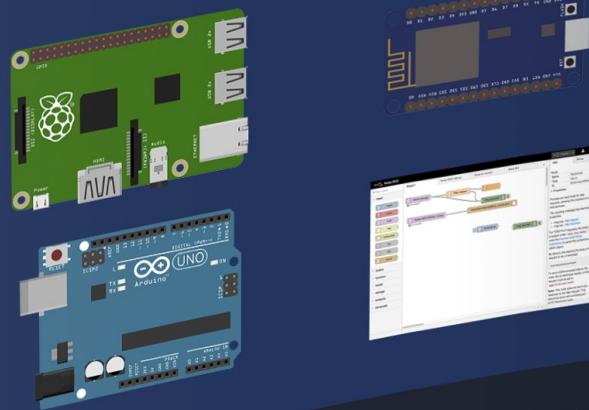


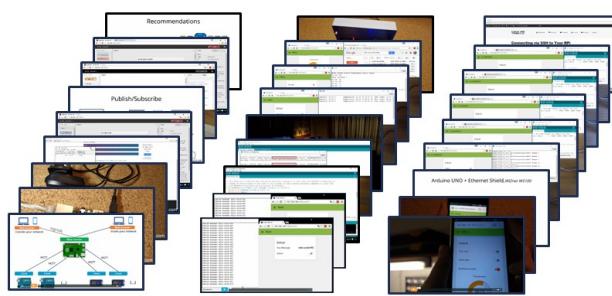
BUILD A HOME AUTOMATION SYSTEM FOR \$100

Learn Raspberry Pi, ESP8266, Arduino and Node-RED



This is a premium step-by-step course to get you building a real world home automation system using open-source hardware and software

Written by Rui Santos



VERSION 1.9

Security Notice

This is the kind of thing I hate having to write about, but the evidence is clear: piracy for digital products is over all the internet.

For that reason, I've taken certain steps to protect my intellectual property contained in this eBook.

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- <https://randomnerdtutorials.com/products>
- <https://rntlab.com>

Please send an email to the author (Rui Santos - hello@ruisantos.me), if you found this eBook anywhere else.

What I really want to say is thank you for purchasing this eBook and I hope you have fun with it!

Disclaimer

This eBook has been written for information purposes only. Every effort has been made to make this eBook as complete and accurate as possible. The purpose of this eBook is to educate. The author (Rui Santos) does not warrant that the information contained in this eBook is fully complete and shall not be responsible for any errors or omissions.

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Other helpful links

- [Join Private Facebook Group](#)
- [Terms and Conditions](#)

About the Author

Hey there!

Thank you for purchasing my course "[Build a Home Automation System for \\$100](#)"!

I'm Rui Santos, founder of the [Random Nerd Tutorials blog](#), [MakerAdvisor.com](#), [RNTLab.com](#) and author of [BeagleBone For Dummies](#).

If you're new to the world of Home Automation, this eBook is perfect for you! If you are already familiar with what Home Automation allows you to do, I'm sure you'll also learn something new.

This eBook contains the information you need to get up to speed quickly and start your own venture with the open-source hardware and software! Learn Raspberry Pi, ESP8266, Arduino and Node-RED.

Thanks for reading,

Rui Santos

P.S. If you would like the longer version of my story, you can find it over [here](#).



Join the Private Facebook Group

This eBook comes with an opportunity to join a private community of like-minded people. If you purchased this eBook, you can join our private Facebook Group today!

Inside that group you can ask questions and create discussions about everything related to ESP8266, Arduino, Raspberry Pi, Node-RED, etc.

See it for yourself!

- Step #1: Go to -> <http://randomnerdtutorials.com/fb>
- Step #2: Click “Join Group” button
- Step #3: I’ll approve your request within less than 24 hours

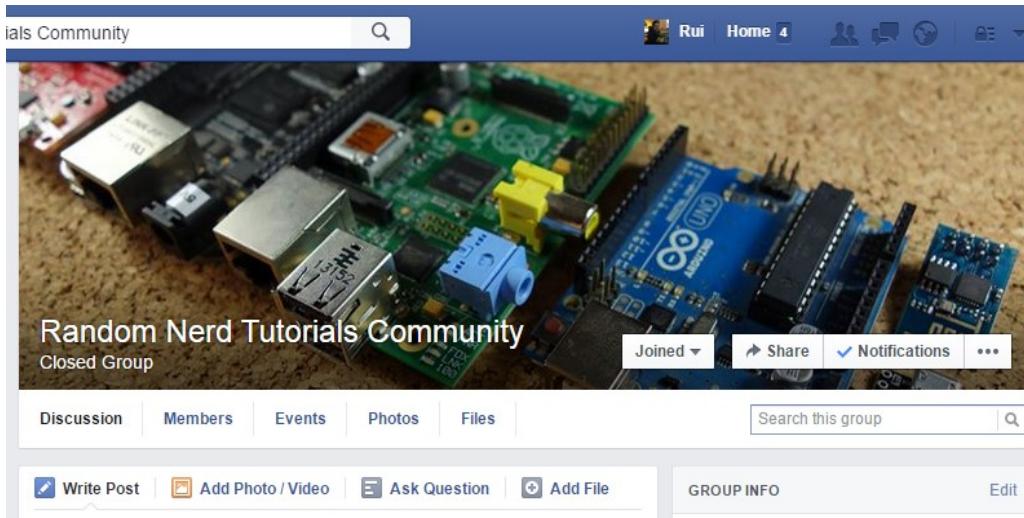


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How to Watch the Videos

The Build a Home Automation System for \$100 course comes with video demonstrations and tutorials.

To watch the companion video tutorials, go to this link: <https://rntlab.com/watch-has-videos> and login with your account.

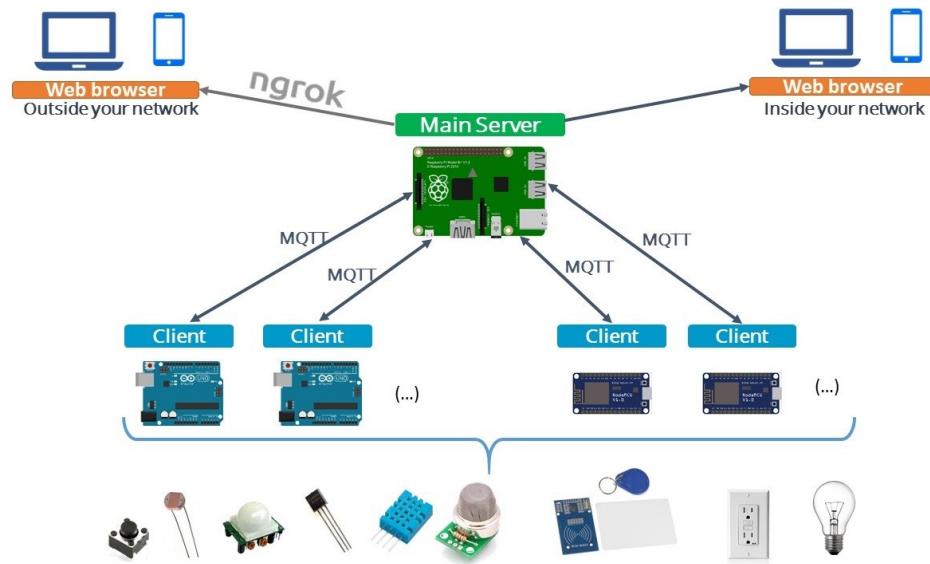
Each video is numbered, so you can easily find the video that you're looking for.

Forgot password? Reset your account here: <https://rntlab.com/login>

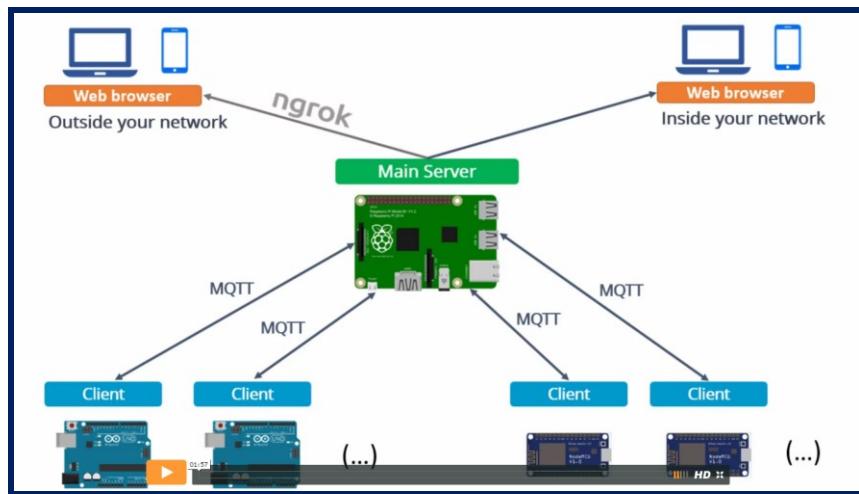
Click here to Watch the Videos
<https://rntlab.com/watch-has-videos>

MODULE 1

Getting Started with the Raspberry Pi



Unit 1 - Course Overview



Video # 1 – <https://rntlab.com/watch-has-videos>

Hi there!

Welcome to the **Build a Home Automation System for \$100** course.

A hands-on introductory course designed to teach you how to build a complete home automation system using open-source hardware and software.

This course is designed for people who find home automation or internet of things (IoT) subject interesting.

There's no previous knowledge required to complete the course. If I think that there is something extra that you need to learn during the course, I'll point you to the right resource.

The course contains video, image and text. So, it is straightforward to follow.

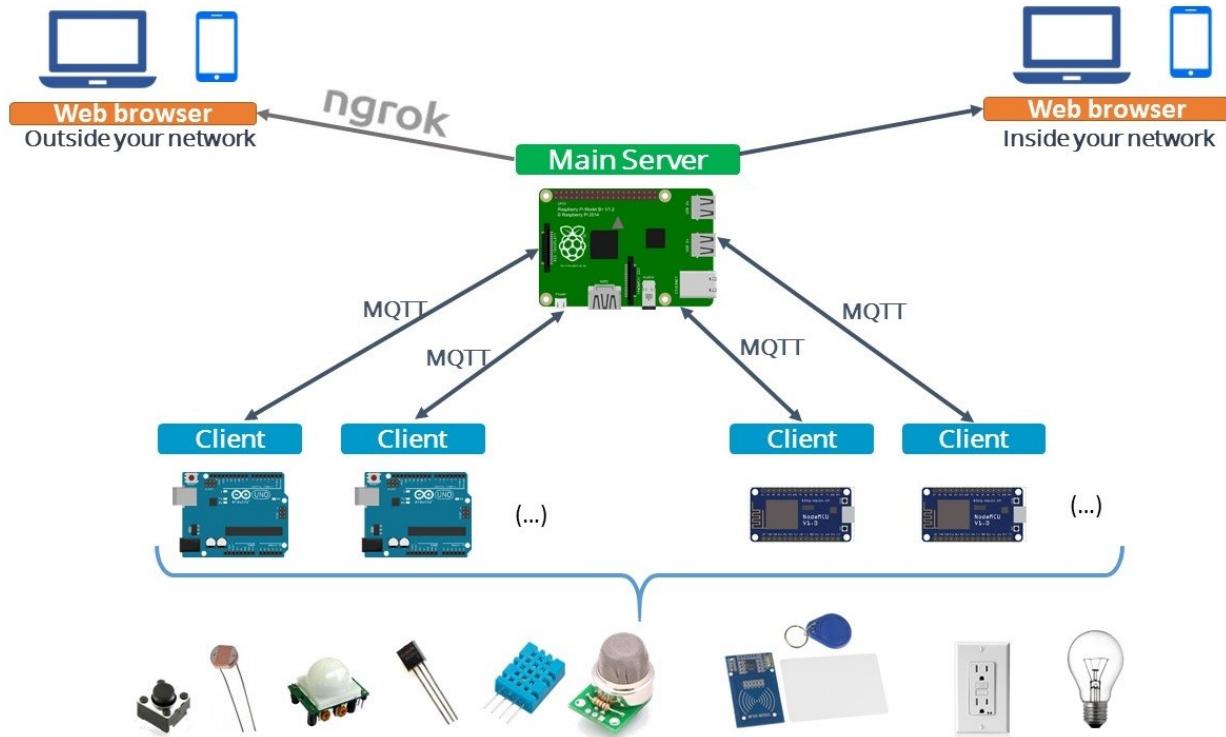
About Home Automation

Home automation can include the scheduling and automatic operation of lighting, heating, air conditioning, window blinds, security systems and more. Home automation may also allow vital home functions to be controlled remotely from anywhere in the world using any device with a browser that has an Internet connection.

Application Overview

By the end of the course, you'll have a home automation application running on your RPi that allows you to monitor and control various devices in your house.

Here's a quick overview of the application that we're going to build.



The brain of the operation is the Raspberry Pi. Any Raspberry Pi Model B will work. You'll need to install the Operating System (Raspbian) and some software in your Pi.

You'll learn how to connect the Arduino and the ESP8266 development boards to your Raspberry. They are going to talk via a protocol called MQTT.

You'll access your application from any web browser: whether it's using a laptop, a tablet or your smartphone. Your application will be accessible from anywhere using a secure tunnel.

Unit 2 - List of Components and Parts

The following list shows all the components and parts required to complete the Build a Home Automation System for \$100 course.

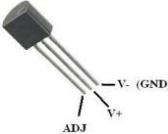
Don't worry, you don't need to buy all the components right away, because during the course I will mention the exact parts you need for each project.

List of Components and Parts

Note: I recommend the Raspberry Pi 3 Model B, but you can use the Raspberry Pi 1/2 Model B or the Raspberry Pi Model B+.

Figure	Name	Check Price
	Raspberry Pi 3 Model B Recommended	Find best price on Maker Advisor Or read our Best Raspberry Pi 3 Starter Kits post
	Raspberry Pi 2 Model B Alternative	Don't buy this board, but you can use it if you already have one
	Raspberry Pi 1 Model B/B+ Alternative	Don't buy this board, but you can use it if you already have one
	5V DC Power Supply	Find best price on Maker Advisor
	MicroSD Card 8Gb or 16GB Class 10	Find best price on Maker Advisor

	Ethernet Cable	You probably already have this cable
	Breadboard	Find best price on Maker Advisor
	Jumper Wires - Female to Male and Male to Male	Find best price on Maker Advisor
	LEDs	Find best price on Maker Advisor
	Resistors	Find best price on Maker Advisor
	ESP8266-12E	Find best price on Maker Advisor
	433MHz Remote Controlled Sockets	Make sure you buy the right plug for your country and that operates at 433MHz (read the product description and look for the remote frequency specification) Find best price on Maker Advisor
	1x 433MHz Receiver and 2x 433MHz Transmitter	Find best price on Maker Advisor

	1x Buzzer	Find best price on Maker Advisor
	Arduino UNO	Find best price on Maker Advisor
	DHT11 Temperature and Humidity Sensor	Find best price on Maker Advisor
	PIR Motion Sensor	Find best price on Maker Advisor
	MQ-2 Gas Sensor	Find best price on Maker Advisor
	Project Box Enclosure	Find best price on Maker Advisor
	Ethernet Shield (WIZnet W5100)	Find best price on Maker Advisor
	LM335 Temperature Sensor	Find best price on Maker Advisor
	Light-dependent Resistor (LDR)	Find best price on Maker Advisor

Unit 3 - Read This Before You Continue

I truly appreciate you taking the time to study this topic, and I hope that you will enjoy the Build a Home Automation System course.

Problems during the course

As you go through the course, it is likely that you will encounter some sort of technical problem.

I highly encourage you to spend a bit of time trying to fix technical problems by yourself. Fixing technical problems, yourself is a very good way to learn a new subject. If you're encountering an error, I recommend searching on Google that exact error and it's very likely that someone else had that problem and posted the solution.

If you have done your best, you can always rely on the community to help you out. You can join the [Facebook Group](#) to get in touch.

MODULE 2

Installing the Operating System



```
pi@raspberrypi: ~
pi@raspberrypi:~ $ sudo reboot
Broadcast message from pi@raspberrypi on pts/0 (Wed 2015-12-30 19:35:15 UTC):
The system is going down for reboot NOW!
pi@raspberrypi:~ $ [
```

Unit 1 - Choosing and Downloading the Operating System



Video # 2 - <https://rntlab.com/watch-has-videos>

In this module, I'll show you how to download and prepare your Raspberry Pi with the latest version of the **Raspbian Lite** Operating System (OS).

The Raspberry Pi is a computer and like any other computer it needs an OS installed.

The Pi doesn't have built-in memory, so you'll need a microSD card to install your OS. I recommend using a microSD card class 10 with at least 8GB of memory.



If you go to the Raspberry Pi website and you open the downloads section: <https://www.raspberrypi.org/downloads>. You'll find all the official Operating Systems that you can download.

I recommend using **Raspbian**, because it is the most supported OS by the Raspberry Pi community. Throughout this course we're going to use **Raspbian Lite**.



RASPBIAN

Why Raspbian Lite?

Because it is a lightweight version of the Raspbian and it doesn't have a graphical user interface installed. This means that it doesn't have any unnecessary software installed that we don't need for our projects, so this makes it the perfect solution for our home automation project.

Click the **Download ZIP button** to download the Raspbian Lite Operating System.

The screenshot shows the Raspbian Stretch Lite download page. On the left is a graphic of a microSD card with the Raspbian logo on it. To the right, the text "RASPBIAN STRETCH LITE" is displayed in large, bold, black capital letters. Below it, in smaller text, is "Minimal image based on Debian Stretch". A table follows, listing the version as "September 2017", the release date as "2017-09-07", the kernel version as "4.9", and a link to "Release notes". At the bottom are two red buttons: one for "Download Torrent" and one for "Download ZIP".

Version:	September 2017
Release date:	2017-09-07
Kernel version:	4.9
Release notes:	Link

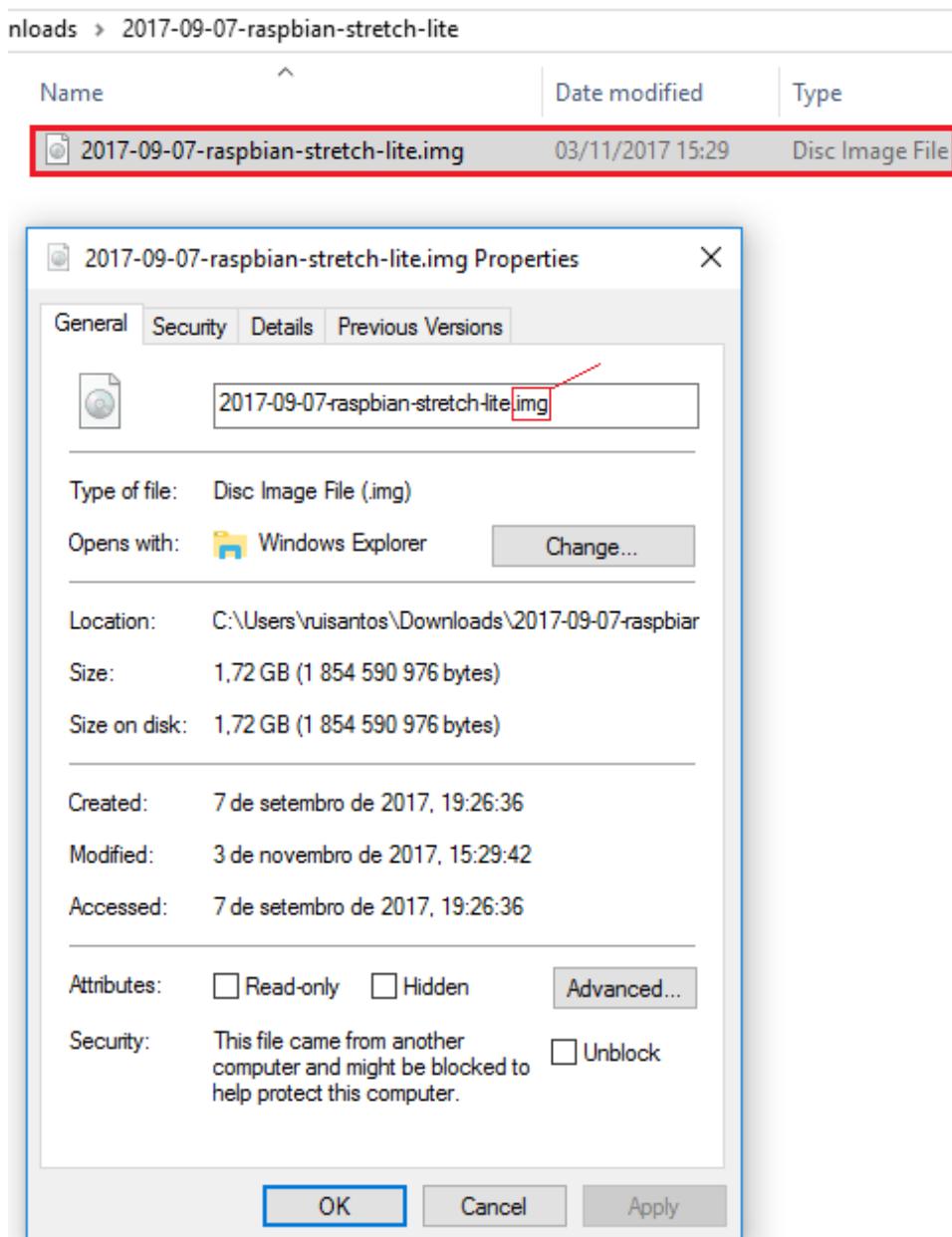
[Download Torrent](#) | [Download ZIP](#)

In the next Unit I'll show you how to prepare your microSD Card.

Unit 2 - Installing Raspbian Lite in Your MicroSD Card

After downloading the Raspbian Lite OS, you should have a **.zip** file in your **Downloads** folder.

Unzip it and inside you'll find a **.img** file (as shown in the Figure below).

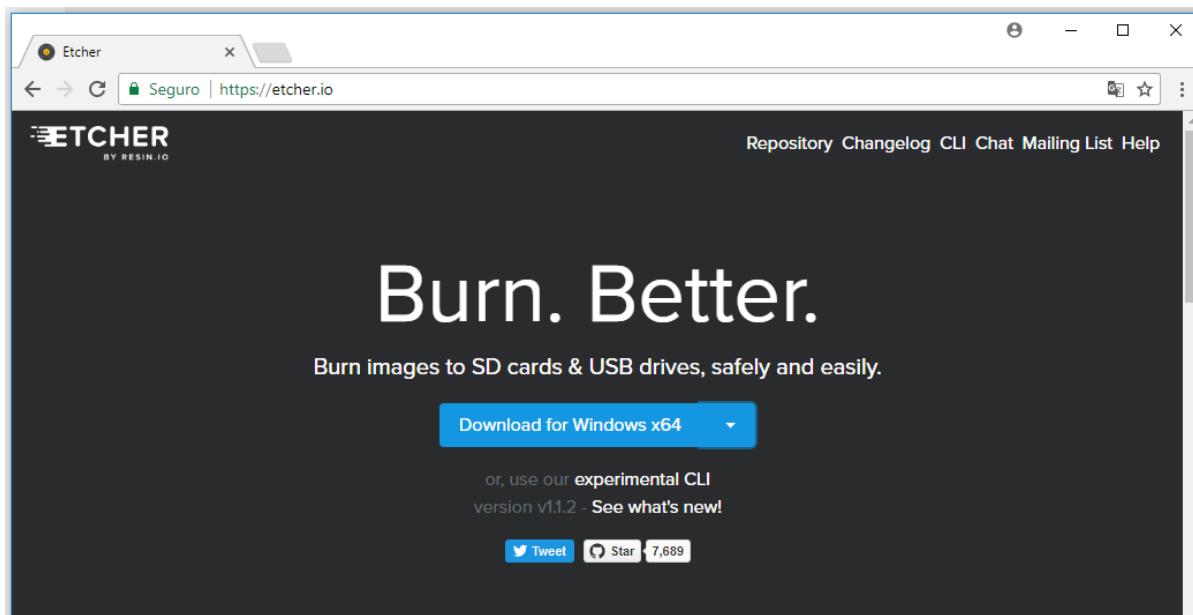


Downloading Etcher

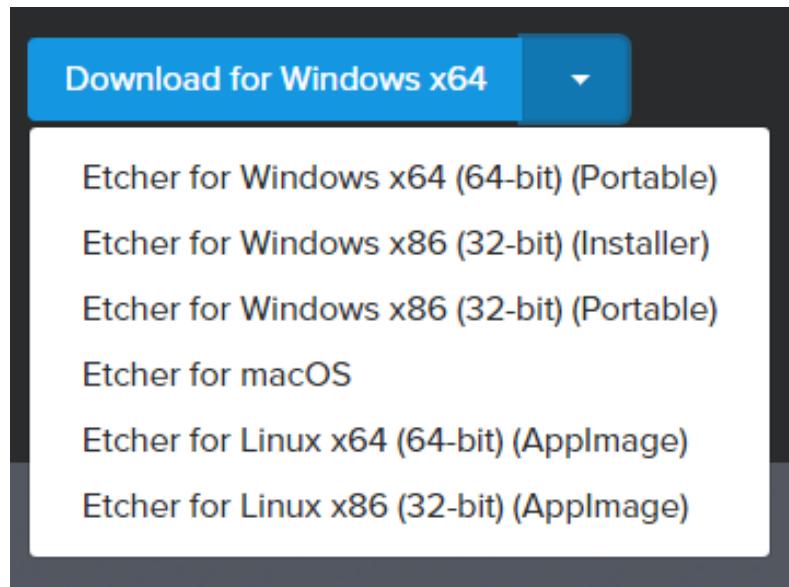
To flash your microSD Card with a **.img** file with your computer, it requires an application called **Etcher**, which is available for free download.

Follow these steps to install it:

- 1) Go to the Etcher.io website at <https://etcher.io/>

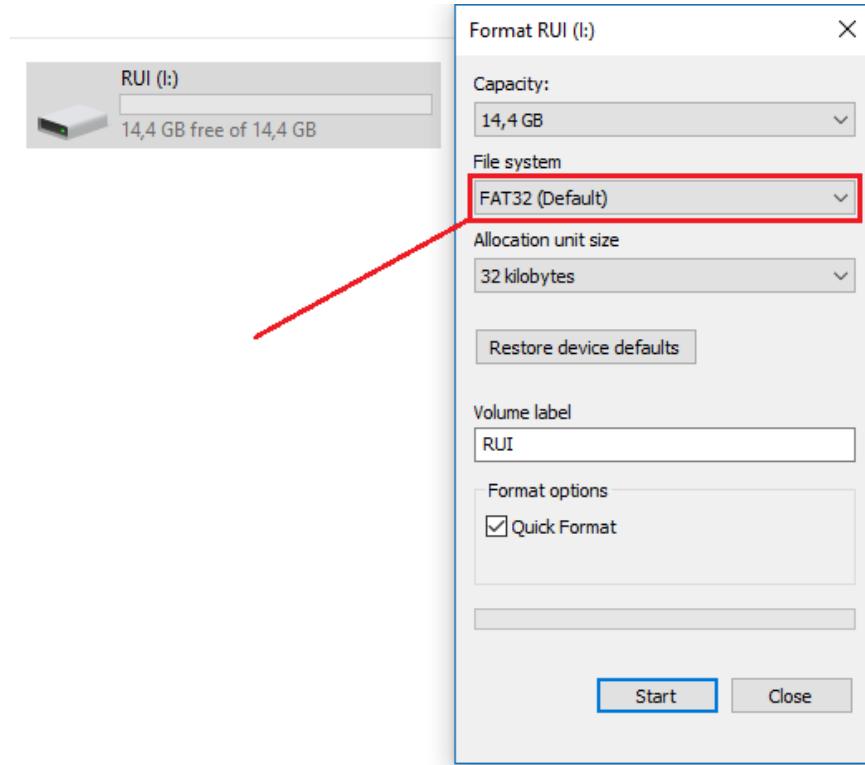


- 2) Click the **Download** button to retrieve the installer for your Operating System.



- 3) Run the Etcher application installer. With Etcher installed, you're ready to write the **.img** file in your microSD card.

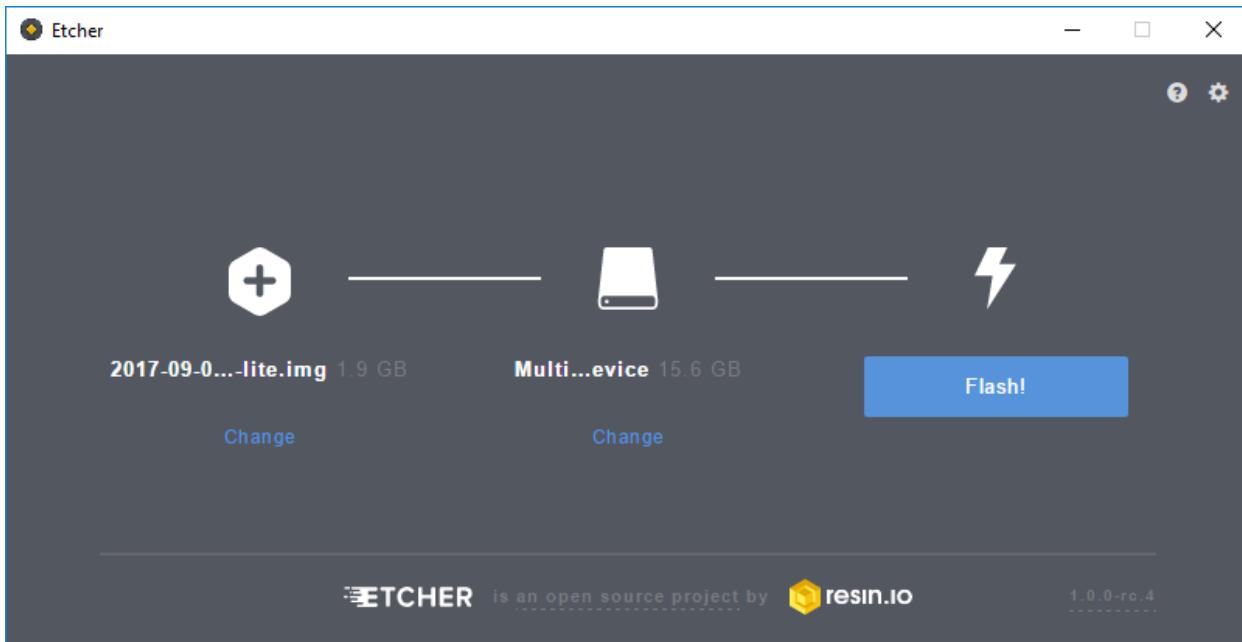
Connect your microSD card to your computer. Open its properties window and check if it is formatted in FAT32. Otherwise, you need to format your SD card and set the FAT32 file system.



Flashing Your MicroSD Card

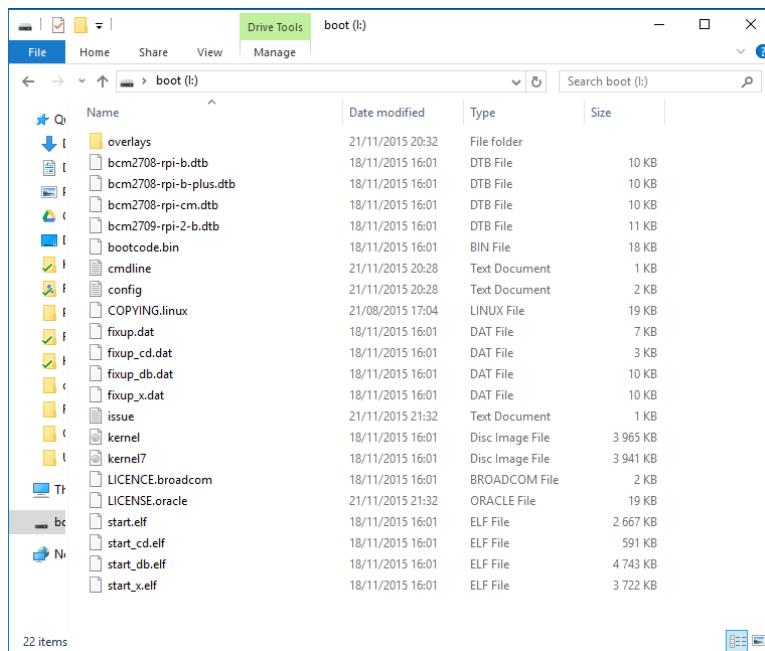
After opening Etcher program, follow these steps:

- 1) Select your Raspbian Lite **.zip** folder or **.img** file.
- 2) Select your microSD card as the device. **This process erases and overwrites the selected device.** Be certain that you've selected the microSD card, and be certain that you have copies of any files that you need from the card. I can't stress this enough: **Be certain that the microSD card is the device you chose!**
- 3) Press **Flash!** to start writing the image to the microSD card. This process takes between 5 and 20 minutes, depending on your microSD card class number and your SD card writer's transfer speed.



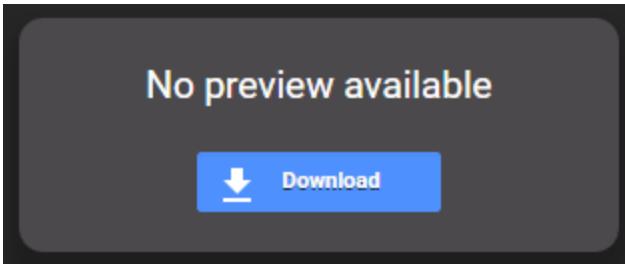
Enabling SSH

After the flash process is completed, open your microSD card and you should see something like the image below:

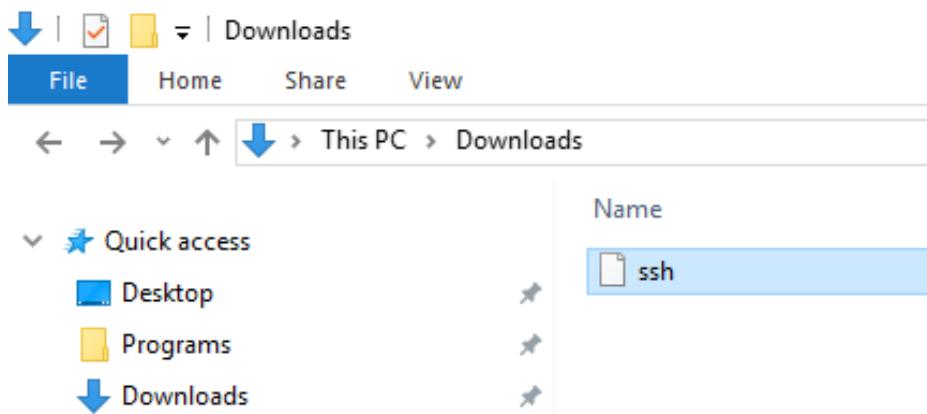


You must enable SSH communication, so that you can establish a communication with your Pi.

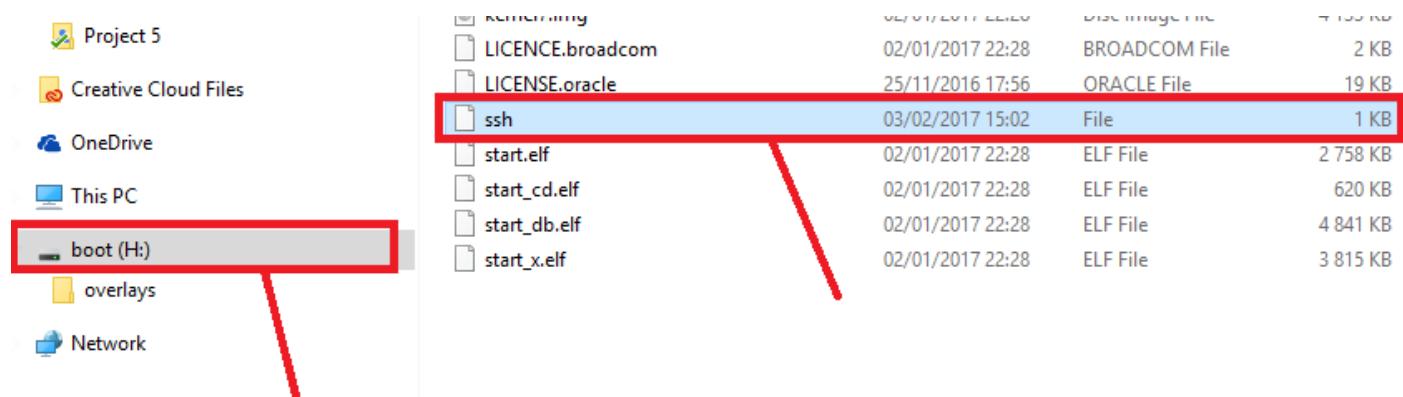
To do that, go to this link https://drive.google.com/open?id=0B_BzxRImIcd-SWE2NVNPT1FycFE and download a blank file called **ssh** by click the download button.



You should have the **ssh** file in your **Downloads** folder.

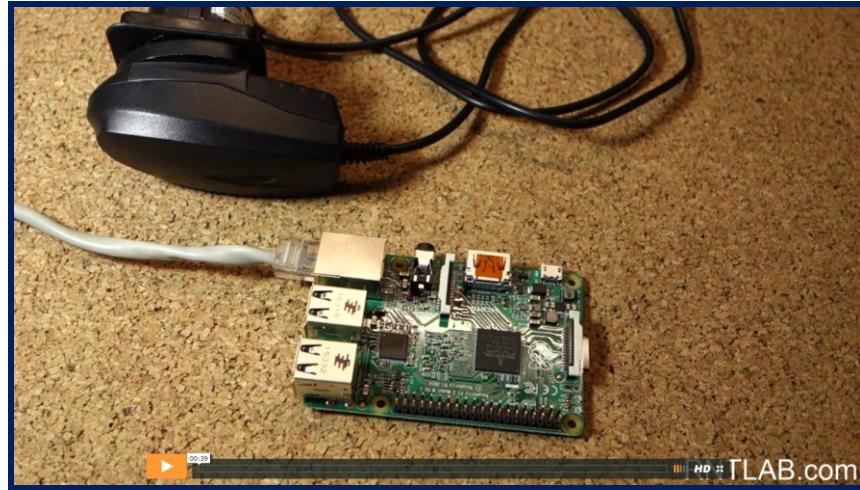


Move the **ssh** file to the microSD card as shown below:



Raspbian Lite was successfully flashed into your microSD card and you can now remove your microSD card!

Unit 3 - Booting Up Your Pi



Video # 3 - <https://rntlab.com/watch-has-videos>

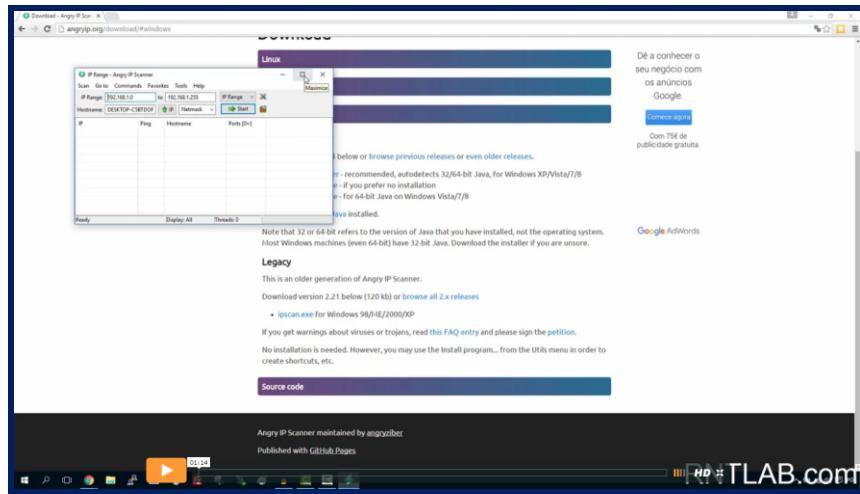
After installing Raspbian Lite in your microSD, it is time to boot up your RPi for the first time.

Follow these instructions:

- 1)** Insert your microSD card in your Raspberry Pi
- 2)** Connect an Ethernet cable from your Raspberry Pi to your router to ensure you have an internet connection
- 3)** Connect your 5V DC power adapter to power your Pi

In the next couple of Units, I'll show you how to establish an SSH communication with your Raspberry Pi.

Unit 4 - Searching for Your Pi on Your Network



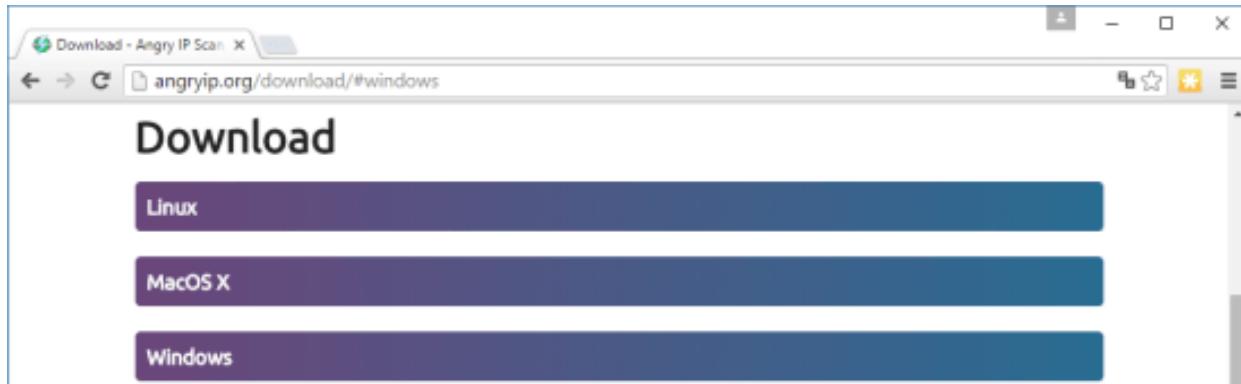
Video # 4 - <https://rntlab.com/watch-has-videos>

After booting up your Raspberry Pi, you need to find its IP Address. To find your RPi in your network, you need to install a software that scans your network for devices.

I'll use a software called **Angry IP Scanner**. It runs on Windows, Mac OS X or Linux.

Downloading Angry IP Scanner

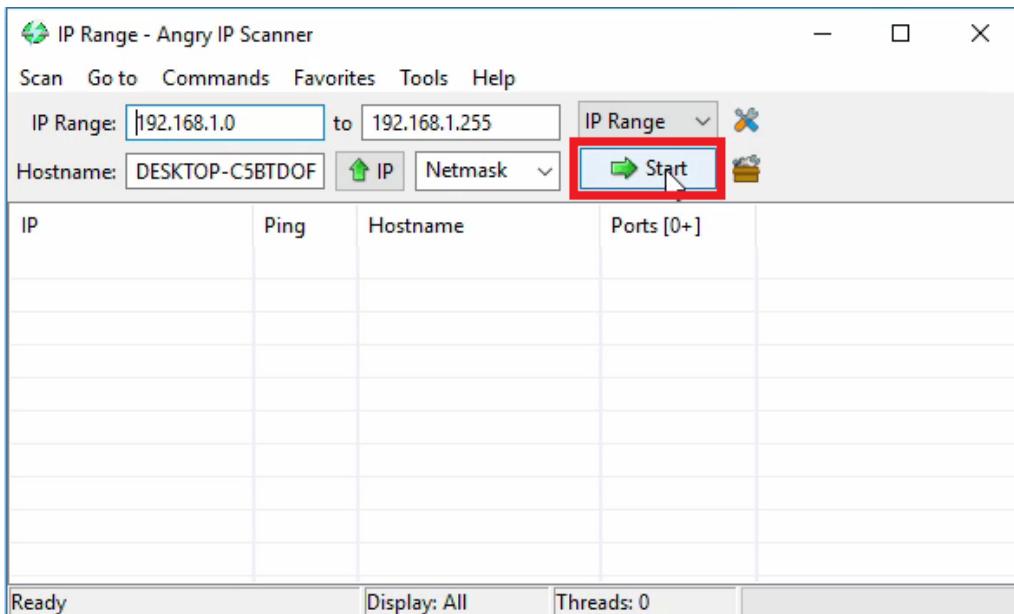
Go to the downloads section of the Angry IP Scanner software: <http://angryip.org/download>. Select the right installation file for your computer. In my case, I'm using 64-bit Windows PC.



Note: Make sure you have [Java](#) installed.

Running Angry IP Scanner

Now, run the Angry IP Scanner. When you launch the software, it should automatically pick the **IP Range** for your network, so all you need to do is press **Start** and wait a few seconds.



Angry IP Scanner found my Pi on the local network with its default **Hostname** of "**raspberrypi.local**".

IP	Ping	Hostname	Ports [0+]
192.168.1.66	0 ms	DESKTOP-C5BTDOF.lan	[n/s]
192.168.1.253	3 ms	MEO	[n/s]
192.168.1.98	268 ms	raspberrypi.local	[n/s]
192.168.1.64	500 ms	[n/a]	[n/s]
192.168.1.74	431 ms	[n/a]	[n/s]
192.168.1.254	1 ms	[n/a]	[n/s]
192.168.1.1	[n/a]	[n/s]	[n/s]
192.168.1.2	[n/a]	[n/s]	[n/s]
192.168.1.3	[n/a]	[n/s]	[n/s]
192.168.1.4	[n/a]	[n/s]	[n/s]

Save your IP address in a notepad (for example 192.168.1.98), because you'll need it later in this course.

Important: Your Raspberry Pi may have a different IP address depending on whether it's connected to your router through Wi-Fi or Ethernet, and that address might even change from time to time. If you ever find yourself unable to connect via SSH, you can always double-check the IP address using the Angry IP software!

Unit 5 - Connecting via SSH to Your RPi

This Unit is divided into two sections: one for **A) Windows** and **B) Mac OS X/Linux**.

Choose a title below to read the instructions for the Operating System that you have installed in your computer:

A) Read Windows Version

SSH (which stands for secure shell) is a method of establishing a communication with another computer securely. All data sent via SSH is encrypted.

SSH is based on a Unix shell, so it allows you to access your Raspberry Pi files from a remote machine by using terminal commands. It has grown to be one of the most popular methods for communication between different devices.

Download PuTTY

If you use Windows, you need to download and install a free application called PuTTY.

Here's how to install it:

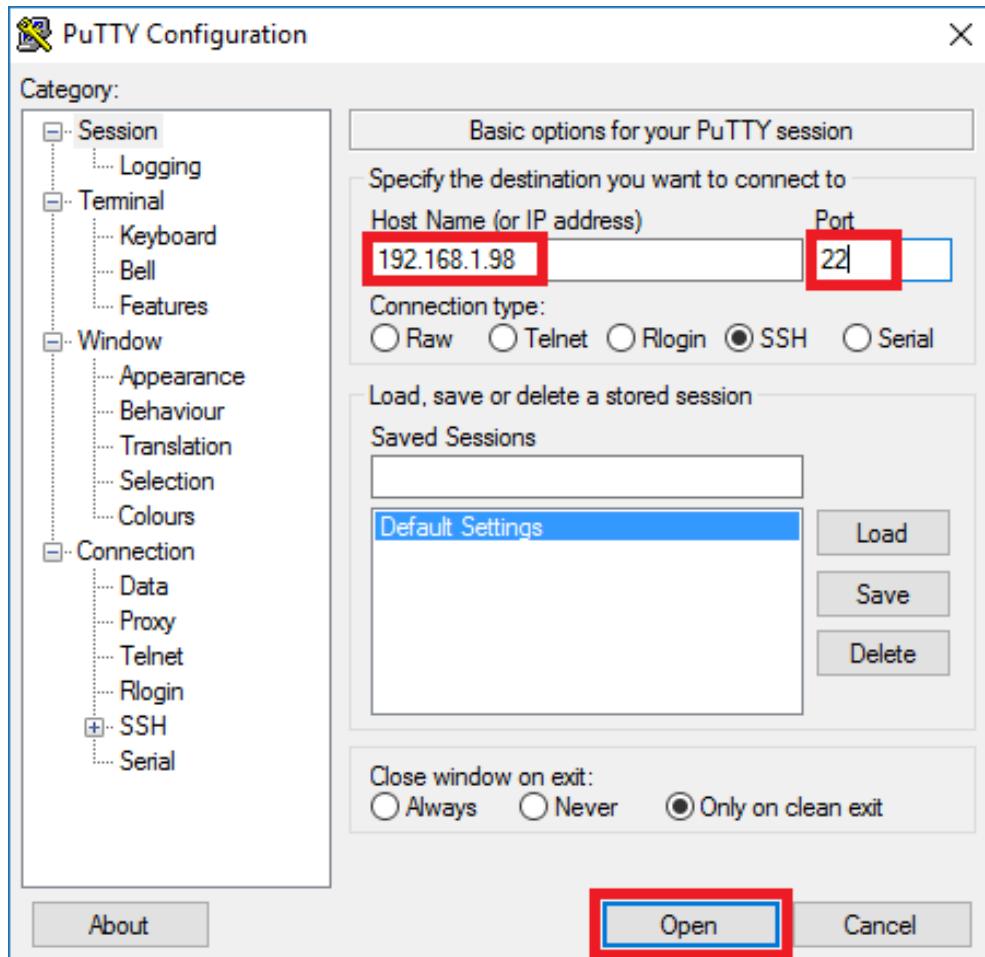
- 1) Open your web browser.
- 2) Go to www.putty.org.
- 3) Click the **putty.exe** file to download it.
- 4) Run the **putty.exe** file to install the software.

Opening PuTTY

With PuTTY installed, power up your Raspberry Pi and follow these steps:

- 1) Open PuTTY.
- 2) In the PuTTY Configuration dialog box, select SSH as your connection type.
- 3) Type your IP address from the previous Unit, in my case is **192.168.1.98** as the host. The port needs to remain at the default number, which is **22**.

The dialog box should have the settings shown in the Figure below:

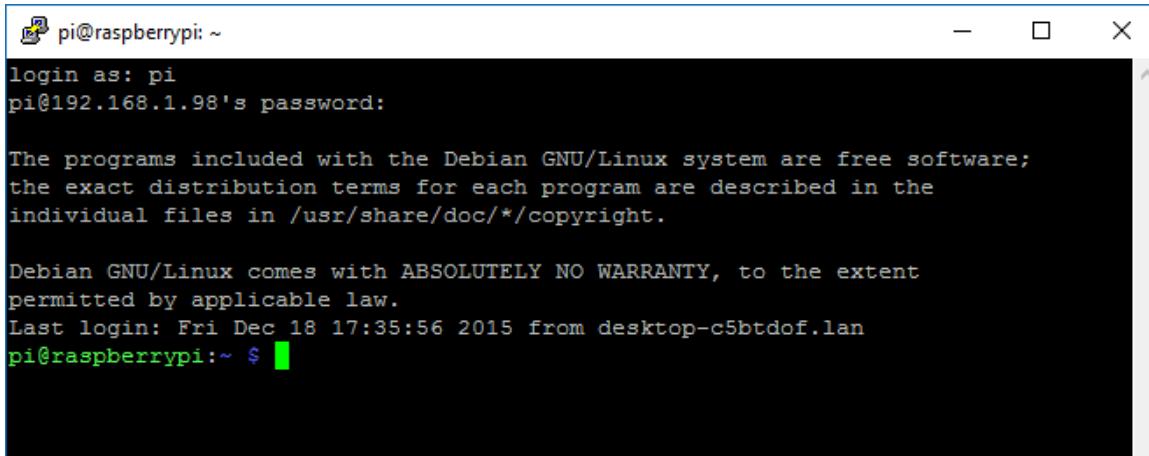


- 5) Click **Open**.
- 6) When you're asked to log in, type **pi** and press **Enter**.
- 7) When you're asked to type a password, type **raspberry**.

A screenshot of the PuTTY terminal window titled '192.168.1.98 - PuTTY'. The window displays the following text:
login as: pi
pi@192.168.1.98's password: █

Note: default settings for Raspbian Lite OS are: username = **pi** and password = **raspberry** – while you're typing your password you won't see anything appearing in your screen, but continue to type your password and press Enter key.

When you connect your computer to your Raspberry Pi for the first time, you're prompted by a message warning you that you're attempting to establish a connection with an unknown host. Simply click **OK** to proceed.



```
pi@raspberrypi: ~
login as: pi
pi@192.168.1.98's password:

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Fri Dec 18 17:35:56 2015 from desktop-c5btddof.lan
pi@raspberrypi: ~ $
```

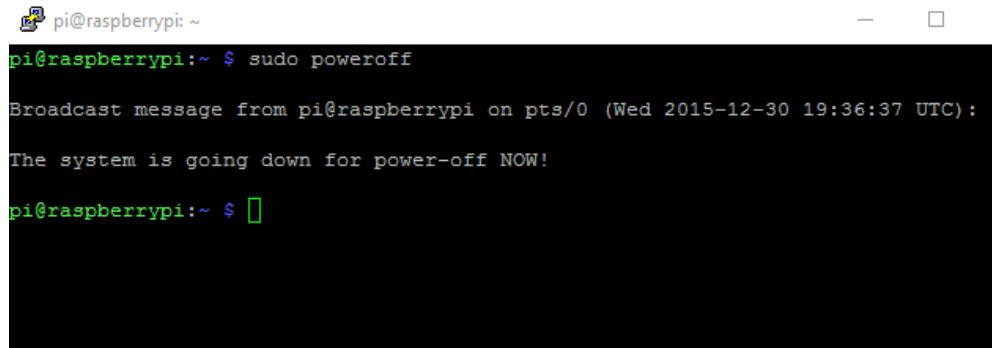
Now you have an SSH communication established with your Raspberry Pi. This will be useful to install software in your Pi, run your programs, create folders or files, etc...

Shutting down and rebooting

To shut down your Raspberry Pi, simply type this command on the command line:

```
pi@raspberry: ~ $ sudo poweroff
```

You see the following information after you use the shutdown command:



```
pi@raspberrypi: ~
pi@raspberrypi: ~ $ sudo poweroff

Broadcast message from pi@raspberrypi on pts/0 (Wed 2015-12-30 19:36:37 UTC):

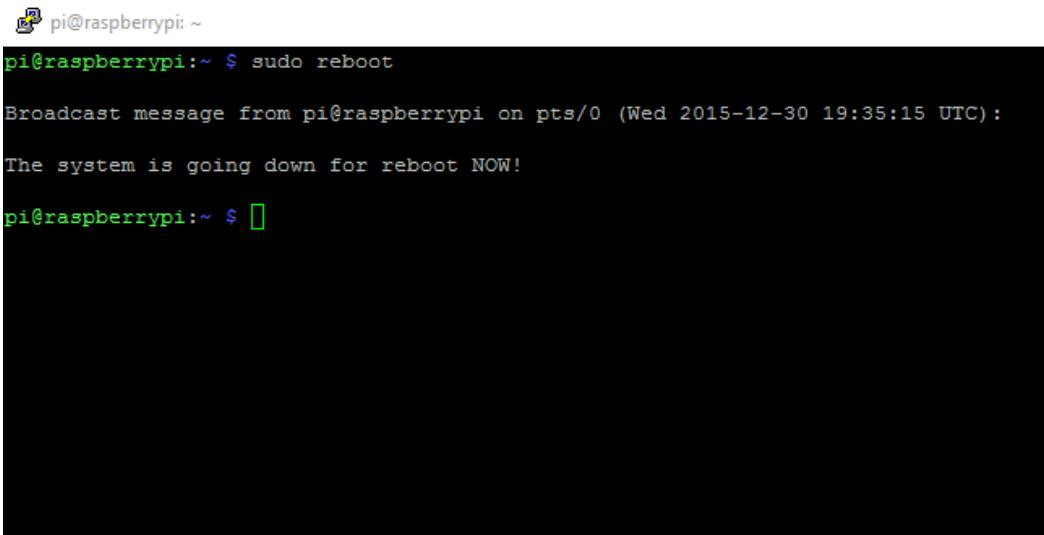
The system is going down for power-off NOW!

pi@raspberrypi: ~ $
```

To reboot, type this:

```
pi@raspberry: ~ $ sudo reboot
```

This is the result:



```
pi@raspberrypi: ~
pi@raspberrypi:~ $ sudo reboot
Broadcast message from pi@raspberrypi on pts/0 (Wed 2015-12-30 19:35:15 UTC):
The system is going down for reboot NOW!
pi@raspberrypi:~ $ [
```

B) Read Mac OS X/Linux Version

SSH (which stands for secure shell) is a method of establishing a communication with another computer securely. All data sent via SSH is encrypted.

SSH is based on a Unix shell, so it allows you to access your Raspberry Pi files from a remote machine by using terminal commands. It has grown to be one of the most popular methods for communication between different devices.

Establishing an SSH Communication

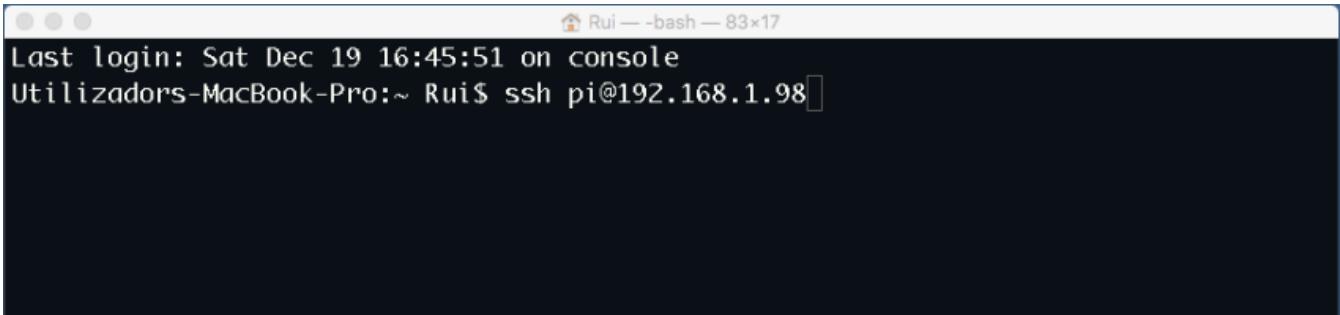
In Mac OS X and Linux, you can use the default Terminal window to establish an SSH communication, because SSH comes in all Unix-based OSes. Follow these steps:

- 1) Boot up your Raspberry Pi
- 2) Open a new Terminal window
- 3) Type the following command:

```
$ sudo ssh pi@ip_address
```

Make sure you replace the **ip_address** part with the real IP address of your Raspberry Pi that you found in the previous Unit. In my case, I'll run the following command:

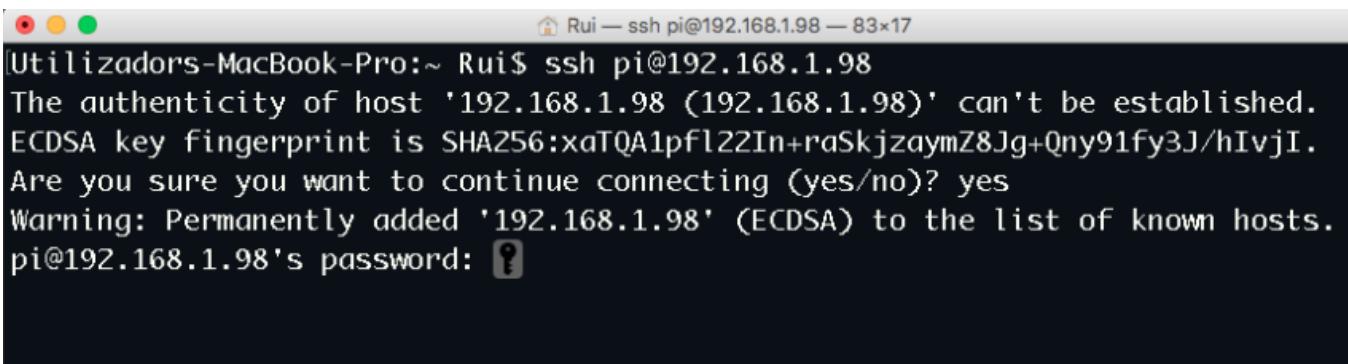
```
$ sudo ssh pi@192.168.1.98
```



```
Rui — bash — 83x17
Last login: Sat Dec 19 16:45:51 on console
Utilizadors-MacBook-Pro:~ Rui$ ssh pi@192.168.1.98
```

- 4) Enter your computer password (so you can run a `sudo` command), and type **yes**.
- 5) When you're asked to type a password for your Raspberry Pi type **raspberry**, press **Enter/Return**.

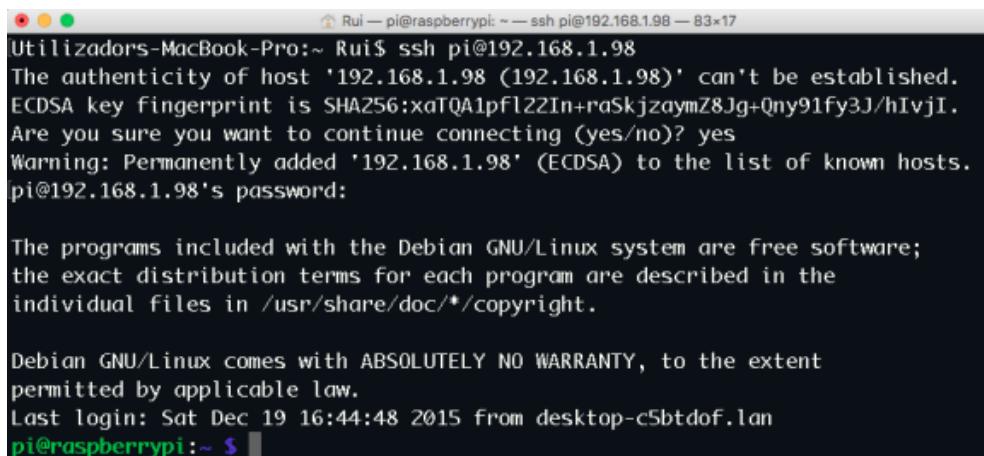
Your Terminal window should look like the Figure below:



```
Rui — ssh pi@192.168.1.98 — 83x17
Utilizadors-MacBook-Pro:~ Rui$ ssh pi@192.168.1.98
The authenticity of host '192.168.1.98 (192.168.1.98)' can't be established.
ECDSA key fingerprint is SHA256:xaTQA1pfI2ZIn+raSkjzaymZ8Jg+Qny91fy3J/hIvjI.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '192.168.1.98' (ECDSA) to the list of known hosts.
pi@192.168.1.98's password: ?
```

Note: default settings for Raspbian Lite OS are: username = **pi** and password = **raspberry** – while you're typing your password you won't see anything appearing in your screen, but continue to type your password and press Enter key.

When you connect your computer to your Raspberry Pi for the first time, you're prompted by a message warning you that you're attempting to establish a connection with an unknown host. Simply click **OK** to proceed.



```
Rui — pi@raspberrypi: ~ — ssh pi@192.168.1.98 — 83x17
Utilizadors-MacBook-Pro:~ Rui$ ssh pi@192.168.1.98
The authenticity of host '192.168.1.98 (192.168.1.98)' can't be established.
ECDSA key fingerprint is SHA256:xaTQA1pfI2ZIn+raSkjzaymZ8Jg+Qny91fy3J/hIvjI.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '192.168.1.98' (ECDSA) to the list of known hosts.
pi@192.168.1.98's password:

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Sat Dec 19 16:44:48 2015 from desktop-c5btodf.lan
pi@raspberrypi:~ $
```

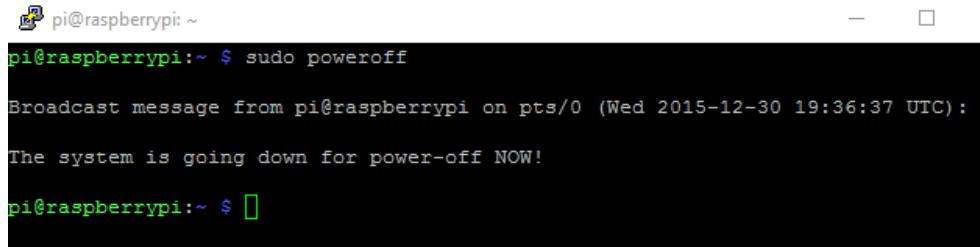
Now you have an SSH communication established with your Raspberry Pi. This will be useful to install software in your Pi, run your programs, create folders or files, etc...

Shutting down and rebooting

To shut down your Raspberry Pi, simply type this command on the command line:

```
pi@raspberry:~ $ sudo poweroff
```

You see the following information after you use the shutdown command:

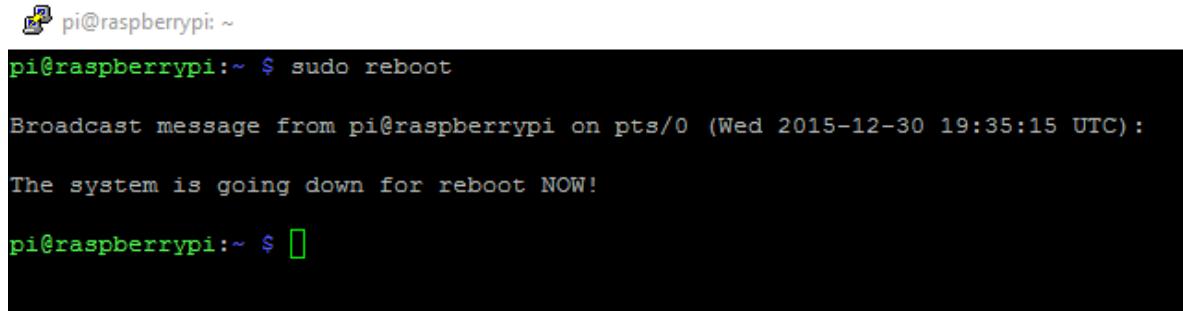


```
pi@raspberrypi: ~
pi@raspberrypi:~ $ sudo poweroff
Broadcast message from pi@raspberrypi on pts/0 (Wed 2015-12-30 19:36:37 UTC):
The system is going down for power-off NOW!
pi@raspberrypi:~ $
```

To reboot, type this:

```
pi@raspberry:~ $ sudo reboot
```

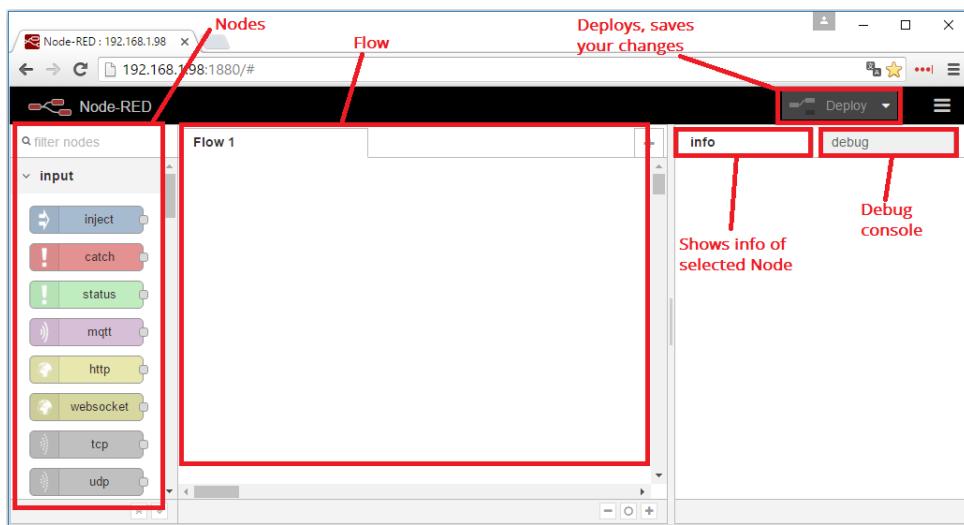
This is the result:



```
pi@raspberrypi: ~
pi@raspberrypi:~ $ sudo reboot
Broadcast message from pi@raspberrypi on pts/0 (Wed 2015-12-30 19:35:15 UTC):
The system is going down for reboot NOW!
pi@raspberrypi:~ $
```

MODULE 3

Getting started with Node-RED

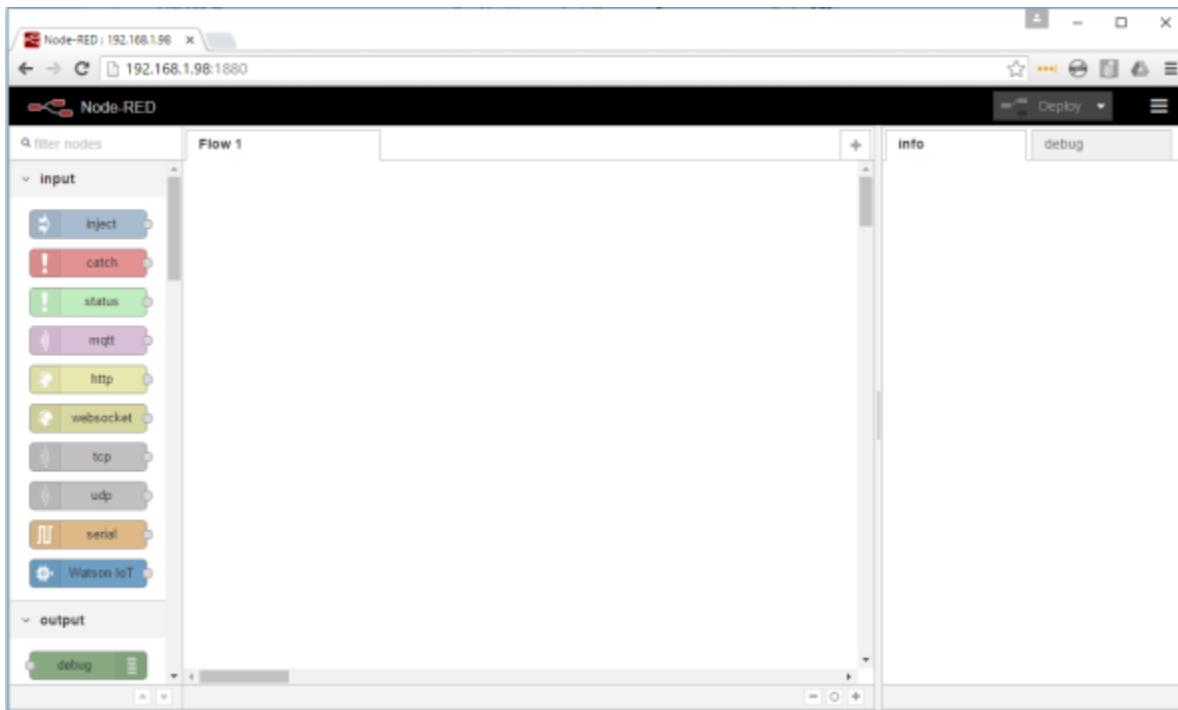


Unit 1 - What's Node-RED?

[Node-RED](#) is a powerful open source tool for building Internet of Things (IoT) applications with the goal of simplifying the programming component.

It uses a visual programming that allows you to connect code blocks, known as **nodes**, together to perform a task.

The nodes when wired together are called **flows**.



Why is Node-RED a great solution?

Node-RED is open source and developed by IBM.

The Raspberry Pi runs Node-RED perfectly.

With Node-RED you can spend more time making cool stuff, rather than spending countless hours writing code.

Don't get me wrong. I love programming and there is code that needs to be written throughout this course, but Node-RED allows you to prototype a complex home automation system quickly.

What can you do with Node-RED?

Node-RED makes it easy to:

- Access your RPi GPIOs
- Establish an MQTT connection with other boards (Arduino, ESP8266, etc)
- Create a responsive graphical user interface for your projects
- Communicate with third-party services (IFTTT.com, Adafruit.io, Thing Speak, etc)
- Retrieve data from the web (weather forecast, stock prices, emails. etc)
- Create time triggered events
- Store and retrieve data from a database

Here's a library [with some examples of flows and nodes](#) for Node-RED.

Let's install it!

Unit 2 - Installing Node-RED

Getting Node-RED installed in your Raspberry Pi is quick and easy. It just takes a few commands.

Having an SSH connection established with your Raspberry Pi, enter the next exact command to install and upgrade Node-RED (along with its dependencies):

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

The installation should be completed after a couple of minutes (up to 30 minutes).

