbox"/>	Device ID	Device Type	Class ID	Date Added
●	device1	TempAndLightSensor	Device	Apr 5, 2019 6:46 PM
●	device2	TempAndLightSensor	Device	Apr 5, 2019 6:41 PM

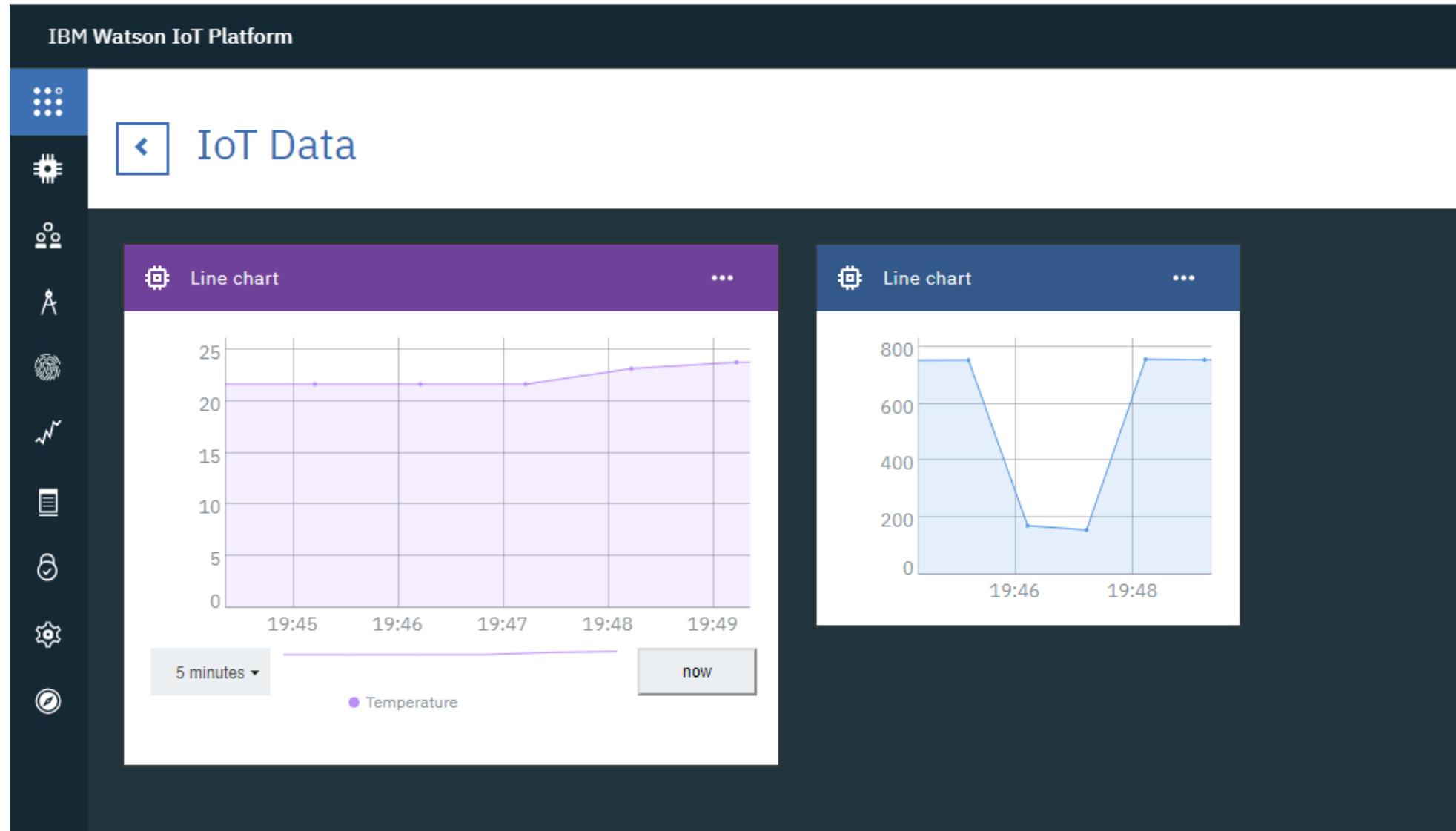
2 results

Identity Device Information Recent Events State Logs

Showing Raw Data | The recent events listed show the live stream of data that is coming and going from this device.

