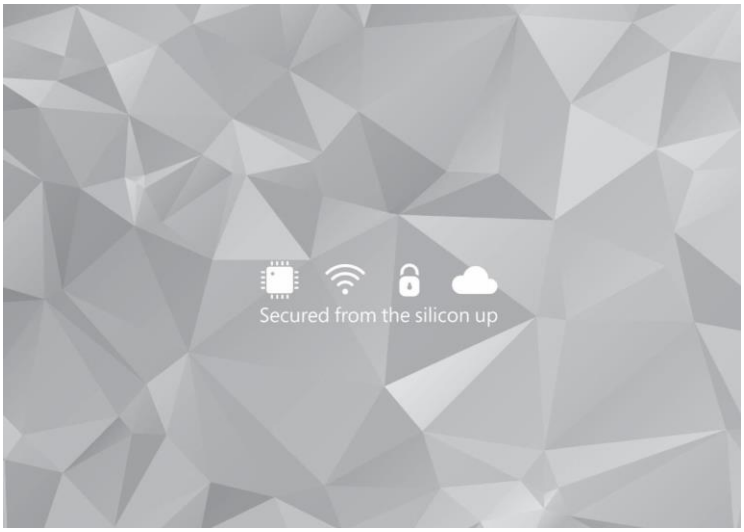

Azure Sphere Boot Camp

Lab MCUtoMT3620toAzure

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Version: 1.0

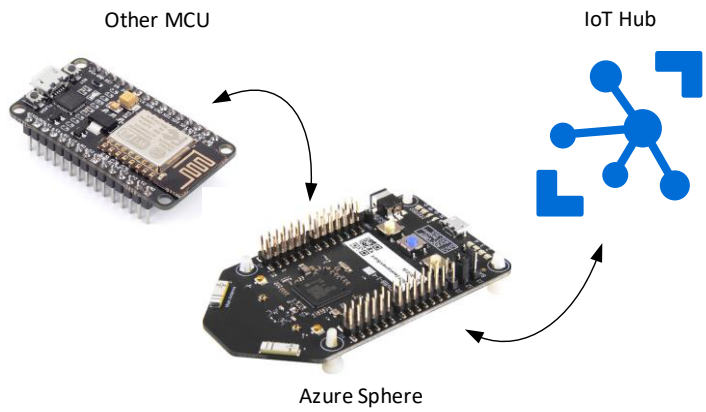
Date: 14 November 2018

CONTENTS

1 LAB OVERVIEW

This lab should be run after Lab 2 has been completed. I

In this lab, we will receive serial (UART) data from another device, convert it to JSON and Azure Sphere will securely send it to Azure IoT Hub. The diagram below illustrates the flow. NOTE, the MT3620 board is a 3.3v board so either use a 3.3v MCU or a Logic Level to convert the volts.



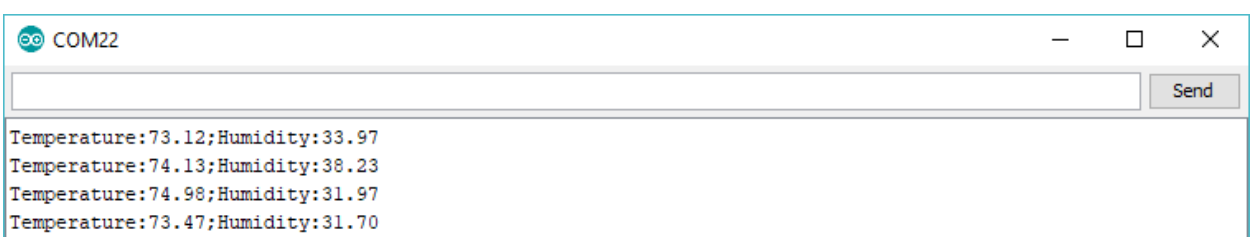
For this lab, an existing MCU is provided that already produces the serial data. For your own lab, the code is as follows:

```
float temp, humidity;
String message;

void setup() {
  Serial.begin(9600);
  pinMode(LED_BUILTIN, OUTPUT);
}

void loop() {
  // turn LED on and output randomized temperature and humidity once per second
  digitalWrite(LED_BUILTIN, LOW);
  temp = random(7100, 7500);
  humidity = random(3000, 4000);
  message = "Temperature:";
  message += temp / 100;
  message += ";Humidity:";
  message += humidity / 100;
  Serial.println(message);
  delay(100);
  // turn LED off
  digitalWrite(LED_BUILTIN, HIGH);
  delay(900);
}
```