Autostart Node-RED on Boot

To automatically run Node-RED when the Pi boots up, you need to enter the following command:

```
pi@raspberry:~ $ sudo systemctl enable nodered.service
```

Now, restart your Pi so the autostart takes effect:

```
pi@raspberry:~ $ sudo reboot
```

Testing the Installation

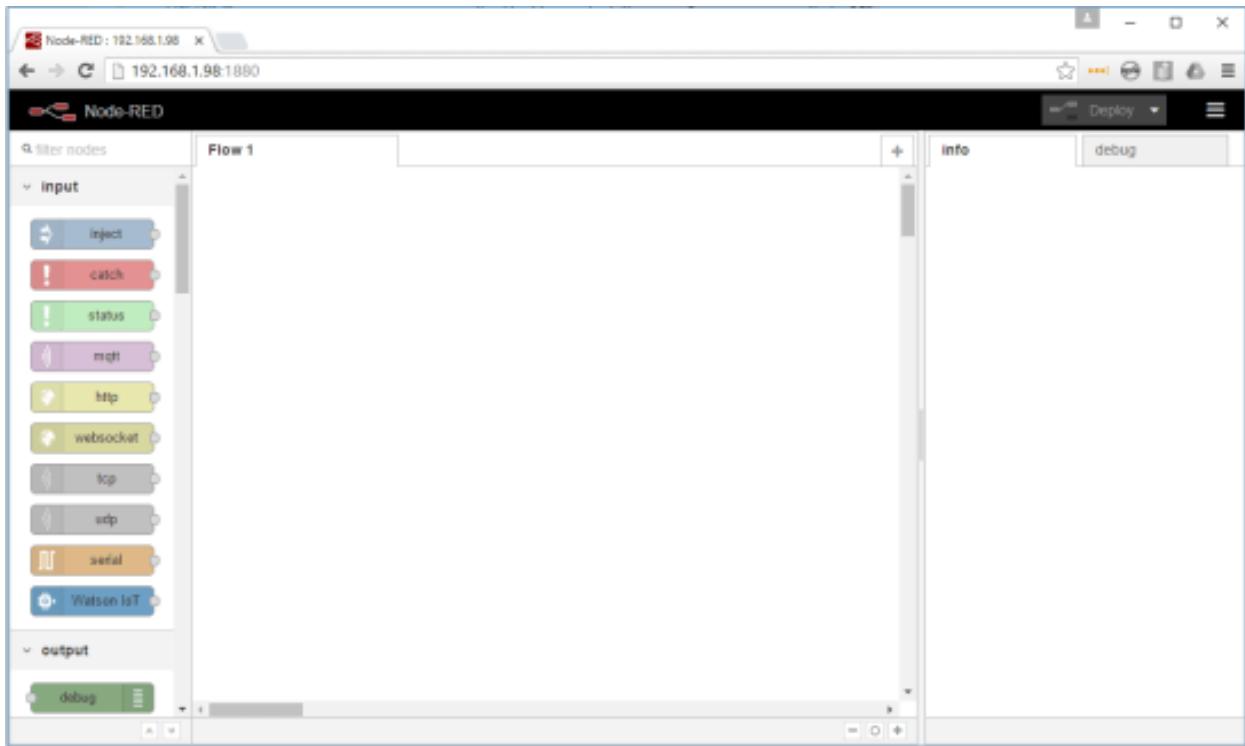
When your Pi is back on, you can test the installation by entering the IP address of your Pi in a web browser followed by the **1880** port number:

```
http://YOUR_RPi_IP_ADDRESS:1880
```

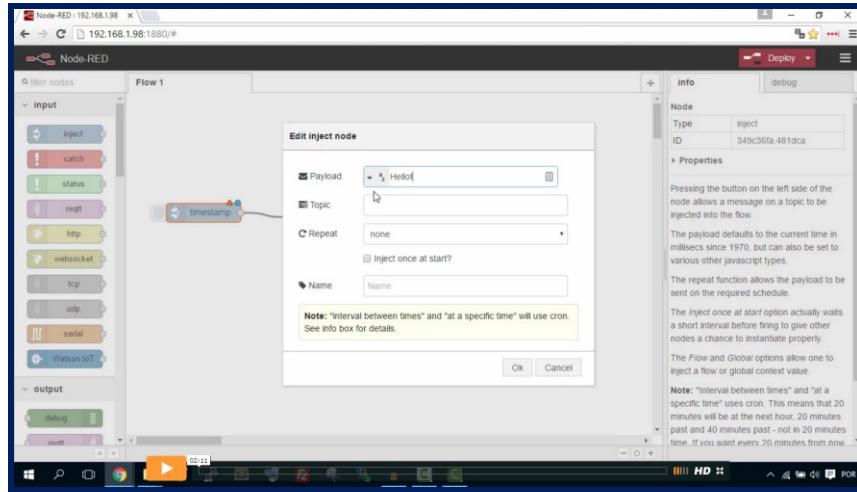
In my case is:

```
http://192.168.1.98:1880
```

A page like this loads:



Unit 3 - Node-RED Overview



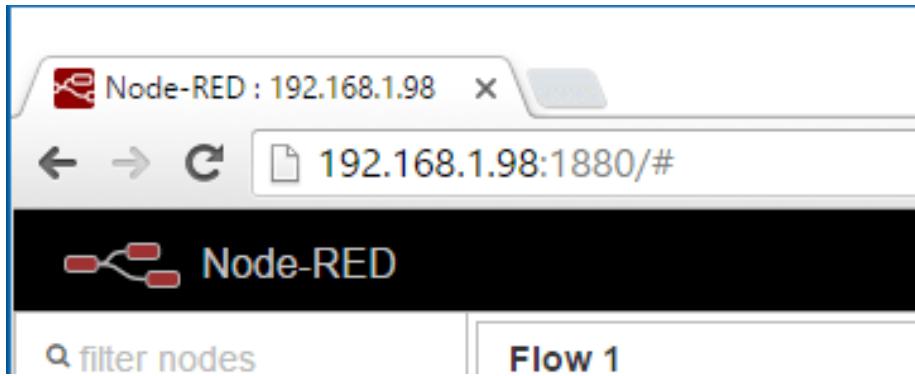
Video # 5 - <https://rntlab.com/watch-has-videos>

Let's look at the Node-RED visual interface. To access the Node-RED program, type in your browser your Raspberry Pi IP address followed by the port number **1880**.

http://YOUR_RPi_IP_ADDRESS:1880

In my case is:

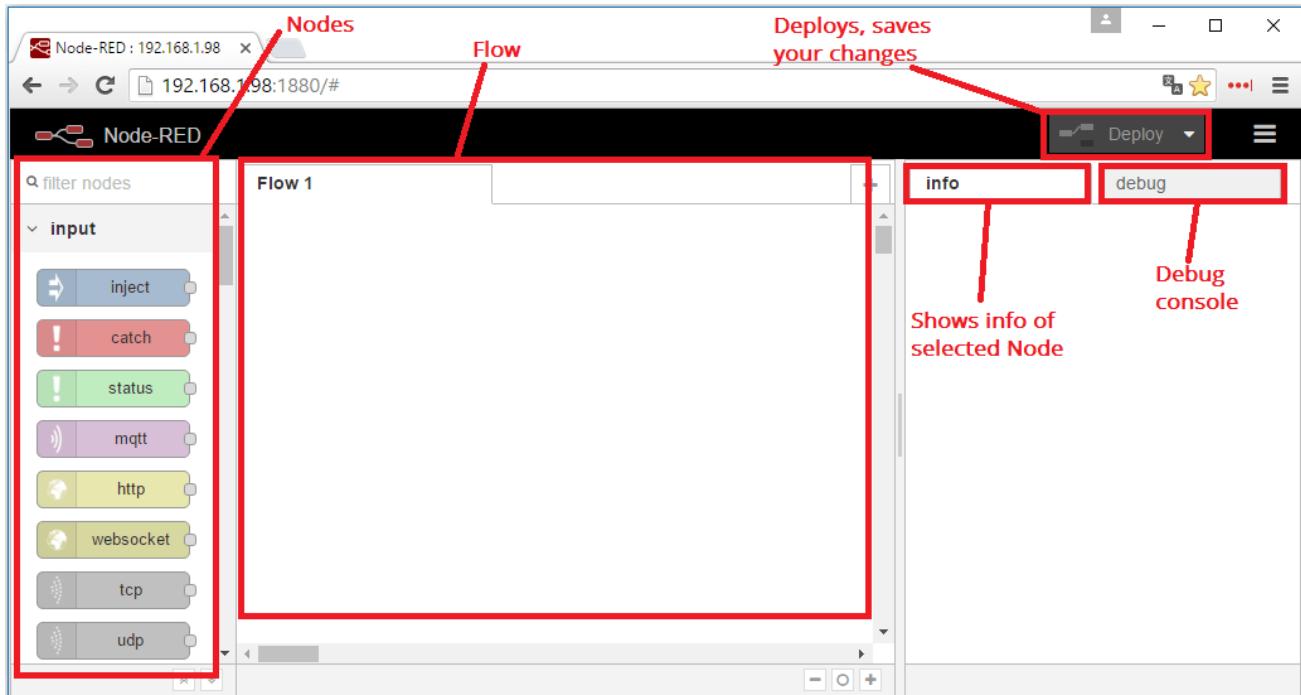
http://192.168.1.98:1880



Main Sections

On the left-side, you can see a list with a bunch of blocks. These blocks are called **nodes** and they are separated by their functionality. If you select a node, you can see how it works in the **info** tab.

In the center, you have the **Flow** and this is where you place the nodes.



Creating a Simple Flow

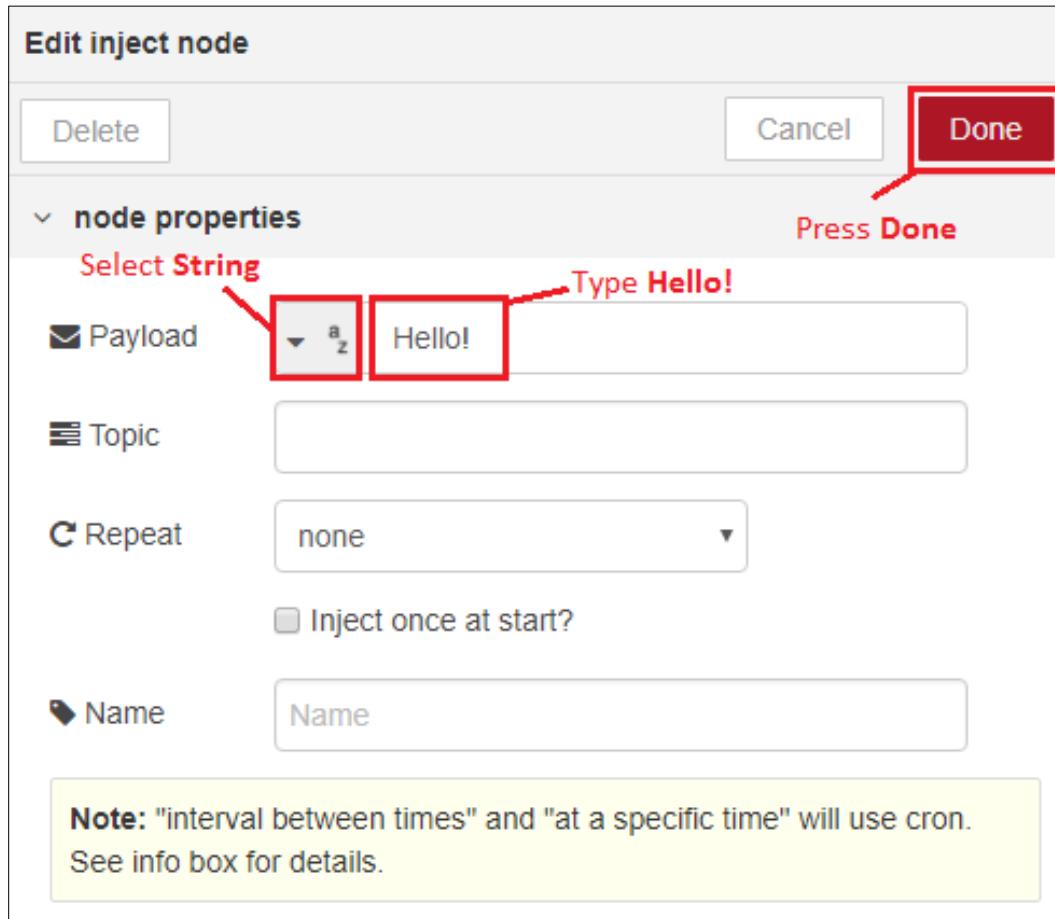
Let's test a simple example of a flow. Start by dragging an **Inject** node to your flow. Then, also drag a **Debug** node.



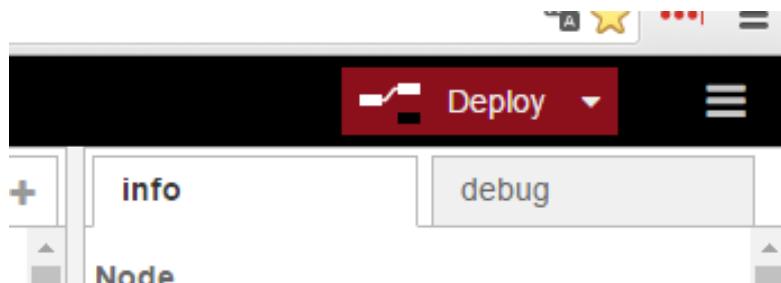
Connect your nodes together. You can drag them to confirm that they are connected.

Now, let's edit the inject node. Double-click the node. In the figure below, you can see different settings you can change.

Select **string**, type **Hello!** and press **Done**.



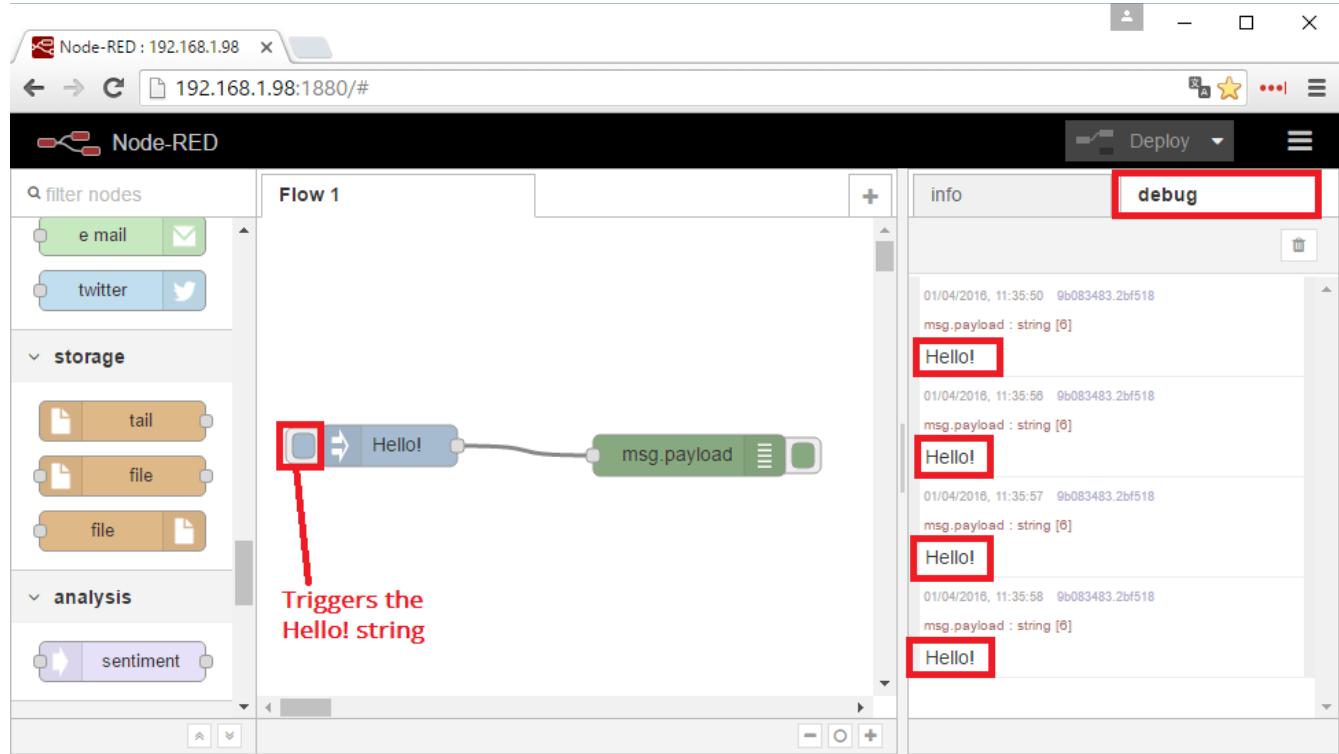
To save your application, you need to click the **Deploy** button on the top right corner.



Your application is saved.

Testing the Flow

Let's test our simple flow. Open the debug window and click the Inject node to trigger the "Hello!" string.



As you can see, our message is being printed in the **debug** window. This is a very basic example and it doesn't do anything useful. However, the purpose of this Unit is to get you familiar with the Node-RED interface.

Go to the next Unit to learn how to control an LED with Node-RED.

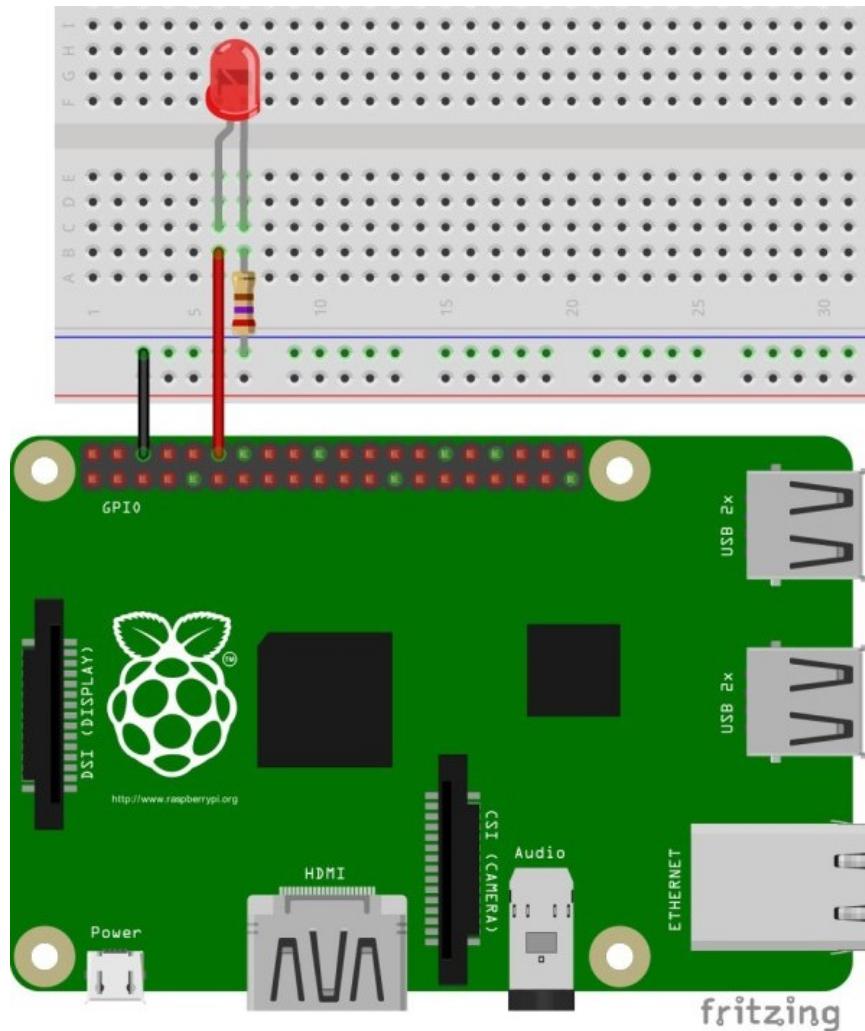
Unit 4 - Controlling an LED with Node-RED

Controlling an LED it's usually the very first thing you do when you play with a new development board. So, let's control an LED with Node-RED.

Schematics

Here's the hardware required to complete this project:

- [Raspberry Pi](#)
- [LED \(5mm\)](#)
- [270Ω resistor](#)
- [Breadboard](#)
- [Jumper wires](#)

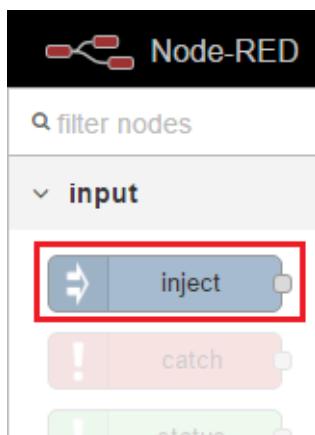


Wire your circuit by following the image above or these instructions:

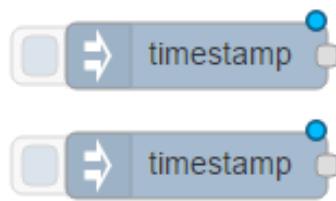
- Longest lead of the LED -> pin 12
- Shortest lead of the LED -> 270Ω resistor
- Resistor connected to GND
- Pin 6 is GND

Preparing Your Flow

Drag two **Inject** nodes into your flow.



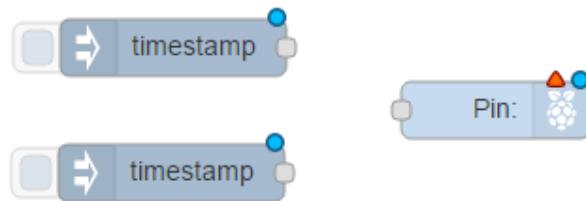
They will look like this in your flow:



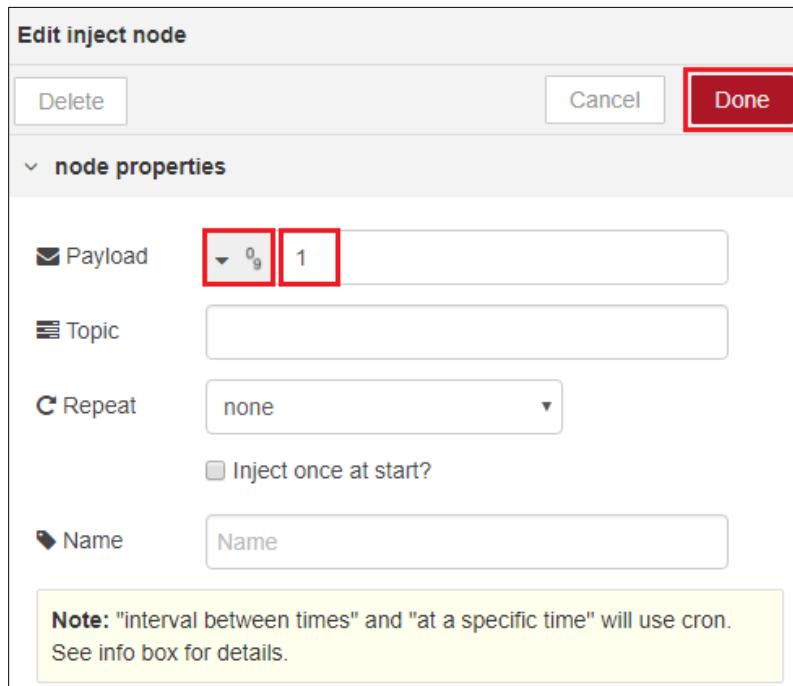
Then, add the **rpi-gpio out** node to your flow:



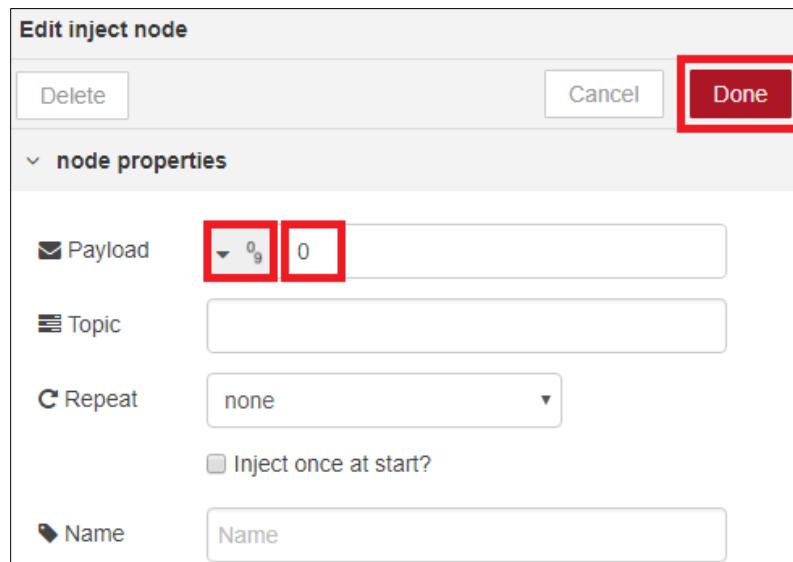
Here's what you should see:



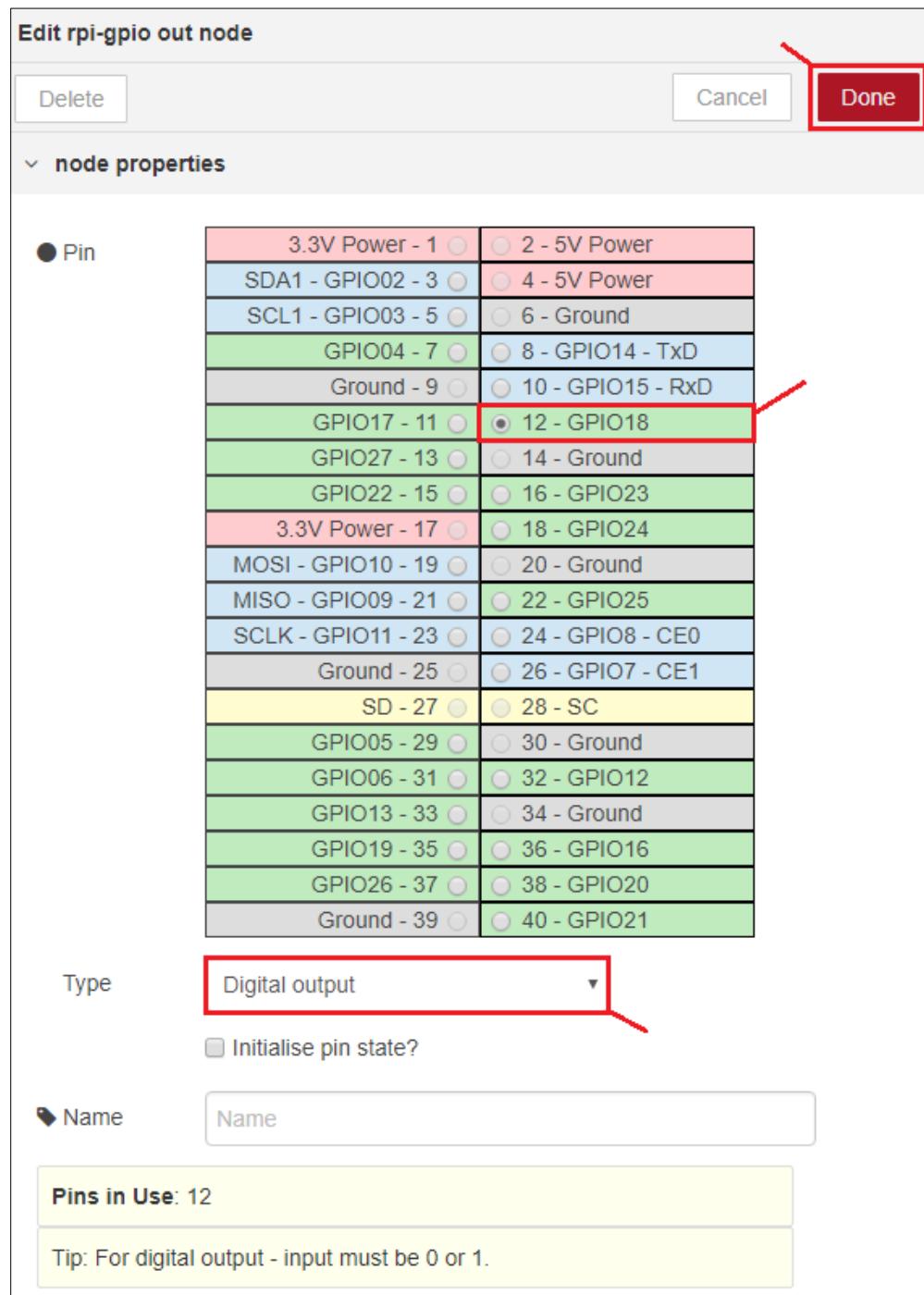
Double-click the first **Inject** node to edit its properties. Select **number** and type **1**. Press **Done**.



Edit **Inject** node number two. Select **number** and type **0**. Press **Done**.

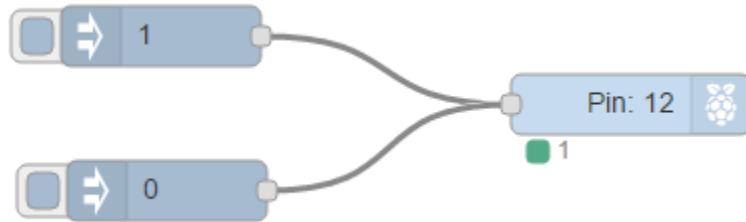


Lastly, edit the **rpi-gpio out** node. Set the type as a **digital output** and the **12 – GPIO 18** pin (that's where your LED is plugged in).

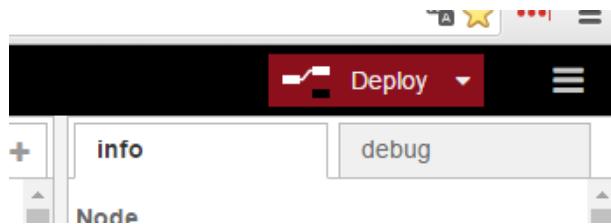


Deploying the Application

After editing each node, your flow should look like this:

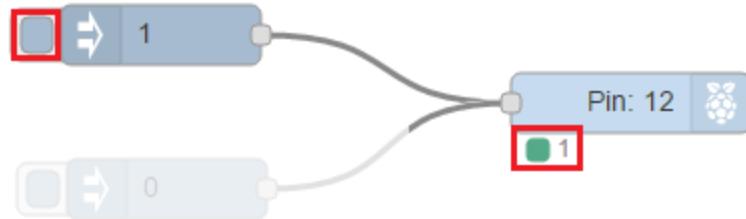


Click the **Deploy** button on the top-right corner to save your application.

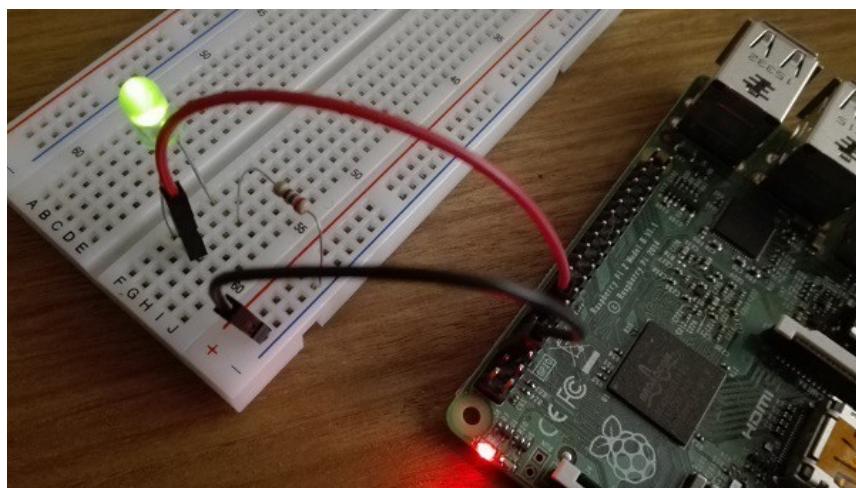


Testing the Application

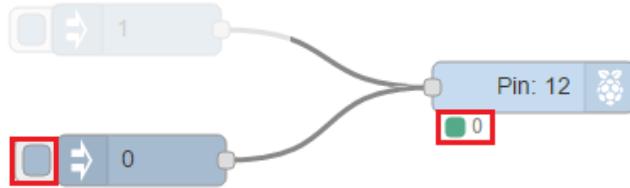
Now, press the square of the **Inject 1** node.



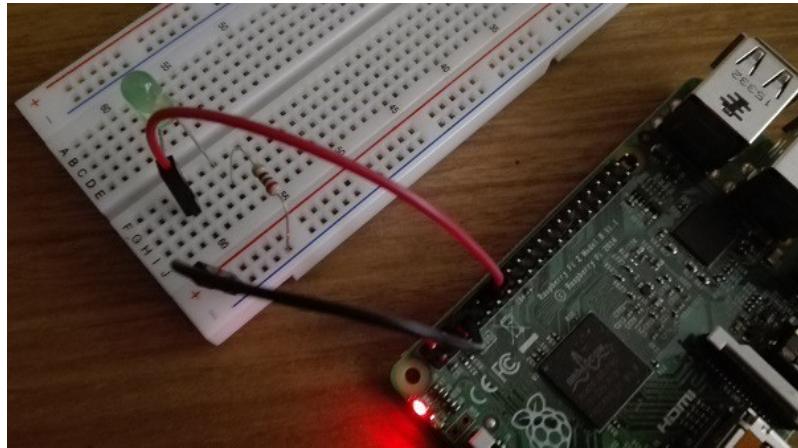
Your LED turns on:



And when you press the **Inject 0** node.



Your LED turns off:

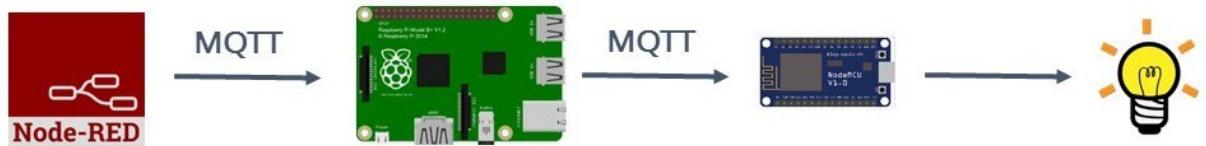


This shows how easy it is to access your Raspberry Pi GPIOs with Node-RED.

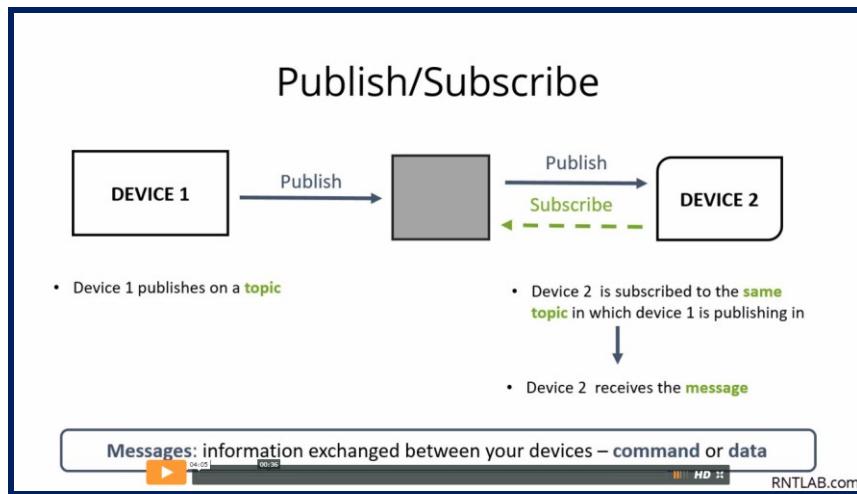
In the next Module, we're going to explore the MQTT protocol to integrate with your RPi and other popular development boards (Arduino and ESP8266).

MODULE 4

Experimenting with MQTT



Unit 1 - What is MQTT?



Video # 6 - <https://rntlab.com/watch-has-videos>

Introducing MQTT

In this Unit, I'm going to introduce you to the MQTT protocol. MQTT stands for **MQ Telemetry Transport** or **Message Queue Telemetry Transport**.

It is a nice lightweight publish and subscribe system where you can publish and receive messages as a client. It makes it easy to establish a communication between multiple devices.



It is a simple messaging protocol, designed for constrained devices and with low-bandwidth.

So, it's the perfect solution for Internet of Things applications.

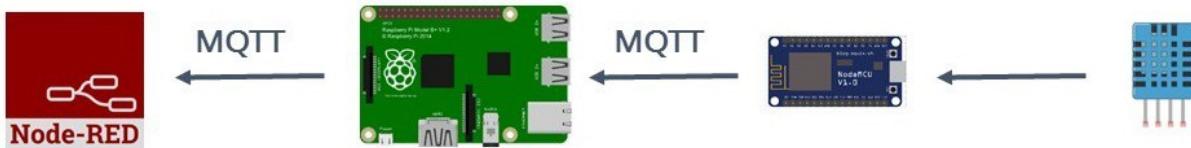
High Level Overview

Here's a quick high-level overview of what MQTT allows you to do.

You can **send a command** to control an **output**:



Or you can **read data** from a **sensor** and **publish** it:



MQTT Basic Concepts

In MQTT there are a few basic concepts that you need to understand:

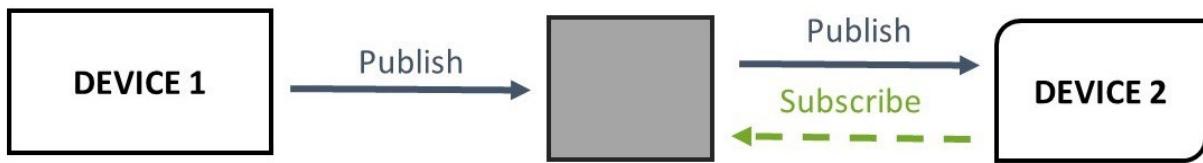
- Publish/Subscribe
- Messages
- Topics
- Broker

MQTT Publish/Subscribe

The first concept is the publish and subscribe system.

What does that mean?

This means that a device can publish messages to your devices. Or your device can subscribe to a topic to receive those messages.



- For example, **device 1 publishes** on a topic.
- **Device 2 is subscribed** to the same topic as **device 1 is publishing in**.
- So, **device 2 receives** the message.

MQTT Messages

Messages are the information that you want to exchange between your devices. Whether it's a command or data.

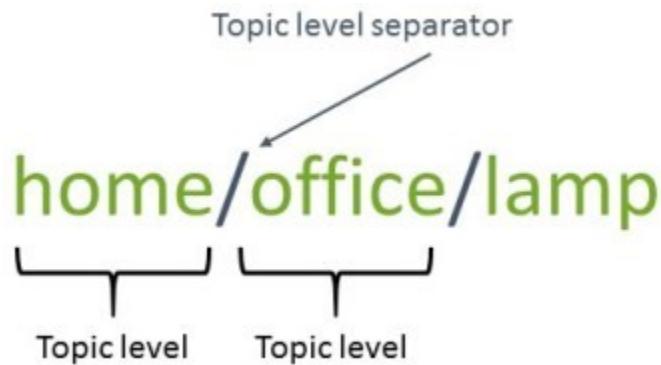
With the publish and subscribe system you can do pretty much anything you could ever wanted in your home automation projects.

MQTT Topics

Another important concept is topics. Topics are the way you register interest for incoming messages or how you specify where you want to publish your message.

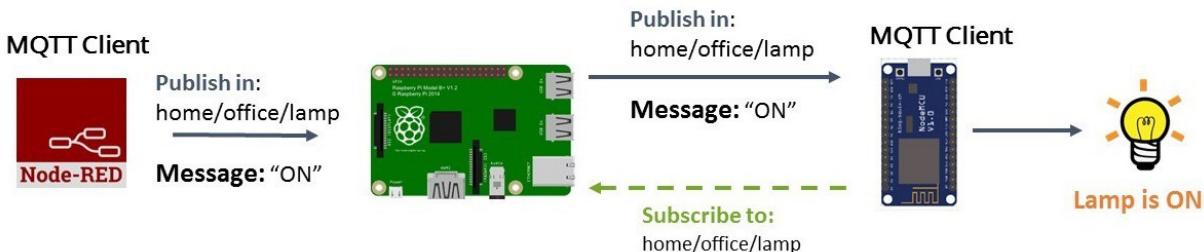
Topics are represented with strings separated by slashes. The slashes indicate the topic level.

Here's an example on how you would create a topic for a lamp in your home office:



For example, if you would like to turn on a lamp in your home office you would publish a message to a topic using Node-RED saying “ON”.

Your ESP8266 would be subscribed to that same topic, so it would receive the “ON” message and finally turn on the lamp.



Note: topics are case-sensitive, which makes these two topics different:

home/office/lamp

≠

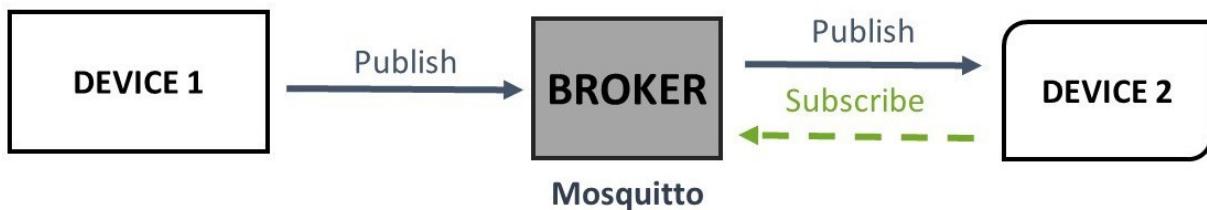
home/office/LAmp

MQTT Broker

At last, you also need to be aware of the term broker.

The broker is primarily responsible for **receiving** all messages, **filtering** the messages, **decide** who is interested in it and then **publishing** the message to all subscribed clients.

There are several brokers you can use. We’re going to use the **Mosquitto broker** which can be installed in the Raspberry Pi.



In the next Units, we will experiment with MQTT and Node-RED to see how everything works with practical examples.

Unit 2 - Installing Mosquitto Broker

Let's install the [Mosquitto broker](#). The broker receives all messages, filters the messages, decide who is interested in it and then publishes the messages to all subscribed clients.



Installing

To install the Mosquitto broker and make it auto start, enter the next commands:

```
pi@raspberry:~ $ sudo apt update  
pi@raspberry:~ $ sudo apt install -y mosquitto mosquitto-clients  
pi@raspberry:~ $ sudo systemctl enable mosquitto.service
```

You'll have to type **Y** and press **Enter** to confirm the installation.

Testing

Send the command:

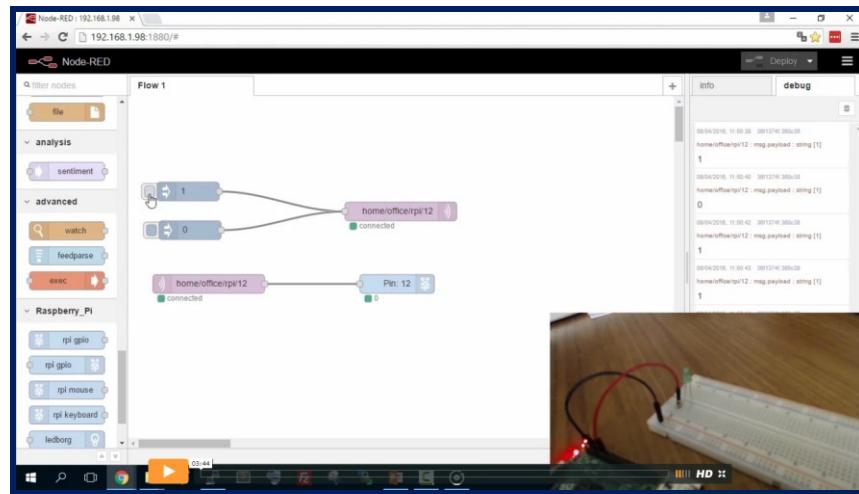
```
pi@raspberry:~ $ mosquitto -v
```

This returns the Mosquitto version that is currently running in your Raspberry Pi. It should be 1.4 or above.

```
pi@raspberrypi:~ $ mosquitto -v  
1498820350: mosquitto version 1.4.12 (build date Thu,  
) starting  
1498820350: Using default config.  
1498820350: Opening ipv4 listen socket on port 1883.  
1498820350: Error: Address already in use
```

Note: the Mosquitto command returns the Mosquitto version that is currently installed, but it also tries to initialize Mosquitto again. Since Mosquitto is already running it prompts an error message. Don't worry Mosquitto is properly installed and running if you see a similar message.

Unit 3 - Establishing an MQTT communication with Node-RED

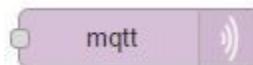


Video # 7 - <https://rntlab.com/watch-has-videos>

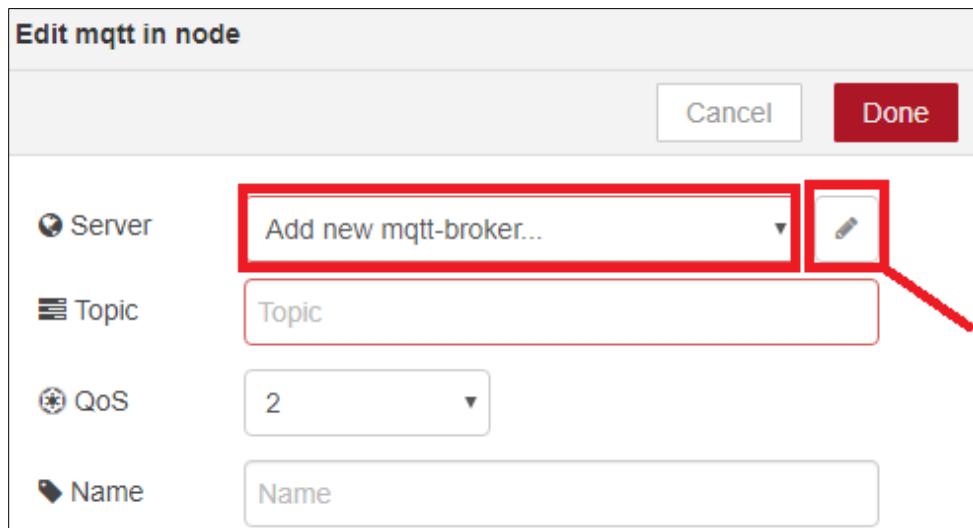
In this Unit, we're going to establish an MQTT communication using Node-RED nodes.

Creating the Publish Flow

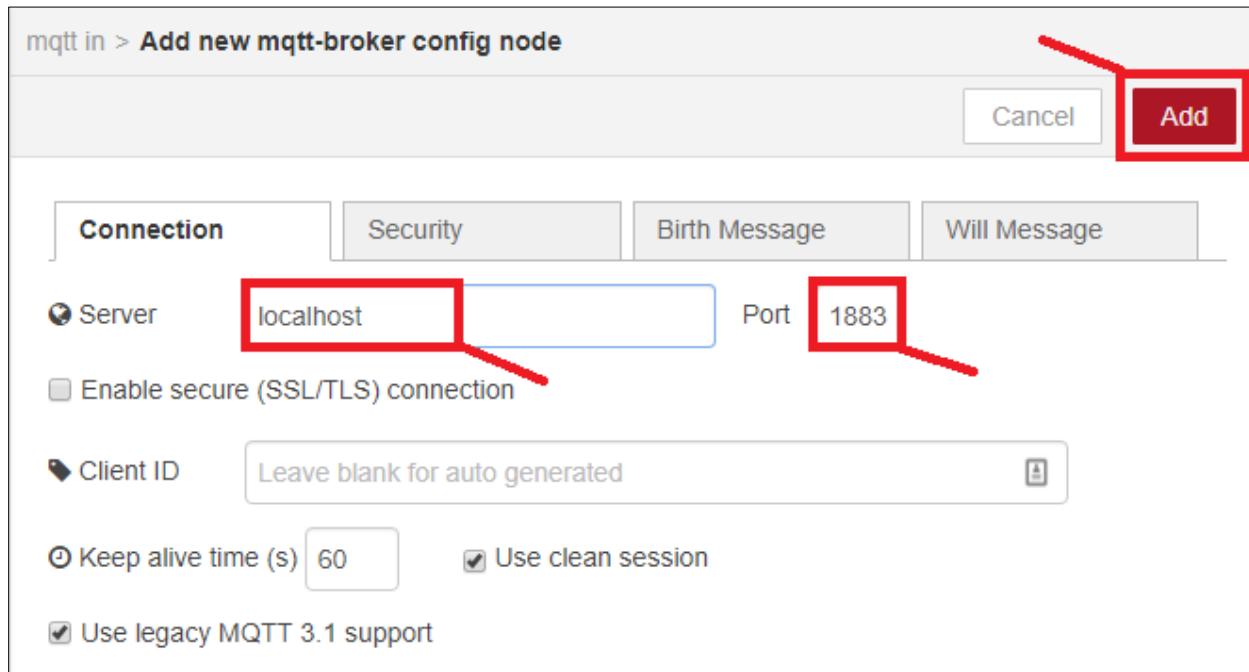
First drag an **MQTT output** node to the flow.



You need to connect Node-RED to your MQTT broker. Double-click the **MQTT output** node. Click the **Add new mqtt-broker** option.

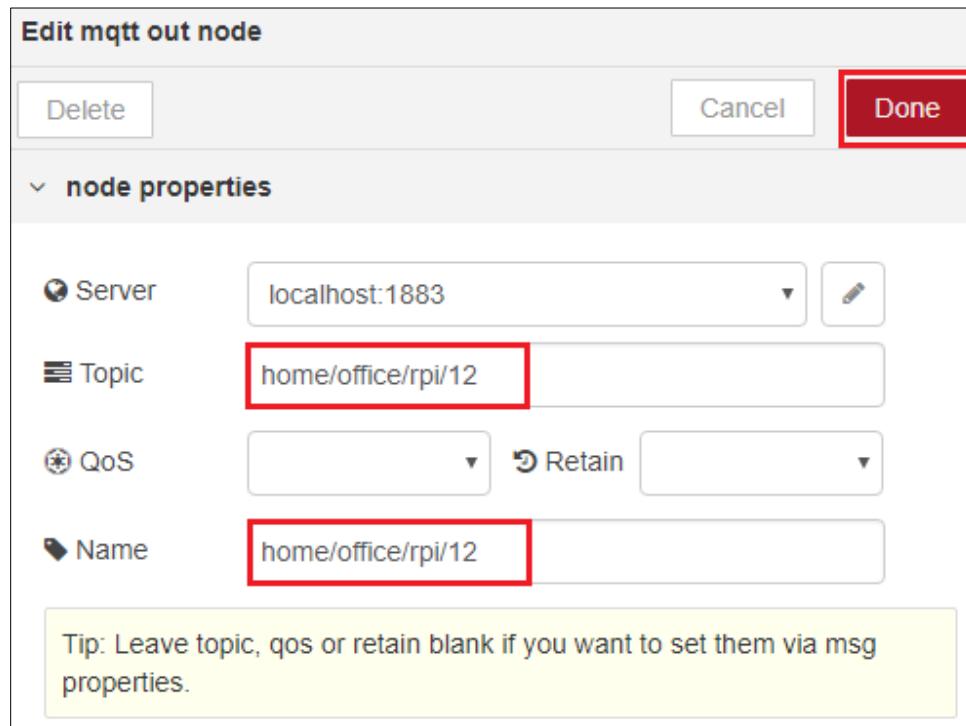


Type **localhost** in the server field and all the other settings are configured properly by default.



Press **Add** and the **MQTT output** node automatically connects to your broker.

Now, let's imagine you would like to control the Raspberry Pi pin 12, and your RPi is in your home office. A good choice for a topic that controls pin 12 would be **home/office/rpi/12**.



Press **Done** to save your node.

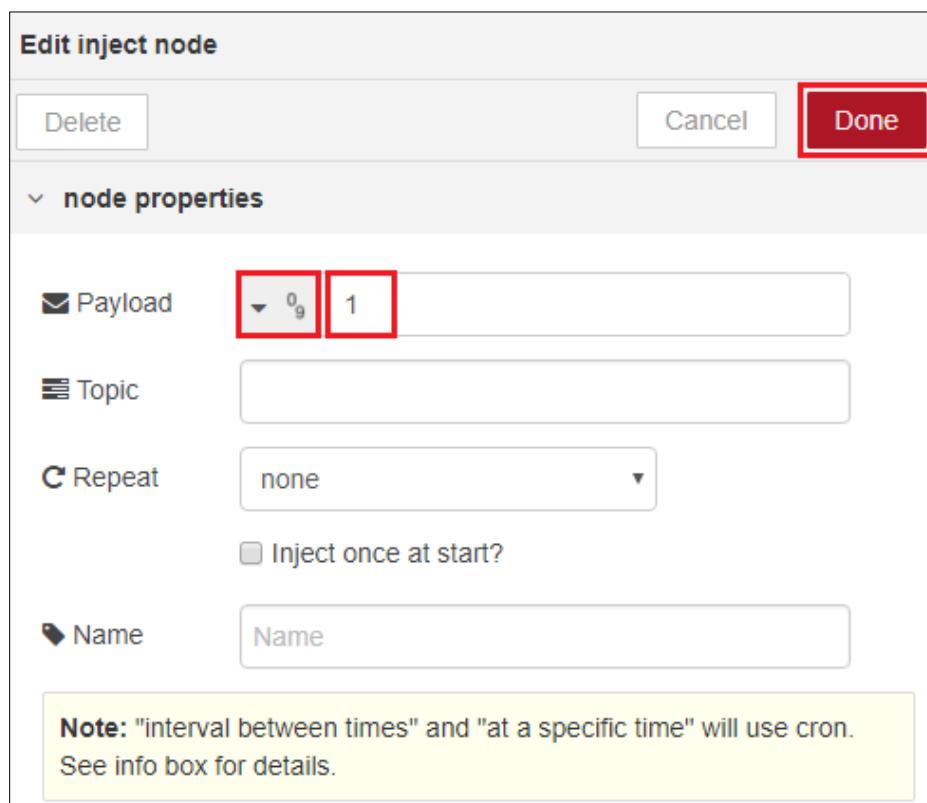
There are only two messages that make sense to publish to any device that is subscribed to this topic. Those messages can be **1** or **0**. This turns the Raspberry Pi pin either on or off.

Drag two **Inject** nodes to your flow.

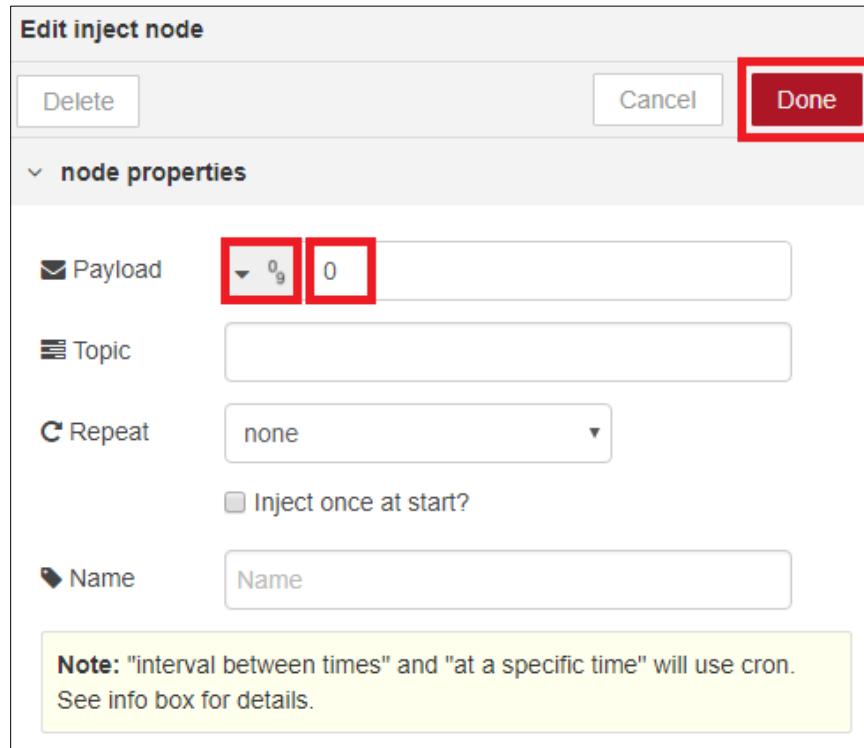


Double-click the first **Inject** node to edit its properties. Select **number** and type **1**.

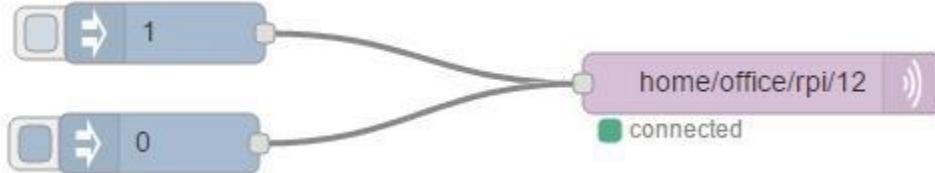
Press **Done**.



Edit **Inject** node number two. Select **number** and type **0**. Press **Done**.



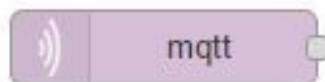
Connect both **Inject** nodes to the **MQTT output** node.



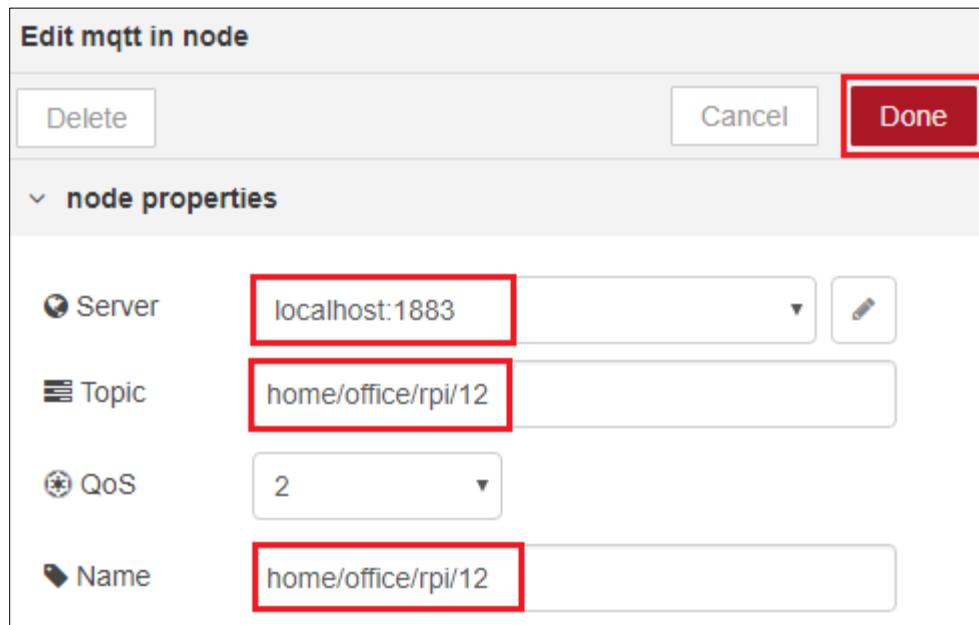
Creating the Subscribe Node

We need a node that is subscribed to this exact topic, so it receives the message and ultimately does something.

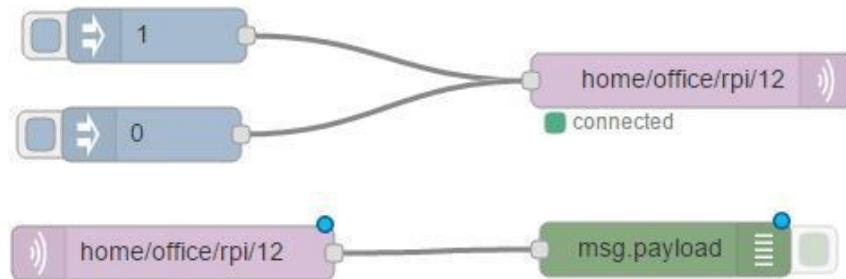
Drag an **MQTT input** node to the flow.



Select the MQTT broker. Type the exact topic created previously.

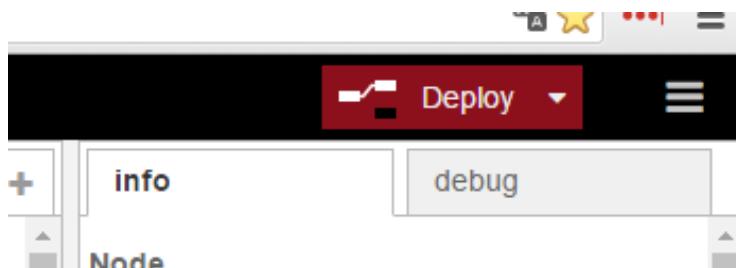


Drag a **Debug** node, so we can print the message received. Connect both nodes.



Testing the MQTT Connection

Press the **Deploy** button on the top-right corner to save your application.



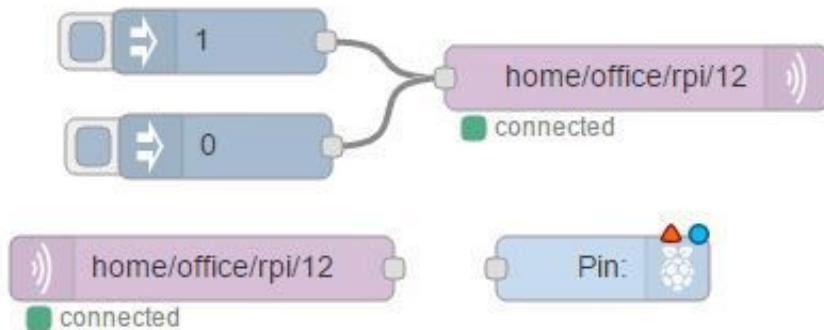
Open the **debug** window, trigger the **Inject** node with **0** and **1**. As you can see the message is being received and printed in the **debug** window.



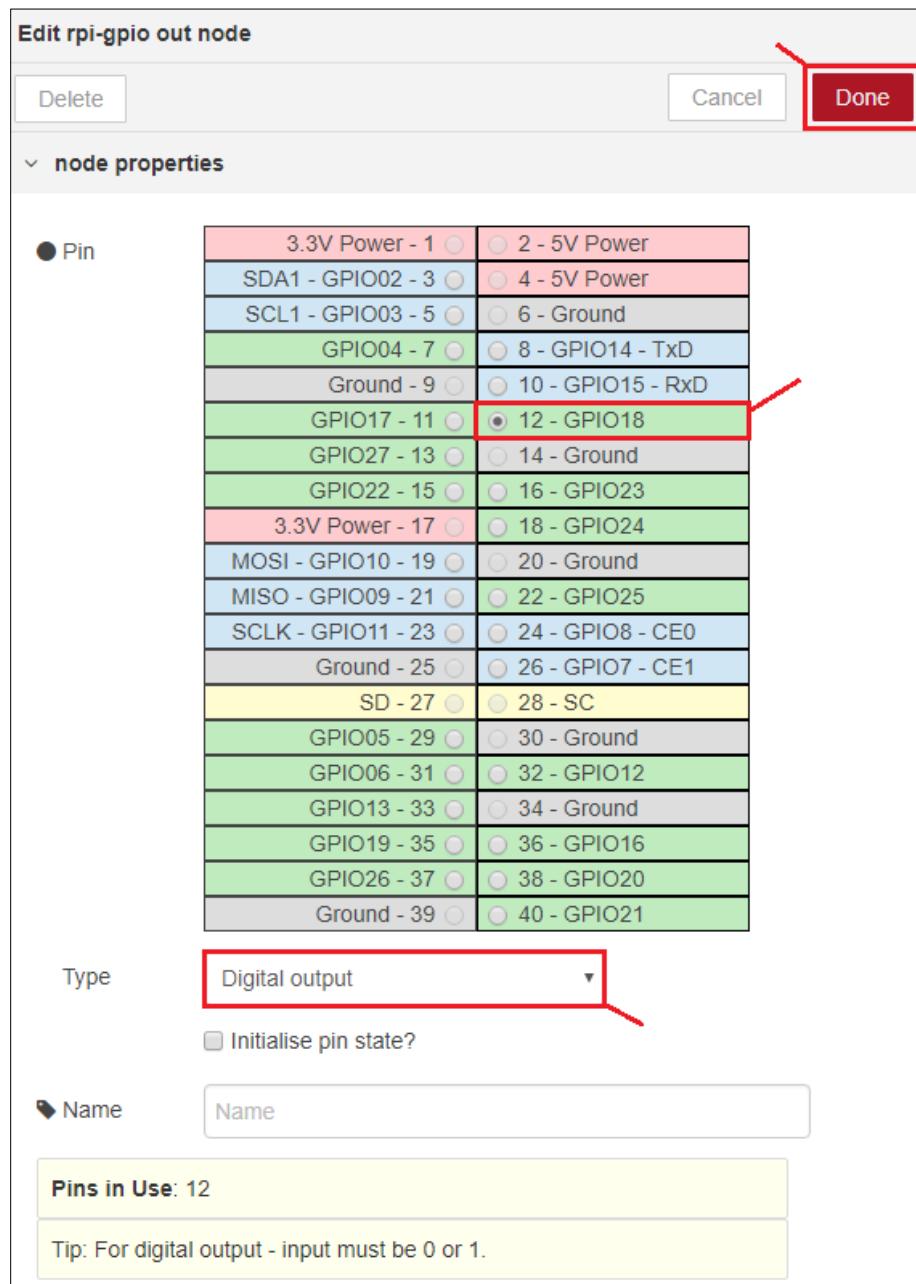
This is how you make a publish and subscribe system.

Connecting the rpi-gpio out Node

Now, delete the debug node. Drag a **rpi-gpio out** node.



Lastly, edit the **rpi-gpio out** node. Set the type as a **Digital output** and the GPIO Pin **12** (that's where your LED will be connected to). Click **Ok**.

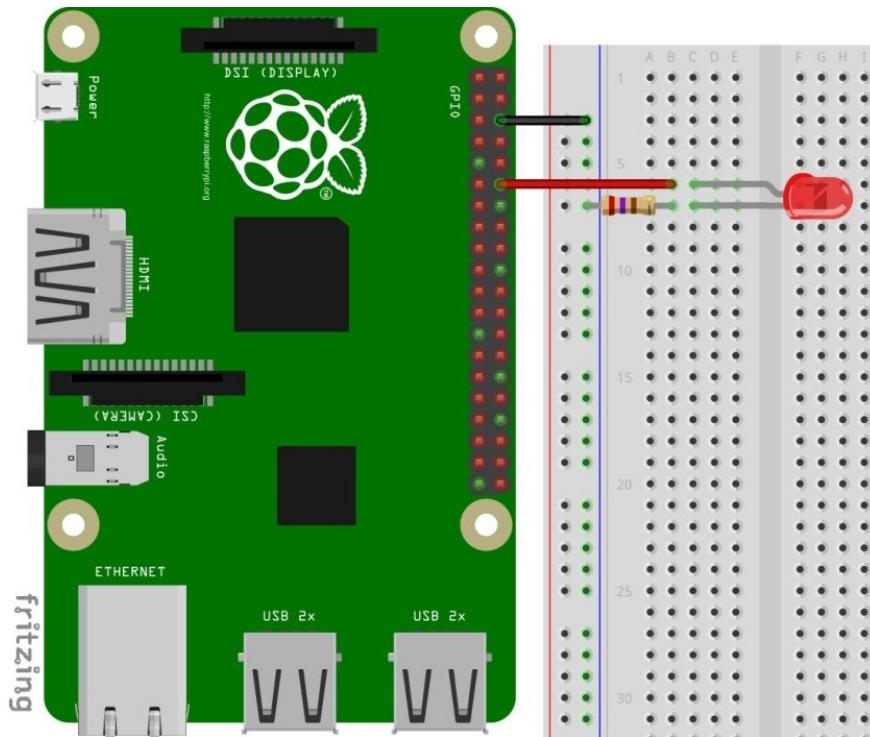


Schematics

Here's the hardware required to complete this project and connect an LED to pin 12:

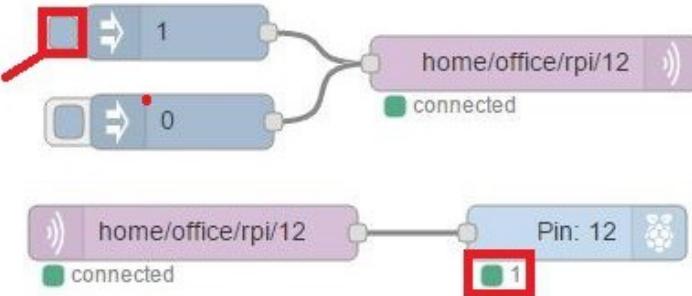
- [Raspberry Pi](#)
- [LED \(5mm\)](#)
- [270Ω resistor](#)

- [Breadboard](#)
- [Jumper wires](#)

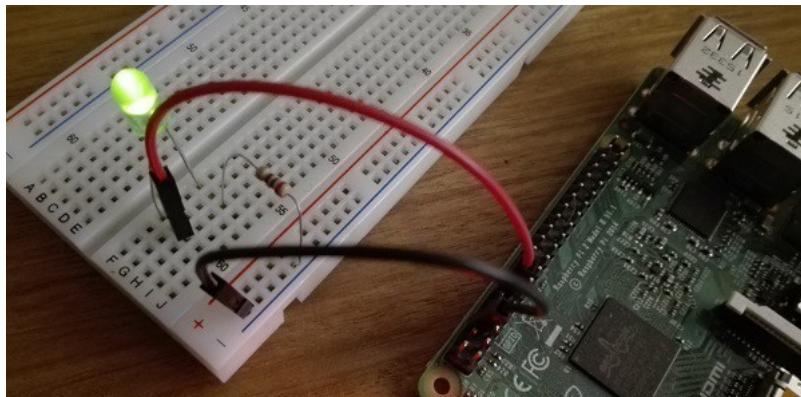


Deploy your application and now you can control the LED on and off.

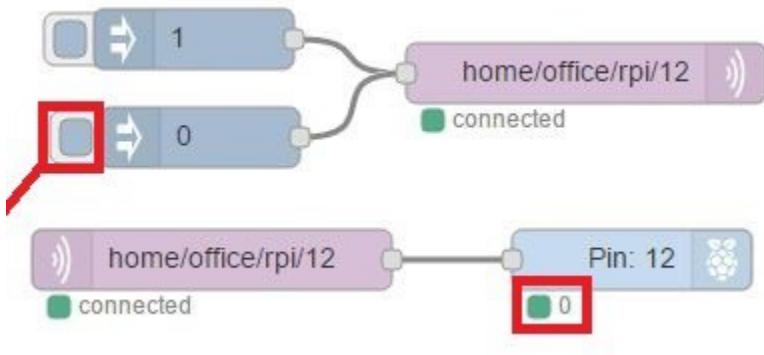
Now, press the square of the **Inject 1** node.



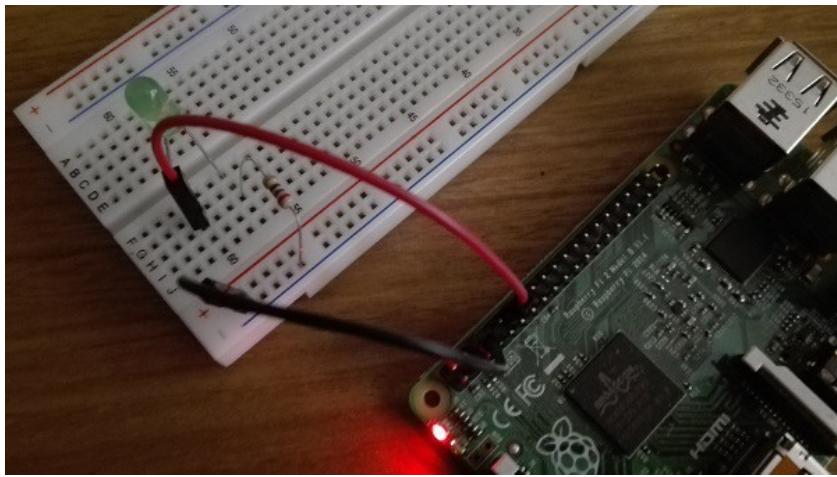
Your LED turns on:



And when you press the 0 **Inject** node.



Your LED turns off:



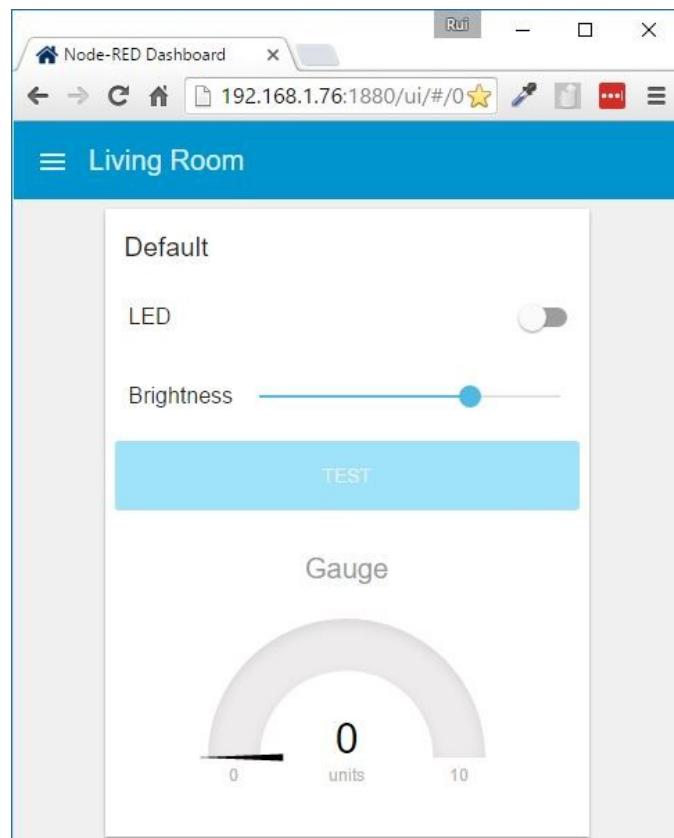
Keep in mind this is just a basic demonstration and these nodes can be connected to your Arduino and your ESP8266.

In the next Module, you're going to learn how to design the graphical user interface to control the GPIOs with the MQTT protocol.

In the future Modules, you'll learn how to connect the Arduino and the ESP8266 to your main server and control any output or read any sensor data.

MODULE 5

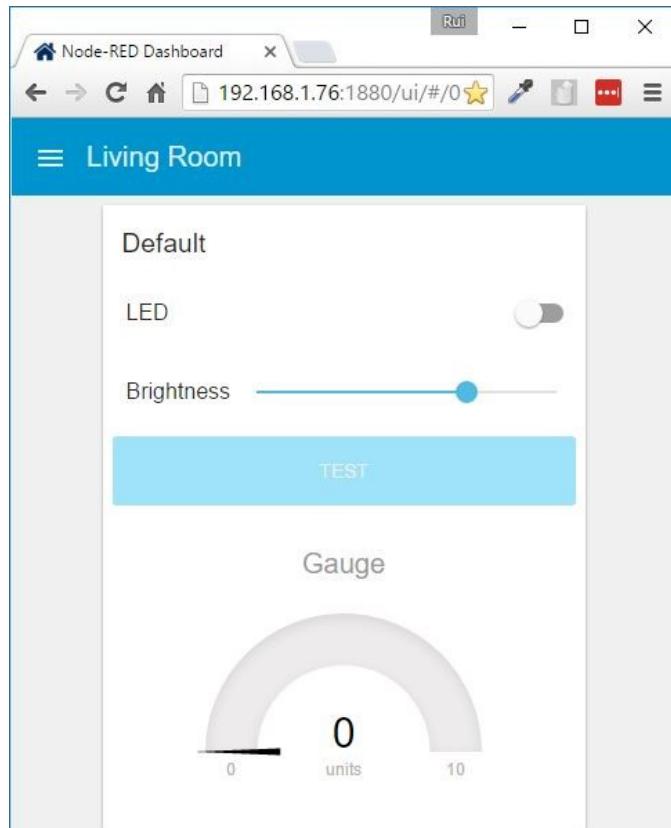
Designing the Graphical User Interface



Unit 1 - Installing Node-RED Dashboard

In this Module you're going to install a Node-RED package called **Node-RED Dashboard**.