Event	Value	Format	Last Received
light	{"light":756}	json	15 minutes ago
temp	{"temp":21.81}	json	15 minutes ago
light	{"light":757}	json	16 minutes ago
temp	{"temp":21.75}	json	16 minutes ago
light	{"light":760}	json	17 minutes ago

# Leveraging the Cloud





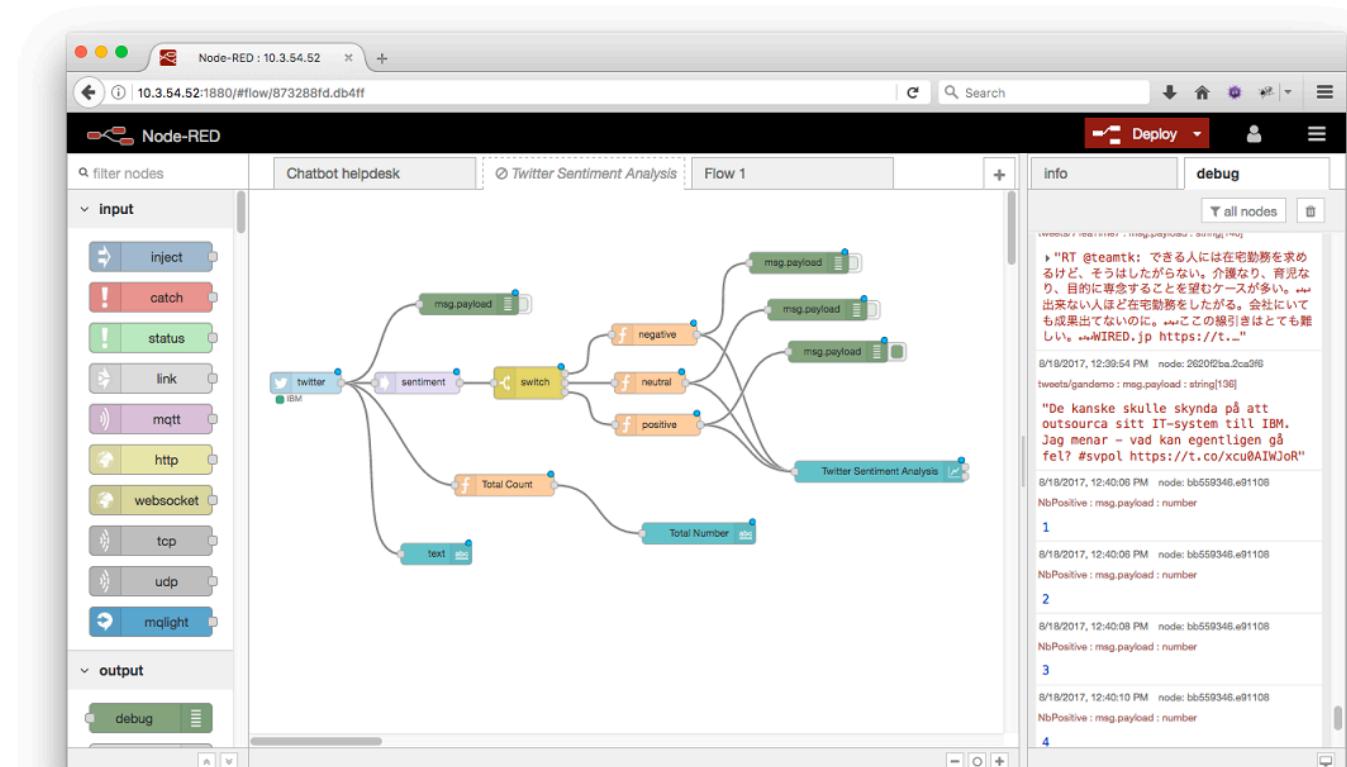
# Consuming Data on IBMi (client-ibmcloud.js)

```
const fs = require('fs');
const path = require('path');
const mqtt = require('mqtt');

// setup mqtt
let mqttOptions;
mqttOptions = {
    key: fs.readFileSync(path.join(__dirname, 'mqttclient', '/client.key')),
    cert: fs.readFileSync(path.join(__dirname, 'mqttclient', '/client.cert')),