The output from the other MCU is as follows:



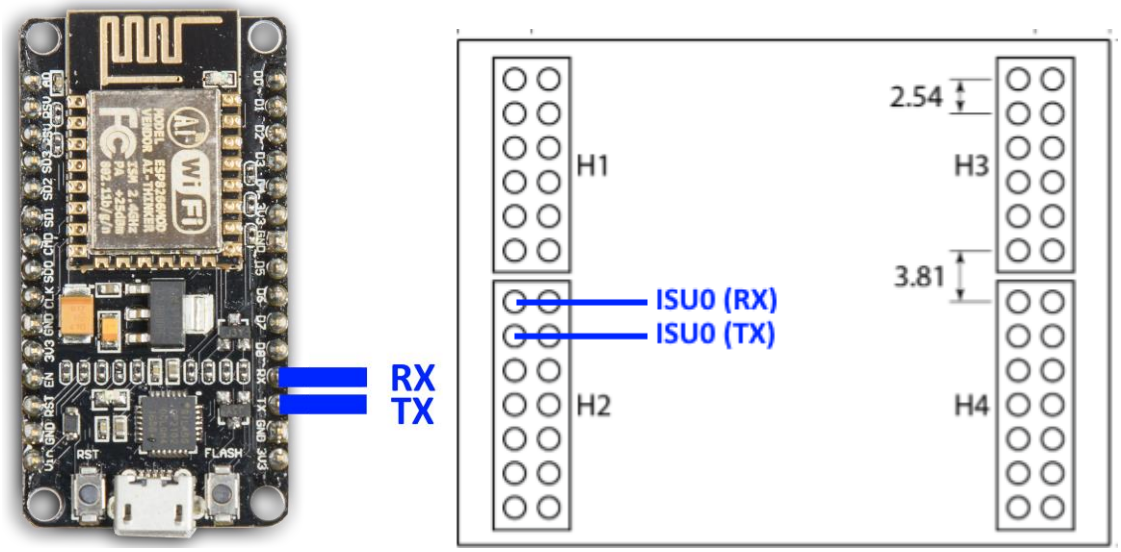
1.1 Wiring the Devices – for Node MCU

This step assumes you are using the smaller NodeMCUs. If using the Arduino R3, refer to section 1.2.

With the Sphere and the other MCU unplugged from power, wire the device as follows:

Purpose	MT3620	Other MCU
Transmit from MCU to Sphere	RX (Header 2, pin 1)	TX (pin varies)
Receive from Sphere to MCU	TX (Header 2, pin 4)	RX (pin varies)

Notice that the Transmit on one MCU is wired to the Receive on the other MCU. If both boards are not connected to the same PC, you would also need a ground wire between them.



For information on the pinout of the MT3620 board, see MT3620ReferenceBoardDesignTP4.0.1.pdf.

1.2 Wiring the Devices – for Arduino Uno R3

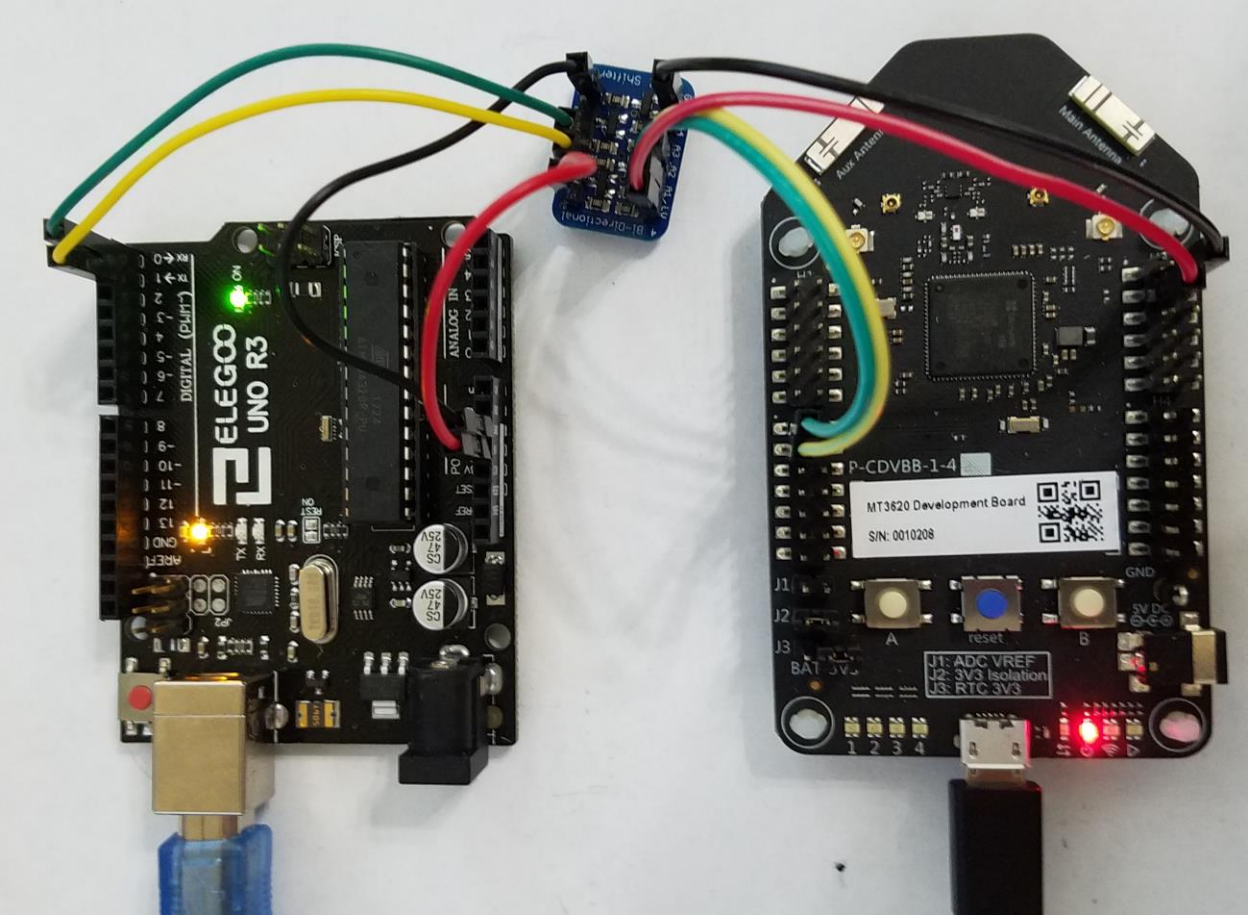
This section is for the Arduino Uno R3. If using the Node MCU, refer to section 1.1.

Because the Arduino Uno R3 is a 5.0 volt board and the Azure Sphere is a 3.3 volt, we will use a Logic Level Shifter to convert voltages.

Wire the UNO to the Level Shifter to the MT3620 as shown below. The following table explains the wiring:

UNO	Wire Color	Level Shifter		Wire Color	MT 3620
Pin 0 (RX)	Green	B1	A1	Yellow	H2 Pin 3
Pin 1 (TX)	Yellow	B2	A2	Green	H2 Pin 1
GND	Black	GND	GND	Black	H3 Pin 2
5-volt power	Red	HV	LV	Red	H3 Pin 3

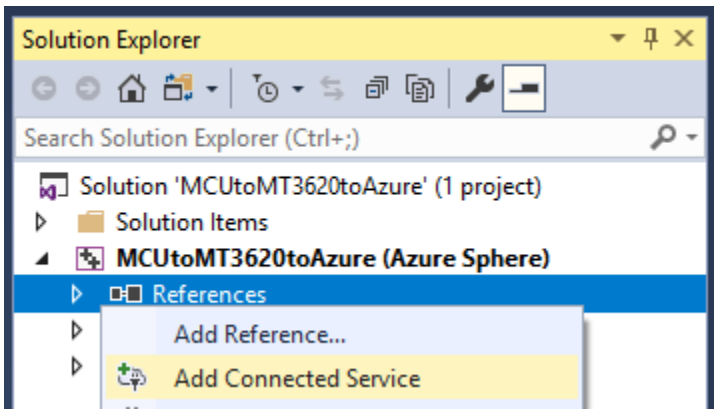
This picture shows the boards wired up:



1.3 Modifying the Code

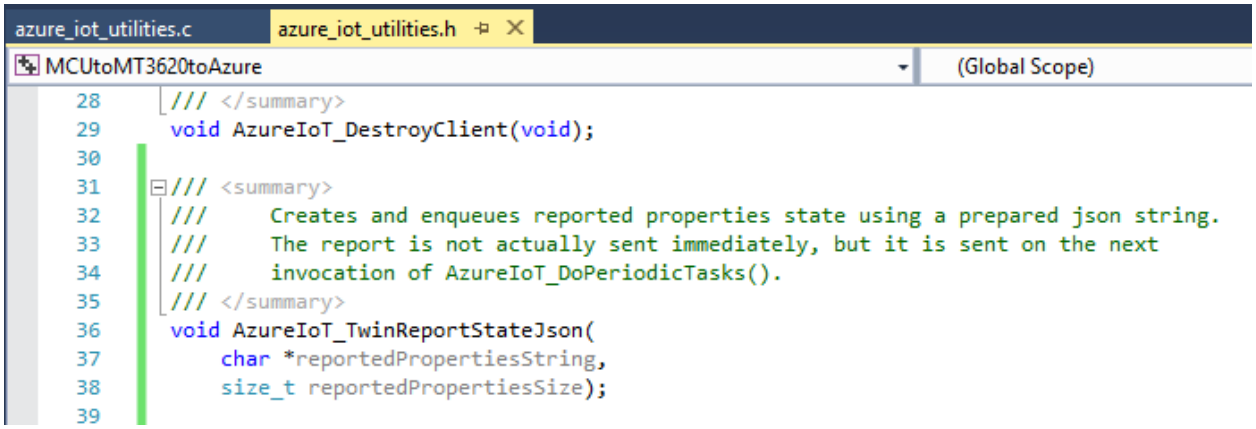
Step 1. In Visual Studio, open `MCUtoMT3620toAzure\MCUtoMT3620toAzure.sln` from the zip file provided by the instructor.

Step 2. In the Solution Explorer, under the `MCUtoMT3620toAzure` solution, right click on Reference and "Add Connected Service" as shown below:



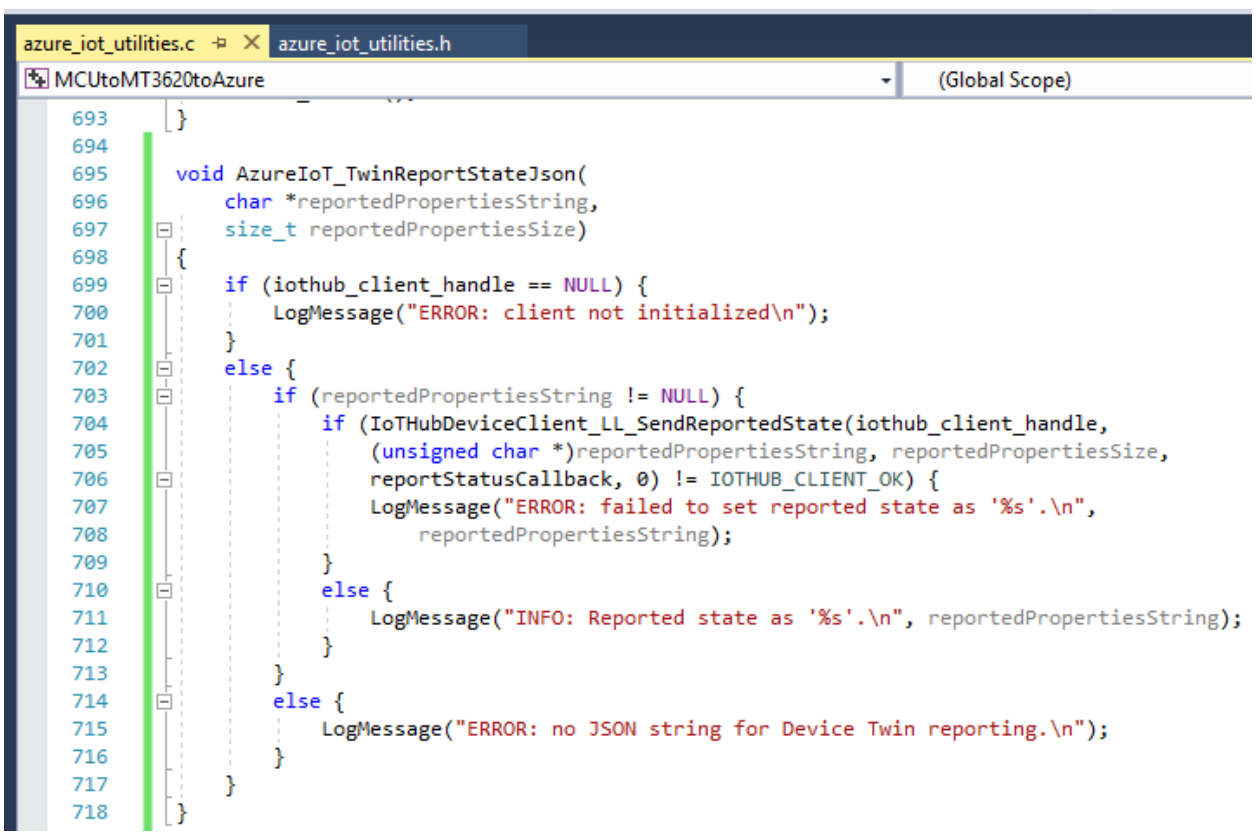
Step 3. Open `azure_iot_utilities.h` on or about line #31 and add the following code as shown below

```
/// <summary>
///     Creates and enqueues reported properties state using a prepared json string.
///     The report is not actually sent immediately, but it is sent on the next
///     invocation of AzureIoT_DoPeriodicTasks().
/// </summary>
void AzureIoT_TwinReportStateJson(
    char *reportedPropertiesString,
    size_t reportedPropertiesSize);
```



Step 4. Open `azure_iot_utilities.c` and at the end of the file, on or about line 695 add the following code, as shown below

```
void AzureIoT_TwinReportStateJson(
    char *reportedPropertiesString,
    size_t reportedPropertiesSize)
{
    if (iothub_client_handle == NULL) {
            LogMessage("ERROR: client not initialized\n");
    }
    else {
            if (reportedPropertiesString != NULL) {
                    if (IoTHubDeviceClient_LL_SendReportedState(iothub_client_handle,
                            (unsigned char *)reportedPropertiesString,
reportedPropertiesSize,
                            reportStatusCallback, 0) != IOTHUB_CLIENT_OK) {
                            LogMessage("ERROR: failed to set reported state as
'%s'.\n",
                                    reportedPropertiesString);
                    }
                    else {
                            LogMessage("INFO: Reported state as '%s'.\n",
reportedPropertiesString);
                    }
            }
            else {
                    LogMessage("ERROR: no JSON string for Device Twin reporting.\n");
            }
    }
}
```



Step 5. In Visual Studio, click “Remote GDB Debugger” to compile, deploy, run and debug the code on the device.

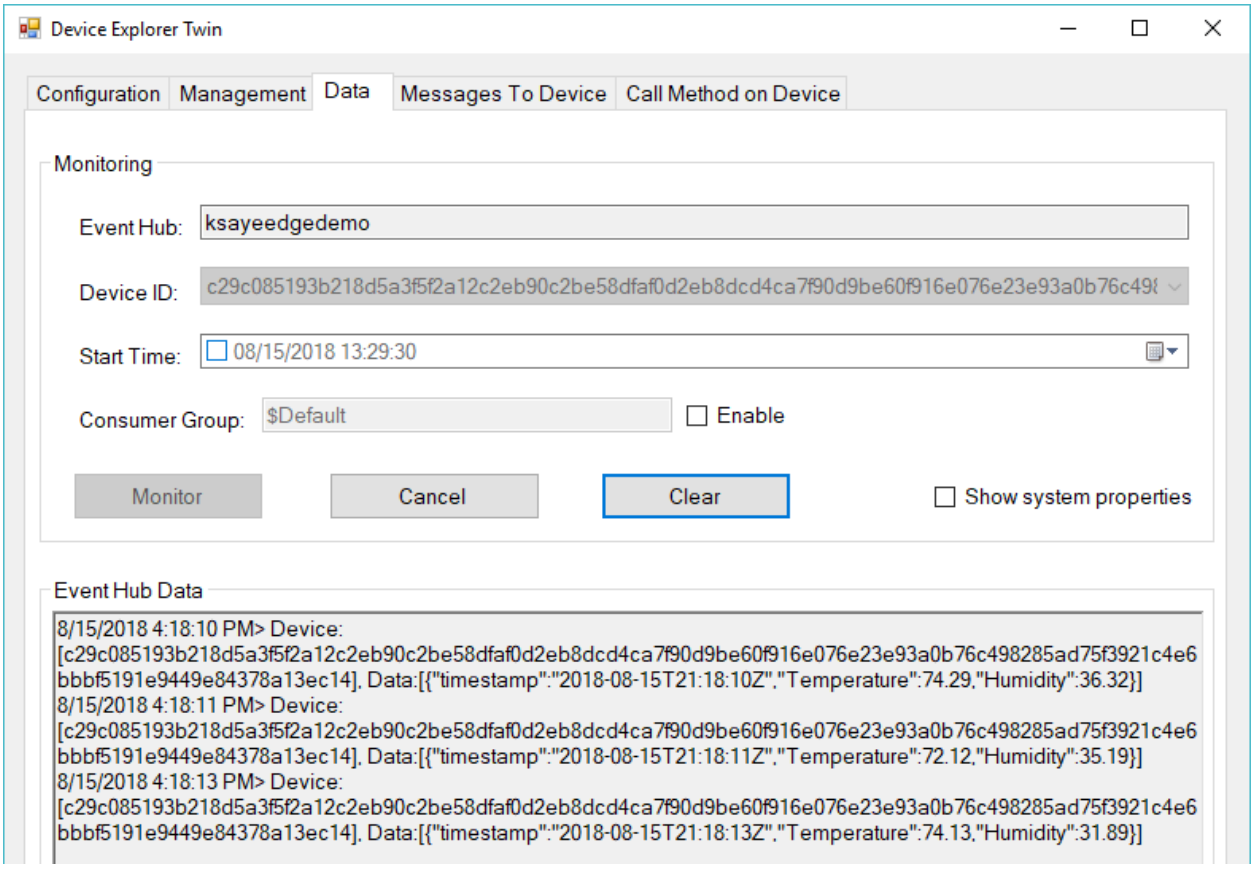
Step 6. Monitoring the output window in Visual Studio, you should see the device send the temperature every second as shown below. Note how we send telemetry for the Temperature and Humidity while updating a TWIN when the maximum and minimum temperature change.

```
Output
Show output from: Device Output
Remote debugging from host 192.168.35.1
MCUtoMt3620toAzure application starting
[Azure IoT] IoTHubDeviceClient_CreateWithAzureSphereDeviceAuthProvisioning returned 'AZURE_SPHERE_PROV_RESULT_OK'.
[Azure IoT Hub client] INFO: AzureIoT_DoPeriodicTasks calls in progress...
[UART] Received line: Temperature:71.58;Humidity:39.54
[MCU] Sending telemetry {"timestamp":"2018-08-15T21:14:29Z","Temperature":71.58,"Humidity":39.54}
[Azure IoT] INFO: IoTHubClient accepted the message for delivery
[MCU] Updating device twin: {"TemperatureMinimum":71.58,"TemperatureMaximum":71.58}
[Azure IoT] INFO: Reported state as '{"TemperatureMinimum":71.58,"TemperatureMaximum":71.58}'.
[Azure IoT] INFO: connection to the IoT Hub has been established (IOTHUB_CLIENT_CONNECTION_OK).
[UART] Received line: Temperature:72.67;Humidity:33.13
[MCU] Updating device twin: {"TemperatureMinimum":71.58,"TemperatureMaximum":72.67}
[Azure IoT] INFO: Reported state as '{"TemperatureMinimum":71.58,"TemperatureMaximum":72.67}'.
```

Step 7. Using Azure Device Explorer, viewing the TWIN properties you should see the min and max temperature received.

```
Device Twin
Refresh   c29c085193b218d5a3f5f2a12c2eb90c2be58dfaf0d2eb8dcd4ca7f90d9be60f916e076e23e93a0b76c4
Send ( use Json format )
Entire Twin | Tags | Reported Properties | Desired Properties
{
  "TemperatureMinimum": 71.3,
  "TemperatureMaximum": 74.95,
  "$metadata": {
    "$lastUpdated": "2018-08-15T21:16:42.6643189Z",
    "TemperatureMinimum": {
      "$lastUpdated": "2018-08-15T21:16:42.6643189Z"
    },
    "TemperatureMaximum": {
      "$lastUpdated": "2018-08-15T21:16:42.6643189Z"
    }
  },
  "$version": 5
}
{
  "properties": {
    "desired": {}
  }
}
```

Step 8. Using Azure Device Explorer, monitoring the data, you should see both temperature and humidity sent as a JSON message.



Step 9. Unique to this lab, we enabled the Uart `ISU0` in the `app_manifest.json` as shown below:

1.4 Reviewing the Code (main.c)

Lines 19 - 20 includes the UART and MCU utilities, not part of the Azure Sphere SDK.

```
16
17  #include "mt3620_rdb.h"
18  #include "azure_iot_utilities.h"
19  #include "UART_utilities.h"
20  #include "MCU_utilities.h"
```

Lines 125 - 134 verify the connectivity and permission to the UART and set a handler.

```
123     sigaction(SIGTERM, &action, NULL);
124
125     epollFd = CreateEpollFd();
126     if (epollFd < 0) {
127         return -1;
128     }
129
130     // Create a UART_Config object, open the UART and set up UART event handler
131     if ((uartFd = UART_InitializeAndAddToEpoll(MT3620_RDB_HEADER2_ISU0_UART, epollFd, &MCU_ParseDataToIotHub)) < 0)
132     {
133         return -1;
134     }
```

Lines 189 – 191 call the event handler.

```
188
189         if (WaitForEventAndCallHandler(epollFd) != 0) {
190             terminationRequired = true;
191         }
192
193         // AzureIoT_DoPeriodicTasks() needs to be called frequently in order to keep active
194         // the flow of data with the Azure IoT Hub
195         AzureIoT_DoPeriodicTasks();
```

1.5 Reviewing the Code (UART_utilities.c)

Lines 113 – 140 initialize and set the settings for the UART.

```
UART_utilities.c   MCU_utilities.c   main.c   app_manifest.json   azure_iot_utilities.c   azure_iot_utilities.h
MCUtoMT3620toAzure                                                (Global Scope)
112     ///<returns>UART file decriptor or -1 on error</returns>
113     int UART_InitializeAndAddToEpoll(UART_Id uartId, int epollFd, uart_line_received_handler_t handleLineReceived)
114     {
115         m_UartId = uartId;
116         m_HandleLineReceived = handleLineReceived;
117         // Create a UART_Config object, open the UART and set up UART event handler
118         UART_Config uartConfig;
119         UART_InitConfig(&uartConfig);
120         uartConfig.baudRate = 9600;
121         uartConfig.flowControl = UART_FlowControl_None;
122         m_UartFd = UART_Open(uartId, &uartConfig);
123         if (m_UartFd < 0) {
124             Log_Debug("ERROR: Could not open UART: %s (%d).\n", strerror(errno), errno);
125             return -1;
126         }
127
128         struct epoll_event eventToAdd;
129         eventToAdd.data.ptr = &handleUartEvent;
130         eventToAdd.events = EPOLLIN;
131
132         // Register the UART file descriptor on the epoll instance referred by epollFd
133         // and register the eventHandler handler for events in epollEventMask
134         if (epoll_ctl(epollFd, EPOLL_CTL_ADD, m_UartFd, &eventToAdd) == -1) {
135             Log_Debug("ERROR: Could not add event to epoll instance %s (%d)\n", strerror(errno), errno);
136             return -1;
137         }
138
139         return m_UartFd;
140     }
```

Lines 50 reads the data from the UART.

```
UART_utilities.c   MCU_utilities.c   main.c   app_manifest.json   azure_iot_utilities.c   azure_iot_utilities.h
MCUtoMT3620toAzure                                                (Global Scope)
43      /// </summary>
44      static void handleUartEvent()
45      {
46          char *pszLine = NULL;
47          char *pchSegment = &receiveBuffer[nBytesInBuffer];
48
49          // Poll the UART and store the byte(s) behind already received bytes
50          ssize_t nBytesRead = read(m_UartFd, (void *)pchSegment, RECEIVE_BUFFER_SIZE - nBytesInBuffer);
51
```

You may continue reviewing both `UART_utilities.h/UART_utilities.c` and `MCU_utilities.h/ MCU_utilities.c` as time allows.