This package allows you to add buttons, sliders, switches, charts, gauges and much more to your projects.



Here's two links that might be helpful to extend your knowledge about this package:

- Node-RED site: <http://flows.nodered.org/node/node-red-dashboard>
- GitHub: <https://github.com/node-red/node-red-dashboard>

Installing Node-RED Dashboard

To install Node-RED Dashboard run these 3 commands:

```
pi@raspberry:~ $ node-red-stop  
pi@raspberry:~ $ cd ~/.node-red  
pi@raspberry:~/node-red $ npm install node-red-dashboard
```

Rebooting your Raspberry Pi

Reboot your Raspberry Pi:

```
pi@raspberry:~ $ sudo reboot
```

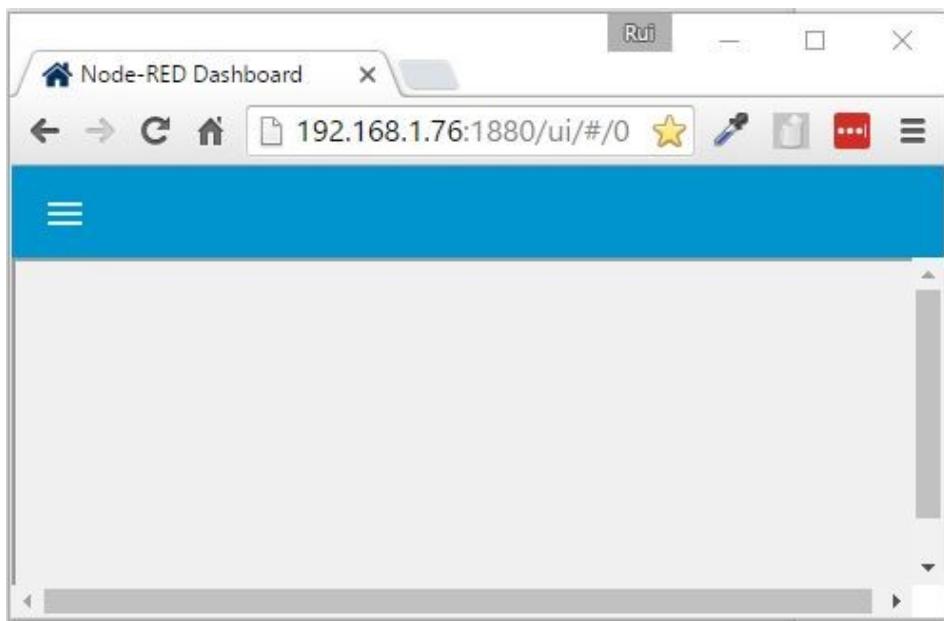
When your Pi is back on, you can open the UI by entering the RPi IP address in a web browser followed by :**1880/ui** as follows:

```
http://YOUR_RPi_IP_ADDRESS:1880/ui
```

In my case is:

```
http://192.168.1.98:1880/ui
```

A page like this loads:



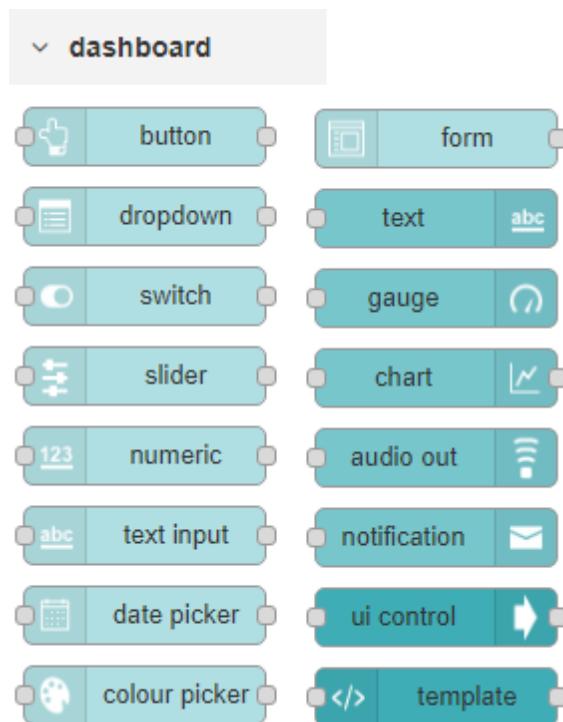
Unit 2 - Experimenting with Node-RED Dashboard

If you've followed the previous Unit, you have Node-RED Dashboard installed in your Raspberry Pi. Open two tabs in your web browser, one with Node-RED and the other with Node-RED Dashboard:

```
http://YOUR_RPi_IP_ADDRESS:1880  
http://YOUR_RPi_IP_ADDRESS:1880/ui
```

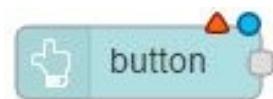
Now that you have **Node-RED Dashboard** installed, if you scroll down, you can see a new section of nodes called Dashboard.

At a first glance, you see that you have the option to create buttons, dropdowns, switches, sliders, text inputs and more...



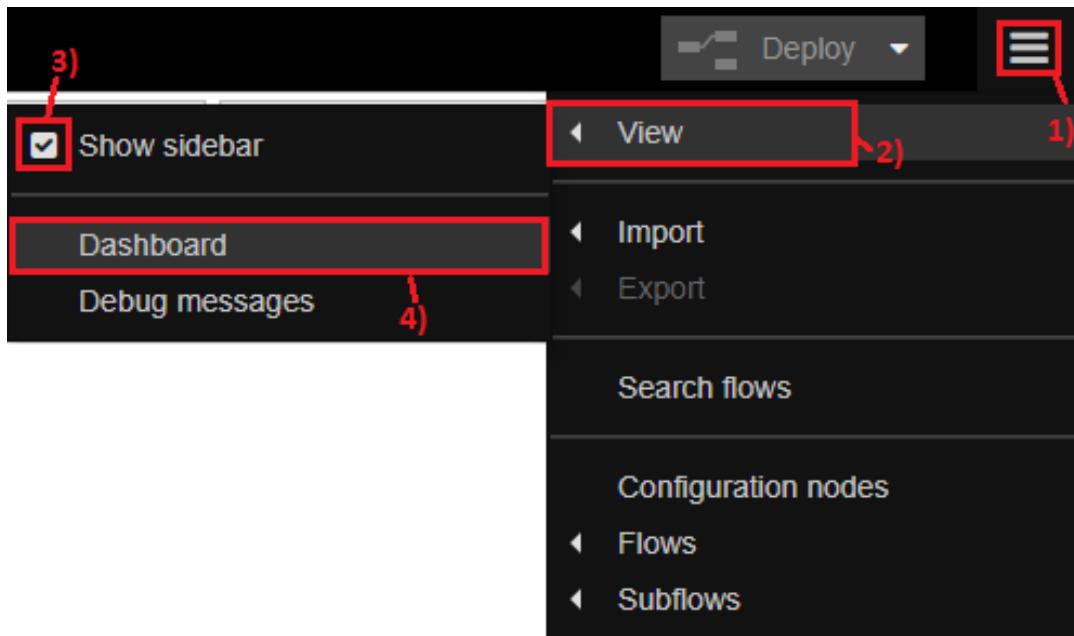
Button Node

Let's start by dragging a **Button** node to the flow.



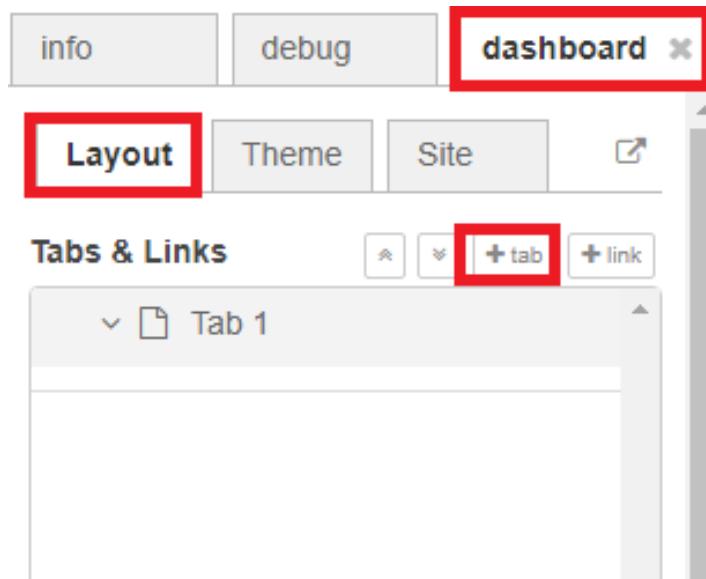
If you Deploy your application and go to the Dashboard page. You see that the Dashboard is completely empty.

In your Dashboard, you can create tabs. Tabs are useful to define your rooms or the different sections in your home. Open the tab manager window. Go to the **top menu > View > Dashboard** – make sure you also have the **Show sidebar** ticked.

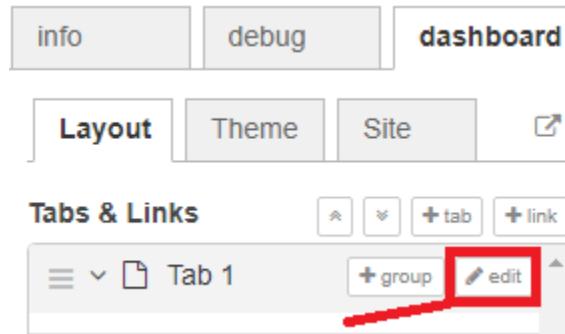


A new window called dashboard opens in the right side.

That's where you can create tabs, groups and organize the buttons of the interface. Click the **+tab** button.



Then click the **edit** button.

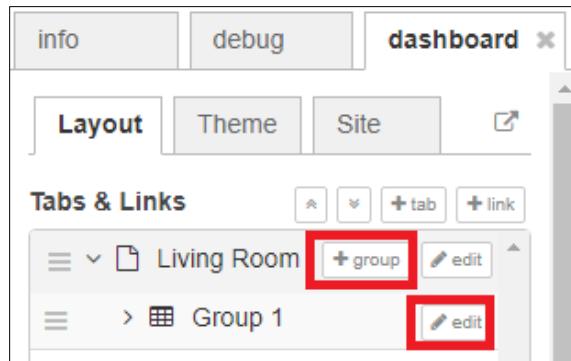


Call it **Living Room** and click the Update button.

Edit dashboard tab node

Delete	Cancel	Update
Name	Living Room	
Icon	dashboard	

Finally, you have to set a group. Press the **+group** and the **edit** button

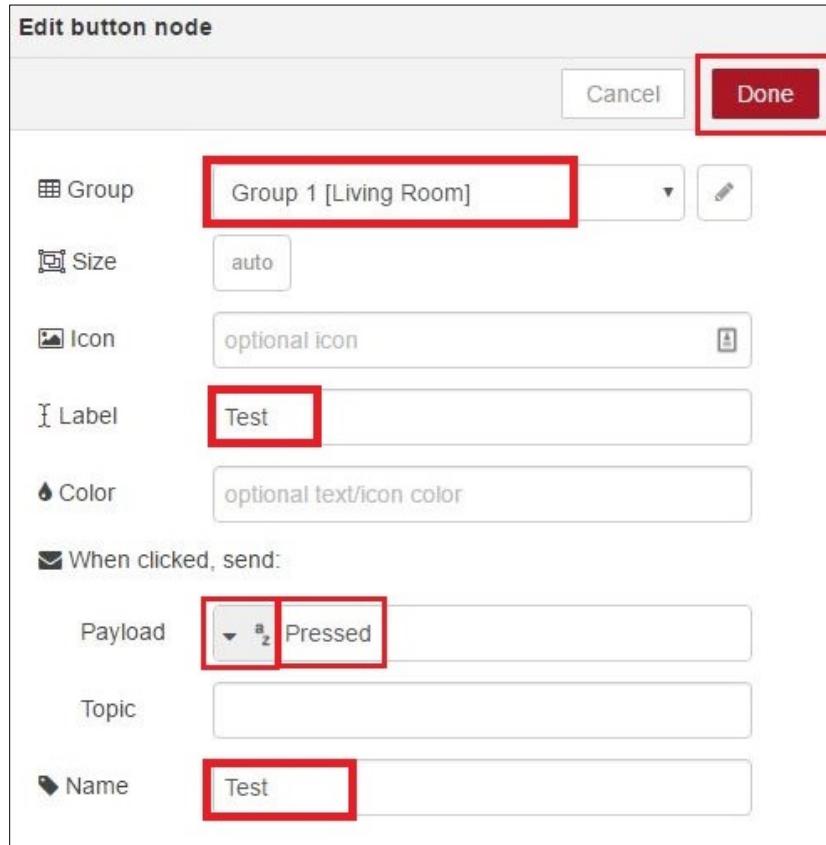


All the default setting should be ok, but you can change the Group's name:

Edit dashboard group node

Delete	Cancel	Update
Name	Group 1	
Tab	Living Room	
Width	6	

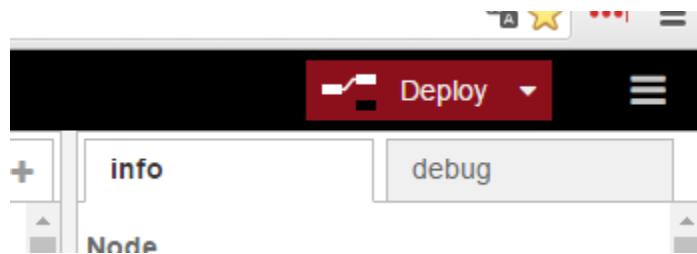
Double-click the **Button** node to edit its settings. Select the **Living Room** tab, call your button **Test** and make it print the message “**Pressed**” when it’s pressed.



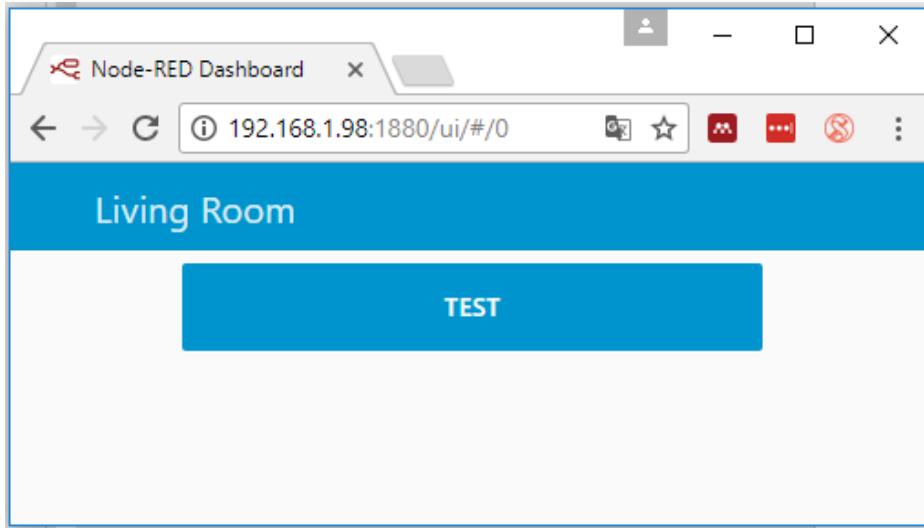
Connect a **Debug** node to your **Button** node:



Click the **Deploy** button on the top-right corner to save your application.



Go to the dashboard page and you can see the **Living Room** tab. And you can see your **TEST** button



If you press it, it will print the message "**Pressed**" in your **debug** window.

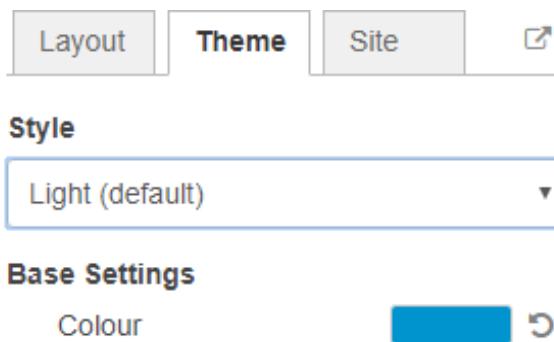


You can use this mechanism to trigger events. You're going to learn how to do that in future Modules.

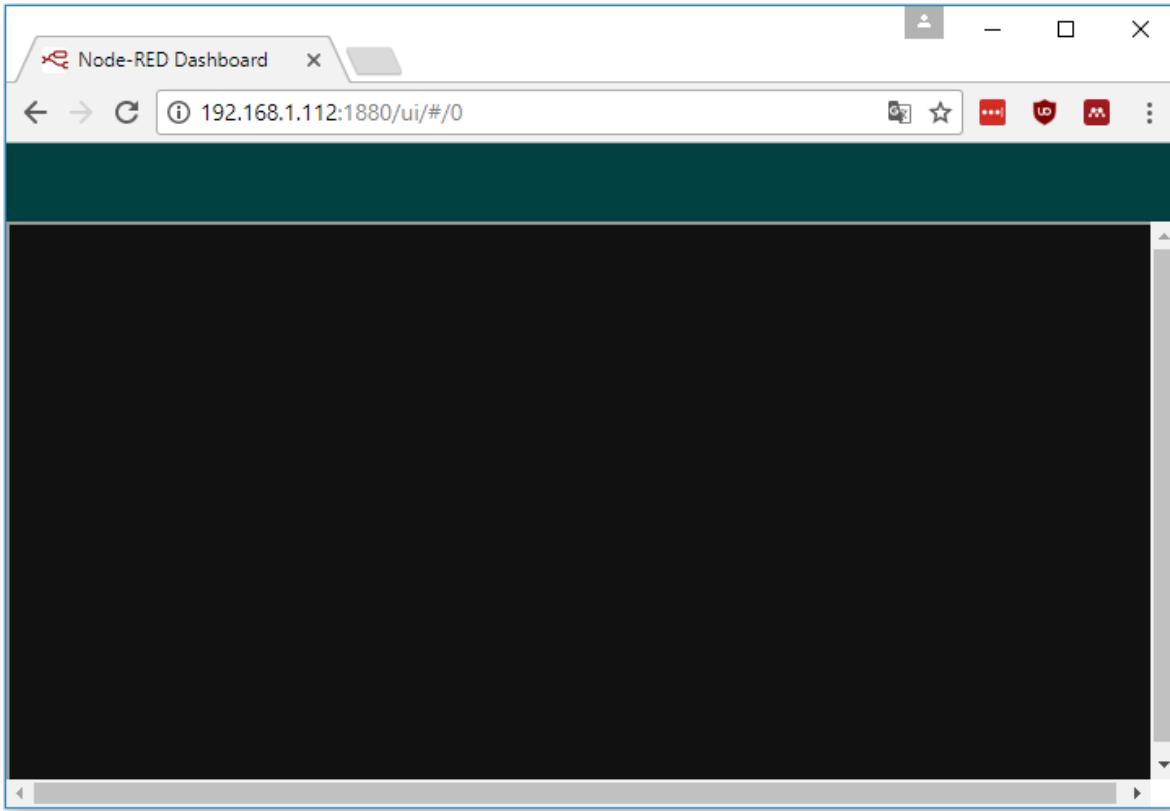
Delete those nodes and move on to the next example.

Dashboard Theme

The Node-RED Dashboard has a white background and a light blue bar by default. You can edit its colors in the **Theme** tab on the up-right corner as show in the following figure.



Change the style, deploy the changes and see the Dashboard UI changing its colors. For example, like in the following figure:



Dashboard Site

At the right upper corner of the Node-RED window, you have another tab called **Site** that allows you to do further customization as show in the figure below.

A screenshot of the "Site" configuration tab in Node-RED. The tab is active, indicated by a blue border. Below the tab are several configuration sections: "Title" (set to "Node-RED Dashboard"), "Options" (dropdown menus for "Show the title bar" and "No swipe between tabs"), "Date Format" (set to "DD/MM/YYYY"), and "Sizes" (configurable fields for "1x1 Widget Size" and "Widget Spacing").

Feel free to change the settings, then deploy the changes and see how the Dashboard looks. You won't notice much difference because you haven't added anything to the dashboard yet. Those changes will be noticeable when you start adding widgets to the Dashboard.

Switch and Slider Nodes

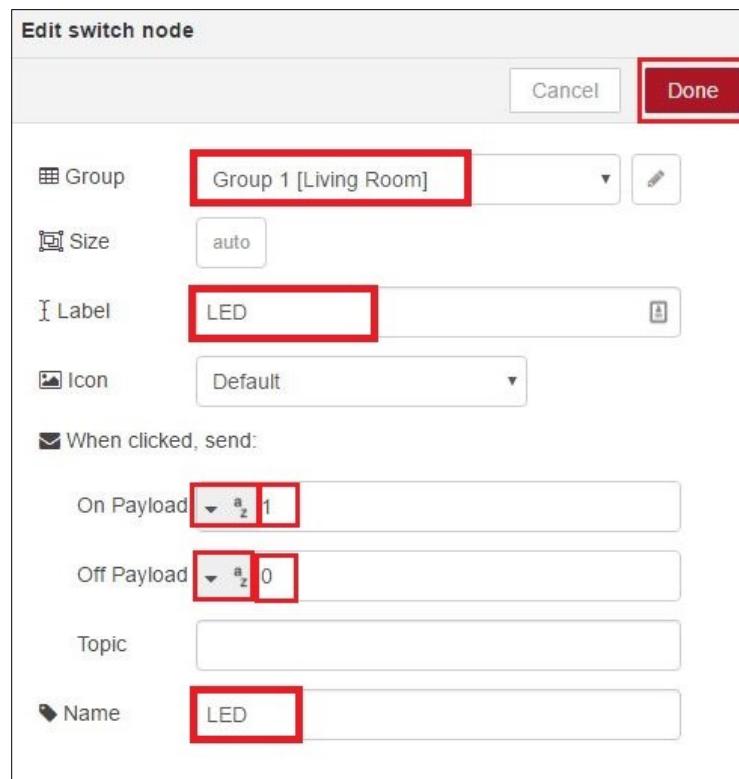
Add the **Switch** and **Slider** nodes to your flow.



With these nodes you can control your Raspberry Pi GPIOs:

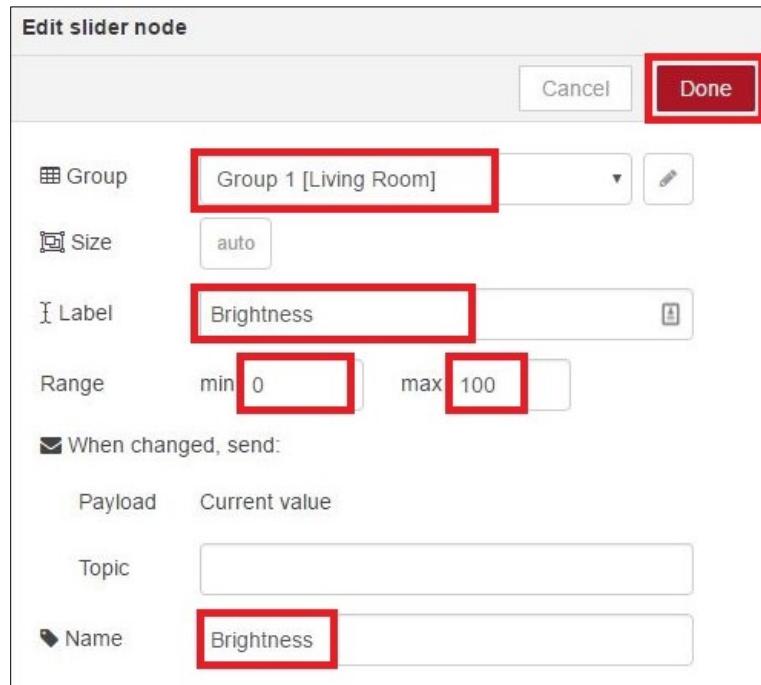
- **Switch** node: turns LED on and off
- **Slider** node: controls the LED brightness

Double-click the **Switch** node and call it **LED**. Set the on value to **1** and the off value to **0**.

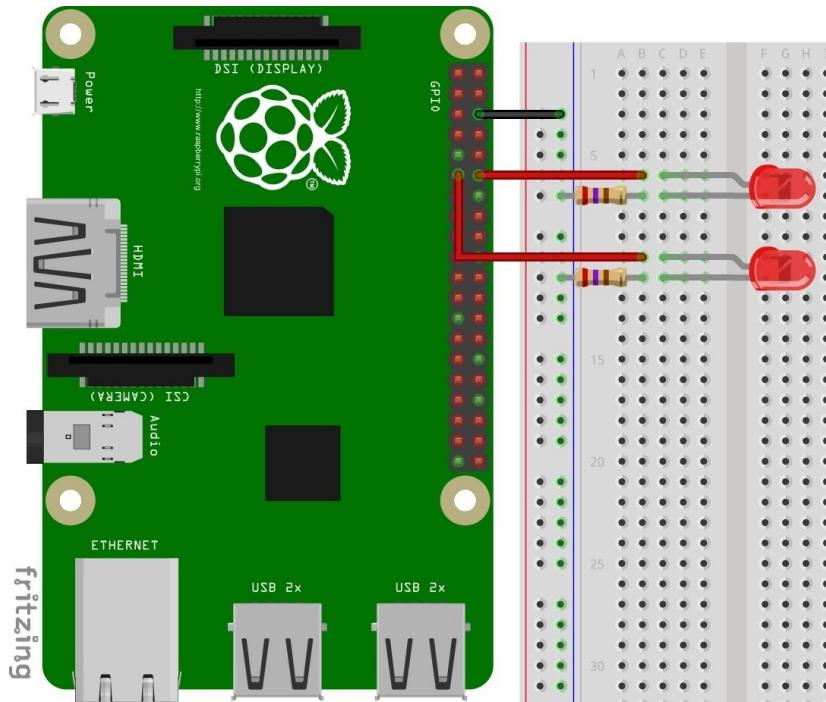


Important: sometimes the switch node keeps the default values **true** and **false** after you press Done. If your project isn't working, double-check that your **On Payload** and your **Off Payload** fields are set to **1** and **0**, respectively (see screenshot above).

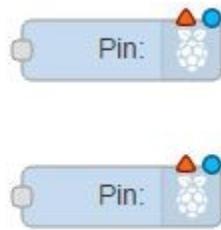
Double-click the **Slider** node and call it **Brightness**. The min should be **0** and the max should be **100**.



Follow the schematic to connect two LEDs to your Pi.



Go back to the Node-RED software and drag two **rpi-gpio out** nodes to your flow.



Assign **Pin 12** and select the type **Digital output**.

Edit rpi-gpio out node

Delete Cancel Done

node properties

Pin

3.3V Power - 1	2 - 5V Power
SDA1 - GPIO2 - 3	4 - 5V Power
SCL1 - GPIO3 - 5	6 - Ground
GPIO4 - 7	8 - GPIO14 - TxD
Ground - 9	10 - GPIO15 - RxD
GPIO17 - 11	12 - GPIO18
GPIO27 - 13	14 - Ground
GPIO22 - 15	16 - GPIO23
3.3V Power - 17	18 - GPIO24
MOSI - GPIO10 - 19	20 - Ground
MISO - GPIO09 - 21	22 - GPIO25
SCLK - GPIO11 - 23	24 - GPIO8 - CE0
Ground - 25	26 - GPIO7 - CE1
SD - 27	28 - SC
GPIO05 - 29	30 - Ground
GPIO06 - 31	32 - GPIO12
GPIO13 - 33	34 - Ground
GPIO19 - 35	36 - GPIO16
GPIO26 - 37	38 - GPIO20
Ground - 39	40 - GPIO21

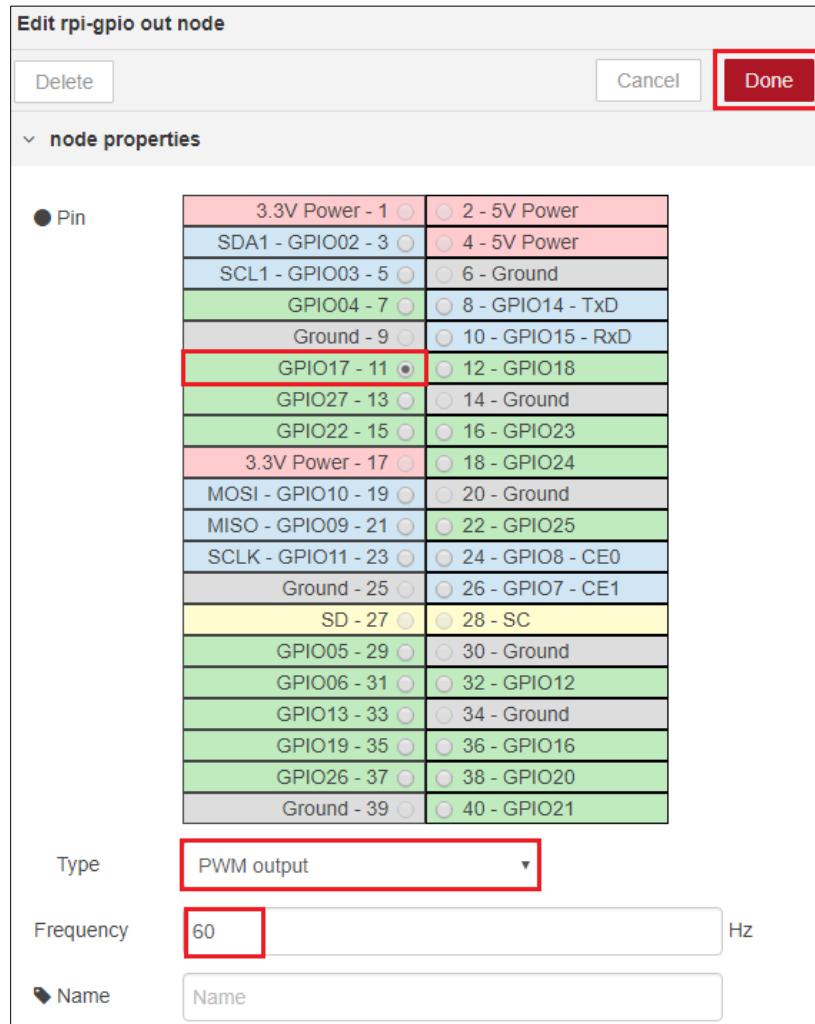
Type Digital output

Initialise pin state?

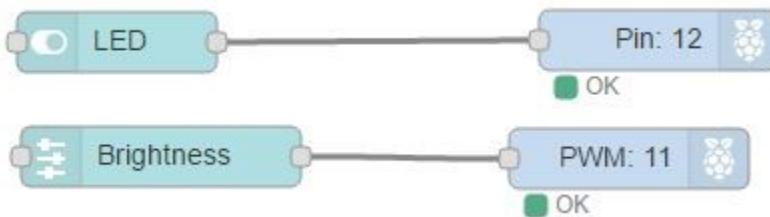
Name Name

The screenshot shows the "Edit rpi-gpio out node" dialog. The "Done" button is highlighted with a red box and a red arrow pointing to it from the top right. The "Type" dropdown is also highlighted with a red box and a red arrow pointing to it from the bottom right. The "Digital output" option is selected in the dropdown. The "Initialise pin state?" checkbox is unchecked. The "Name" field contains the text "Name". A large portion of the GPIO pin list table is also highlighted with a red box and a red arrow pointing to it from the middle right.

The other node assign **Pin 11**, select the type **PWM output** and frequency **60**.

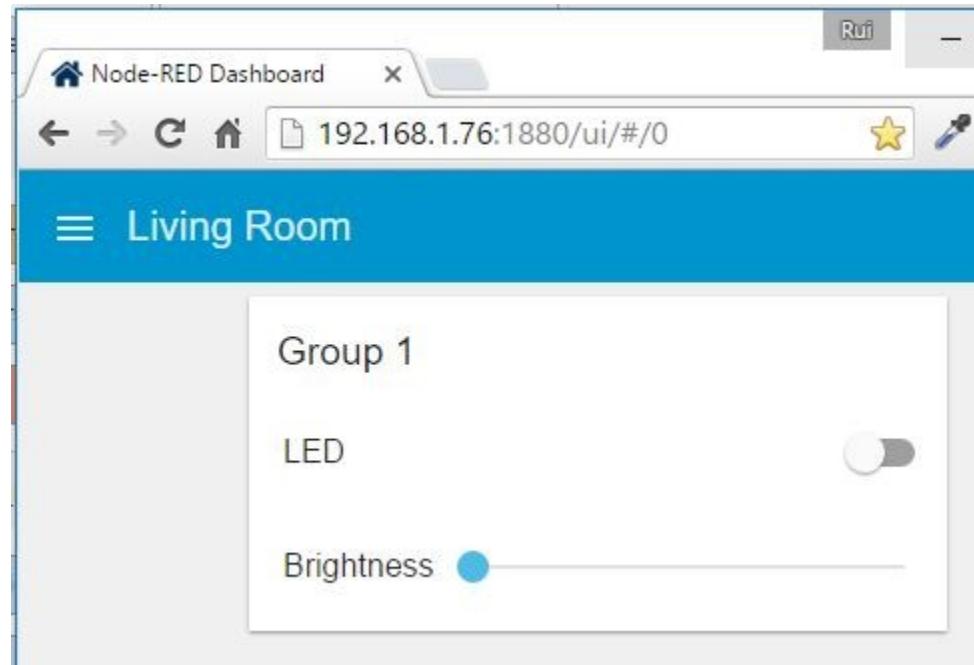


Deploy your application.

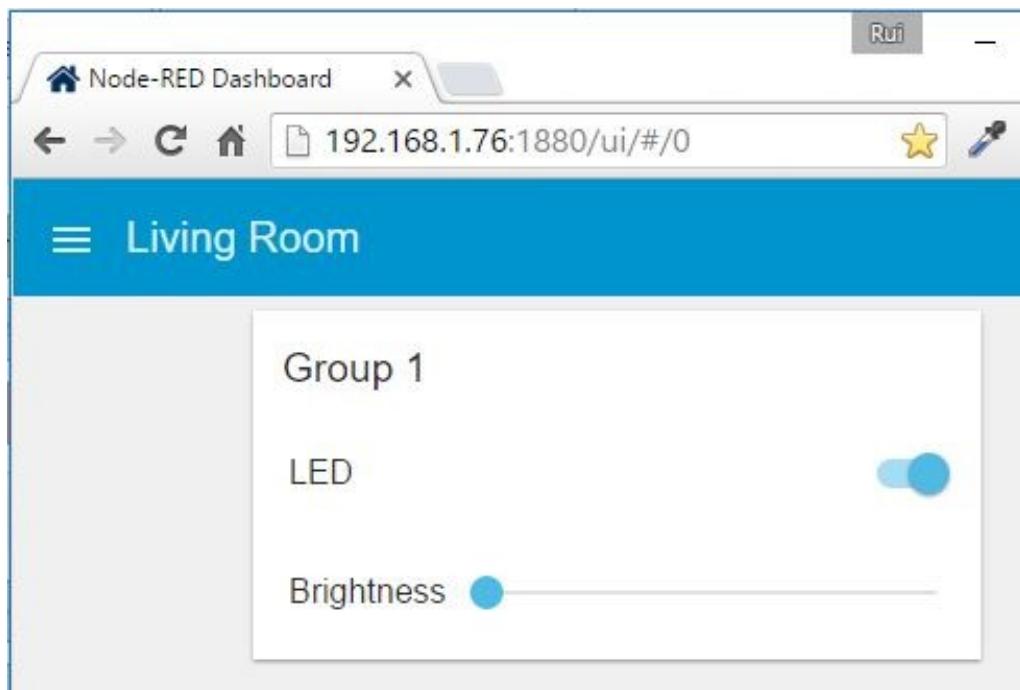


When you go to the dashboard page you can control the two LEDs.

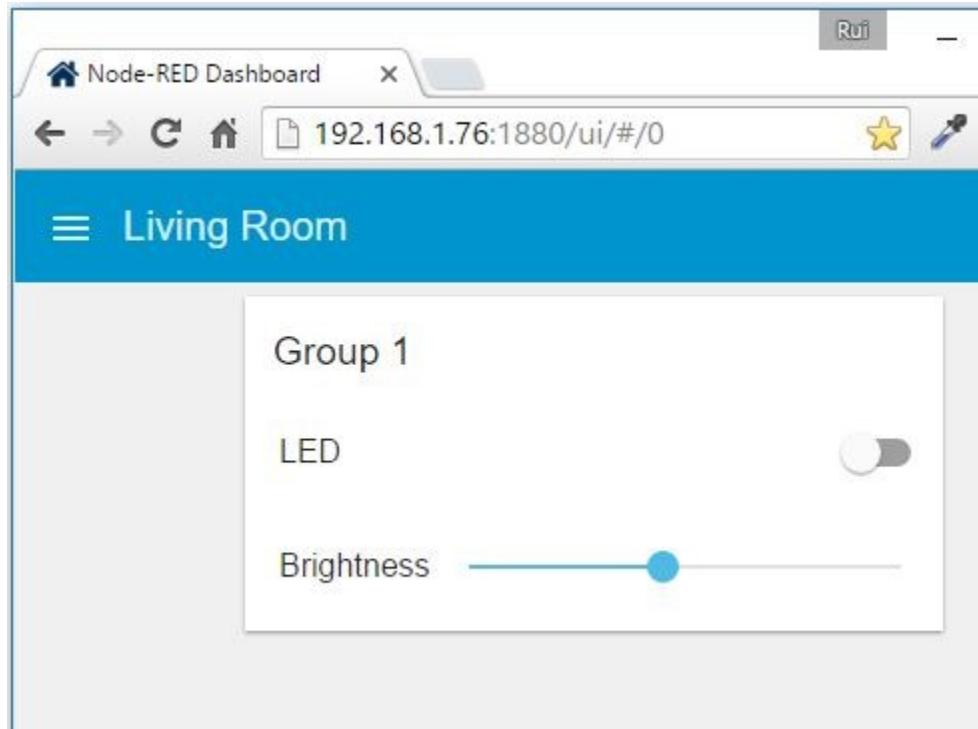
Pin 12 is currently turned off and if you press the switch:



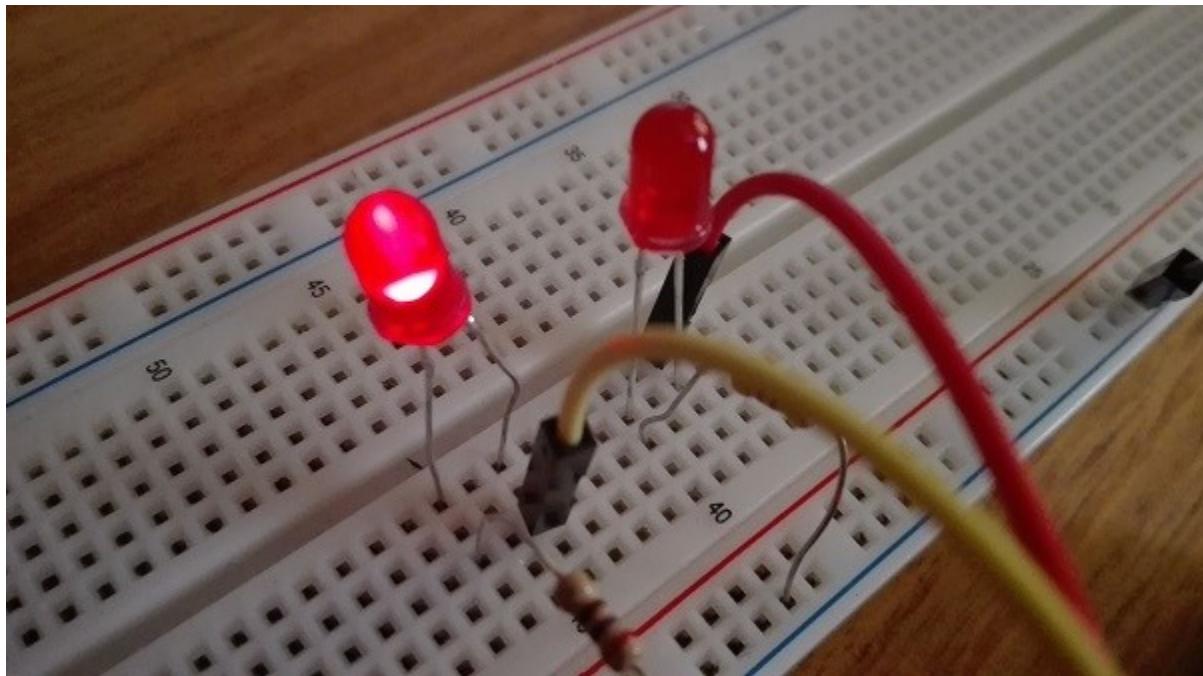
It turns your LED on.



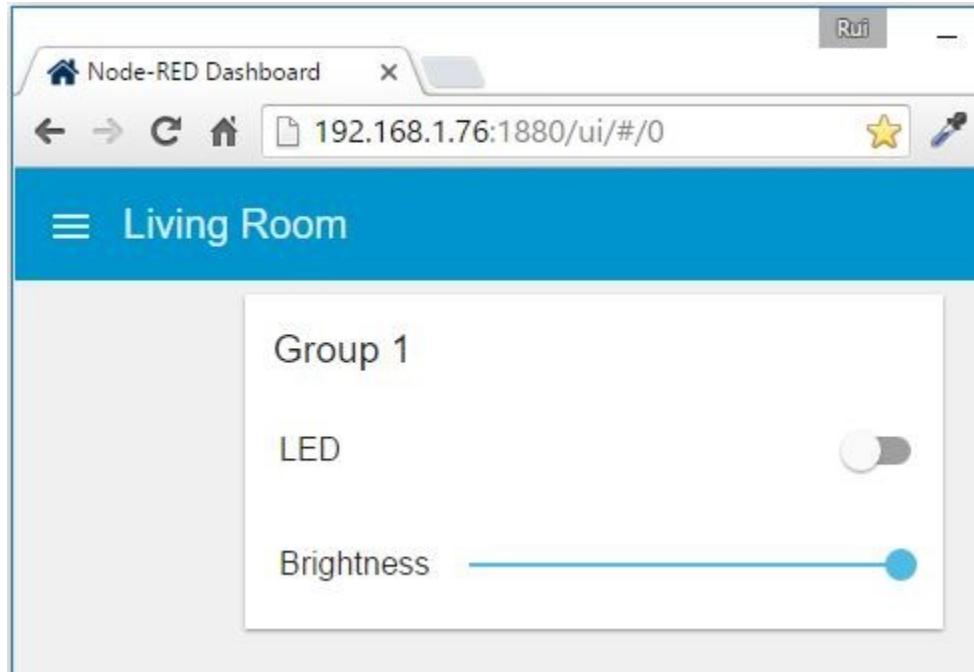
You can also control the LED brightness with the slider, if you move the slider.



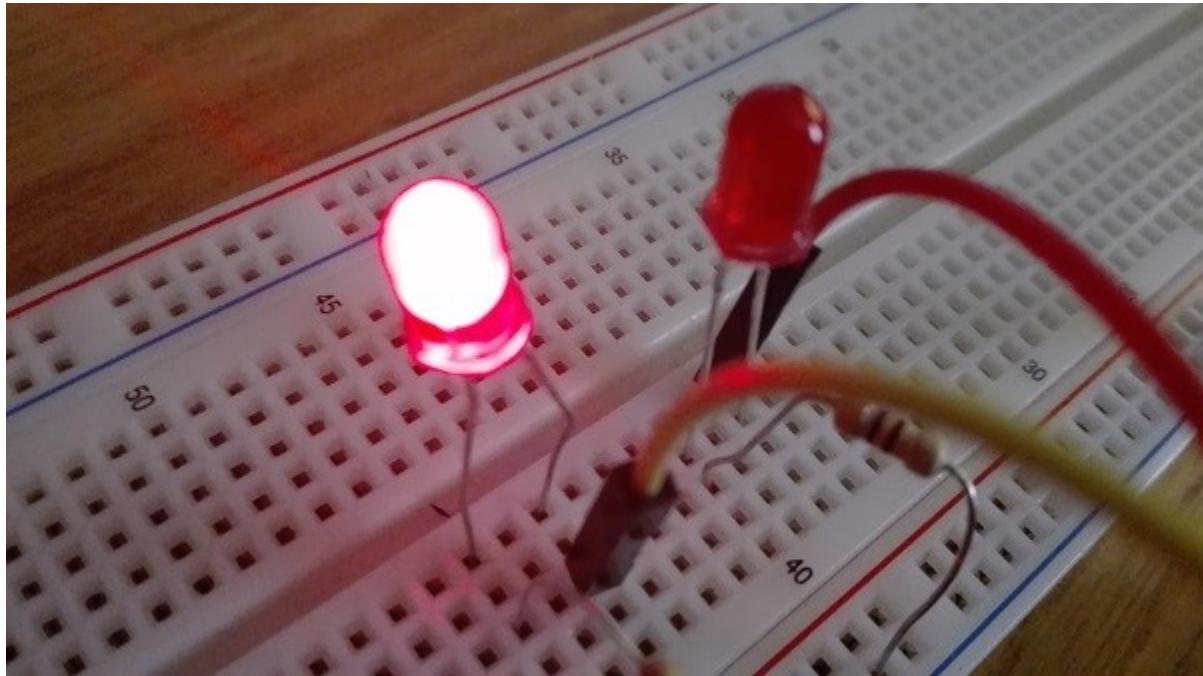
The brightness of your LED on Pin 11 changes (see previous figure):



And if you move the slider all the way up:

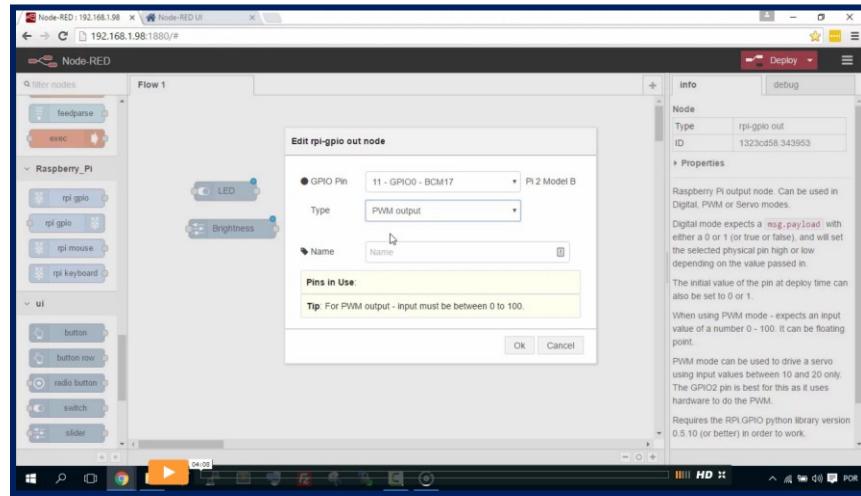


It turns your LED to its maximum brightness:



Keep in mind that you can access the user interface with any device that has a web browser. It will update the dashboard with the new states without refreshing the web page to all connected clients.

Here's the video demonstration



Video # 8 - <https://rntlab.com/watch-has-videos>

I encourage you to open the Node-RED Dashboard in your smartphone to control the LEDs with the switch and slider.

There are other Dashboard nodes that I didn't mention in this Unit, but you will use them in future Modules.

Feel free to experiment with the other Dashboard nodes in the meanwhile.

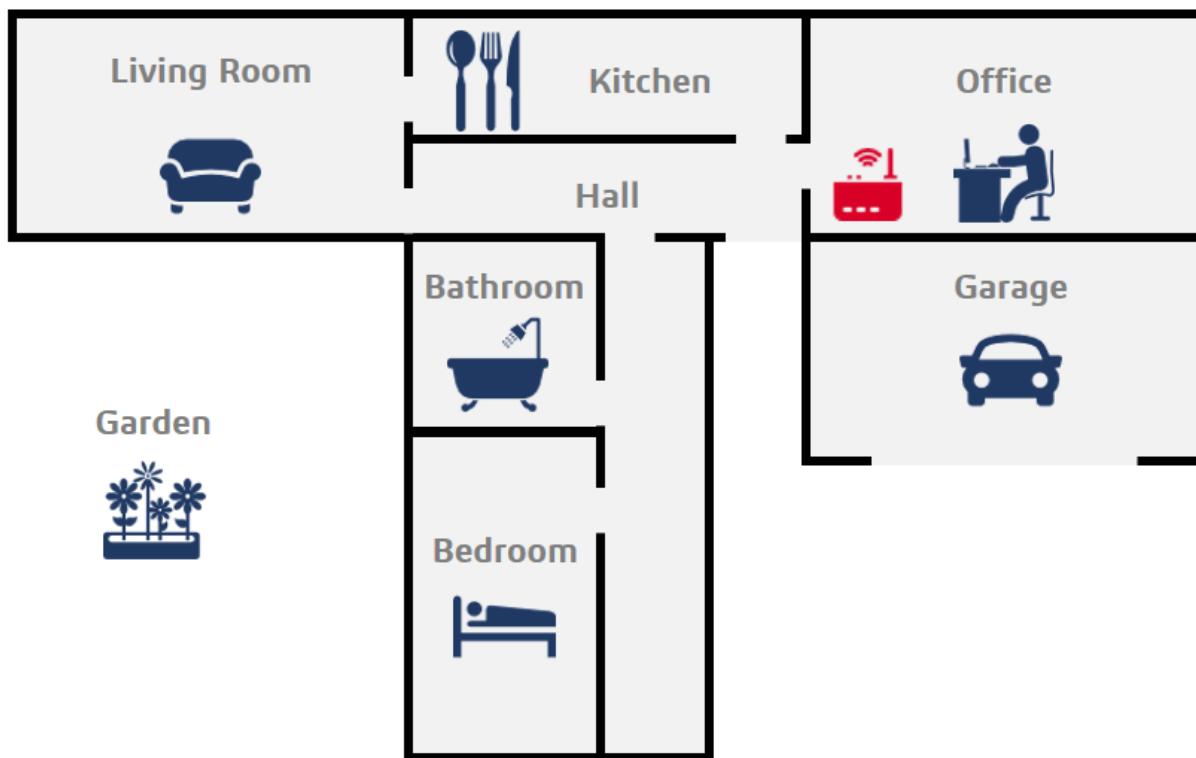
Unit 3 - Sketching Your Home Rooms

In this Unit, you will start planning which rooms of your home you would like to automate.

Rooms

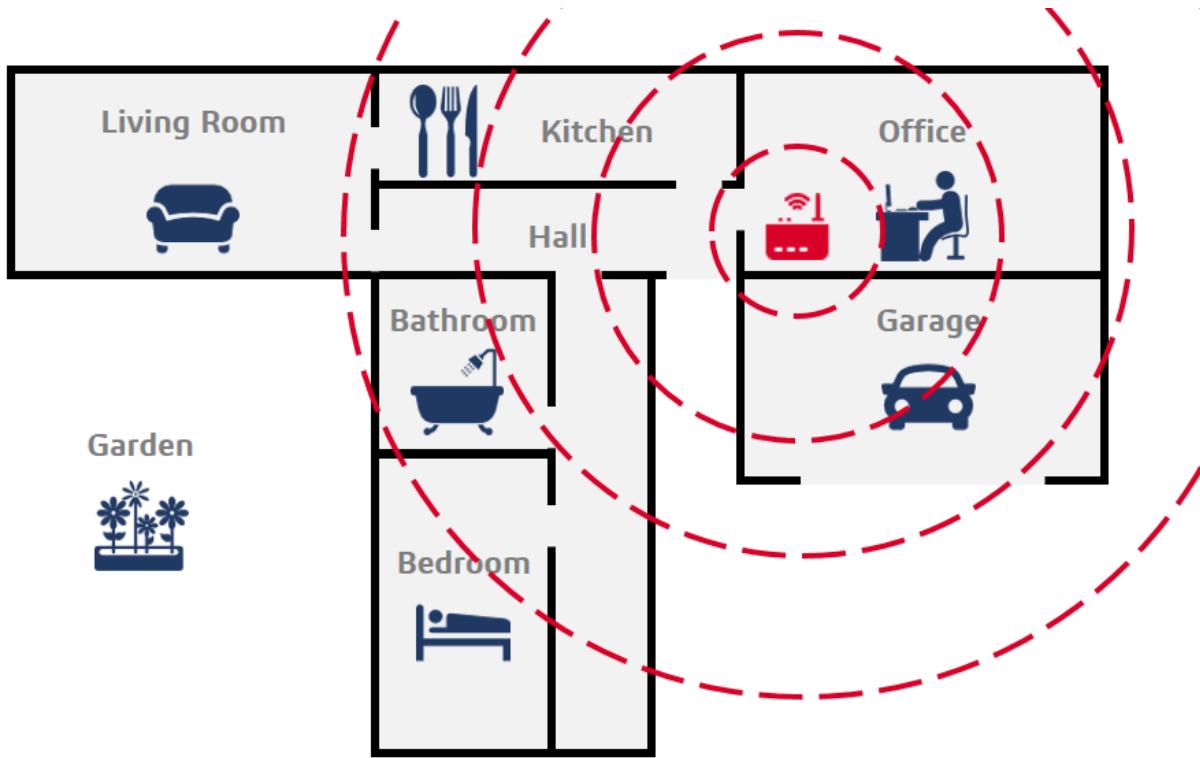
By now, you don't need to think about the result, but it's important to at least have an idea on how your house is divided and which sections you would like to control and monitor.

Below there's a simplified sketch of my home.



You should draw something like this to represent your house and use it as a reference.

As you can see, my router is located almost in the center of my home. The location of your router is very important. You need to assure that all the devices can establish a stable wireless communication with your router.



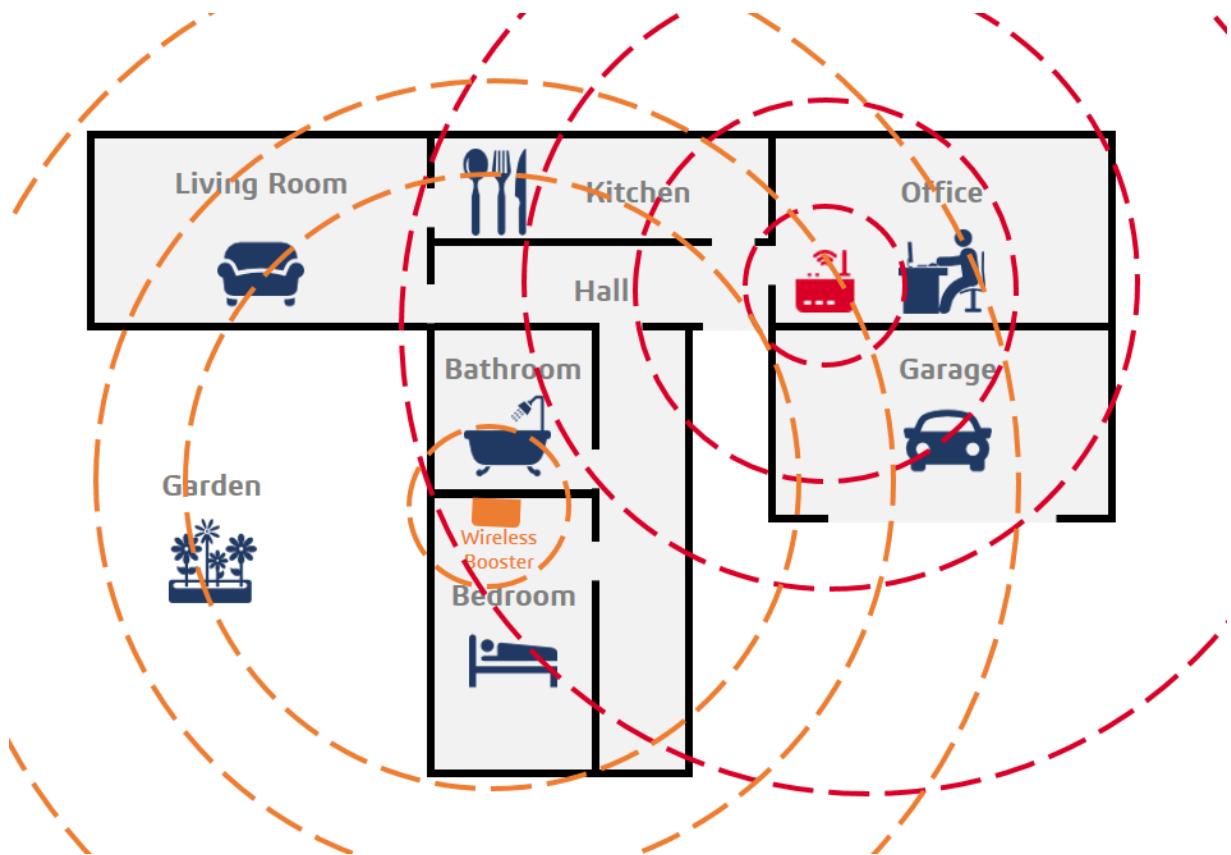
Wireless Booster

Some of the devices that you're going to add to your project may be too far away from the router and consequently won't establish a wireless communication or they will receive a weak signal....

There is a solution for this problem. You can buy a [**wireless booster**](#) to extend the wireless signal of your router.



For example, I need to have a [wireless booster](#) to extend the wireless signal to my bedroom and living room.



This is just something that you might want to start thinking about, but you don't have to decide or do anything about that at the moment.

Unit 4 - Creating Tabs on Node-RED Dashboard for each Room

This Unit shows how you can configure and organize the different tabs in the Dashboard, and customize the icons.

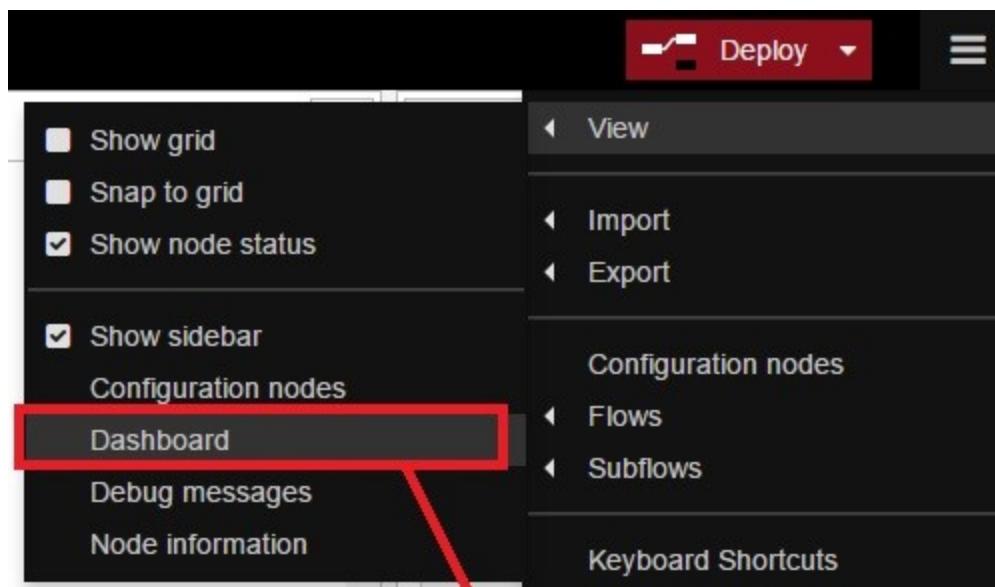
In my home I want to automate these rooms:

1. Main (This isn't a room, but it's the main tab)
2. Office
3. Living Room
4. Kitchen
5. Bedroom

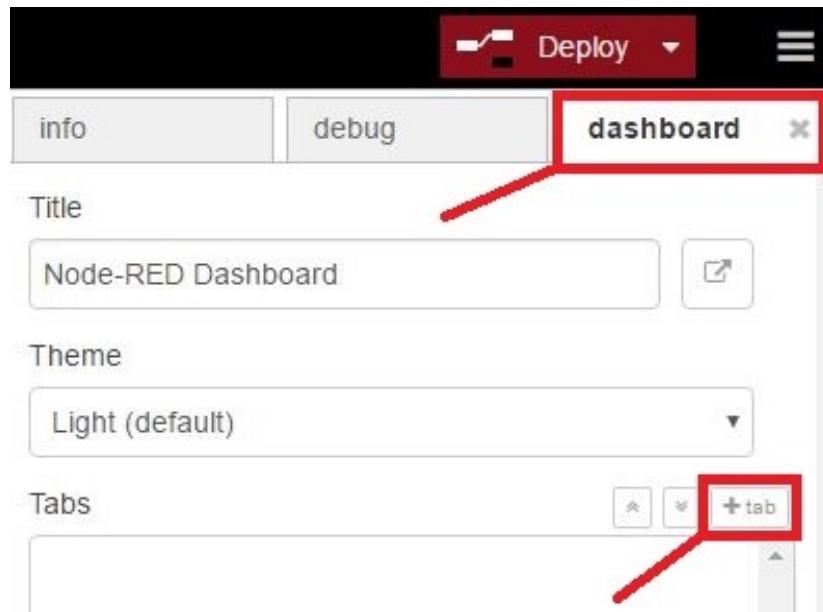
Drag 5 **Button** nodes to your flow:



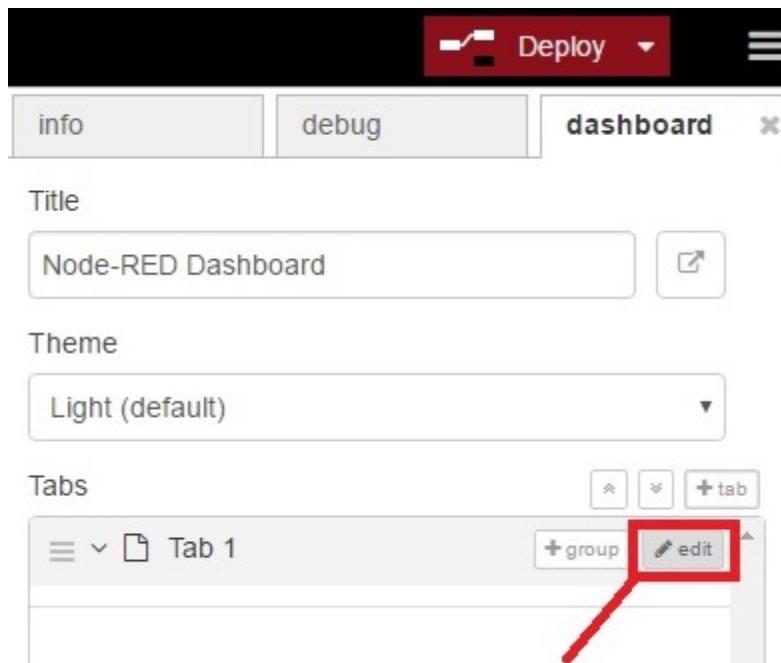
In your Dashboard, you can create tabs. Tabs are useful to define your rooms or the different sections in your home. Open the tab manager window. Go to the **top menu > View > Dashboard**.



A new window called dashboard opens in the right side. That's where you can create tabs, groups and organize the buttons of the interface. Click the **+tab** button.



Then click the **edit** button.



In the **edit tab** window you can configure the tab name and the icon that appears in your screen:

- Name: whatever you want (it should describe your room)
- Icon: name it according to these icon names <https://klarsys.github.io/angular-material-icons>

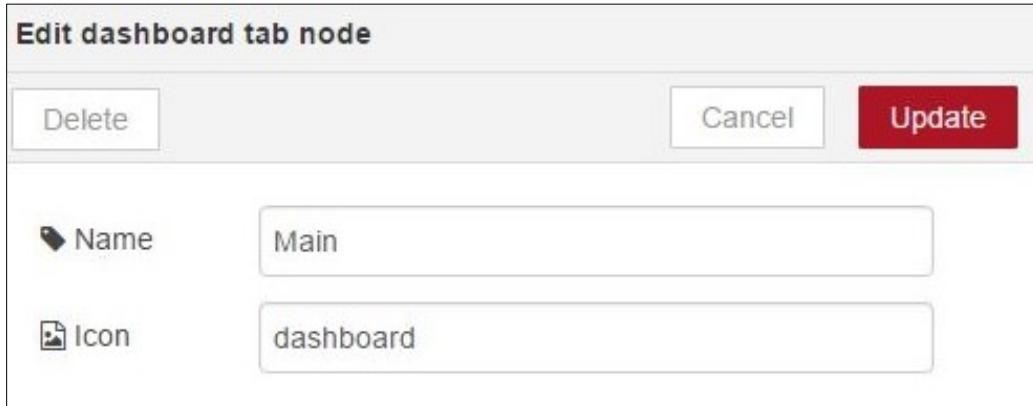
Set your tab with the name **Main** and icon **dashboard**.

Edit dashboard tab node

Delete Cancel Update

Name: Main

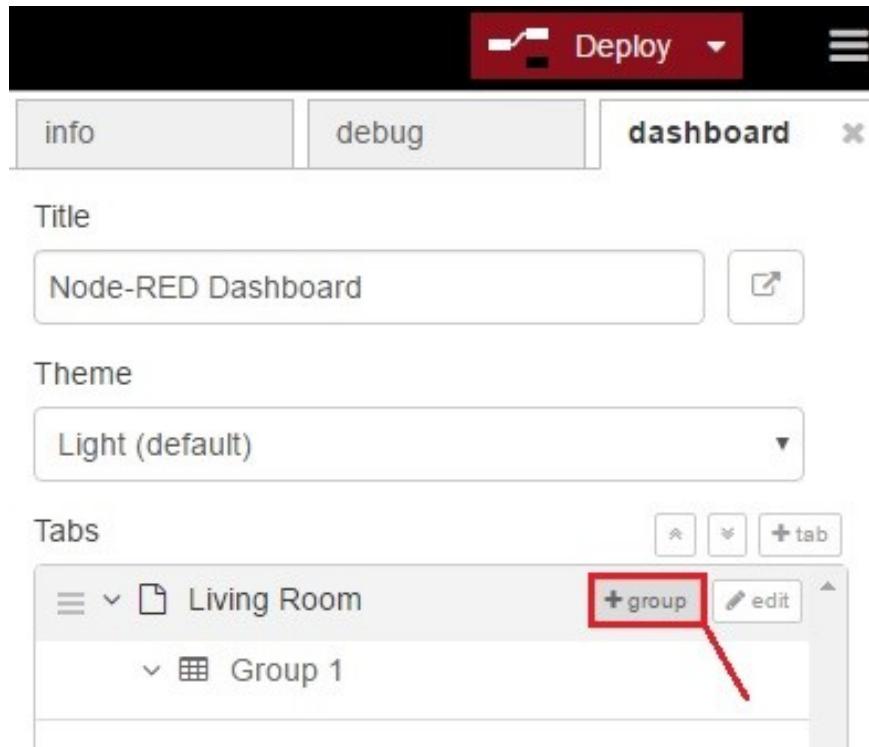
Icon: dashboard



Here's the **dashboard** icon:



Press **+group** button.



Deploy

info debug dashboard ×

Title

Node-RED Dashboard

Theme

Light (default)

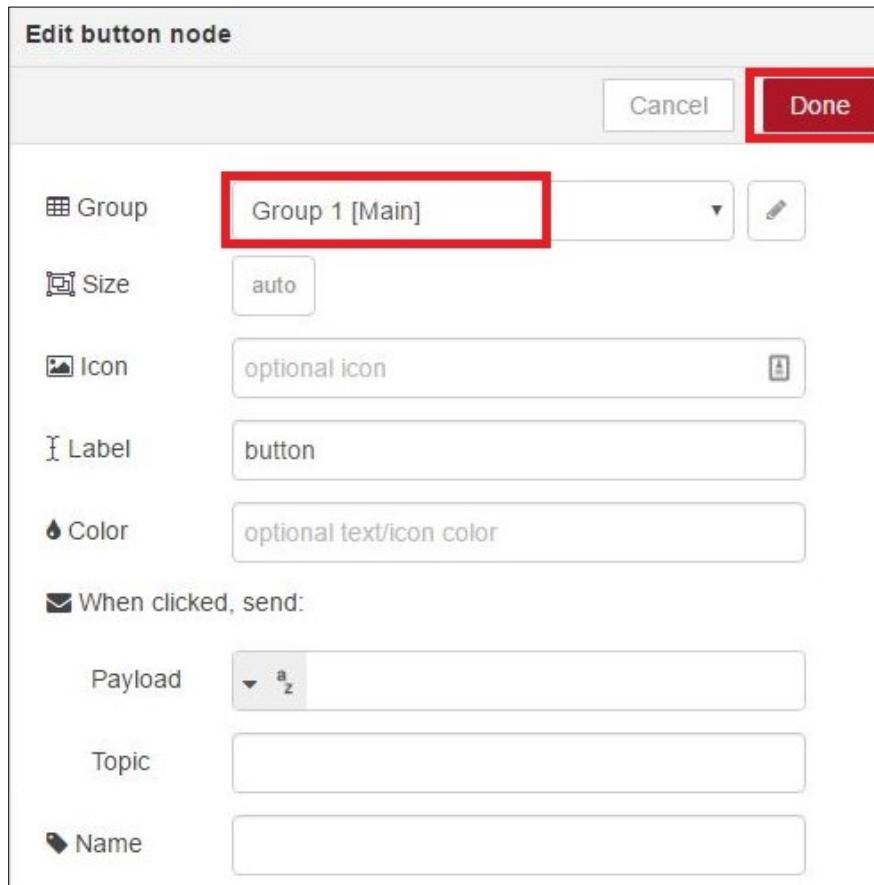
Tabs

Living Room

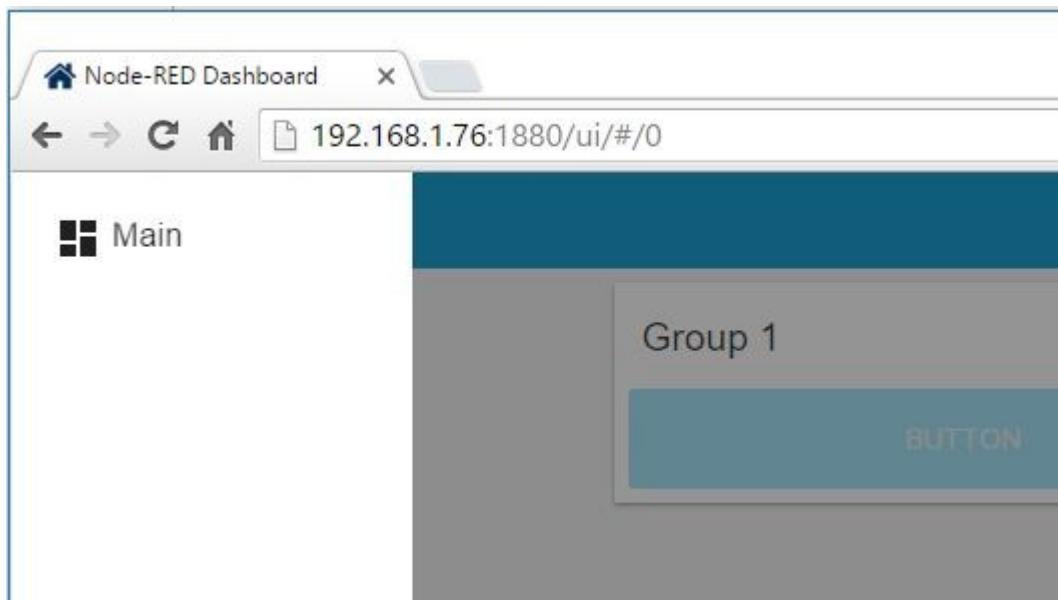
Group 1

+ group

Note: each tab should have a group assigned. Double-click the button node and select the Group 1 of the **Main** tab.