    ca: fs.readFileSync(path.join(__dirname, 'mqttclient', '/ca.cert')),
    clientId: 'A:xxxxxx:xxxxxxxxxx',
    checkServerIdentity: function() { return undefined },
    rejectUnauthorized: false,
    username: 'a-xxxxxx-xxxxxxxxxx',
    password: 'xxxxxxxxxxxxxxxx'
}

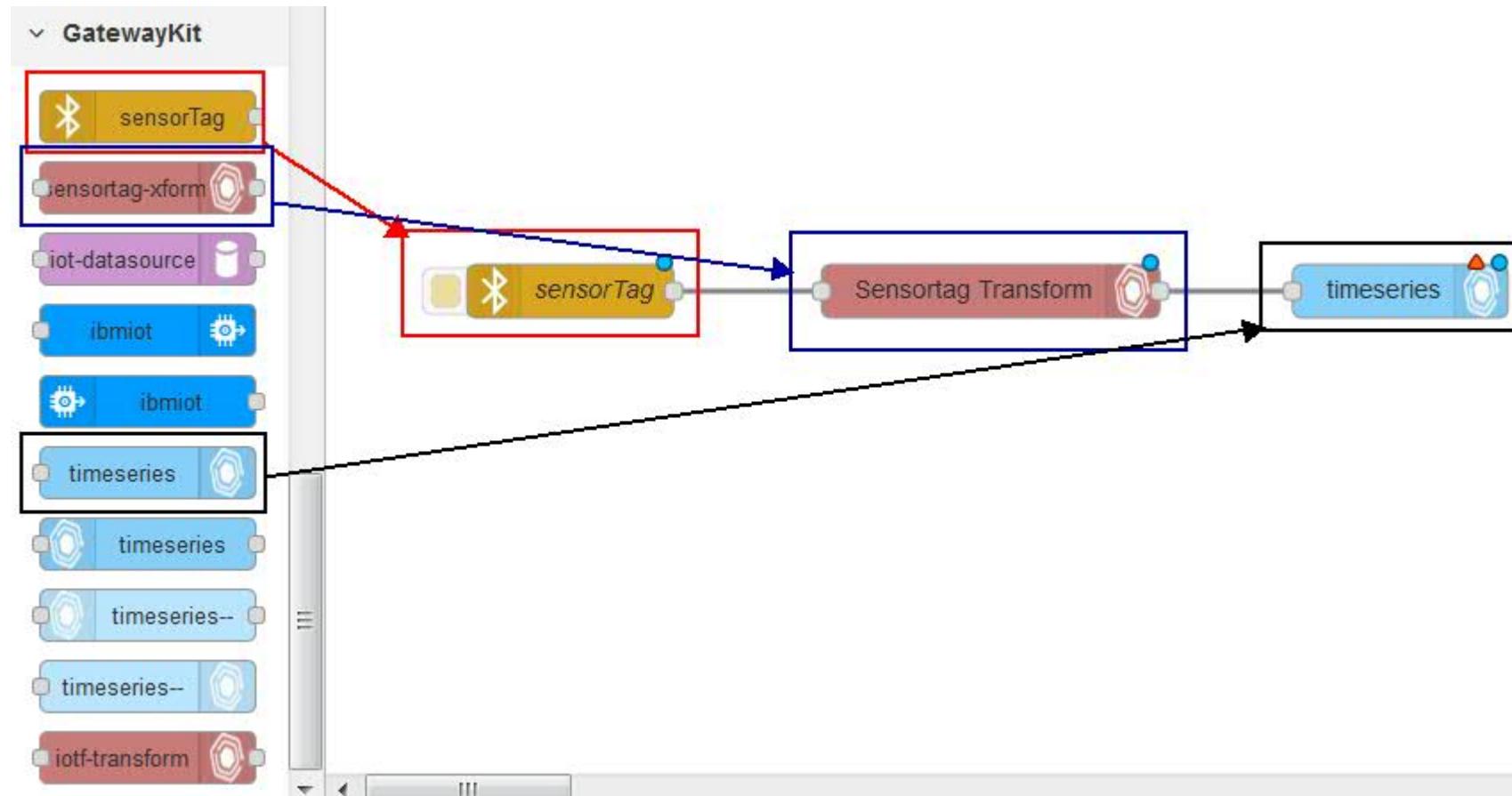
const mqttClient = mqtt.connect('mqtt://xxxxxxxx.messaging.internetofthings.ibmcloud.com:8883', mqttOptions);
mqttClient.on('connect', () => {
    console.log('connected');
    mqttClient.subscribe('iot-2/type/+id/+evt/+fmt/+');
    mqttClient.on('message', (topic, message) => {
        console.log('message received topic (' + topic + ') message (' + message.toString() + ')');
    });
});
```

- Created by IBM
- Low-code graphical way to write flow-based programs
- <https://developer.ibm.com/tutorials/i-running-node-red/>
- Nodes can be any building block that can receive and send messages. Examples include:
  - Db2 for i queries
  - IoT devices
  - Web pages
  - Web APIs
  - Cloud services
  - Dashboards



# Node-RED for IoT

- [https://www.ibm.com/developerworks/community/blogs/cee6c09c-a315-4b04-ad14-57d6a60fa8bb/entry/Creating\\_A\\_Node\\_red\\_Flow\\_for\\_IoT?lang=en](https://www.ibm.com/developerworks/community/blogs/cee6c09c-a315-4b04-ad14-57d6a60fa8bb/entry/Creating_A_Node_red_Flow_for_IoT?lang=en)



# Summary

---

- Intro to IoT and MQTT
- Using MQTT with Node.js and IBM i
- Lets Look at some devices
- Anatomy of a simple MQTT Light and Temperature Sensor
- Consuming MQTT data on IBMi
- Leveraging the Cloud
- Nod-Red learn more in the next session



The screenshot shows a web browser window with the title bar "Apache ActiveMQ". The address bar contains "common1.iinthecloud.com:8161". The main content area displays the Apache ActiveMQ homepage. The page features a large "ActiveMQ" logo with a feather graphic. To the right is the "The Apache Software Foundation" logo with the URL "http://www.apache.org". A red horizontal bar across the middle of the page contains the text "Welcome to the Apache ActiveMQ!" and a "Support" link. Below this, a list of actions includes "Manage ActiveMQ broker" and "See some Web demos (demos not included in default configuration)". On the right side, there is a sidebar titled "Useful Links" with links to "Documentation", "FAQ", "Downloads", and "Forums". At the bottom of the page is a black footer bar with the text "Copyright 2005-2013 The Apache Software Foundation." and "Graphic Design By Hiram".

The screenshot shows the ActiveMQ Administration Console interface. At the top, there's a navigation bar with links: Home, Queues, Topics, Subscribers, Connections, Network, Scheduled, and Send. On the right side, there's a sidebar with sections for Queue Views, Topic Views, Subscribers Views, and Useful Links. The main content area displays a table of topics. The table has columns: Name, Number Of Consumers, Messages Enqueued, Messages Dequeued, and Operations. There are two rows in the table:

Name	Number Of Consumers	Messages Enqueued	Messages Dequeued	Operations
ActiveMQ.Advisory.Connection	0	3	0	Send To Active Subscribers Active Producers Delete
ActiveMQ.Advisory.Consumer.Topic.factory.1.light	0	2	0	Send To Active Subscribers Active Producers Delete

The screenshot shows a web browser window titled "localhost : Topics" displaying a list of ActiveMQ topics. The URL is "common1.iinthecloud.com:8161/admin/topics.jsp". The page includes a header with File, Edit, View, History, Bookmarks, Tools, Help, and a search bar. The main content is a table with the following data:

Topic	Producers	Consumers	Subscribers	Active
ActiveMQ.Advisory.MasterBroker	0	1	0	Subscribers Active Producers Delete
ActiveMQ.Advisory.Topic	0	3	0	Send To Active Subscribers Active Producers Delete
factory.1.light	0	0	0	Send To Active Subscribers Active Producers Delete
factory.1.temp	0	0	0	Send To Active Subscribers Active Producers Delete
onibmi.topic	0	36	0	Send To Active Subscribers Active Producers Delete

Active Durable Topic Subscribers										
Client ID	Subscription Name	Connection ID	Destination	Selector	Pending Queue Size	Dispatched Queue Size	Dispatched Counter	Enqueue Counter	Dequeue Counter	Operations
Offline Durable Topic Subscribers										
Client ID	Subscription Name	Connection ID	Destination	Selector	Pending Queue Size	Dispatched Queue Size	Dispatched Counter	Enqueue Counter	Dequeue Counter	Operations
Active Non-Durable Topic Subscribers										
Client ID	Subscription Name	Connection ID	Destination	Selector	Pending Queue Size	Dispatched Queue Size	Dispatched Counter	Enqueue Counter	Dequeue Counter	Operations
simple-...	ID:COMM...	factory...			0	0	0	0	0	
simple-...	ID:COMM...	factory...			0	0	0	0	0	

Screenshot of a web browser displaying the ActiveMQ administration interface. The URL is [common1.iinthecloud.com:8161/admin/connections.jsp](http://common1.iinthecloud.com:8161/admin/connections.jsp).

The page title is "ActiveMQ™". The Apache Software Foundation logo is visible on the right.

Navigation menu:

- File Edit View History Bookmarks Tools Help
- localhost : Connections
- + (New tab)
- common1.iinthecloud.com:8161/admin/connections.jsp
- 2009
- ... ⌂ ⌂ ⌂
- Search

Main content area:

# ActiveMQ™

Connections

## Connector mqtt+nio

Name ↑	Remote Address	Active	Slow
simple publish	tcp://127.0.0.1:51379	true	false
simple-client	tcp://172.29.5.242:51368	true	false

## Network Connectors

Support

- Queue Views
  - Graph
  - XML
- Topic Views
  - XML
- Subscribers Views
  - XML
- Useful Links

# The END!



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Revised September 26, 2006



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