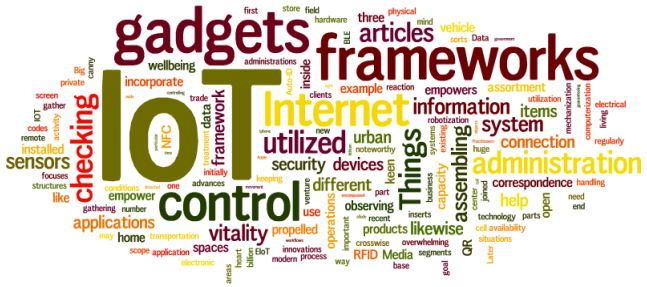
CS578: Internet of Things

Smart Home Monitoring Using ESP8266 and Webserver



Dr. Manas Khatua

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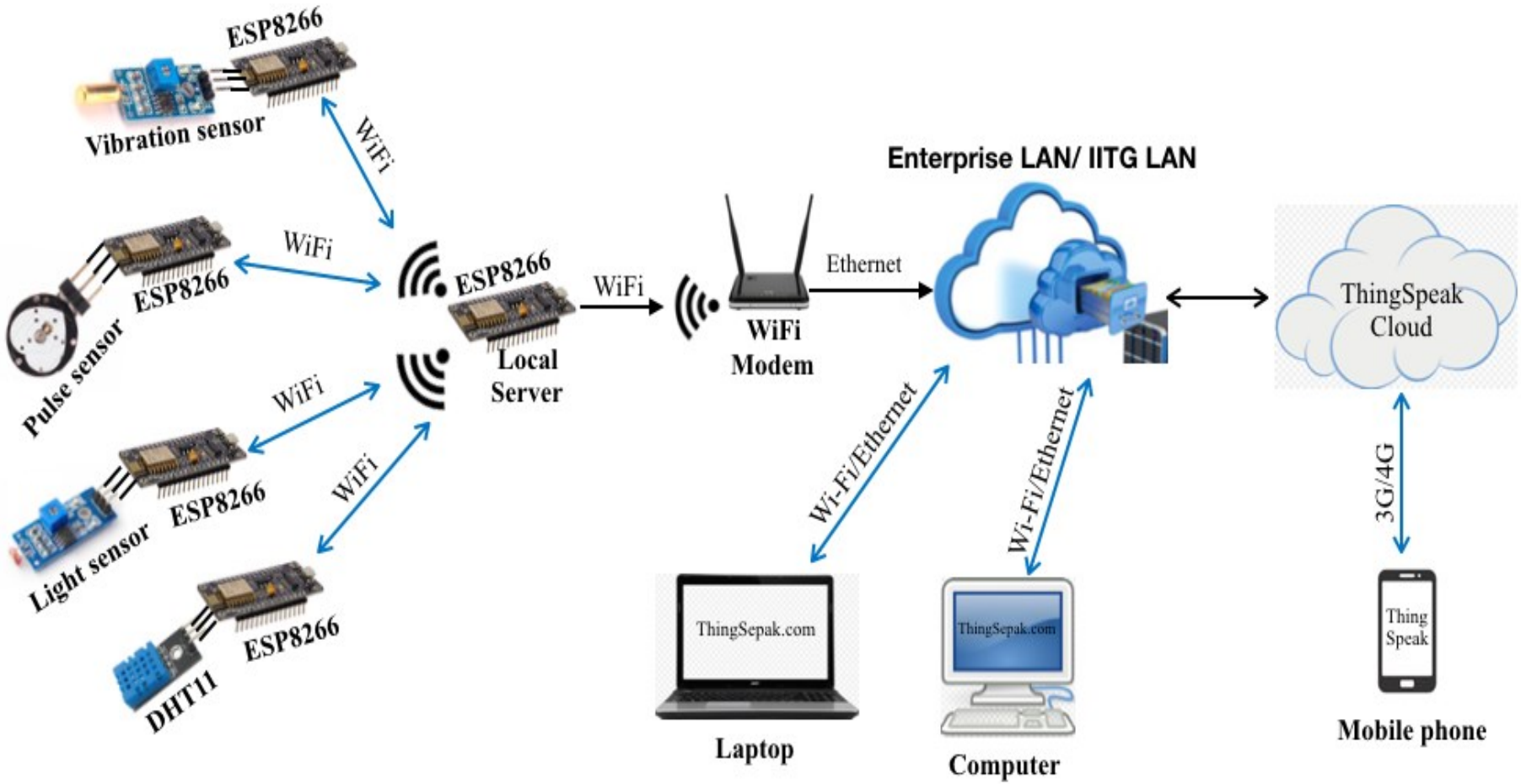
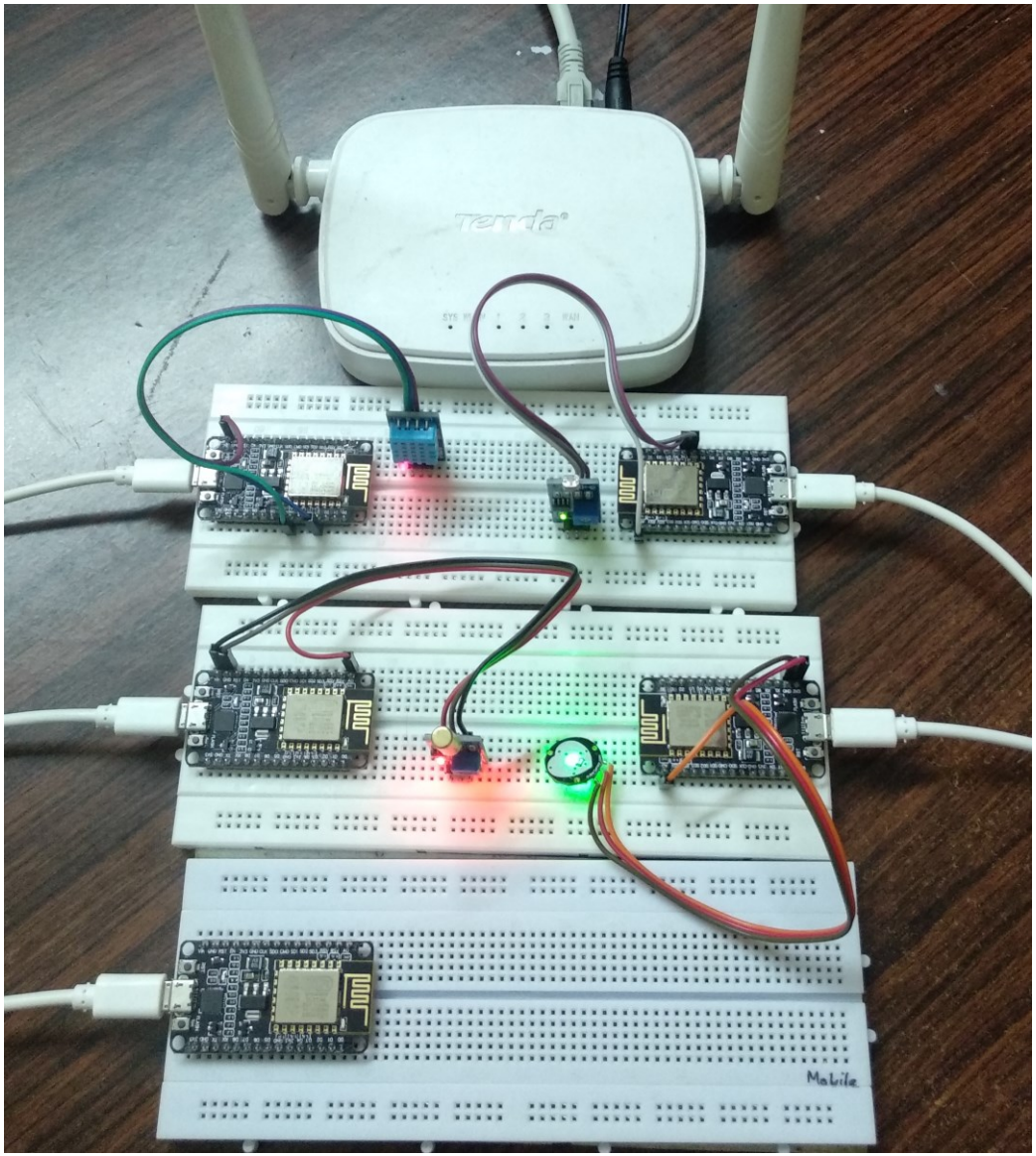
"Try not to become a man of success. Rather become a man of value." – **Albert Einstein**

System Diagram

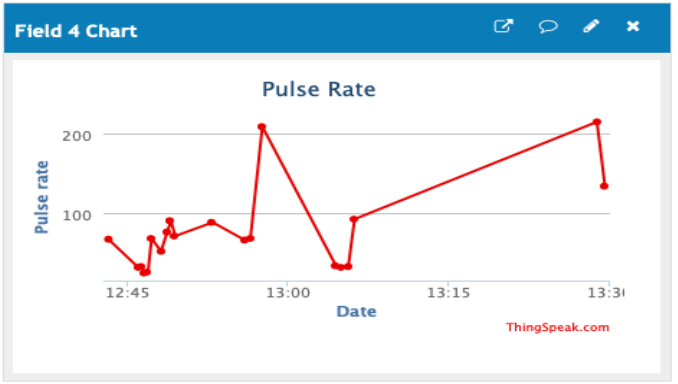


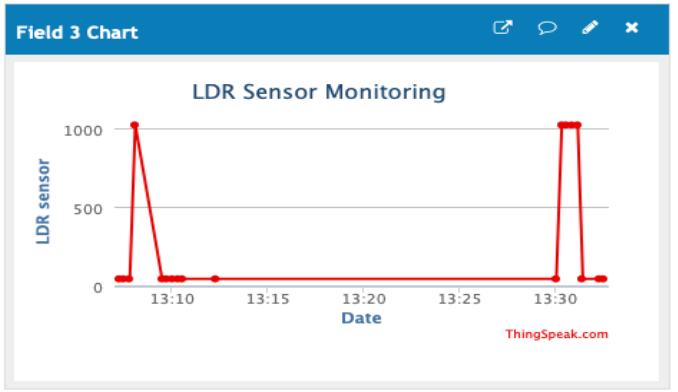
Physical Setup



ThingSpeak cloud server

accessing from a Laptop/PC/Smartphone





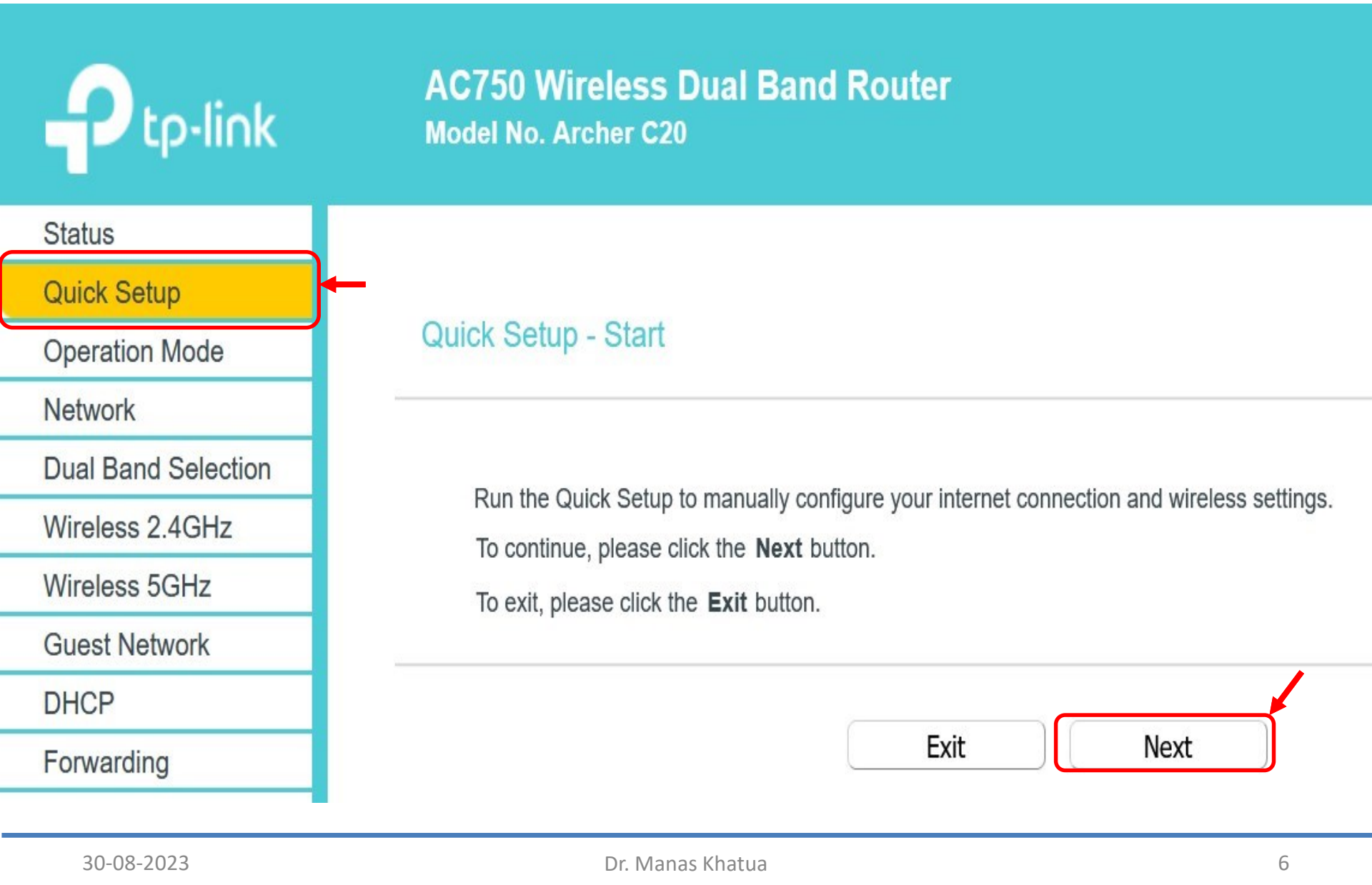
Router Configuration
To Connect with IITG Internet

Router Configuration

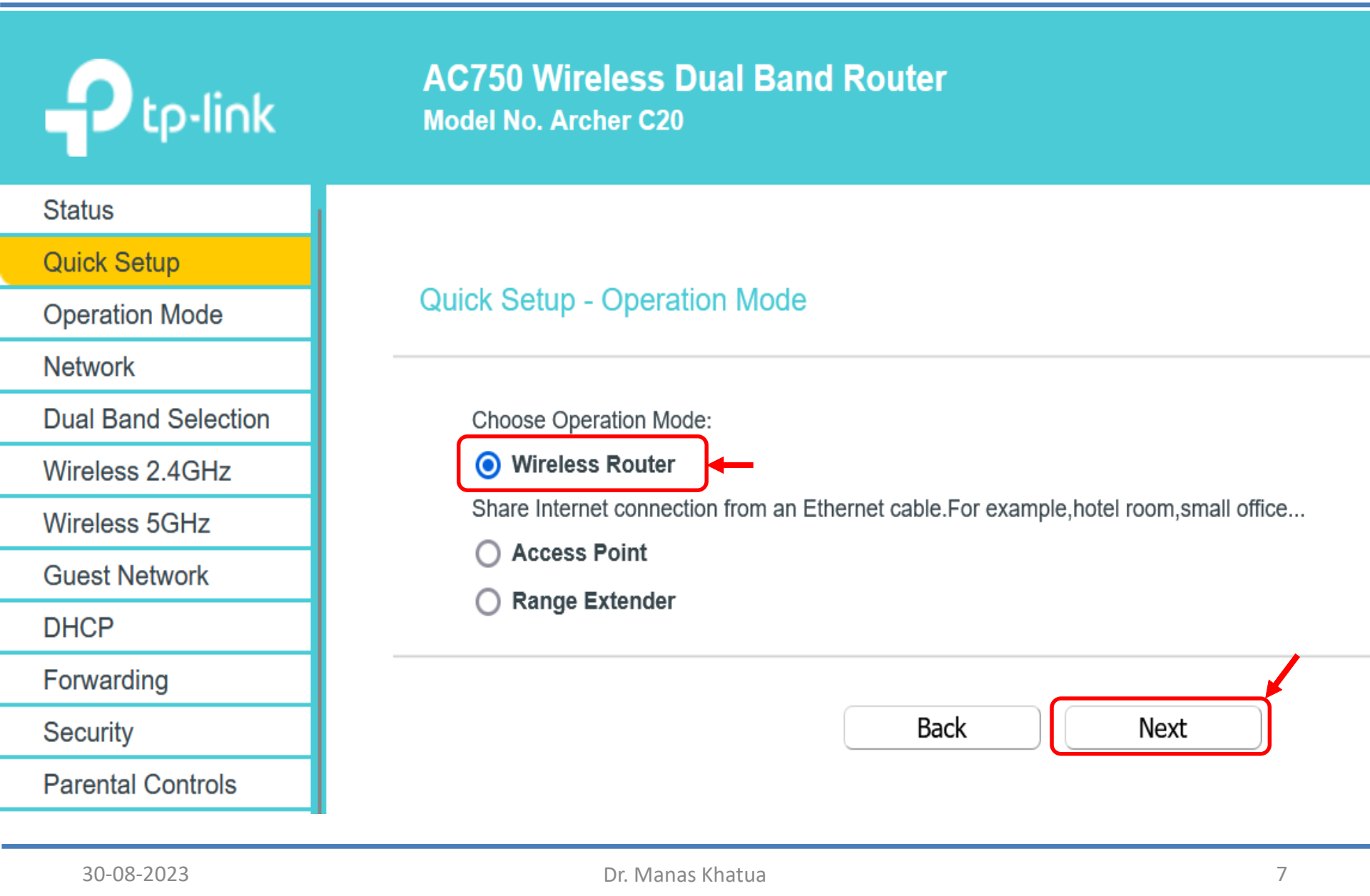
- This is TP-Link WiFi Router
- ESP8266 (local server) will connect to this WiFi AP
- Sensor data will be uploaded to ThingSpeak server through this WiFi AP.

- Login TP-Link WiFi using given IP (**192.168.0.1**) and password written on its label.
- Do the following:
  - Go to Quick Setup and click on Next.
  - Choose Operation Mode as Wireless Router and click on Next.
  - Select WAN Connection Type as Static IP and click on Next.
  - Set the **Static IP**, **Subnet Mask**, **Default Gateway**, **Primary DNS Server**, **Secondary DNS Server** and click on Next.
  - Select the radio bands (2.4 GHz and/or 5 GHz) and click on Next.
  - Setup the Wireless radio bands selected above and click on Next.
  - Confirm the setup by clicking on Save. The router reboots and reconnects.

Cont…


tp-link
AC750 Wireless Dual Band Router
Model No. Archer C20
Status
Quick Setup
Operation Mode
Network
Dual Band Selection
Wireless 2.4GHz
Wireless 5GHz
Guest Network
DHCP
Forwarding
Quick Setup - Start
Run the Quick Setup to manually configure your internet connection and wireless settings.
To continue, please click the Next button.
To exit, please click the Exit button.
Exit
Next

Cont…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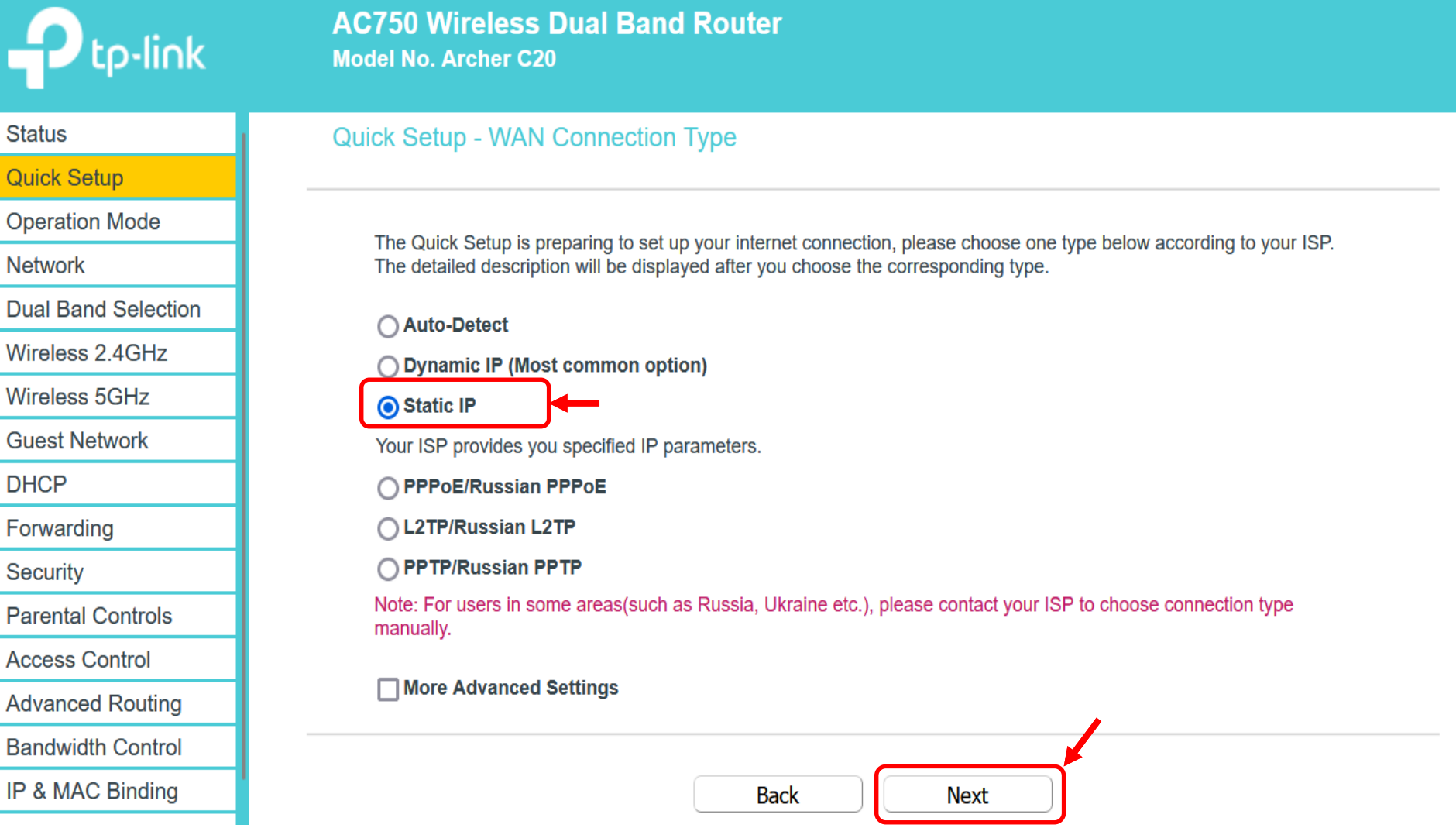
AC750 Wireless Dual Band Router
Model No. Archer C20
Status
Quick Setup
Operation Mode
Network
Dual Band Selection
Wireless 2.4GHz
Wireless 5GHz
Guest Network
DHCP
Forwarding
Security
Parental Controls
Quick Setup - Operation Mode
Choose Operation Mode:
Wireless Router
Share Internet connection from an Ethernet cable.For example,hotel room,small office...
Access Point
Range Extender
Back
Next

Cont…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Model No. Archer C20
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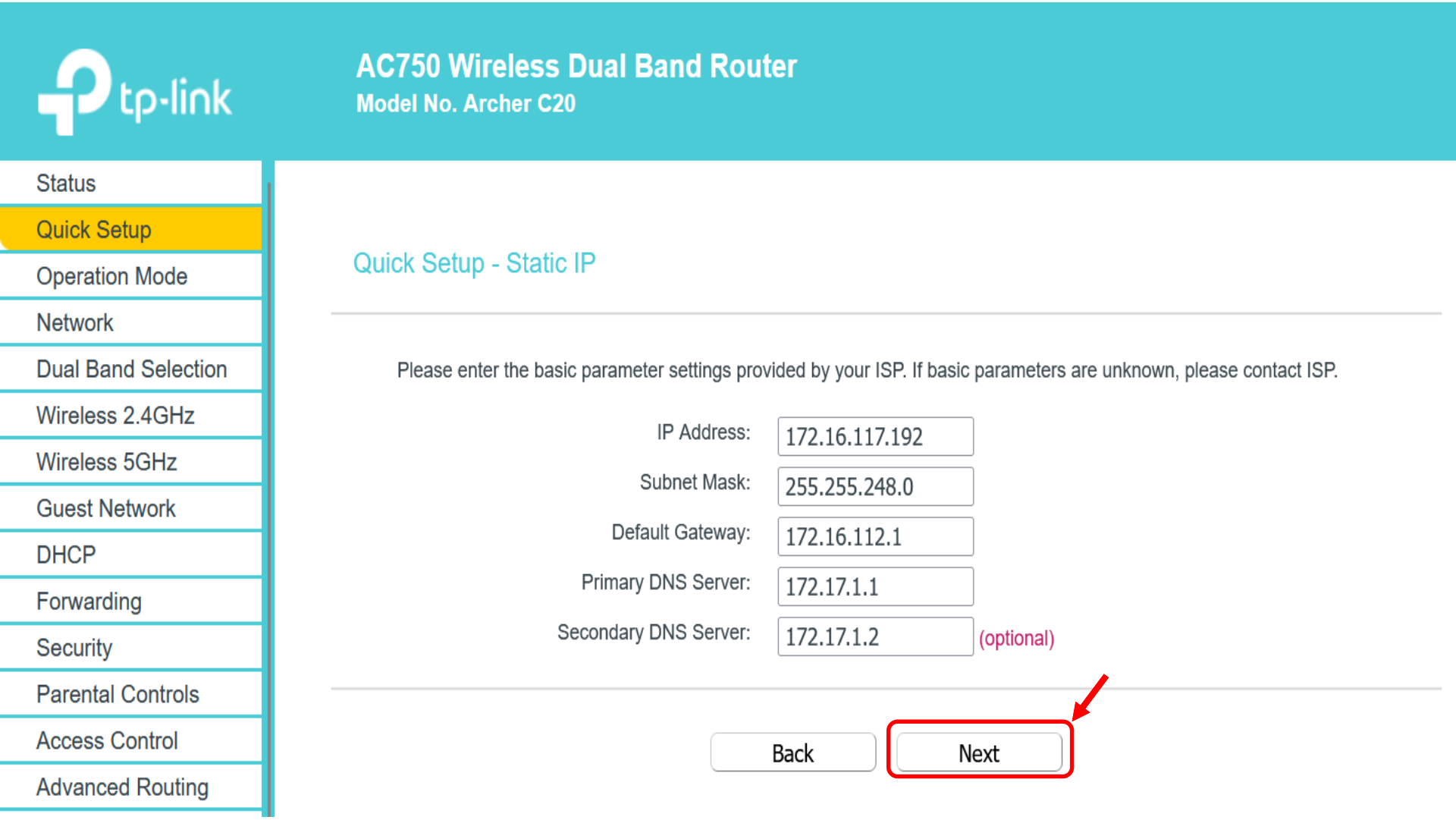
Quick Setup
Operation Mode
Network
Dual Band Selection
Wireless 2.4GHz
Wireless 5GHz
Guest Network
DHCP
Forwarding
Security
Parental Controls
Access Control
Advanced Routing
Bandwidth Control
IP & MAC Binding
Quick Setup - WAN Connection Type
The Quick Setup is preparing to set up your internet connection, please choose one type below according to your ISP.
The detailed description will be displayed after you choose the corresponding type.
Auto-Detect
Dynamic IP (Most common option)
Static IP
Your ISP provides you specified IP parameters.
PPPoE/Russian PPPoE
L2TP/Russian L2TP
PPTP/Russian PPTP
Note: For users in some areas(such as Russia, Ukraine etc.), please contact your ISP to choose connection type manually.
More Advanced Settings
Back
Next

Cont…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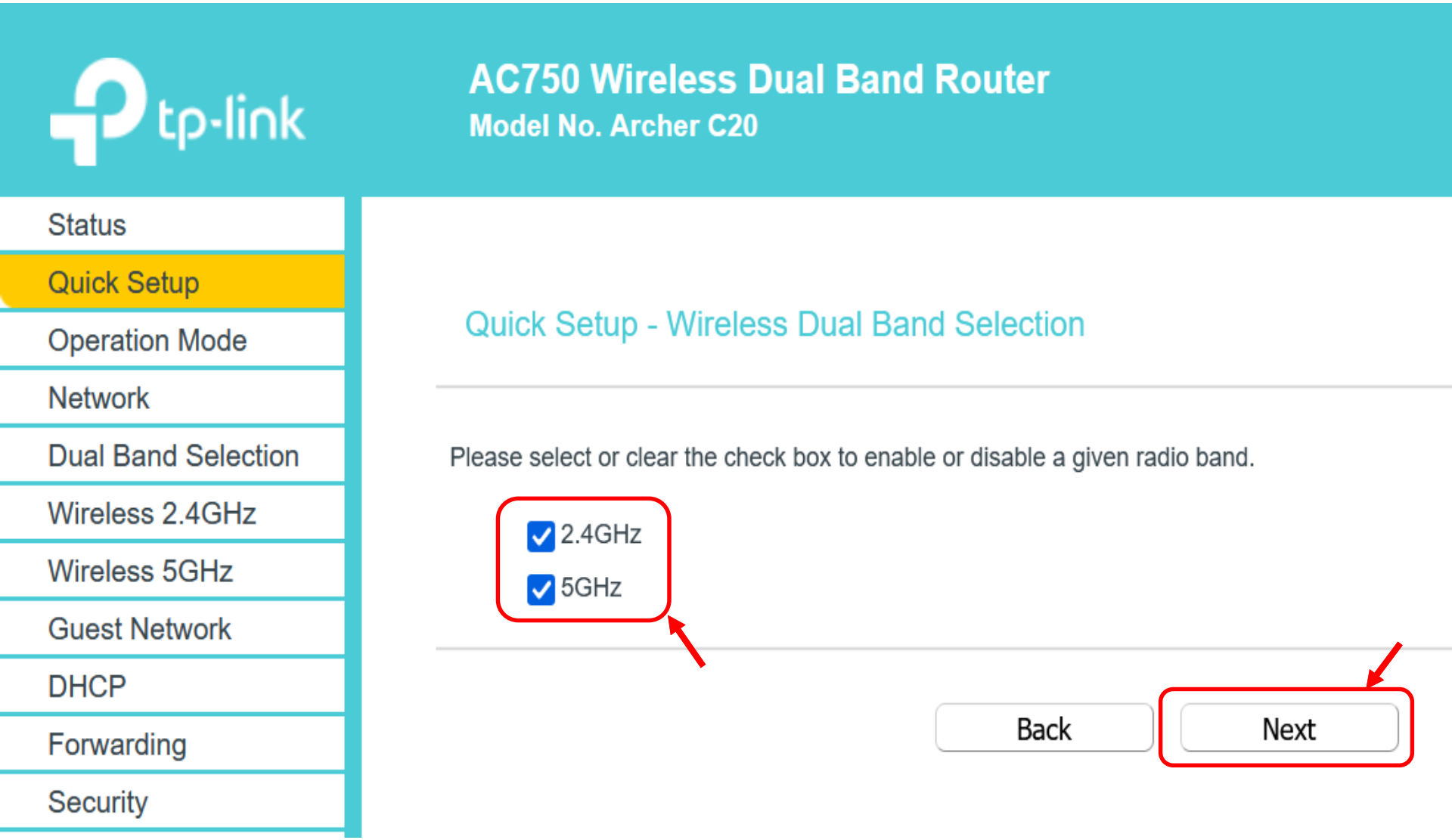
Quick Setup
Operation Mode
Network
Dual Band Selection
Wireless 2.4GHz
Wireless 5GHz
Guest Network
DHCP
Forwarding
Security
Parental Controls
Access Control
Advanced Routing
Quick Setup - Static IP
Please enter the basic parameter settings provided by your ISP. If basic parameters are unknown, please contact ISP.
IP Address: 172.16.117.192
Subnet Mask: 255.255.248.0
Default Gateway: 172.16.112.1
Primary DNS Server: 172.17.1.1
Secondary DNS Server: 172.17.1.2 (optional)
Back
Next

Cont…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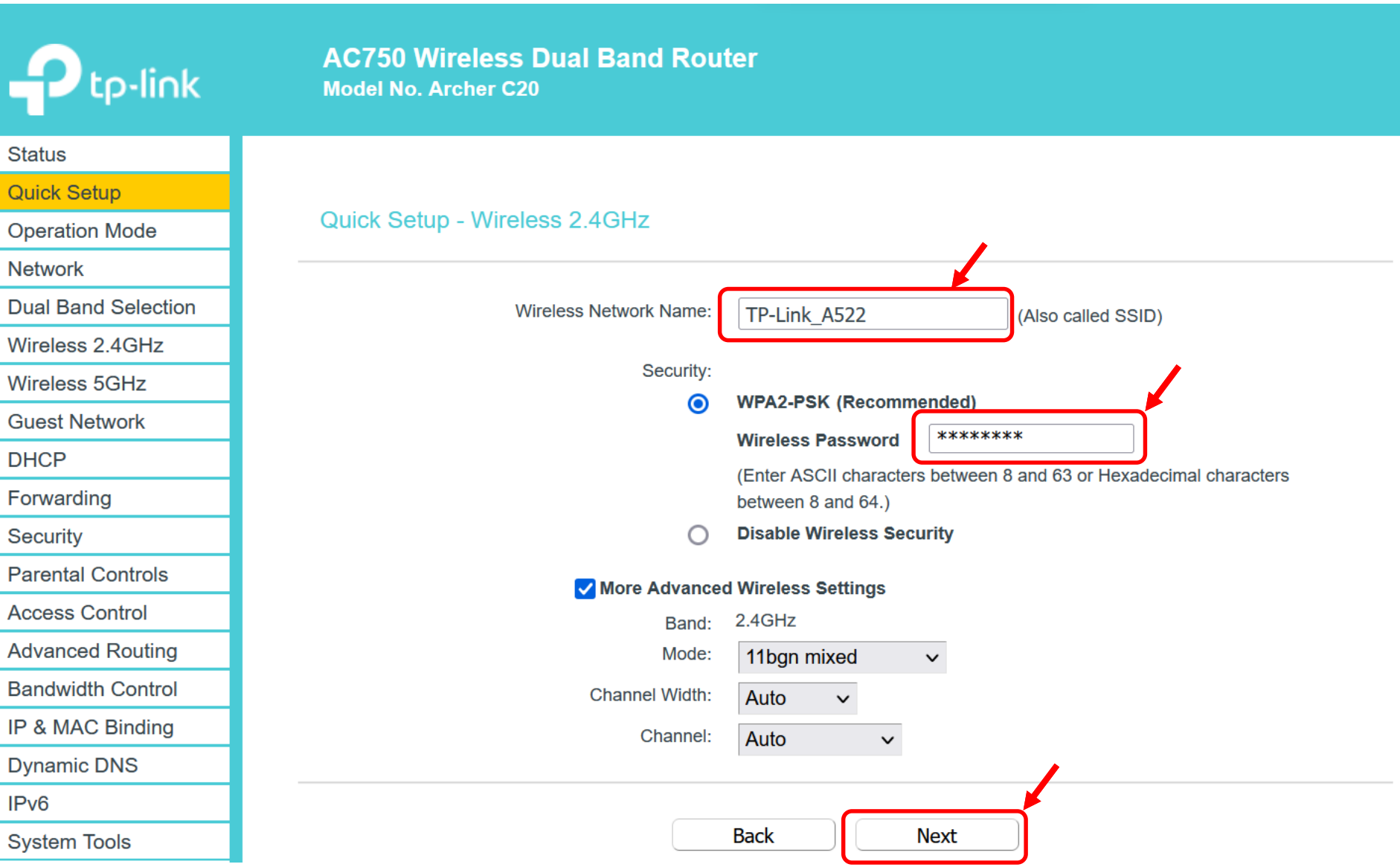
AC750 Wireless Dual Band Router
Model No. Archer C20
Status
Quick Setup
Operation Mode
Network
Dual Band Selection
Wireless 2.4GHz
Wireless 5GHz
Guest Network
DHCP
Forwarding
Security
Quick Setup - Wireless Dual Band Selection
Please select or clear the check box to enable or disable a given radio band.
2.4GHz
5GHz
Back
Next

Cont…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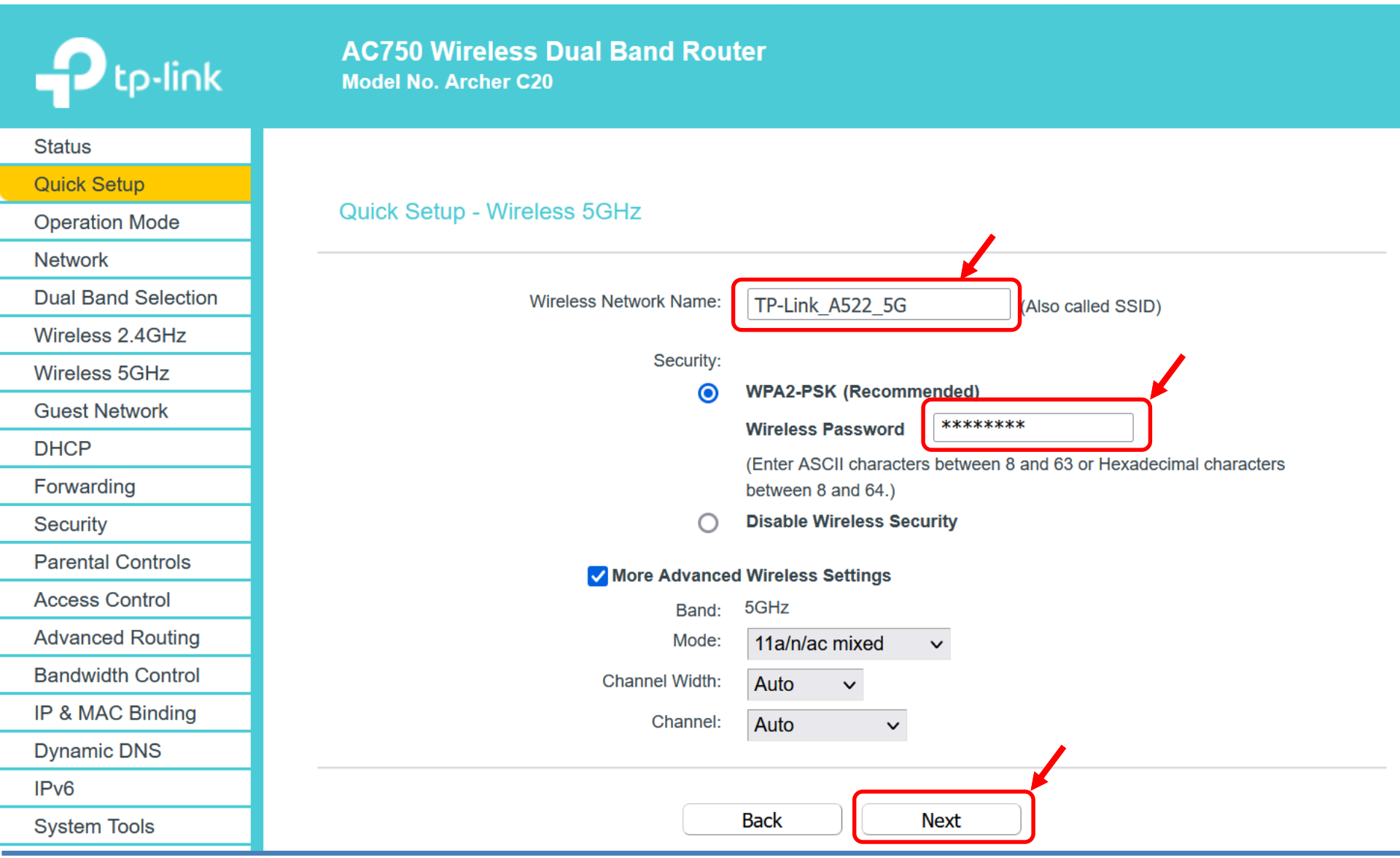
Wireless 2.4GHz
Wireless 5GHz
Guest Network
DHCP
Forwarding
Security
Parental Controls
Access Control
Advanced Routing
Bandwidth Control
IP & MAC Binding
Dynamic DNS
IPv6
System Tools
Quick Setup - Wireless 2.4GHz
Wireless Network Name:
TP-Link_A522
(Also called SSID)
Security:
WPA2-PSK (Recommended)
Wireless Password
****
(Enter ASCII characters between 8 and 63 or Hexadecimal characters between 8 and 64.)
Disable Wireless Security
More Advanced Wireless Settings
Band:
2.4GHz
Mode:
11bgn mixed
Channel Width:
Auto
Channel:
Auto
Back
Next

Cont…


tp-link
AC750 Wireless Dual Band Router
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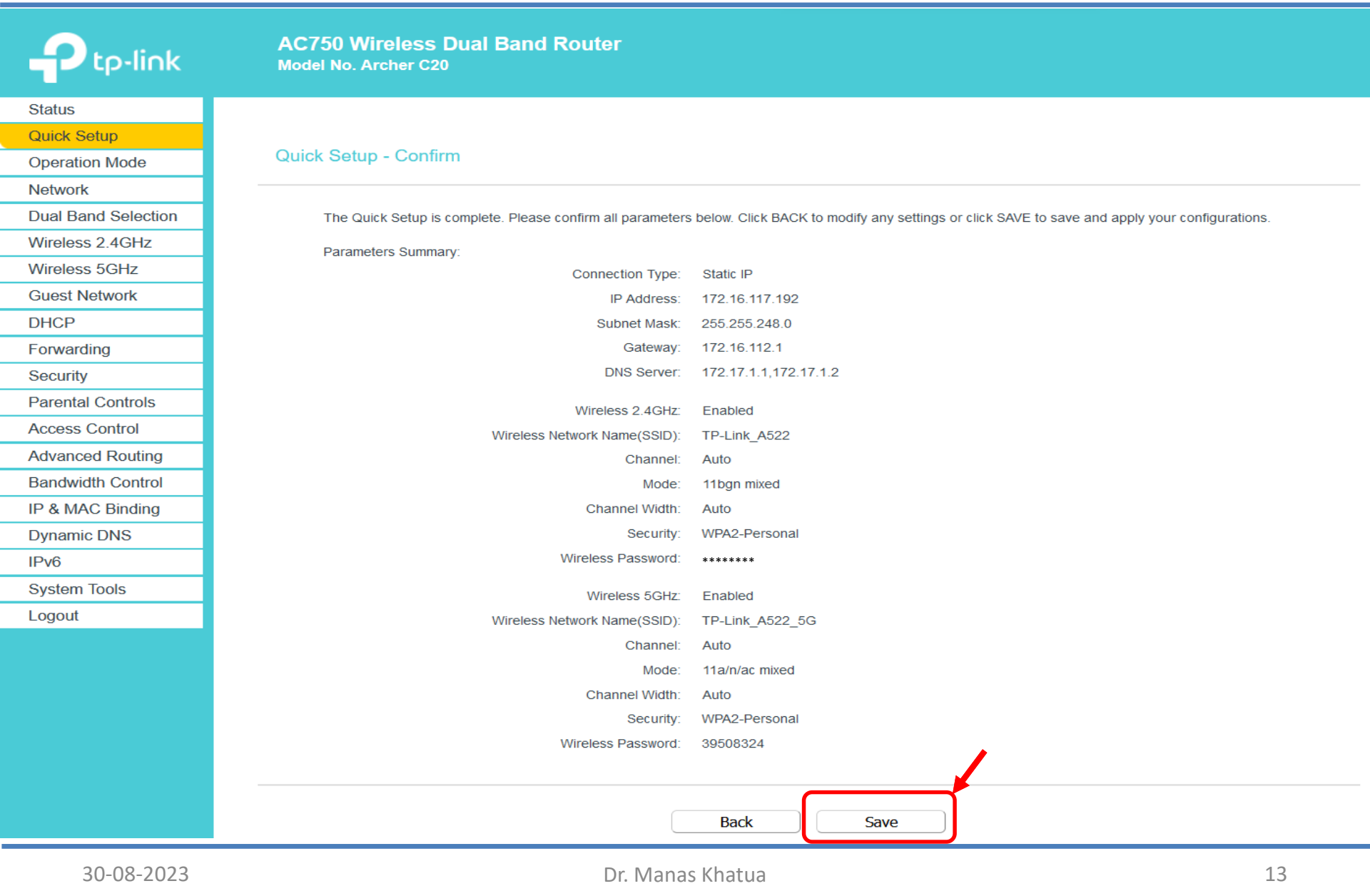
Quick Setup
Operation Mode
Network
Dual Band Selection
Wireless 2.4GHz
Wireless 5GHz
Guest Network
DHCP
Forwarding
Security
Parental Controls
Access Control
Advanced Routing
Bandwidth Control
IP & MAC Binding
Dynamic DNS
IPv6
System Tools
Quick Setup - Wireless 5GHz
Wireless Network Name:
TP-Link_A522_5G
(Also called SSID)
Security:
WPA2-PSK (Recommended)
Wireless Password
****
(Enter ASCII characters between 8 and 63 or Hexadecimal characters between 8 and 64.)
Disable Wireless Security
More Advanced Wireless Settings
Band:
5GHz
Mode:
11a/n/ac mixed
Channel Width:
Auto
Channel:
Auto
Back
Next

Cont…


tp-link
AC750 Wireless Dual Band Router
Model No. Archer C20
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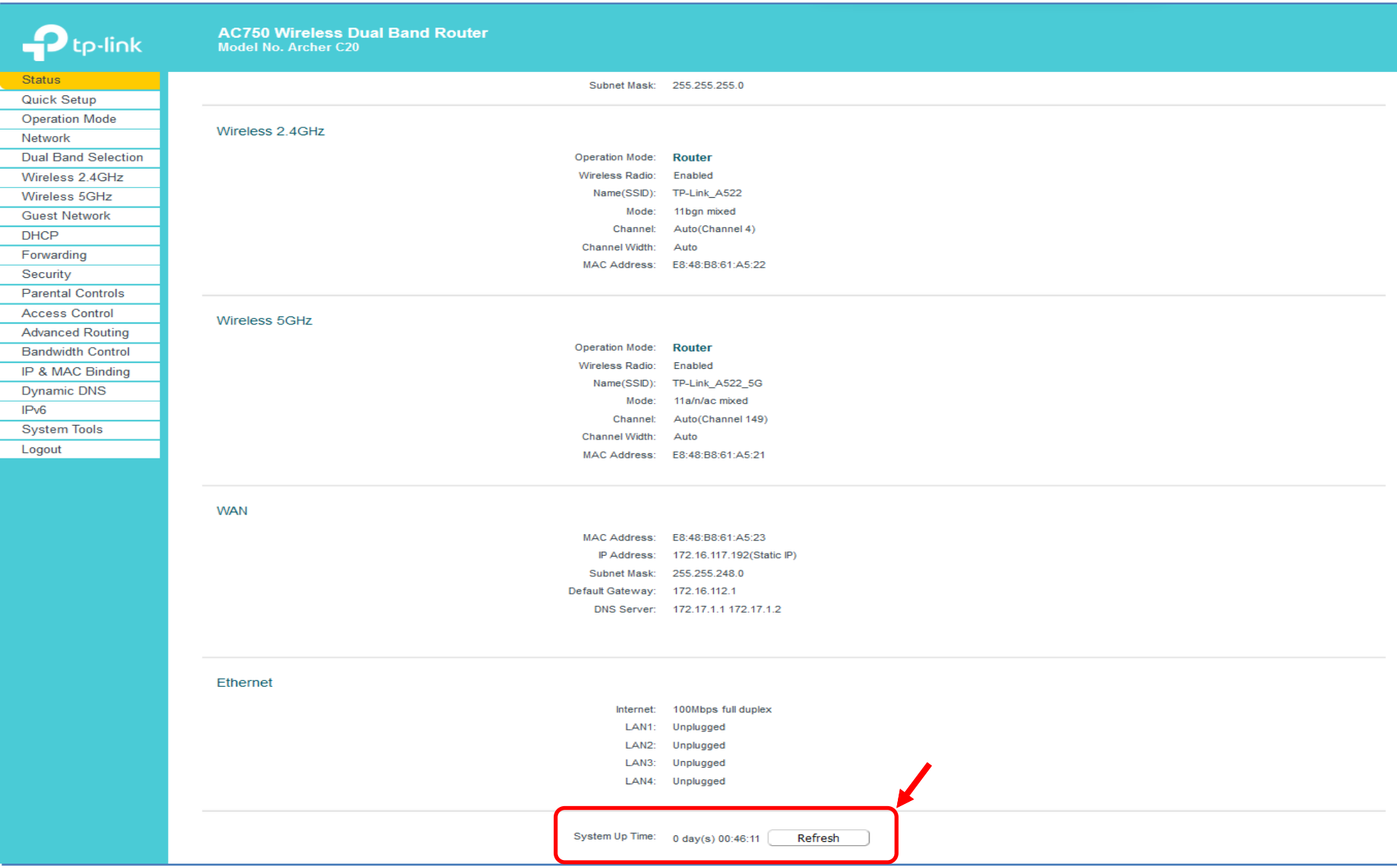
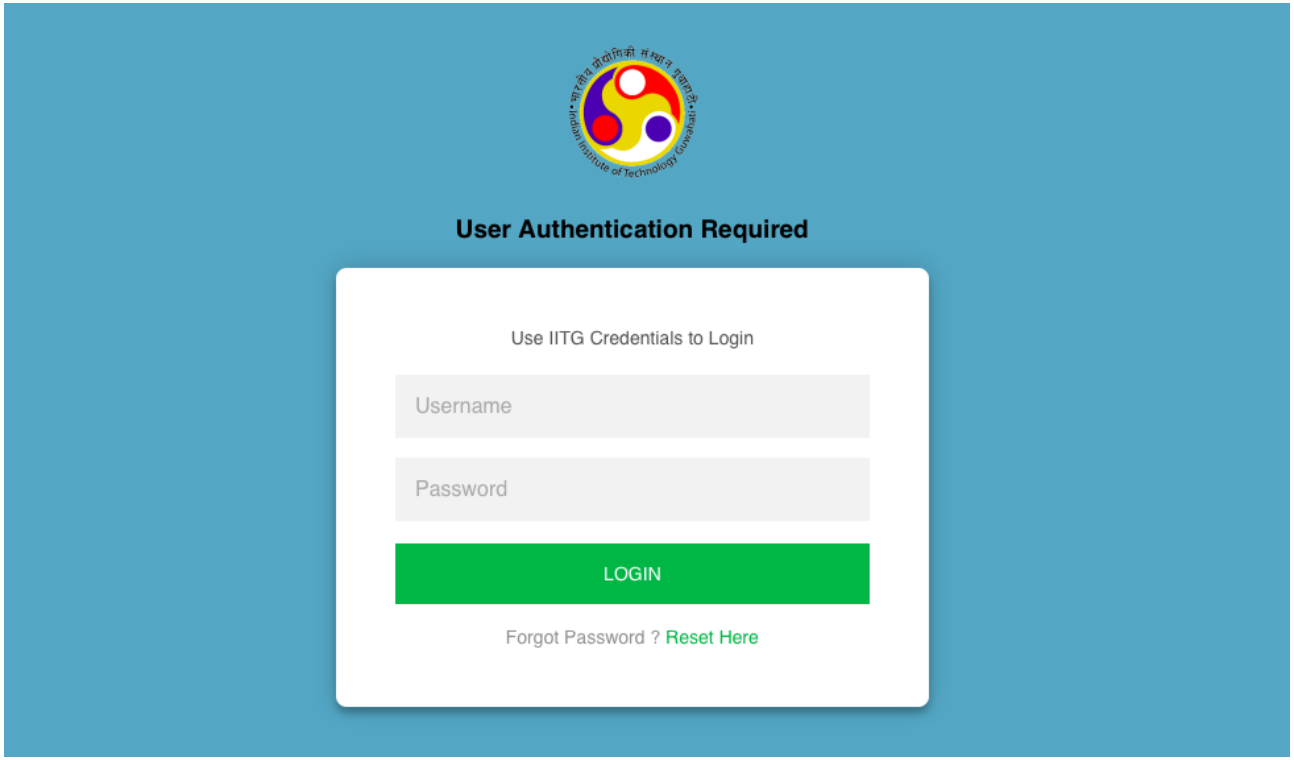
Quick Setup
Operation Mode
Network
Dual Band Selection
Wireless 2.4GHz
Wireless 5GHz
Guest Network
DHCP
Forwarding
Security
Parental Controls
Access Control
Advanced Routing
Bandwidth Control
IP & MAC Binding
Dynamic DNS
IPv6
System Tools
Logout
Quick Setup - Confirm
The Quick Setup is complete. Please confirm all parameters below. Click BACK to modify any settings or click SAVE to save and apply your configurations.
Parameters Summary:
Connection Type: Static IP
IP Address: 172.16.117.192
Subnet Mask: 255.255.248.0
Gateway: 172.16.112.1
DNS Server: 172.17.1.1,172.17.1.2
Wireless 2.4GHz: Enabled
Wireless Network Name(SSID): TP-Link_A522
Channel: Auto
Mode: 11bgn mixed
Channel Width: Auto
Security: WPA2-Personal
Wireless Password: ********
Wireless 5GHz: Enabled
Wireless Network Name(SSID): TP-Link_A522_5G
Channel: Auto
Mode: 11a/n/ac mixed
Channel Width: Auto
Security: WPA2-Personal
Wireless Password: 39508324
Back
Save

Cont…


tp-link
AC750 Wireless Dual Band Router
Model No. Archer C20
Status
Quick Setup
Operation Mode
Network
Dual Band Selection
Wireless 2.4GHz
Wireless 5GHz
Guest Network
DHCP
Forwarding
Security
Parental Controls
Access Control
Advanced Routing
Bandwidth Control
IP & MAC Binding
Dynamic DNS
IPv6
System Tools
Logout
Subnet Mask: 255.255.255.0
Wireless 2.4GHz
Operation Mode: Router
Wireless Radio: Enabled
Name(SSID): TP-Link_A522
Mode: 11bgn mixed
Channel: Auto(Channel 4)
Channel Width: Auto
MAC Address: E8:48:B8:61:A5:22
Wireless 5GHz
Operation Mode: Router
Wireless Radio: Enabled
Name(SSID): TP-Link_A522_5G
Mode: 11a/n/ac mixed
Channel: Auto(Channel 149)
Channel Width: Auto
MAC Address: E8:48:B8:61:A5:21
WAN
MAC Address: E8:48:B8:61:A5:23
IP Address: 172.16.117.192(Static IP)
Subnet Mask: 255.255.248.0
Default Gateway: 172.16.112.1
DNS Server: 172.17.1.1 172.17.1.2
Ethernet
Internet: 100Mbps full duplex
LAN1: Unplugged
LAN2: Unplugged
LAN3: Unplugged
LAN4: Unplugged
System Up Time: 0 day(s) 00:46:11
Refresh

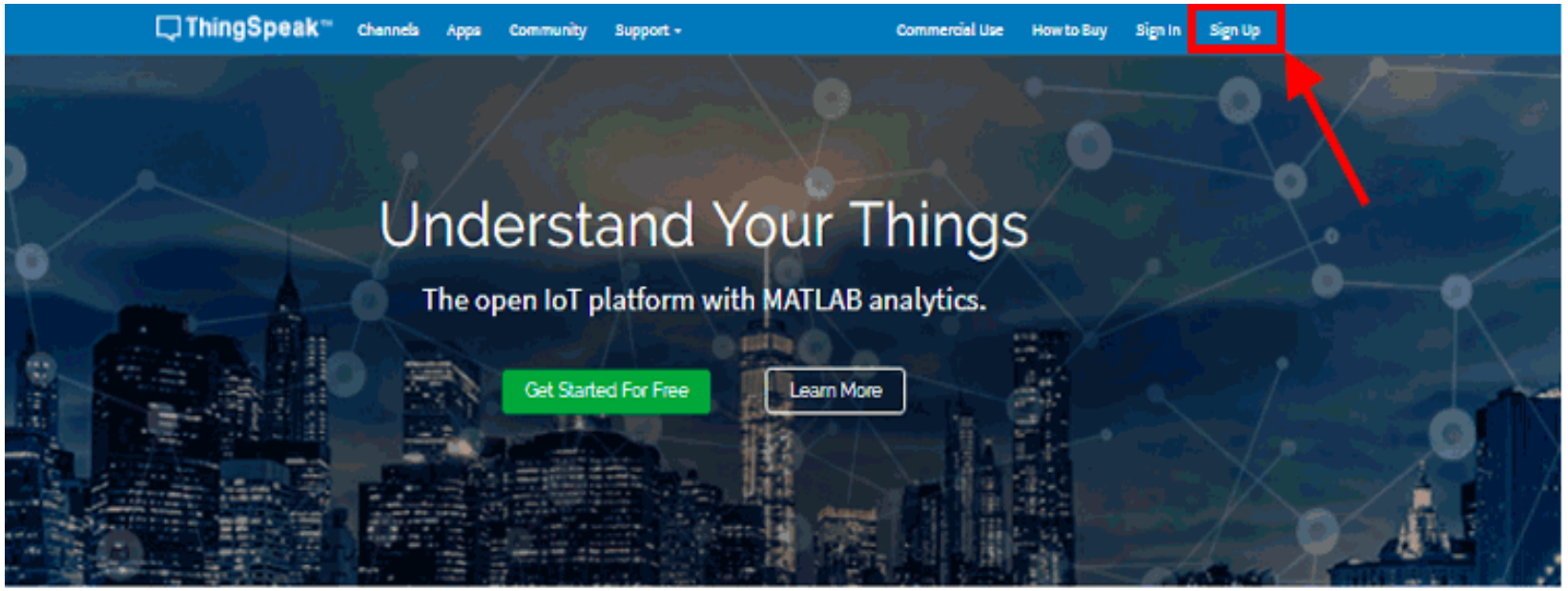
Connecting with Internet



- You should be able to access Internet in your Mobile/Laptop using TP-Link WiFi AP

Cloud Server Configuration to Access Web Service

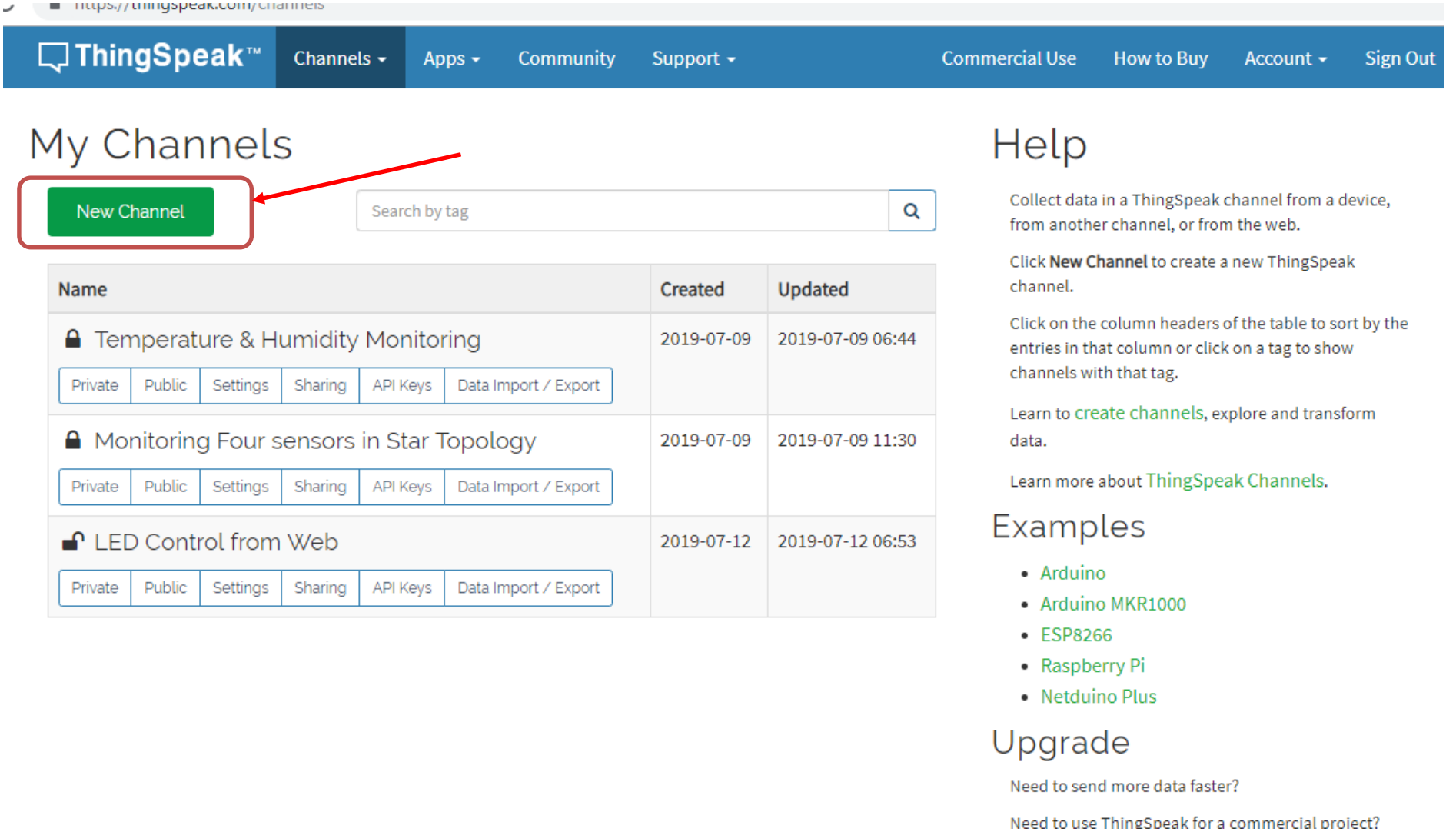
Configure to use Cloud Server



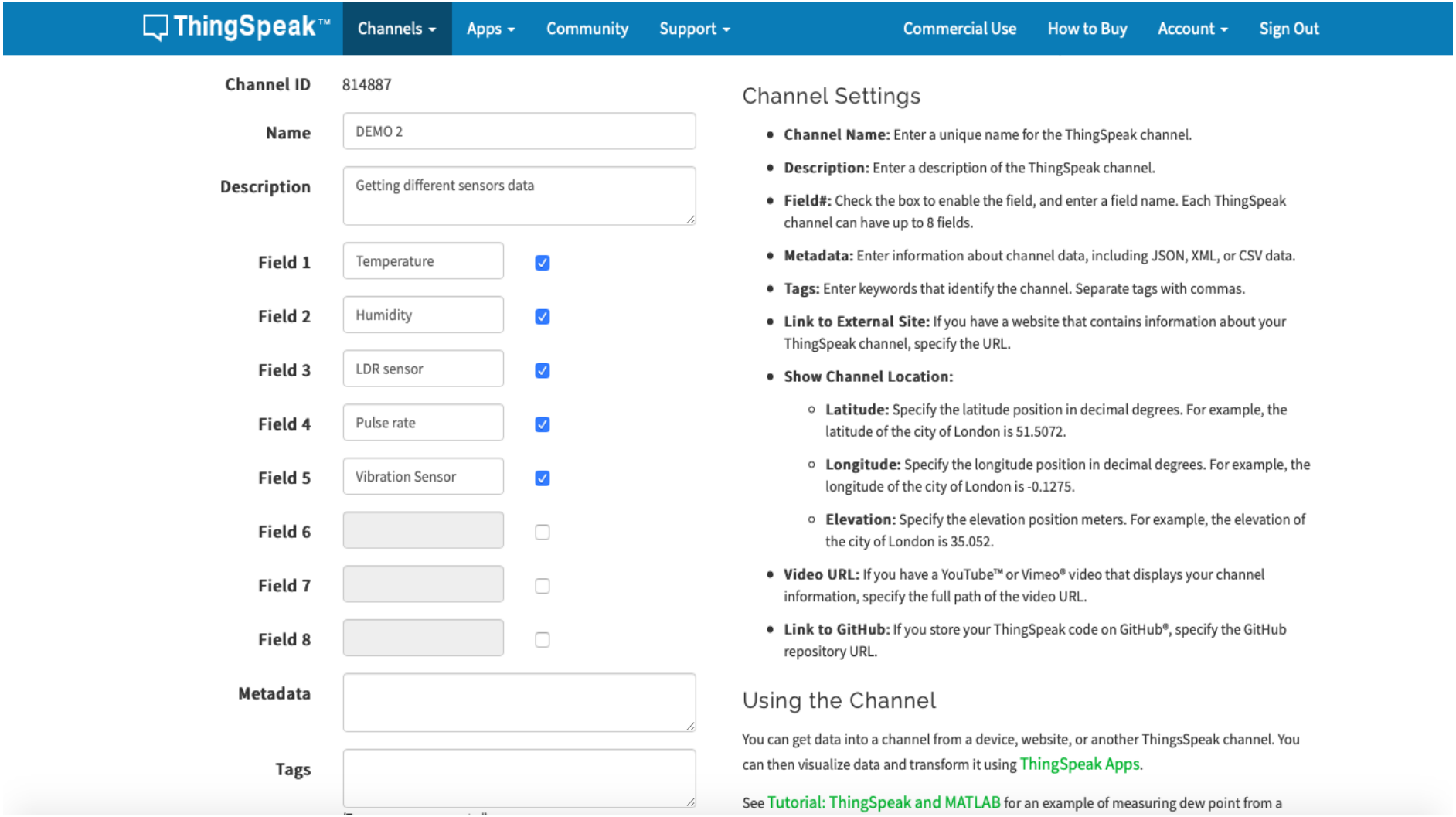
- We use ThingSpeak server **http://www.thingspeak.com**

- First create an user account
- Then create a channel on the ThingSpeak to upload the data

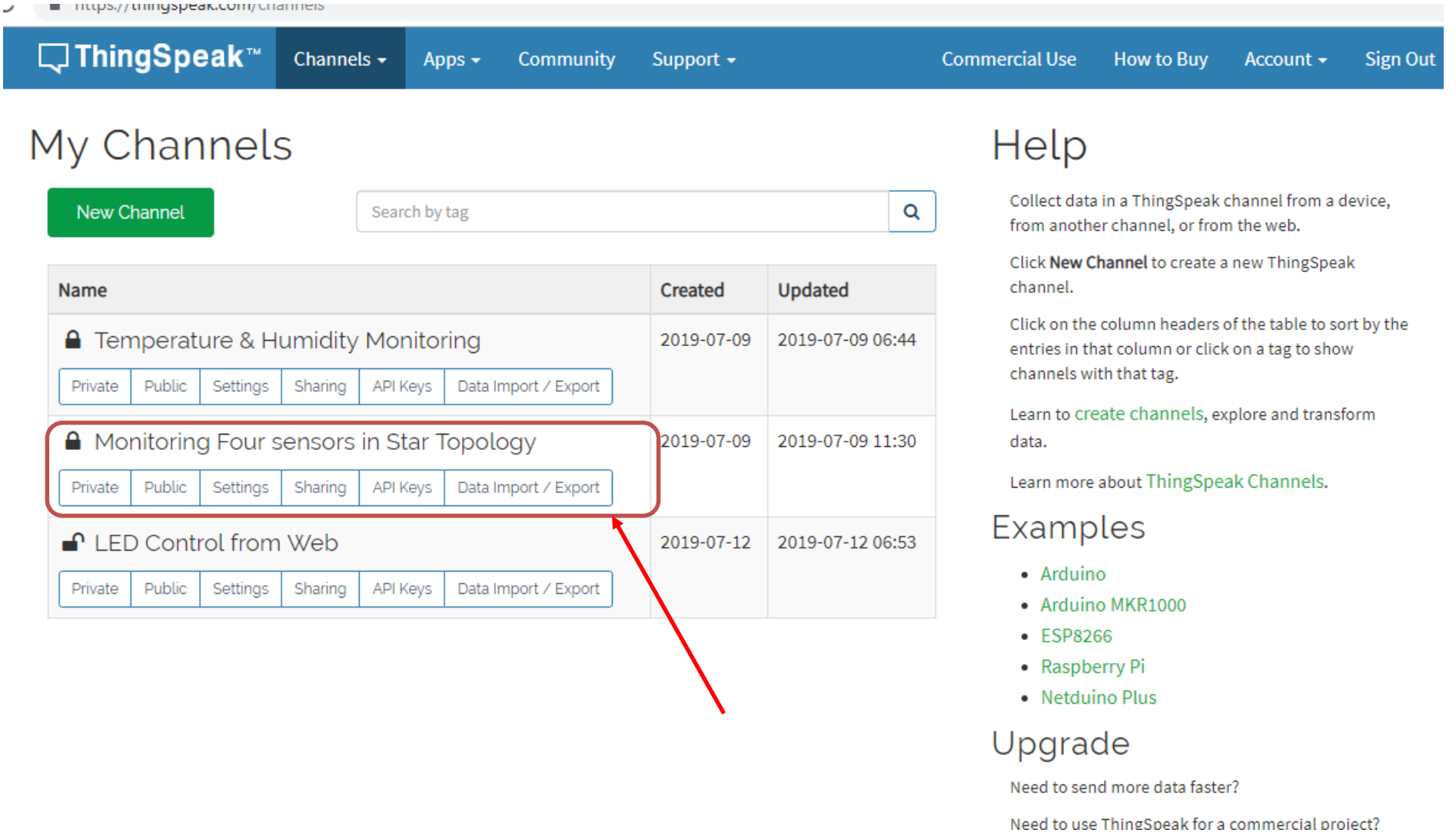
Cont…


ThingSpeak™
Channels
Apps
Community
Support
Commercial Use
How to Buy
Account
Sign Out
My Channels
New Channel
Search by tag
Name
Created
Updated
Temperature & Humidity Monitoring
2019-07-09
2019-07-09 06:44
Private
Public
Settings
Sharing
API Keys
Data Import / Export
Monitoring Four sensors in Star Topology
2019-07-09
2019-07-09 11:30
Private
Public
Settings
Sharing
API Keys
Data Import / Export
LED Control from Web
2019-07-12
2019-07-12 06:53
Private
Public
Settings
Sharing
API Keys
Data Import / Export
Help
Collect data in a ThingSpeak channel from a device, from another channel, or from the web.
Click New Channel to create a new ThingSpeak channel.
Click on the column headers of the table to sort by the entries in that column or click on a tag to show channels with that tag.
Learn to create channels, explore and transform data.
Learn more about ThingSpeak Channels.
Examples
Arduino
Arduino MKR1000
ESP8266
Raspberry Pi
Netduino Plus
Upgrade
Need to send more data faster?
Need to use ThingSpeak for a commercial project?

Cont...


ThingSpeak™
Channels
Apps
Community
Support
Commercial Use
How to Buy
Account
Sign Out
Channel ID
814887
Name
DEMO 2
Description
Getting different sensors data
Field 1
Temperature
Field 2
Humidity
Field 3
LDR sensor
Field 4
Pulse rate
Field 5
Vibration Sensor
Field 6
Field 7
Field 8
Metadata
Tags
Channel Settings
Channel Name: Enter a unique name for the ThingSpeak channel.
Description: Enter a description of the ThingSpeak channel.
Field#: Check the box to enable the field, and enter a field name. Each ThingSpeak channel can have up to 8 fields.
Metadata: Enter information about channel data, including JSON, XML, or CSV data.
Tags: Enter keywords that identify the channel. Separate tags with commas.
Link to External Site: If you have a website that contains information about your ThingSpeak channel, specify the URL.
Show Channel Location:
Latitude: Specify the latitude position in decimal degrees. For example, the latitude of the city of London is 51.5072.
Longitude: Specify the longitude position in decimal degrees. For example, the longitude of the city of London is -0.1275.
Elevation: Specify the elevation position meters. For example, the elevation of the city of London is 35.052.
Video URL: If you have a YouTube™ or Vimeo® video that displays your channel information, specify the full path of the video URL.
Link to GitHub: If you store your ThingSpeak code on GitHub®, specify the GitHub repository URL.
Using the Channel
You can get data into a channel from a device, website, or another ThingsSpeak channel. You can then visualize data and transform it using ThingSpeak Apps.
See Tutorial: ThingSpeak and MATLAB for an example of measuring dew point from a

Cont…


ThingSpeak™
Channels
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How to Buy
Account
Sign Out
My Channels
New Channel
Search by tag
Name
Created
Updated
Temperature & Humidity Monitoring
2019-07-09
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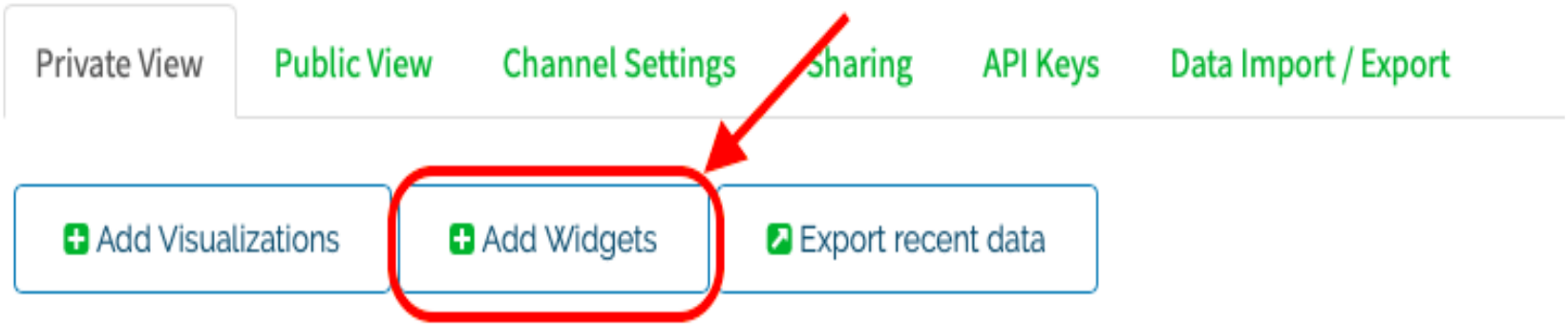
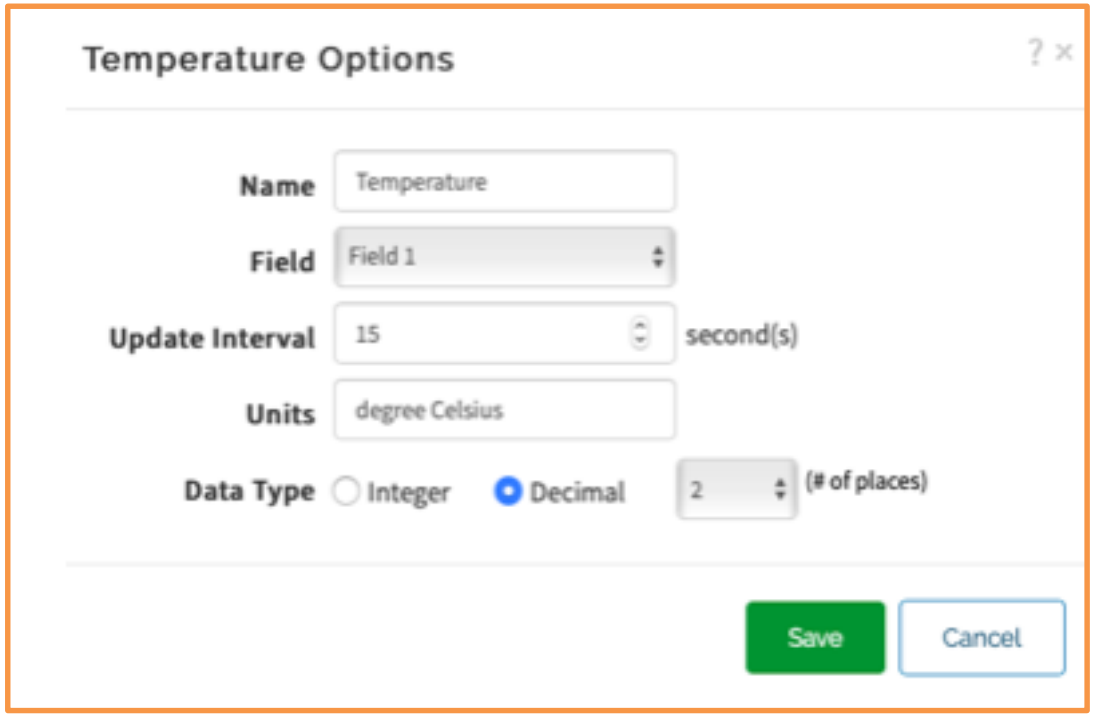
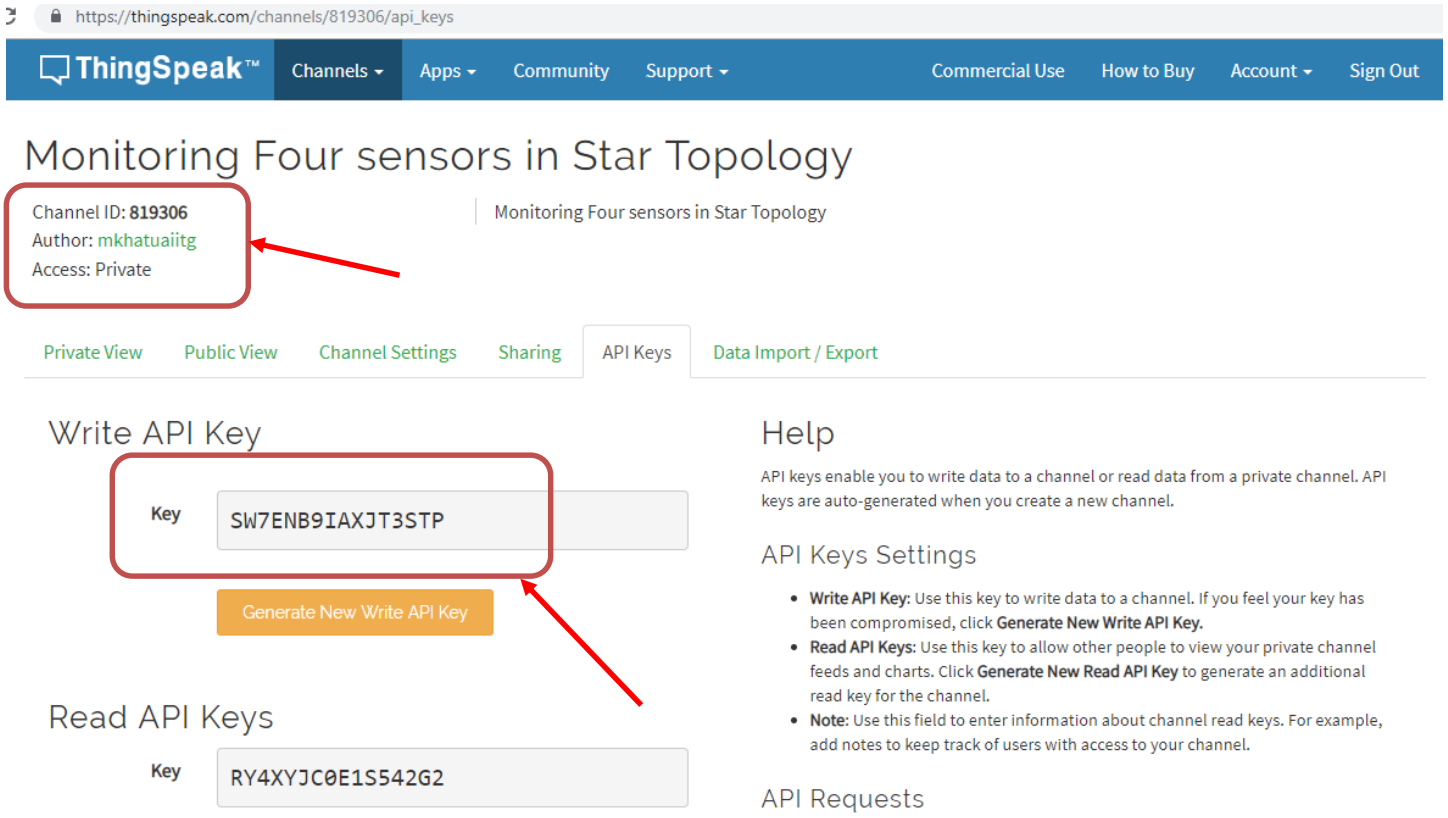
Create Channel Display





- Select **Private View** of the created channel.
- Click **Add Widgets**
- Select the Numeric Display widget, and then set the display options.

API Key and Channel ID



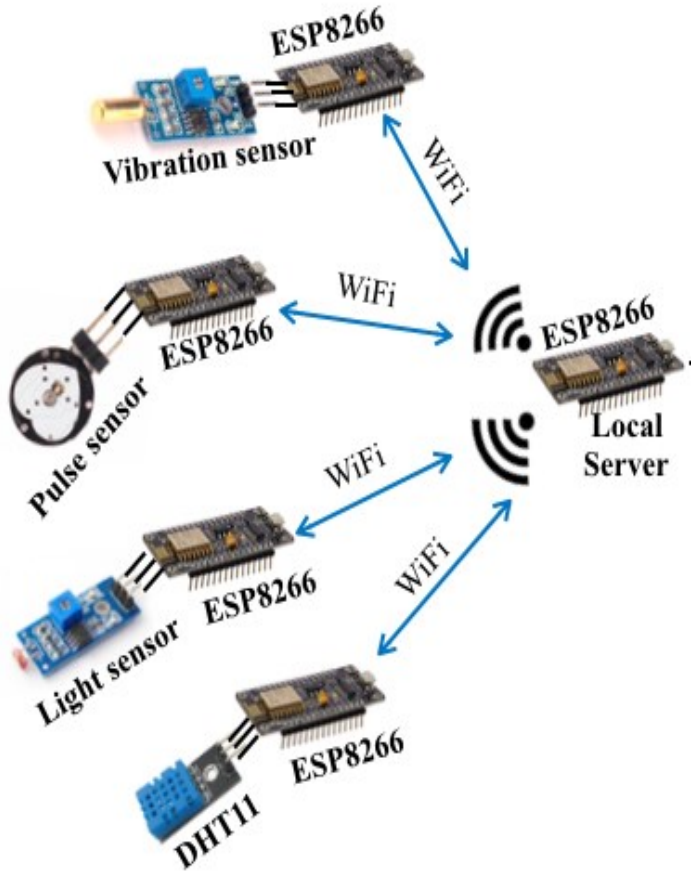
- To send data to ThingSpeak, we need unique write API key and Channel ID, which will be used later in code to upload the data to ThingSpeak website

- Click on “API Keys” button to get your unique “Write API Key”
- “Channel ID” is also given on the top

IoT Network Configuration

IoT Network Configuration

- There are total five ESP8266
  - one is acting as server,
  - other four as clients in local network.



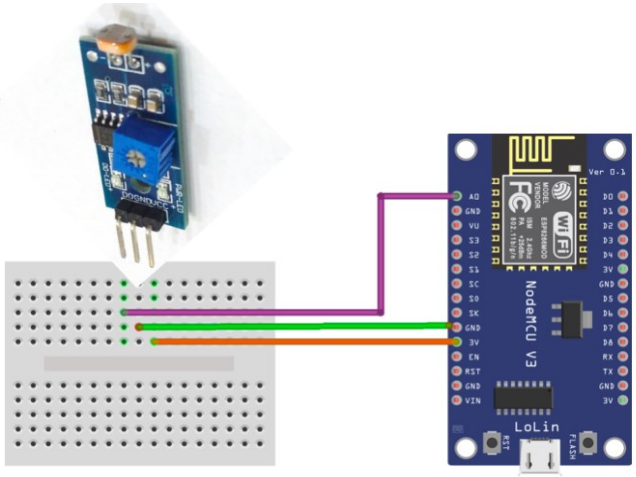
- ESP1- ESP8266 acting as local server
- ESP2- ESP8266 with Light sensor
- ESP3- ESP8266 with Pulse sensor
- ESP4- ESP8266 with vibration sensor
- ESP5- ESP8266 with temperature & humidity sensor

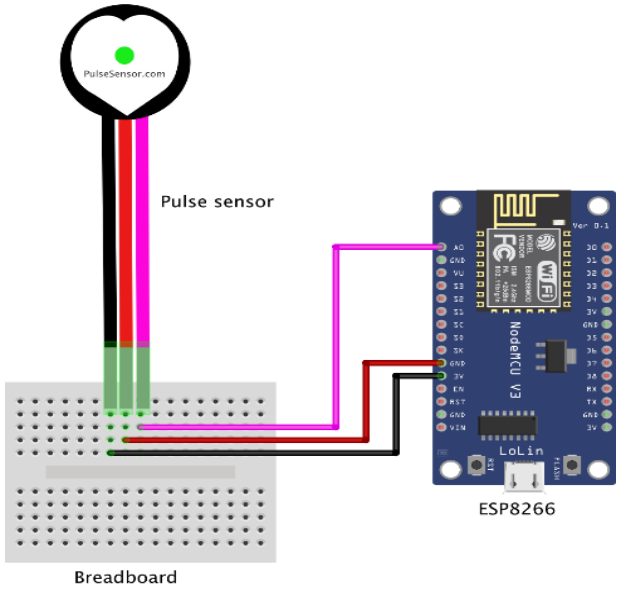
- **Note**: Unique ID for each ESP will be needed in programming

Sensor Configuration

ESP8266 with LDR Sensor

- Connect VCC pin of LDR sensor with 3V3 pin of ESP2
- Connect GND pin of LDR sensor with GND pin of ESP2
- Connect DATA OUT pin of LDR sensor with A0 pin of ESP2.





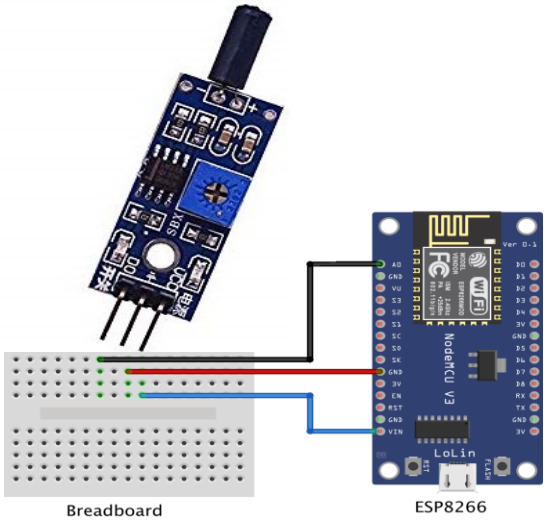
ESP8266 with Pulse Sensor

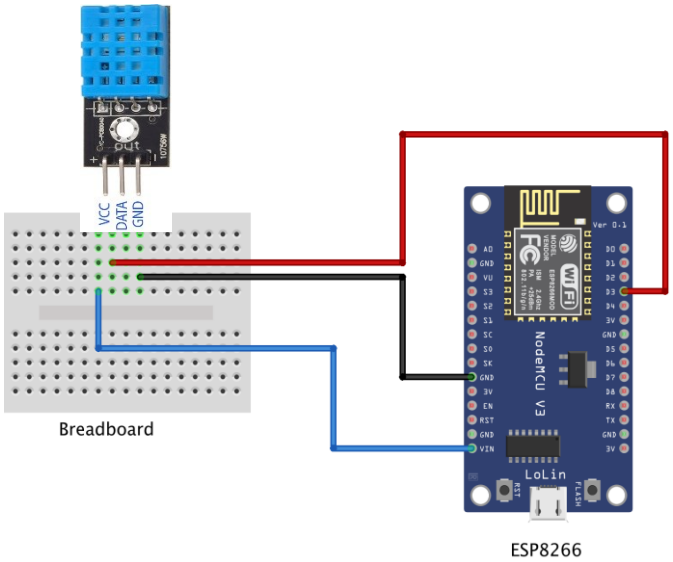
- Connect VCC pin of pulse sensor with 3V3 pin of ESP3
- Connect GND pin of pulse sensor with GND pin of ESP3
- Connect SIGNAL pin of pulse sensor with A0 pin of ESP3

Cont…

ESP8266 with Vibration Sensor

- Connect VCC pin of vibration sensor with VIN pin of ESP4
- Connect GND pin of vibration sensor with GND pin of ESP4
- Connect DATA OUT pin of vibration sensor with A0 pin of ESP4





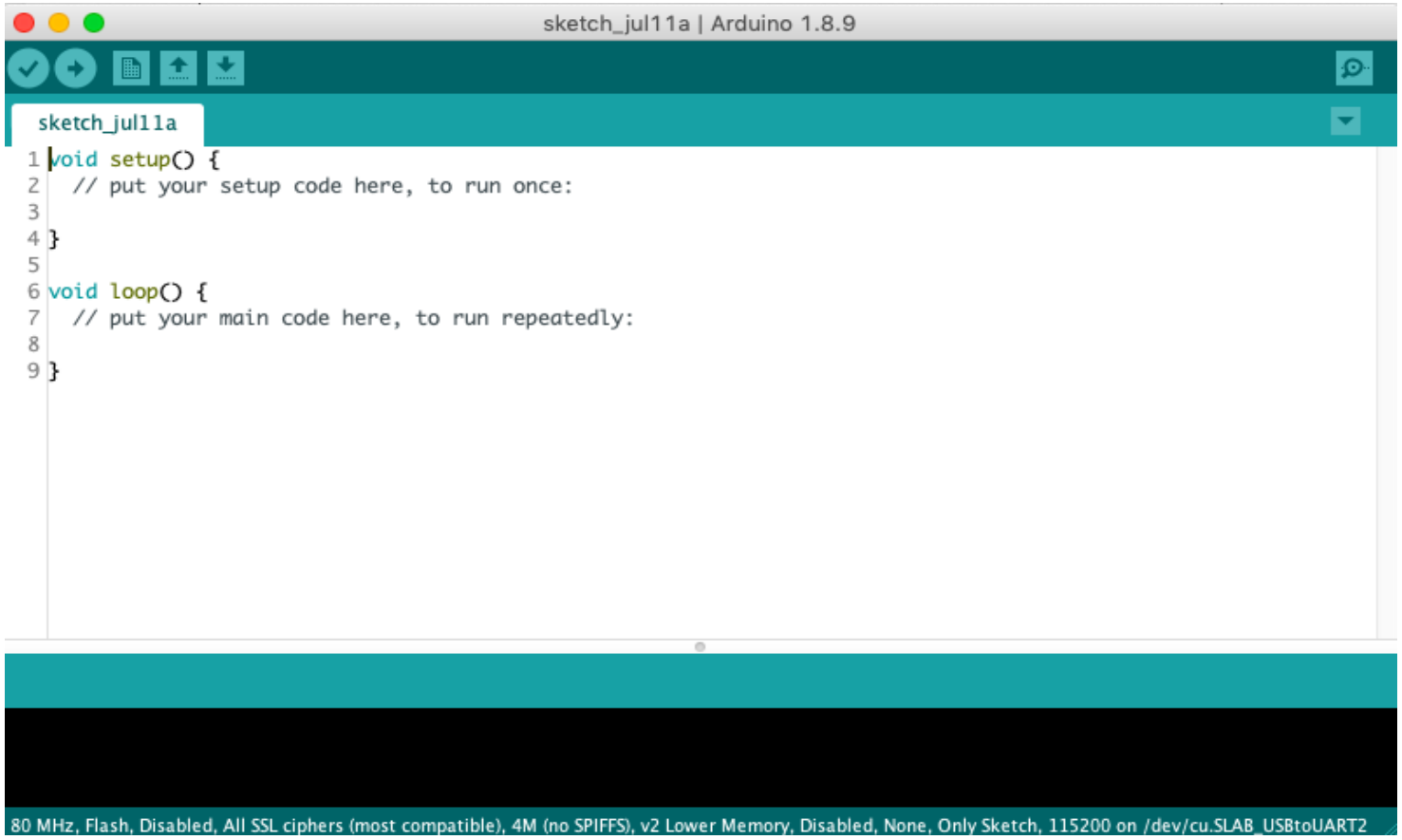
ESP8266 with Temperature & Humidity Sensor (DHT11)

- Connect VCC pin of DHT11 with VIN pin of ESP5
- Connect DATA OUT pin of DHT11 with D3 pin of ESP5
- Connect GND pin of DHT11 with GND pin of ESP5

Arduino
Tool Configuration

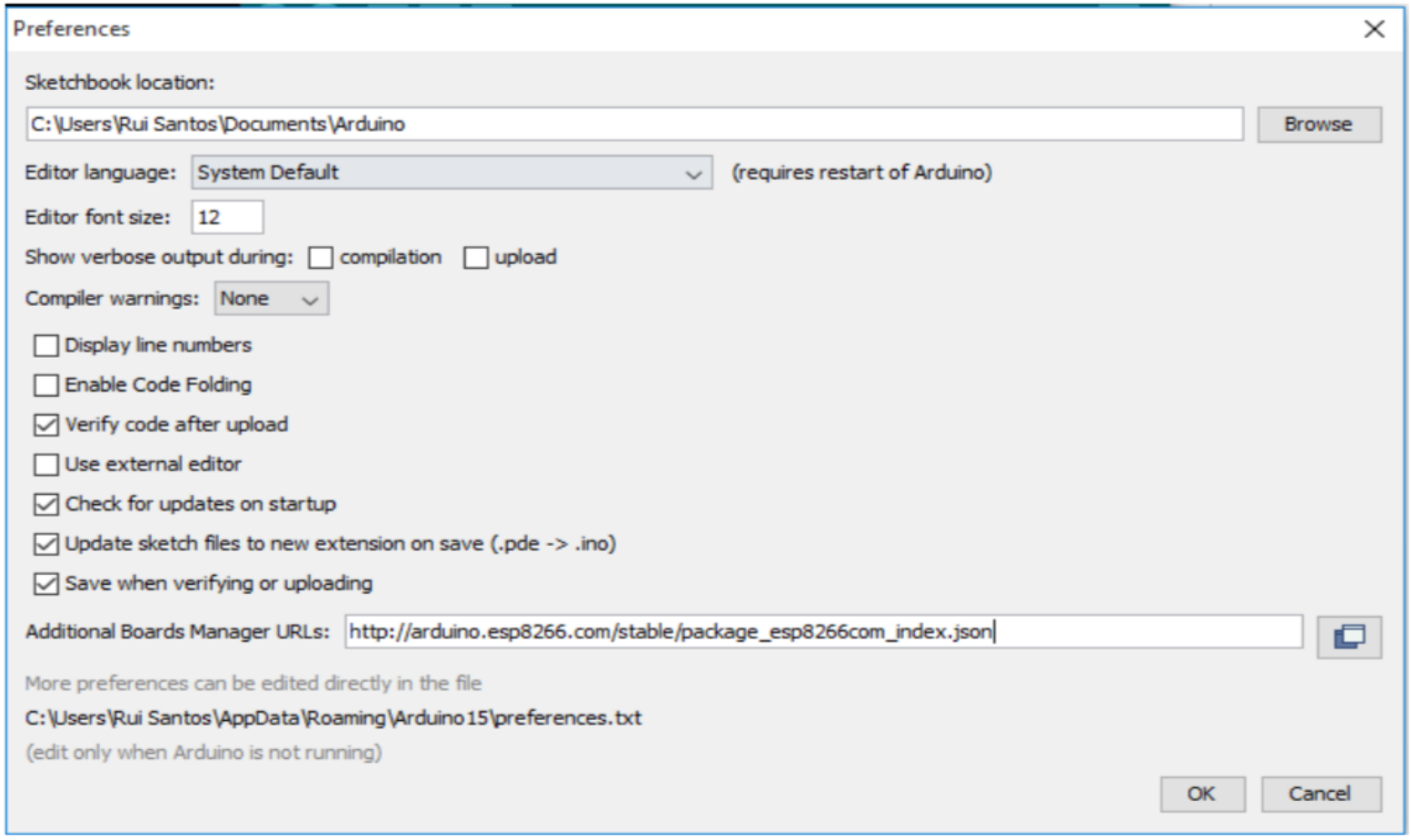
Configure Arduino IDE

- **Download and Install Arduino IDE https://www.arduino.cc/en/Main/Software**
- When the Arduino IDE first opens, this is what you should see:



Install ESP8266 Board in IDE

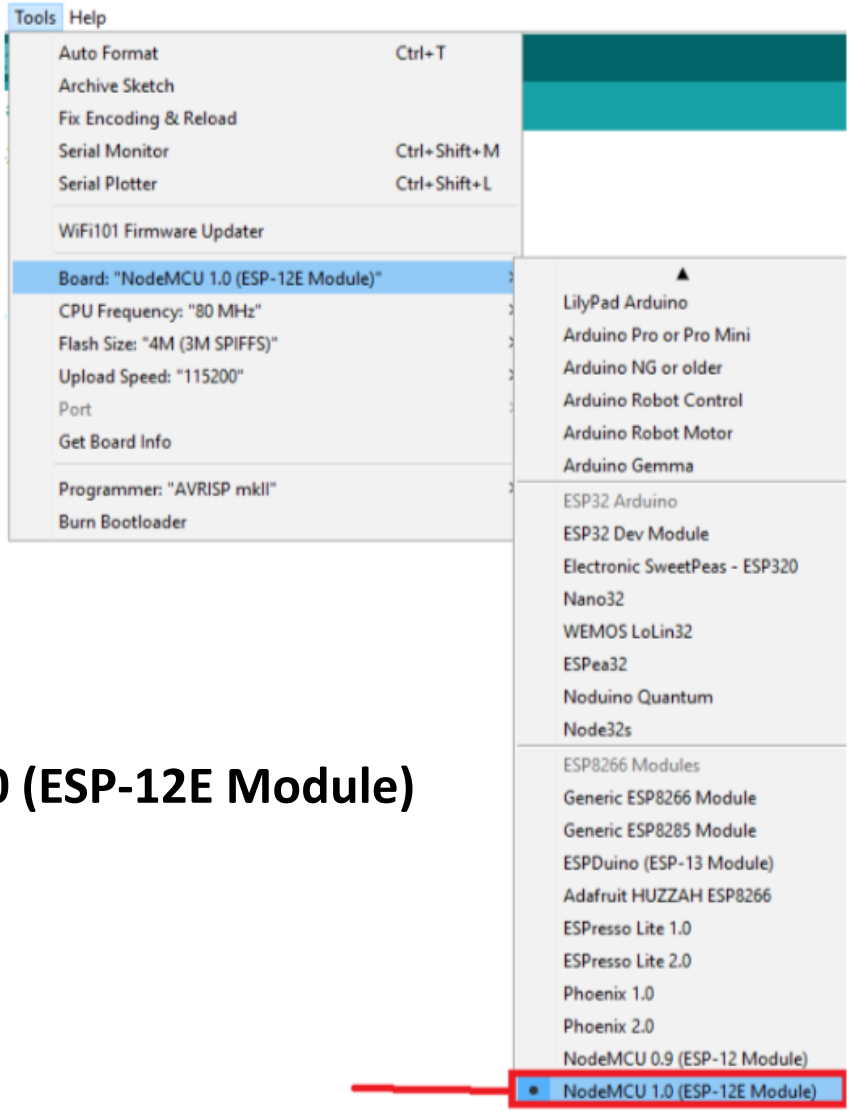
- Go to **File --> Preferences**
- Enter the below URL into **Additional Board Manager URLs** field and press the “OK” button
  http://arduino.esp8266.com/stable/package_esp8266com_index.json OR
  https://github.com/esp8266/Arduino/releases/download/2.3.0/package_esp8266com_index.json



Cont…

- Go to **Tools > Board > Board Manager**
- Scroll down, select the ESP8266 board menu and **install** "**esp8266 by ESP8266 Community**"

Cont...

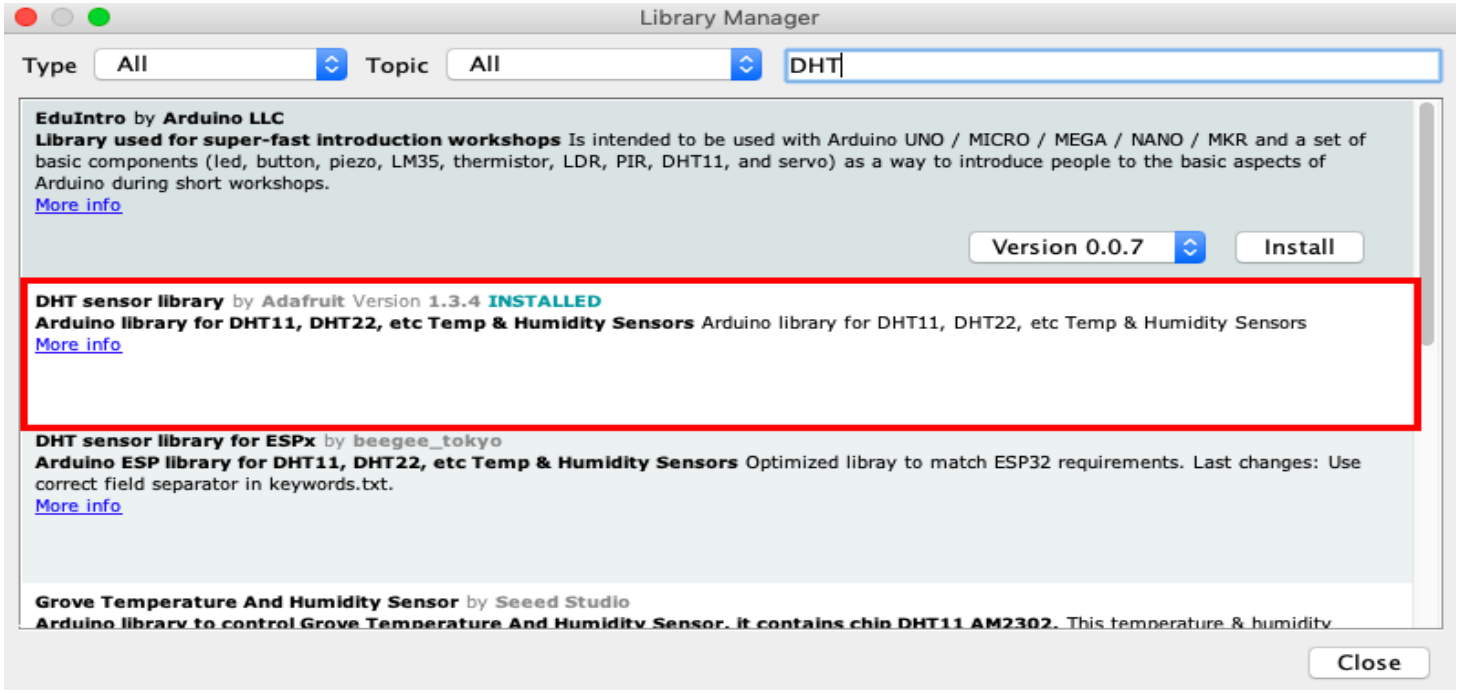


- Select the appropriate board
  - Go to **Tools >Board > NodeMCU 1.0 (ESP-12E Module)**
- Finally, re-open the Arduino IDE

Install Sensor Libraries

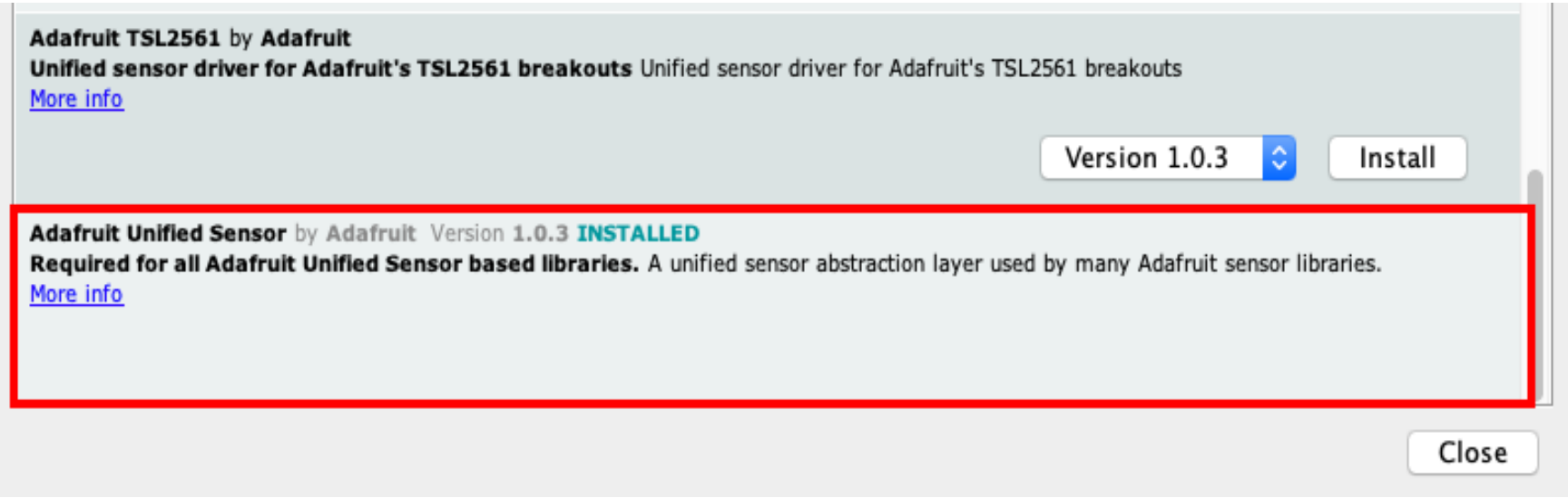
- In this demo, we use DHT11 sensor for which we will be using **DHT.h** header file in the code. So, this header file should be installed.

- **Install Using the Library Manager**
  - click to **Sketch** menu then **Include Library > Manage Libraries**
  - Search for "**DHT**" on the Search box and install the DHT library from **Adafruit**.



Cont…

- After installing the DHT library from Adafruit, install "**Adafruit Unified Sensor**" libraries.



- There exist other methods for installing libraries
  - **Importing a .zip Library**
    - Sketch --> Include Library --> Add .Zip Library
  - **Manual Installation of Library**
    - Download the library as .Zip --> extract it
    - Place the files in File --> Preferences --> Sketchbook location
    - Restart Arduino IDE

MCU Programming

ESP8266 with Local Server

For ESP5, write the following code in the Arduino IDE and save as **Local_Server_ESP1.ino**
Install **ThingSpeak.h** library. Change the **red colored text** in code according to your setup.

```
#include <ESP8266WiFi.h>          //Including ESP8266 library
#include<ESP8266WebServer.h>      //Including ESP8266WebServer library for web server
#include<ThingSpeak.h>            //Including ThingSpeak library

IPAddress IP(172,16,117,192);     //Static IP address of local server
IPAddress gateway(172,16,112,1);  //Gateway of the network
IPAddress mask(255, 255, 248, 0); //Subnet mask of the network
WiFiClient client;
WiFiServer server(80);

unsigned long myChannelNumber = 2244718;  //Replace with channelID of ThingSpeak channel ID
const char * myWriteAPIKey = "T4N14GFNKOPDWIWL";  //Replace WriteAPIKey of channel

const char* softAPssid = "ESP1_Server";      //SSID of the hotspot of ESP8266 acting as local server
const char* password = "12345678";           //Password of the hotspot of ESP8266 acting as local server

const char* wifissid = “TP-Link_A522";       //Replace with SSID of WIFI router providing internet access
const char* pass = "12345678";               //Password of WIFI router providing internet access
```

Cont…

```
void setup() {
  WiFi.mode(WIFI_AP_STA);              //station mode and access point mode both at the same time
  Serial.begin(9600);                  //Serial communication at baud rate of 9600 for debugging purpose
  delay(100);
  Serial.println(WiFi.getMode());
  Serial.print("Configuring SoftAP....");
  Serial.println(WiFi.softAPConfig(IP, gateway, mask)? "Ready" : "Failed");
  delay(10);
  Serial.println("Setting SoftAP...");
  Serial.println(WiFi.softAP(softAPssid, password));
  delay(10);
  Serial.println(WiFi.softAPIP());
  delay(500);
  WiFi.begin(wifissid, pass);
  while(WiFi.status()!=WL_CONNECTED)  {
    Serial.print(".");
    delay(500);
  }
  Serial.print("Connected to Wifi with ssid ");
  Serial.println(wifissid);
  Serial.print("WiFi IP address: ");
  Serial.println(WiFi.localIP());      // WIFI router IP address
  ThingSpeak.begin(client);
  server.begin();                      //Start local server
}
```

- Two functions exist in the programme: setup () and loop ()
  - **setup():** This function runs once when ESP first boots
  - **loop():** This function reads the LDR sensor value and connects to local server then send sends data to local server

Cont…

```
void loop() {
  Serial.printf("Stations connected = %d\n", WiFi.softAPgetStationNum());
  WiFiClient client = server.available();          //Waiting for the incoming data if client is ready to send
  if (!client) {return;}
  String select_fun = client.readStringUntil('\r');          //Reads the ESP8266 ID (of clients)

  if(select_fun=="5") {                                      //If ESP5 sends the data
    String temp = client.readStringUntil('\r');              //Reads the temperature value
    String Humidity = client.readStringUntil('\r');          //Reads the humidity value
                        //Upload the temp value to ThingSpeak server as first field of channel

    ThingSpeak.writeField(myChannelNumber, 1, temp, myWriteAPIKey);
    delay(15000);       //Wait for 15 sec after one entry
                        //Upload the humidity value to ThingSpeak server as second field of channel

    ThingSpeak.writeField(myChannelNumber, 2, Humidity, myWriteAPIKey);
    Serial.print("Temperature: ");
    Serial.print(temp);
    Serial.print(" degree celsius, Humidity: ");
    Serial.print(Humidity);
    Serial.print("%. ");
    Serial.println("Sent to ThingSpeak Server...");
  }
```

Cont…

```
 if(select_fun=="2") {                                    //If ESP2 sends the data
      String LDRval = client.readStringUntil('\r');        //Reads light sensor value
                              //Upload the light sensor value to ThingSpeak server as third field of channel
      ThingSpeak.writeField(myChannelNumber, 3, LDRval, myWriteAPIKey);
      Serial.print("LDR sensor data value: ");
      Serial.println(LDRval);
      Serial.println("Sent to ThingSpeak Server...");
   }
if(select_fun=="3") {                                    //If ESP3 sends the data
      String pulseRate = client.readStringUntil('\r');    //Reads pulse rate
                               //Upload the pulse rate to ThingSpeak server as fourth field of channel
      ThingSpeak.writeField(myChannelNumber, 4, pulseRate, myWriteAPIKey);
      Serial.print("Pulse rate: ");
      Serial.print(pulseRate);
      Serial.println(" BPM. Sent to ThingSpeak Server..");
   }
   if(select_fun=="4"){                                  //If ESP4 sends the data
      String Vibval = client.readStringUntil('\r');      //Reads vibration sensor data
                              //Upload the vibration sensor data value to ThingSpeak server as fifth field of channel
      ThingSpeak.writeField(myChannelNumber, 5, Vibval, myWriteAPIKey);
      Serial.print("Vibration Sensor data: ");
      Serial.print(Vibval);
      Serial.println(" Sent to ThingSpeak server..");
   }
   delay(15000);              //waits for 15 secs after each transmission
}
```

ESP8266 with LDR Sensor

For **ESP2**, write the following code in the Arduino IDE and save as **LDR_client.ino**

```
#include<ESP8266WiFi.h>          // Including ESP8266 library

char ssid[]="ESP1_Server";       //Network ssid of hotspot of local server
char pass[]="12345678";          // Password of hotspot of local server
int val;
int LDRpin = A0;                 //LDR Pin Connected to A0 pin
IPAddress server(172,16,117,192);          // IP address of local server
WiFiClient client;
```

- Change the IP address of Local Server (i.e. ESP1)
- Change the SSID and Password of WiFi AP hosted in Local Server

- Two functions exist in the programme: setup () and loop ()
  - **setup():** This function runs once when ESP first boots
  - **loop():** This function reads the LDR sensor value and connects to local server then send sends data to local server

Cont…

```
void setup()
{
  Serial.begin(9600);                  // Serial communication at baud rate of 9600 for debugging purpose
  delay(10);
  WiFi.mode(WIFI_STA);                 // ESP8266 in station mode
  Serial.print("Connecting to ");
  Serial.println(ssid);
  WiFi.begin(ssid, pass);
  Serial.println();
  while (WiFi.status() != WL_CONNECTED)
  {
    Serial.print(".");
    delay(500);
  }
  Serial.println();
  Serial.println("WiFi connected");
  Serial.print("LocalIP:"); Serial.println(WiFi.localIP());
  Serial.println("MAC:" + WiFi.macAddress());
  Serial.print("Gateway:"); Serial.println(WiFi.gatewayIP());
  Serial.print("AP MAC:"); Serial.println(WiFi.BSSIDstr());                    // MAC address of access point
}
```

Cont…

```
void loop()
{
   val = analogRead(LDRpin);                    // Reads the light sensor value
   if(client.connect(server,80))                // Connect to local server
   {
      client.print("2\r");                      // before sending data first send ESP8266 ID as 2
      Serial.print("LDR sensor value: ");
      Serial.println(val);
      String LDRval = String(val);
      LDRval += "\r";                           // Add end delimiter
      client.print(LDRval);                     // Send to local server
      Serial.println("Sent to Local Server..");
      delay(15000);
   }
   client.stop();
}
```

ESP8266 with Pulse Sensor

```
#define pulsePin A0                  // Pulse sensor input pin A0
#include<ESP8266WiFi.h>              // Including ESP8266 library

 char ssid[] = "ESP1_Server";        // Replace with SSID of hotspot of local server
 char pass[] = "12345678";           // Replace with password of hotspot of local server
  IPAddress server(172,16,117,192);              // IP address of local server
 WiFiClient client;

 int rate[10];                        // array to hold last ten IBI value
 unsigned long sampleCounter = 0;  // used to determine pulse timing
 unsigned long lastBeatTime = 0;     // used to find IBI
 unsigned long lastTime = 0, N;
 int BPM = 0;                 // int that holds raw analog in 0. updated every 2mS
 int IBI = 0;                // int that holds time interval between beats! Must be seeded!
 int P = 512;                // used to find peak in pulse wave, seeded
 int T = 512;                // used to find trough in pulse wave, seeded
 int thresh = 512;           // used to find instant moment of heart beat, seeded
 int amp = 100;              // used to hold amplitude of pulse waveform, seeded
 int Signal;                 // holds incoming raw data
 boolean Pulse = false;              // "True" when heartbeat is detected. "False" when not a "live beat".
 boolean firstBeat = true;           // used to seed rate array so we startup with reasonable BPM
 boolean secondBeat = true;          // used to seed rate array so we startup with reasonable BPM
 boolean QS = false;                 // Becomes true when ESP8266 finds a beat
```

For **ESP3**, write the following code in the Arduino IDE and save as **Pulse_client.ino**

Cont…

```
void setup()
{
  Serial.begin(9600);                    // Serial communication at baud rate of 9600 for debugging purpose
  delay(10);
  WiFi.mode(WIFI_STA);                   // ESP8266 in station mode
  Serial.print("Connecting to ");
  Serial.println(ssid);
  WiFi.begin(ssid, pass);
  Serial.println();
  while (WiFi.status() != WL_CONNECTED)
  {
    Serial.print(".");
    delay(500);
  }
  Serial.println();
  Serial.println("WiFi connected");
  Serial.print("LocalIP:"); Serial.println(WiFi.localIP());
  Serial.println("MAC:" + WiFi.macAddress());
  Serial.print("Gateway:"); Serial.println(WiFi.gatewayIP());
  Serial.print("AP MAC:"); Serial.println(WiFi.BSSIDstr());      // MAC address of access point
}
```

Cont…

```
void loop(){
  if (QS == true){                                  //if ESP8266 finds a beat
       if (client.connect(server, 80)){             // Connect to local server
         client.print("3\r");                       // before sending data first send ESP8266 ID as 3
         String pulseRate = String(BPM);            // Convert into string
         pulseRate +="\r";                          // Add "r" as end delimiter
         Serial.print("Pulse rate: ");
         Serial.print(BPM);
         Serial.println(" BPM.");
         client.print(pulseRate);                   // send data to local server
         Serial.println("Sent to local server..");
       }
       QS = false;
       client.stop();
       delay(15000);
     }
     else if(millis() >= (lastTime + 2)) {
       readPulse();
       lastTime = millis();
     }
}
```

Cont…

```
void readPulse() {
  Signal = analogRead(pulsePin);              //Read pulse sensor value
  sampleCounter += 2;                         // Keeps track of the time in mS
  int N = sampleCounter - lastBeatTime; // Monitor the time since the last beat to avoid noise
  detectSetHighLow();                         // find the peak and trough of the pulse wave
                                               // Now it's time to look for the heart beat
                                              // signal surges up in value every time there is a pulse
  if(N > 250){                                 // avoid high frequency noise
   if((Signal > thresh) && (Pulse == false) && (N > (IBI/5)*3))
      pulseDetected();
  }
  if (Signal < thresh && Pulse == true) {
    Pulse = false;
    amp = P - T;
    thresh = amp / 2 + T;
    P = thresh;
    T = thresh;
  }
  if (N > 2500) {
    thresh = 512;
    P = 512;
    T = 512;
    lastBeatTime = sampleCounter;
    firstBeat = true;
    secondBeat = true;
   }
}
```

```
void detectSetHighLow() {
   if(Signal < thresh && N > (IBI/5)* 3)
                // avoid dichrotic noise by waiting 3/5 of last IBI
    {
      if (Signal < T) {          // T is the trough
        T = Signal;              // Keep track of lowest point in pulse wave
      }
    }
   if (Signal > thresh && Signal > P) // thresh condition helps avoid noise
    {
      P = Signal;                // P is the peak
    }                             // Keep track of highest point in pulse wave
}
```

Cont…

```
void pulseDetected()
{
  Pulse = true;          // set the pulse flag when there is a pulse
  IBI = sampleCounter - lastBeatTime; // time between beats in mS
  lastBeatTime = sampleCounter;       //keep track of time for next pulse
  if (firstBeat)                      // if it's the first time beat is found
  {
    firstBeat = false;           //clear firstBeat flag
    return;
   }
  if (secondBeat)                 // if this is second beat
  {
     secondBeat = false;   // clear secondBeat flag
     for (int i = 0; i <= 9; i++)
     {
       rate[i] = IBI;
     }
   }
   word runningTotal = 0; // clear the runningTotal variable
   for (int i = 0; i <= 8; i++) //Shift data in the rate array
   {
    rate[i] = rate[i + 1];        // and drop the oldest IBI value
    runningTotal += rate[i];   // add up the 9 oldest IBI value
   }
   rate[9] = IBI;               // add the latest IBI to the rate array
   runningTotal += rate[9];    //add the latest IBI to runningTotal
   runningTotal /= 10;          // average the last 10 IBI values
    BPM = 60000 / runningTotal;
    // how many beats can fit into a minute? that's BPM!
    QS = true;
    if (client.connect(server, 80))  //Connects to local server
    {
      client.print("3\r");
                  //before sending the data sends ESP8266 ID as 3
      String pulseRate = String(BPM);
                  // Converting integer data into string
      pulseRate +="\r";
                  // Add end Delimiter "r" in the data
      Serial.print("Pulse rate: ");
      Serial.print(BPM);
      Serial.println(" BPM.");
      client.print(pulseRate);       //sends data to locals server
      Serial.println("Sent to local server..");
    }
    client.stop();
    delay(15000);
                  // Wait for 15 seconds after each transmission
}
```

ESP8266 with Vibration Sensor

For **ESP4**, write the following code in the Arduino IDE and save as **Vibration_client.ino**

```
#include <ESP8266WiFi.h>          // Including ESP8266 library
#define vib A0                    // sensor input from A0 pin of ESP8266

 char ssid[] = "ESP1_Server";     //Replace with SSID of hotspot of local server
 char pass[] = "12345678";        // Replace with password of hotspot of local server

IPAddress server(172,16,117,192);          // IP address of local server
WiFiClient client;
```

- Change the IP address of Local Server (i.e. ESP1)
- Change the SSID and Password of WiFi AP hosted in Local Server

Cont…

```
void setup(){
   Serial.begin(9600);                  // Serial communication at baud rate of 9600 for debugging purpose
   delay(10);
   pinMode(vib, INPUT);                 // Input of vibration sensor
   WiFi.mode(WIFI_STA);                 // ESP8266 as station mode
   Serial.print("Connecting to ");
   Serial.println(ssid);
   WiFi.begin(ssid, pass);
   Serial.println();
   while (WiFi.status() != WL_CONNECTED)   {
      Serial.print(".");
      delay(500);
   }
   Serial.println();
   Serial.println("WiFi connected");
   Serial.print("LocalIP:"); Serial.println(WiFi.localIP());        // IP address of local server
   Serial.println("MAC:" + WiFi.macAddress());
   Serial.print("Gateway:"); Serial.println(WiFi.gatewayIP());
   Serial.print("AP MAC:"); Serial.println(WiFi.BSSIDstr());    // MAC address of access point
}
```

Cont…

```
void loop(){
   int val = analogRead(vib);            // Reads the sensor value
   if(client.connect(server,80))         //connects to local server
   {
     client.print("4\r");                 // Before sending the data sends ESP8266 ID as 4
     Serial.print("Vibration sensor value: ");
     Serial.println(val);
     String data = String(val);          // Converting integer data into string type
     data += "\r";                       // Add end delimiter "r" in the data
     client.print(data);                 // sends sensor data to local server
     Serial.println("Sent to Local server..!! ");
     delay(15000);                                  // After each transmission wait for 15 seconds
     client.stop();
   }
}
```

ESP8266 with DHT11 Sensor

For **ESP5**, write the following code in the Arduino IDE and save as **Temp_Humidity_Client.ino**

```
#include<DHT.h>                    //Including temperature and Humidity sensor library
#include<ESP8266WiFi.h>            //Including ESP8266 library
#define DHTPIN 0                   // D3 pin of ESP8266

char ssid[] = "ESP1_Server";       //Replace with ssid of hotspot of local server
char pass[] = "12345678";          // Replace with password of hotspot of local server

IPAddress server(172,16,117,192); // Static IP address of local server. Replace whatever you want.
WiFiClient client;

DHT dht(DHTPIN, DHT11);            // Data of DHT11 sensor in D3 pin of ESP8266
```

- Change the IP address of Local Server (i.e. ESP1)
- Change the SSID and Password of WiFi AP hosted in Local Server

- Install the **DHT11** library and **Adafruit Unified Sensor** library for DHT11 sensor

Cont…

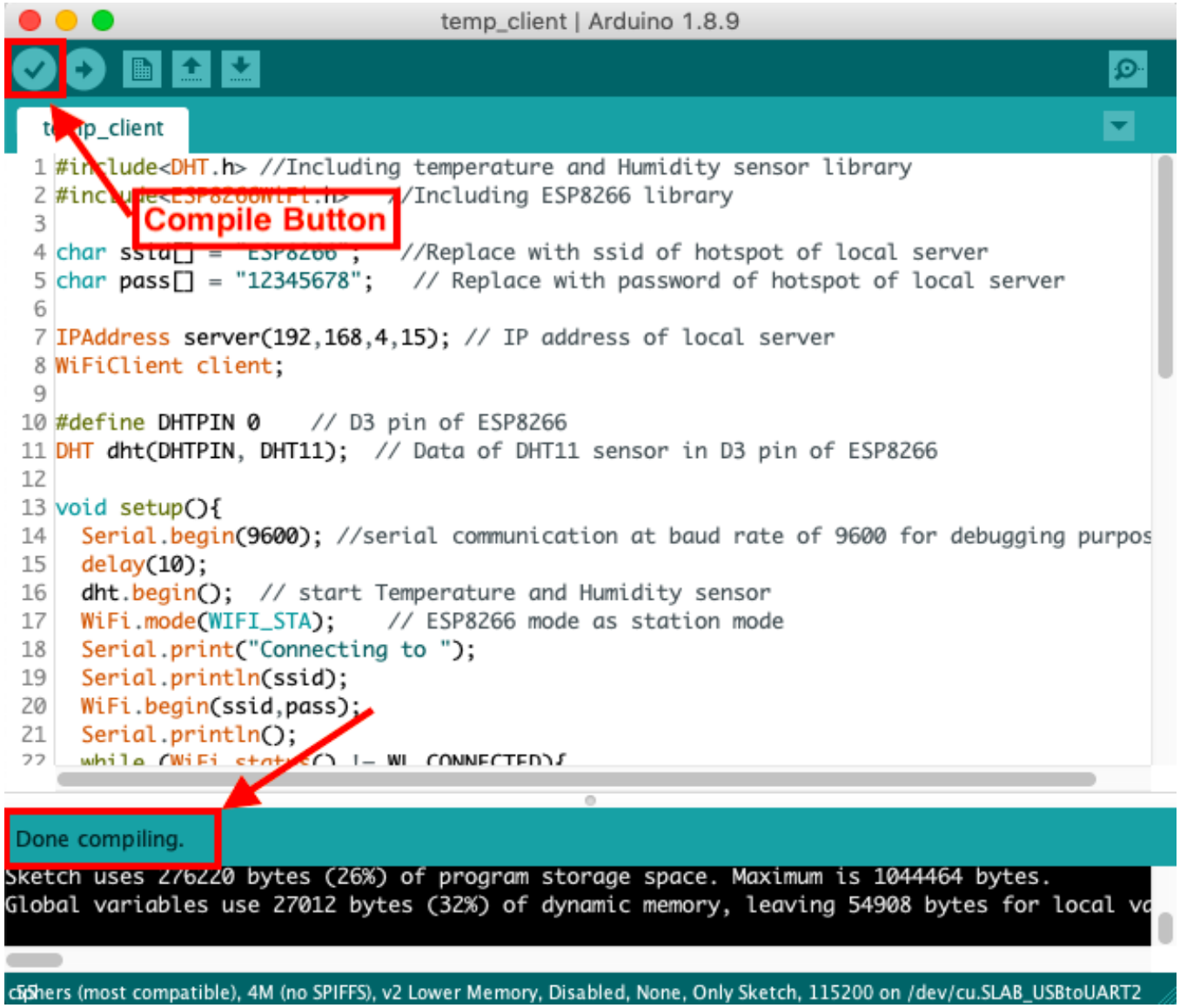
```
void setup() {
   Serial.begin(9600);                  //serial communication at baud rate of 9600 for debugging purpose
   delay(10);
   dht.begin();                         // start Temperature and Humidity sensor
   WiFi.mode(WIFI_STA);                 // ESP8266 mode as station mode
   Serial.print("Connecting to ");
   Serial.println(ssid);
   WiFi.begin(ssid, pass);
   Serial.println();
   while (WiFi.status() != WL_CONNECTED)   {
     Serial.print(".");
     delay(500);
   }
   Serial.println();
   Serial.println("WiFi connected");
   Serial.print("LocalIP:"); Serial.println(WiFi.localIP());
   Serial.println("MAC:" + WiFi.macAddress());
   Serial.print("Gateway:"); Serial.println(WiFi.gatewayIP());
   Serial.print("AP MAC:"); Serial.println(WiFi.BSSIDstr());    // MAC address of access point
}
```

Cont…

```
void loop() {
   float h = dht.readHumidity();              // Read Humidity value from sensor
   float t = dht.readTemperature();           // Read temp value from sensor
   if(isnan(h) || isnan(t))    {
      Serial.println("Failed to read from DHT sensor");                    // Error message
      return;
   }
   if(client.connect(server,80))              // Connect to local server
   {
      client.print("5\r");                    // before sending the data first send ESP8266 ID as 5
      String temp = String(t);
      temp += "\r";                           // Add "r" as end delimiter
      client.print(temp);                     //  send temperature to local server
      Serial.print("Temperature: ");
      Serial.print(t);
      Serial.print(" degree celsius, Humidity: ");
      Serial.print(h);
      Serial.print("%. ");
      String humidity = String(h);
      humidity += "\r";                       // Add "r" in data as end delimiter
      client.print(humidity);                 // send to Local server
      Serial.println("Sent to local server ");
      delay(15000);                           // delay of 15sec after each transmission
   }
   client.stop();
}
```

Code Compilation and Upload

Code Compilation

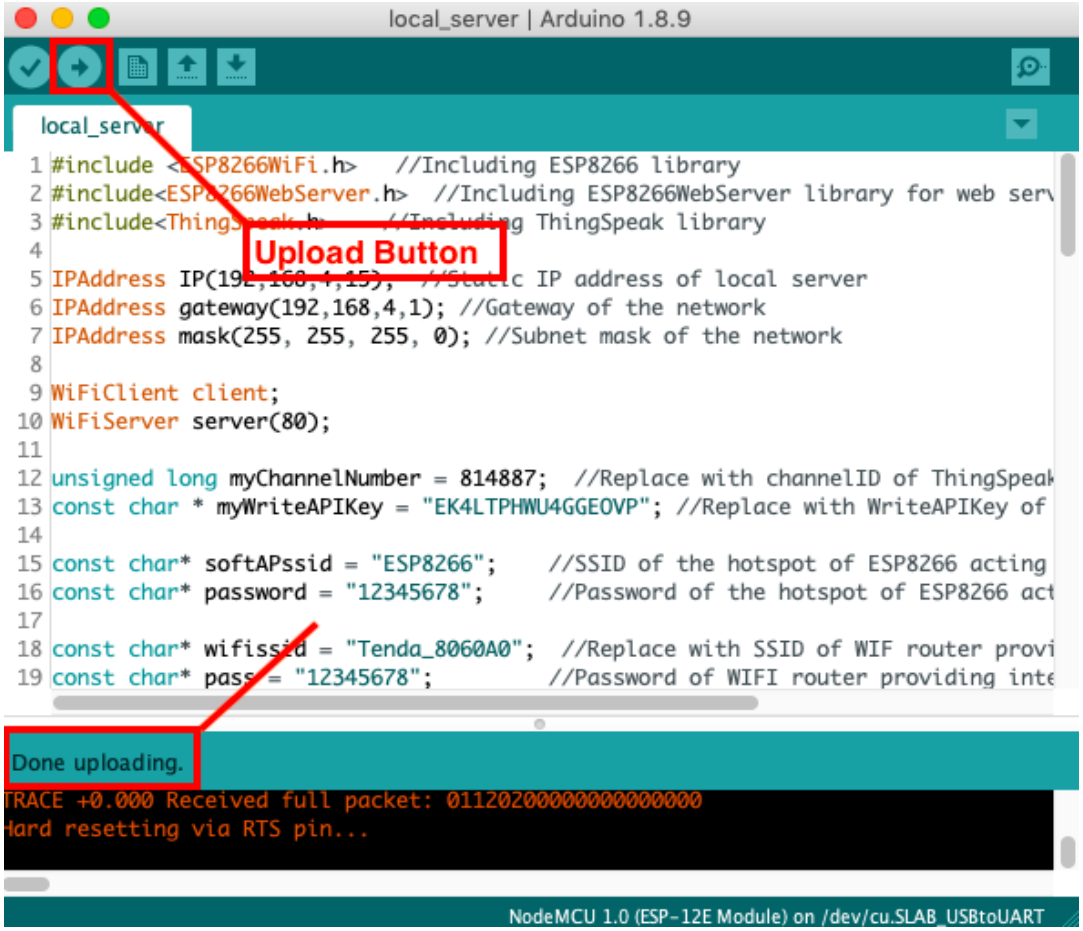


Compilation successful message in bottom left corner.

Code Uploading

- Plug in the ESP8266 boards one by one to PC/Laptop via USB cable
- Go to **Tool** menu, select Board "**NodeMCU 1.0 (ESP-12E Module)"** and Port "**COM3"**.
- Open the corresponding code and do uploading code in Node MCU.

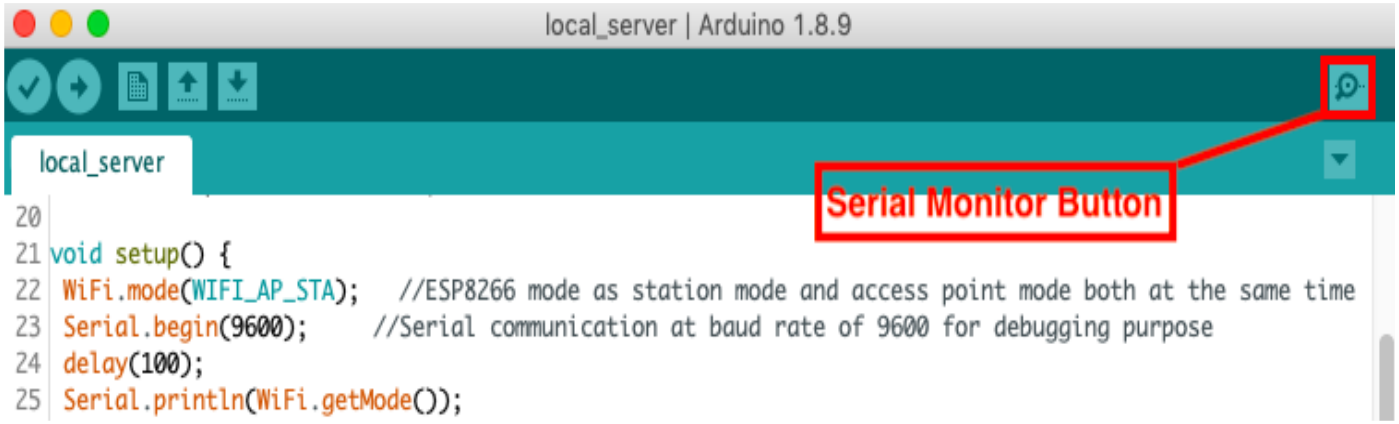
Note: If COM port is not detected automatically then it is needed to install. Download port drivers from the given link and then install and then restart the system: https://www.silabs.com/products/development-tools/software/usb-to-uart-bridge-vcp-drivers



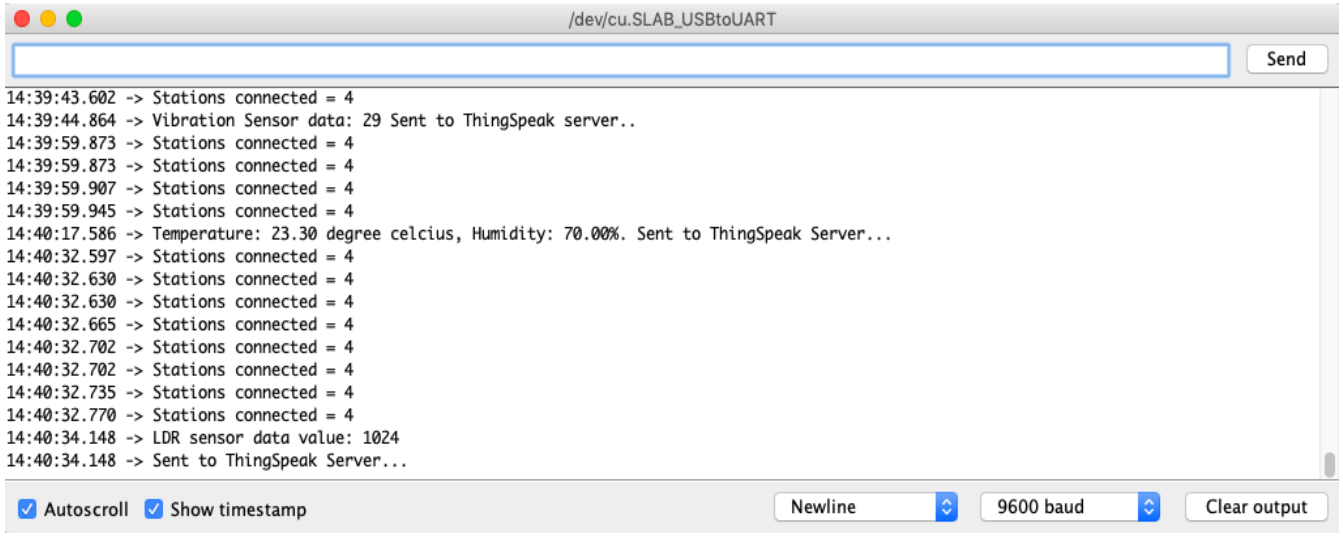
Observe Outputs

Open Serial Monitor

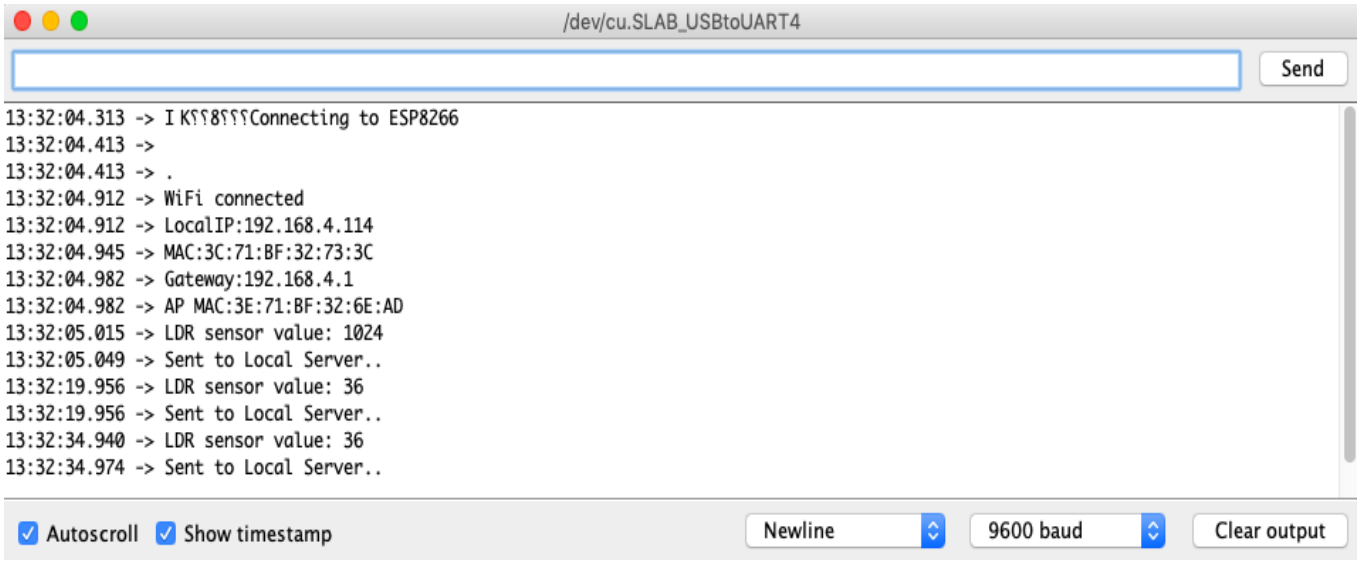
- First **select the port** (go to Tools > Port:) to which the board is connected then click the icon of **Serial Monitor** on the top right side of the Arduino IDE



Serial Monitor of Local Server

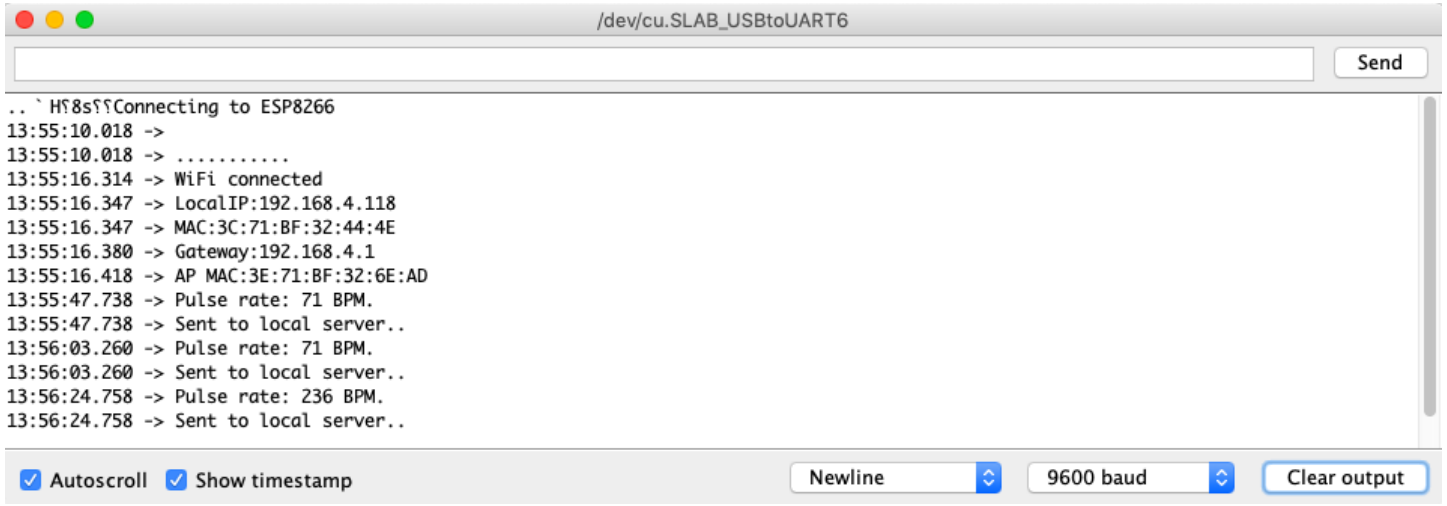


Cont…

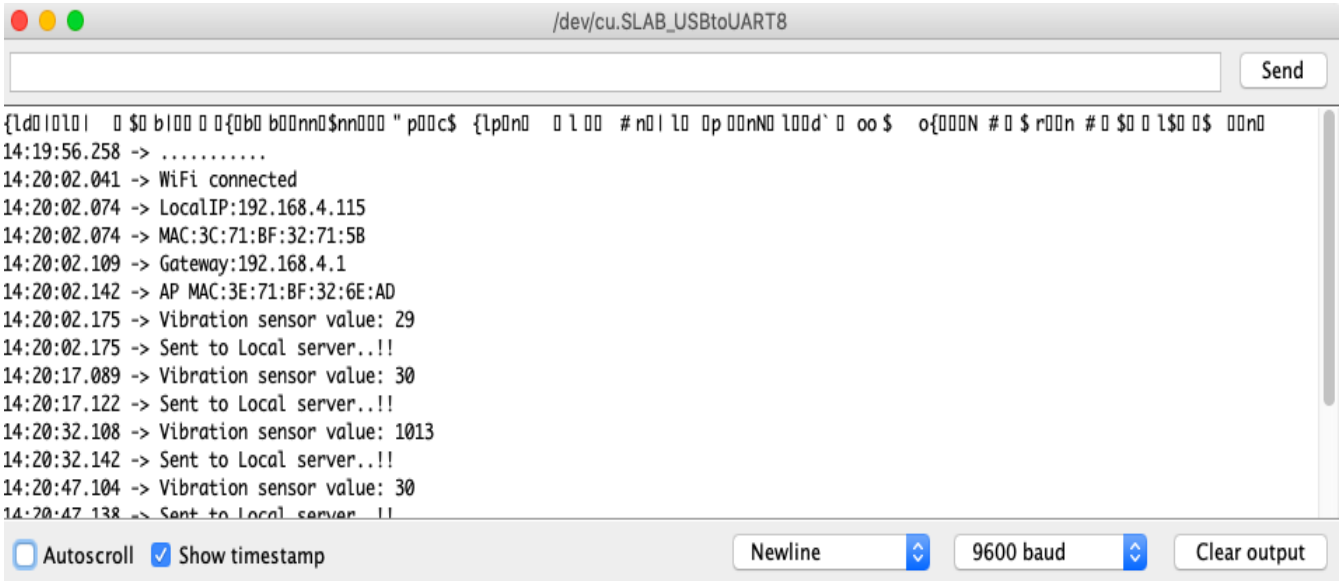


Serial Monitor of ESP2

Serial Monitor of ESP3

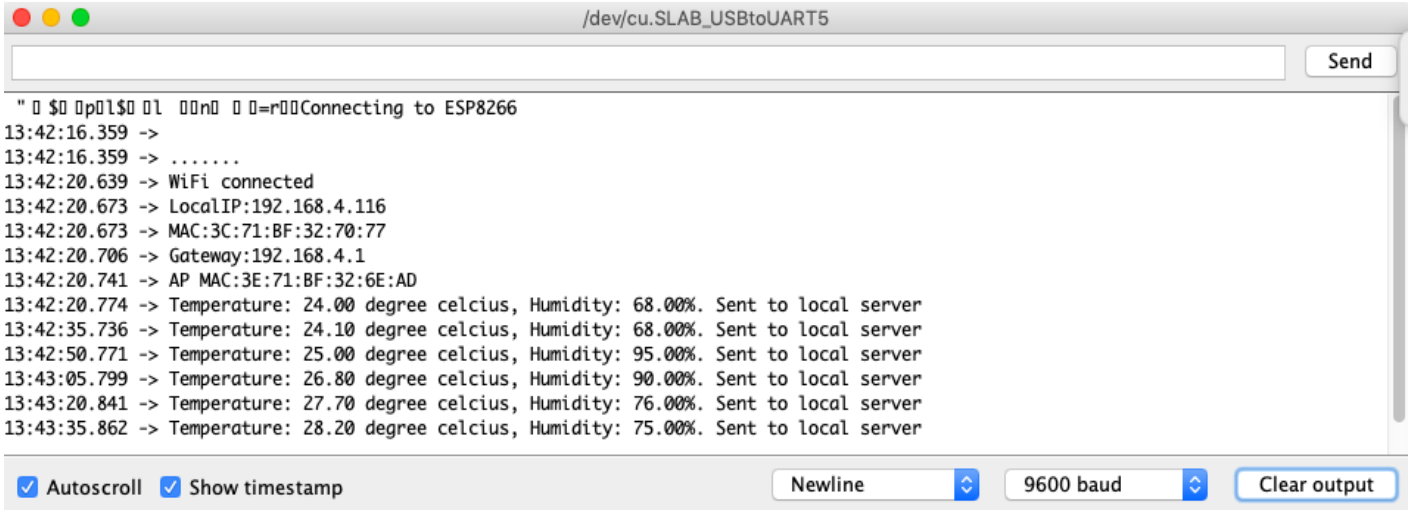


Cont…



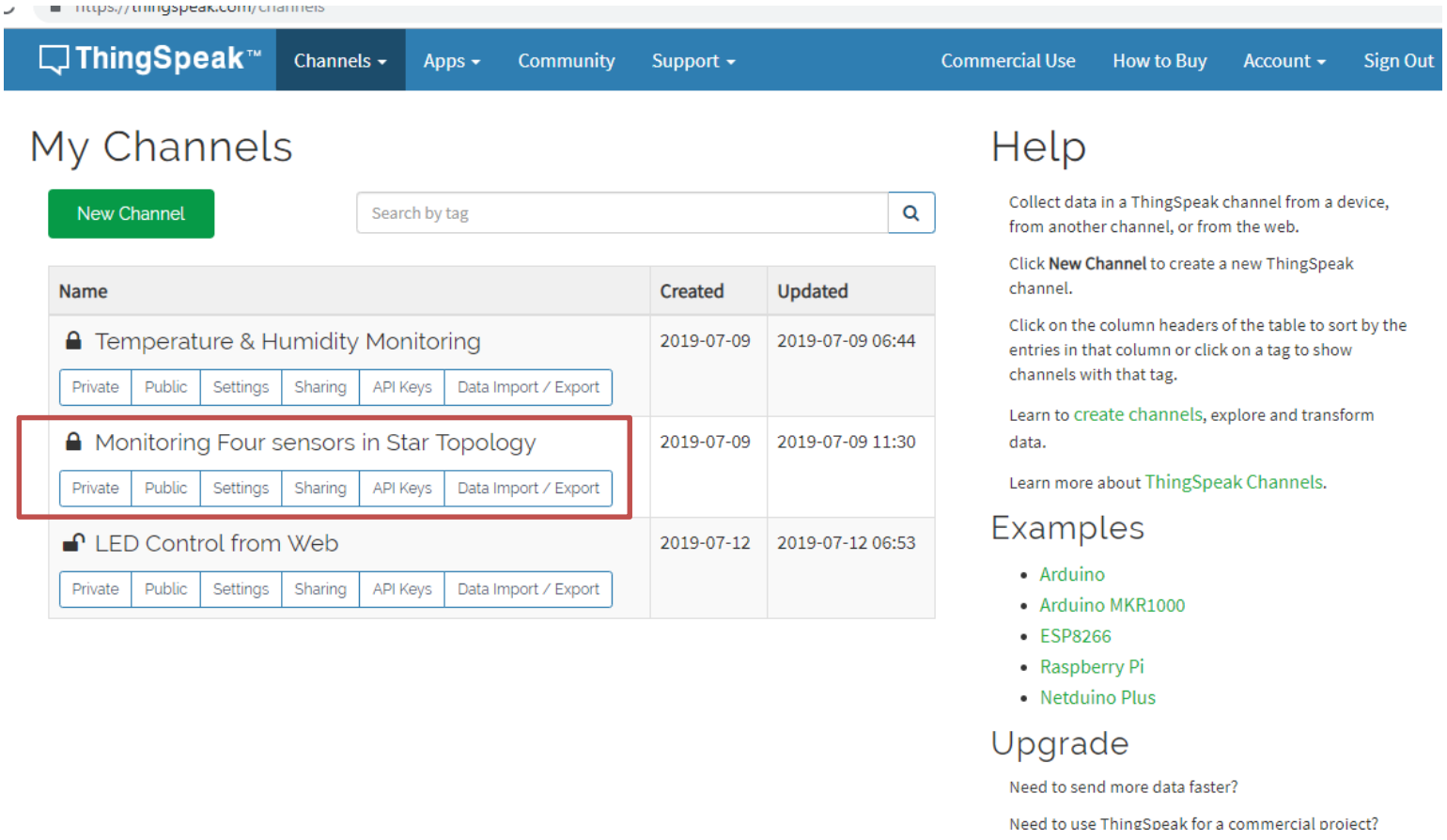
Serial Monitor of ESP4

Serial Monitor of ESP5



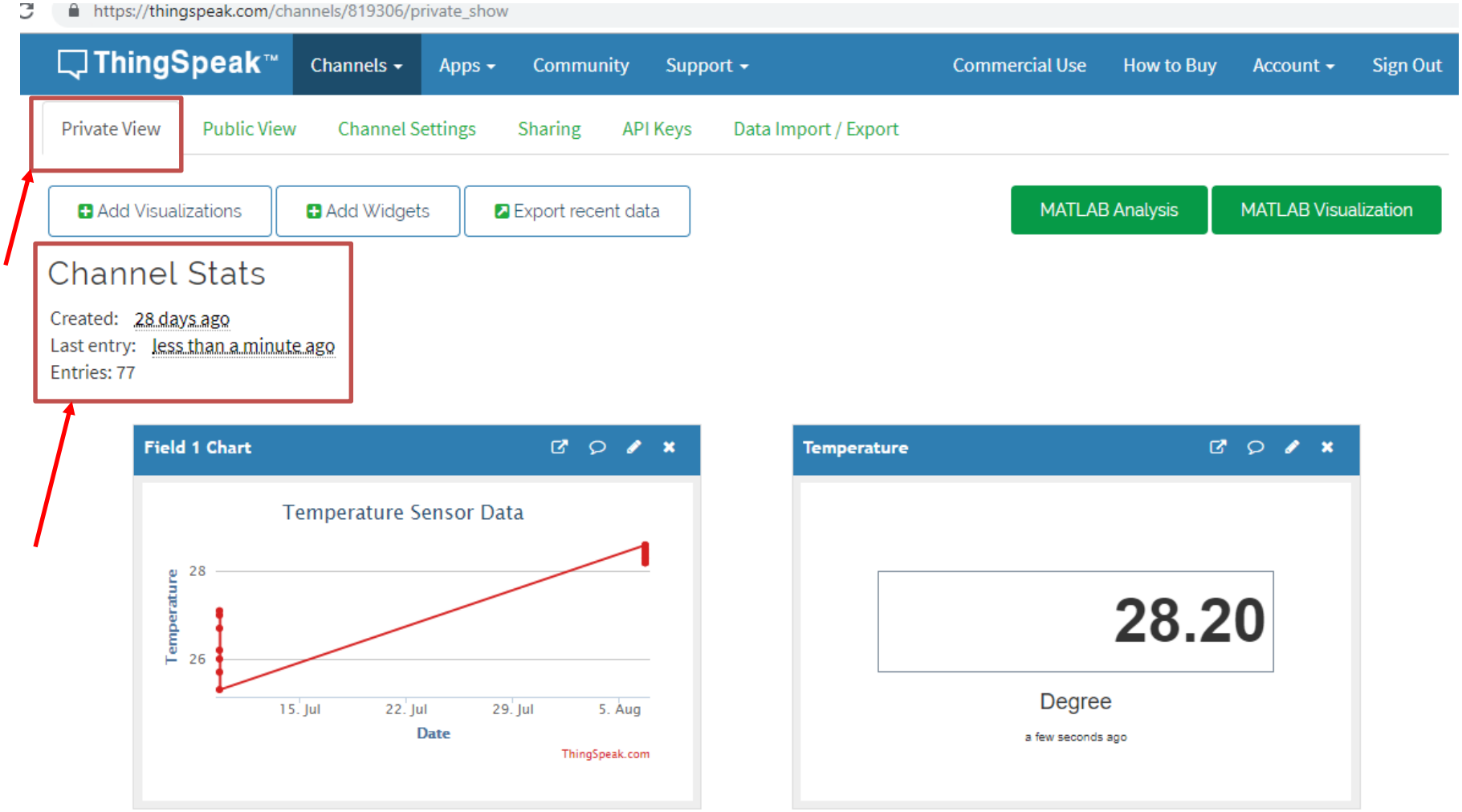
Results & Graphs in Web

- Open the ThingSpeak page and click on **Channels > My channels**
- Now select the channel that is created for this experiment (In this case '**Monitoring Four Sensors in Star Topology**').



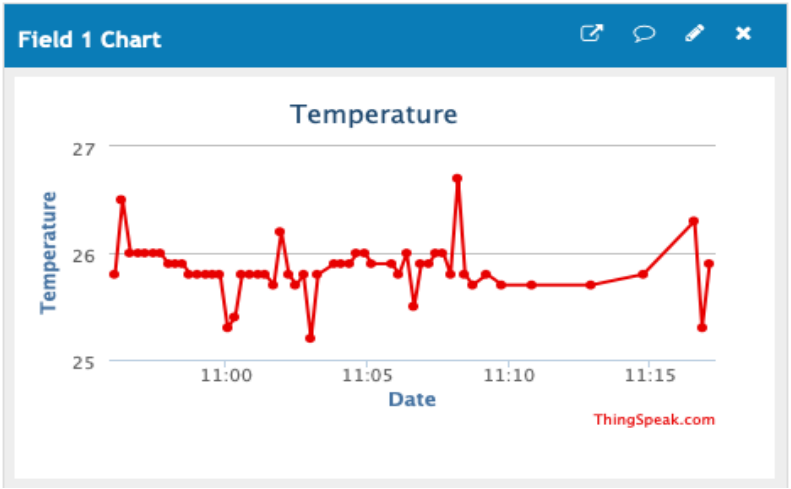
Cont…

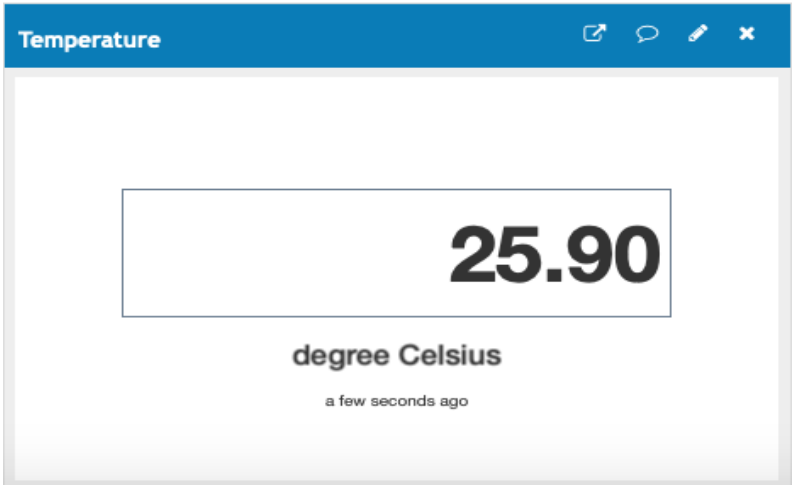
- click on '**Private View**' to see the uploaded data

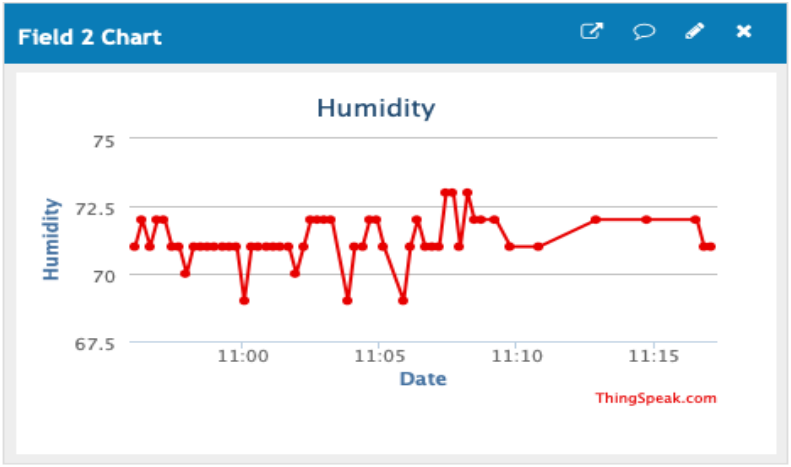


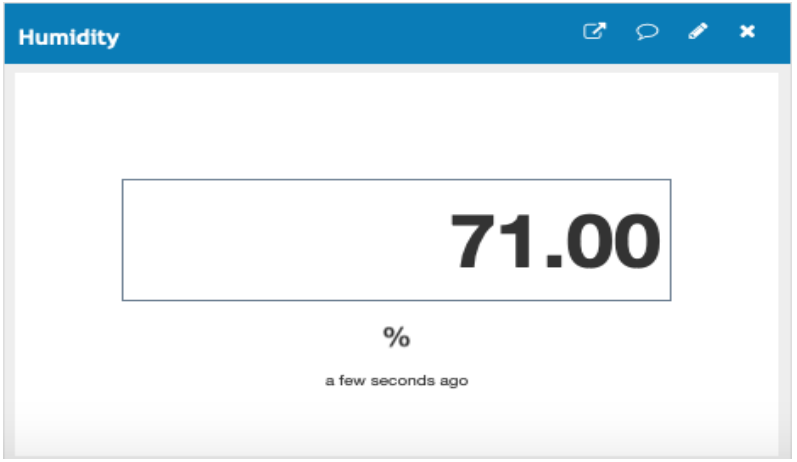
Cont…

- Temperature and Humidity







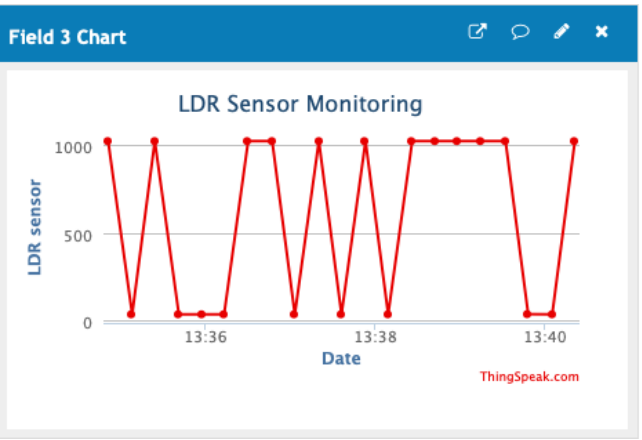


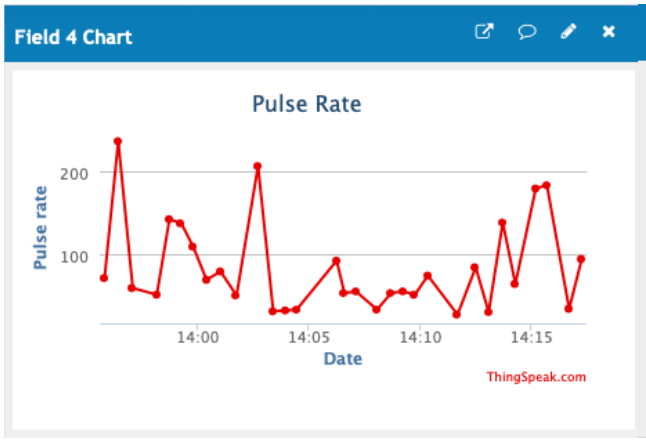
Cont…

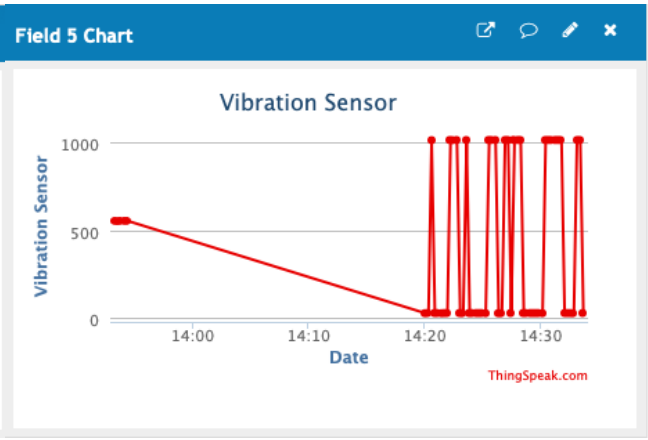
Light Sensor

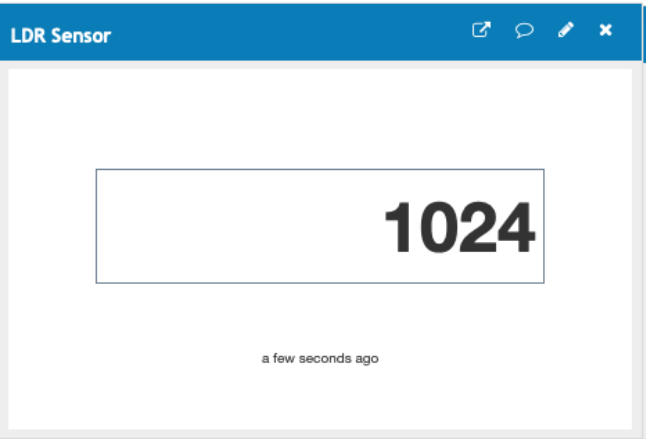
Pulse Sensor

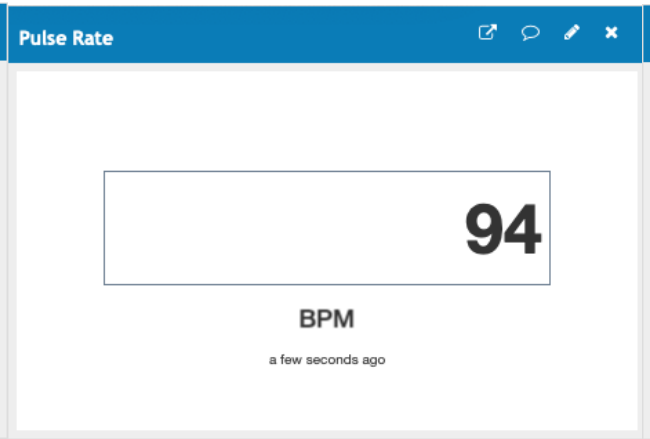
Vibration Sensor

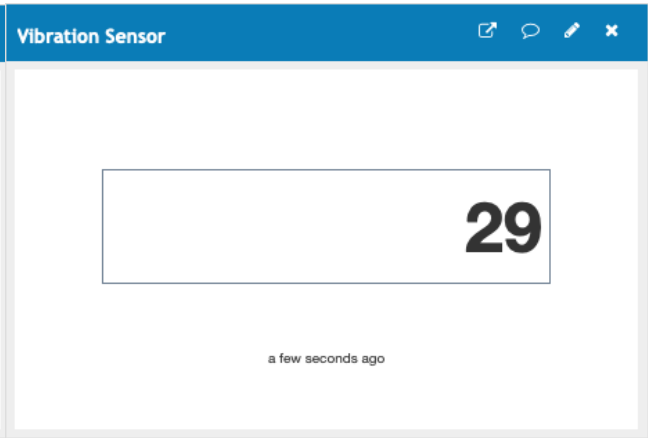












Thanks!