If you deploy your application and you go to the Dashboard page, you can see your new tab along with its icon:



For the second tab follow these configurations:

Edit dashboard tab node

Delete Cancel Update

Name: Office

Icon: work

work icon for the **Office** tab:



Assign the button node to the **Office** tab:

Edit button node

Cancel Done

Group: Group 1 [Office]

Size: auto

Icon: optional icon

Label: button

Color: optional text/icon color

When clicked, send:

Payload: a_z

Topic:

Name:

Here's the third tab:

Edit dashboard tab node

<input type="button" value="Delete"/>	<input type="button" value="Cancel"/>	<input style="background-color: red; color: white; font-weight: bold;" type="button" value="Update"/>
Name	Living Room	
Icon	tv	

tv icon for the **Living Room** tab:



Assign the button node to the **Living Room** tab:

Edit button node

<input type="button" value="Cancel"/>	<input style="background-color: red; color: white; font-weight: bold;" type="button" value="Done"/>
Group	Group 1 [Living Room] <input type="button" value="▼"/> <input type="button" value="edit icon"/>
Size	auto
Icon	optional icon <input type="button" value="edit icon"/>
Label	button
Color	optional text/icon color
<input checked="" type="checkbox"/> When clicked, send:	
Payload	<input type="button" value="▼"/> <input type="button" value="a-z"/>
Topic	<input type="text"/>
Name	<input type="text"/>

The **Kitchen** tab comes in fourth place:

Edit dashboard tab node

<input type="button" value="Delete"/>	<input type="button" value="Cancel"/>	<input style="background-color: red; color: white; font-weight: bold;" type="button" value="Update"/>
<input checked="" type="checkbox"/> Name	Kitchen	
<input checked="" type="checkbox"/> Icon	restaurant_menu	

restaurant_menu for the **Kitchen** tab:



Assign the button node to the **Kitchen** tab:

Edit button node

<input type="button" value="Cancel"/>	<input style="background-color: red; color: white; font-weight: bold;" type="button" value="Done"/>
<input checked="" type="checkbox"/> Group	Group 1 [Kitchen]
<input checked="" type="checkbox"/> Size	auto
<input checked="" type="checkbox"/> Icon	optional icon
<input checked="" type="checkbox"/> Label	button
<input checked="" type="checkbox"/> Color	optional text/icon color
<input checked="" type="checkbox"/> When clicked, send:	
Payload	<input type="text" value="a_z"/>
Topic	<input type="text"/>
<input checked="" type="checkbox"/> Name	<input type="text"/>

Finally, I've created the **Bedroom** tab:

Edit dashboard tab node

<input type="button" value="Delete"/>	<input type="button" value="Cancel"/>	<input style="background-color: red; color: white; font-weight: bold;" type="button" value="Update"/>
Name	Bedroom	
Icon	brightness_2	

brightness_2 icon for the **Bedroom** tab:

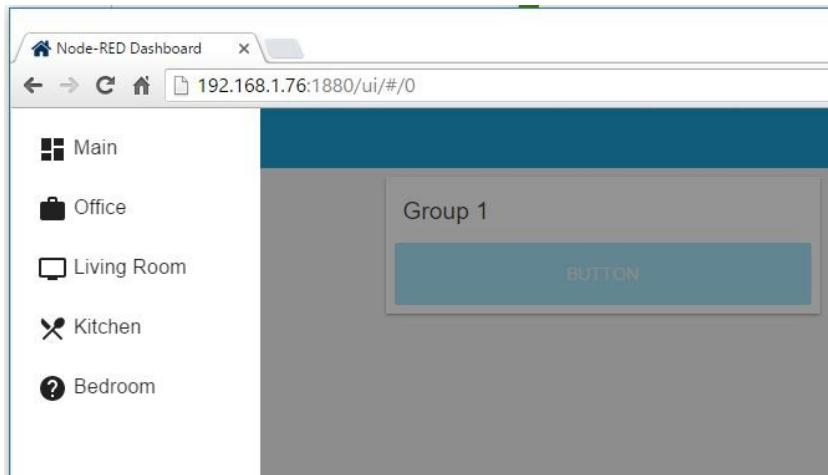


Assign the button node to the **Bedroom** tab:

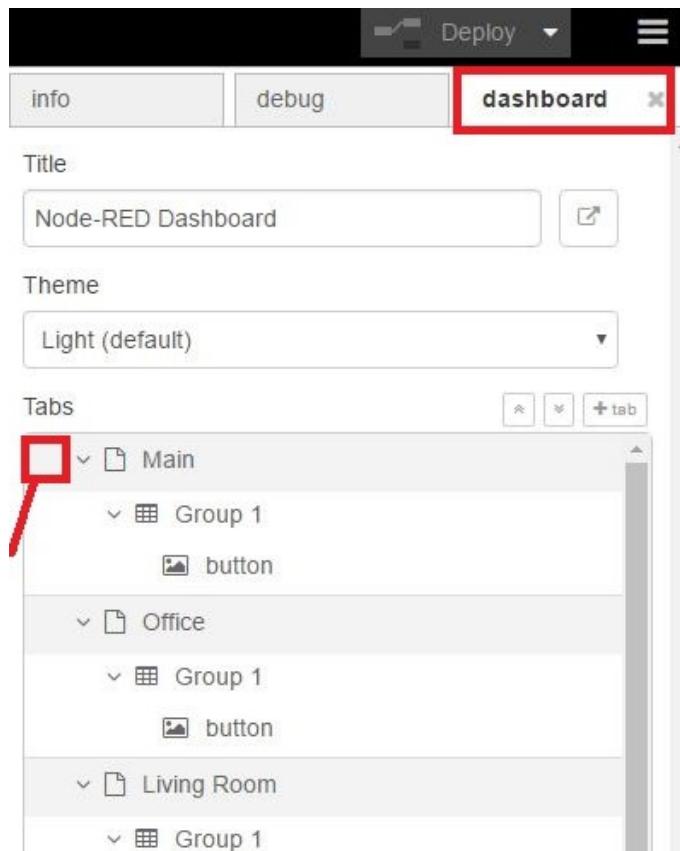
Edit button node

<input type="button" value="Cancel"/>	<input style="background-color: red; color: white; font-weight: bold;" type="button" value="Done"/>
Group	Group 1 [Bedroom] <input type="button" value="▼"/>
Size	auto
Icon	optional icon <input type="button" value=""/>
Label	button
Color	optional text/icon color
When clicked, send:	
Payload	<input type="button" value="▼"/> <input type="button" value="a_z"/>
Topic	<input type="button"/>
Name	<input type="button"/>

If you deploy your application and you go to the Dashboard page, you'll see the tabs organized:



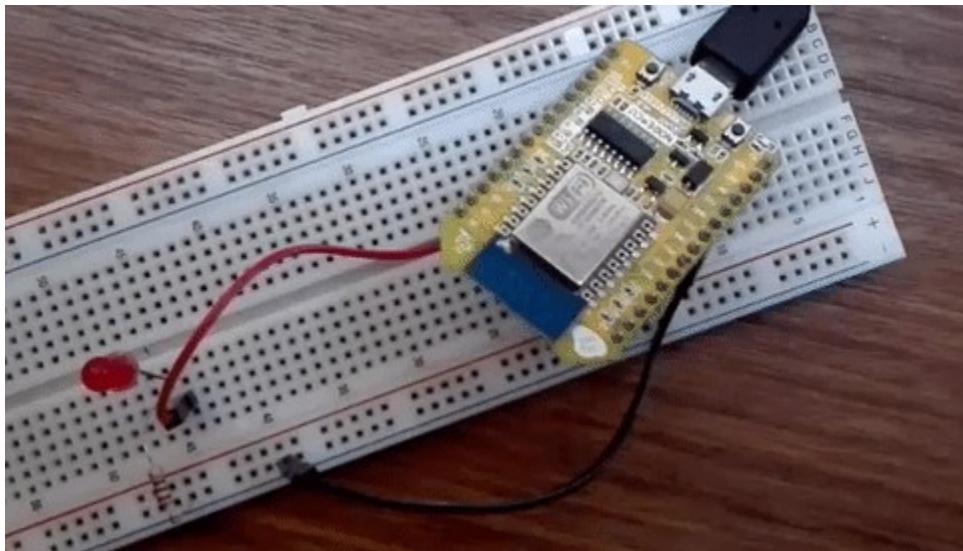
In the dashboard window within Node-RED software, you can organize the tabs with the drag-and-drop feature that is highlighted in the figure below:



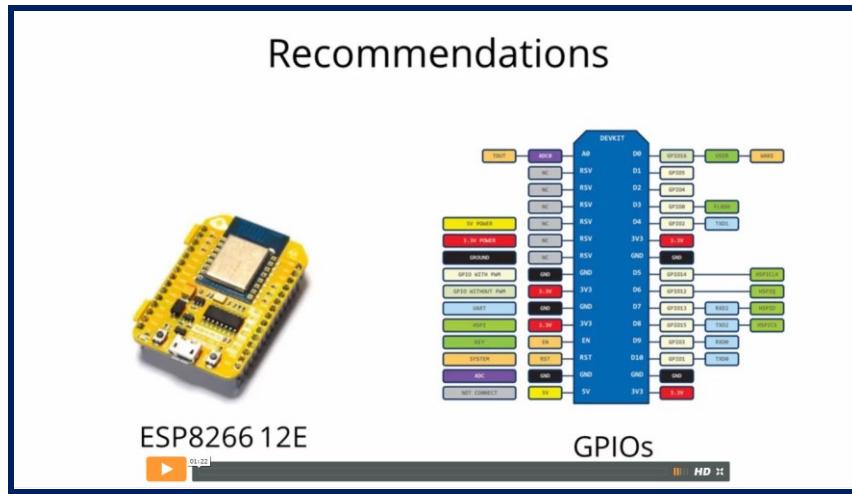
In the next couple of Modules, you'll start programming the ESP8266 and connect it to your Raspberry Pi to control outputs and monitor sensors.

MODULE 6

Connecting the ESP8266 - Part 1



Unit 1 - Introducing the ESP8266



Video # 9 - <https://rntlab.com/watch-has-videos>

The ESP8266 is a low-cost Wi-Fi module which is a great platform for any home automation project.

Comparing the ESP with other Wi-Fi modules in the market, this is a great option for most “Internet of Things” projects! It’s easy to see why it’s so popular: it only costs a few dollars and can be integrated in advanced projects.

ESP8266 Applications

You can create a web server, send HTTP requests, establish an MQTT communication, control outputs, read inputs and interrupts, send emails, post tweets, etc.

Here's a list of tutorials that I've already created that you might find useful:

- [ESP8266 Web Server Arduino IDE](#)
- [ESP8266 DHT11 Arduino IDE](#)
- [Posting a Tweet with the ESP8266](#)
- [How to Control Your ESP8266 From Anywhere in the World](#)
- [Retrieving Bitcoin Price Using ESP8266 Wi-Fi Module](#)
- [ESP8266 Web Server Tutorial using NodeMCU](#)
- [Door Status Monitor using the ESP8266](#)

ESP8266 specifications

- 11 b/g/n protocol
- Wi-Fi Direct (P2P), soft-AP
- Integrated TCP/IP protocol stack
- Built-in low-power 32-bit CPU
- SDIO 2.0, SPI, UART

Finding Your ESP8266

The ESP8266 comes in a wide variety of versions (as shown in the figure below). The ESP-12E or often called ESP-12E NodeMCU Kit is currently the most practical version and that's the module we'll be using most throughout this eBook.



Note: I cannot ensure that all code presented in this eBook works with other ESP8266 boards, but other boards should be compatible with the projects in this eBook with changes in the pin assignment.

Recommended ESP8266 Board

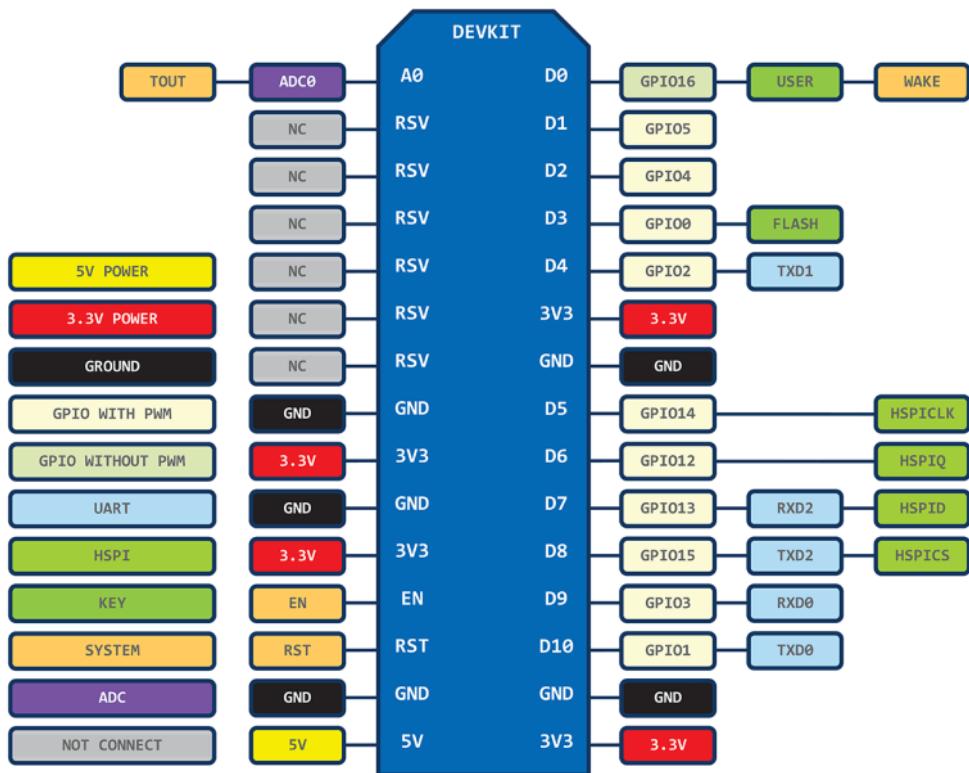
This eBook was tested with [ESP-01](#), [ESP-07](#), [ESP-12](#), [ESP-12E](#) [NodeMCU Kit](#), and [WeMos D1 Mini](#). You can make all the projects presented in this eBook using any of those boards.

I highly recommend using the [ESP8266-12E NodeMCU Kit](#), the one that has built-in programmer. The built-in programmer makes it easy to prototype and upload your programs. [Click here to find the best price](#).



ESP-12E Pinout

Throughout this course, **we'll be using the ESP8266-12E NodeMCU Kit**. Here's a quick overview of the ESP-12E NodeMCU Kit pinout:



Programming the ESP8266 with Arduino IDE

There are a few ways of programming the ESP8266. In this course you'll program your ESP using the Arduino IDE software.



If you are already familiar with the ESP you probably can skip the next two Units, but it's still important that you at least take a look at them to ensure that you aren't missing anything.

Unit 2 - How to Install the ESP8266 Board in Arduino IDE

There are a variety of development environments that can be used to program the ESP8266.

The ESP8266 community created an add-on for the Arduino IDE that allows you to program the ESP8266 using the Arduino IDE and its programming language.

Downloading Arduino IDE

First, download the Arduino IDE to ensure that you have the latest software version (some older versions won't work), visit the following URL: <https://www.arduino.cc/en/Main/Software>.

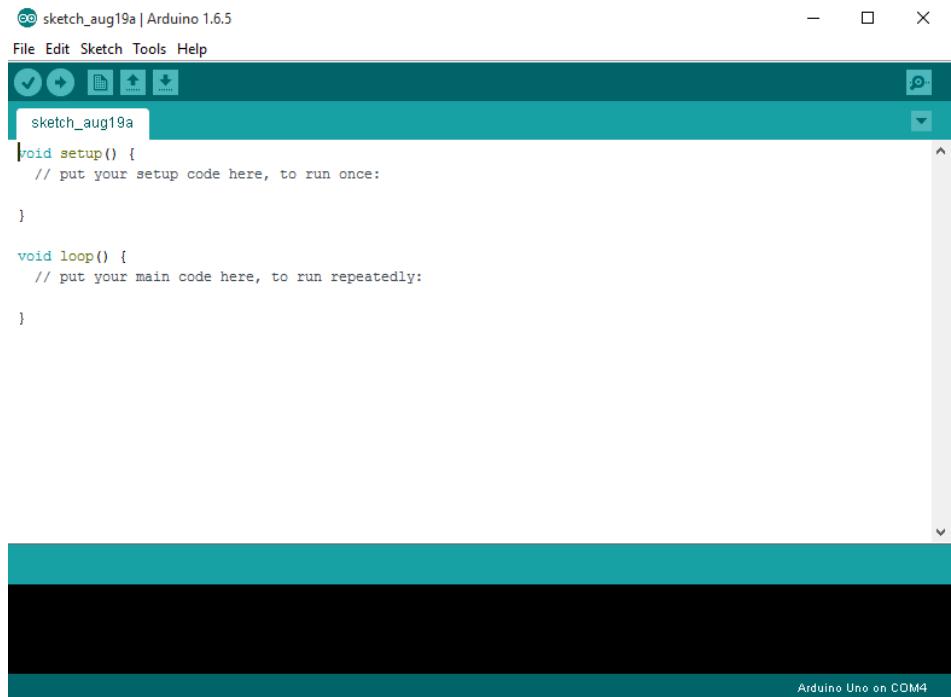
Then, select your operating system and download the latest software release of the Arduino IDE.

Installing Arduino IDE

Grab the file that you have just downloaded and open the Arduino IDE application file (see figure below).

Name	Date modified	Type
dist	13/08/2015 20:53	File folder
drivers	13/08/2015 20:53	File folder
examples	13/08/2015 20:54	File folder
hardware	13/08/2015 20:54	File folder
java	13/08/2015 20:57	File folder
lib	13/08/2015 20:59	File folder
libraries	11/09/2015 13:38	File folder
reference	13/08/2015 21:03	File folder
tools	13/08/2015 21:03	File folder
arduino	14/08/2015 17:42	Application

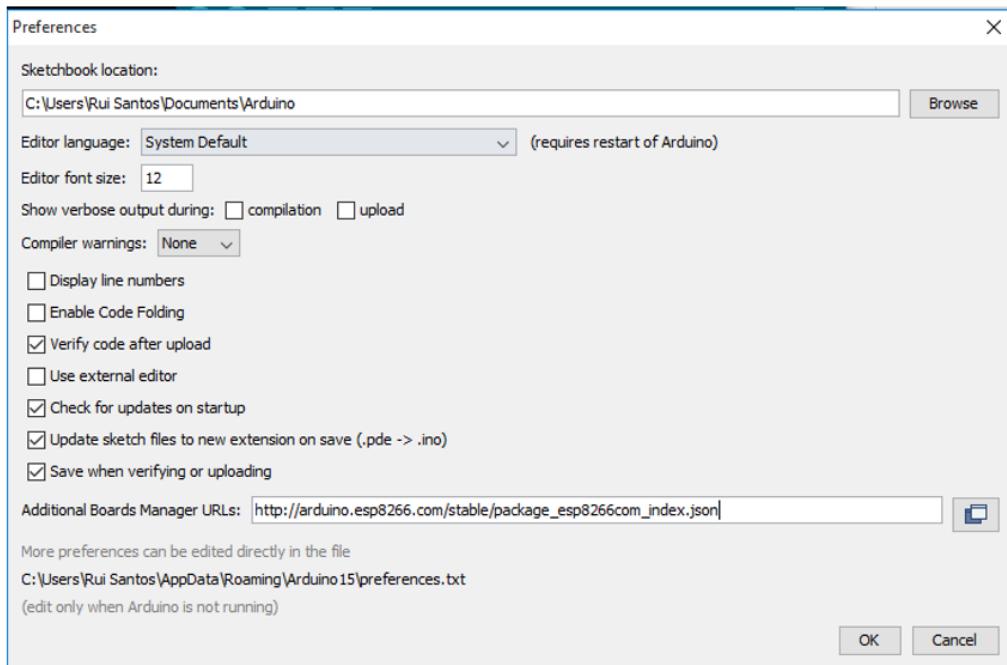
When the Arduino IDE first opens, this is what you should see:



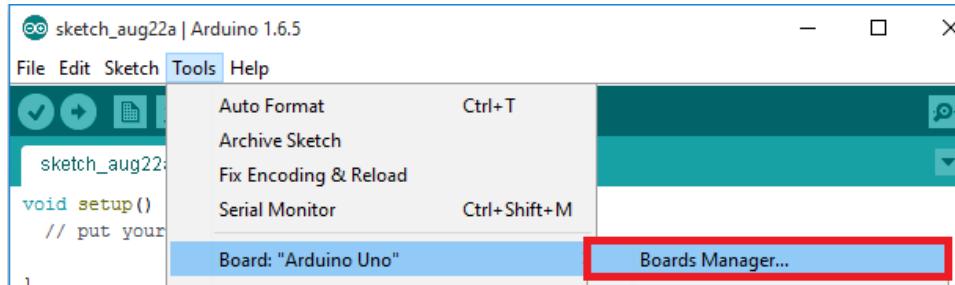
Installing the ESP8266 Board

To install the ESP8266 board in your Arduino IDE, follow these next instructions:

- 1)** Open the preferences window from the Arduino IDE. Go to **File > Preferences**
- 2)** Enter **http://arduino.esp8266.com/stable/package_esp8266com_index.json** into Additional Board Manager URLs field and click the "**OK**" button



3) Open boards manager. Go to Tools > Board > Boards Manager...

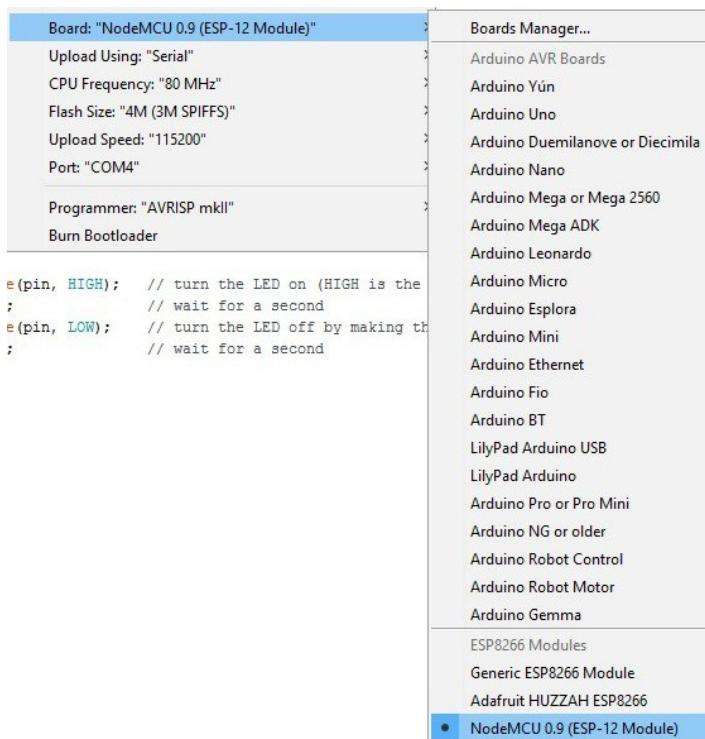


4) Scroll down, select the ESP8266 board menu and install "esp8266 platform"



5) Choose your ESP8266 board from Tools > Board > NodeMCU 0.9(in my case).

Then, restart your Arduino IDE.



Unit 3 - Testing the Installation

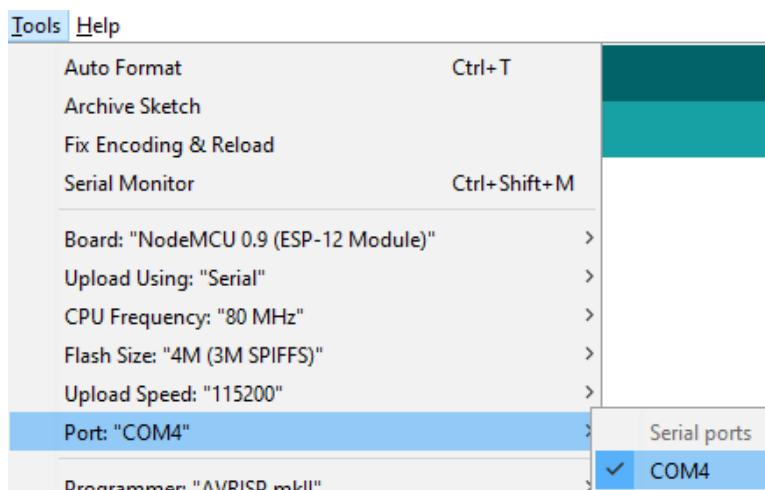
To test the ESP8266 add-on installation, let's see if we can blink an LED with the ESP8266 using the Arduino programming language.

Uploading Code

Connect a USB cable from your ESP to your computer to upload code.

Having your Arduino IDE open and the right board selected follow these next instructions:

- 1) Select your ESP port number under the **Tools > Port > COM4** (in my case)



- 2) Copy and paste the sketch below to your Arduino IDE

```
*****
Rui Santos
Complete project details at http://randomnerdtutorials.com
*****/

int pin = 2;

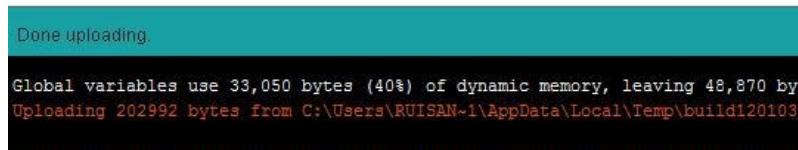
void setup() {
  // initialize GPIO 2 as an output.
  pinMode(pin, OUTPUT);
}

// the loop function runs over and over again forever
void loop() {
  digitalWrite(pin, HIGH); // turn the LED on (HIGH is the voltage level)
  delay(1000);           // wait for a second
  digitalWrite(pin, LOW); // turn the LED off by making the voltage LOW
  delay(1000);           // wait for a second
}
```

DOWNLOAD SOURCE CODE

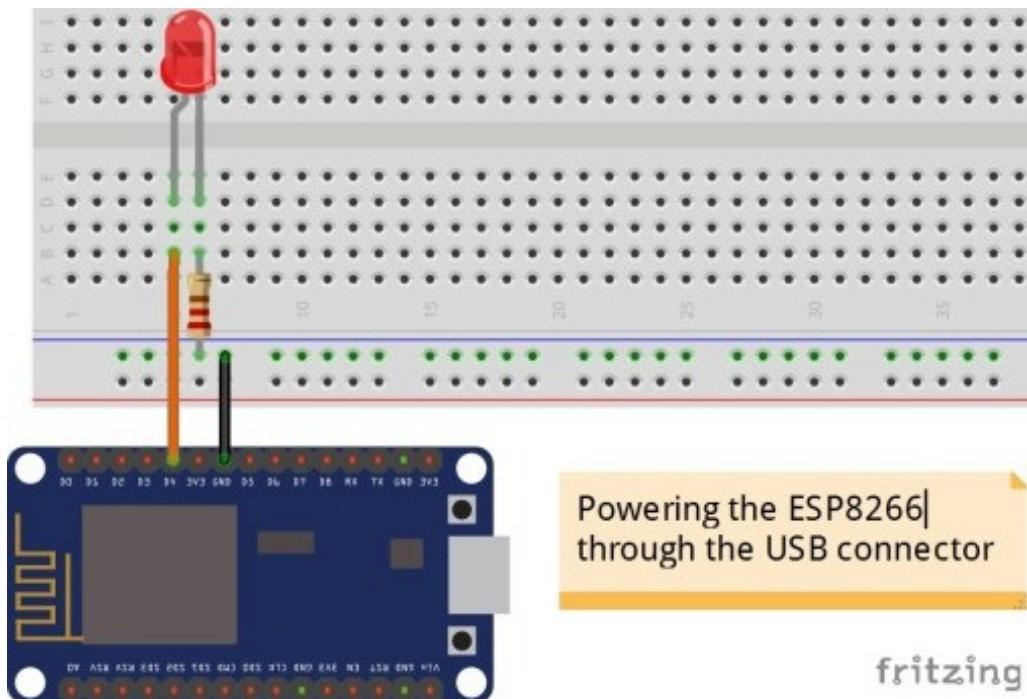
https://github.com/RuiSantosdotme/Home-Automation-Course/blob/master/code/blink_led_esp8266.ino

- 3) Click the “**Upload**” button. You should see “**Done Uploading**” after a few seconds



Demonstration

Connect an LED and a 220 Ohm resistor to your ESP D4 (GPIO 2).



Your LED should be blinking every 1 second.

Unit 4 - Installing the PubSubClient Library

The [PubSubClient library](#) provides a client for doing simple publish/subscribe messaging with a server that supports MQTT (basically allows your ESP8266 to talk with Node-RED).

Installing the Library

- 1) [Click here to download the PubSubClient library.](#) You should have a **.zip** folder in your Downloads folder



- 2) Unzip the **.zip** folder and you should get **pubsubclient-master** folder



- 3) Rename your folder from **pubsubclient-master** to **pubsubclient**



- 4) Move the **pubsubclient** folder to your Arduino IDE installation **libraries** folder

Name	Date modified	Type	Size
Bridge	08/03/2016 17:07	File folder	
Esplora	20/05/2015 17:10	File folder	
Ethernet	09/03/2016 16:11	File folder	
Firmata	16/02/2016 01:32	File folder	
GSM	09/03/2016 16:11	File folder	
Keyboard	08/03/2016 17:05	File folder	
LiquidCrystal	09/03/2016 16:11	File folder	
Mouse	08/03/2016 17:04	File folder	
pubsubclient	16/04/2016 11:16	File folder	
Robot_Control	10/06/2015 15:00	File folder	
Robot_Motor	10/06/2015 15:00	File folder	
RobotIRremote	10/06/2015 15:00	File folder	
SD	09/03/2016 16:11	File folder	
Servo	09/03/2016 16:11	File folder	
SpacebrewYun	27/03/2015 15:01	File folder	

- 5) Then, re-open your Arduino IDE.

This library comes with several examples sketches that you can use in your projects.

See **File >Examples > PubSubClient** within the Arduino IDE software.

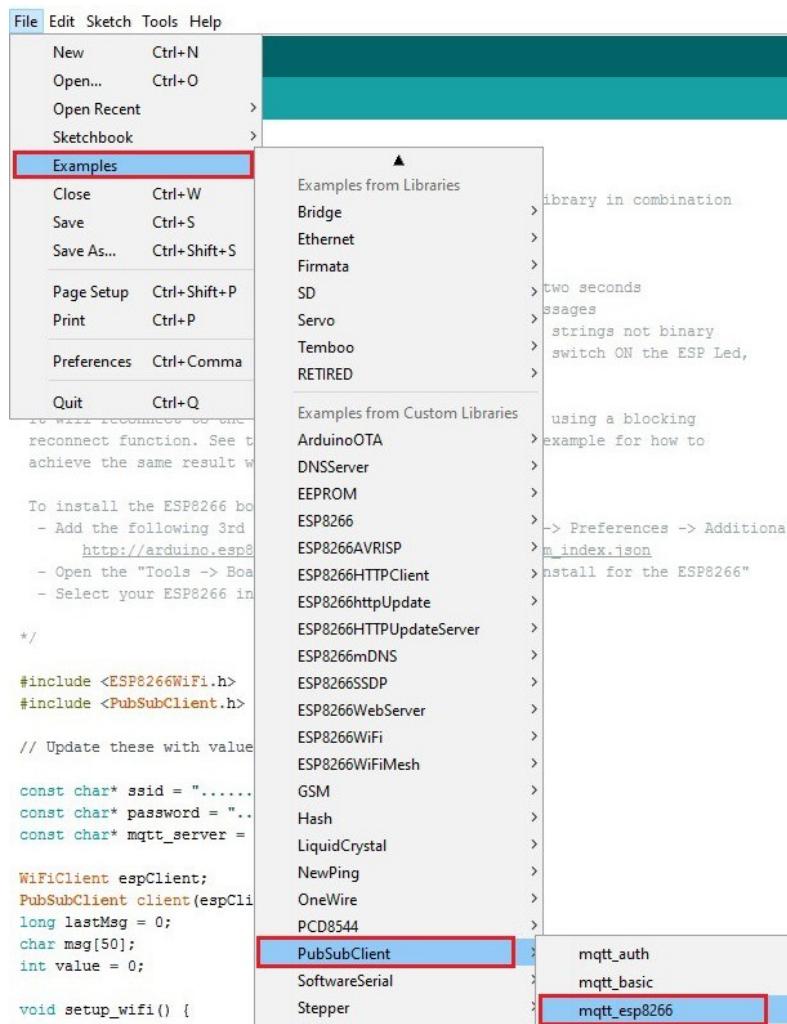
Unit 5 - Connecting the ESP8266 to the Node-RED Nodes

This Unit shows how you can publish messages and subscribe to a topic with MQTT using an ESP8266 and Node-RED.

These are the basic concepts that will allow you to turn on lights and monitor sensors (which we are going to cover in the next Module).

Writing Your ESP Sketch

Open the Arduino IDE. Go to **File > Examples > PubSubClient > mqtt_esp8266**.



That **mqtt_esp8266** sketch publishes messages and subscribes to a topic with MQTT.

Understanding How the Sketch Works

First, it starts by loading the **ESP8266WiFi** library and the **PubSubClient** library.

```
#include <ESP8266WiFi.h>
#include <PubSubClient.h>
```

Then, it configures the module with your own credentials (SSID, password and MQTT broker IP address).

You need to replace those 3 variables with your credentials, so that your ESP8266 can connect to your network and MQTT broker.

```
const char* ssid = "YOUR_SSID";
const char* password = "YOUR_PASSWORD";
const char* mqtt_server = "YOUR_RPi_IP_Address";
```

It initializes the `espClient` and creates three variables.

```
WiFiClient espClient;
PubSubClient client(espClient);
long lastMsg = 0;
char msg[50];
int value = 0;
```

setup

The `setup()` function sets the ESP8266 built-in LED as an OUTPUT and starts the serial communication at a baud rate of 115200.

The `setup()` also:

- calls the `setup_wifi()` function
- connects your ESP to the MQTT broker
- sets the `callback()` function

```
void setup() {
  pinMode(BUILTIN_LED, OUTPUT);      // Initialize the BUILTIN_LED pin as an output
  Serial.begin(115200);
  setup_wifi();
  client.setServer(mqtt_server, 1883);
  client.setCallback(callback);
}
```

setup wifi

The `setup_wifi()` function connects your ESP to your home router with the credentials that you have provided. If the Wi-Fi connection is successful, your ESP IP address will be printed in the Arduino IDE serial monitor.

```
void setup_wifi() {  
  
    delay(10);  
    // We start by connecting to a WiFi network  
    Serial.println();  
    Serial.print("Connecting to ");  
    Serial.println(ssid);  
  
    WiFi.begin(ssid, password);  
  
    while (WiFi.status() != WL_CONNECTED) {  
        delay(500);  
        Serial.print(".");  
    }  
  
    Serial.println("");  
    Serial.println("WiFi connected");  
    Serial.println("IP address: ");  
    Serial.println(WiFi.localIP());  
}
```

loop

The `loop()` function checks if your ESP is connected to the MQTT broker. If your ESP isn't connected, it will try to connect/reconnect.

Then, we have a timer that every 2 seconds publishes the message saying "hello world" to a topic called **outTopic**.

```
void loop() {  
  
    if (!client.connected()) {  
        reconnect();  
    }  
    client.loop();  
  
    long now = millis();  
    if (now - lastMsg > 2000) {  
        lastMsg = now;  
        ++value;  
        sprintf (msg, 75, "hello world #%ld", value);  
        Serial.print("Publish message: ");  
        Serial.println(msg);  
        client.publish("outTopic", msg);  
    }  
}
```

reconnect

If the ESP8266 loses connection with the MQTT broker, it calls the `reconnect()` function.

If for some reason your ESP can't establish an MQTT communication with your broker, your ESP keeps trying to reconnect every 5 seconds.

When the connection is finally established, it does the following:

- Publishes a message to the **outTopic** topic
- Subscribes to the **inTopic** topic

```
void reconnect() {
    // Loop until we're reconnected
    while (!client.connected()) {
        Serial.print("Attempting MQTT connection...");
        // Attempt to connect
        if (client.connect("ESP8266Client")) {
            Serial.println("connected");
            // Once connected, publish an announcement...
            client.publish("outTopic", "hello world");
            // ... and resubscribe
            client.subscribe("inTopic");
        } else {
            Serial.print("failed, rc=");
            Serial.print(client.state());
            Serial.println(" try again in 5 seconds");
            // Wait 5 seconds before retrying
            delay(5000);
        }
    }
}
```

callback

The `callback()` function is triggered every time that another device publishes a message to your ESP (in our example it will be the Raspberry Pi).

In this sketch the messages received will be printed in your serial monitor. Later, you are going to use this mechanism to turn on and off your lights.

```

void callback(char* topic, byte* payload, unsigned int length) {
    Serial.print("Message arrived [");
    Serial.print(topic);
    Serial.print("] ");
    for (int i = 0; i < length; i++) {
        Serial.print((char)payload[i]);
    }
    Serial.println();

    // Switch on the LED if an 1 was received as first character
    if ((char)payload[0] == '1') {
        digitalWrite(BUILTIN_LED, LOW);    // Turn the LED on (Note that LOW is the voltage level
        // but actually the LED is on; this is because
        // it is active low on the ESP-01)
    } else {
        digitalWrite(BUILTIN_LED, HIGH);   // Turn the LED off by making the voltage HIGH
    }
}

```

Uploading the Sketch

Finally, you can upload the full sketch to your ESP8266 (replace with your SSID, password and RPi IP address):

```

/*
Basic ESP8266 MQTT example
Forked from http://bit.ly/1qH7Gsf
*/

#include <ESP8266WiFi.h>
#include <PubSubClient.h>

// Update these with values suitable for your network.

const char* ssid = "YOUR_SSID";
const char* password = "YOUR_PASSWORD";
const char* mqtt_server = "YOUR_RPi_IP_Address";

WiFiClient espClient;
PubSubClient client(espClient);
long lastMsg = 0;
char msg[50];
int value = 0;

void setup_wifi() {

    delay(10);
    // We start by connecting to a WiFi network
    Serial.println();
    Serial.print("Connecting to ");
    Serial.println(ssid);

    WiFi.begin(ssid, password);

```

```

while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
}

Serial.println("");
Serial.println("WiFi connected");
Serial.println("IP address: ");
Serial.println(WiFi.localIP());
}

void callback(char* topic, byte* payload, unsigned int length) {
    Serial.print("Message arrived [");
    Serial.print(topic);
    Serial.print("] ");
    for (int i = 0; i < length; i++) {
        Serial.print((char)payload[i]);
    }
    Serial.println();
}

// Switch on the LED if an 1 was received as first character
if ((char)payload[0] == '1') {
    digitalWrite(BUILTIN_LED, LOW); // Turn the LED on (Note that LOW is the voltage level
    // but actually the LED is on; this is because
    // it is active low on the ESP-01)
} else {
    digitalWrite(BUILTIN_LED, HIGH); // Turn the LED off by making the voltage HIGH
}

}

void reconnect() {
    // Loop until we're reconnected
    while (!client.connected()) {
        Serial.print("Attempting MQTT connection...");
        // Attempt to connect
        if (client.connect("ESP8266Client")) {
            Serial.println("connected");
            // Once connected, publish an announcement...
            client.publish("outTopic", "hello world");
            // ... and resubscribe
            client.subscribe("inTopic");
        } else {
            Serial.print("failed, rc=");
            Serial.print(client.state());
            Serial.println(" try again in 5 seconds");
            // Wait 5 seconds before retrying
            delay(5000);
        }
    }
}

void setup() {
    pinMode(BUILTIN_LED, OUTPUT); // Initialize the BUILTIN_LED pin as an output
    Serial.begin(115200);
    setup_wifi();
    client.setServer(mqtt_server, 1883);
    client.setCallback(callback);
}

```

```

}

void loop() {
    if (!client.connected()) {
        reconnect();
    }
    client.loop();

    long now = millis();
    if (now - lastMsg > 2000) {
        lastMsg = now;
        ++value;
        sprintf(msg, 75, "hello world #%ld", value);
        Serial.print("Publish message: ");
        Serial.println(msg);
        client.publish("outTopic", msg);
    }
}

```

[DOWNLOAD SOURCE CODE](#)

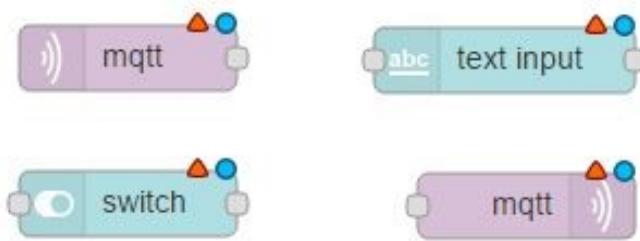
https://github.com/RuiSantosdotme/Home-Automation-Course/blob/master/code/mqtt_esp8266.ino

Creating Your Flow

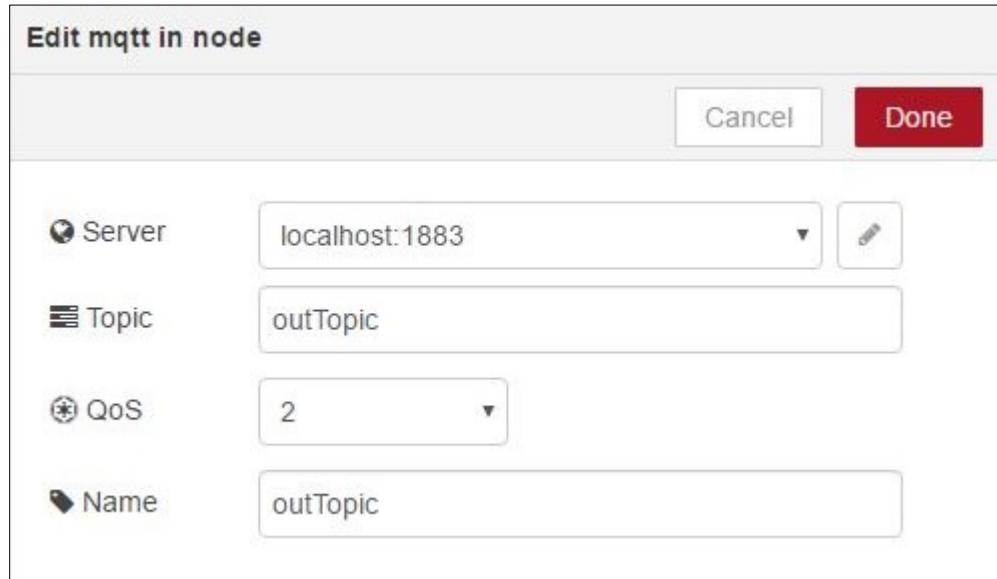
You must create a Node-RED flow to subscribe to the **outTopic** topic and to publish messages to the **inTopic** topic.

Drag 4 nodes to your flow:

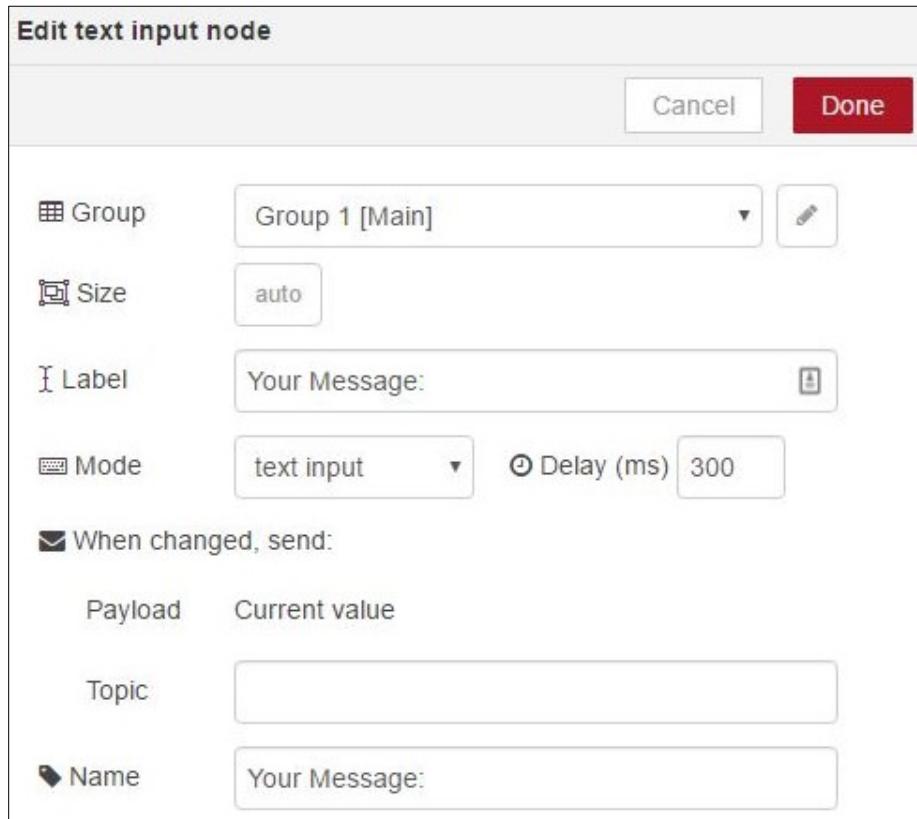
- mqtt in
- Text UI
- Switch UI
- mqtt out



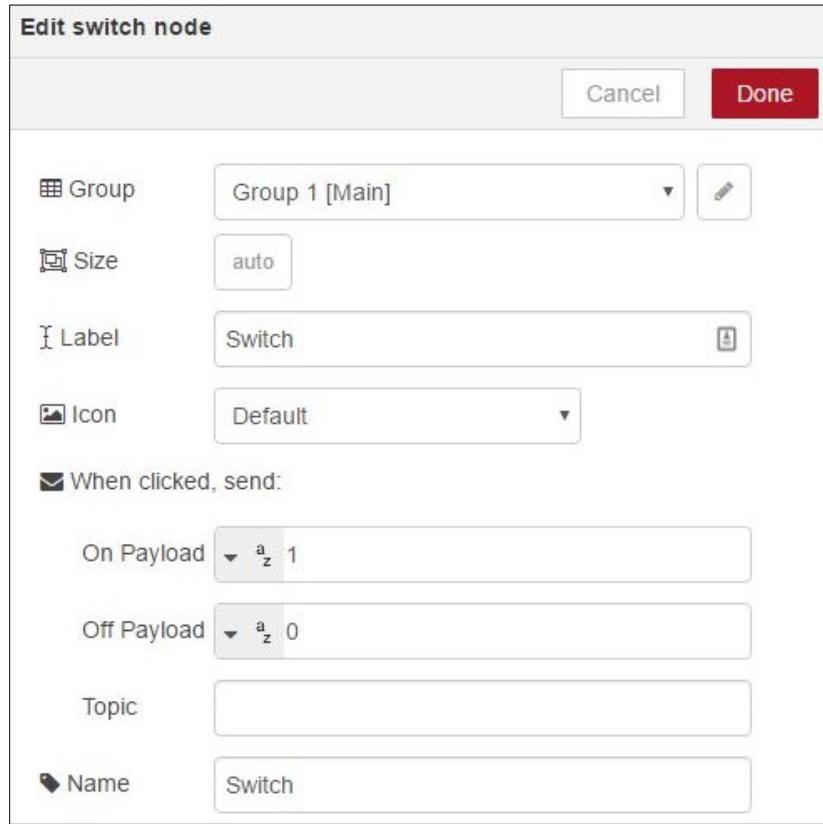
Double-click the **mqtt out** node to edit its settings. Select the **localhost** option and type **outTopic**.



Double-click the **text input** node. Select the **Main** tab and type “**Your Message:**” in the name field.

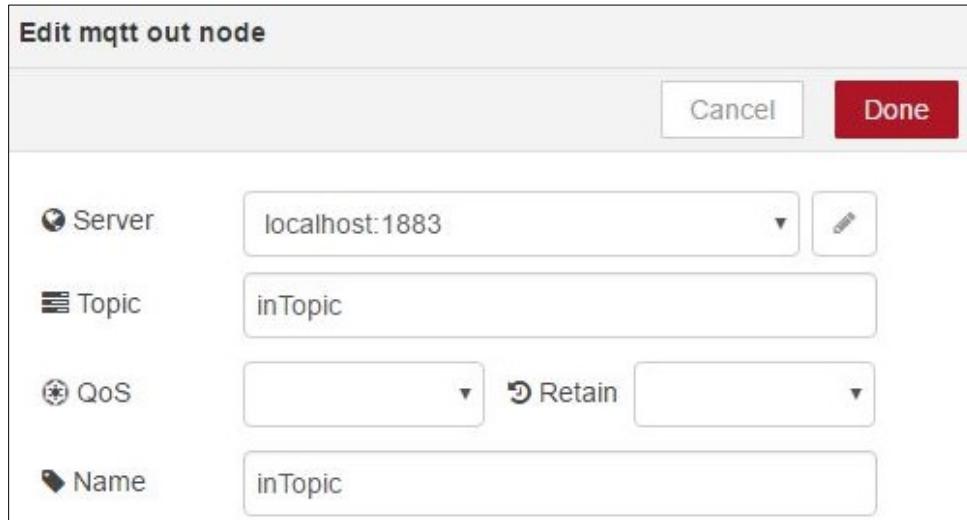


Edit the **switch** node. Select the **Main** tab and name it “**Switch**”. Then, set the On Value to “**1**” and the Off Value to “**0**”.

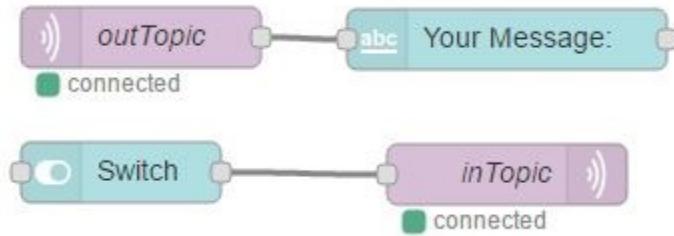


Important: sometimes the switch node keeps the default values **true** and **false** after you press Done. If your project isn't working, double-check that your **On Payload** and your **Off Payload** fields are set to **1** and **0**, respectively (see screenshot above).

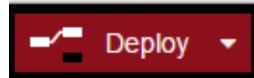
Double-click the **mqtt in** node to edit its settings. Select the **localhost** option and type **inTopic**.



This is how it should look like in the end:

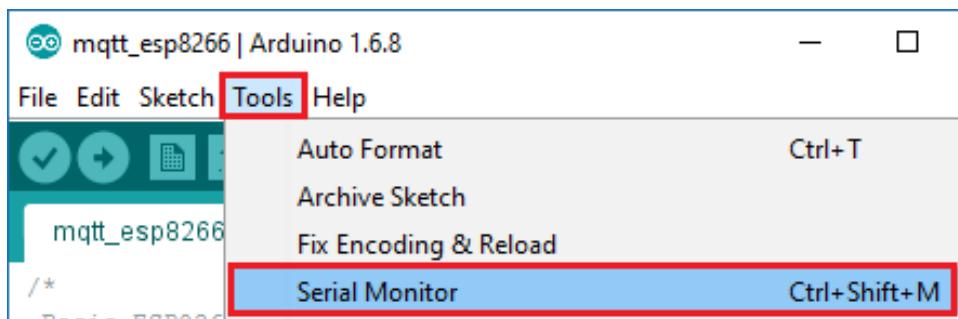


Click the **Deploy** button on the top-right corner to save your application.

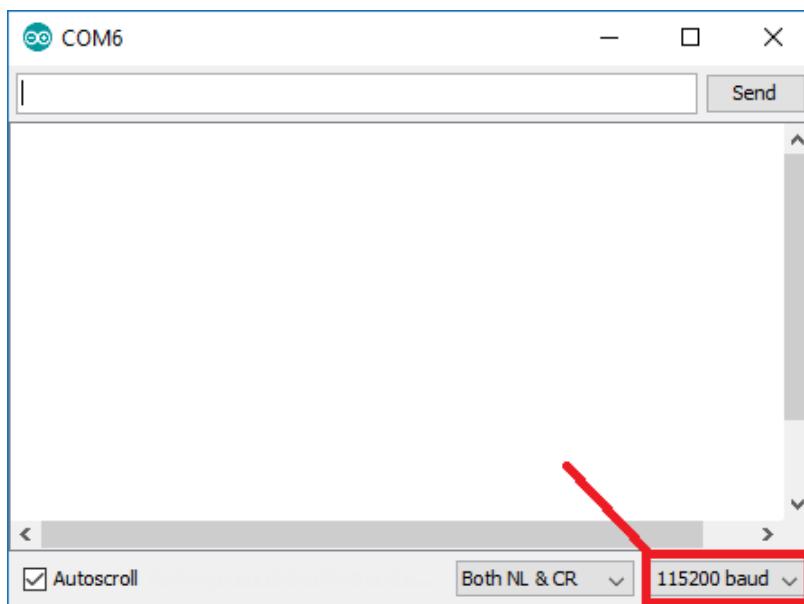


Opening the Node-RED Dashboard

Open the Arduino IDE serial monitor:



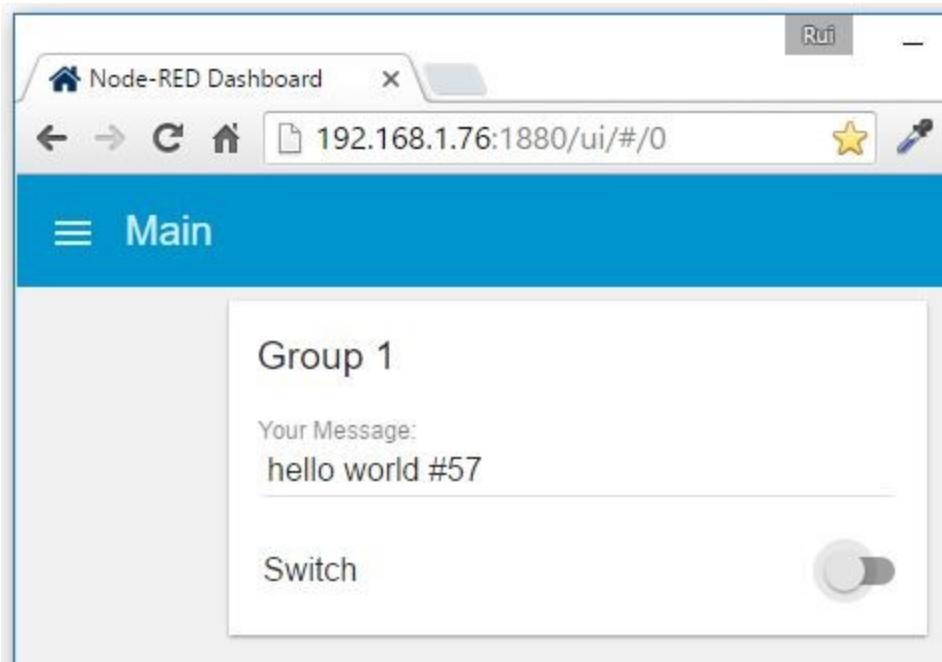
Set the baud rate to 115200:



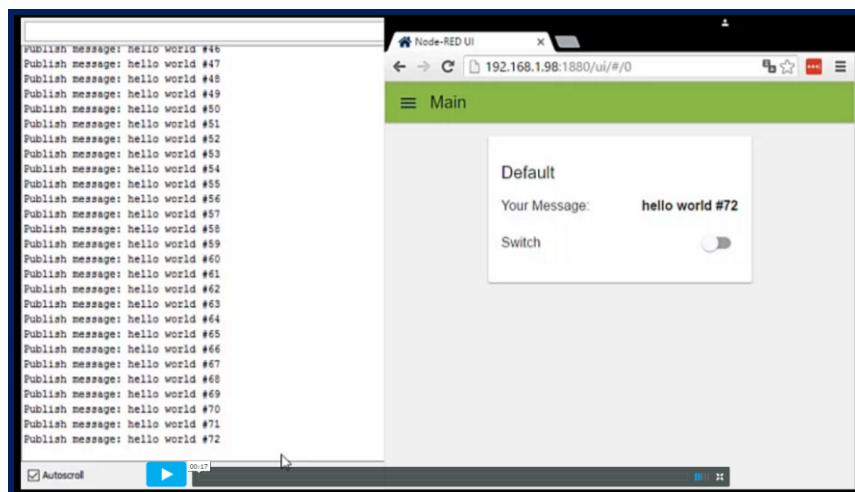
Open the Node-RED Dashboard.

`http://YOUR_RPi_IP_ADDRESS:1880/ui`

At this point, the Text ui node is subscribed to the **outTopic** topic, so it receives the message "hello world #57" from your ESP8266.

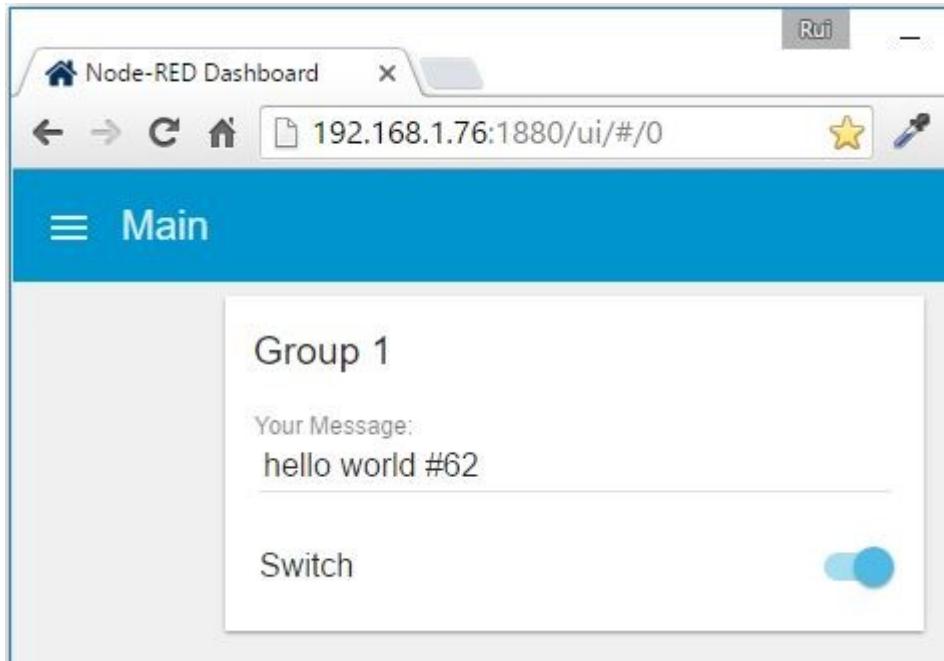


Watch the quick video demonstration of the Node-RED Dashboard receiving the messages from your ESP8266.

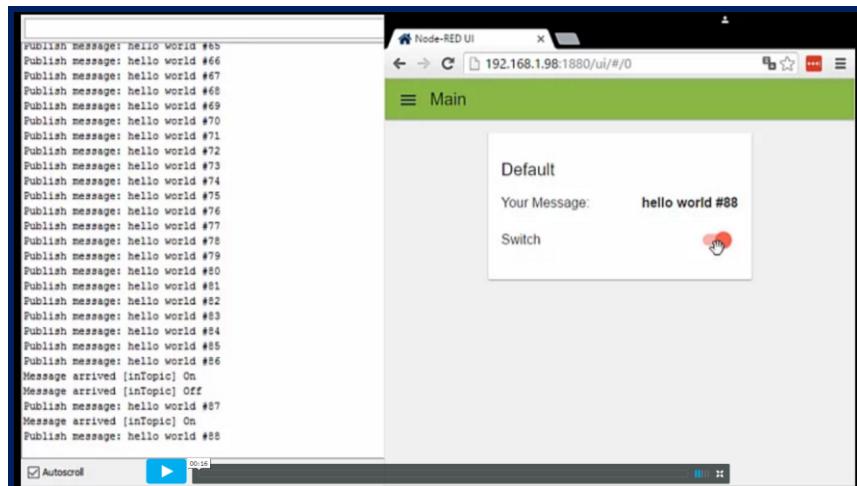


Video # 10 - <https://rntlab.com/watch-has-videos>

If you press the Switch, you can publish messages to the **inTopic** topic that your ESP is subscribed to.



As you can see, the ESP8266 is receiving the commands **On** and **Off** when I press the Switch button.



Video # 11 - <https://rntlab.com/watch-has-videos>

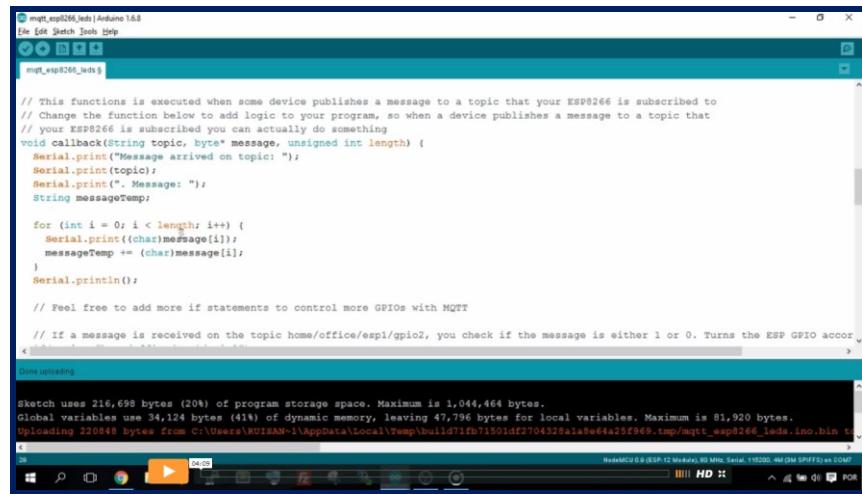
By now you have acquired all the basic concepts. In the next Module, the real home automation project begins. You'll start controlling real lamps and monitor sensors with your ESP8266.

MODULE 7

Connecting the ESP8266 - Part 2



Unit 1 - Controlling Outputs with ESP using MQTT



The screenshot shows the Arduino IDE interface with the sketch named "mqtt_esp8266_leds.ino". The code is as follows:

```
// This function is executed when some device publishes a message to a topic that your ESP8266 is subscribed to
// Change the function below to add logic to your program, so when a device publishes a message to a topic that
// your ESP8266 is subscribed you can actually do something
void callback(String topic, byte* message, unsigned int length) {
    Serial.print("Message arrived on topic: ");
    Serial.print(topic);
    Serial.print(": Message: ");
    String messageTemp;
    for (int i = 0; i < length; i++) {
        Serial.print((char)message[i]);
        messageTemp += (char)message[i];
    }
    Serial.println();
}

// Feel free to add more if statements to control more GPIOs with MQTT

// If a message is received on the topic home/office/esp1/gpio2, you check if the message is either 1 or 0. Turns the ESP GPIO accordingly
<code>
</code>
```

Below the code, the status bar shows "Done uploading". The bottom status bar indicates "Sketch uses 216,698 bytes (20%) of program storage space. Maximum is 1,044,464 bytes. Global variables use 34,124 bytes (41%) of dynamic memory, leaving 47,796 bytes for local variables. Maximum is 81,920 bytes. Uploading 320848 bytes from C:\Users\RUISAM-1\AppData\Local\Temp\build71fb71501df2704326a1a8e64a25f969.tmp\mqtt_esp8266_leds.ino.bin to NodeMCU 1.0 (ESP-12E Module) at 80 MHz, Serial: 115200, 4M (34 SPIFFS) on COM3".

Video # 12 - <https://rntlab.com/watch-has-videos>

In the previous Unit, I've showed how to subscribe and publish messages to a topic. You're going to use that mechanism to control two LEDs which will be replaced with real lights.

The sketch for this Unit is very similar to the example that you have just used, but it has a few important modifications.

I've also added comments to the sketch to explain what each function does, what you should and shouldn't change. I think it's easier to understand.

You can open this link or scroll down this page to see the complete sketch and follow along:

- https://github.com/RuiSantosdotme/Home-Automation-Course/blob/master/code/mqtt_esp8266_leds.ino

Understanding How the Sketch Works

First, you need to replace those 3 variables with your credentials, so that your ESP8266 can connect to your network and MQTT broker.

```
const char* ssid = "YOUR_SSID";
const char* password = "YOUR_PASSWORD";
const char* mqtt_server = "YOUR_RPi_IP_Address";
```

Define two variables that refer to D1 (GPIO 2) and D4 (GPIO 5) of your ESP.

```
// Connect an LED to each GPIO of your ESP8266
const int ledGPIO2 = 2;
const int ledGPIO5 = 5;
```

setup wifi

The `setup_wifi()` function connects your ESP8266 to your router and you don't need to modify anything.

```
void setup_wifi() {
    delay(10);
    // We start by connecting to a WiFi network
    Serial.println();
    Serial.print("Connecting to ");
    Serial.println(ssid);
    WiFi.begin(ssid, password);
    while (WiFi.status() != WL_CONNECTED) {
        delay(500);
        Serial.print(".");
    }
    Serial.println("");
    Serial.print("WiFi connected - ESP IP address: ");
    Serial.println(WiFi.localIP());
}
```

callback

Then you have the `callback()` function.

```
void callback(String topic, byte* message, unsigned int length) {
```

This function is executed when a device publishes a message to a topic that your ESP8266 is subscribed to.

You can change the preceding function to add logic to your programs. For example, when a device publishes a message to a topic that your ESP is subscribed, you can actually do something useful with that message.

These next lines of code turn the LEDs on and off. If a message is received on the topic **home/office/esp1/gpio2**, you check if the message is either **1** or **0**.

Turns the ESP GPIO 2 according to the message.

```
if(topic=="home/office/esp1/gpio2") {
    Serial.print("Changing GPIO 2 to ");
    if(messageTemp == "1"){
        digitalWrite(ledGPIO2, HIGH);
        Serial.print("On");
    }
    else if(messageTemp == "0"){
        digitalWrite(ledGPIO2, LOW);
        Serial.print("Off");
    }
}
```

reconnect

The function `reconnect()` reconnects your ESP to your MQTT broker.

```
void reconnect() {
```

It also subscribes to two topics

- `home/office/esp1/gpio52`
- `home/office/esp1/gpio2`

```
client.subscribe("home/office/esp1/gpio5");
client.subscribe("home/office/esp1/gpio2");
```

If you would like to control more GPIOs, you need to subscribe to more topics. Feel free to experiment with that.

setup

The `setup()` function sets your ESP GPIOs as OUTPUTs, starts the serial communication, connects your ESP to your router, sets your MQTT broker and sets the `callback()`.

```
void setup() {
    pinMode(ledGPIO2, OUTPUT);
    pinMode(ledGPIO5, OUTPUT);

    Serial.begin(115200);
    setup_wifi();
    client.setServer(mqtt_server, 1883);
    client.setCallback(callback);
}
```

loop

For this project, you don't need to change anything in the `loop()` function. The `loop()` function checks if your ESP is connected to the MQTT broker. If your ESP isn't connected, it will try to connect/reconnect.

```
void loop() {  
  
    if (!client.connected()) {  
        reconnect();  
    }  
    client.loop();  
}
```

Uploading the Final Sketch

You can copy the final sketch to your Arduino IDE and upload it to your ESP (after changing the credentials and RPi IP address).

```
*****  
  
All the resources for this project:  
https://rntlab.com/  
  
*****/  
  
// Loading the ESP8266WiFi library and the PubSubClient library  
#include <ESP8266WiFi.h>  
#include <PubSubClient.h>  
  
// Change the credentials below, so your ESP8266 connects to your router  
const char* ssid = "YOUR_SSID";  
const char* password = "YOUR_PASSWORD";  
  
// Change the variable to your Raspberry Pi IP address, so it connects to your MQTT broker  
const char* mqtt_server = "YOUR_RPi_IP_Address";  
  
// Initializes the espClient  
WiFiClient espClient;  
PubSubClient client(espClient);  
  
// Connect an LED to each GPIO of your ESP8266  
const int ledGPIO2 = 2;  
const int ledGPIO5 = 5;  
  
// Don't change the function below. This functions connects your ESP8266 to your router  
void setup_wifi() {  
    delay(10);  
    // We start by connecting to a WiFi network  
    Serial.println();  
    Serial.print("Connecting to ");  
    Serial.println(ssid);
```

```

WiFi.begin(ssid, password);
while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
}
Serial.println("");
Serial.print("WiFi connected - ESP IP address: ");
Serial.println(WiFi.localIP());
}

// This functions is executed when some device publishes a message to a topic that your ESP8266 is
// subscribed to
// Change the function below to add logic to your program, so when a device publishes a message to a topic
// that
// your ESP8266 is subscribed you can actually do something
void callback(String topic, byte* message, unsigned int length) {
    Serial.print("Message arrived on topic: ");
    Serial.print(topic);
    Serial.print(". Message: ");
    String messageTemp;

    for (int i = 0; i < length; i++) {
        Serial.print((char)message[i]);
        messageTemp += (char)message[i];
    }
    Serial.println();
}

// Feel free to add more if statements to control more GPIOs with MQTT

// If a message is received on the topic home/office/esp1/gpio2, you check if the message is either 1 or 0.
// Turns the ESP GPIO according to the message
if(topic=="home/office/esp1/gpio2"){
    Serial.print("Changing GPIO 2 to ");
    if(messageTemp == "1"){
        digitalWrite(ledGPIO2, HIGH);
        Serial.print("On");
    }
    else if(messageTemp == "0"){
        digitalWrite(ledGPIO2, LOW);
        Serial.print("Off");
    }
}
if(topic=="home/office/esp1/gpio5"){
    Serial.print("Changing GPIO 5 to ");
    if(messageTemp == "1"){
        digitalWrite(ledGPIO5, HIGH);
        Serial.print("On");
    }
    else if(messageTemp == "0"){
        digitalWrite(ledGPIO5, LOW);
        Serial.print("Off");
    }
}
Serial.println();
}

// This functions reconnects your ESP8266 to your MQTT broker
// Change the function below if you want to subscribe to more topics with your ESP8266
void reconnect() {

```

```

// Loop until we're reconnected
while (!client.connected()) {
    Serial.print("Attempting MQTT connection...");
    // Attempt to connect
    if (client.connect("ESP8266Client")) {
        Serial.println("connected");
        // Subscribe or resubscribe to a topic
        // You can subscribe to more topics (to control more LEDs in this example)
        client.subscribe("home/office/esp1/gpio5");
        client.subscribe("home/office/esp1/gpio2");
    } else {
        Serial.print("failed, rc=");
        Serial.print(client.state());
        Serial.println(" try again in 5 seconds");
        // Wait 5 seconds before retrying
        delay(5000);
    }
}

// The setup function sets your ESP GPIOs to Outputs, starts the serial communication at a baud rate of
// 115200
// Sets your mqtt broker and sets the callback function
// The callback function is what receives messages and actually controls the LEDs
void setup() {
    pinMode(ledGPIO2, OUTPUT);
    pinMode(ledGPIO5, OUTPUT);

    Serial.begin(115200);
    setup_wifi();
    client.setServer(mqtt_server, 1883);
    client.setCallback(callback);
}

// For this project, you don't need to change anything in the loop function.
// Basically it ensures that your ESP is connected to your broker
void loop() {

    if (!client.connected()) {
        reconnect();
    }
    client.loop();
}

```

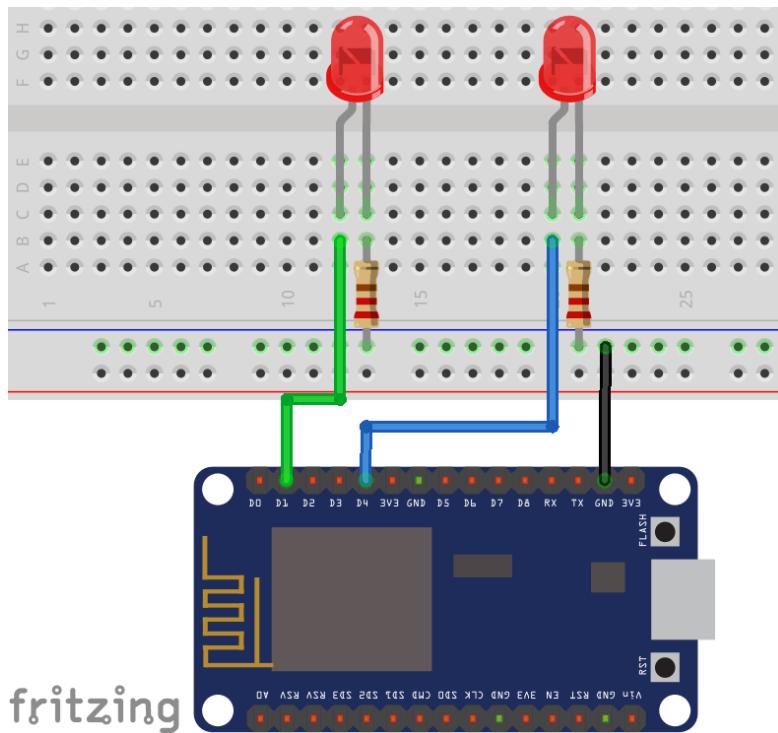
DOWNLOAD SOURCE CODE

[https://github.com/RuiSantosdotme/Home-Automation-
Course/blob/master/code/mqtt_esp8266_leds.ino](https://github.com/RuiSantosdotme/Home-Automation-Course/blob/master/code/mqtt_esp8266_leds.ino)

Schematics

The schematics for this project are very straightforward. Simply connect two LEDs with two resistors to your ESP8266 as shown in the figure below.

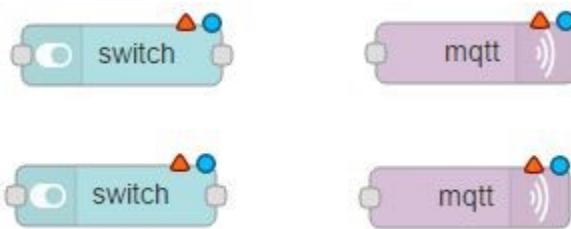
- [ESP8266 12-E NodeMCU Kit](#)
- [LED \(5mm\)](#)
- [2x 220Ω resistors](#)
- [Breadboard](#)
- [Jumper wires](#)



Creating the Flow

Go to the Node-RED software and you should create a flow by following these next 7 steps:

1 – Drag 4 Nodes



2 – GPIO 2 Switch node

Edit switch node

Cancel Done

Group Group 1 [Main]

Size auto

Label GPIO 2

Icon Default

When clicked, send:

On Payload 1

Off Payload 0

Topic

Name GPIO 2

3 – GPIO 5 Switch node

Edit switch node

Cancel Done

Group Group 1 [Main]

Size auto

Label GPIO 5

Icon Default

When clicked, send:

On Payload 1

Off Payload 0

Topic

Name GPIO 5

4 – GPIO 2 MQTT out node

Edit mqtt out node

Cancel Done

Server	localhost:1883	<input type="button" value="edit"/>
Topic	home/office/esp1/gpio2	
QoS	<input type="button" value="dropdown"/> Retain <input type="button" value="dropdown"/>	
Name	Name	

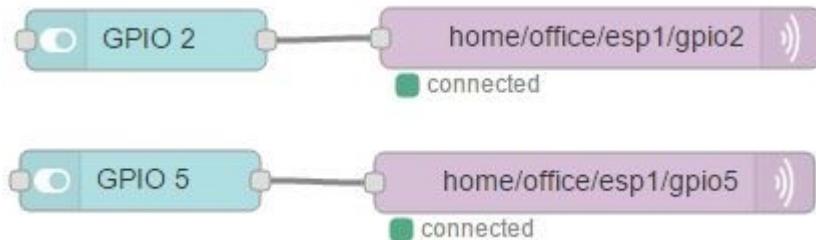
5 – GPIO 2 MQTT out node

Edit mqtt out node

Cancel Done

Server	localhost:1883	<input type="button" value="edit"/>
Topic	home/office/esp1/gpio5	
QoS	<input type="button" value="dropdown"/> Retain <input type="button" value="dropdown"/>	
Name	Name	

6 – Connect Nodes

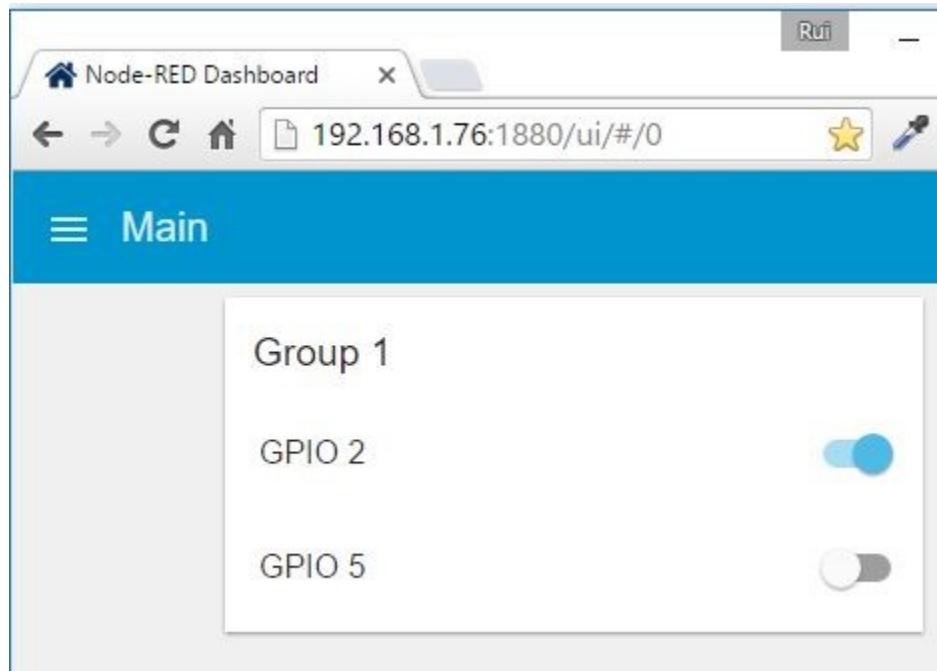


7 – Deploy your application



Open Node-RED Dashboard

You can control the LEDs by pressing the switch buttons.



In the next Unit, you're going to replace those LEDs with real lamps.

Unit 2 - Decoding RF Signals to Control Outlets

After so many Units the real fun begins. You are finally going to control real things and make useful stuff.

I've tried different methods of controlling the mains voltage, but some of the methods require:

1. **Experience** dealing with AC voltage
2. **Opening holes** in your wall/ceiling/switches
3. **Modifying** the electrical panel
4. **Knowing** the electrical rules for each country

It was very hard to come up with a solution that is safe and works for everyone.

Solution

I wanted to create a course that would work regardless of the country. The solution for this problem was using radio frequency (RF) controlled outlets.

Why? Using remote controlled outlets have 5 benefits:

1. **Fairly inexpensive**
2. **Easy to get**
3. **Works** with ESP8266 and Arduino
4. **Safe** to use
5. **Works** in any country

Parts Required

To complete this Unit you need:

- [Arduino UNO](#)
- [433MHz RF Receiver](#)
- [Remote Controlled Outlets that operate at 433MHz](#)

You can see the complete list of components and parts in Module 1.

Note: you need to buy remote controlled outlets that operate at a RF of 433MHz. They should say the operating RF either in the product page or in the label.

Example

Here's how they look:



There are also [E27 Lamp Bulb Holders](#) that are controlled with an RF remote. They should also operate at 433MHz and they work like the outlets.



You simply connect an E27 lamp to the E27 remote controlled holder.



Then, you attach this to the lamp holder that you want to control. You can turn the light on and off with your remote control:



Setting the RF Channels

I've set my remote control to the **I** position.



The outlets must be both on the **I** position. I've selected channels **3** and **4** for the outlets (you can use any channel you want).



If you plug them to an outlet, you should be able to control the remote controlled outlets with your remote control.

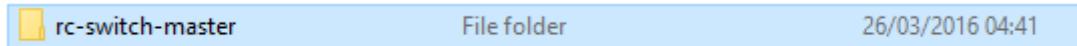
Installing the RC Switch Library

The [RC Switch library](#) provides an easy way of using your ESP8266, Arduino or Raspberry Pi to operate remote radio controlled devices. This will most likely work with all popular low-cost power outlet sockets.

- 1) [Click here to download the RC Switch library](#). You should have a **.zip** folder in your **Downloads** folder



- 2) Unzip the **.zip** folder and you should get **rc-switch-master** folder



- 3) Rename your folder from **rc-switch-master** to **rc_switch**



- 4) Move the `rc_switch` folder to your Arduino IDE installation **libraries** folder**



- 5) Then, re-open your Arduino IDE**

Opening the Decoder Sketch

You need to decode the signals that your remote control sends, so that the ESP8266 can reproduce those signals and ultimately control the outlets.

The library comes with several sketch examples. Within the Arduino IDE software, you need to go to **File > Examples > RC_Switch > ReceiveDemo_Advanced**.

A screenshot of the Arduino IDE interface. The title bar says 'ReceiveDemo_Advanced | Arduino 1.6.8'. The menu bar includes File, Edit, Sketch, Tools, Help. The toolbar has icons for file operations. The main window shows the code for 'ReceiveDemo_Advanced'. The code is as follows:

```
/*
Example for receiving

http://code.google.com/p/rc-switch/

If you want to visualize a telegram copy the raw data and
paste it into http://test.sui.li/oszi/
*/

#include <RCswitch.h>

RCswitch mySwitch = RCswitch();

void setup() {
  Serial.begin(9600);
  mySwitch.enableReceive(0); // Receiver on interrupt 0 => that is pin #2
}

void loop() {
```

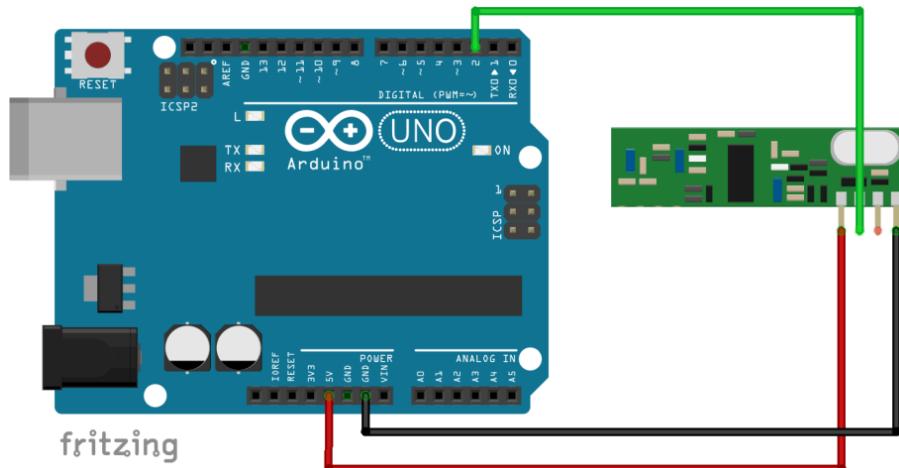
The status bar at the bottom right says 'Arduino/Genuino Uno on COM7'.

Having an Arduino board connected to your computer follow these instructions:

1. Go to the **Tools** tab
2. Select **Arduino UNO** board
3. Select the **COM** port
4. Press the **Upload** button.

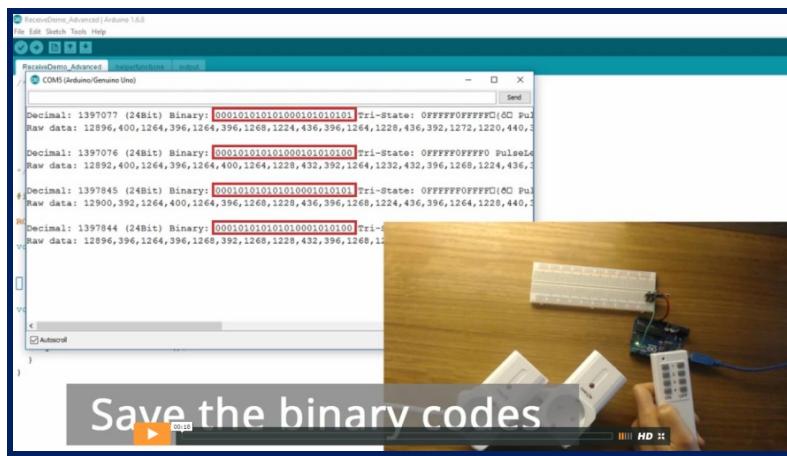
Schematics

After uploading the sketch, connect an 433MHz RF receiver to Digital Pin 2 of your Arduino UNO board:



Decoding the RF Signals

Open the Arduino IDE serial monitor and start pressing the buttons. As shown in the video demonstration below:



Video # 13 - <https://rntlab.com/watch-has-videos>

After pressing each button one time, you can see the binary code for each button (it's highlighted in red):

```
COM5 (Arduino/Genuino Uno)

Decimal: 1397077 (24Bit) Binary: 000101010101000101010101 Tri-State: 0FFFFF0FFFFF PulseLength: 416 microseconds Protocol: 1
Raw data: 12924,392,1272,396,1272,392,1272,1224,440,392,1276,1224,440,392,1272,1224,444,388,1276,1224,440,392,1276,1224,444,388

Decimal: 1397076 (24Bit) Binary: 000101010101000101010100 Tri-State: 0FFFFF0FFF0 PulseLength: 416 microseconds Protocol: 1
Raw data: 12924,392,1272,396,1268,396,1268,1228,436,388,1276,1224,440,392,1272,1224,440,396,1268,1228,440,392,1272,1224,440,392

Decimal: 1397845 (24Bit) Binary: 000101010101000101010101 Tri-State: 0FFFFFF0FFFF PulseLength: 416 microseconds Protocol: 1
Raw data: 12928,388,1276,392,1272,392,1272,1228,440,388,1276,1224,444,388,1276,1220,444,388,1276,1224,440,392,1272,1220,444,388

Decimal: 1397844 (24Bit) Binary: 0001010101010001010100 Tri-State: 0FFFFFF0FFF0 PulseLength: 416 microseconds Protocol: 1
Raw data: 12928,396,1268,396,1268,396,1268,1228,436,396,1272,1224,440,396,1268,1224,444,392,1272,1224,440,392,1276,1216,448,384
```

Save your binary codes for each button press:

- **Button 3 ON = (24Bit)** Binary: 000101010101000101010101
- **Button 3 OFF = (24Bit)** Binary: 000101010101000101010100
- **Button 4 ON = (24Bit)** Binary: 000101010101000101010101
- **Button 4 OFF = (24Bit)** Binary: 0001010101010001010100

Save your Pulse Length: 416 Microseconds.

Save your Protocol: 1.

You'll need your binary codes, pulse length and protocol in the next Unit.

Unit 3 - Controlling Lamps and Outlets with ESP using MQTT

It's time to control the outlets with Node-RED Dashboard (watch the video at the end of the Unit to see this project in action).

Understanding How the Sketch Works

You can open the complete sketch in a new window here to follow along:

- https://github.com/RuiSantosdotme/Home-Automation-Course/blob/master/code/v2/mqtt_esp8266_sockets.ino

It's almost the exact same sketch that you've used to control the LEDs. Here's the main differences:

Preparing RC Switch

Loading the RC Switch library:

```
#include <RCSwitch.h>
```

This line creates the `mySwitch` variable:

```
RCSwitch mySwitch = RCSwitch();
```

In the `setup()` function, you set D0 (GPIO 16) as a transmitter:

```
mySwitch.enableTransmit(16);
```

Set your pulse length:

```
mySwitch.setPulseLength(REPLACE_WITH_YOUR_PULSE_LENGTH);
```

Set your protocol:

```
mySwitch.setProtocol(REPLACE_WITH_YOUR_PROTOCOL);
```

Subscribing to 2 topics

In the `reconnect()` function, you subscribe to 2 topics that identify where your ESP is located and which outlet you want to control:

```
client.subscribe("home/office/esp1/desk");
client.subscribe("home/office/esp1/workbench");
```

Important: I recommend that you follow this Unit with these exact same topics. However, the idea is to replace them later with topics that clearly identify where your ESP is located and the light you are trying to control.

Sending the binary codes

In the `callback()` function, you create 2 `if` statements for each outlet that send the binary code to turn the outlet on and off.

You have to replace the binary codes with your own:

```
if(topic=="home/office/esp1/desk"){
    Serial.print("Changing Desk Light to ");
    if(messageTemp == "1"){
        // Sends binary code to turn on Desk Light
        mySwitch.send("0001010101000101010101");
        Serial.print("On");
    }
    else if(messageTemp == "0"){
        // Sends binary code to turn off Desk Light
        mySwitch.send("000101010101000101010100");
        Serial.print("Off");
    }
}
if(topic=="home/office/esp1/workbench"){
    Serial.print("Changing Workbench Light to ");
    if(messageTemp == "1"){
        // Sends binary code to turn on Workbench Light
        mySwitch.send("0001010101010001010101");
        Serial.print("On");
    }
    else if(messageTemp == "0"){
        // Sends binary code to turn off Workbench Light
        mySwitch.send("000101010101010001010100");
        Serial.print("Off");
    }
}
```

Important: in case you change the topics, you also have to change the `if` statements to match the topics that your ESP8266 is subscribed.

Uploading the Final Sketch

You can copy the final sketch to your Arduino IDE and upload it to your ESP (after changing the credentials, RPi IP address and binary codes of your remote control).

Note: make sure you select the ESP **board** in the **Tools** tab and the correct **COM** port.

```
*****  
All the resources for this project:  
https://rntlab.com/  
*****/  
  
// Loading the ESP8266WiFi library and the PubSubClient library  
#include <ESP8266WiFi.h>  
#include <PubSubClient.h>  
// Loading the RCSSwitch library to control the outlets  
#include <RCSSwitch.h>  
  
// Change the credentials below, so your ESP8266 connects to your router  
const char* ssid = "YOUR_SSID";  
const char* password = "YOUR_PASSWORD";  
  
// Change the variable to your Raspberry Pi IP address, so it connects to your MQTT broker  
const char* mqtt_server = "YOUR_RPi_IP_Address";  
  
// Initializes the espClient. You have to change the espClient name if you have multiple ESPs running in your  
home automation system  
WiFiClient espClient;  
PubSubClient client(espClient);  
  
// Initializes the RCSSwitch  
RCSSwitch mySwitch = RCSSwitch();  
  
// Don't change the function below. This functions connects your ESP8266 to your router  
void setup_wifi() {  
    delay(10);  
    // We start by connecting to a WiFi network  
    Serial.println();  
    Serial.print("Connecting to ");  
    Serial.println(ssid);  
    WiFi.begin(ssid, password);  
    while (WiFi.status() != WL_CONNECTED) {  
        delay(500);  
        Serial.print(".");  
    }  
    Serial.println("");  
    Serial.print("WiFi connected - ESP IP address: ");  
    Serial.println(WiFi.localIP());  
}  
  
// This functions is executed when some device publishes a message to a topic that your ESP8266 is  
subscribed to  
// Change the function below to add logic to your program, so when a device publishes a message to a topic  
that
```

```

// your ESP8266 is subscribed you can actually do something
void callback(String topic, byte* message, unsigned int length) {
    Serial.print("Message arrived on topic: ");
    Serial.print(topic);
    Serial.print(". Message: ");
    String messageTemp;

    for (int i = 0; i < length; i++) {
        Serial.print((char)message[i]);
        messageTemp += (char)message[i];
    }
    Serial.println();
}

// Feel free to add more if statements to control more GPIOs with MQTT

// If a message is received on the topic home/office/esp1/gpio2, you check if the message is either 1 or 0.
// Turns the ESP GPIO according to the message
if(topic=="home/office/esp1/desk"){
    Serial.print("Changing Desk Light to ");
    if(messageTemp == "1"){
        // Sends binary code to turn on Desk Light
        // BINARY CODE EXAMPLE. REPLACE WITH YOUR BINARY CODE
        mySwitch.send("000101010101000101010101");
        Serial.print("On");
    }
    else if(messageTemp == "0"){
        // Sends binary code to turn off Desk Light
        // BINARY CODE EXAMPLE. REPLACE WITH YOUR BINARY CODE
        mySwitch.send("000101010101000101010100");
        Serial.print("Off");
    }
}
if(topic=="home/office/esp1/workbench"){
    Serial.print("Changing Workbench Light to ");
    if(messageTemp == "1"){
        // Sends binary code to turn on Workbench Light
        // BINARY CODE EXAMPLE. REPLACE WITH YOUR BINARY CODE
        mySwitch.send("000101010101000101010101");
        Serial.print("On");
    }
    else if(messageTemp == "0"){
        // Sends binary code to turn off Workbench Light
        // BINARY CODE EXAMPLE. REPLACE WITH YOUR BINARY CODE
        mySwitch.send("000101010101000101010100");
        Serial.print("Off");
    }
}
Serial.println();
}

// This functions reconnects your ESP8266 to your MQTT broker
// Change the function below if you want to subscribe to more topics with your ESP8266
void reconnect() {
    // Loop until we're reconnected
    while (!client.connected()) {
        Serial.print("Attempting MQTT connection...");
        // Attempt to connect
        if (client.connect("ESP8266Client")) {
            Serial.println("connected");

```

```

// Subscribe or resubscribe to a topic
// You can subscribe to more topics (to control more LEDs in this example)
client.subscribe("home/office/esp1/desk");
client.subscribe("home/office/esp1/workbench");
} else {
Serial.print("failed, rc=");
Serial.print(client.state());
Serial.println(" try again in 5 seconds");
// Wait 5 seconds before retrying
delay(5000);
}
}

// The setup function sets your ESP GPIOs to Outputs, starts the serial communication at a baud rate of
115200
// Sets your mqtt broker and sets the callback function
// The callback function is what receives messages and actually controls the LEDs
void setup() {

Serial.begin(115200);
setup_wifi();
client.setServer(mqtt_server, 1883);
client.setCallback(callback);

mySwitch.enableTransmit(16);

// SET YOUR PULSE LENGTH
mySwitch.setPulseLength(REPLACE_WITH_YOUR_PULSE_LENGTH);

// SET YOUR PROTOCOL (default is 1, will work for most outlets)
mySwitch.setProtocol(REPLACE_WITH_YOUR_PROTOCOL);

// Set number of transmission repetitions.
mySwitch.setRepeatTransmit(15);
}

// For this project, you don't need to change anything in the loop function. Basically it ensures that you ESP is
connected to your broker
void loop() {

if (!client.connected()) {
reconnect();
}
if(!client.loop())
client.connect("espClient");
}

```

DOWNLOAD SOURCE CODE

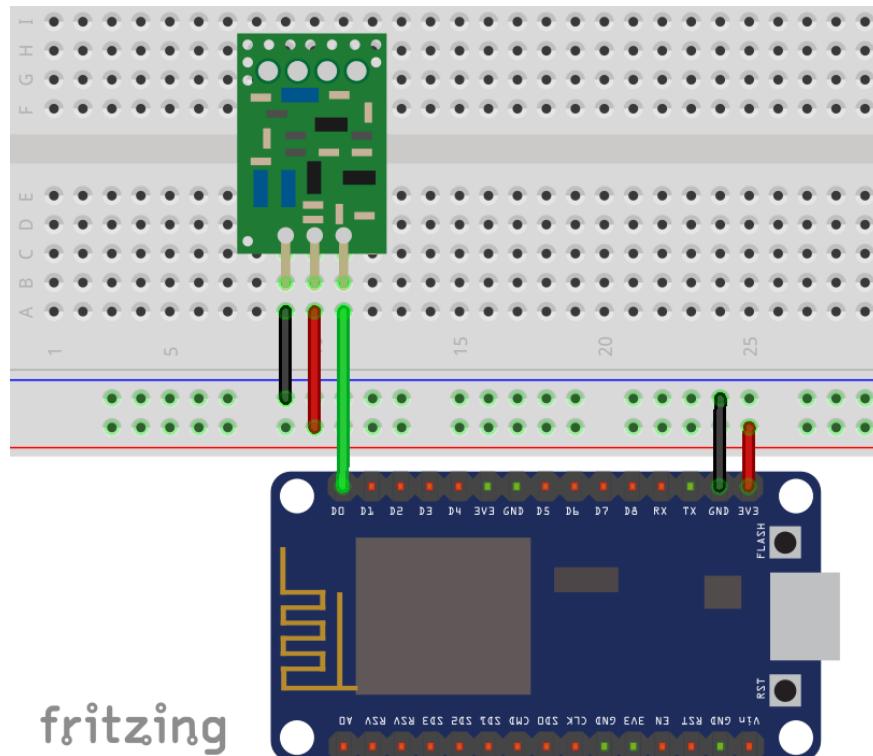
https://github.com/RuiSantosdotme/Home-Automation-Course/blob/master/code/v2/mqtt_esp8266_sockets.ino

Schematics

To complete this Unit you need:

- [ESP8266-12E](#)
- [433MHz RF Transmitter](#)
- [Remote Controlled Outlets that operate at 433MHz](#)

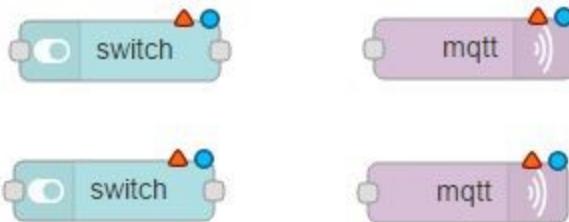
Here's the schematics:



Creating the Flow

The flow is very simple and similar to one presented in an earlier Unit. Here's the 7 steps that you need to follow:

1 – Drag 4 Nodes



2 – Desk Switch node

Edit switch node

Cancel Done

Group: Group 1 [Office]

Size: auto

Label: Desk Light

Icon: Default

When clicked, send:

On Payload: 1

Off Payload: 0

Topic:

Name: Desk Light

3 – Workbench Switch node

Edit switch node

Cancel Done

Group: Group 1 [Office]

Size: auto

Label: Workbench Ligh

Icon: Default

When clicked, send:

On Payload: 1

Off Payload: 0

Topic:

Name: Workbench Ligh

4 – Desk MQTT out node

Edit mqtt out node

Cancel Done

Server: localhost:1883

Topic: home/office/esp1/desk

QoS: 0 Retain: checked

Name: Name

Tip: Leave topic, qos or retain blank if you want to set them via msg properties.

5 – Workbench MQTT out node

Edit mqtt out node

Cancel Done

Server: localhost:1883

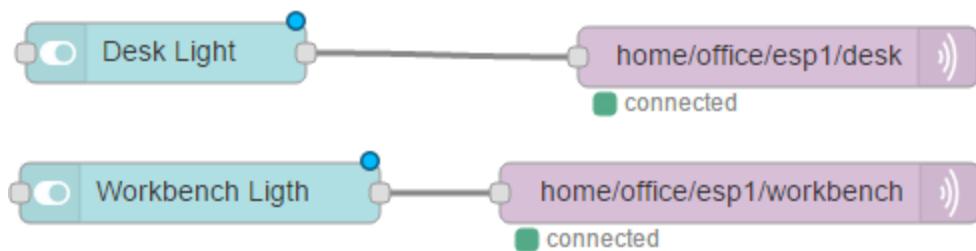
Topic: home/office/esp1/workbench

QoS: 0 Retain: checked

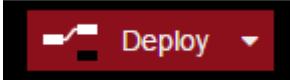
Name: Name

Tip: Leave topic, qos or retain blank if you want to set them via msg properties.

6 – Connect Nodes

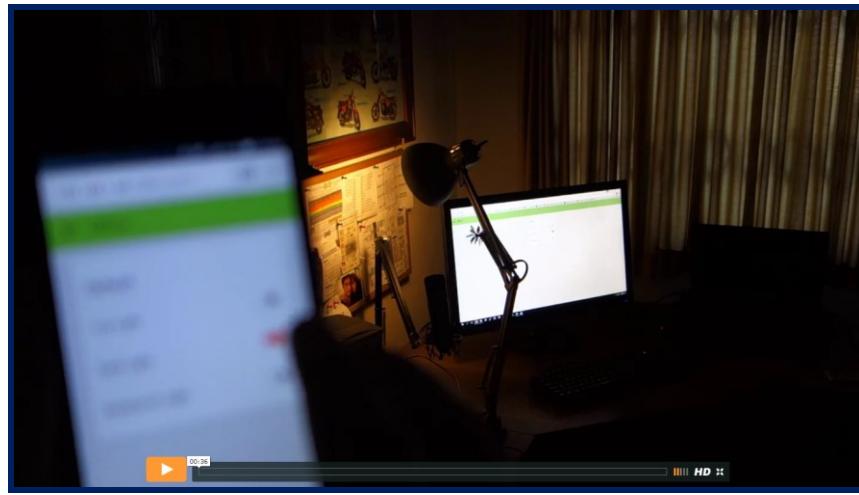


7 – Deploy your application



Watch the Video Demonstration

Finally, you can control the light and any outlet in your home with any device that has a web browser. **Watch this video to see it in action:**



Video # 14 - <https://rntlab.com/watch-has-videos>

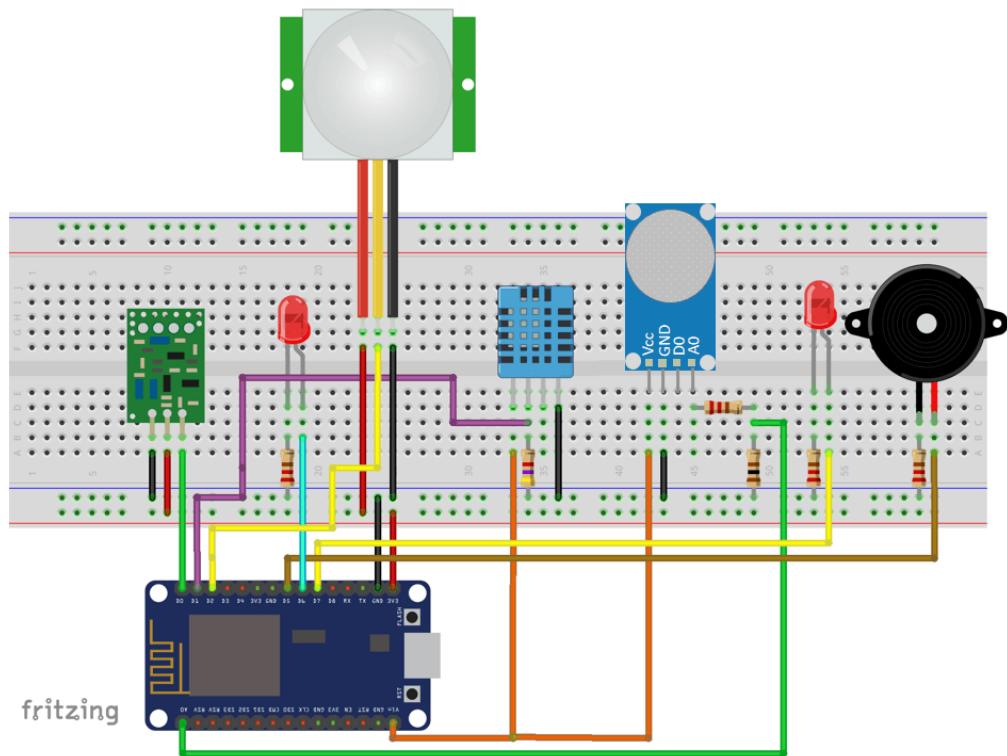
In the next Module, you're going to add a motion sensor to detect movement and notify you via email.

You're also going to connect a gas sensor to detect flammable gases. Lastly, you're going to store everything inside a project box.

MODULE 8

Connecting the ESP8266

- Part 3

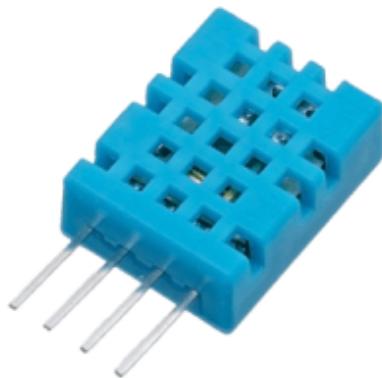


Unit 1 - Reading the Temperature and Humidity

(You should keep the sketch, circuit and nodes from the previous Unit and add this new sensor to your project)

This Unit shows you how to read temperature and humidity with an ESP8266 and how to publish those values to the Node-RED Dashboard.

Throughout this Unit you're going to use the DHT11 sensor.



Installing the DHT Sensor Library

The [DHT sensor library](#) provides an easy way of using any DHT sensor to read temperature and humidity with your ESP8266 or Arduino boards.

- 1) [Click here to download the DHT sensor library](#). You should have a **.zip** folder in your Downloads folder



- 2) Unzip the **.zip** folder and you should get **DHT-sensor-library-master** folder



- 3) Rename your folder from **DHT-sensor-library-master** to **DHT**



4) Move the **DHT** folder to your Arduino IDE installation **libraries** folder

arduino-1.6.8 > libraries	
Name	Type
Bridge	File folder
DHT	File folder
Esplora	File folder

5) Then, re-open your Arduino IDE

Understanding How the Sketch Works

You can open the complete sketch in a new window here to follow along:

- https://github.com/RuiSantosdotme/Home-Automation-Course/blob/master/code/v2/mqtt_esp8266_temperature_humidity.ino

Preparing DHT

The following line loads the DHT sensor library:

```
#include "DHT.h"
```

You have to define the type of DHT sensor that you're using. In my case, I'm using the DHT11, but if you're using another version you can comment the DHT11 line and uncomment your sensor version.

```
// Uncomment one of the lines below for whatever DHT sensor type you're using!
#define DHTTYPE DHT11    // DHT 11
//#define DHTTYPE DHT21    // DHT 21 (AM2301)
//#define DHTTYPE DHT22    // DHT 22 (AM2302), AM2321
```

Then, you set the D1 (GPIO 5) as the pin `DHTPin` variable and you prepare the `dht` sensor variable:

```
// DHT Sensor
const int DHTPin = 5;

// Initialize DHT sensor.
DHT dht(DHTPin, DHTTYPE);
```

You need two variables to keep track of the time, so that you can create a timer that publishes new temperature and humidity measurements every 30 seconds.

```
// Timers auxiliar variables
long now = millis();
long lastMeasure = 0;
```

setup

In the `setup()` function, you begin the DHT sensor:

```
dht.begin();
```

loop

Finally, you have the `loop()` function that contains a timer that compares the time that has passed since the last sensor measurement.

If it has passed 30 seconds, it goes into that `if` statement.

```
now = millis();
// Publishes new temperature and humidity every 30 seconds
if (now - lastMeasure > 30000) {
    lastMeasure = now;
```

Note: I recommend you to only read the DHT sensor every 30 seconds or above, because the DHT sensor takes a long time to read the values and it might interfere with other actions that your ESP8266 is performing.

These first 3 lines of code read the humidity, temperature in Celsius and Fahrenheit. It also checks if the sensor reading was successful.

```
// Sensor readings may also be up to 2 seconds 'old' (its a very slow sensor)
float h = dht.readHumidity();
// Read temperature as Celsius (the default)
float t = dht.readTemperature();
// Read temperature as Fahrenheit (isFahrenheit = true)
float f = dht.readTemperature(true);

// Check if any reads failed and exit early (to try again).
if (isnan(h) || isnan(t) || isnan(f)) {
    Serial.println("Failed to read from DHT sensor!");
    return;
}
```

The next snippet of code computes the sensor values and saves them in temporary variables (converts float to char).

Tip: you can comment the Celsius code and uncomment the Fahrenheit code, if you prefer.

```
// Computes temperature values in Celsius
float hic = dht.computeHeatIndex(t, h, false);
static char temperatureTemp[7];
dtostrf(hic, 6, 2, temperatureTemp);

// Uncomment to compute temperature values in Fahrenheit
// float hif = dht.computeHeatIndex(f, h);
// static char temperatureTemp[7];
// dtostrf(hic, 6, 2, temperatureTemp);

static char humidityTemp[7];
dtostrf(h, 6, 2, humidityTemp);
```

Finally, you need to publish the temperature and humidity measurements to the following MQTT topics:

- **home/office/esp1/temperature**
- **home/office/esp1/humidity**

Later, you can change these topics to fit your rooms or devices.

```
// Publishes Temperature and Humidity values
client.publish("home/office/esp1/temperature", temperatureTemp);
client.publish("home/office/esp1/humidity", humidityTemp);
```

Lastly, you have these lines of code to print the temperature and humidity values in the Arduino IDE serial monitor.

Note: you can delete these next `Serial.print()` lines after testing your project:

```

    Serial.print("Humidity: ");
    Serial.print(h);
    Serial.print(" \t Temperature: ");
    Serial.print(t);
    Serial.print(" *C ");
    Serial.print(f);
    Serial.print(" *F\t Heat index: ");
    Serial.print(hic);
    Serial.println(" *C ");
    // Serial.print(hif);
    // Serial.println(" *F");

```

Uploading the Final Sketch

You can copy the final sketch to your Arduino IDE and upload it to your ESP (after changing the credentials, RPi IP address and binary codes of your remote control).

Note #1: Make sure you select the **ESP board** in the **Tools** tab and the correct **COM** port.

Note #2: You can comment/uncomment some lines if you're using another DHT sensor or if you're reading temperature in Fahrenheit.

```

*****
All the resources for this project:
https://rntlab.com/
*****

#include <ESP8266WiFi.h>
#include <PubSubClient.h>
// Loading the RCswitch library to control the outlets
#include <RCswitch.h>
#include "DHT.h"

// Uncomment one of the lines below for whatever DHT sensor type you're
using!
#define DHTTYPE DHT11    // DHT 11
// #define DHTTYPE DHT21    // DHT 21 (AM2301)
// #define DHTTYPE DHT22    // DHT 22 (AM2302), AM2321

// Change the credentials below, so your ESP8266 connects to your router
const char* ssid = "YOUR_SSID";
const char* password = "YOUR_PASSWORD";

// Change the variable to your Raspberry Pi IP address, so it connects to
your MQTT broker

```

```

const char* mqtt_server = "YOUR_RPi_IP_Address";

// Initializes the espClient. You have to change the espClient name if you
// have multiple ESPs running in your home automation system
WiFiClient espClient;
PubSubClient client(espClient);

RCSwitch mySwitch = RCSwitch();

// DHT Sensor
const int DHTPin = 5;

// Initialize DHT sensor.
DHT dht(DHTPin, DHTTYPE);

// Timers auxiliar variables
long now = millis();
long lastMeasure = 0;

// Don't change the function below. This functions connects your ESP8266 to
// your router
void setup_wifi() {
    delay(10);
    // We start by connecting to a WiFi network
    Serial.println();
    Serial.print("Connecting to ");
    Serial.println(ssid);
    WiFi.begin(ssid, password);
    while (WiFi.status() != WL_CONNECTED) {
        delay(500);
        Serial.print(".");
    }
    Serial.println("");
    Serial.print("WiFi connected - ESP IP address: ");
    Serial.println(WiFi.localIP());
}

// This functions is executed when some device publishes a message to a topic
// that your ESP8266 is subscribed to
// Change the function below to add logic to your program, so when a device
// publishes a message to a topic that
// your ESP8266 is subscribed you can actually do something
void callback(String topic, byte* message, unsigned int length) {
    Serial.print("Message arrived on topic: ");
    Serial.print(topic);
    Serial.print(". Message: ");
    String messageTemp;

    for (int i = 0; i < length; i++) {
        Serial.print((char)message[i]);
        messageTemp += (char)message[i];
    }
    Serial.println();

    // Feel free to add more if statements to control more GPIOs with MQTT

    // If a message is received on the topic home/office/espl/desk, you check
    // if the message is either 1 or 0. Turns the Desk outlet according to the
    // message
    if(topic=="home/office/espl/desk"){
        Serial.print("Changing Desk light to ");
}

```

```

    if(messageTemp == "1"){
        mySwitch.send("0001010101010001010101");
        Serial.print("On");
    }
    else if(messageTemp == "0"){
        mySwitch.send("0001010101010001010100");
        Serial.print("Off");
    }
}
if(topic=="home/office/esp1/workbench"){
    Serial.print("Changing Workbench light to ");
    if(messageTemp == "1"){
        mySwitch.send("0001010101010001010101");
        Serial.print("On");
    }
    else if(messageTemp == "0"){
        mySwitch.send("0001010101010001010100");
        Serial.print("Off");
    }
}
Serial.println();
}

// This functions reconnects your ESP8266 to your MQTT broker
// Change the function below if you want to subscribe to more topics with
your ESP8266
void reconnect() {
    // Loop until we're reconnected
    while (!client.connected()) {
        Serial.print("Attempting MQTT connection...");
        // Attempt to connect
        if (client.connect("ESP8266Client")) {
            Serial.println("connected");
            // Subscribe or resubscribe to a topic
            // You can subscribe to more topics (to control more LEDs in this
example)
            client.subscribe("home/office/esp1/desk");
            client.subscribe("home/office/esp1/workbench");
        } else {
            Serial.print("failed, rc=");
            Serial.print(client.state());
            Serial.println(" try again in 5 seconds");
            // Wait 5 seconds before retrying
            delay(5000);
        }
    }
}

// The setup function sets your ESP GPIOs to Outputs, starts the serial
communication at a baud rate of 115200
// Sets your mqtt broker and sets the callback function
// The callback function is what receives messages and actually controls the
LEDs
void setup() {

    dht.begin();

    Serial.begin(115200);
    setup_wifi();
    client.setServer(mqtt_server, 1883);
    client.setCallback(callback);
}

```

```

mySwitch.enableTransmit(16);

// SET YOUR PULSE LENGTH
mySwitch.setPulseLength(REPLACE_WITH_YOUR_PULSE_LENGTH);

// SET YOUR PROTOCOL (default is 1, will work for most outlets)
mySwitch.setProtocol(REPLACE_WITH_YOUR_PROTOCOL);

// Set number of transmission repetitions.
mySwitch.setRepeatTransmit(15);
}

// For this project, you don't need to change anything in the loop function.
// Basically it ensures that your ESP is connected to your broker
void loop() {

    if (!client.connected()) {
        reconnect();
    }
    if(!client.loop())
        client.connect("espClient");

    now = millis();
    // Publishes new temperature and humidity every 30 seconds
    if (now - lastMeasure > 30000) {
        lastMeasure = now;
        // Sensor readings may also be up to 2 seconds 'old' (its a very slow
        sensor)
        float h = dht.readHumidity();
        // Read temperature as Celsius (the default)
        float t = dht.readTemperature();
        // Read temperature as Fahrenheit (isFahrenheit = true)
        float f = dht.readTemperature(true);

        // Check if any reads failed and exit early (to try again).
        if (isnan(h) || isnan(t) || isnan(f)) {
            Serial.println("Failed to read from DHT sensor!");
            return;
        }

        // Computes temperature values in Celsius
        float hic = dht.computeHeatIndex(t, h, false);
        static char temperatureTemp[7];
        dtostrf(hic, 6, 2, temperatureTemp);

        // Uncomment to compute temperature values in Fahrenheit
        // float hif = dht.computeHeatIndex(f, h);
        // static char temperatureTemp[7];
        // dtostrf(hic, 6, 2, temperatureTemp);

        static char humidityTemp[7];
        dtostrf(h, 6, 2, humidityTemp);

        // Publishes Temperature and Humidity values
        client.publish("home/office/esp1/temperature", temperatureTemp);
        client.publish("home/office/esp1/humidity", humidityTemp);

        Serial.print("Humidity: ");
        Serial.print(h);
        Serial.print(" %\t Temperature: ");
    }
}

```

```

        Serial.print(t);
        Serial.print(" *C ");
        Serial.print(f);
        Serial.print(" *F\t Heat index: ");
        Serial.print(hic);
        Serial.println(" *C ");
        // Serial.print(hif);
        // Serial.println(" *F");
    }
}

```

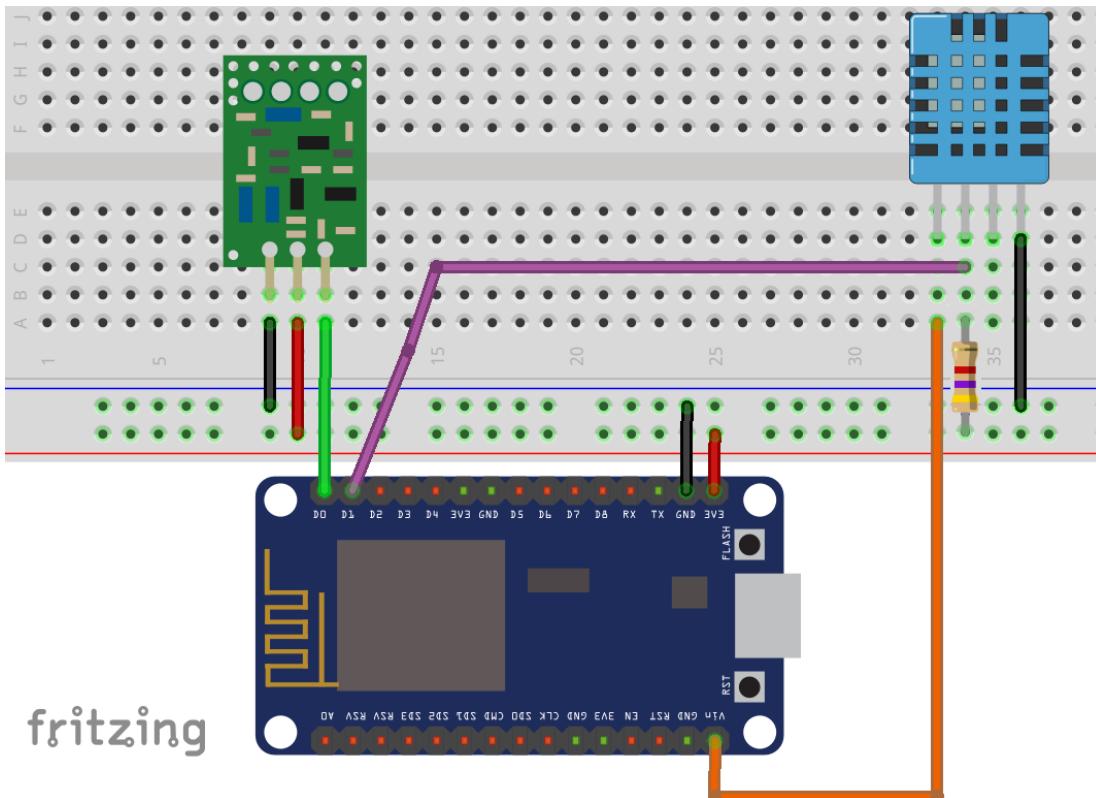
DOWNLOAD SOURCE CODE

https://github.com/RuiSantosdotme/Home-Automation-Course/blob/master/code/v2/mqtt_esp8266_temperature_humidity.ino

Schematics

To complete this Unit you need (highlighted you can see the new components):

- [ESP8266-12E](#)
- [433MHz RF Transmitter](#)
- [Remote Controlled Outlets that operate at 433MHz](#)
- [DHT11 Sensor](#)
- [4700 Ohm Resistor](#)



Note: other DHT sensor types will also work with a small change in the code (as described in a preceding section).

Important: The DHT sensor requires 5V to operate properly, so make sure you use the Vin pin from your ESP8266 that outputs 5V.

Creating the Flow

In this flow, you're going to use a node called **Gauge** to plot the temperature and humidity values. Follow these next 8 steps to create your flow:

1 – Drag 4 Nodes



2 – MQTT out Temperature

Edit mqtt in node

Cancel Done

Server	localhost:1883	
Topic	home/office/esp1/temperature	
QoS	2	
Name	Name	

3 – MQTT out Humidity

Edit mqtt in node

Cancel Done

Server	localhost:1883	
Topic	home/office/esp1/humidity	
QoS	2	
Name	Name	

4 – Gauge Temperature for Celsius

Edit gauge node

Cancel Done

Group	Group 1 [Office]	
Size	auto	
Type	Gauge	
Title	Temperature	
Value format	{{value}}	
Label	units	
Range	min -10	max 40
Name	Temperature	

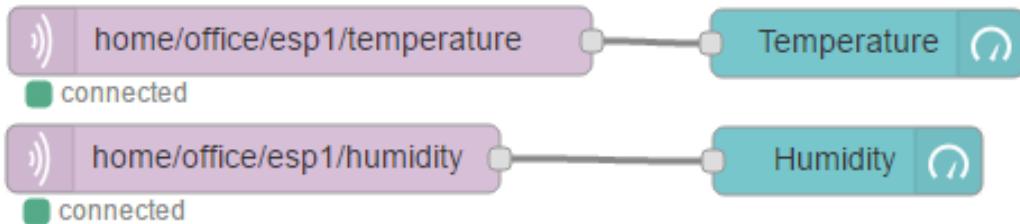
5 – Gauge Humidity (0 to 100%)

Edit gauge node

Cancel Done

Group	Group 1 [Office]	
Size	auto	
Type	Gauge	
Title	Humidity	
Value format	<code>{{value}}</code>	
Label	units	
Range	min 0	max 100
Name	Humidity	

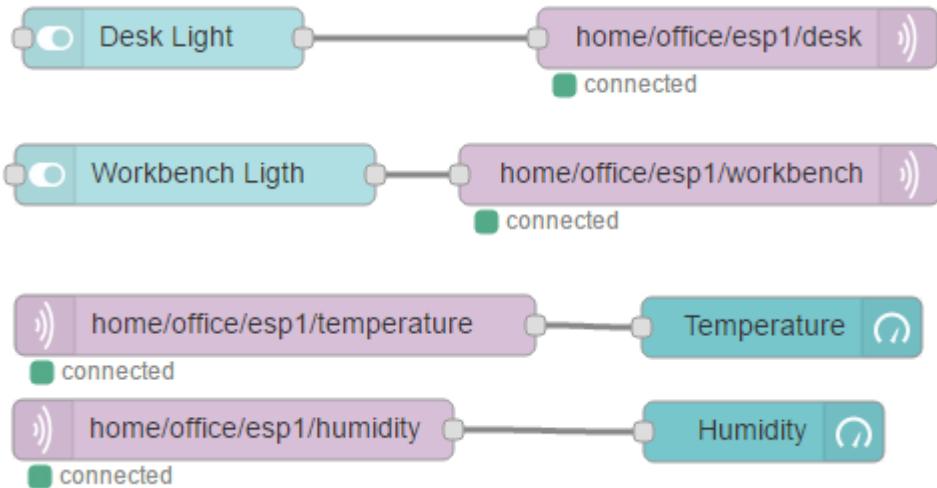
6 – Connecting Nodes



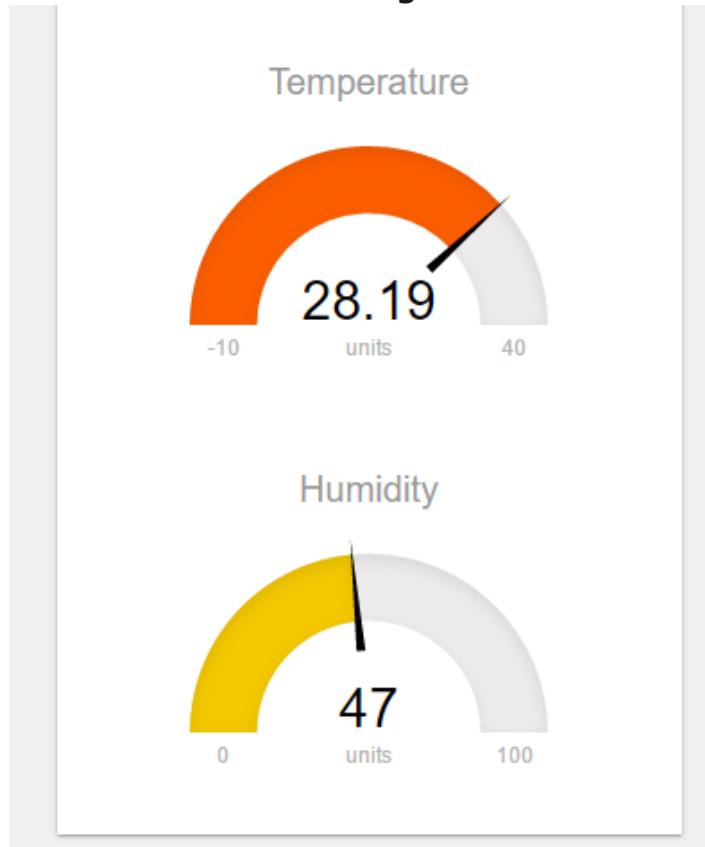
7 – Deploy your application

Deploy ▾

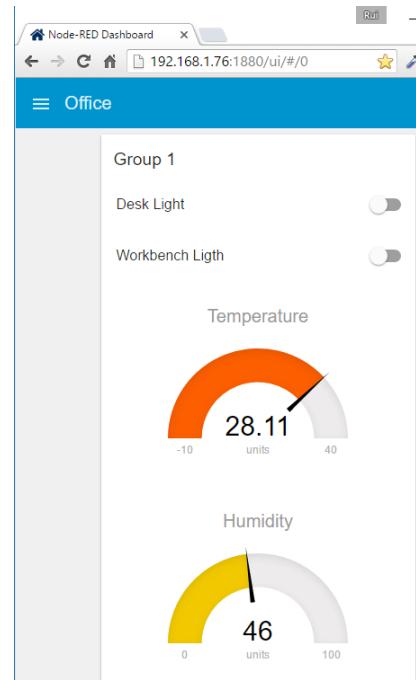
Final Flow



8 – Gauges

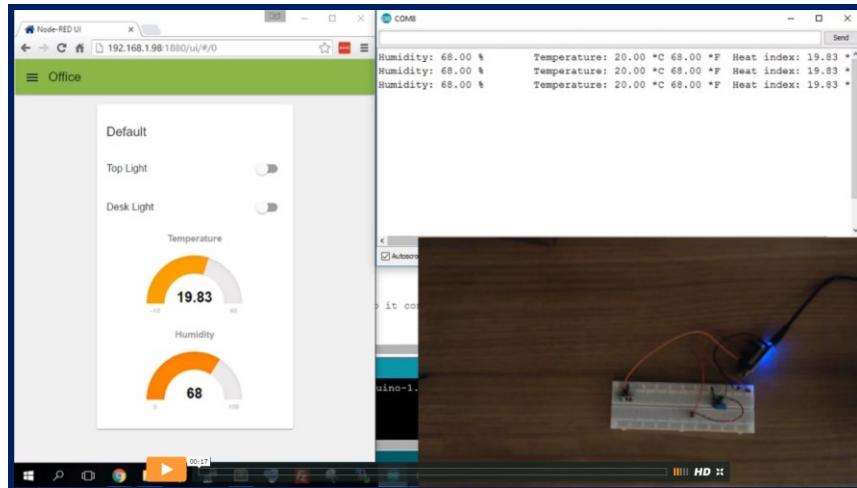


When you go to the Node-RED Dashboard tab, here's what you should see:



Watch the Video Demonstration

You can see your room temperature and humidity updated every 30 seconds in the Node-RED Dashboard. **Watch this video to see it in action:**



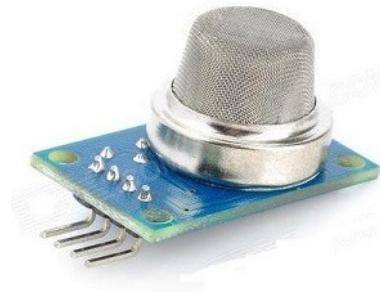
Video # 15 - <https://rntlab.com/watch-has-videos>

Unit 2 - Smoke and Gas Detector

(You should keep the sketch, circuit and nodes from the previous Units and add this new sensor to your project)

This Unit shows you how to build a flammable gas detector that beeps when it detects gas and publishes a notification to the Node-RED Dashboard.

Throughout this Unit you're going to use the MQ-2 sensor.



Understanding How the Sketch Works

You can open the complete sketch in a new window here to follow along:

- https://github.com/RuiSantosdotme/Home-Automation-Course/blob/master/code/v2/mqtt_esp8266_smoke.ino

Preparing the variables

Assign the Analog pin A0 to the `smokePin` variable.

```
// Smoke Sensor  
int smokePin = A0;
```

Then, assign the pin D5 (GPIO 14) to the `buzzerPin` variable.

```
// Buzzer  
const int buzzerPin = 14;
```

You also need to define a threshold value for the smoke sensor, I'll be using `smokeThres=60` (you might need to change this value to adjust the smoke sensor sensitivity).

I've also created a control variable called `armSmoke` to arm/disarm the smoke sensor. The `smokeTriggered` variable is used to trigger the notification message to the Node-RED Dashboard just once.

```
// Smoke Threshold  
int smokeThres = 60;  
  
// Control Variables  
boolean armSmoke = false;  
boolean smokeTriggered = false;
```

The next variable is used to create a timer that keeps checking the smoke value every few milliseconds.

```
long lastSmokeCheck = 0;
```

setup

In the `setup()` function, you need to set the LED and buzzer as OUTPUTs and the smoke sensor is set as an INPUT.

```
pinMode(smokeLED, OUTPUT);  
pinMode(buzzerPin, OUTPUT);  
  
pinMode(smokePin, INPUT);
```

reconnect

The `reconnect()` function publishes two messages when the ESP connects to the broker:

```
// Once connected, publish an announcement...  
client.publish("home/office/esp1/smoke/status", "Not Armed");  
client.publish("home/office/esp1/smoke/notification", "NO SMOKE");
```

You also have to be subscribed to the following topic:

- **home/office/esp1/smoke**

So you can send commands from the Node-RED Dashboard to arm/disarm the smoke sensor.

```
client.subscribe("home/office/esp1/smoke");
```

callback

Inside the `callback()` function, you receive commands from the Node-RED Dashboard to actually arm/disarm the smoke sensor.

```
if(topic=="home/office/esp1/smoke"){
    Serial.print("SMOKE SENSOR STATUS CHANGE");
    if(messageTemp == "1"){
        Serial.print("Smoke Sensor Armed");
        client.publish("home/office/esp1/smoke/status", "Armed");
        client.publish("home/office/esp1/smoke/notification", "NO SMOKE");
        armSmoke = true;
        smokeTriggered = false;
        digitalWrite(smokeLED, HIGH);
    }
    else if(messageTemp == "0"){
        Serial.print("Smoke Sensor Not Armed");
        client.publish("home/office/esp1/smoke/status", "Not Armed");
        client.publish("home/office/esp1/smoke/notification", "NO SMOKE");
        armSmoke = false;
        smokeTriggered = false;
        digitalWrite(smokeLED, LOW);
    }
}
```

loop

In the `loop()` function, your ESP keeps checking, every 200 milliseconds, the current value of the smoke sensor:

```
if (now - lastSmokeCheck > 200) {
    lastSmokeCheck = now;
```

If the `smokeValue` is greater than the `smokeThres` value and if the sensor is armed, it sends a warning message saying “SMOKE DETECTED” to the Node-RED Dashboard.

```
if (now - lastSmokeCheck > 200) {  
    lastSmokeCheck = now;  
    int smokeValue = analogRead(smokePin);  
    if (smokeValue > smokeThres && armSmoke){  
        Serial.print("Pin A0: ");  
        Serial.println(smokeValue);  
        tone(buzzerPin, 1000, 200);  
        if(!smokeTriggered){  
            Serial.println("SMOKE DETECTED!!!!");  
            smokeTriggered = true;  
            client.publish("home/office/esp1/smoke/notification", "SMOKE DETECTED");  
        }  
    }  
}
```

Uploading the Final Sketch

You can copy the final sketch to your Arduino IDE and upload it to your ESP (after changing the credentials, RPi IP address and binary codes of your remote control).

Note #1: Make sure you select the **ESP board** in the **Tools** tab and the correct **COM** port.

Note #2: You can change the variable `smokeThres` to adjust the sensitivity of your gas sensor (or you might need to rotate the potentiometer on the back of the sensor).

```
*****  
  
All the resources for this project:  
https://rntlab.com/  
  
*****  
  
// Loading the required libraries  
#include <ESP8266WiFi.h>  
#include <PubSubClient.h>  
#include <RCSwitch.h>  
#include "DHT.h"  
  
// Uncomment one of the lines below for whatever DHT sensor type you're  
using!  
#define DHTTYPE DHT11 // DHT 11  
// #define DHTTYPE DHT21 // DHT 21 (AM2301)  
// #define DHTTYPE DHT22 // DHT 22 (AM2302), AM2321  
  
// Change the credentials below, so your ESP8266 connects to your router  
const char* ssid = "YOUR_SSID";  
const char* password = "YOUR_PASSWORD";
```

```

// Change the variable to your Raspberry Pi IP address, so it connects to
your MQTT broker
const char* mqtt_server = "YOUR_RPi_IP_Address";

// Initializes the espClient. You have to change the espClient name if you
have multiple ESPs running in your home automation system
WiFiClient espClient;
PubSubClient client(espClient);

RCSwitch mySwitch = RCSwitch();

// Smoke Sensor
int smokePin = A0;
// DHT Sensor
const int DHTPin = 5;

// Initialize DHT sensor.
DHT dht(DHTPin, DHTTYPE);

// Smoke Threshold
int smokeThres = 60;

// Control Variables
boolean armSmoke = false;
boolean smokeTriggered = false;

// Status LEDs
const int smokeLED = 13;

// Buzzer
const int buzzerPin = 14;

// Timers auxiliar variables
long now = millis();
long lastMeasure = 0;
long lastSmokeCheck = 0;

// Don't change the function below. This functions connects your ESP8266 to
your router
void setup_wifi() {
    delay(10);
    // We start by connecting to a WiFi network
    Serial.println();
    Serial.print("Connecting to ");
    Serial.println(ssid);
    WiFi.begin(ssid, password);
    while (WiFi.status() != WL_CONNECTED) {
        delay(500);
        Serial.print(".");
    }
    Serial.println("");
    Serial.print("WiFi connected - ESP IP address: ");
    Serial.println(WiFi.localIP());
}

// This functions is executed when some device publishes a message to a topic
that your ESP8266 is subscribed to
// Change the function below to add logic to your program, so when a device
publishes a message to a topic that
// your ESP8266 is subscribed you can actually do something

```

```

void callback(String topic, byte* message, unsigned int length) {
    Serial.print("Message arrived on topic: ");
    Serial.print(topic);
    Serial.print(". Message: ");
    String messageTemp;

    for (int i = 0; i < length; i++) {
        Serial.print((char)message[i]);
        messageTemp += (char)message[i];
    }
    Serial.println();

    // Feel free to add more if statements to control more GPIOs with MQTT

    // If a message is received on the topic home/office/esp1/desk, you check
    if (topic == "home/office/esp1/desk") {
        if (messageTemp == "1") {
            mySwitch.send("000101010101000101010101");
            Serial.print("On");
        } else if (messageTemp == "0") {
            mySwitch.send("000101010101000101010100");
            Serial.print("Off");
        }
    }
    if (topic == "home/office/esp1/workbench") {
        if (messageTemp == "1") {
            mySwitch.send("000101010101000101010101");
            Serial.print("On");
        } else if (messageTemp == "0") {
            mySwitch.send("000101010101000101010100");
            Serial.print("Off");
        }
    }
    if (topic == "home/office/esp1/smoke") {
        Serial.print("SMOKE SENSOR STATUS CHANGE");
        if (messageTemp == "1") {
            Serial.print("Smoke Sensor Armed");
            client.publish("home/office/esp1/smoke/status", "Armed");
            client.publish("home/office/esp1/smoke/notification", "NO SMOKE");
            armSmoke = true;
            smokeTriggered = false;
            digitalWrite(smokeLED, HIGH);
        } else if (messageTemp == "0") {
            Serial.print("Smoke Sensor Not Armed");
            client.publish("home/office/esp1/smoke/status", "Not Armed");
            client.publish("home/office/esp1/smoke/notification", "NO SMOKE");
            armSmoke = false;
            smokeTriggered = false;
            digitalWrite(smokeLED, LOW);
        }
    }
    Serial.println();
}

```

```

// This functions reconnects your ESP8266 to your MQTT broker
// Change the function below if you want to subscribe to more topics with
your ESP8266
void reconnect() {
    // Loop until we're reconnected
    while (!client.connected()) {
        Serial.print("Attempting MQTT connection...");
        // Attempt to connect
        if (client.connect("ESP8266Client")) {
            Serial.println("connected");
            // Once connected, publish an announcement...
            client.publish("home/office/esp1/smoke/status", "Not Armed");
            client.publish("home/office/esp1/smoke/notification", "NO SMOKE");
            // Subscribe or resubscribe to a topic
            // You can subscribe to more topics (to control more LEDs in this
example)
            client.subscribe("home/office/esp1/desk");
            client.subscribe("home/office/esp1/workbench");
            client.subscribe("home/office/esp1/smoke");
        } else {
            Serial.print("failed, rc=");
            Serial.print(client.state());
            Serial.println(" try again in 5 seconds");
            // Wait 5 seconds before retrying
            delay(5000);
        }
    }
}

// The setup function sets your ESP GPIOs to Outputs, starts the serial
communication at a baud rate of 115200
// Sets your mqtt broker and sets the callback function
// The callback function is what receives messages and actually controls the
LEDs
void setup() {
    pinMode(smokeLED, OUTPUT);
    pinMode(buzzerPin, OUTPUT);

    pinMode(smokePin, INPUT);

    dht.begin();

    Serial.begin(115200);
    setup_wifi();
    client.setServer(mqtt_server, 1883);
    client.setCallback(callback);

    mySwitch.enableTransmit(16);

    // SET YOUR PULSE LENGTH
    mySwitch.setPulseLength(REPLACE_WITH_YOUR_PULSE_LENGTH);

    // SET YOUR PROTOCOL (default is 1, will work for most outlets)
    mySwitch.setProtocol(REPLACE_WITH_YOUR_PROTOCOL);

    // Set number of transmission repetitions.
    mySwitch.setRepeatTransmit(15);
}

// For this project, you don't need to change anything in the loop function.
Basically it ensures that your ESP is connected to your broker

```

```

void loop() {

    if (!client.connected()) {
        reconnect();
    }
    if(!client.loop())
        client.connect("espClient");

    now = millis();
    // Publishes new temperature and humidity every 30 seconds
    if (now - lastMeasure > 30000) {
        lastMeasure = now;
        // Sensor readings may also be up to 2 seconds 'old' (its a very slow
sensor)
        float h = dht.readHumidity();
        // Read temperature as Celsius (the default)
        float t = dht.readTemperature();
        // Read temperature as Fahrenheit (isFahrenheit = true)
        float f = dht.readTemperature(true);

        // Check if any reads failed and exit early (to try again).
        if (isnan(h) || isnan(t) || isnan(f)) {
            Serial.println("Failed to read from DHT sensor!");
            return;
        }

        // Computes temperature values in Celsius
        float hic = dht.computeHeatIndex(t, h, false);
        static char temperatureTemp[7];
        dtostrf(hic, 6, 2, temperatureTemp);

        // Uncomment to compute temperature values in Fahrenheit
        // float hif = dht.computeHeatIndex(f, h);
        // static char temperatureTemp[7];
        // dtostrf(hic, 6, 2, temperatureTemp);

        static char humidityTemp[7];
        dtostrf(h, 6, 2, humidityTemp);

        // Publishes Temperature and Humidity values
        client.publish("home/office/esp1/temperature", temperatureTemp);
        client.publish("home/office/esp1/humidity", humidityTemp);

        Serial.print("Humidity: ");
        Serial.print(h);
        Serial.print(" \t Temperature: ");
        Serial.print(t);
        Serial.print(" *C ");
        Serial.print(f);
        Serial.print(" *F\t Heat index: ");
        Serial.print(hic);
        Serial.println(" *C ");
        // Serial.print(hif);
        // Serial.println(" *F");
    }
    // Checks smoke
    if (now - lastSmokeCheck > 200) {
        lastSmokeCheck = now;
        int smokeValue = analogRead(smokePin);
        if (smokeValue > smokeThres && armSmoke) {
            Serial.print("Pin A0: ");

```

```

Serial.println(smokeValue);
tone(buzzerPin, 1000, 200);
if (!smokeTriggered) {
    Serial.println("SMOKE DETECTED!!!");
    smokeTriggered = true;
    client.publish("home/office/esp1/smoke/notification", "SMOKE
DETECTED");
}
}
}
}

```

DOWNLOAD SOURCE CODE

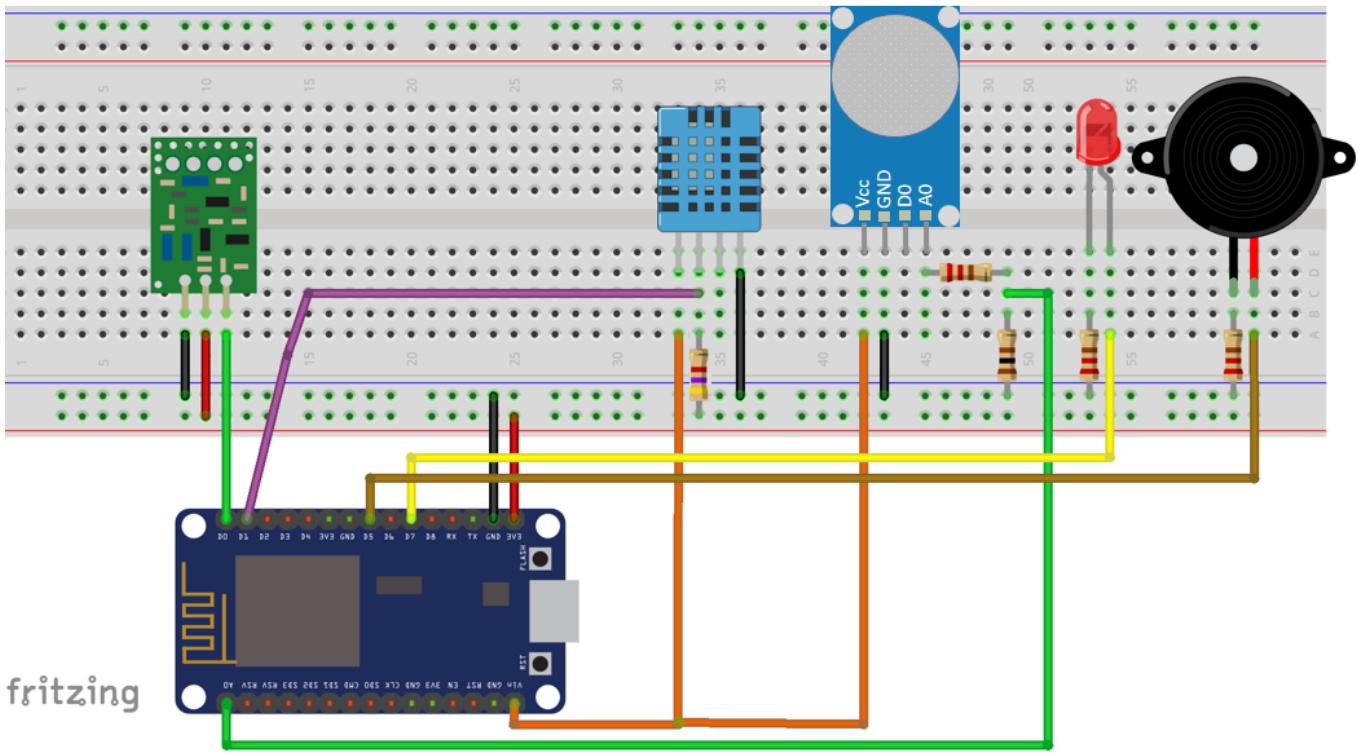
https://github.com/RuiSantosdotme/Home-Automation-Course/blob/master/code/v2/mqtt_esp8266_smoke.ino

Schematics

To complete this Unit you need:

- [ESP8266-12E](#)
- [433MHz RF Transmitter](#)
- [Remote Controlled Outlets that operate at 433MHz](#)
- [DHT11 Sensor](#)
- [4700 Ohm Resistor](#)
- [MQ-2 Gas Sensor](#)
- [Buzzer](#)
- [LED \(5mm\)](#)
- [3x 220 Ohm Resistors](#)
- [100 Ohm Resistor](#)

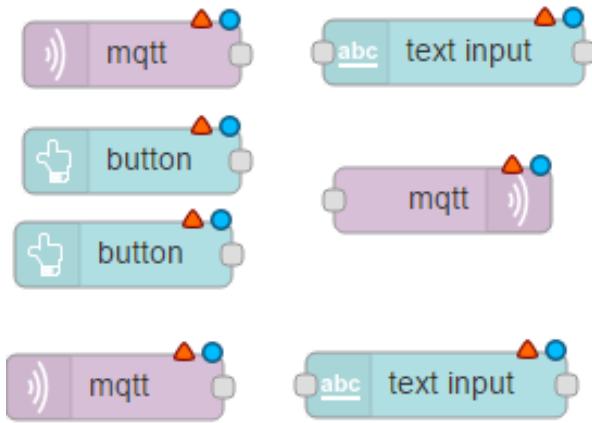
Important: The gas sensor requires 5V to operate properly, so make sure you use the Vin pin from your ESP8266 that outputs 5V.



Creating the Flow

The flow is similar to the previous Unit. Here's the 11 steps that you need to follow:

1 – Drag 6 Nodes



2 – MQTT in subscribes to status

Edit mqtt in node

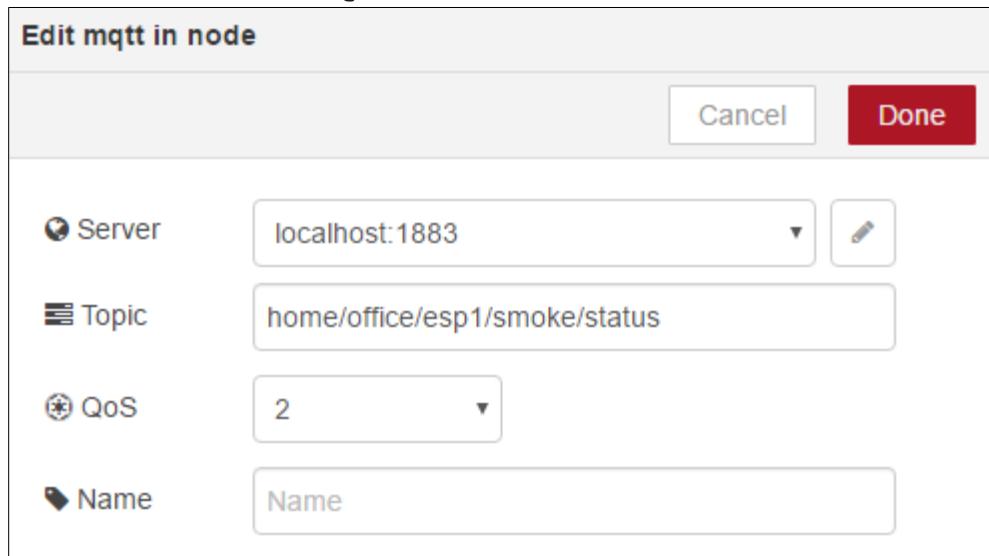
Cancel Done

Server: localhost:1883

Topic: home/office/esp1/smoke/status

QoS: 2

Name: Name



3 – Displays current status

Edit text input node

Cancel Done

Group: Group 1 [Office]

Size: auto

Label: Your smoke sensor is:

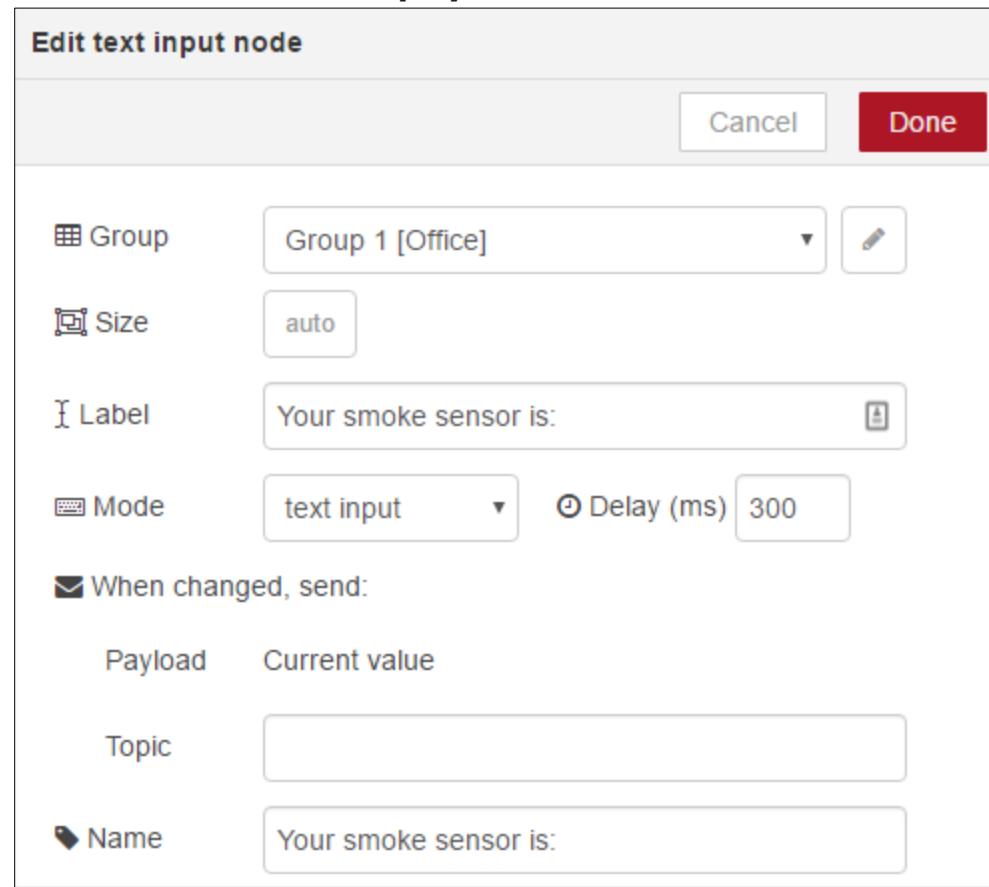
Mode: text input Delay (ms): 300

When changed, send:

Payload: Current value

Topic:

Name: Your smoke sensor is:



4 – Button to arm smoke sensor

Edit button node

Cancel Done

Group	Group 1 [Office]	<input type="button" value=""/>
Size	auto	
Icon	optional icon	<input type="button" value=""/>
Label	Arm	
Color	optional text/icon color	
When clicked, send:		
Payload	a_z 1	
Topic		
Name	Arm	

5 – Button to disarm smoke sensor

Edit button node

Cancel Done

Group	Group 1 [Office]	<input type="button" value=""/>
Size	auto	
Icon	optional icon	<input type="button" value=""/>
Label	Disarm	
Color	optional text/icon color	
When clicked, send:		
Payload	a_z 0	
Topic		
Name	Disarm	

6 – MQTT out sends arm or disarm command to ESP8266

Edit mqtt out node

Cancel Done

Server: localhost:1883

Topic: home/office/esp1/smoke

QoS: 0 Retain: checked

Name: home/office/esp1/smoke

7 – MQTT in subscribes to notification

Edit mqtt in node

Cancel Done

Server: localhost:1883

Topic: home/office/esp1/smoke/notification

QoS: 2

Name: home/office/esp1/smoke/notification

8 – Displays notification status

Edit text input node

Cancel Done

Group: Group 1 [Office]

Size: auto

Label: Notifications

Mode: text input Delay (ms): 300

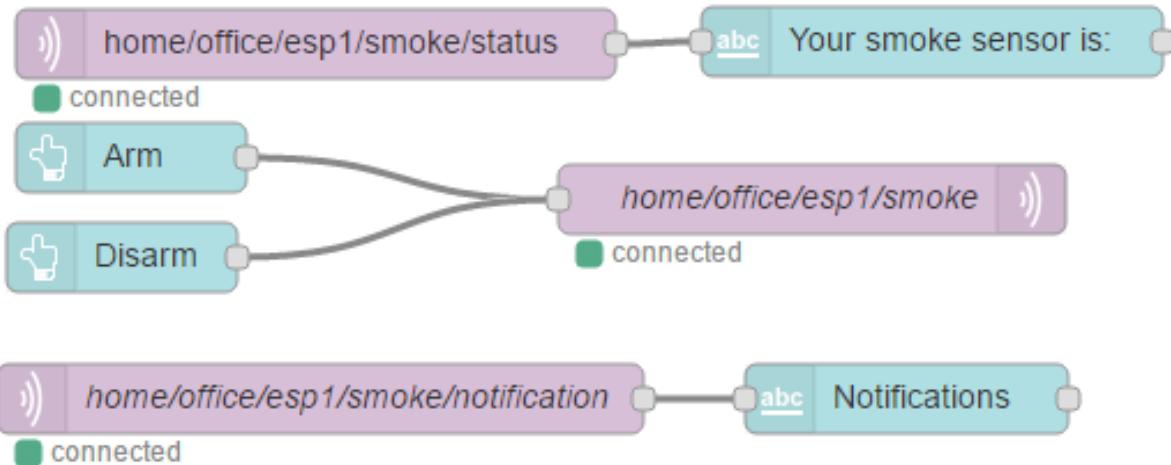
When changed, send:

Payload: Current value

Topic:

Name: Notifications

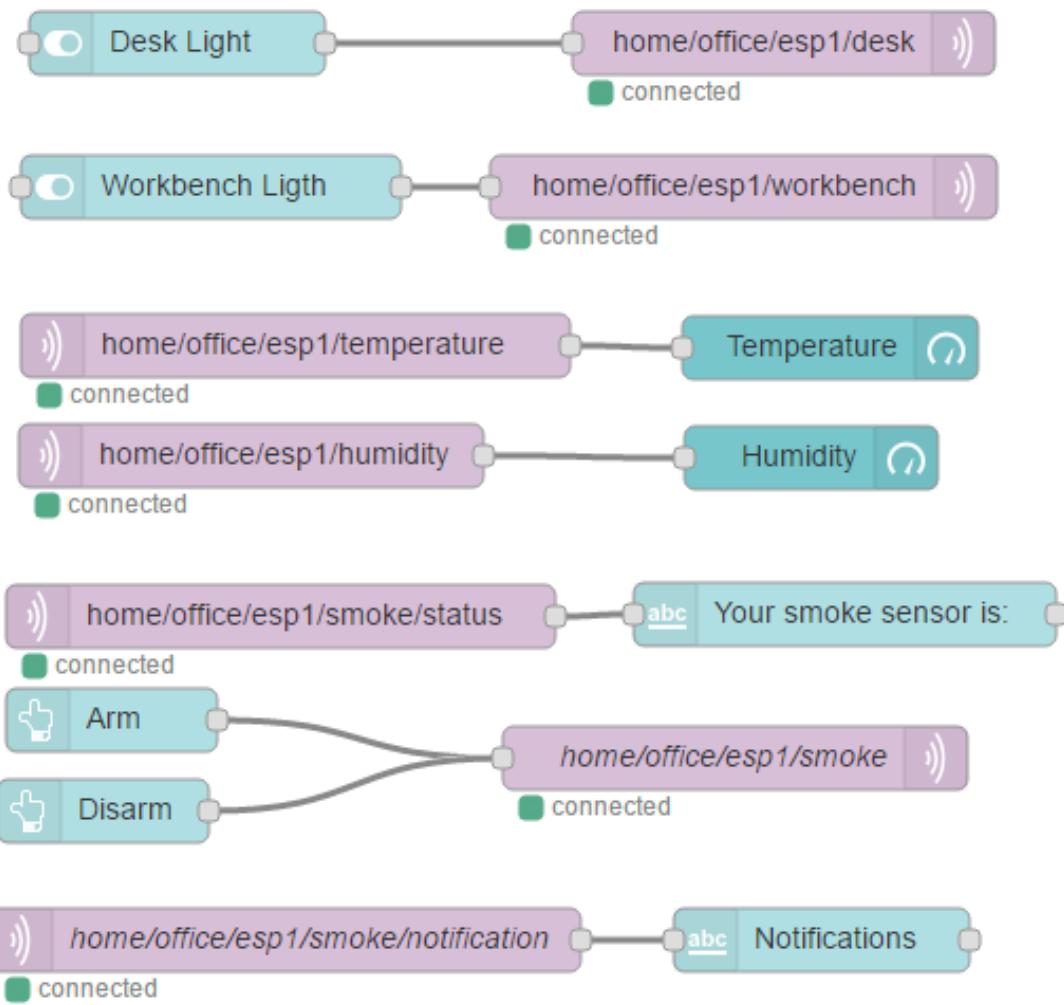
9 – Connecting nodes



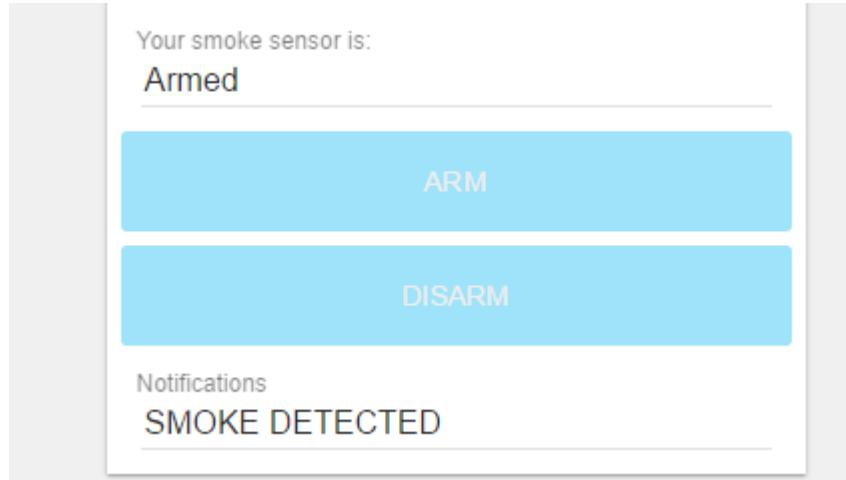
10 – Deploy your application



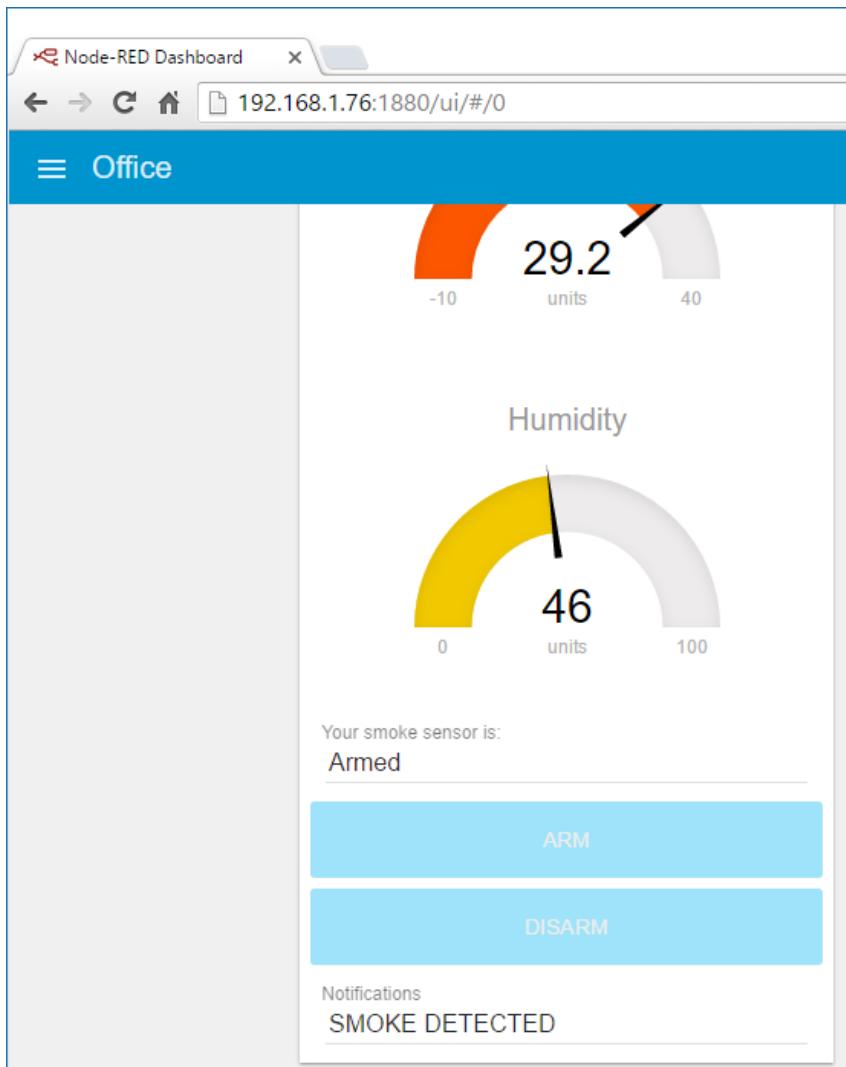
Final Flow



11 – Arm or Disarm smoke sensor and current status

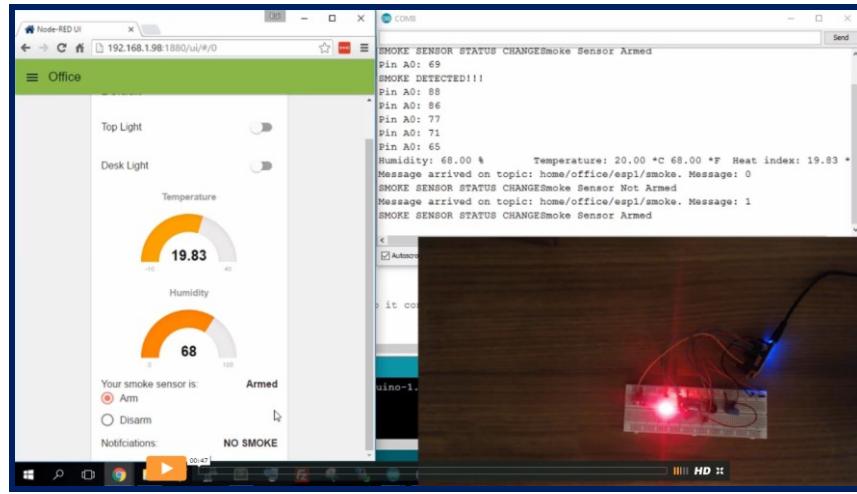


When you go to the Node-RED Dashboard page, here's what you should see:



Watch the Video Demonstration

If there's any flammable gas in your room, your gas sensor will detect it and you'll be notified with a message (you can arm/disarm the sensor). **Watch this video to see it in action:**



Video # 16 - <https://rntlab.com/watch-has-videos>

Unit 3 - Motion Detector with Email Notification

(You should keep the sketch, circuit and nodes from the previous Units and add this new sensor to your project)

This Unit shows you how to detect motion with an ESP8266 and how to send an email notification.

Throughout this Unit you're going to use the PIR Motion sensor. You can learn more about this sensor in my [blog post](#).



Understanding How the Sketch Works

You can open the complete sketch in a new window here to follow along:

- https://github.com/RuiSantosdotme/Home-Automation-Course/blob/master/code/v2/mqtt_esp8266_final.ino

Preparing the variables

Assign the D2 (GPIO 4) to the `motionSensor` variable.

```
const int motionSensor = 4;
```

I've also created a control variable called `armMotion` to arm/disarm the motion sensor. The `motionTriggered` control variable is used to trigger the notification message to the Node-RED Dashboard just once.

```
boolean armMotion = false;  
boolean motionTriggered = false;
```

setup

In the `setup()` function, you need to set the LED as an OUTPUT and the motion sensor is set as an INTERRUPT that is activated in RISING mode.

```
pinMode(motionLED, OUTPUT);  
  
attachInterrupt(digitalPinToInterruption(motionSensor), detectsMovement, RISING);
```

reconnect

The `reconnect()` function publishes two messages when the ESP connects to the broker:

```
client.publish("home/office/esp1/motion/status", "Not Armed");  
client.publish("home/office/esp1/motion/notification", "NO MOTION");
```

You also have to be subscribed to the following topic:

- **home/office/esp1/motion**

So, you can send commands from the Node-RED Dashboard to arm/disarm the motion sensor.

```
client.subscribe("home/office/esp1/motion");
```

detectsMovement

The `detectsMovement()` function sends a message “MOTION DETECTED” to the Node-RED when the sensor is armed and triggered. That message is displayed in the Node-RED Dashboard and you’ll also receive an email notification.

```
void detectsMovement() {  
    if (armMotion && !motionTriggered) {  
        Serial.println("MOTION DETECTED!!!");  
        motionTriggered = true;  
        client.publish("home/office/esp1/motion/notification", "MOTION DETECTED");  
    }  
}
```

callback

Inside the `callback()` function, you receive commands from the Node-RED Dashboard to actually arm/disarm the motion sensor. It also changes the LED to on and off to indicated the current status of the sensor.

```
if(topic=="home/office/esp1/motion"){  
    Serial.print("MOTION SENSOR STATUS CHANGE");  
    if(messageTemp == "1"){  
        Serial.print("Motion Sensor Armed");  
        client.publish("home/office/esp1/motion/status", "Armed");  
        client.publish("home/office/esp1/motion/notification", "NO MOTION");  
        armMotion = true;  
        motionTriggered = false;  
        digitalWrite(motionLED, HIGH);  
    }  
    else if(messageTemp == "0"){  
        Serial.print("Motion Sensor Not Armed");  
        client.publish("home/office/esp1/motion/status", "Not Armed");  
        client.publish("home/office/esp1/motion/notification", "NO MOTION");  
        armMotion=false;  
        motionTriggered = false;  
        digitalWrite(motionLED, LOW);  
    }  
}
```

Uploading the Final Sketch

You can copy the final sketch to your Arduino IDE and upload it to your ESP (after changing the credentials, RPi IP address and binary codes of your remote control).

Note: Make sure you select the ESP board in the Tools tab and the correct COM port.

```
*****  
All the resources for this project:  
https://rntlab.com/  
*****  
  
// Loading the required libraries  
#include <ESP8266WiFi.h>  
#include <PubSubClient.h>  
#include <RCSwitch.h>  
#include "DHT.h"  
  
// Uncomment one of the lines below for whatever DHT sensor type you're  
using!  
#define DHTTYPE DHT11 // DHT 11  
// #define DHTTYPE DHT21 // DHT 21 (AM2301)  
// #define DHTTYPE DHT22 // DHT 22 (AM2302), AM2321  
  
// Change the credentials below, so your ESP8266 connects to your router  
const char* ssid = "YOUR_SSID";  
const char* password = "YOUR_PASSWORD";  
  
// Change the variable to your Raspberry Pi IP address, so it connects to  
your MQTT broker  
const char* mqtt_server = "YOUR_RPi_IP_Address";  
  
// Initializes the espClient. You should change the espClient name if you  
have multiple ESPs running in your home automation system  
WiFiClient espClient;  
PubSubClient client(espClient);  
  
RCSwitch mySwitch = RCSwitch();  
  
// Smoke Sensor  
int smokePin = A0;  
// DHT Sensor  
const int DHTPin = 5;  
  
// Initialize DHT sensor.  
DHT dht(DHTPin, DHTTYPE);  
  
// Smoke Threshold  
int smokeThres = 60;  
  
// Control Variables  
boolean armMotion = false;  
boolean armSmoke = false;  
boolean smokeTriggered = false;  
boolean motionTriggered = false;  
  
// PIR Motion Sensor  
const int motionSensor = 4;  
  
// Status LEDs  
const int smokeLED = 13;  
const int motionLED = 12;
```

```

// Buzzer
const int buzzerPin = 14;

// Timers auxiliar variables
long now = millis();
long lastMeasure = 0;
long lastSmokeCheck = 0;

// Don't change the function below. This functions connects your ESP8266 to
your router
void setup_wifi() {
    delay(10);
    // We start by connecting to a WiFi network
    Serial.println();
    Serial.print("Connecting to ");
    Serial.println(ssid);
    WiFi.begin(ssid, password);
    while (WiFi.status() != WL_CONNECTED) {
        delay(500);
        Serial.print(".");
    }
    Serial.println("");
    Serial.print("WiFi connected - ESP IP address: ");
    Serial.println(WiFi.localIP());
}

// This functions is executed when some device publishes a message to a topic
that your ESP8266 is subscribed to
// Change the function below to add logic to your program, so when a device
publishes a message to a topic that
// your ESP8266 is subscribed you can actually do something
void callback(String topic, byte* message, unsigned int length) {
    Serial.print("Message arrived on topic: ");
    Serial.print(topic);
    Serial.print(". Message: ");
    String messageTemp;

    for (int i = 0; i < length; i++) {
        Serial.print((char)message[i]);
        messageTemp += (char)message[i];
    }
    Serial.println();

    // Feel free to add more if statements to control more GPIOs with MQTT

    // If a message is received on the topic home/office/esp1/desk, you check
    if the message is either 1 or 0. Turns the Desk outlet according to the
    message
    if(topic=="home/office/esp1/desk"){
        Serial.print("Changing Desk light to ");
        if(messageTemp == "1"){
            mySwitch.send("000101010101000101010101");
            Serial.print("On");
        }
        else if(messageTemp == "0"){
            mySwitch.send("000101010101000101010100");
            Serial.print("Off");
        }
    }
    if(topic=="home/office/esp1/workbench"){
        Serial.print("Changing Workbench light to ");
    }
}

```

```

if(messageTemp == "1"){
    mySwitch.send("000101010101010001010101");
    Serial.print("On");
}
else if(messageTemp == "0"){
    mySwitch.send("000101010101010001010100");
    Serial.print("Off");
}
}
if(topic=="home/office/esp1/smoke"){
    Serial.print("SMOKE SENSOR STATUS CHANGE");
    if(messageTemp == "1"){
        Serial.print("Smoke Sensor Armed");
        client.publish("home/office/esp1/smoke/status", "Armed");
        client.publish("home/office/esp1/smoke/notification", "NO SMOKE");
        armSmoke = true;
        smokeTriggered = false;
        digitalWrite(smokeLED, HIGH);
    }
    else if(messageTemp == "0"){
        Serial.print("Smoke Sensor Not Armed");
        client.publish("home/office/esp1/smoke/status", "Not Armed");
        client.publish("home/office/esp1/smoke/notification", "NO SMOKE");
        armSmoke = false;
        smokeTriggered = false;
        digitalWrite(smokeLED, LOW);
    }
}
if(topic=="home/office/esp1/motion"){
    Serial.print("MOTION SENSOR STATUS CHANGE");
    if(messageTemp == "1"){
        Serial.print("Motion Sensor Armed");
        client.publish("home/office/esp1/motion/status", "Armed");
        client.publish("home/office/esp1/motion/notification", "NO MOTION");
        armMotion = true;
        motionTriggered = false;
        digitalWrite(motionLED, HIGH);
    }
    else if(messageTemp == "0"){
        Serial.print("Motion Sensor Not Armed");
        client.publish("home/office/esp1/motion/status", "Not Armed");
        client.publish("home/office/esp1/motion/notification", "NO MOTION");
        armMotion=false;
        motionTriggered = false;
        digitalWrite(motionLED, LOW);
    }
}
Serial.println();
}

// This function reconnects your ESP8266 to your MQTT broker
// Change the function below if you want to subscribe to more topics with
your ESP8266
void reconnect() {
    // Loop until we're reconnected
    while (!client.connected()) {
        Serial.print("Attempting MQTT connection...");
        // Attempt to connect
        /*
        YOU MIGHT NEED TO CHANGE THIS LINE, IF YOU'RE HAVING PROBLEMS WITH MQTT
MULTIPLE CONNECTIONS

```

```

To change the ESP device ID, you will have to give a new name to the
ESP8266.

Here's how it looks:
if (client.connect("ESP8266Client")) {
You can do it like this:
if (client.connect("ESP1_Office")) {
Then, for the other ESP:
if (client.connect("ESP2_Garage")) {
That should solve your MQTT multiple connections problem
*/
if (client.connect ("ESP8266Client")) {
Serial.println("connected");
// Once connected, publish an announcement...
client.publish("home/office/esp1/smoke/status", "Not Armed");
client.publish("home/office/esp1/motion/status", "Not Armed");
client.publish("home/office/esp1/smoke/notification", "NO SMOKE");
client.publish("home/office/esp1/motion/notification", "NO MOTION");
// Subscribe or resubscribe to a topic
// You can subscribe to more topics (to control more LEDs in this
example)
client.subscribe("home/office/esp1/desk");
client.subscribe("home/office/esp1/workbench");
client.subscribe("home/office/esp1/smoke");
client.subscribe("home/office/esp1/motion");

} else {
Serial.print("failed, rc=");
Serial.print(client.state());
Serial.println(" try again in 5 seconds");
// Wait 5 seconds before retrying
delay(5000);
}
}

// Checks motion
void detectsMovement() {
if (armMotion && !motionTriggered) {
Serial.println("MOTION DETECTED!!!");
motionTriggered = true;
client.publish("home/office/esp1/motion/notification", "MOTION
DETECTED");
}
}

// The setup function sets your ESP GPIOs to Outputs, starts the serial
communication at a baud rate of 115200
// Sets your mqtt broker and sets the callback function
// The callback function is what receives messages and actually controls the
LEDs
void setup() {
pinMode(smokeLED, OUTPUT);
pinMode(motionLED, OUTPUT);
pinMode(buzzerPin, OUTPUT);

pinMode(smokePin, INPUT);
attachInterrupt(digitalPinToInterruption(motionSensor), detectsMovement,
RISING);
dht.begin();

Serial.begin(115200);
}

```

```

setup_wifi();
client.setServer(mqtt_server, 1883);
client.setCallback(callback);

mySwitch.enableTransmit(16);

// SET YOUR PULSE LENGTH
mySwitch.setPulseLength(REPLACE_WITH_YOUR_PULSE_LENGTH);

// SET YOUR PROTOCOL (default is 1, will work for most outlets)
mySwitch.setProtocol(REPLACE_WITH_YOUR_PROTOCOL);

// Set number of transmission repetitions.
mySwitch.setRepeatTransmit(15);
}

// For this project, you don't need to change anything in the loop function.
// Basically it ensures that your ESP is connected to your broker
void loop() {

    if (!client.connected()) {
        reconnect();
    }
    if (!client.loop())
        client.connect("ESP8266Client");

    now = millis();
    // Publishes new temperature and humidity every 30 seconds
    if (now - lastMeasure > 30000) {
        lastMeasure = now;
        // Sensor readings may also be up to 2 seconds 'old' (its a very slow
        sensor)
        float h = dht.readHumidity();
        // Read temperature as Celsius (the default)
        float t = dht.readTemperature();
        // Read temperature as Fahrenheit (isFahrenheit = true)
        float f = dht.readTemperature(true);

        // Check if any reads failed and exit early (to try again).
        if (isnan(h) || isnan(t) || isnan(f)) {
            Serial.println("Failed to read from DHT sensor!");
            return;
        }

        // Computes temperature values in Celsius
        float hic = dht.computeHeatIndex(t, h, false);
        static char temperatureTemp[6];
        dtostrf(hic, 6, 2, temperatureTemp);

        // Uncomment to compute temperature values in Fahrenheit
        // float hif = dht.computeHeatIndex(f, h);
        // static char temperatureTemp[6];
        // dtostrf(hic, 6, 2, temperatureTemp);

        static char humidityTemp[6];
        dtostrf(h, 6, 2, humidityTemp);

        // Publishes Temperature and Humidity values
        client.publish("home/office/espl/temperature", temperatureTemp);
        client.publish("home/office/espl/humidity", humidityTemp);
    }
}

```

```

Serial.print("Humidity: ");
Serial.print(h);
Serial.print(" %\t Temperature: ");
Serial.print(t);
Serial.print(" *C ");
Serial.print(f);
Serial.print(" *F\t Heat index: ");
Serial.print(hic);
Serial.println(" *C ");
// Serial.print(hif);
// Serial.println(" *F");
}
// Checks smoke
if (now - lastSmokeCheck > 200) {
    lastSmokeCheck = now;
    int smokeValue = analogRead(smokePin);
    if (smokeValue > smokeThres && armSmoke) {
        Serial.print("Pin A0: ");
        Serial.println(smokeValue);
        tone(buzzerPin, 1000, 200);
        if (!smokeTriggered) {
            Serial.println("SMOKE DETECTED!!!!");
            smokeTriggered = true;
            client.publish("home/office/esp1/smoke/notification", "SMOKE
DETECTED");
        }
    }
}
}

```

DOWNLOAD SOURCE CODE

https://github.com/RuiSantosdotme/Home-Automation-Course/blob/master/code/v2/mqtt_esp8266_final.ino

Schematics

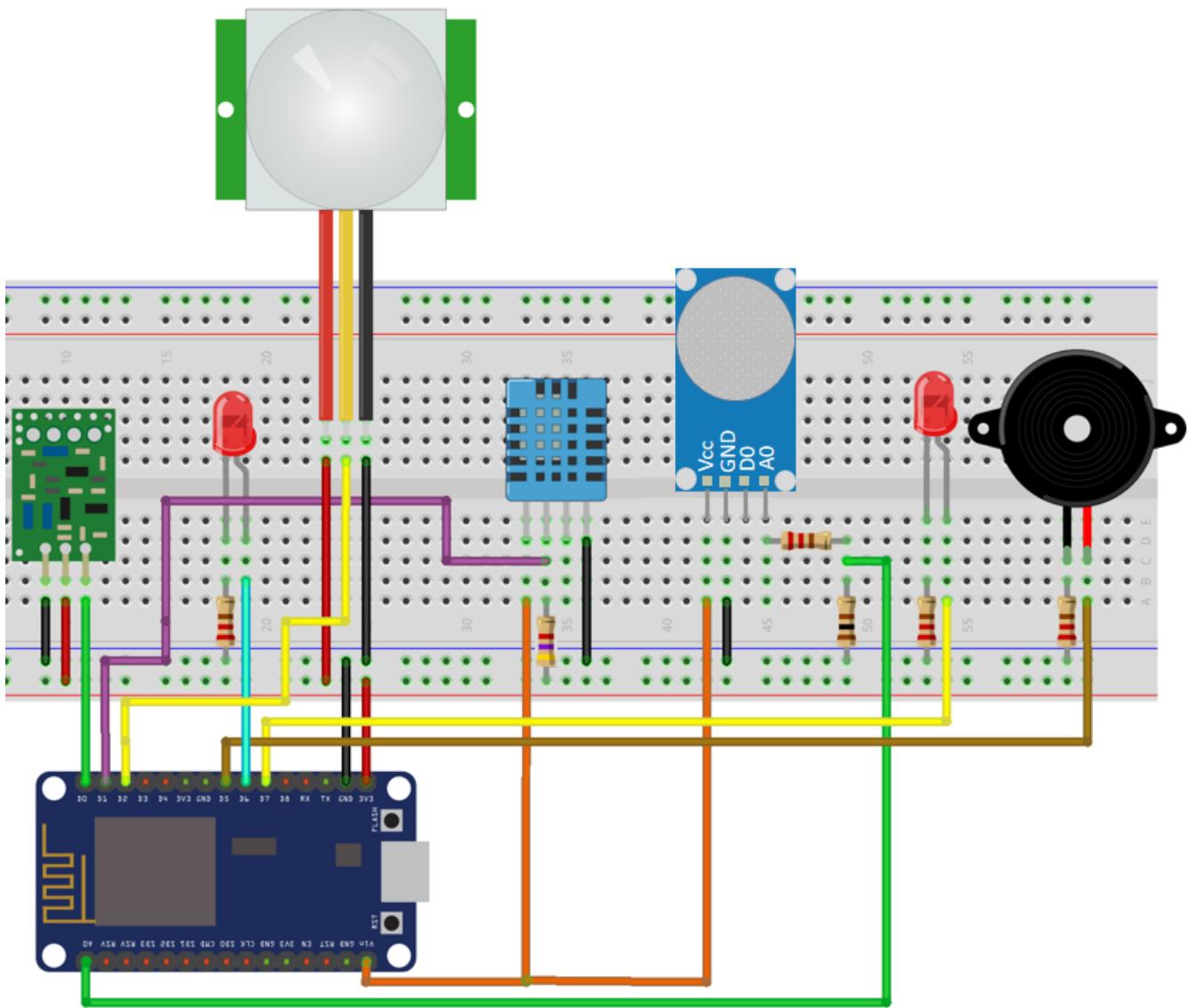
To complete this Unit you need:

- [ESP8266-12E](#)
- [433MHz RF Transmitter](#)
- [Remote Controlled Outlets that operate at 433MHz](#)
- [DHT11 Sensor](#)
- [4700 Ohm Resistor](#)
- [MQ-2 Gas Sensor](#)
- [Buzzer](#)
- [LED \(5mm\)](#)
- [3x 220 Ohm Resistors](#)

- [100 Ohm Resistor](#)
- [PIR Motion Sensor](#)
- [LED \(5mm\)](#)
- [220 Ohm Resistor](#)

Important: The PIR motion sensor by default operates at 5V, you can modify the sensor to operate at 3.3V. [Click here to learn](#) how to change the voltage from 5V to 3.3V, otherwise you need to use the `Vin` pin from your ESP8266 that outputs 5V.

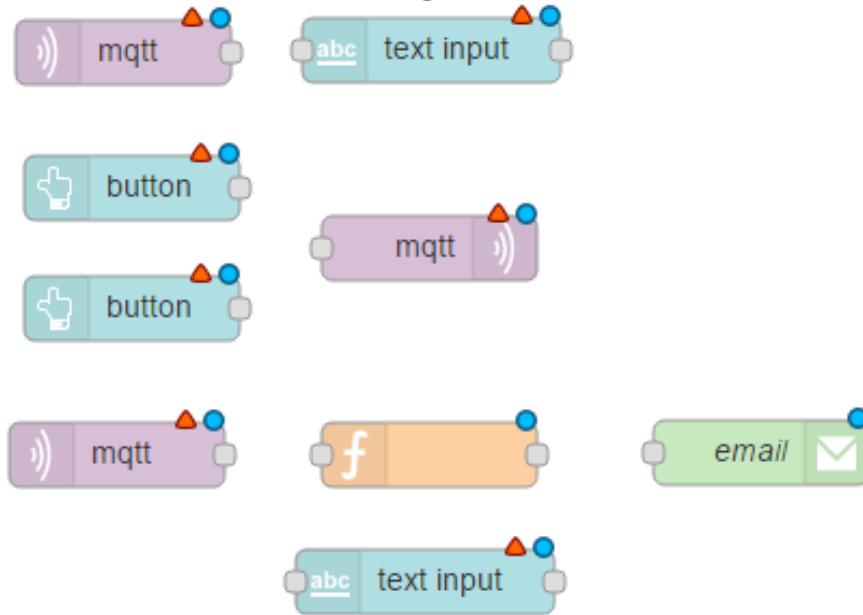
Here's the schematics powering the PIR motion sensor at 3.3V:



Creating the Flow

This flow has 9 nodes. Here's the 13 steps that you need to follow:

1 – Drag 9 nodes



2 – MQTT in subscribed to status

Edit mqtt in node

		<input type="button" value="Cancel"/>	<input type="button" value="Done"/>
<input checked="" type="radio"/> Server	localhost:1883	<input type="button" value=""/>	
<input type="checkbox"/> Topic	home/office/esp1/motion/status		
<input checked="" type="radio"/> QoS	2		
<input checked="" type="radio"/> Name	home/office/esp1/motion/status		

3 – Displays sensor status (arm or not armed)

Edit text input node

Cancel Done

Group Group 1 [Office] ▾

Size auto

Label Your motion sensor is:

Mode text input ▾ Delay (ms) 300

When changed, send:

Payload Current value

Topic

Name Your motion sensor is:

4 – Button to arm smoke sensor

Edit button node

Cancel Done

Group Group 1 [Office] ▾

Size auto

Icon optional icon

Label Arm

Color optional text/icon color

When clicked, send:

Payload ▾ a_z 1

Topic

Name Arm

5 – Button to disarm smoke sensor

Edit button node

Cancel Done

Group: Group 1 [Office]

Size: auto

Icon: optional icon

Label: Disarm

Color: optional text/icon color

When clicked, send:

Payload:

Topic:

Name: Disarm

6 – MQTT out sends arm or disarm command to ESP8266

Edit mqtt out node

Cancel Done

Server: localhost:1883

Topic: home/office/esp1/motion

QoS: Retain

Name: home/office/esp1/motion

7 – MQTT in subscribed to notification

Edit mqtt in node

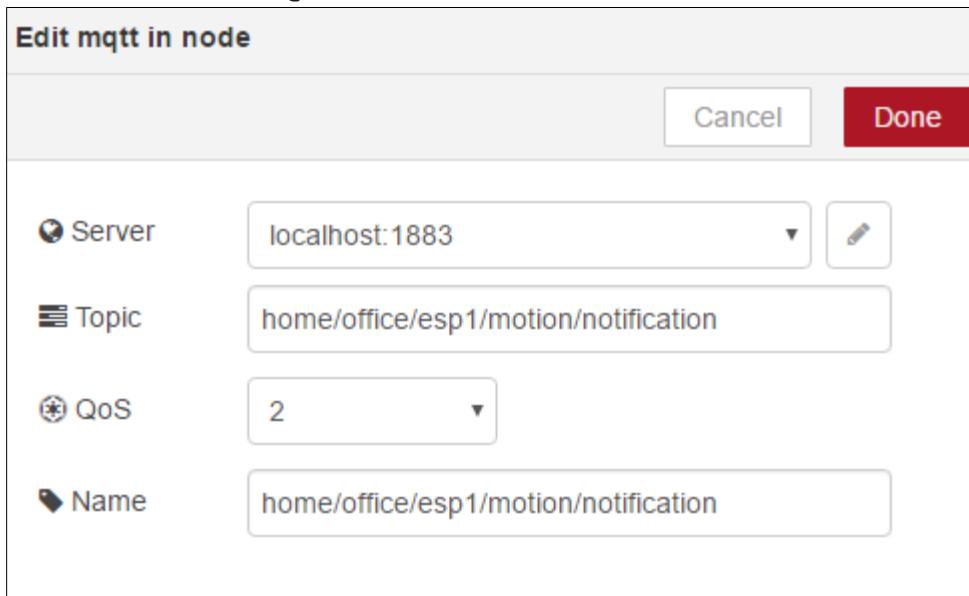
Cancel Done

Server: localhost:1883

Topic: home/office/esp1/motion/notification

QoS: 2

Name: home/office/esp1/motion/notification



8 – Function node to create the Email title and Message

Edit function node

Name:

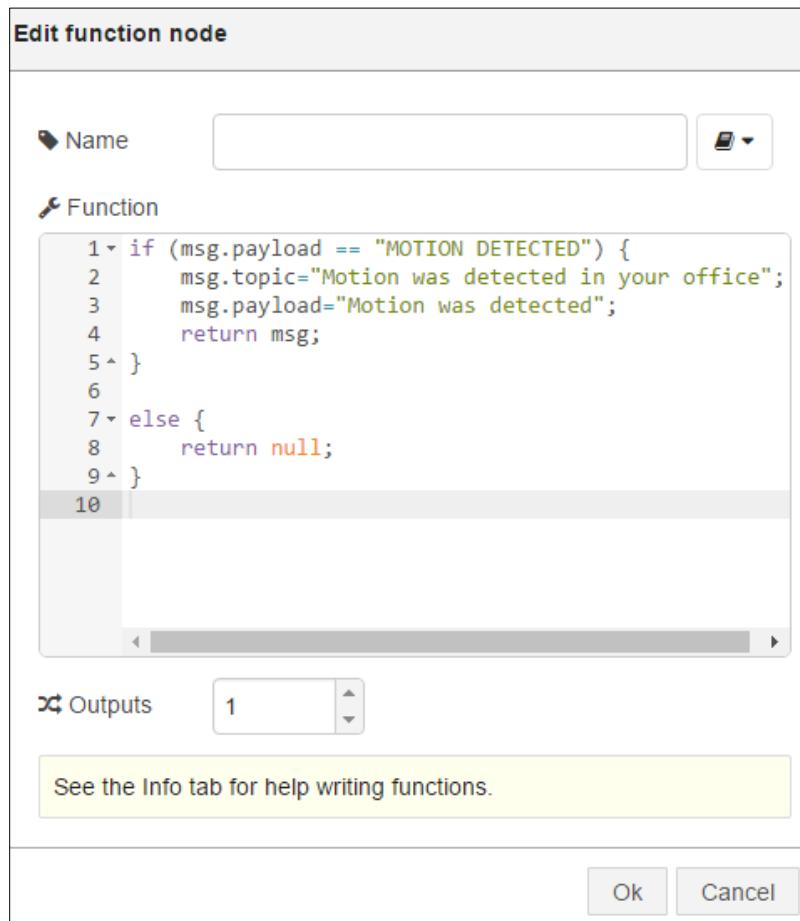
Function:

```
1 if (msg.payload == "MOTION DETECTED") {  
2     msg.topic="Motion was detected in your office";  
3     msg.payload="Motion was detected";  
4     return msg;  
5 }  
6  
7 else {  
8     return null;  
9 }  
10
```

Outputs: 1

See the Info tab for help writing functions.

Ok Cancel



9 – Email notification settings

Edit e-mail node

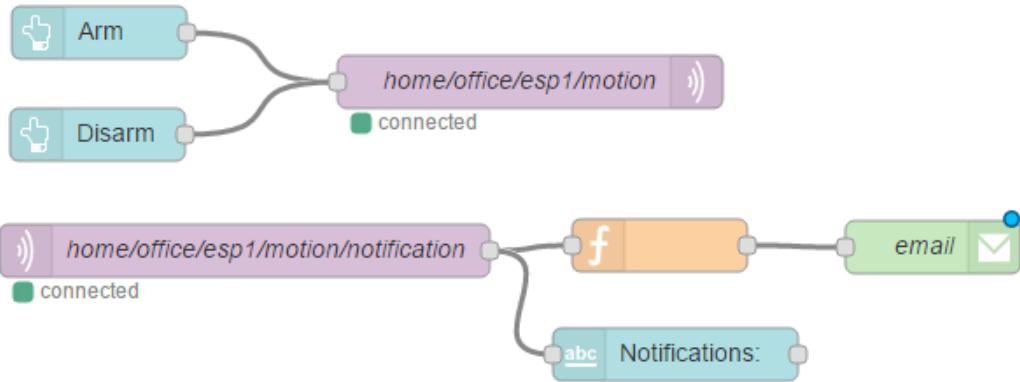
To	hello@ruisantos.me	
Server	smtp.gmail.com	
Port	465	
Userid	randomnerdtutorials	
Password	
Name	Email Notification	

10 – Displays notifications from ESP8266

Edit text input node

	Group	Group 1 [Office]	
	Size	auto	
	Label	Notifications:	
	Mode	text input	Delay (ms) 300
	When changed, send:		
	Payload	Current value	
	Topic	<input type="text"/>	
	Name	Notifications:	

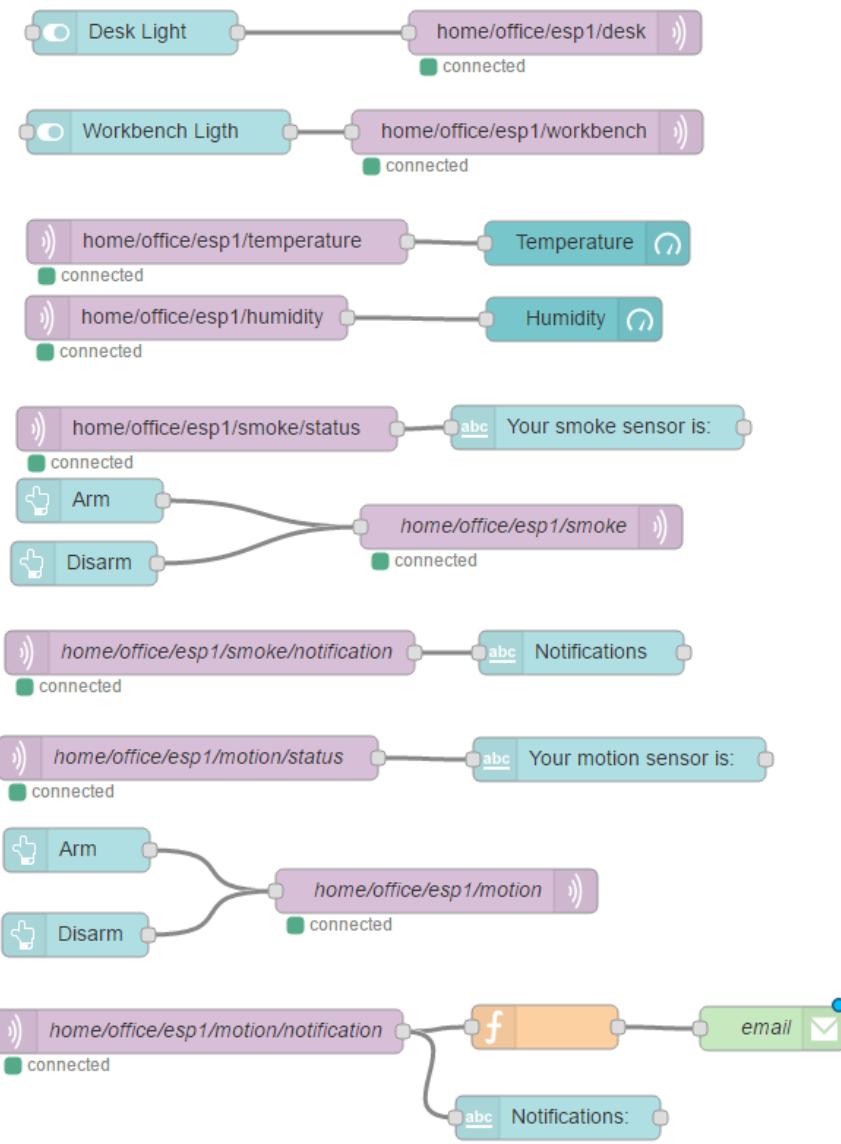
11 – Connecting nodes



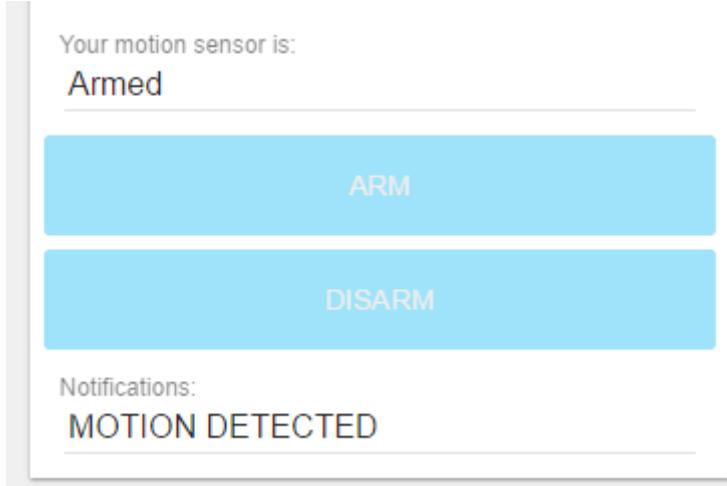
12 – Deploy your application



Final Flow



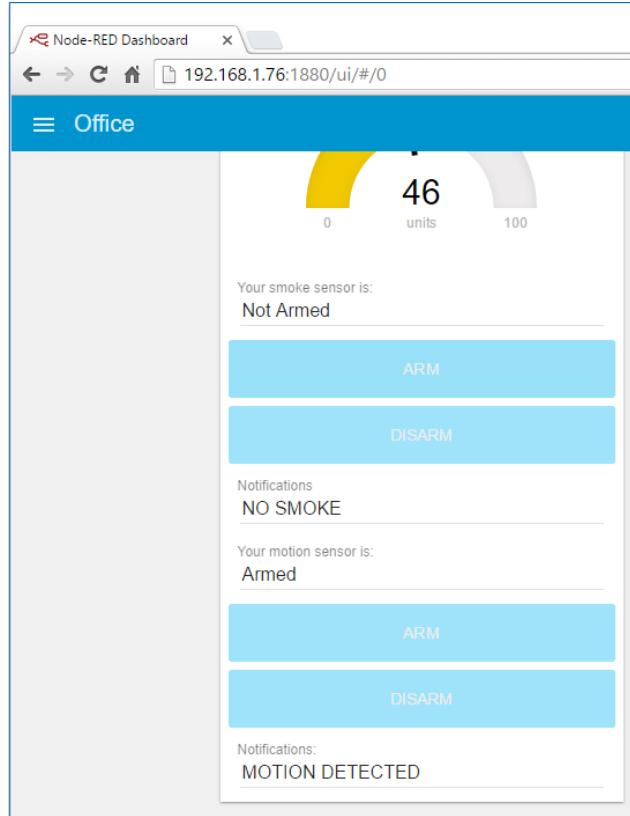
13 – Arm or Disarm smoke sensor and current status



Important: If you use Gmail to send emails, you need to activate the "Allowing Less Secure Apps" feature in your account by [following this tutorial](#).

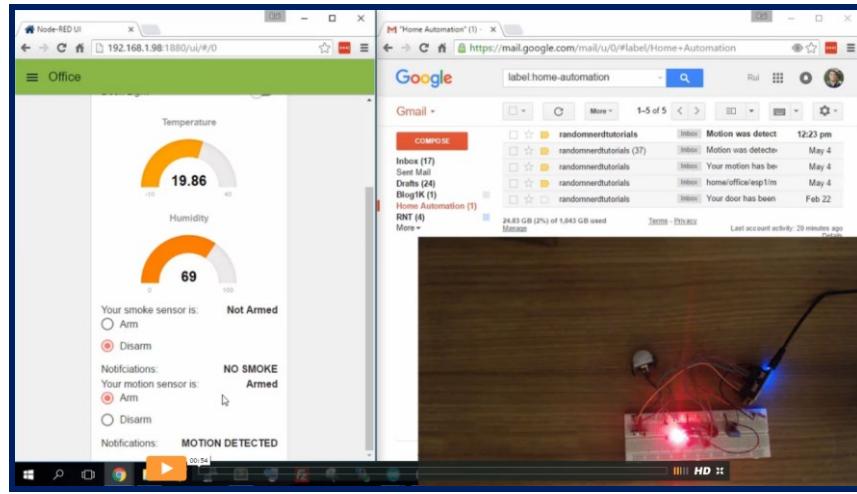
Note: If you use another email client, you can search for "your email client name" + SMTP and you should find the settings to configure the Node-RED **Email** node.

When you go to the Node-RED Dashboard page, here's what you should see:



Watch the Video Demonstration

Now, you can detect motion with your ESP8266. If your ESP detects any motion in your room, you'll receive an email notification (you can arm/disarm the sensor). **Watch this video to see it in action:**



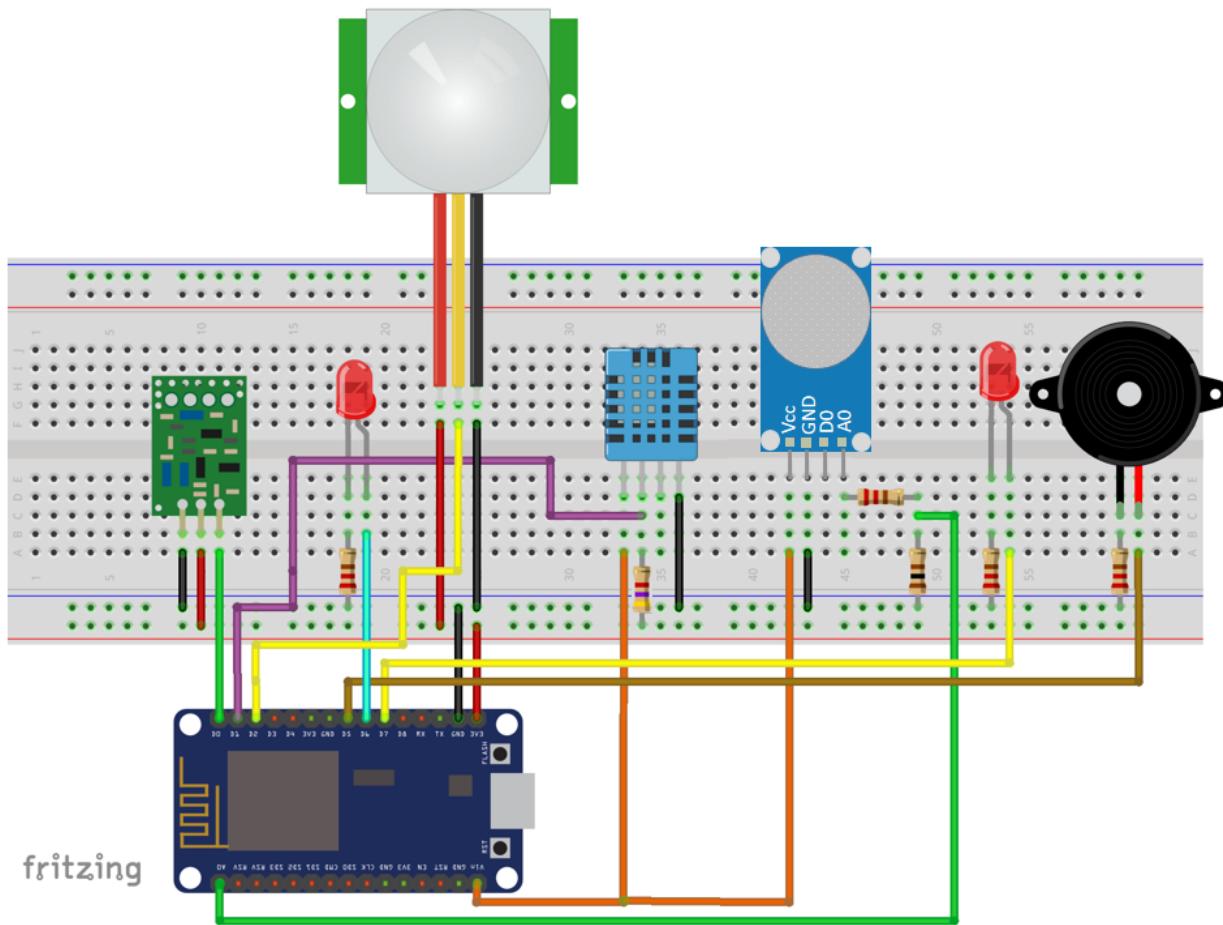
Video # 17 - <https://rntlab.com/watch-has-videos>

Unit 4 - Storing Your Circuit in a Project Box Enclosure



Video # 18 - <https://rntlab.com/watch-has-videos>

After completing the previous Units, you should have this circuit on a breadboard.



The ESP can:

1. Control outlets
2. Read the temperature and humidity
3. Detect smoke and motion

Circuits on a breadboard are temporary and if you're not careful with your circuit, a wire disconnects very easily, and your project stops working.

In my opinion, I think you should take it a step further and make this circuit permanent on a stripboard.

Parts Required

You simply need to gather a couple of components. Here's the complete list:

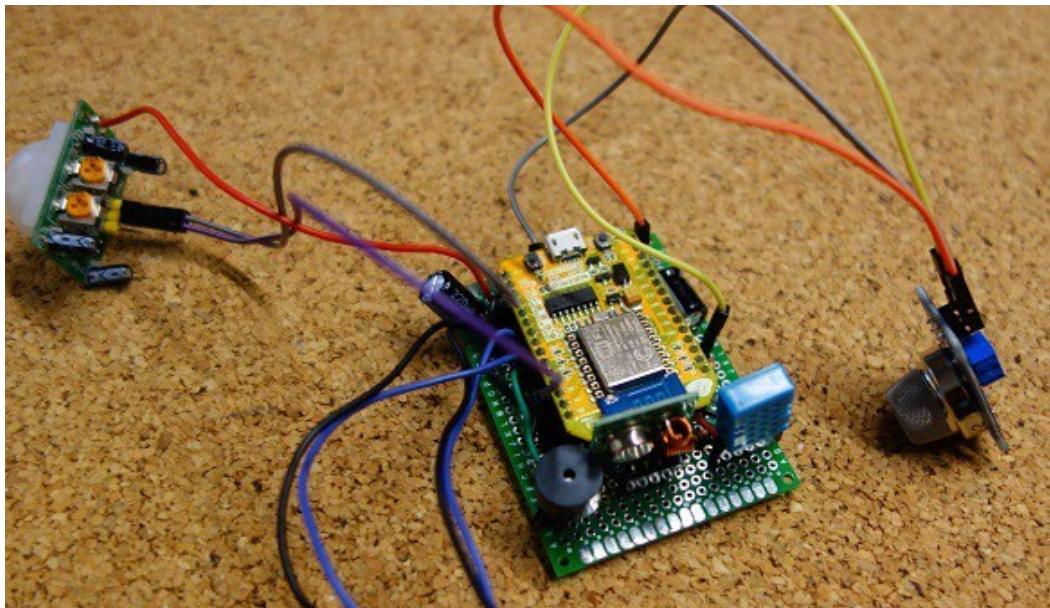
- [ESP8266-12E](#)
- [433MHz RF Transmitter](#)
- [Remote Controlled Outlets \(433MHz\)](#)
- [DHT11 Sensor](#)
- [4700 Ohm Resistor](#)
- [MQ-2 Gas Sensor](#)
- [Buzzer](#)
- [2x LEDs \(5mm\)](#) with 2x LED Holders
- [4x 220 Ohm Resistors](#)
- [100 Ohm Resistor](#)
- [PIR Motion Sensor](#)
- [Stripboard \(Prototyping Circuit Board\)](#)
- [Project Box Enclosure](#)
- [2x 220 Microfarad Electrolytic Capacitors](#)

Then, you solder each component in a stripboard according to the breadboard diagram shown earlier.

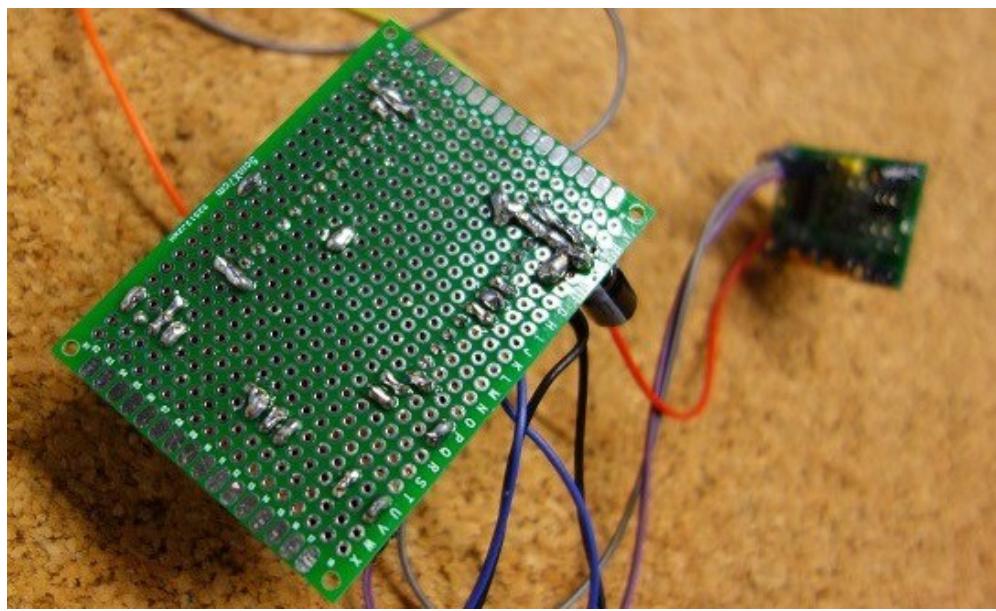
Note: The soldering skill is outside the course scope, so I will not show you how to solder.

Your Custom Circuit

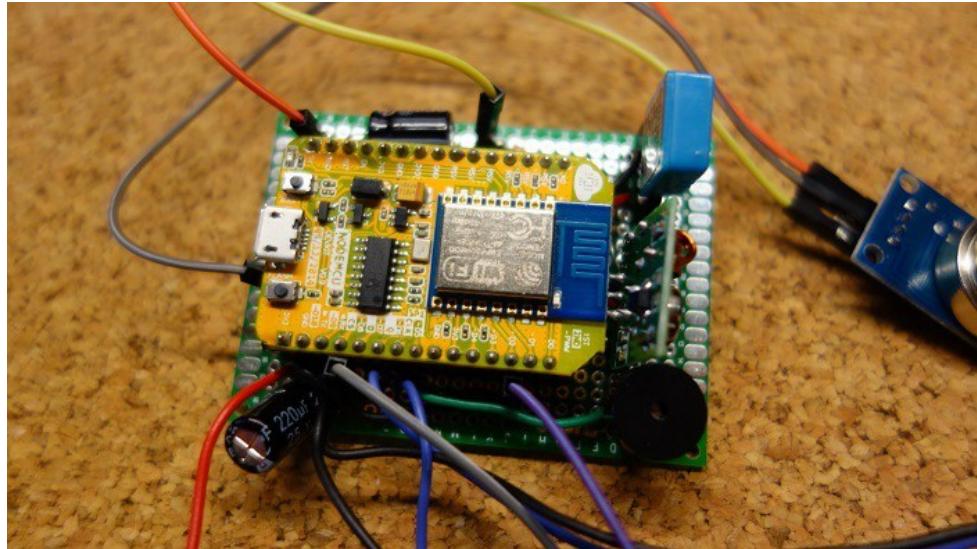
After soldering, you should have a very similar circuit.



Circuit viewed from the bottom:



Note: I've added two electrolytic capacitors in the 3.3V-GND rails and the other in the 5V-GND rails.



This prevents your ESP from having power issues when connected to a USB port (by the way, these are 220 Microfarad capacitors).

Project Box Enclosure

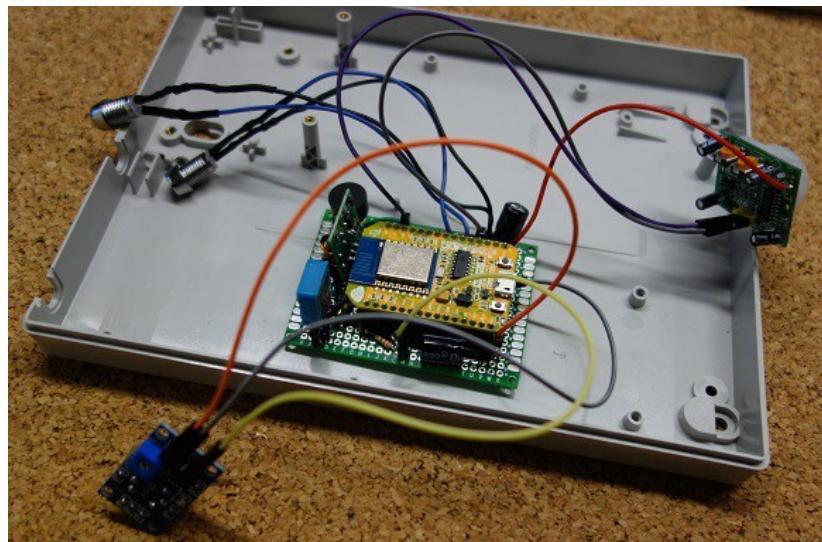
Finally, I've bought a project box enclosure to store my final circuit.



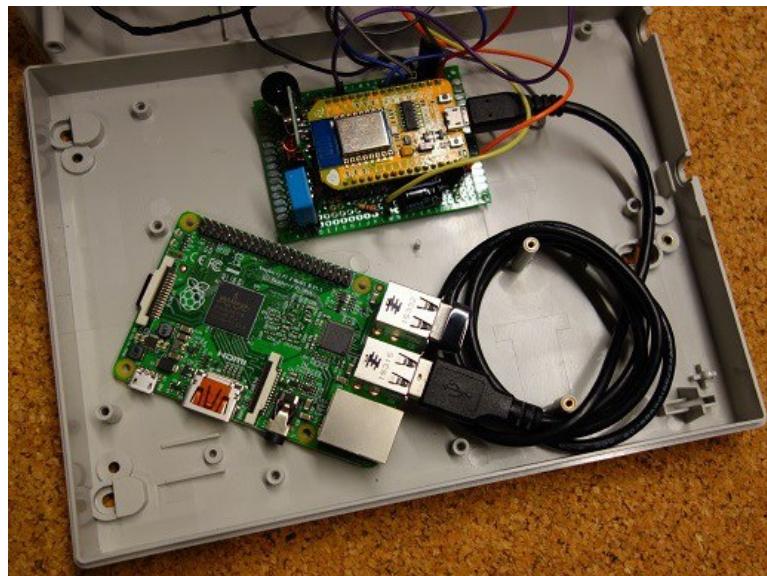
I've drilled 4 holes. Two for the LEDs, one for the motion sensor and the other for the smoke sensor.



My project enclosure is quite big, but you can get a smaller one. I bought this enclosure, because I also plan store my Raspberry Pi in that same enclosure.



The ESP is going to be powered through the Raspberry Pi USB port, however you can also use a 5V power adapter and plug your ESP directly to an outlet.



You might need to drill some extra holes in the enclosure to have some airflow.

You can assemble everything inside the project box, install the screws and it's done.



In the next Unit, you're going to see the final demonstration to quickly recap all the features and see the project in action.



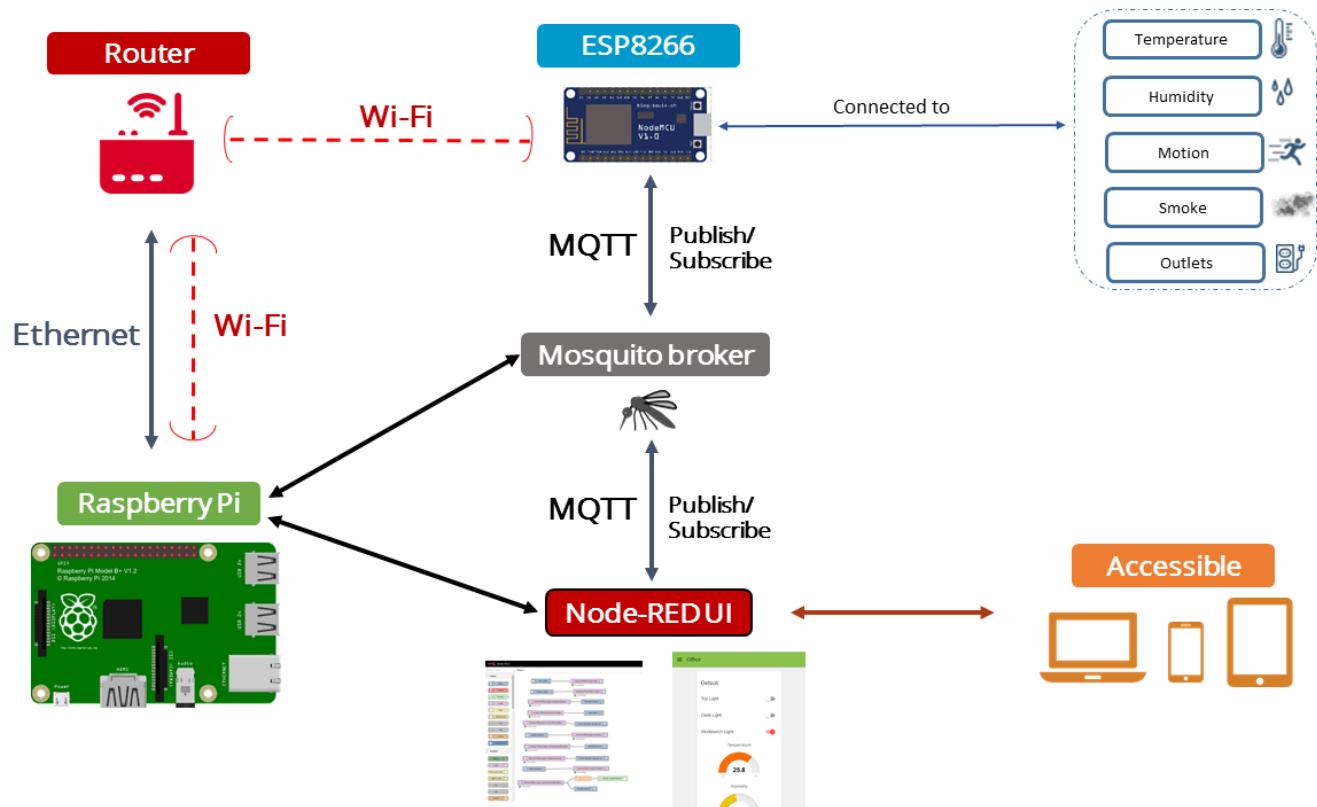
Unit 5 - ESP8266 Final Demonstration

So, let's quickly recap what we have accomplished so far. Inside the project box, we have a Raspberry Pi hosting the Mosquitto Broker and the Node-RED software.

We also have an ESP8266 being powered through the Raspberry Pi USB port.

Diagram

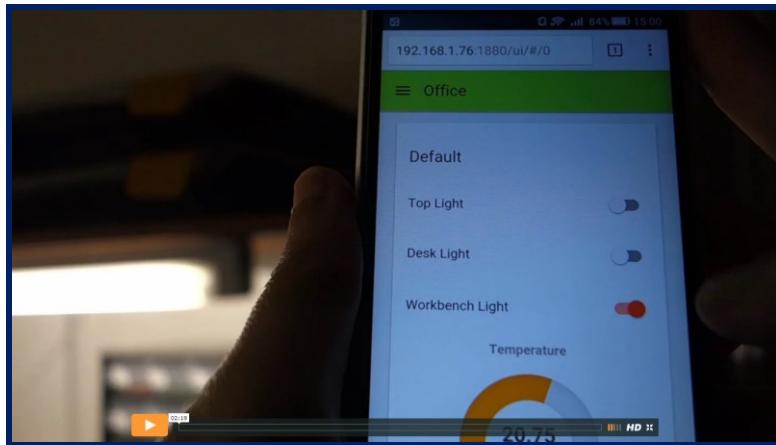
Here's a diagram that illustrates how everything is connected:



The ESP can:

1. Control outlets
2. Read the temperature and humidity
3. Check the room for smoke
4. Detect motion and send email notifications

Watch the ESP8266 Final Video Demonstration

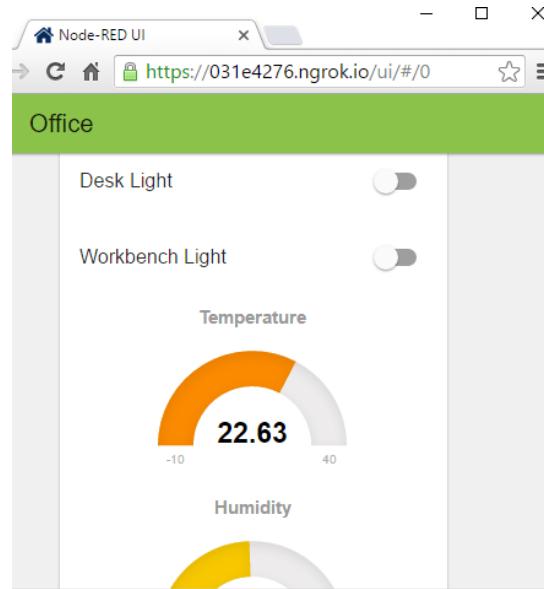


Video # 19 - <https://rntlab.com/watch-has-videos>

This project can be extended to other rooms in your home and that's what I encourage you to do next.

MODULE 9

Accessing Node-RED Dashboard From Anywhere in the World



Unit 1 - Accessing Node-RED Dashboard

From Anywhere (it's encrypted and password protected)

In this Unit you're going to make your Node-RED Dashboard accessible from anywhere in the world.

At this moment, the Node-RED Dashboard is only accessible when you are connected to your network. Luckily, in just a few minutes you'll be able to control and monitor your home from anywhere.

Introducing ngrok

You are going to use a free service called **ngrok** to create an encrypted password protected tunnel to your Raspberry Pi.

Go to <https://ngrok.com> to create your account. Click the green “**Sign up**” button:



Secure tunnels to localhost

"I want to expose a local server behind a NAT or firewall to the internet."

[Download](#)

[Sign up](#)

Enter your details in the fields.

Sign up

Your Name

Your Email

Confirm Email

Password

Sign up

After creating your account, login and go to the “**Auth**” tab to find **Your Tunnel Authtoken**.

Copy your unique Your Tunnel Authtoken to a safe place (you’ll need them later in this Unit).

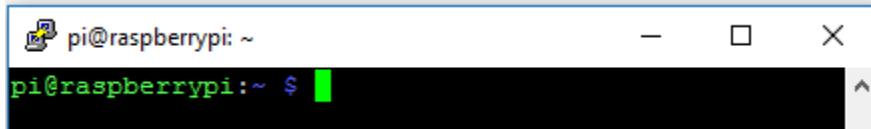
The screenshot shows the ngrok dashboard with a navigation bar at the top. The "Auth" tab is highlighted with a red box and a red arrow pointing to it from the text above. Below the navigation bar, there's a section titled "Your Tunnel Authtoken" with a text input field containing the token "3V1MfHcNMD9rhBizf8TRs_2whamY91tqX4". A "Copy" button is next to the input field. A red arrow points from the text "You only need to do this one time." down to the input field. At the bottom, there's a code snippet in a terminal window: `./ngrok authtoken 3V1MfHcNMD9rhBizf8TRs_2whamY91tqX4`.

My Tunnel Authtoken is:

```
3V1MfHcNMD9rhBifzf8TRs_2whamY91tqX4
```

Installing ngrok in the RPi

Having an SSH communication established with your Raspberry Pi:



Send the following command to download the latest version of ngrok software:

```
pi@raspberry:~ $ wget http://randomnerdtutorials.com/ngrokARM
```

Unzip the ngrok software using:

```
pi@raspberry:~ $ unzip ngrokARM
```

Running ngrok

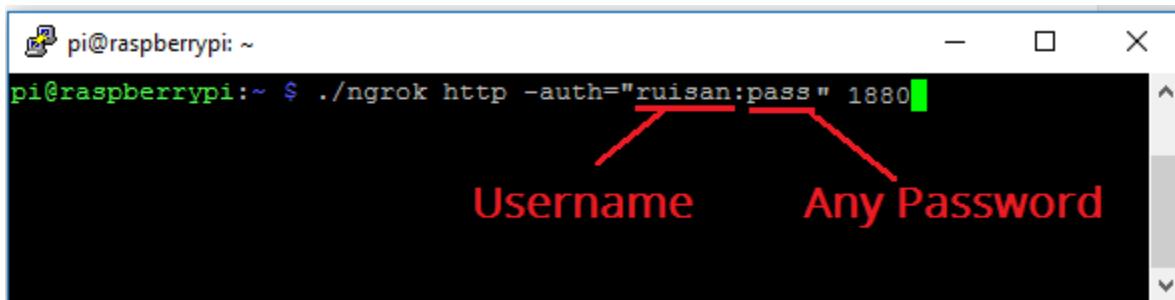
Enter the following command to authenticate your ngrok account (replace the red highlighted text with your own Tunnel Authtoken):

```
pi@raspberry:~ $ ./ngrok authtoken  
3V1MfHcNMD9rhBifzf8TRs_2whamY91tqX4
```

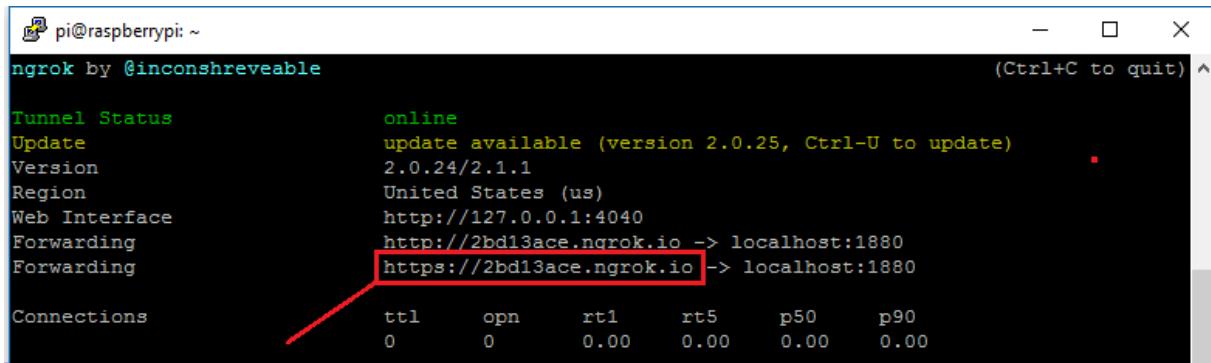
In your terminal window, enter the following command and replace the red text with your desired credentials:

```
pi@raspberry:~ $ ./ngrok http -auth="ruisan:pass" 1880
```

When you try to access the UI, you'll be asked to enter a username (**ruisan**) and a password (**pass**).



When you run the previous command, a new window that looks like this appears:



```
pi@raspberrypi: ~
ngrok by @inconshreveable
Tunnel Status          online
Update                update available (version 2.0.25, Ctrl-U to update)
Version               2.0.24/2.1.1
Region                United States (us)
Web Interface         http://127.0.0.1:4040
Forwarding            http://2bd13ace.ngrok.io -> localhost:1880
Forwarding            https://2bd13ace.ngrok.io -> localhost:1880
Connections           ttl     opn      rt1     rt5      p50      p90
                      0       0       0.00    0.00    0.00    0.00
```

Copy your unique link (it is highlighted in the preceding figure):

https://2bd13ace.ngrok.io

Important: do not use the **http** link, because that link is not encrypted:

http://2bd13ace.ngrok.io

Important: you should always use the **https** link:

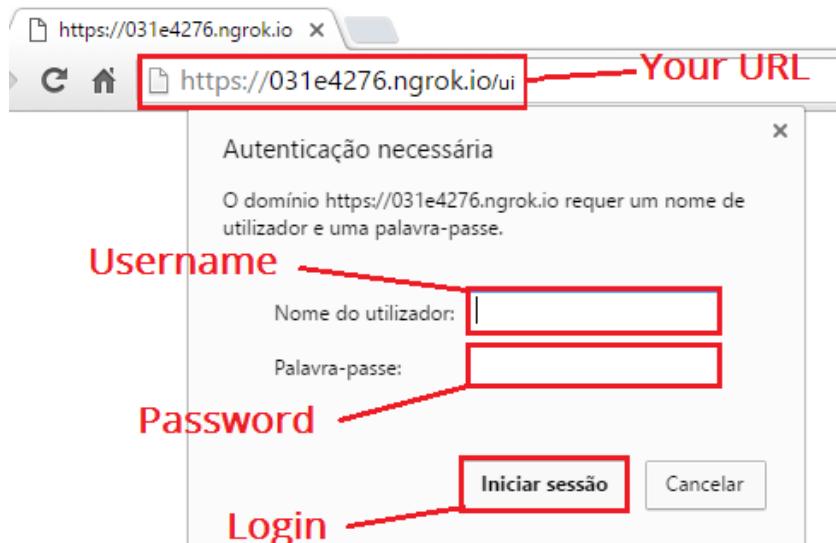
https://2bd13ace.ngrok.io

Accessing Your UI from Anywhere

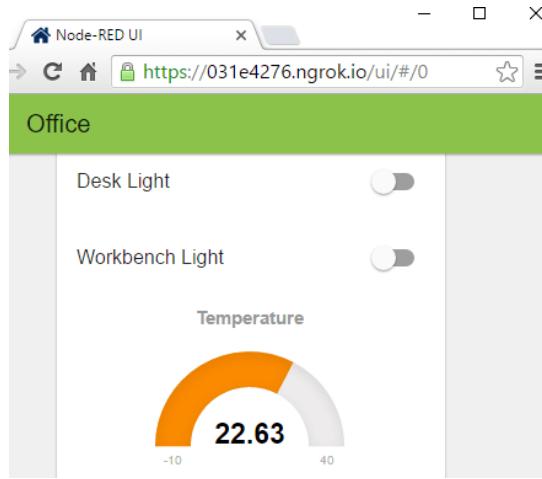
If everything runs smoothly, you can open the Node-RED Dashboard from any web browser in the world. By entering the following URL in any browser:

https://2bd13ace.ngrok.io/ui

You'll be asked to enter a username (**ruisan**) and password (**pass**):

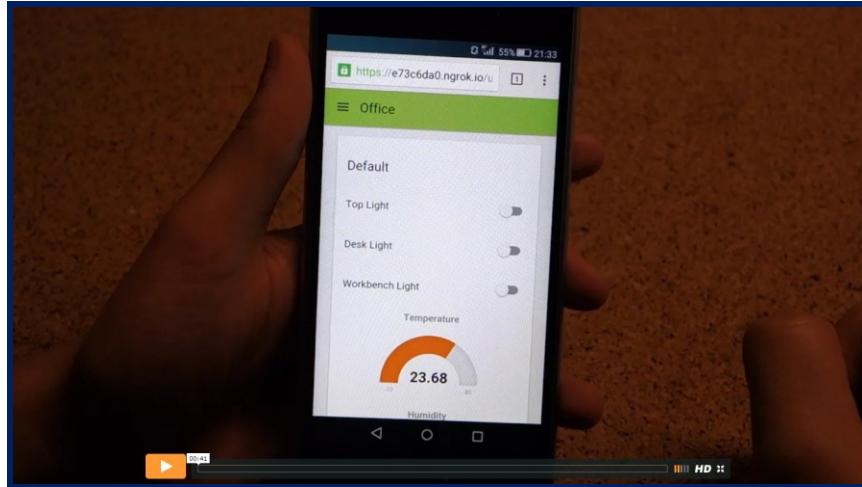


After entering the correct credentials for your tunnel, your Node-RED Dashboard loads. Now, you have full control over your home!



Important: You can close the SSH window, but you can't quit the ngrok software, otherwise your tunnel stops.

Watch the Video Demonstration



Video # 20 - <https://rntlab.com/watch-has-videos>

Note #1: you can reserve a custom subdomain name, so you'll always have the exact same link to access your Dashboard (but that's a paid option in ngrok software).

Note #2: you'll be asked to enter your username and password to open your UI for the first time. If you want to "logout": You'll have to clear the cache in your web browser or You can use the incognito window in your web browser, so it automatically logs off from the Dashboard when you close the web browser

Unit 2 - Another Way of Making Node-RED Dashboard Accessible

If you've followed the previous Unit, you don't need to do anything else. You can skip/ignore this Unit.

I personally think that the method implemented in the previous Unit (using ngrok) is the best option to make Node-RED Dashboard accessible from anywhere.

However, I think it's important to share the most popular method of making the Raspberry Pi accessible from anywhere.

Port Forwarding Your RPi

Doing port forwarding is a bit tricky and it's different for everyone, because every router has a different configurations menu.

Gus from Pi My Life Up blog did an excellent job documenting how to do port forwarding with a Raspberry Pi.

He also created a video that goes throughout the entire process (you can watch the video tutorial below):

```
Raspberry Pi Port Forwarding & Dynamic DNS raspberrypi: ~
noip2.c:1826:13: warning: variable 'x' set but not used [-Wunused-but-set-variable]
noip2.c: In function 'hosts':
noip2.c:1838:20: warning: variable 'y' set but not used [-Wunused-but-set-variable]
if [ ! -d /usr/local/bin ]; then mkdir -p /usr/local/bin;fi
if [ ! -d /usr/local/etc ]; then mkdir -p /usr/local/etc;fi
cp noip2 /usr/local/bin/noip2
/usr/local/bin/noip2 -C -c /tmp/no-ip2.conf

Auto configuration for Linux client of no-ip.com.

Please enter the login/email string for no-ip.com pimylifeup@outlook.com
Please enter the password for user 'pimylifeup@outlook.com' *****
Only one host [pimylifeup.ddns.net] is registered to this account.
It will be used.
Please enter an update interval:[30] 30
Do you wish to run something at successful update?[N] (y/N) n

New configuration file '/tmp/no-ip2.conf' created.

mv /tmp/no-ip2.conf /usr/local/etc/no-ip2.conf
root@raspberrypi:~#
```

Extra - <https://rntlab.com/28hasvideos>

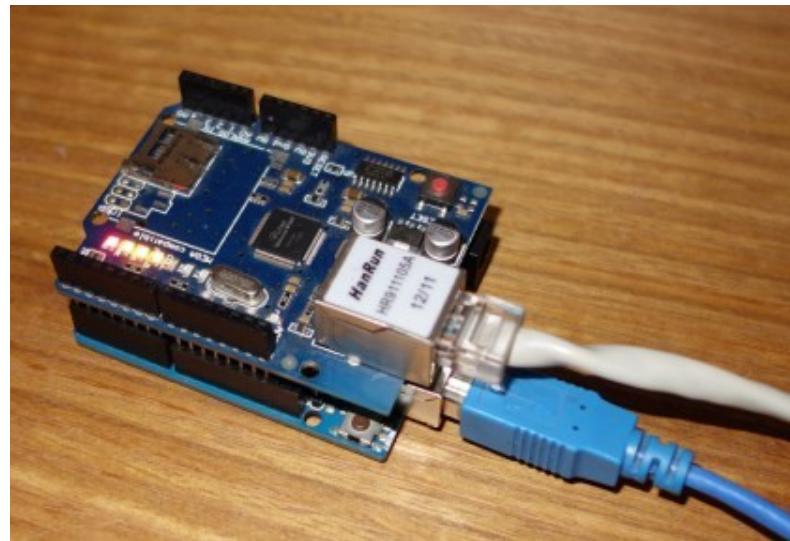
You can go to this link for all the resources mentioned: <https://pimylifeup.com/raspberry-pi-port-forwarding> and follow the instructions in that tutorial.

Important: keep in mind that you want to expose port number 1880 (instead of port 80).

Note: There is a great website that shows the different configurations of port forwarding for each router. Go to this website <http://portforward.com> and search for your router model (or simply type in Google your “router name” + “port forwarding”).

MODULE 10

Connecting the Arduino - Part 1



Unit 1 - Introducing the Arduino



Video # 21 - <https://rntlab.com/watch-has-videos>

If you've followed the previous Modules, you know how easy it is to use the ESP8266 with your home automation system.

About the Arduino

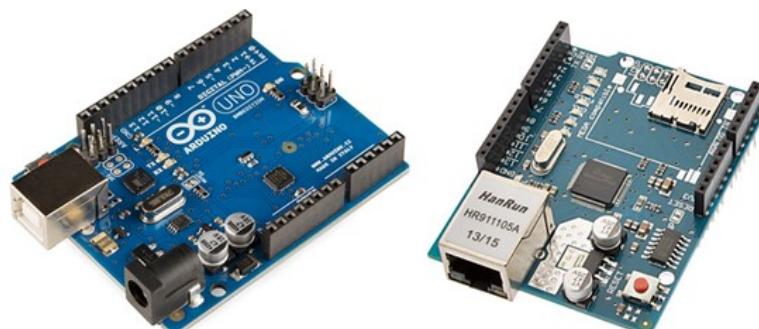
However, in this Module I would like to introduce you to the Arduino board and how you can integrate an Arduino in your home automation system.

Attaching an Ethernet Shield to Your Arduino

You're going to attach an Ethernet shield to your Arduino board.

The Ethernet shield when attached to your Arduino board, connects it to your network and you can establish an MQTT connection with Node-RED.

For this course I recommend using an [Ethernet shield with the WIZnet W5100](#) chip.



So what can you do with an Arduino?

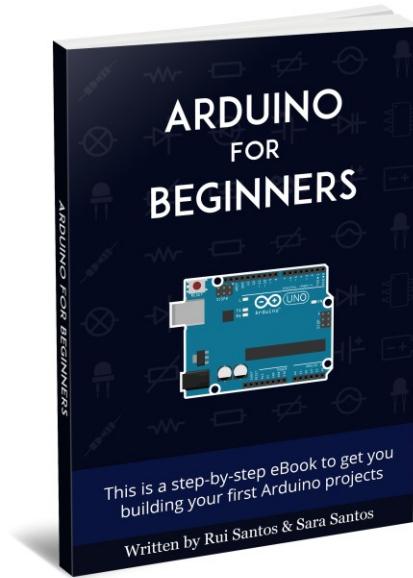
The Arduino is a very versatile board and allows you to:

- Attach various sensors
- Access 6 analog pins
- Establish an MQTT communication
- Trigger actions
- Save sensor data

Read the Arduino eBook

I've also prepared a PDF eBook called Arduino For Beginners and you can download it from the Toolbox.

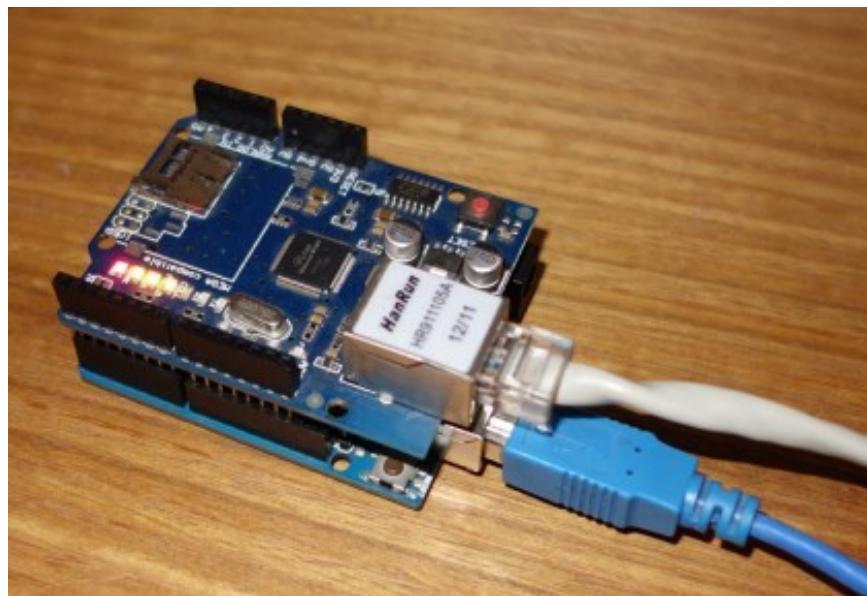
That eBook only covers the Arduino basic concepts, but it will be helpful if you've never used an Arduino before.



Mounting an Ethernet Shield

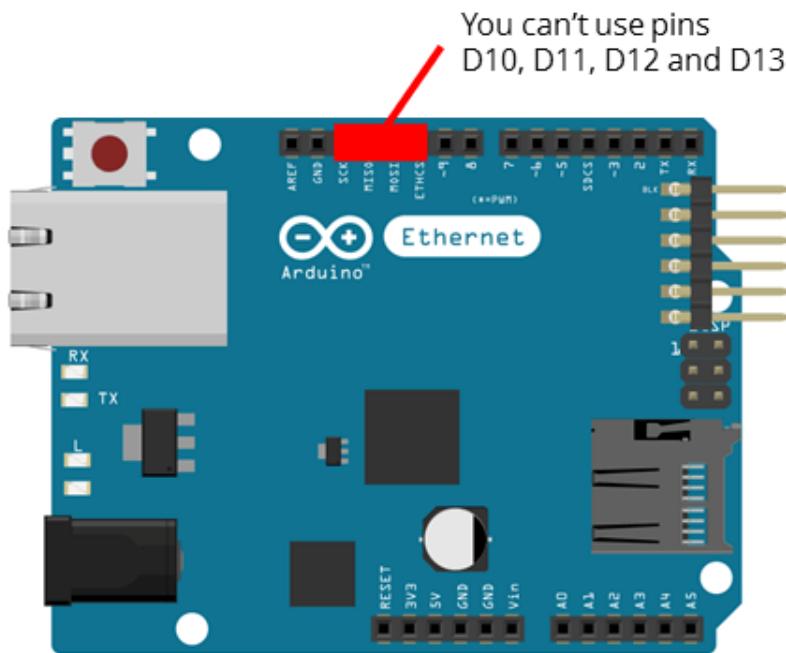
You can easily mount an Ethernet shield to an Arduino board. Then, you can power your Arduino through the USB cable.

Note: you must connect an Ethernet cable from your router to your Ethernet shield as shown in the following figure.



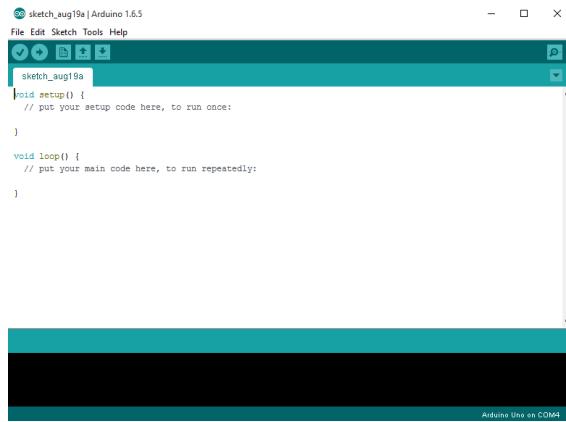
Pin Usage

When the Arduino is connected to an Ethernet shield, you can't use Digital pins from 10 to 13, because they are being used in order to establish a communication between the Arduino and the Ethernet shield.



Installing the Arduino IDE

In this course, you've already programmed your ESP using the Arduino IDE software. So, you should have the Arduino IDE installed in your computer.



If you have already followed the ESP8266 Modules, the next three Units are fairly similar, but it's still important that you go through them to ensure that you aren't missing anything.

Unit 2 - Installing the PubSubClient Library

If you have completed the previous Modules you already have the PubSubClient library installed in the Arduino IDE, so you can skip this Unit.

The [PubSubClient library](#) provides a client for doing simple publish/subscribe messaging with a server that supports MQTT (basically allows your Arduino to talk with Node-RED).

Installing the Library

- 1) Click here to download the PubSubClient library. You should have a .zip folder in your Downloads folder



- 2) Unzip the .zip folder and you should get **pubsubclient-master** folder



- 3) Rename your folder from **pubsubclient-master** to **pubsubclient**



- 4) Move the **pubsubclient** folder to your Arduino IDE installation **libraries** folder

Name	Date modified	Type	Size
Bridge	08/03/2016 17:07	File folder	
Esplora	20/05/2015 17:10	File folder	
Ethernet	09/03/2016 16:11	File folder	
Firmata	16/02/2016 01:32	File folder	
GSM	09/03/2016 16:11	File folder	
Keyboard	08/03/2016 17:05	File folder	
LiquidCrystal	09/03/2016 16:11	File folder	
Mouse	08/03/2016 17:04	File folder	
pubsubclient	16/04/2016 11:16	File folder	
Robot_Control	10/06/2015 15:00	File folder	

- 5) Then, re-open your Arduino IDE

The library comes with several examples sketches that I recommend experimenting with. See **File> Examples > PubSubClient** within the Arduino IDE software.

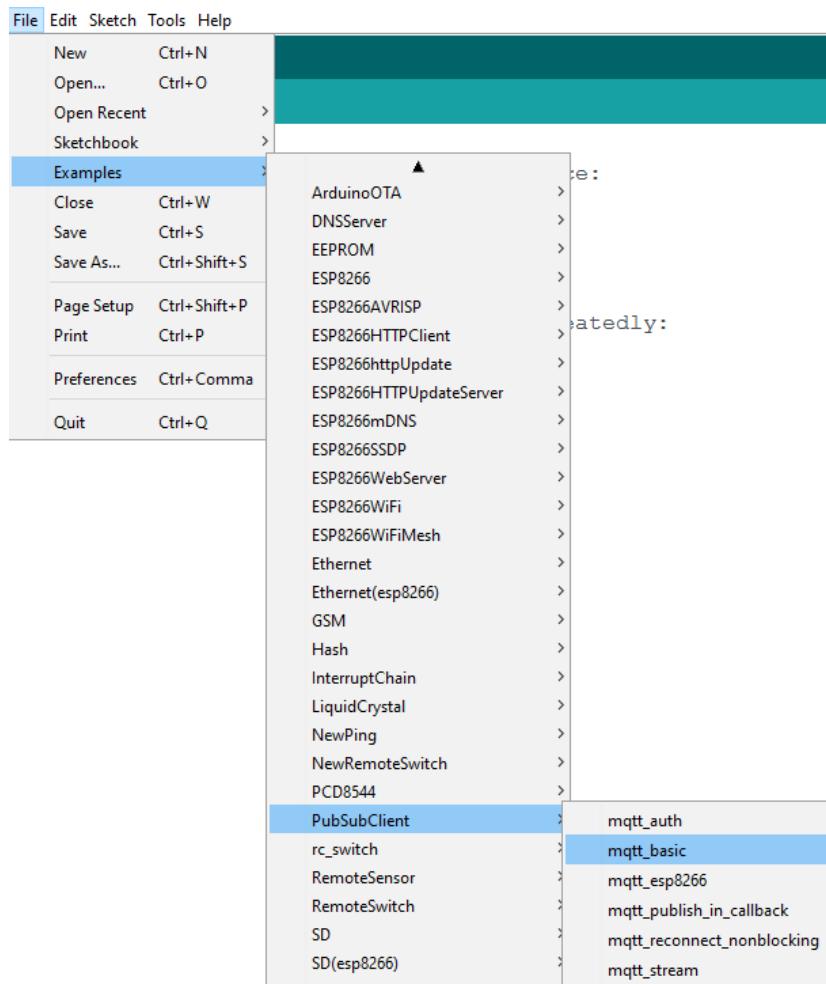
Unit 3 - Connecting the Arduino to the Node-RED Nodes

This Unit shows how you can publish messages and subscribe to a topic with MQTT using an Arduino with an Ethernet shield.

These are the basic concepts that will allow you to turn on your lights and monitor your sensors (which we are going to cover in the next Module).

Writing Your Arduino Sketch

Open the Arduino IDE. Go to **File > Examples > PubSubClient> mqtt_basic**.



A new sketch opens in your Arduino IDE. You'll use that sketch to publish a message and subscribe to a topic with MQTT.

Understanding How the Sketch Works

First, it starts by loading the **SPI** library, the **Ethernet** library and the **PubSubClient** library.

```
#include <SPI.h>
#include <Ethernet.h>
#include <PubSubClient.h>
```

It initializes the `ethClient` and creates a client.

```
EthernetClient ethClient;
PubSubClient client(ethClient);
```

Configuring your network

Then, it configures the Arduino with your network details.

```
// Update these with values suitable for your network.
byte mac[] = { 0xDE, 0xED, 0xBA, 0xFE, 0xFE, 0xED };
IPAddress ip(192, 168, 1, 99);
IPAddress server(192, 168, 1, 76);
```

Important: You need to replace those two variables with appropriate values that are suitable for your network, otherwise your Arduino will not establish a connection with your network neither with your MQTT broker.

Replace the following line with an IP that is available and suitable for your network:

```
IPAddress ip(X, X, X, X);
```

In my case, my IP range is **192.168.1.X** and with the software [Angry IP Scanner](#) I know that the IP **192.168.1.99** is available in my network, because it doesn't have any active device in my network with that exact same IP address:

```
IPAddress ip(192, 168, 1, 99);
```

Replace the next line with your Raspberry Pi IP Address:

```
IPAddress server(X, X, X, X);
```

My RPi IP address is 192.168.1.76, so it becomes:

IPAddress server(192, 168, 1, 76);

Note: Your IP range is very likely to be different from mine, but if you already know the RPi IP address you know the range that you are working with.

callback

The `callback()` function is triggered every time another device publishes a messages to your Arduino (in our example it will be the Raspberry Pi through the Node-RED software).

At the moment, it only prints that message in your serial monitor. Later, you are actually going to use this mechanism to turn on/off your lights.

```
void callback(char* topic, byte* payload, unsigned int length) {
    Serial.print("Message arrived [");
    Serial.print(topic);
    Serial.print("] ");
    for (int i=0;i<length;i++) {
        Serial.print((char)payload[i]);
    }
    Serial.println();
}
```

reconnect

If the Arduino loses connection with the MQTT broker it executes the `reconnect()` function.

If for some reason your Arduino can't establish an MQTT communication with your broker, your Arduino will keep trying to reconnect every 5 seconds.

When the connection is established, it does two things:

- Publishes a message to the **outTopic** topic
- Subscribes to the **inTopic** topic

```

void reconnect() {
    // Loop until we're reconnected
    while (!client.connected()) {
        Serial.print("Attempting MQTT connection...");
        // Attempt to connect
        if (client.connect("arduinoClient")) {
            Serial.println("connected");
            // Once connected, publish an announcement...
            client.publish("outTopic", "hello world");
            // ... and resubscribe
            client.subscribe("inTopic");
        } else {
            Serial.print("failed, rc=");
            Serial.print(client.state());
            Serial.println(" try again in 5 seconds");
            // Wait 5 seconds before retrying
            delay(5000);
        }
    }
}

```

setup

The `setup()` function starts the serial communication at a baud rate of 57600.

The `setup()` also:

- connects your Arduino to the MQTT broker
- sets the `callback()` function
- prepares the Ethernet

```

void setup()
{
    Serial.begin(57600);

    client.setServer(server, 1883);
    client.setCallback(callback);

    Ethernet.begin(mac, ip);
    // Allow the hardware to sort itself out
    delay(1500);
}

```

loop

The `loop()` function only checks if your Arduino is connected to the MQTT broker. If your Arduino isn't connected, it tries to connect/reconnect.

```
void loop()
{
    if (!client.connected()) {
        reconnect();
    }
    client.loop();
}
```

Uploading the Sketch

Finally, you can upload the full sketch to your Arduino (replace with the appropriate IP and RPi IP address for your network):

```
****

All the resources for this project:  

https://rntlab.com/

****

#include <SPI.h>
#include <Ethernet.h>
#include <PubSubClient.h>

// Update these with values suitable for your network.
byte mac[] = { 0xDE, 0xED, 0xBA, 0xFE, 0xFE, 0xED };
IPAddress ip(192, 168, 1, 99);
IPAddress server(192, 168, 1, 76);

void callback(char* topic, byte* payload, unsigned int length) {
    Serial.print("Message arrived [");
    Serial.print(topic);
    Serial.print("] ");
    for (int i=0;i<length;i++) {
        Serial.print((char)payload[i]);
    }
    Serial.println();
}

EthernetClient ethClient;
PubSubClient client(ethClient);

void reconnect() {
    // Loop until we're reconnected
    while (!client.connected()) {
        Serial.print("Attempting MQTT connection...");
        // ...
```

```

// Attempt to connect
if(client.connect("arduinoClient")) {
    Serial.println("connected");
    // Once connected, publish an announcement...
    client.publish("outTopic","hello world");
    // ... and resubscribe
    client.subscribe("inTopic");
} else {
    Serial.print("failed, rc=");
    Serial.print(client.state());
    Serial.println(" try again in 5 seconds");
    // Wait 5 seconds before retrying
    delay(5000);
}
}

void setup()
{
    Serial.begin(57600);

    client.setServer(server, 1883);
    client.setCallback(callback);

    Ethernet.begin(mac, ip);
    // Allow the hardware to sort itself out
    delay(1500);
}

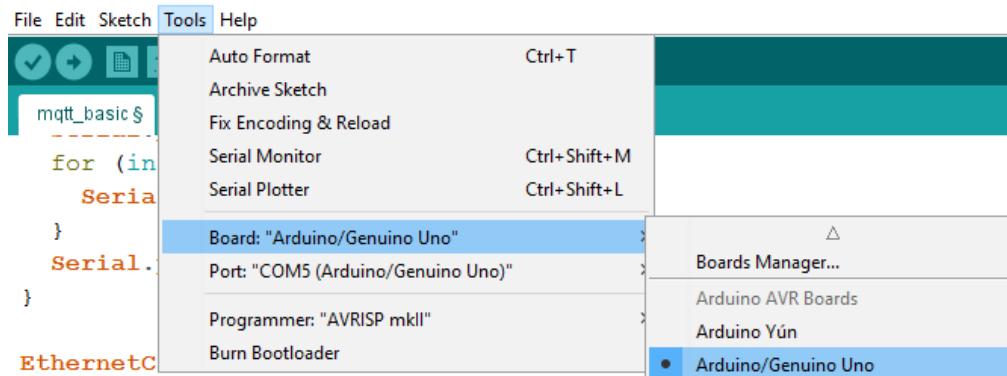
void loop()
{
    if (!client.connected()) {
        reconnect();
    }
    client.loop();
}

```

[DOWNLOAD SOURCE CODE](#)

https://github.com/RuiSantosdotme/Home-Automation-Course/blob/master/code/mqtt_arduino.ino

To upload the sketch, you must select the **Arduino/Genuino** board under **Tools > Board** menu:

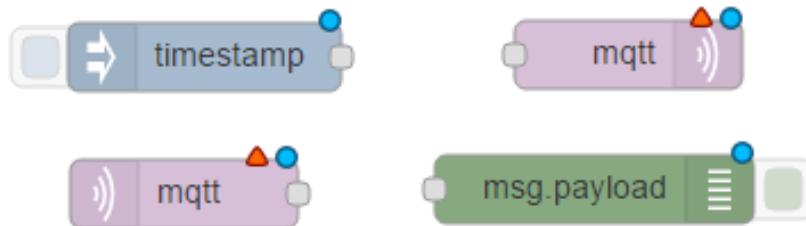


Creating Your Flow

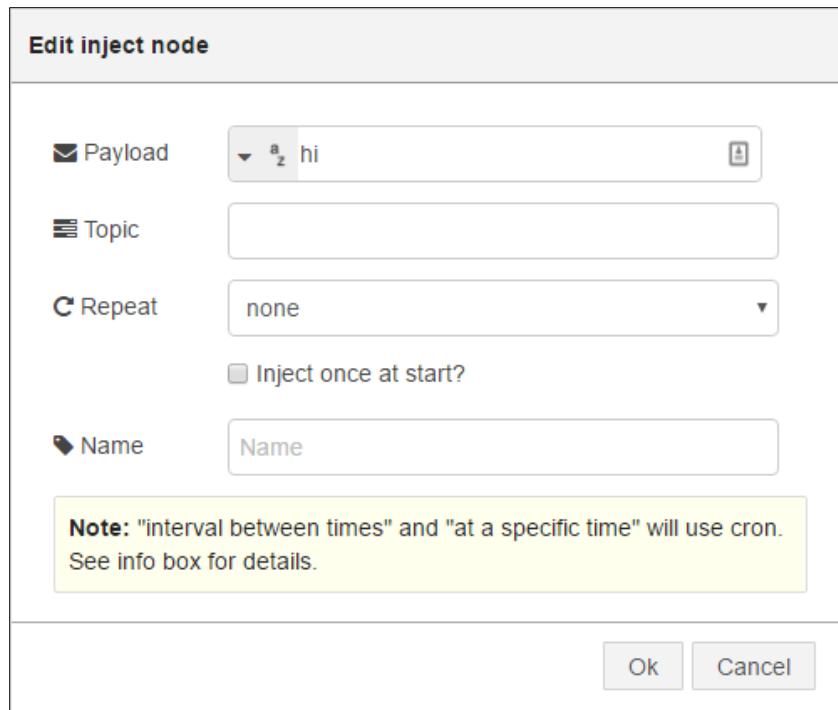
Lastly, you must create a Node-RED flow to subscribe to the **outTopic** topic and to publish messages to the **inTopic** topic.

Let's start by dragging 4 nodes to your flow:

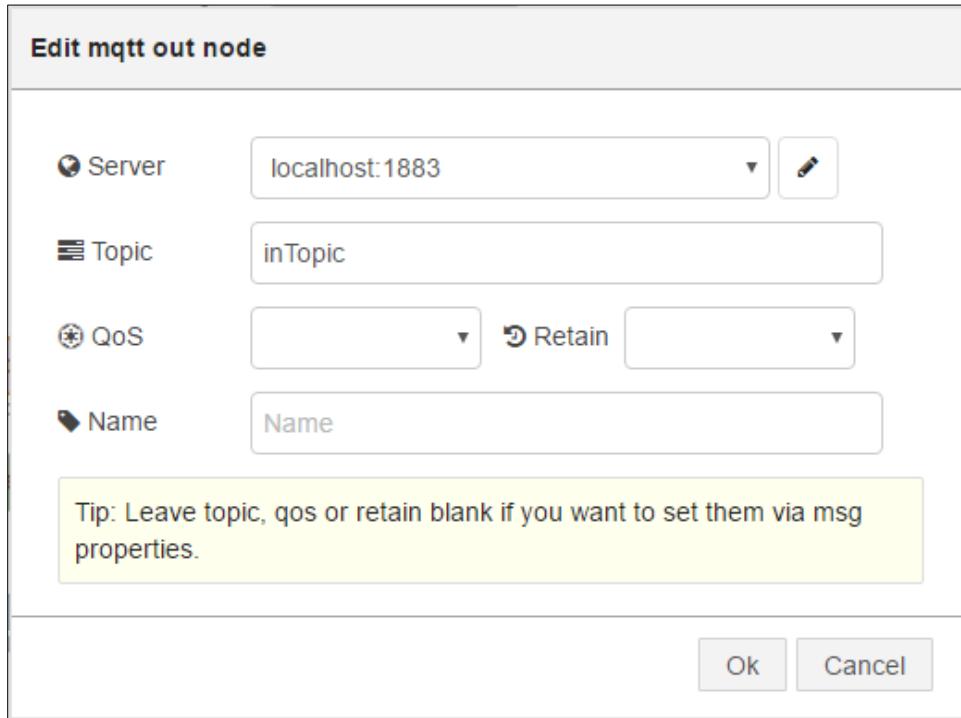
- Inject node
- mqtt out
- mqtt in
- Debug node



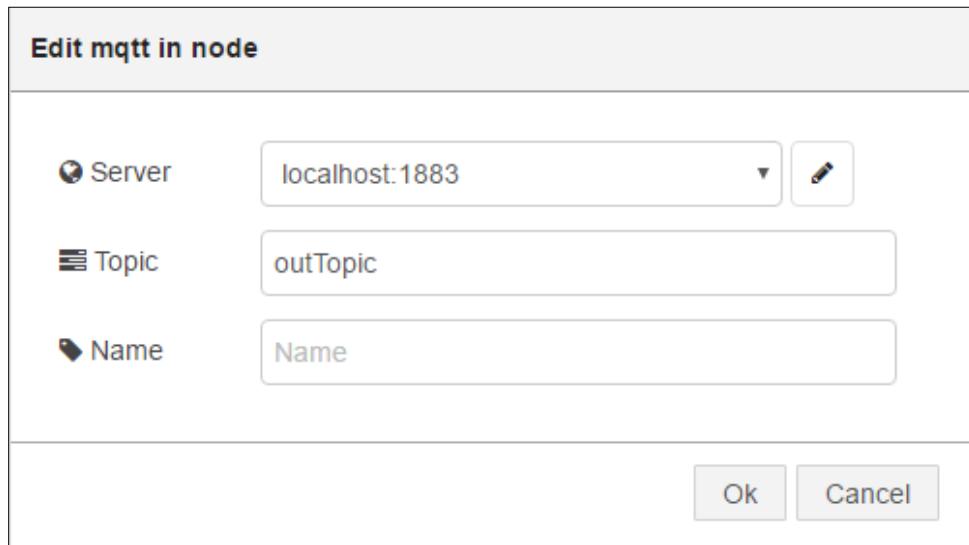
Edit the **Inject** node. Select the **String** payload and type any message in the payload field, for example "hi".



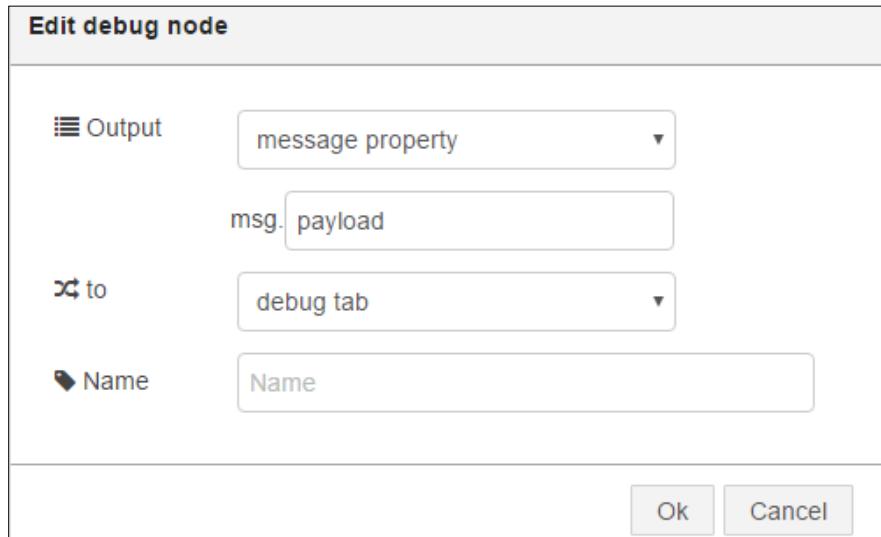
Double-click the **mqtt in** node to edit its settings. Select the **localhost** option and type **inTopic**.



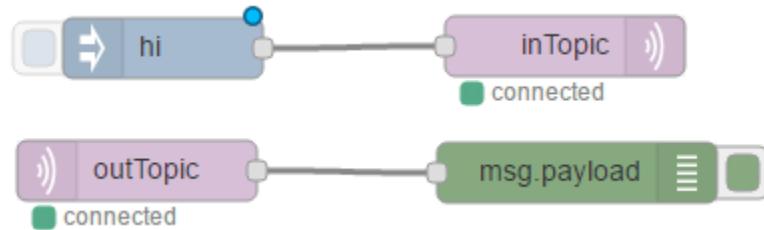
Double-click the **mqtt out** node to edit its settings. Select the **localhost** option and type **outTopic**.



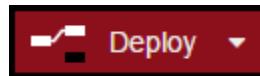
All the settings for the **Debug** node are configured properly by default.



This is how it should look like in the end:

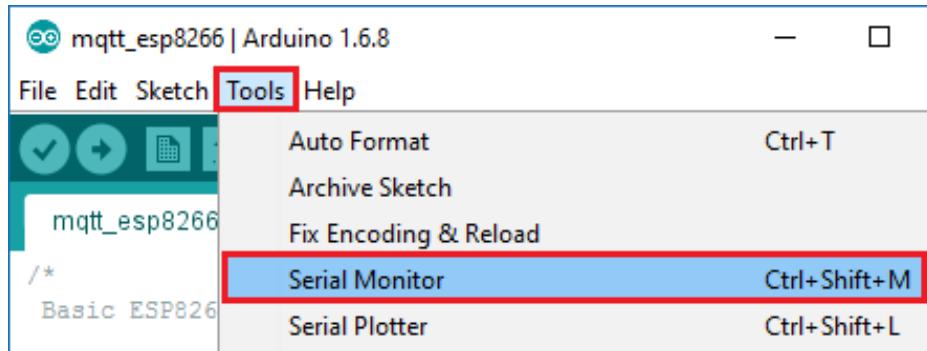


Click the **Deploy** button on the top-right corner to save your application.

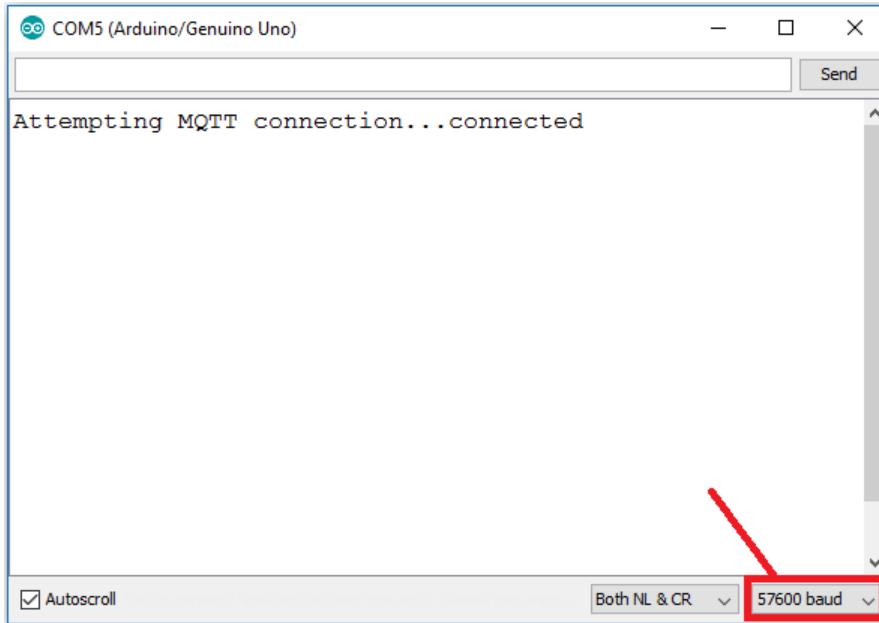


Opening the Node-RED

Open the Arduino IDE serial monitor:



Set the baud rate to 57600:



Open the Node-RED software.

http://YOUR_RPi_IP_ADDRESS:1880

outTopic

At this point, the Debug node is subscribed to the **outTopic** topic, so receives the message “hello world” from your Arduino on boot up.

Click the reset button of your Arduino board (see figure below), because the “hello world” message is only published once on boot up.



Open the debug window in the Node-RED software and you should see the “hello world” message there.

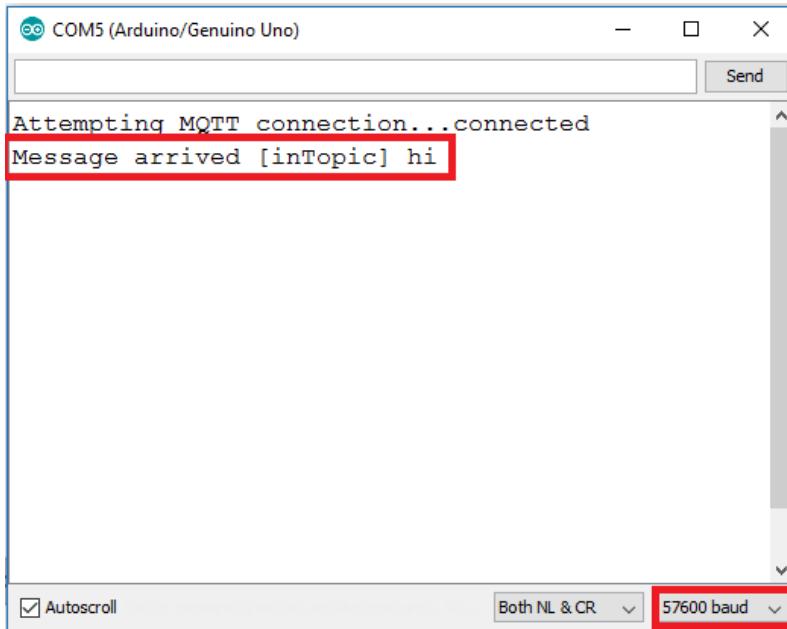


inTopic

If you trigger the **Inject** node, you can publish messages to the **inTopic** topic.



Since your Arduino is subscribed to the **inTopic** topic, it receives the “hi” message and prints it in the serial monitor every time you trigger the **Inject** node.



By now, you have acquired all the basic MQTT concepts with the Arduino (Publish/Subscribe). In the next Module, you'll start controlling real lamps and monitor sensors with your Arduino.

Unit 4 - Controlling Outputs with Arduino using MQTT

In the previous Unit, I've demonstrated how to subscribe and publish messages to a topic. Now, you're going to use that mechanism to control two LEDs, which later will be replaced with real lights.

The sketch presented in this Unit shows you how to control an LED on/off or adjust the brightness through the Node-RED Dashboard.

I've also added additional comments to the sketch to explain what each function does and what you should and shouldn't change.

You can open this link or scroll down this page to see the complete sketch and follow along:

- https://github.com/RuiSantosdotme/Home-Automation-Course/blob/master/code/v2/mqtt_arduino_leds.ino

Understanding How the Sketch Works

First, it starts by loading the **SPI** library, the **Ethernet** library and the **PubSubClient** library.

```
#include <SPI.h>
#include <Ethernet.h>
#include <PubSubClient.h>
```

Configuring your network

Then, it configures the Arduino with your network details.

Important: You need to replace those two variables with appropriate values that are suitable for your network, otherwise your Arduino will not establish a connection with your network neither with your MQTT broker.

Replace the following line with an IP that is available and suitable for your network:

```
IPAddress ip(X, X, X, X);
```

In my case, my IP values range is **192.168.1.X** and with the software [Angry IP Scanner](#) I know that the IP **192.168.1.99** is available in my network, because it doesn't have any device in my network with that exact same IP address, so this works:

```
IPAddress ip(192, 168, 1, 99);
```

Replace that line with your Raspberry Pi IP Address:

```
IPAddress server(X, X, X, X);
```

My RPi IP address is 192.168.1.76, so it becomes:

```
IPAddress server(192, 168, 1, 76);
```

The MAC address can remain the same:

```
byte mac[] = { 0xDE, 0xED, 0xBA, 0xFE, 0xFE, 0xED };
```

Creating variables

It initializes the `ethClient` and creates a client.

```
EthernetClient ethClient;
PubSubClient client(ethClient);
```

Defines two variables that refer to Digital pin 6 and Digital pin 7 of your Arduino.

```
const int ledPin6 = 6;
const int ledPin7 = 7;
```

callback

Here, you have the `callback()` function.

```
void callback(char* topic, byte* message, unsigned int length) {
    Serial.print("Message arrived on topic: ");
    Serial.print(topic);
    Serial.print(". Message: ");
    String messageTemp;

    for (int i = 0; i < length; i++) {
        Serial.print((char)message[i]);
        messageTemp += (char)message[i];
    }
    Serial.println();
    // Feel free to add more if statements to control more Pins with

    // If a message is received on the topic home/livingroom/arduino
    // It's a value between 0 and 255 to adjust the LED brightness
    if(String(topic)=="home/livingroom/arduino/ledPin6"){
        Serial.print("Changing Digital Pin 6 Brithness to ");
        Serial.print(messageTemp);
        analogWrite(ledPin6, messageTemp.toInt());
    }
    // If a message is received on the topic home/livingroom/arduino
    //you check if the message is either 1 or 0. Turns the Arduino D
    if(String(topic)=="home/livingroom/arduino/ledPin7"){
        Serial.print("Changing Digital Pin 7 to ");
        if(messageTemp == "1"){
            digitalWrite(ledPin7, HIGH);
            Serial.print("On");
        }
        else if(messageTemp == "0"){
            digitalWrite(ledPin7, LOW);
            Serial.print("Off");
        }
    }
    Serial.println();
}
```

This function is executed when a device publishes a message to a topic that your Arduino is subscribed to.

You can change the function above to add logic to your programs, so when a device publishes a message to a topic that your Arduino is subscribed to, you can actually do something useful with that message.

These are the lines of code that change the brightness of your LED. If a message is received on the topic **home/livingroom/arduino/ledPin6**, you convert the message to an int value to change the brightness of the LED.

```
if(String(topic)=="home/livingroom/arduino/ledPin6"){
    Serial.print("Changing Digital Pin 6 Brightness to ");
    Serial.print(messageTemp);
    analogWrite(ledPin6, messageTemp.toInt());
}
```

The next snippet of code turn the LED on/off. If a message is received on the topic **home/livingroom/arduino/ledPin7**, you check if the message is either **1** or **0**.

Then, it turns the Arduino Digital pin 7 on/off according to the message.

```
if(String(topic)=="home/livingroom/arduino/ledPin7"){
    Serial.print("Changing Digital Pin 7 to ");
    if(messageTemp == "1"){
        digitalWrite(ledPin7, HIGH);
        Serial.print("On");
    }
    else if(messageTemp == "0"){
        digitalWrite(ledPin7, LOW);
        Serial.print("Off");
    }
}
```

reconnect

The `reconnect()` function connects/reconnects your Arduino to your MQTT broker. You can change this function if you want your Arduino subscribed to more topics.

```
void reconnect() {
    // Loop until we're reconnected
    while (!client.connected()) {
        Serial.print("Attempting MQTT connection...");
        // Attempt to connect
        if (client.connect("arduinoClient")) {
            Serial.println("connected");
            // Subscribe or resubscribe to a topic
            // You can subscribe to more topics (to control more LEDs)
            client.subscribe("home/livingroom/arduino/ledPin6");
            client.subscribe("home/livingroom/arduino/ledPin7");
        } else {
            Serial.print("failed, rc=");
            Serial.print(client.state());
            Serial.println(" try again in 5 seconds");
            // Wait 5 seconds before retrying
            delay(5000);
        }
    }
}
```

In this case, I'm subscribed to only two topics:

- **home/livingroom/arduino/ledPin6**
- **home/livingroom/arduino/ledPin7.**

You can add more topics, if you would like to control more LEDs. Feel free to experiment with that.

setup

The `setup()` function:

- sets your Arduino pins as OUTPUTs
- starts the serial communication at a baud rate of 57600
- sets your mqtt broker
- sets the `callback()` function
- starts the Ethernet communication

```
void setup()
{
    pinMode(ledPin6, OUTPUT);
    pinMode(ledPin7, OUTPUT);

    Serial.begin(57600);

    client.setServer(server, 1883);
    client.setCallback(callback);

    Ethernet.begin(mac, ip);
    // Allow the hardware to sort itself out
    delay(1500);
}
```

loop

For this project, you don't need to change anything in the `loop()` function. Basically, it keeps checking that your Arduino is connected to your broker, otherwise it tries to reconnect.

```
void loop()
{
    if (!client.connected()) {
        reconnect();
    }
    client.loop();
}
```

Uploading the Final Sketch

You can copy the final sketch to your Arduino IDE and upload it to your Arduino board (after adding the appropriate IP and RPi IP address for your network).

```
*****  
All the resources for this project:  
https://rntlab.com/  
*****/  
  
// Loading the libraries  
#include <SPI.h>  
#include <Ethernet.h>  
#include <PubSubClient.h>  
  
// This MAC addres can remain the same  
byte mac[] = { 0xDE, 0xED, 0xBA, 0xFE, 0xFE, 0xED };  
  
/*  
 * IMPORTANT!  
 * YOU MUST UPDATE THESE NEXT TWO VARIABLES WITH VALUES SUITABLE TO YOUR NETWORK!  
 *  
 */  
  
// Replace with an IP that is suitable for your network. I could use any IP in this range: 192.168.1.X  
// I've used a tool http://angryip.org/ to see an available IP address and I ended up using 192.168.1.99  
IPAddress ip(192, 168, 1, 99);  
  
// Replace with your Raspberry Pi IP Address. In my case, the RPi IP Address is 192.168.1.76  
IPAddress server(192, 168, 1, 76);  
  
// Initializes the clients  
EthernetClient ethClient;  
PubSubClient client(ethClient);  
  
// Connect two LEDs to your Arduino. One to pin 6 and the other to pin 7  
const int ledPin6 = 6;  
const int ledPin7 = 7;  
  
// This functions is executed when some device publishes a message to a topic that your Arduino is  
// subscribed to  
// Change the function below to add logic to your program, so when a device publishes a message to a topic  
// that  
// your Arduino is subscribed you can actually do something  
void callback(char* topic, byte* message, unsigned int length) {  
    Serial.print("Message arrived on topic: ");  
    Serial.print(topic);  
    Serial.print(". Message: ");  
    String messageTemp;  
  
    for (int i = 0; i < length; i++) {  
        Serial.print((char)message[i]);  
        messageTemp += (char)message[i];  
    }  
}
```

```

Serial.println();
// Feel free to add more if statements to control more Pins with MQTT

// If a message is received on the topic home/livingroom/arduino/ledPin6
// It's a value between 0 and 255 to adjust the LED brightness
if(String(topic)=="home/livingroom/arduino/ledPin6"){
    Serial.print("Changing Digital Pin 6 Brightness to ");
    Serial.print(messageTemp);
    analogWrite(ledPin6, messageTemp.toInt());
}

// If a message is received on the topic home/livingroom/arduino/ledPin7,
// you check if the message is either 1 or 0. Turns the Arduino Digital Pin according to the message
if(String(topic)=="home/livingroom/arduino/ledPin7"){
    Serial.print("Changing Digital Pin 7 to ");
    if(messageTemp == "1"){
        digitalWrite(ledPin7, HIGH);
        Serial.print("On");
    }
    else if(messageTemp == "0"){
        digitalWrite(ledPin7, LOW);
        Serial.print("Off");
    }
}
Serial.println();
}

// This function reconnects your Arduino to your MQTT broker
// Change the function below if you want to subscribe to more topics with your Arduino
void reconnect() {
    // Loop until we're reconnected
    while (!client.connected()) {
        Serial.print("Attempting MQTT connection...");
        // Attempt to connect
        if (client.connect("arduinoClient")) {
            Serial.println("connected");
            // Subscribe or resubscribe to a topic
            // You can subscribe to more topics (to control more LEDs in this example)
            client.subscribe("home/livingroom/arduino/ledPin6");
            client.subscribe("home/livingroom/arduino/ledPin7");
        } else {
            Serial.print("failed, rc=");
            Serial.print(client.state());
            Serial.println(" try again in 5 seconds");
            // Wait 5 seconds before retrying
            delay(5000);
        }
    }
}

// The setup function sets your Arduino pins as Outputs, starts the serial communication at a baud rate of
// 57600
// Sets your mqtt broker and sets the callback function. The callback function is what receives messages and
// actually controls the LEDs. Finally starts the Ethernet communication
void setup()
{
    pinMode(ledPin6, OUTPUT);
    pinMode(ledPin7, OUTPUT);
}

```

```

Serial.begin(57600);

client.setServer(server, 1883);
client.setCallback(callback);

Ethernet.begin(mac, ip);
// Allow the hardware to sort itself out
delay(1500);
}

// For this project, you don't need to change anything in the loop function.
// Basically it ensures that your Arduino is connected to your broker
void loop()
{
  if (!client.connected()) {
    reconnect();
  }
  if(!client.loop())
    client.connect("ethClient");
}

```

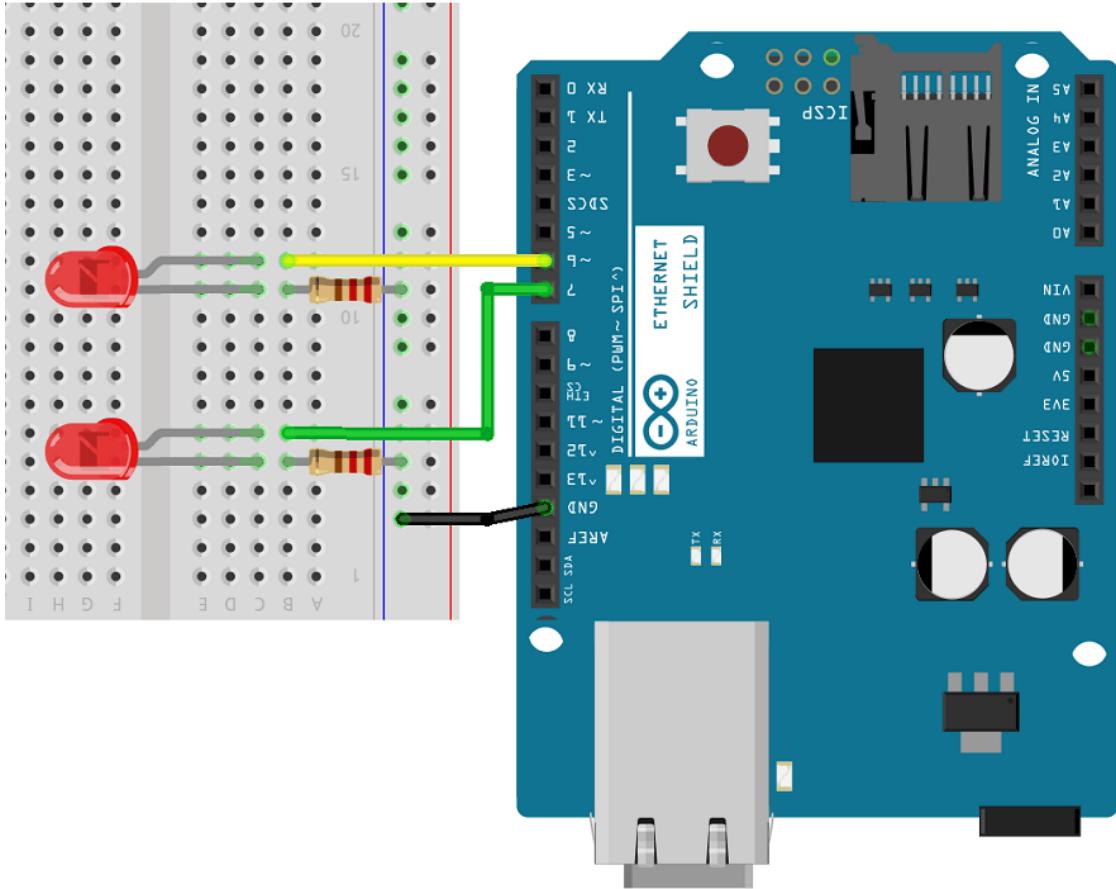
DOWNLOAD SOURCE CODE

https://github.com/RuiSantosdotme/Home-Automation-Course/blob/master/code/v2/mqtt_arduino_leds.ino

Schematics

The schematics for this project are very straightforward. Simply connect two LEDs with two 220 Ohm resistors to your Arduino as shown in the figure below.

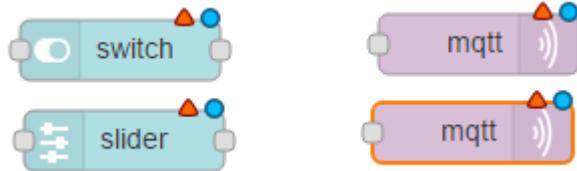
- [Arduino UNO](#)
- [Ethernet Shield W5100](#)
- [2x LEDs \(5mm\)](#)
- [2x 220 Ohm resistors](#)
- [Breadboard](#)
- [Jumper wires](#)



Creating the Flow

Go to the Node-RED software and you should create a flow by following these next 7 steps:

1 – Drag 4 nodes



2 – Switch digital pin 7

Edit switch node

Delete Cancel Done

node properties

Group: Group 1 [Living Room] Size: auto Label: Switch Icon: Default

→ If `msg` arrives on input, pass through to output:

✉ When clicked, send:

On Payload: `a_z` 1

Off Payload: `a_z` 0

Topic:

🏷 Name: Switch

3 – MQTT out node publishes a message 0 or 1

Edit mqtt out node

Cancel Done

Server: localhost:1883 Topic: home/livingroom/arduino/ledPin7

QoS: Retain:

🏷 Name: home/livingroom/arduino/ledPin7

4 – Slider digital pin 6

Edit slider node

Cancel Done

Group: Group 1 [Living Room]

Size: auto

Label: Slider

Range: min 0 max 255

When changed, send:

Payload: Current value

Topic:

Name: Slider

5 – MQTT out node publishes a message from 0 to 255

Edit mqtt out node

Cancel Done

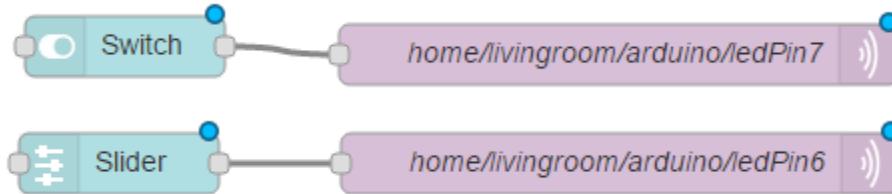
Server: localhost:1883

Topic: home/livingroom/arduino/ledPin6

QoS: Retain

Name: home/livingroom/arduino/ledPin6

6 – Final flow

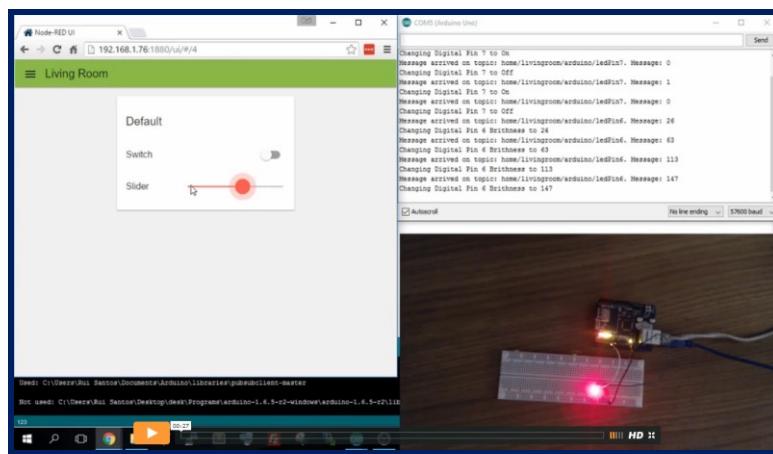
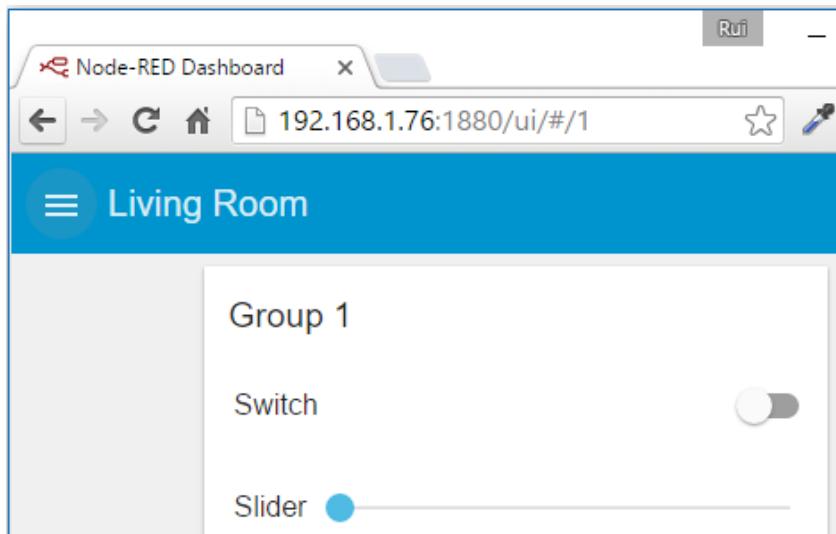


7 – Deploy your application



Opening the Node-RED Dashboard

You can control the LED on/off by pressing the Switch button and adjust the LED brightness with the Slider (for a demonstration watch the video below).

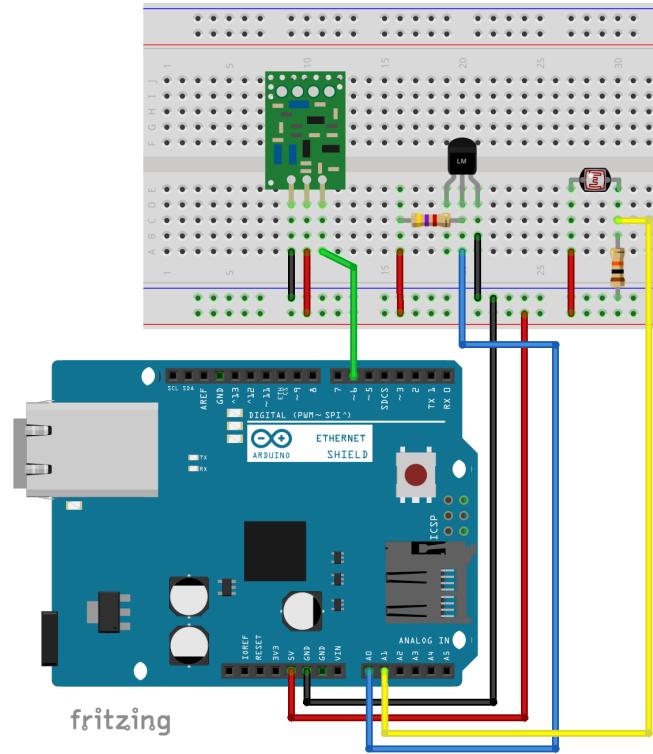


Video # 22 - <https://rntlab.com/watch-has-videos>

In the next Module, you're going to replace those LEDs with outlets

MODULE 11

Connecting the Arduino - Part 2



Unit 1 - Decoding RF Signals to Control Outlets

If you've followed all previous Modules, this Unit is repeated and it's very likely that you already know how it works. You can go through this Unit again to decode the binary codes from another set of RF controlled outlets that are going to be controlled with your Arduino.

You are finally going to control real things with your Arduino and make useful stuff.

I've tried different methods of controlling the mains voltage, but some of the methods require:

1. **Experience** dealing with AC voltage
2. **Opening holes** in your wall/ceiling/switches
3. **Modifying** the electrical panel
4. **Knowing** the electrical rules for each country

It was very hard to come up with a solution that is safe and works for everyone.

Solution

I wanted to create a course that would work regardless of the country. The solution for this problem was using radio frequency (RF) controlled outlets.

Why? Using these remote controlled outlets have 5 benefits:

1. **Fairly inexpensive**
2. **Easy to get**
3. **Works** with ESP8266 and Arduino
4. **Safe** to use
5. **Works** in any country

Parts Required

To complete this Unit you need:

- [Arduino UNO](#)

- [433MHz RF Receiver](#)
- [Remote Controlled Outlets that operate at 433MHz](#)

You can see the complete list of components and parts in Module 1.

Note: you need to buy remote controlled outlets that operate at a RF of 433MHz. They should say the operating RF either in the product page or in the label.

Example

Here's how they look:



There are also [E27 Lamp Bulb Holders](#) that are controlled with an RF remote. They should also operate at 433MHz and they work like the outlets.



You simply connect an E27 lamp to the E27 remote controlled holder.



Then, you attach this to the lamp holder that you want to control. You can turn the light on and off with your remote control:



Setting the RF Channels

I set my remote control to the **I** position.



The outlets must be both on the **I** position. I've selected channels **3** and **4** for the outlets (you can use any channel you want).



If you plug them to an outlet, you should be able to control the remote controlled outlets with your remote control.

Installing the RC Switch Library

The [RC Switch library](#) provides an easy way of using your ESP8266, Arduino or Raspberry Pi to operate remote radio controlled devices. This will most likely work with all popular low-cost power outlet sockets.

- 1) [Click here to download the RC Switch library](#). You should have a **.zip** folder in your **Downloads** folder

rc-switch-master Compressed (zipp...) 20 KB

- 2) Unzip the .zip folder and you should get **rc-switch-master** folder

rc-switch-master File folder 26/03/2016 04:41

- 3) Rename your folder from **rc-switch-master** to **rc_switch**

rc_switch File folder

- 4) Move the **rc_switch** folder to your Arduino IDE installation **libraries** folder

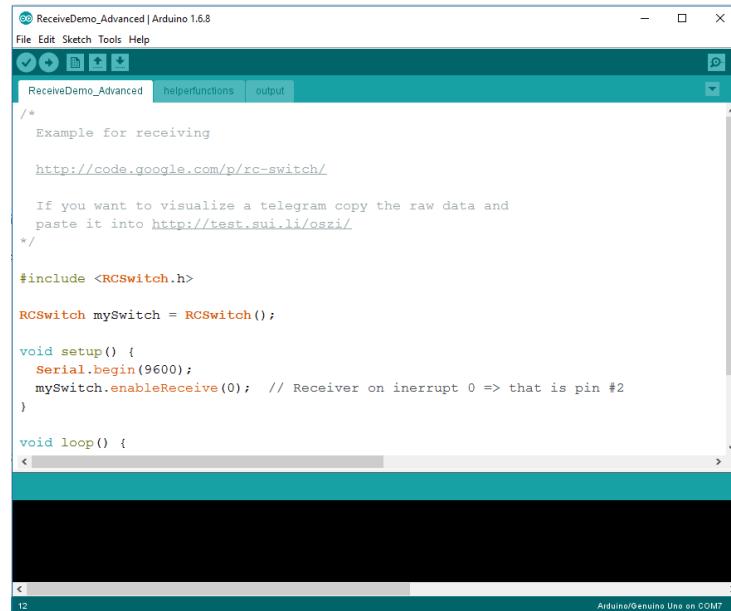
arduino-1.6.8 > libraries	
Name	Type
Bridge	File folder
Explora	File folder
Ethernet	File folder
Firmata	File folder
GSM	File folder
InterruptChain	File folder
Keyboard	File folder
LiquidCrystal	File folder
Mouse	File folder
NewRemoteSwitch	File folder
pubsubclient	File folder
rc_switch	File folder

5) Then, re-open your Arduino IDE

Opening the Decoder Sketch

You need to decode the signals that your remote control sends, so that the Arduino can reproduce those signals and ultimately control the outlets.

The library comes with several sketch examples. Within the Arduino IDE software, you need to go to **File > Examples > RC_Switch > ReceiveDemo_Advanced**.



```
ReceiveDemo_Advanced | Arduino 1.6.8
File Edit Sketch Tools Help
ReceiveDemo_Advanced helpfunctions output
/*
  Example for receiving

  http://code.google.com/p/rc-switch/

  If you want to visualize a telegram copy the raw data and
  paste it into http://test.suili/oszil/
*/
#include <RCswitch.h>

RCswitch mySwitch = RCswitch();

void setup() {
  Serial.begin(9600);
  mySwitch.enableReceive(0); // Receiver on interrupt 0 => that is pin #2
}

void loop() {
<   >
}
```

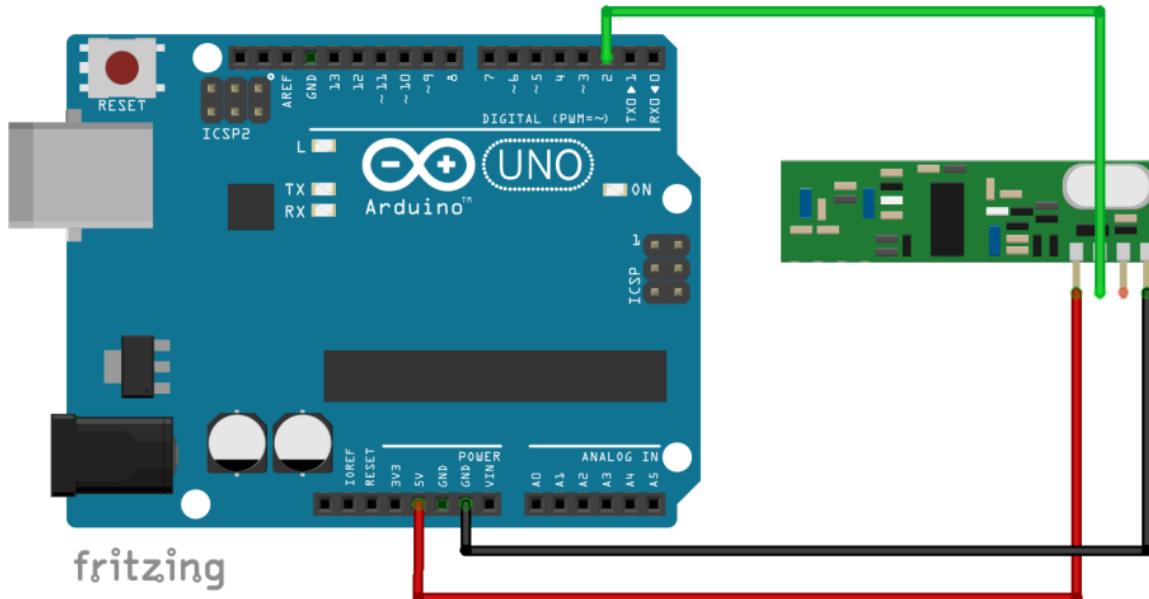
Having an Arduino board connected to your computer follow these instructions:

1. Go to the **Tools** tab
2. Select **Arduino UNO** board

3. Select the **COM** port
4. Press the **Upload** button

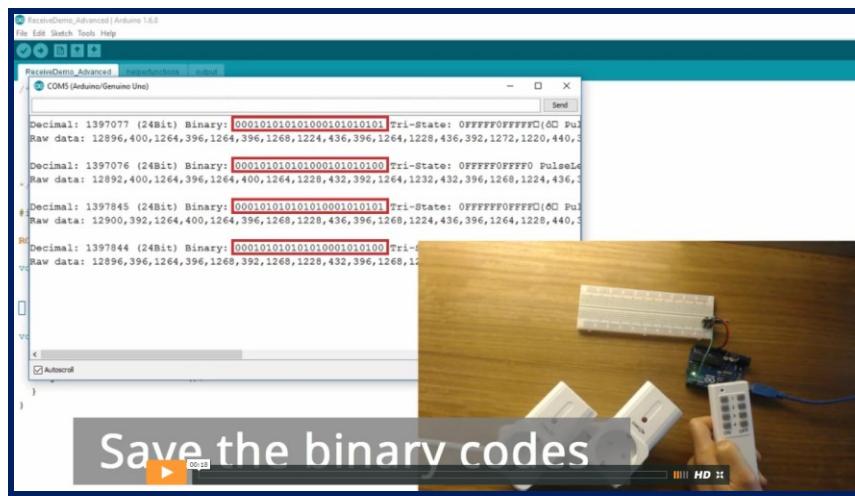
Schematics

After the sketch is uploaded connect an 433MHz RF receiver to Digital Pin 2 of your Arduino UNO board:



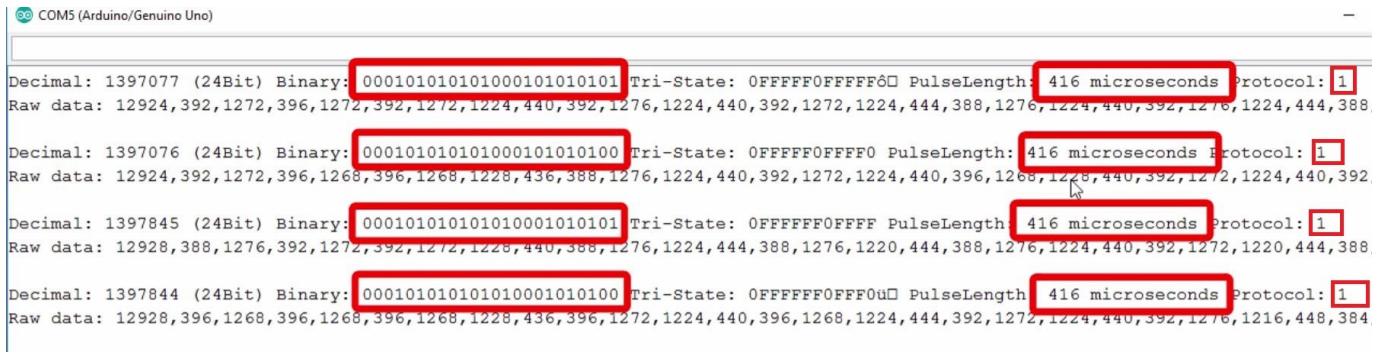
Decoding the RF Signals

Open the Arduino IDE serial monitor and start pressing the buttons. As shown in the video demonstration below:



Video # 23 - <https://rntlab.com/watch-has-videos>

After pressing each button one time, you can see the binary code for each button (it's highlighted in red):



COM5 (Arduino/Genuino Uno)

```
Decimal: 1397077 (24Bit) Binary: 000101010101000101010101 Tri-State: 0FFFFF0FFFFF0 PulseLength: 416 microseconds Protocol: 1
Raw data: 12924,392,1272,396,1272,392,1272,1224,440,392,1276,1224,440,392,1272,1224,444,388,1276,1224,440,392,1276,1224,444,388

Decimal: 1397076 (24Bit) Binary: 000101010101000101010100 Tri-State: 0FFFFF0FFF0 PulseLength: 416 microseconds Protocol: 1
Raw data: 12924,392,1272,396,1268,396,1268,1228,436,388,1276,1224,440,392,1272,1224,440,396,1268,440,392,1272,1224,440,392

Decimal: 1397845 (24Bit) Binary: 000101010101000101010101 Tri-State: 0FFFFF0FFF PulseLength: 416 microseconds Protocol: 1
Raw data: 12928,388,1276,392,1272,392,1272,1228,440,388,1276,1224,444,388,1276,1220,444,388,1276,1224,440,392,1272,1220,444,388

Decimal: 1397844 (24Bit) Binary: 00010101010100010101000 Tri-State: 0FFFFF0FFF0u PulseLength: 416 microseconds Protocol: 1
Raw data: 12928,396,1268,396,1268,396,1268,1228,436,396,1272,1224,440,396,1268,1224,444,392,1272,1224,440,392,1276,1216,448,384
```

Save your binary codes for each button press:

- **Button 3 ON** = (24Bit) Binary: 000101010101000101010101
- **Button 3 OFF** = (24Bit) Binary: 000101010101000101010100
- **Button 4 ON** = (24Bit) Binary: 0001010101010001010101
- **Button 4 OFF** = (24Bit) Binary: 0001010101010001010100

Save your Pulse Length: 416 Microseconds.

Save your Protocol: 1.

You'll need your binary codes, pulse length and protocol in the next Unit.

Unit 2 - Controlling Lamps and Outlets with Arduino using MQTT

This Unit shows you how to control outlets with your Arduino through the Node-RED Dashboard.

You can open this link or scroll down this page to see the complete sketch and follow along:

- https://github.com/RuiSantosdotme/Home-Automation-Course/blob/master/code/v2/mqtt_arduino_outlets.ino

Understanding How the Sketch Works

Let's see how the new snippets of code work.

Preparing RC Switch

Loads the RCSwitch library:

```
#include <RCSwitch.h>
```

Creates the `mySwitch` variable:

```
RCSwitch mySwitch = RCSwitch();
```

In the `setup()` function you set Digital pin 6 as a transmitter:

```
mySwitch.enableTransmit(6);
```

Set your pulse length:

```
mySwitch.setPulseLength(REPLACE_WITH_YOUR_PULSE_LENGTH);
```

Set your protocol:

```
mySwitch.setProtocol(REPLACE_WITH_YOUR_PROTOCOL);
```

Subscribing to 2 topics

In the `reconnect()` function, you subscribe to 2 topics that identify where your Arduino is located and which outlet you would like to control:

```
client.subscribe("home/livingroom/arduino/outlet1");
client.subscribe("home/livingroom/arduino/outlet2");
```

Important: I recommend that you first try to follow this Unit with these exact same topics. However, the idea is to replace them later with topics that clearly identify where your Arduino is located.

Sending the binary codes

In the `callback()` function, you create 2 `if` statements for each outlet that send the binary code to turn the outlet on/off.

You have to replace those binary codes with your own:

```
// If a message is received on the topic home/livingroom/arduino/outletX,
// you check if the message is either 1 or 0. Turns the outlet according to the message
if(String(topic)=="home/livingroom/arduino/outlet1"){
    Serial.print("Changing outlet 1 to ");
    if(messageTemp == "1"){
        mySwitch.send("000101010101000101010101");
        Serial.print("On");
    }
    else if(messageTemp == "0"){
        mySwitch.send("000101010101000101010100");
        Serial.print("Off");
    }
}
if(String(topic)=="home/livingroom/arduino/outlet2"){
    Serial.print("Changing outlet 2 to ");
    if(messageTemp == "1"){
        mySwitch.send("0001010101010001010101");
        Serial.print("On");
    }
    else if(messageTemp == "0"){
        mySwitch.send("0001010101010001010100");
        Serial.print("Off");
    }
}
```

Important: in case you change the topics, you also have to change the `if` statements to match the topics that your Arduino is subscribed.

Uploading the Final Sketch

You can copy the final sketch to your Arduino IDE and upload it to your Arduino board (after adding the appropriate IP, the RPi IP address and the binary codes for your outlets).

```
*****  
All the resources for this project:  
https://rntlab.com/  
*****/  
  
// Loading the libraries  
#include <SPI.h>  
#include <Ethernet.h>  
#include <PubSubClient.h>  
#include <RCSwitch.h>  
  
// This MAC address can remain the same  
byte mac[] = { 0xDE, 0xED, 0xBA, 0xFE, 0xFE, 0xED };  
  
/*  
 * IMPORTANT!  
 * YOU MUST UPDATE THESE NEXT TWO VARIABLES WITH VALUES SUITABLE TO YOUR NETWORK!  
 *  
 */  
  
// Replace with an IP that is suitable for your network. I could use any IP in this range: 192.168.1.X  
// I've used a tool http://angryip.org/ to see an available IP address and I ended up using 192.168.1.99  
IPAddress ip(192, 168, 1, 99);  
  
// Replace with your Raspberry Pi IP Address. In my case, the RPi IP Address is 192.168.1.76  
IPAddress server(192, 168, 1, 76);  
  
// Initializes the ethClient. You have to change the ethClient name if you have multiple ESPs running in your  
// home automation system  
EthernetClient ethClient;  
PubSubClient client(ethClient);  
  
RCSwitch mySwitch = RCSwitch();  
  
// This function is executed when some device publishes a message to a topic that your ESP8266 is  
// subscribed to  
// Change the function below to add logic to your program, so when a device publishes a message to a topic  
// that  
// your ESP8266 is subscribed you can actually do something  
void callback(char* topic, byte* message, unsigned int length) {  
    Serial.print("Message arrived on topic: ");  
    Serial.print(topic);  
    Serial.print(". Message: ");  
    String messageTemp;  
  
    for (int i = 0; i < length; i++) {  
        Serial.print((char)message[i]);  
    }  
}
```

```

        messageTemp += (char)message[i];
    }
    Serial.println();
    // Feel free to add more if statements to control more outlets with MQTT

    // If a message is received on the topic home/livingroom/arduino/outletX,
    // you check if the message is either 1 or 0. Turns the outlet according to the message
    if(String(topic)=="home/livingroom/arduino/outlet1"){
        Serial.print("Changing outlet 1 to ");
        if(messageTemp == "1"){
            mySwitch.send("000101010101000101010101");
            Serial.print("On");
        }
        else if(messageTemp == "0"){
            mySwitch.send("0001010101010001010100");
            Serial.print("Off");
        }
    }
    if(String(topic)=="home/livingroom/arduino/outlet2"){
        Serial.print("Changing outlet 2 to ");
        if(messageTemp == "1"){
            mySwitch.send("0001010101010001010101");
            Serial.print("On");
        }
        else if(messageTemp == "0"){
            mySwitch.send("0001010101010001010100");
            Serial.print("Off");
        }
    }
    Serial.println();
}

// This functions reconnects your Arduino to your MQTT broker
// Change the function below if you want to subscribe to more topics with your Arduino
void reconnect() {
    // Loop until we're reconnected
    while (!client.connected()) {
        Serial.print("Attempting MQTT connection...");
        // Attempt to connect
        if (client.connect("arduinoClient")) {
            Serial.println("Connected");
            // Subscribe or resubscribe to a topic
            // You can subscribe to more topics (to control more LEDs in this example)
            client.subscribe("home/livingroom/arduino/outlet1");
            client.subscribe("home/livingroom/arduino/outlet2");
        } else {
            Serial.print("failed, rc=");
            Serial.print(client.state());
            Serial.println(" try again in 5 seconds");
            // Wait 5 seconds before retrying
            delay(5000);
        }
    }
}

// The setup function sets your Arduino pins as a transmitter, starts the serial communication at a baud rate
// of 57600
// Sets your mqtt broker and sets the callback function. The callback function is what receives messages and

```

```

// actually controls the LEDs. Finally starts the Ethernet communication
void setup()
{
    mySwitch.enableTransmit(6);

    // SET YOUR PULSE LENGTH
    mySwitch.setPulseLength(REPLACE_WITH_YOUR_PULSE_LENGTH);

    // SET YOUR PROTOCOL (default is 1, will work for most outlets)
    mySwitch.setProtocol(REPLACE_WITH_YOUR_PROTOCOL);

    // Set number of transmission repetitions.
    mySwitch.setRepeatTransmit(15);
    Serial.begin(57600);

    client.setServer(server, 1883);
    client.setCallback(callback);

    Ethernet.begin(mac, ip);
    // Allow the hardware to sort itself out
    delay(1500);
}

// For this project, you don't need to change anything in the loop function.
// Basically it ensures that your Arduino is connected to your broker
void loop()
{
    if (!client.connected()) {
        reconnect();
    }
    if (!client.loop())
        client.connect("ethClient");
}

```

DOWNLOAD SOURCE CODE

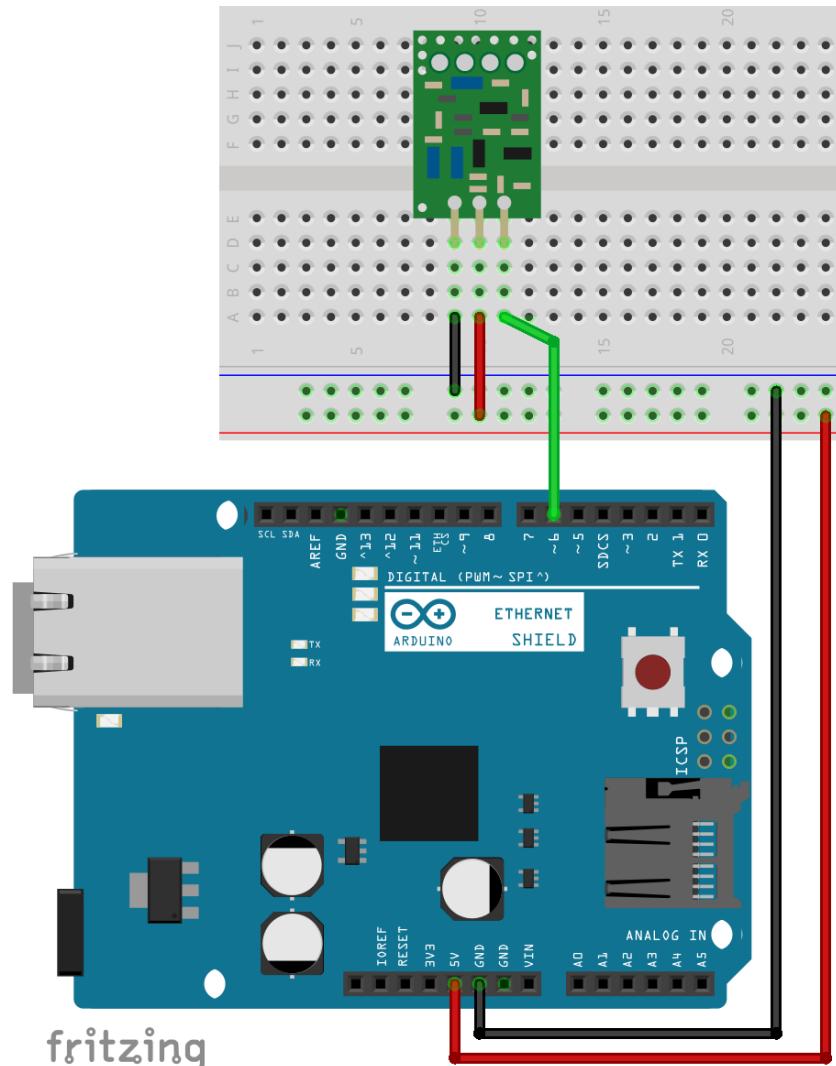
https://github.com/RuiSantosdotme/Home-Automation-Course/blob/master/code/v2/mqtt_arduino_outlets.ino

Schematics

To complete this Unit you need:

- [Arduino UNO](#)
- [Ethernet Shield \(W5100\)](#)
- [433MHz RF Transmitter](#)
- [Remote Controlled Outlets that operate at 433MHz](#)

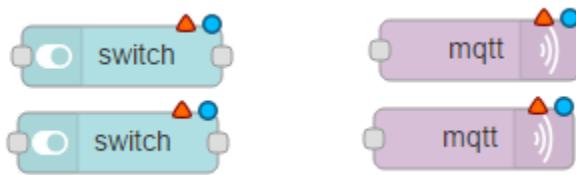
Here's the schematics:



Creating the Flow

In this flow, you're going to add two node **Switches** to control the outlets. Follow these next 8 steps to create your flow:

1 – Drag 4 nodes



2 – Configure Switch node

Edit switch node

Cancel Done

Group: Group 1 [Living Room]

Size: auto

Label: Outlet #1

Icon: Default

When clicked, send:

On Payload: 1

Off Payload: 0

Topic:

Name: Outlet #1

3 – MQTT out node

Edit mqtt out node

Cancel Done

Server: localhost:1883

Topic: home/livingroom/arduino/outlet1

QoS: Retain

Name: home/livingroom/arduino/outlet1

4 – Configure Switch node

Edit switch node

Cancel Done

Group: Group 1 [Living Room]

Size: auto

Label: Outlet #2

Icon: Default

When clicked, send:

On Payload: 1

Off Payload: 0

Topic:

Name: Outlet #2

5 – MQTT out node

Edit mqtt out node

Cancel Done

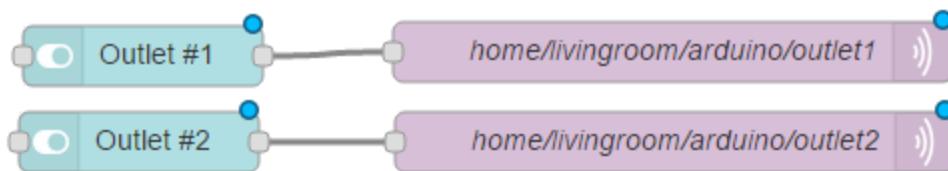
Server: localhost:1883

Topic: home/livingroom/arduino/outlet2

QoS: Retain

Name: home/livingroom/arduino/outlet2

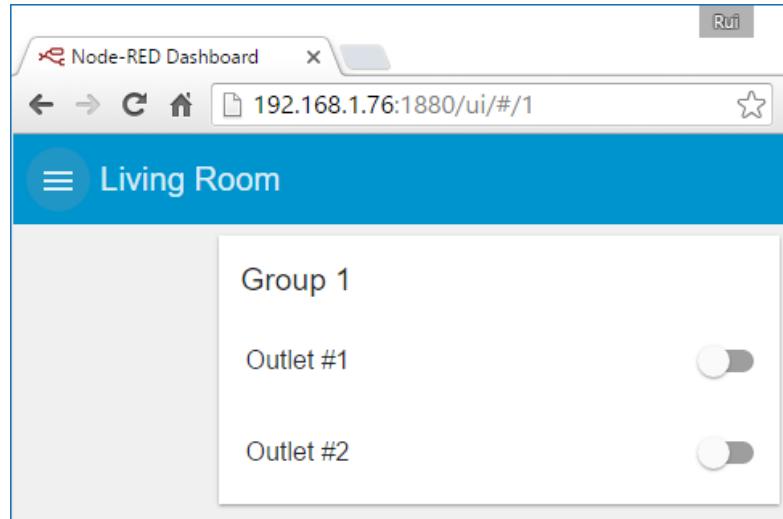
6 – Final Flow



7 – Deploy your application

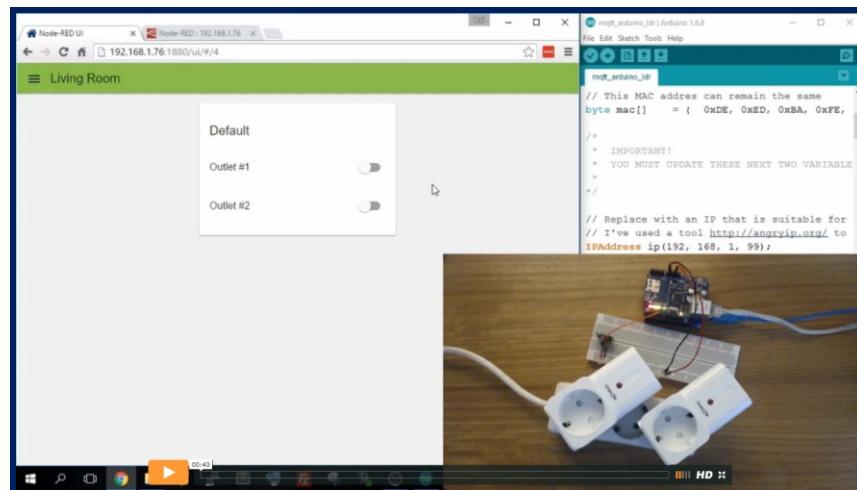


8 – Dashboard



Watch the Video Demonstration

Finally, you can control any outlet in your home with any device that has a web browser. **Watch this video to see it in action:**



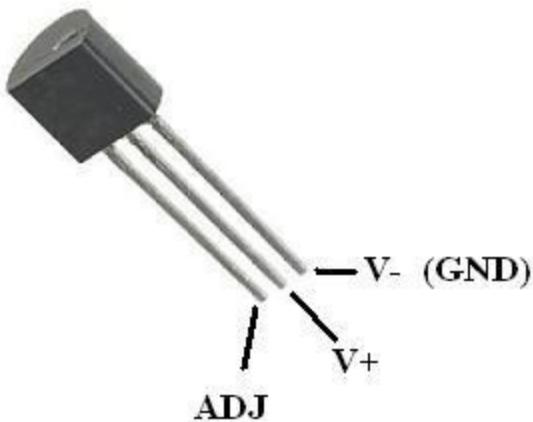
Video # 24 - <https://rntlab.com/watch-has-videos>

Unit 3 - Plotting the Temperature in a Chart

(You should keep the sketch, circuit and nodes from the previous Unit and add this new sensor to your project)

This Unit shows you how to read temperature values with an Arduino and how to publish them to a chart in the Node-RED Dashboard.

Throughout this Unit, you're going to use the LM335 sensor, but if you don't have this exact sensor you can use another temperature sensor with some minor code changes.



Understanding How the Sketch Works

You can open this link or scroll down this page to see the complete sketch and follow along:

- https://github.com/RuiSantosdotme/Home-Automation-Course/blob/master/code/v2/mqtt_arduino_temperature.ino

Let's see how the new snippets of code work.

Preparing the variables

Assign the Analog pin A0 to the `tempAnalogPin` variable.

```
// Defines the analog temperature pin for the LM335 temperature sensor
int tempAnalogPin = A0;
```

The next variable is used to create a timer that checks the temperature value every few milliseconds.

```
// Timers auxiliar variables
long now = millis();
long lastMeasure = 0;
```

loop

The `loop()` function has a timer that compares the time that has passed to the last sensor measurement.

If it has passed 10 seconds, it goes into that `if` statement.

```
now = millis();
// Publishes new temperature and humidity every 10 seconds
if (now - lastMeasure > 10000) {
    lastMeasure = now;
```

These 5 lines of code read the value of the sensor pin, convert the value to millivolts and convert millivolts to degrees Kelvin.

```
// Reads analog pin and computes temperature values in Kelvin
int rawVoltage= analogRead(tempAnalogPin);
float millivolts= (rawVoltage/1024.0) * 5000;
float kelvin= (millivolts/10);
Serial.print(kelvin);
Serial.println(" degrees Kelvin");
```

The next snippet of code converts degrees Kelvin to Celsius and saves the temperature in a temporary variable.

Tip: you can comment the Celsius code and uncomment the Fahrenheit code.

```
// Converts temperature in Kelvin to Celsius, you can comment
// and uncomment the lines below if you prefer Fahrenheit temperature
float celsius = kelvin - 273.15;
Serial.print(celsius);
Serial.println(" degrees Celsius");
static char temperatureTemp[6];
dtostrf(celsius, 6, 2, temperatureTemp);

// Uncomment to convert temperature in Kelvin to Fahrenheit
/*
float fahrenheit = (((kelvin - 273.15) * 9)/5 +32);
Serial.print(fahrenheit);
Serial.println(" degrees Fahrenheit");
static char temperatureTemp[6];
dtostrf(fahrenheit, 6, 2, temperatureTemp);*/
```

Finally, you need to publish the new temperature reading in Celsius to the Node-RED Dashboard chart:

- **home/livingroom/arduino/temperature**

```
// Publishes a new Temperature value
client.publish("home/livingroom/arduino/temperature", temperatureTemp);
```

Uploading the Final Sketch

You can copy the final sketch to your Arduino IDE and upload it to your Arduino board (after adding the appropriate IP, the RPi IP address and the binary codes for your outlets):

```
*****  
  
All the resources for this project:  
https://rntlab.com/  
  
*****/  
  
// Loading the libraries
#include <SPI.h>
#include <Ethernet.h>
#include <PubSubClient.h>
#include <RCSwitch.h>  
  
// This MAC address can remain the same
byte mac[] = { 0xDE, 0xED, 0xBA, 0xFE, 0xFE, 0xED };  
  
/*  
 * IMPORTANT!  
 * YOU MUST UPDATE THESE NEXT TWO VARIABLES WITH VALUES SUITABLE TO YOUR NETWORK!  
 *  
 */  
  
// Replace with an IP that is suitable for your network. I could use any IP in this range: 192.168.1.X
// I've used a tool http://angryip.org/ to see an available IP address and I ended up using 192.168.1.99
IPAddress ip(192, 168, 1, 99);  
  
// Replace with your Raspberry Pi IP Address. In my case, the RPi IP Address is 192.168.1.76
IPAddress server(192, 168, 1, 76);  
  
// Initializes the ethClient. You have to change the ethClient name if you have multiple ESPs running in your
// home automation system
EthernetClient ethClient;
PubSubClient client(ethClient);  
  
RCSwitch mySwitch = RCSwitch();  
  
// Defines the analog temperature pin for the LM335 temperature sensor
int tempAnalogPin = A0;
```

```

// Timers auxiliar variables
long now = millis();
long lastMeasure = 0;

// This functions is executed when some device publishes a message to a topic that your ESP8266 is
subscribed to
// Change the function below to add logic to your program, so when a device publishes a message to a topic
that
// your ESP8266 is subscribed you can actually do something
void callback(char* topic, byte* message, unsigned int length) {
    Serial.print("Message arrived on topic: ");
    Serial.print(topic);
    Serial.print(". Message: ");
    String messageTemp;

    for (int i = 0; i < length; i++) {
        Serial.print((char)message[i]);
        messageTemp += (char)message[i];
    }
    Serial.println();
    // Feel free to add more if statements to control more outlets with MQTT

    // If a message is received on the topic home/livingroom/arduino/outletX,
    // you check if the message is either 1 or 0. Turns the outlet according to the message
    if(String(topic)=="home/livingroom/arduino/outlet1"){
        Serial.print("Changing outlet 1 to ");
        if(messageTemp == "1"){
            mySwitch.send("000101010101000101010101");
            Serial.print("On");
        }
        else if(messageTemp == "0"){
            mySwitch.send("0001010101010001010100");
            Serial.print("Off");
        }
    }
    if(String(topic)=="home/livingroom/arduino/outlet2"){
        Serial.print("Changing outlet 2 to ");
        if(messageTemp == "1"){
            mySwitch.send("0001010101010001010101");
            Serial.print("On");
        }
        else if(messageTemp == "0"){
            mySwitch.send("00010101010100010100");
            Serial.print("Off");
        }
    }
    Serial.println();
}

// This functions reconnects your Arduino to your MQTT broker
// Change the function below if you want to subscribe to more topics with your Arduino
void reconnect() {
    // Loop until we're reconnected
    while (!client.connected()) {
        Serial.print("Attempting MQTT connection...");
        // Attempt to connect
        if (client.connect("arduinoClient")) {

```

```

Serial.println("connected");
// Subscribe or resubscribe to a topic
// You can subscribe to more topics (to control more LEDs in this example)
client.subscribe("home/livingroom/arduino/outlet1");
client.subscribe("home/livingroom/arduino/outlet2");
} else {
Serial.print("failed, rc=");
Serial.print(client.state());
Serial.println(" try again in 5 seconds");
// Wait 5 seconds before retrying
delay(5000);
}
}

// The setup function sets your Arduino pins as a transmitter, starts the serial communication at a baud rate
of 57600
// Sets your mqtt broker and sets the callback function. The callback function is what receives messages and
// actually controls the LEDs. Finally starts the Ethernet communication
void setup()
{
mySwitch.enableTransmit(6);
// SET YOUR PULSE LENGTH
mySwitch.setPulseLength(REPLACE_WITH_YOUR_PULSE_LENGTH);

// SET YOUR PROTOCOL (default is 1, will work for most outlets)
mySwitch.setProtocol(REPLACE_WITH_YOUR_PROTOCOL);

// Set number of transmission repetitions.
mySwitch.setRepeatTransmit(15);

Serial.begin(57600);

client.setServer(server, 1883);
client.setCallback(callback);

Ethernet.begin(mac, ip);
// Allow the hardware to sort itself out
delay(1500);
}

// For this project, you don't need to change anything in the loop function.
// Basically it ensures that your Arduino is connected to your broker
void loop(){
if (!client.connected()) {
reconnect();
}
if(!client.loop())
client.connect("ethClient");
now = millis();
// Publishes new temperature and humidity every 10 seconds
if (now - lastMeasure > 10000) {
lastMeasure = now;

// Reads analog pin and computes temperature values in Kelvin
int rawVoltage= analogRead(tempAnalogPin);
float millivolts= (rawVoltage/1024.0) * 5000;
float kelvin= (millivolts/10);
Serial.print(kelvin);
}
}

```

```

Serial.println(" degrees Kelvin");

// Converts temperature in Kelvin to Celsius, you can comment
// and uncomment the lines below if you prefer Fahrenheit temperature
float celsius = kelvin - 273.15;
Serial.print(celsius);
Serial.println(" degrees Celsius");
static char temperatureTemp[7];
dtostrf(celsius, 6, 2, temperatureTemp);

// Uncomment to convert temperature in Kelvin to Fahrenheit
/*
float fahrenheit = (((kelvin - 273.15) * 9)/5 +32);
Serial.print(fahrenheit);
Serial.println(" degrees Fahrenheit");
static char temperatureTemp[7];
dtostrf(fahrenheit, 6, 2, temperatureTemp); */

// Publishes a new Temperature value
client.publish("home/livingroom/arduino/temperature", temperatureTemp);
}

```

DOWNLOAD SOURCE CODE

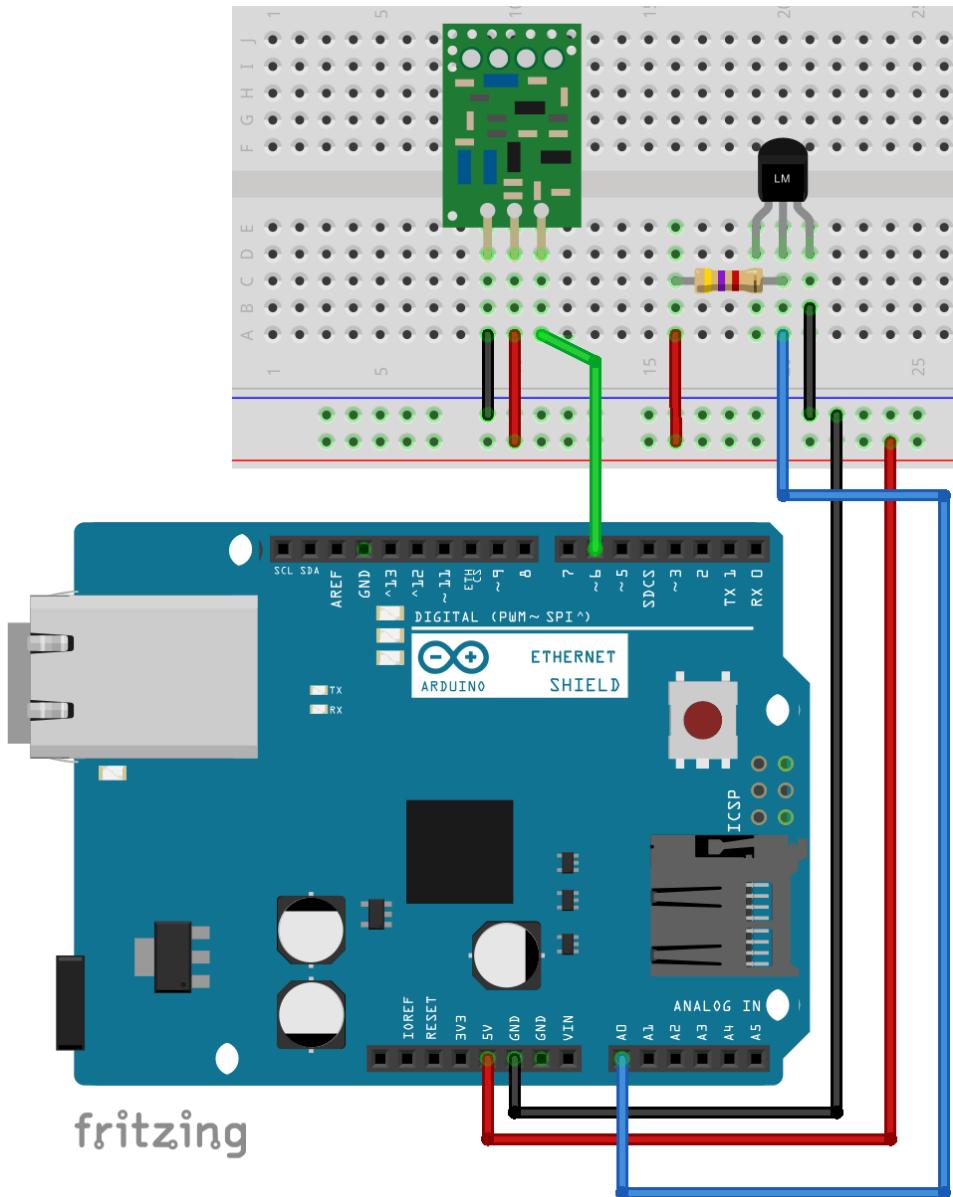
https://github.com/RuiSantosdotme/Home-Automation-Course/blob/master/code/v2/mqtt_arduino_temperature.ino

Schematics

To complete this Unit you need:

- [Arduino UNO](#)
- [Ethernet Shield \(W5100\)](#)
- [433MHz RF Transmitter](#)
- [Remote Controlled Outlets that operate at 433MHz](#)
- [LM335 Temperature Sensor](#)
- [4700 Ohm Resistor](#)

Here's the schematics:



Creating the Flow

In this flow, you're going to add a node **Chart** to plot the temperature values. Follow these next 6 steps to create your flow:

1 – Drag 2 nodes



2 – MQTT in node to receive temperature

Edit mqtt in node

Cancel Done

Server	localhost:1883	
Topic	home/livingroom/arduino/temperature	
QoS	2	
Name	home/livingroom/arduino/temperature	

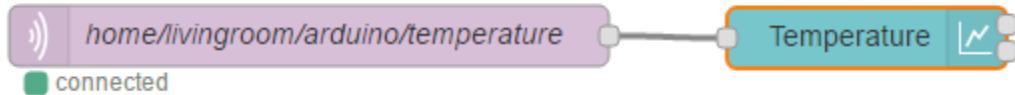
3 – Configure the Chart node

Edit chart node

Cancel Done

Group	Group 1 [Living Room]	
Size	auto	
Label	Temperature	
X-axis	last 1	hours
Y-axis	min	max
Interpolate	linear	
Blank label	display this text before valid data arrives	
Name	Temperature	

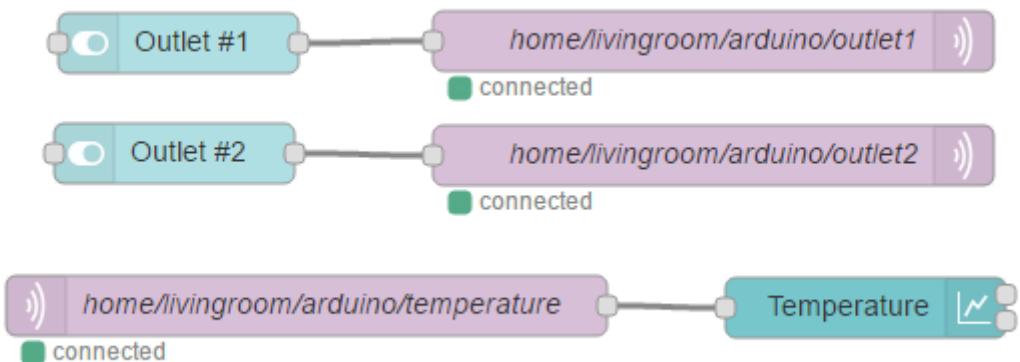
4 – Connect the nodes



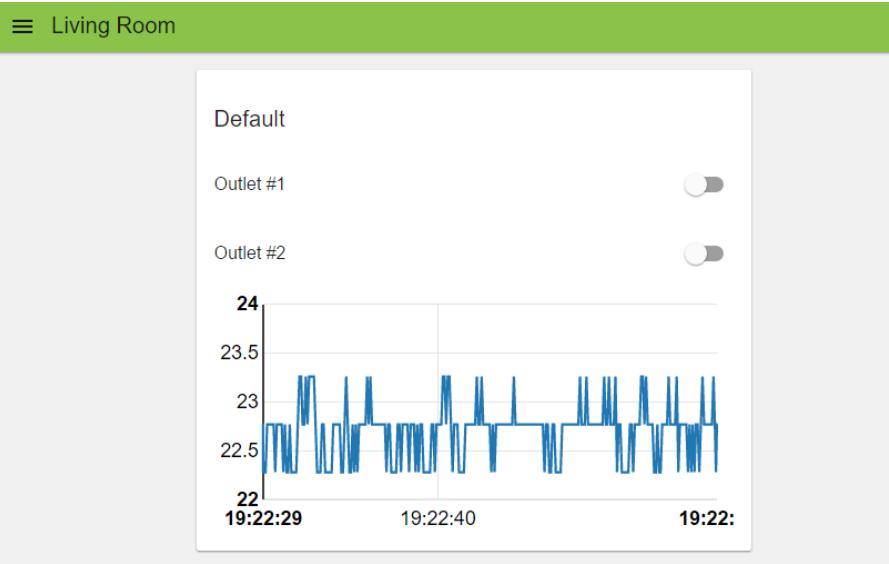
5 – Deploy your application



Final Flow

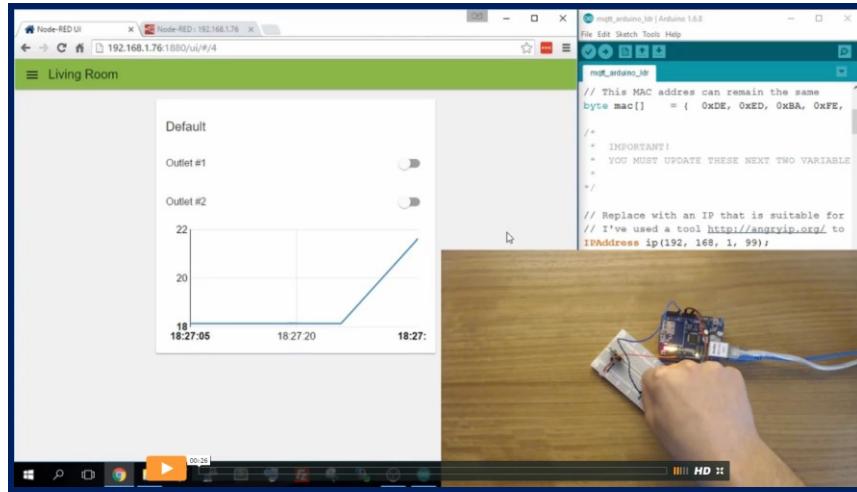


6 – Dashboard with the temperature chart



Watch the Video Demonstration

Now, you can see the temperature in your room displayed in a Chart. **Watch this video to see it in action:**



Video # 25 - <https://rntlab.com/watch-has-videos>

Unit 4 - Reading the Light Intensity

(You should keep the sketch, circuit and nodes from the previous Unit and add this new sensor to your project)

This Unit shows you how to use a light-dependent resistor to measure the light sensitivity in your room with an Arduino and how to publish those values to a gauge.

A light-dependent resistor (LDR) is a light-controlled variable resistor. The resistance of a photoresistor decreases with increasing incident light intensity.



Understanding How the Sketch Works

You can open this link or scroll down this page to see the complete sketch and follow along:

- https://github.com/RuiSantosdotme/Home-Automation-Course/blob/master/code/v2/mqtt_arduino_ldr.ino

Let's see how the new snippets of code work.

Preparing the variables

Assign the Analog pin A1 to the `LDRAnalogPin` variable.

```
// Defines the analog pin for the LDR
int LDRAnalogPin = A1;
```

This following variable is used to create a timer that checks the LDR value every few milliseconds.

```
long lastLDRCheck = 0;
```

loop

In the `loop()` function you keep checking every 1000 milliseconds the current value of the LDR sensor:

```
if ((now - lastLDRCheck) > 1000) {
```

If 1 second has passed since the last check, it reads the LDR value and publishes the value to the Node-RED Dashboard.

```
if ((now - lastLDRCheck) > 1000) {
    lastLDRCheck = now;
    int LDRValue = analogRead(LDRAnalogPin);
    Serial.print("LDR Value: ");
    Serial.println(LDRValue);

    static char LDRTemp[6];
    dtostrf(LDRValue, 5, 0, LDRTemp);

    // Publishes a new LDR value
    client.publish("home/livingroom/arduino/ldr", LDRTemp);
}
```

Uploading the Final Sketch

You can copy the final sketch to your Arduino IDE and upload it to your Arduino board (after adding the appropriate IP, the RPi IP address and the binary codes for your outlets).

```
****

All the resources for this project:  

https://rntlab.com/

****

// Loading the libraries
#include <SPI.h>
#include <Ethernet.h>
#include <PubSubClient.h>
#include <RCSwitch.h>

// This MAC address can remain the same
byte mac[] = { 0xDE, 0xED, 0xBA, 0xFE, 0xFE, 0xED };

/*
 * IMPORTANT!
 * YOU MUST UPDATE THESE NEXT TWO VARIABLES WITH VALUES SUITABLE TO YOUR NETWORK!
 *
```

```

*/
```

```

// Replace with an IP that is suitable for your network. I could use any IP in this range: 192.168.1.X
// I've used a tool http://angryip.org/ to see an available IP address and I ended up using 192.168.1.99
IPAddress ip(192, 168, 1, 99);
```

```

// Replace with your Raspberry Pi IP Address. In my case, the RPi IP Address is 192.168.1.76
IPAddress server(192, 168, 1, 76);
```

```

// Initializes the ethClient. You have to change the ethClient name if you have multiple ESPs running in your
home automation system
EthernetClient ethClient;
PubSubClient client(ethClient);
```

```

RCSwitch mySwitch = RCSwitch();
```

```

// Defines the analog temperature pin for the LM335 temperature sensor
int tempAnalogPin = A0;
```

```

// Defines the analog pin for the LDR
int LDRAnalogPin = A1;
```

```

// Timers auxiliar variables
long now = millis();
long lastMeasure = 0;
long lastLDRCheck = 0;
```

```

// This functions is executed when some device publishes a message to a topic that your ESP8266 is
subscribed to
// Change the function below to add logic to your program, so when a device publishes a message to a topic
that
// your ESP8266 is subscribed you can actually do something
void callback(char* topic, byte* message, unsigned int length) {
    Serial.print("Message arrived on topic: ");
    Serial.print(topic);
    Serial.print(". Message: ");
    String messageTemp;

    for (int i = 0; i < length; i++) {
        Serial.print((char)message[i]);
        messageTemp += (char)message[i];
    }
    Serial.println();
    // Feel free to add more if statements to control more outlets with MQTT

    // If a message is received on the topic home/livingroom/arduino/outletX,
    // you check if the message is either 1 or 0. Turns the outlet according to the message
    if(String(topic)=="home/livingroom/arduino/outlet1"){
        Serial.print("Changing outlet 1 to ");
        if(messageTemp == "1"){
            mySwitch.send("00010101010001010101");
            Serial.print("On");
        }
        else if(messageTemp == "0"){
            mySwitch.send("00010101010001010100");
            Serial.print("Off");
        }
    }
    if(String(topic)=="home/livingroom/arduino/outlet2"){

    }
}
```

```

Serial.print("Changing outlet 2 to ");
if(messageTemp == "1"){
    mySwitch.send("000101010101010001010101");
    Serial.print("On");
}
else if(messageTemp == "0"){
    mySwitch.send("000101010101010001010100");
    Serial.print("Off");
}
}
Serial.println();
}

// This functions reconnects your Arduino to your MQTT broker
// Change the function below if you want to subscribe to more topics with your Arduino
void reconnect() {
    // Loop until we're reconnected
    while (!client.connected()) {
        Serial.print("Attempting MQTT connection...");
        // Attempt to connect
        if (client.connect("arduinoClient")) {
            Serial.println("connected");
            // Subscribe or resubscribe to a topic
            // You can subscribe to more topics (to control more LEDs in this example)
            client.subscribe("home/livingroom/arduino/outlet1");
            client.subscribe("home/livingroom/arduino/outlet2");
        } else {
            Serial.print("failed, rc=");
            Serial.print(client.state());
            Serial.println(" try again in 5 seconds");
            // Wait 5 seconds before retrying
            delay(5000);
        }
    }
}

// The setup function sets your Arduino pins as a transmitter, starts the serial communication at a baud rate
// of 57600
// Sets your mqtt broker and sets the callback function. The callback function is what receives messages and
// actually controls the LEDs. Finally starts the Ethernet communication
void setup()
{
    mySwitch.enableTransmit(6);

    // SET YOUR PULSE LENGTH
    mySwitch.setPulseLength(REPLACE_WITH_YOUR_PULSE_LENGTH);

    // SET YOUR PROTOCOL (default is 1, will work for most outlets)
    mySwitch.setProtocol(REPLACE_WITH_YOUR_PROTOCOL);

    // Set number of transmission repetitions.
    mySwitch.setRepeatTransmit(15);

    Serial.begin(57600);

    client.setServer(server, 1883);
    client.setCallback(callback);
}

```

```

Ethernet.begin(mac, ip);
// Allow the hardware to sort itself out
delay(1500);
}

// For this project, you don't need to change anything in the loop function.
// Basically it ensures that your Arduino is connected to your broker
void loop(){
if (!client.connected()) {
  reconnect();
}
if(!client.loop())
  client.connect("ethClient");

now = millis();
// Publishes new temperature and humidity every 10 seconds
if (now - lastMeasure > 10000) {
  lastMeasure = now;

  // Reads analog pin and computes temperature values in Kelvin
  int rawVoltage= analogRead(tempAnalogPin);
  float millivolts= (rawVoltage/1024.0) * 5000;
  float kelvin= (millivolts/10);
  Serial.print(kelvin);
  Serial.println(" degrees Kelvin");

  // Converts temperature in Kelvin to Celsius, you can comment
  // and uncomment the lines below if you prefer Fahrenheit temperature
  float celsius = kelvin - 273.15;
  Serial.print(celsius);
  Serial.println(" degrees Celsius");
  static char temperatureTemp[6];
  dtostrf(celsius, 6, 2, temperatureTemp);

  // Uncomment to convert temperature in Kelvin to Fahrenheit
  /*
  float fahrenheit = (((kelvin - 273.15) * 9)/5 +32);
  Serial.print(fahrenheit);
  Serial.println(" degrees Fahrenheit");
  static char temperatureTemp[7];
  dtostrf(fahrenheit, 6, 2, temperatureTemp);*/

  // Publishes a new Temperature value
  client.publish("home/livingroom/arduino/temperature", temperatureTemp);
}

// Publishes new LDR value every 1000 milliseconds
if ((now - lastLDRCheck) > 1000) {
  lastLDRCheck = now;
  int LDRValue = analogRead(LDRAnalogPin);
  Serial.print("LDR Value: ");
  Serial.println(LDRValue);

  static char LDRTemp[7];
  dtostrf(LDRValue, 5, 0, LDRTemp);

  // Publishes a new LDR value
  client.publish("home/livingroom/arduino/ldr", LDRTemp);
}
}

```

DOWNLOAD SOURCE CODE

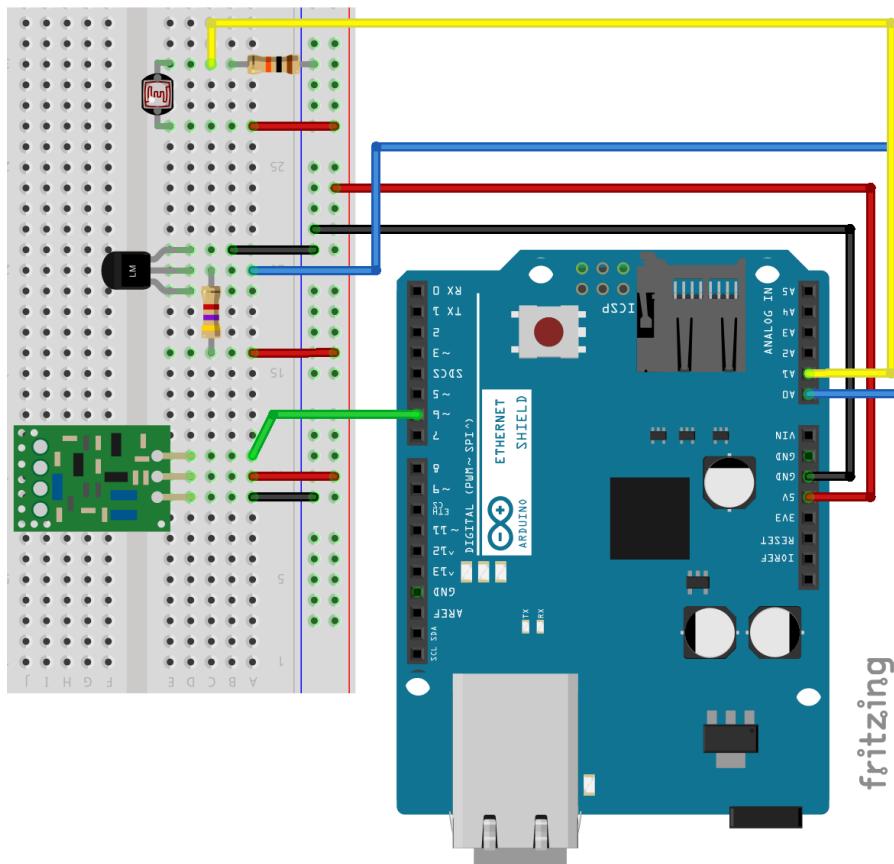
https://github.com/RuiSantosdotme/Home-Automation-Course/blob/master/code/v2/mqtt_arduino_ldr.ino

Schematics

To complete this Unit you need:

- [Arduino UNO](#)
- [Ethernet Shield \(W5100\)](#)
- [433MHz RF Transmitter](#)
- [Remote Controlled Outlets that operate at 433MHz](#)
- [LM335 Temperature Sensor](#)
- [4700 Ohm Resistor](#)
- [LDR](#)
- [10k Ohm Resistor](#)

Here's the schematics:



Creating the Flow

In this flow, you're going to add a Gauge to display the light intensity value in the Node-RED Dashboard. Follow these next 6 steps to create your flow:

1 – Drag 2 nodes



2 – Edit the MQTT in node

Edit mqtt in node

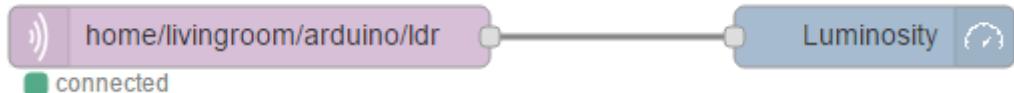
⌚ Server	localhost:1883	
MQTT Topic	home/livingroom/arduino/ldr	
🏷️ Name	Name	
<button>Ok</button> <button>Cancel</button>		

3 – Configure the Gauge node

Edit ui_gauge node

Tab	Living Room	
🏷️ Name	Luminosity	
Group		Order 4
Template	{{value}}	
Min	0	
Max	1000	
<button>Ok</button> <button>Cancel</button>		

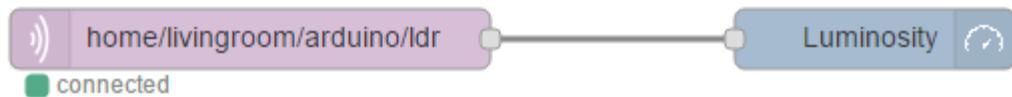
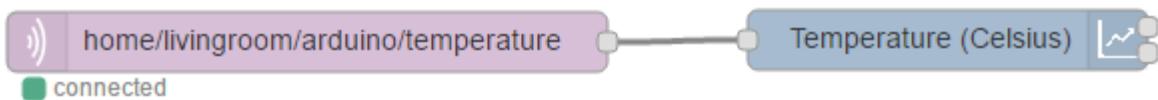
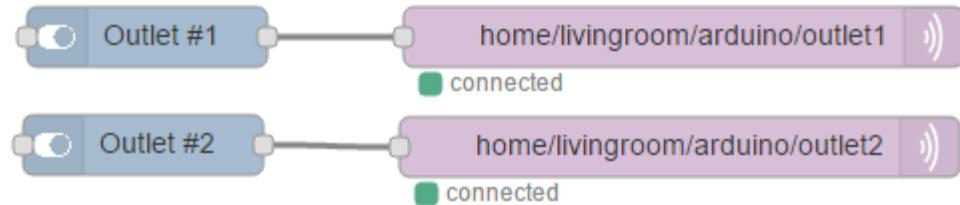
4 – Connect the nodes



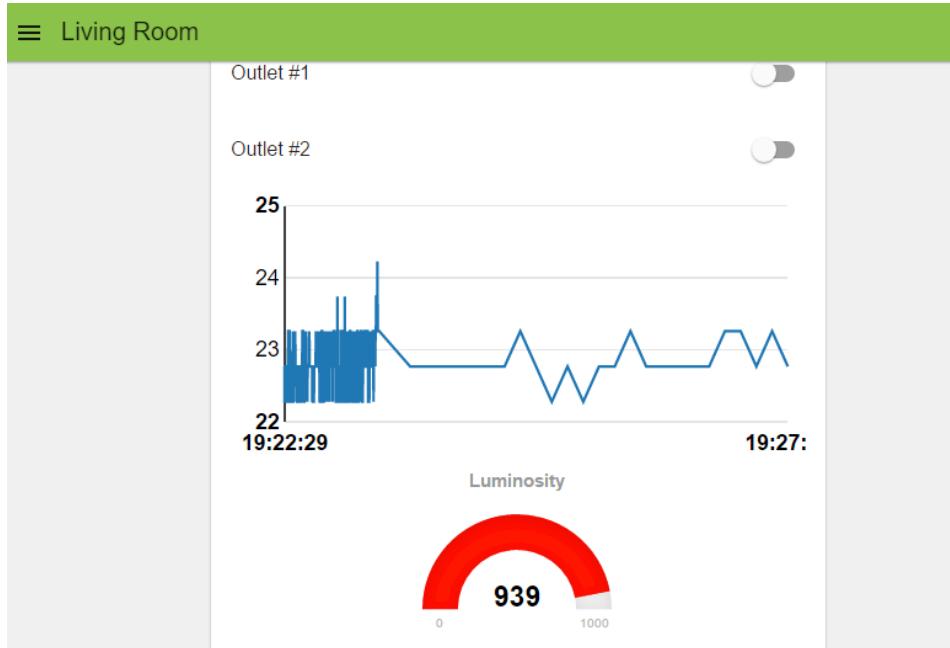
5 – Deploy your application



Final Flow

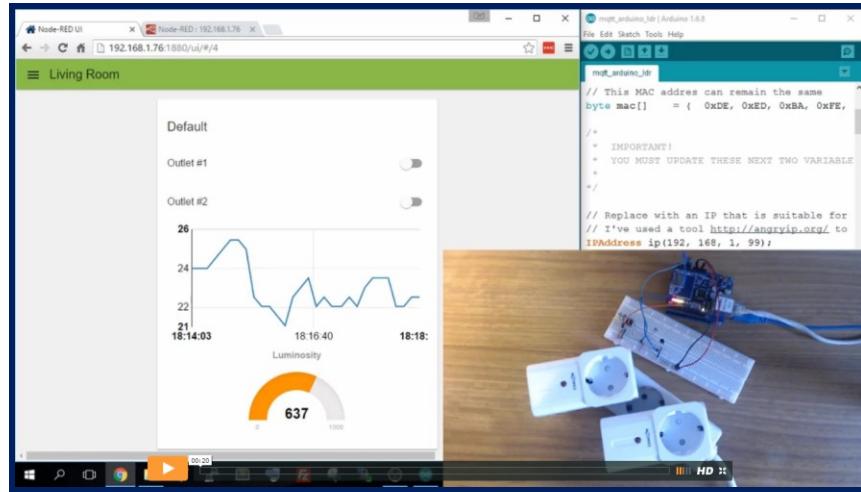


6 – Dashboard



Watch the Video Demonstration

Now, you can check the light intensity in your room displayed in a Gauge. Watch this video to see it in action:



Video # 26 - <https://rntlab.com/watch-has-videos>

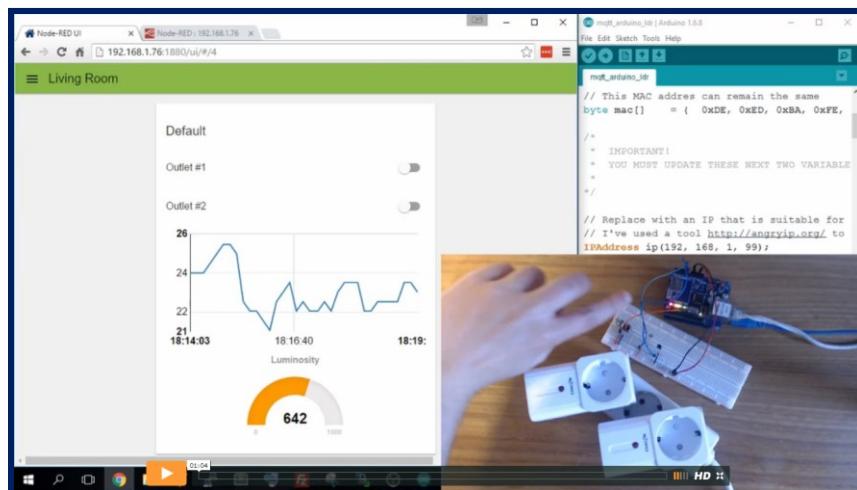
Unit 5 - Triggering Outlets with Temperature and Luminosity

(You should keep the sketch, circuit and nodes from the previous Unit and simply add this new nodes to your flow)

This Unit shows you how to trigger your outlets based on sensor values that you define. If a sensor reading goes below a certain threshold value, it automatically turns your light on or off.

Watch the Video Demonstration

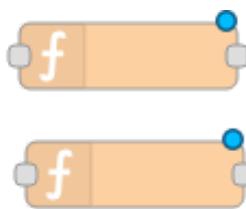
Watch this next video to see the outlets being triggered according to the light intensity in your room:



Video # 27 - <https://rntlab.com/watch-has-videos>

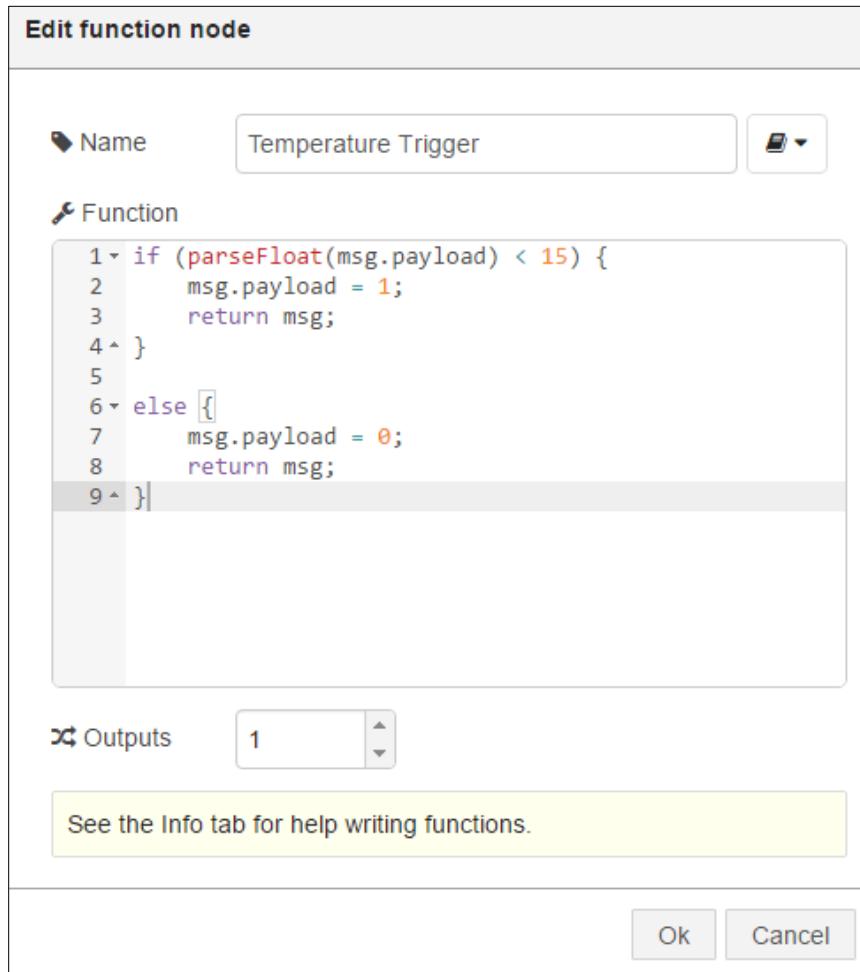
Creating the Flow

In this flow, you're going to turn your outlets on/off according to a threshold value. Start by dragging two **Function** nodes:



Temperature trigger

Double-click one of the **Function** nodes:

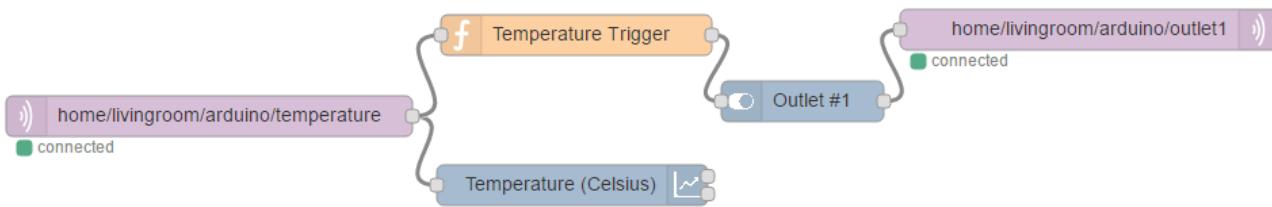


Add the following code in the function field (the value highlighted in red is the temperature threshold value):

```
if (parseFloat(msg.payload) < 15) {
    msg.payload = 1;
    return msg;
}
else {
    msg.payload = 0;
    return msg;
}
```

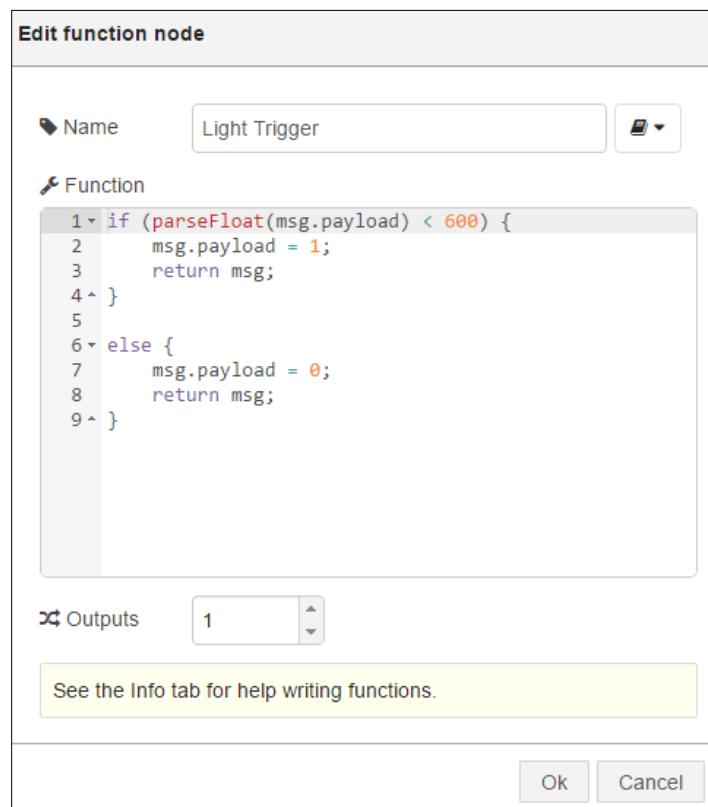
If the temperature reading goes under **15** degrees, it will automatically turn the outlet on. You can attach a heater to that outlet that will be on for as long as the temperature in your room is under **15** degrees.

Connect your nodes as follows:



Light trigger

Double-click the other **Function** node:



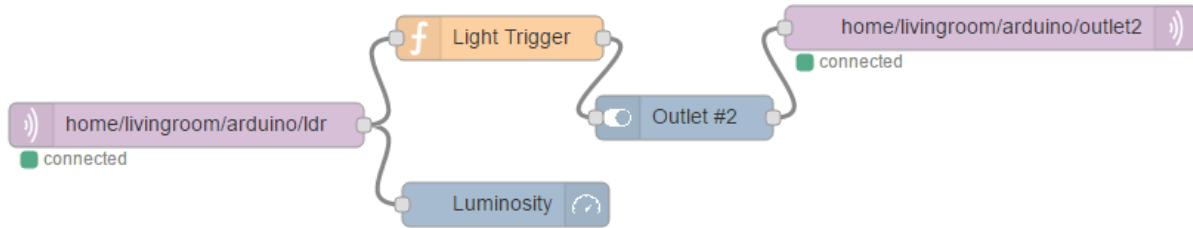
Add the following code in the function field (the value highlighted in red is the light threshold value):

```
if (parseFloat(msg.payload) < 600) {  
    msg.payload = 1;  
    return msg;  
}  
else {  
    msg.payload = 0;  
    return msg;  
}
```

If the light intensity is below **600**, it will automatically turn the outlet on.

You can attach a lamp to the outlet, that will be on when there's no light in your room.

Connect your nodes as shown in the next figure:

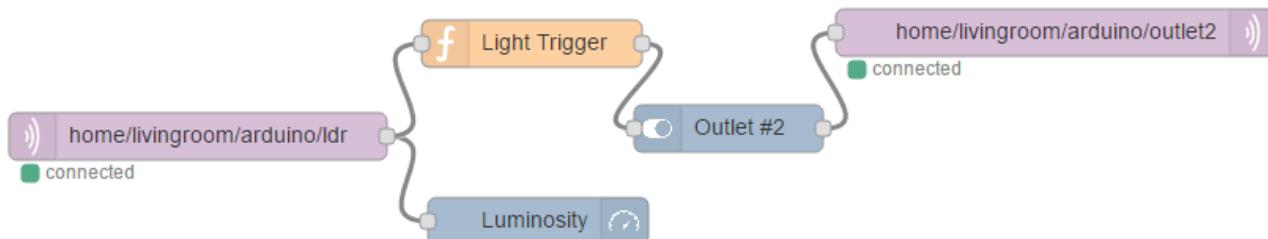
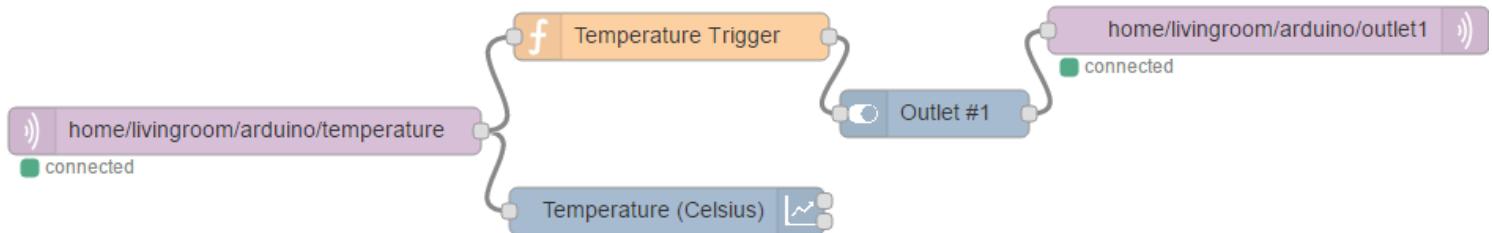


Deploying your application

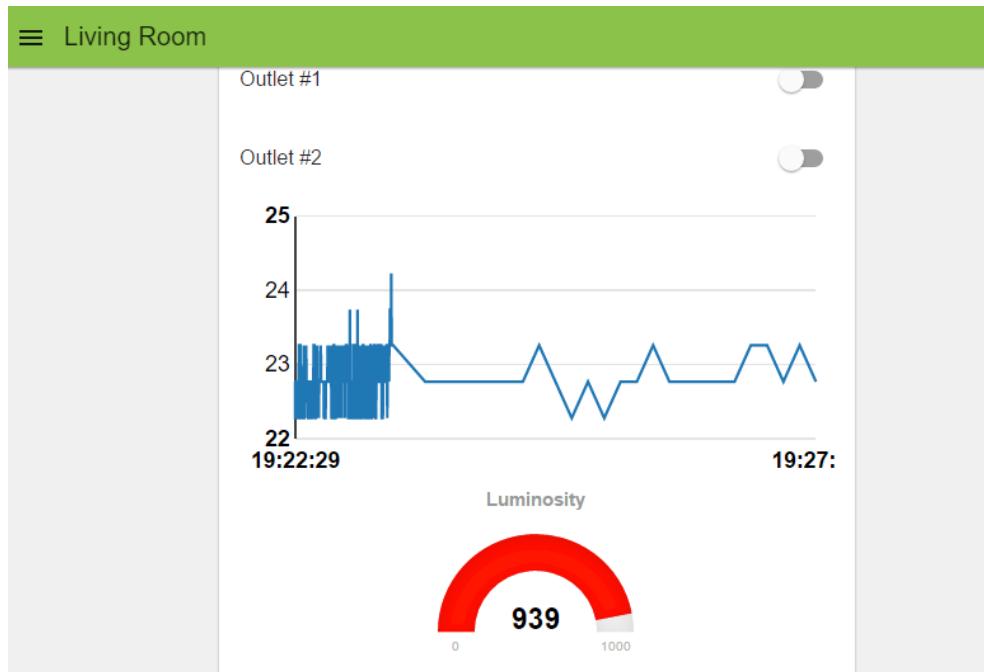
Click the **Deploy** button to save your application.



Here's how the final flow looks:

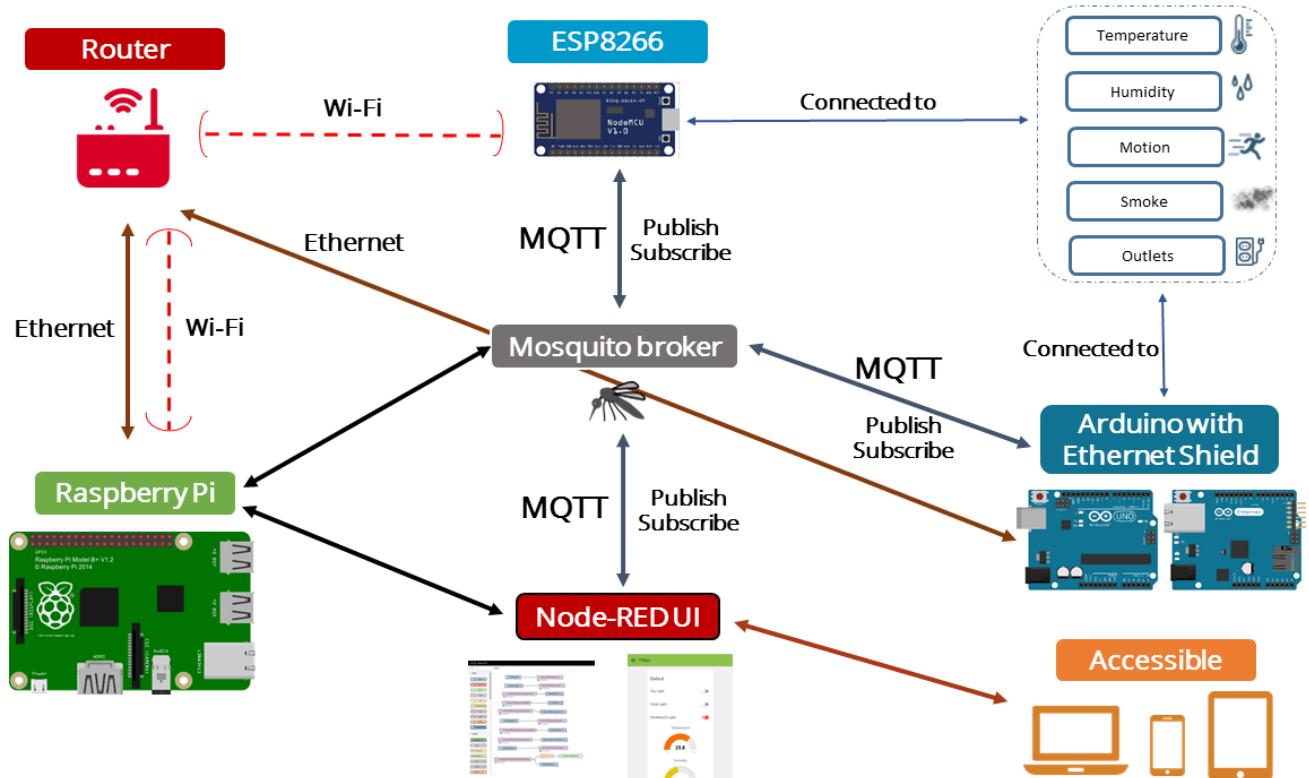


The Node-RED Dashboard keeps the same look from the previous Unit:



Final Diagram

To sum up, here's a diagram that illustrates how everything is connected:



The Arduino can:

- Control outlets
- Read the room temperature and plot those readings in a chart
- Read the light intensity
- Trigger events based on certain sensor readings

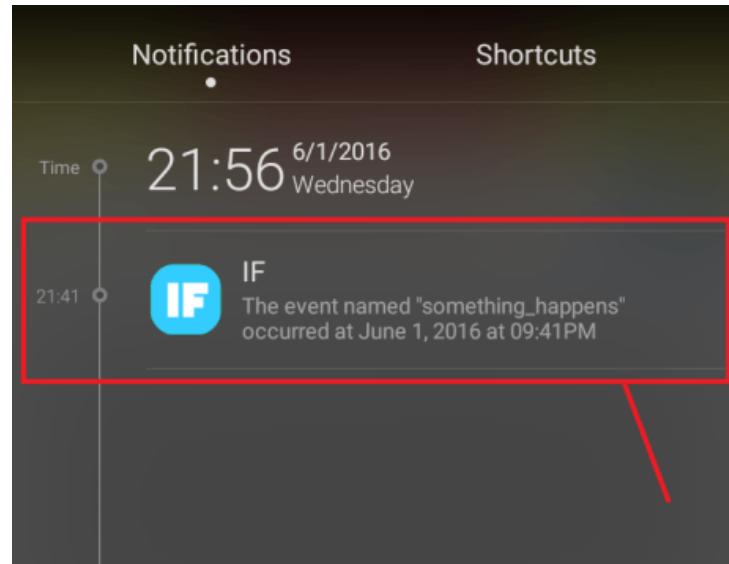
The ESP8266 can:

- Control outlets
- Read the temperature and humidity
- Check the room for smoke
- