

EEL 7170 : Introduction to IoT

Lab Report



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Lab 2: Interfacing OTA Updates

1 InLab

1.1 Objective

The experiment focuses on using Over-the-Air (OTA) updates to modify the NodeMCU's firmware without a wired connection, ensuring real-time updates as if the microcontroller were part of an integrated system.

1.2 Components Used

- NodeMCU (ESP8266)
- DHT11 Temperature and Humidity Sensor
- Jumper Wires (female to female)
- Power Bank/External Power Source
- Wi-Fi Hotspot
- Arduino IDE with OTA capability
- DHT11 Library (DFRobot DHT11)

1.3 Procedure

Part 1: Interfacing with DHT11 Sensor

- **Install DHT11 Library:**
 - Open the Arduino IDE and search for the DFRobot DHT11 library in the Library Manager.
 - Install the library for interfacing with the DHT11 sensor.
- **Connections:** Use female-to-female jumper wires to connect the DHT11 sensor to the NodeMCU:
 - DATA pin to D7 on the NodeMCU.
 - VCC pin to 3V.
 - GND pin to G (ground).
- **Upload the Code:**
 - Open the provided `DHT11_interfacing.ino` file.
 - Upload the code to the NodeMCU to start receiving temperature and humidity data from the sensor.
- **Verify Output:** Check the output on the serial monitor for real-time readings of temperature and humidity.

Part 2: Interfacing with LIDAR (VL53L0X) Sensor

- **Install LIDAR Library:**

- Open the Arduino IDE and search for the Adafruit_VL53L0X library in the Library Manager.
- Install the library for interfacing with the LIDAR sensor.

- **Connections:** Use female-to-female jumper wires to connect the LIDAR sensor to the NodeMCU:

- SCL pin to D1 on the NodeMCU.
- SDA pin to D2.
- VIN pin to 3V.
- GND pin to G (ground).

- **Upload the Code:**

- Open the provided `v153l0x.ino` file.
- Upload the code to the NodeMCU to start receiving data on the object's distance from the sensor.

- **Verify Output:** Check the output on the serial monitor for real-time readings of distance.

Part 3: Over-The-Air (OTA) Update

- **Setting Up OTA:**

- To enable OTA (Over-The-Air) updates, use the BasicOTA example provided in the Arduino IDE (File > Examples > ArduinoOTA > BasicOTA).

- **Wi-Fi Configuration:**

- Modify the OTA code to include your system's Wi-Fi credentials, enabling wireless firmware updates.

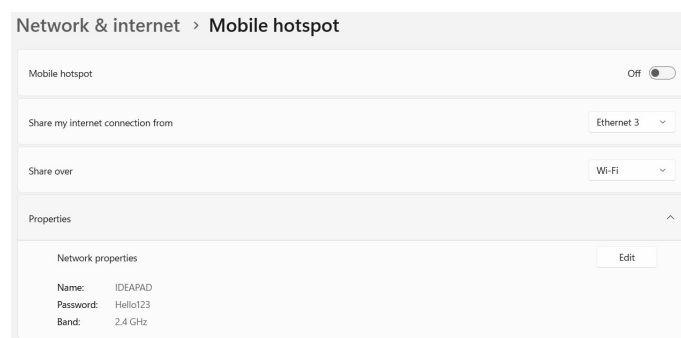


Figure 1: Mobile Hotspot Credentials

```
10 // Wifi credentials
11 #ifndef STASSID
12 #define STASSID "IDEAPAD"
13 #define STAPSK "Hello123"
14 #endif
15 const char* ssid = STASSID;
16 const char* password = STAPSK;
17
```

Figure 2: Change the Wifi Credentials in the code

- Upload the OTA code to the NodeMCU initially through a wired connection.

- **Upload the Updated Code via OTA:**

- Disconnect the NodeMCU from the system and connect it to an external power source.
- Ensure the Wi-Fi hotspot is on, and the NodeMCU will appear as a device in the Arduino IDE's device list for wireless uploads.

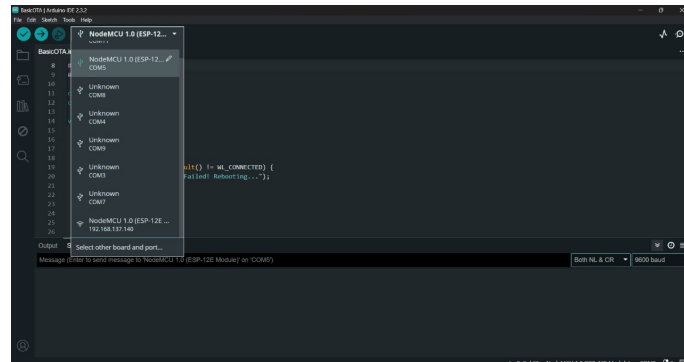


Figure 3: You will see a new device option.

- Notice: The IP Address of NodeMCU is 192.168.137.140
- Modify the code to handle additional requirements.

- **Modify Code via OTA:**

- Modify the code by adding a blinking LED function in the `setup()` and `loop()`.
- Re-upload the updated code wirelessly by entering the default password (123).
- Verify if the onboard LED of the NodeMCU starts blinking.

1.4 Code

1.4.1 Part 1: Interfacing with DHT11 Sensor

```
1  #include "DHT.h"
2
3  #define DHTPIN D7      // what pin we're connected to
4  #define DHTTYPE DHT11  // DHT 11
5  DHT dht(DHTPIN, DHTTYPE);
6
7  void setup() {
8      Serial.begin(9600);
9      dht.begin();
10 }
11
12 void loop() {
13     // Reading temperature or humidity takes about 250 milliseconds!
14     float humidity = dht.readHumidity();
15     // Read temperature as Celsius (the default)
16     float temperature = dht.readTemperature();
17     // Check if any reads failed and exit early (to try again).
18     if (isnan(humidity) || isnan(temperature)) {
19         Serial.println("Failed to read from DHT sensor!");
20         return;
21     }
```

```

21 }
22 Serial.print("Humidity: ");
23 Serial.print(humidity);
24 Serial.print(" %\t");
25 Serial.print("Temperature: ");
26 Serial.print(temperature);
27 Serial.println(" °C");
28 delay(2000); // Delay between readings.
29 }

```

[language=C++]

Part 2: Interfacing with LIDAR (VL53L0X) Sensor

```

1  #include "Adafruit_VL53L0X.h"
2
3  Adafruit_VL53L0X lox = Adafruit_VL53L0X();
4
5  // 3V --> VIN
6  // D1 --> SCL
7  // D2 --> SDA
8  // G  --> GND
9
10 void setup() {
11     Serial.begin(115200);
12
13     // wait until serial port opens for native USB devices
14     while (! Serial) {
15         delay(1);
16     }
17
18     Serial.println("Adafruit_VL53L0X_test");
19     if (!lox.begin()) {
20         Serial.println(F("Failed to boot VL53L0X"));
21         while(1);
22     }
23     // power
24     Serial.println(F("VL53L0X API Simple Ranging example\n\n"));
25 }
26
27
28 void loop() {
29     VL53L0X_RangingMeasurementData_t measure;
30
31     Serial.print("Reading a measurement... ");
32     lox.rangingTest(&measure, false); // pass in 'true' to get debug data
33     ↪ printout!
34
35     if (measure.RangeStatus != 4) { // phase failures have incorrect data
36         Serial.print("Distance (mm): "); Serial.println(measure.
37             ↪ RangeMilliMeter);
38     } else {
39         Serial.println(" out of range ");
40     }
41 }

```

```

40     delay(100);
41 }

```

[language=C++]

Part 3: Over-The-Air (OTA) Update

```

1  #include <ESP8266WiFi.h>
2  #include <ESP8266mDNS.h>
3  #include <WiFiUdp.h>
4  #include <ArduinoOTA.h>
5
6  #ifndef STASSID
7  #define STASSID "your-ssid"
8  #define STAPSK "your-password"
9  #endif
10
11 const char* ssid = STASSID;
12 const char* password = STAPSK;
13
14 void setup() {
15     Serial.begin(115200);
16     Serial.println("Booting");
17     WiFi.mode(WIFI_STA);
18     WiFi.begin(ssid, password);
19     while (WiFi.waitForConnectResult() != WL_CONNECTED) {
20         Serial.println("Connection Failed! Rebooting...");
21         delay(5000);
22         ESP.restart();
23     }
24
25     // Port defaults to 8266
26     // ArduinoOTA.setPort(8266);
27
28     // Hostname defaults to esp8266-[ChipID]
29     // ArduinoOTA.setHostname("myesp8266");
30
31     // No authentication by default
32     // ArduinoOTA.setPassword("admin");
33
34     // Password can be set with it's md5 value as well
35     //MD5(admin)=21232f297a57a5a743894a0e4a801fc3
36     //ArduinoOTA.setPasswordHash("21232f297a57a5a743894a0e4a801fc3");
37
38     ArduinoOTA.onStart([]() {
39         String type;
40         if (ArduinoOTA.getCommand() == U_FLASH) {
41             type = "sketch";
42         } else { // U_FS
43             type = "filesystem";
44         }
45
46         // NOTE: if updating FS this would be the place to unmount FS using FS
47         ↪ .end()
48         Serial.println("Start updating_" + type);

```

```

48  }
49  ArduinoOTA.onEnd([]){
50      Serial.println("\nEnd");
51  };
52  ArduinoOTA.onProgress([](unsigned int progress, unsigned int total){
53      Serial.printf("Progress: %u%%\r", (progress/_(total/_100)));
54  });
55  ArduinoOTA.onError([](ota_error_t error){
56      Serial.printf("Error [%u]: ", error);
57      if_(error==_OTA_AUTH_ERROR){
58          Serial.println("Auth_Failed");
59      }else_if_(error==_OTA_BEGIN_ERROR){
60          Serial.println("Begin_Failed");
61      }else_if_(error==_OTA_CONNECT_ERROR){
62          Serial.println("Connect_Failed");
63      }else_if_(error==_OTA_RECEIVE_ERROR){
64          Serial.println("Receive_Failed");
65      }else_if_(error==_OTA_END_ERROR){
66          Serial.println("End_Failed");
67      }
68  });
69  ArduinoOTA.begin();
70  Serial.println("Ready");
71  Serial.print("IP address: ");
72  Serial.println(WiFi.localIP());
73  }
74
75  void loop(){
76      ArduinoOTA.handle();
77  }

```

[language=C++]

1.5 Observations

- The DHT11 sensor successfully reads temperature and humidity values after proper connection and configuration.

```

humidity: 88.00 %    Temperature: 32.10 *C
humidity: 86.00 %    Temperature: 32.10 *C
humidity: 87.00 %    Temperature: 32.10 *C
humidity: 89.00 %    Temperature: 32.10 *C
humidity: 90.00 %    Temperature: 32.10 *C
humidity: 90.00 %    Temperature: 32.20 *C
humidity: 88.00 %    Temperature: 32.20 *C
humidity: 86.00 %    Temperature: 32.30 *C
humidity: 87.00 %    Temperature: 32.30 *C
humidity: 89.00 %    Temperature: 32.40 *C
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
humidity: 89.00 %    Temperature: 32.50 *C
humidity: 85.00 %    Temperature: 32.50 *C
humidity: 83.00 %    Temperature: 32.60 *C
humidity: 82.00 %    Temperature: 32.60 *C
humidity: 82.00 %    Temperature: 32.60 *C
humidity: 81.00 %    Temperature: 32.60 *C
humidity: 80.00 %    Temperature: 32.60 *C
humidity: 80.00 %    Temperature: 32.60 *C
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humidity: 80.00 %    Temperature: 32.60 *C
humidity: 80.00 %    Temperature: 32.60 *C
humidity: 80.00 %    Temperature: 32.60 *C
humidity: 79.00 %    Temperature: 32.60 *C
humidity: 79.00 %    Temperature: 32.60 *C

```

- The LIDAR sensor successfully reads the distance.

```

Reading a measurement... Distance (mm): 299
Reading a measurement... Distance (mm): 297
Reading a measurement... Distance (mm): 305
Reading a measurement... Distance (mm): 302
Reading a measurement... Distance (mm): 300
Reading a measurement... Distance (mm): 293
Reading a measurement... Distance (mm): 297
Reading a measurement... Distance (mm): 298
Reading a measurement... Distance (mm): 304
Reading a measurement... Distance (mm): 301
Reading a measurement... Distance (mm): 301
Reading a measurement... Distance (mm): 302
Reading a measurement... Distance (mm): 305
Reading a measurement... Distance (mm): 303
Reading a measurement... Distance (mm): 301
Reading a measurement... Distance (mm): 305
Reading a measurement... Distance (mm): 304
Reading a measurement... Distance (mm): 303
Reading a measurement... Distance (mm): 304
Reading a measurement

```

- OTA updates provide flexibility for remote firmware modifications without physical access to the NodeMCU.
- When using OTA, the NodeMCU may take time to appear in the device list, requiring patience or network changes.

1.6 Results

- **Part 1:** The interfacing of the DHT11 sensor with NodeMCU was successful, providing accurate temperature and humidity readings.
- **Part 2:** OTA updates were enabled, and the NodeMCU was successfully updated wirelessly, with the onboard LED indicating successful code modification.

2 Assignment

2.1 Objective

The objective of this assignment is to:

1. Interface a DHT11 temperature and humidity sensor with NodeMCU and fetch real-time data.
2. Use Over-The-Air (OTA) updates to wirelessly upload new firmware to NodeMCU.
3. Upload sensor data to the ThingSpeak platform for real-time visualization.
4. Generate and upload a random number calculated based on admission year and roll number.

2.2 Components Used

- NodeMCU (ESP8266)
- DHT11 Temperature and Humidity Sensor
- Jumper Wires (Female-to-Female)
- USB Cable and External Power Source
- LiDAR Sensor (VL53L0X)
- Wi-Fi Hotspot
- Arduino IDE
- ThingSpeak API

2.3 Procedure

Interfacing with DHT11 Sensor

Over-The-Air (OTA) Update

Uploading Data to ThingSpeak

- Create a ThingSpeak channel and add three fields: Temperature, Humidity, and Random Number.
- Fetch the Write API Key from ThingSpeak and add it to the Arduino code.

```
18 // ThingSpeak API details
19 String serverName_send = "http://api.thingspeak.com/update?api_key=0JIOH52E5SUPMIM1";
20
```

Figure 4: Thingspeak API Key

- Calculate the random number as the product of your admission year and roll number, ie. $6 \times 21 = 126$.
- Upload the DHT11 data and random number to ThingSpeak for visualization.

```
109 // Generate a random number
110 int randomNumber = 126;
111
112 // Create ThingSpeak URL with DHT sensor data and random number
113 WiFiClient client;
114 HTTPClient http;
115
116 String serverPath_send = serverName_send + "&field1=" + String(temperature)
117                                     + "&field2=" + String(humidity)
118                                     + "&field3=" + String(random(randomNumber));
119
120 // Send the HTTP GET request to ThingSpeak
121 http.begin(client, serverPath_send.c_str());
```

2.4 Code

```
1  #include <ESP8266WiFi.h>
2  #include <ESP8266HTTPClient.h>
3  #include <WiFiClient.h>
4  #include <Arduino_JSON.h>
5  #include "DHT.h"
6  #include <ESP8266mDNS.h>
7  #include <WiFiUdp.h>
8  #include <ArduinoOTA.h>
9
10 // WiFi credentials
11 #ifndef STASSID
12 #define STASSID "IDEAPAD"
13 #define STAPSK "Hello123"
14 #endif
15 const char* ssid = STASSID;
16 const char* password = STAPSK;
17
18 // ThinkSpeak API details
19 String serverName_send = "http://api.thingspeak.com/update?api_key=
    ↪ OJIOH52E5SUPMIM1";
20
21 // DHT sensor details
22 #define DHTPIN D7
23 #define DHTTYPE DHT11 // DHT 11
24 DHT dht(DHTPIN, DHTTYPE);
25
26 // Timer delay (20 seconds)
27 unsigned long lastTime = 0;
28 unsigned long timerDelay = 20000;
29
30 void setup() {
31     Serial.begin(115200);
32
33     // Initialize DHT sensor
34     dht.begin();
35
36     // Connect to WiFi
37     WiFi.mode(WIFI_STA);
38     WiFi.begin(ssid, password);
39     Serial.println("Connecting");
40     while (WiFi.waitForConnectResult() != WL_CONNECTED) {
41         Serial.println("Connection Failed! Rebooting...");
42         delay(5000);
43         ESP.restart();
44     }
45
46     Serial.print("Connected to WiFi network with IP Address: ");
47     Serial.println(WiFi.localIP());
48
49     // Setup OTA updates
50     ArduinoOTA.onStart([]() {
51         String type = (ArduinoOTA.getCommand() == U_FLASH) ? "sketch" : "
    ↪ filesystem";
```

```

52     Serial.println("Start updating" + type);
53 });
54
55 ArduinoOTA.onEnd([]() {
56     Serial.println("\nEnd");
57 });
58
59 ArduinoOTA.onProgress([](unsigned int progress, unsigned int total) {
60     Serial.printf("Progress: %u%%\r", (progress / (total / 100)));
61 });
62
63 ArduinoOTA.onError([](ota_error_t error) {
64     Serial.printf("Error[%u]:", error);
65     if (error == OTA_AUTH_ERROR) {
66         Serial.println("Auth Failed");
67     } else if (error == OTA_BEGIN_ERROR) {
68         Serial.println("Begin Failed");
69     } else if (error == OTA_CONNECT_ERROR) {
70         Serial.println("Connect Failed");
71     } else if (error == OTA_RECEIVE_ERROR) {
72         Serial.println("Receive Failed");
73     } else if (error == OTA_END_ERROR) {
74         Serial.println("End Failed");
75     }
76 });
77
78 ArduinoOTA.begin();
79 Serial.println("OTA Ready");
80 }
81
82 void loop() {
83     // Handle OTA updates
84     ArduinoOTA.handle();
85
86     // Check if 20 seconds have passed
87     if ((millis() - lastTime) > timerDelay) {
88         // Check WiFi connection status
89         if (WiFi.status() == WL_CONNECTED) {
90
91             // Read data from the DHT sensor
92             float humidity = dht.readHumidity();
93             float temperature = dht.readTemperature(); // Celsius
94
95             // Check if any reads failed
96             if (isnan(humidity) || isnan(temperature)) {
97                 Serial.println("Failed to read from DHT sensor!");
98                 return;
99             }
100
101             // Debug print DHT sensor values
102             Serial.print("Humidity:");
103             Serial.print(humidity);
104             Serial.print("\t");
105             Serial.print("Temperature:");

```

```

106     Serial.print(temperature);
107     Serial.println("°C");
108
109     // Generate a random number
110     int randomNumber = 126;
111
112     // Create ThinkSpeak URL with DHT sensor data and random number
113     WiFiClient client;
114     HTTPClient http;
115
116     String serverPath_send = serverName_send + "&field1=" + String(
117         ↪ temperature)
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        + "&field2=" + String(
        ↪ humidity)
        + "&field3=" + String(
        ↪ random(randomNumber))
        ↪ ;

    // Send the HTTP GET request to ThinkSpeak
    http.begin(client, serverPath_send.c_str());
    int httpResponseCode = http.GET();

    // Handle HTTP response
    if (httpResponseCode > 0) {
        Serial.print("HTTP_Response_code:");
        Serial.println(httpResponseCode);
        String payload = http.getString();
        Serial.println(payload);
    } else {
        Serial.print("Error_code:");
        Serial.println(httpResponseCode);
    }

    // Free resources
    http.end();
} else {
    Serial.println("WiFi_Disconnected");
}

// Update lastTime to current time
lastTime = millis();
}

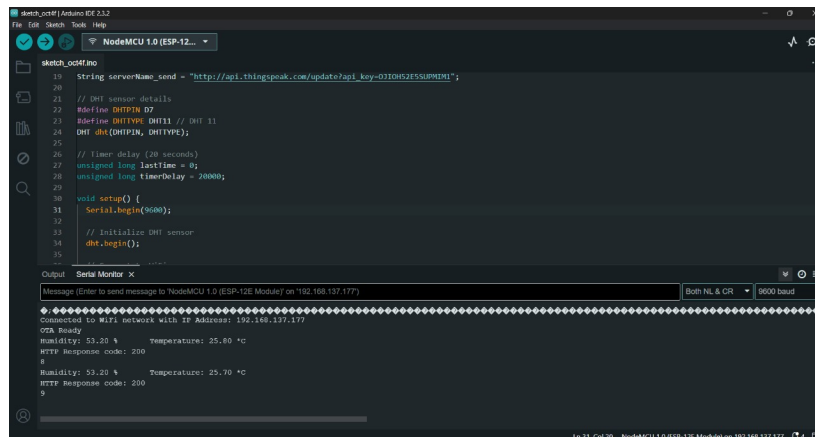
// You can also add other functionality like blinking an LED
digitalWrite(LED_BUILTIN, HIGH); // Turn the LED on
delay(100);                       // Wait for a short period
digitalWrite(LED_BUILTIN, LOW);  // Turn the LED off
delay(100);
}

```

[language=C++]

2.5 Observations

- The DHT11 sensor successfully provided temperature and humidity readings after proper connection and configuration.



```

19 String serverName_send = "http://api.thingspeak.com/update?api_key=OTIOH2ESSUPHMI1";
20
21 // DHT sensor details
22 #define DHTPIN D7
23 #define DHTTYPE DHT11 // DHT 11
24 DHT dht(DHTPIN, DHTTYPE);
25
26 // timer delay (20 seconds)
27 unsigned long lastTime = 0;
28 unsigned long timerDelay = 20000;
29
30 void setup() {
31   Serial.begin(9600);
32   // Initialize DHT sensor
33   dht.begin();
34 }
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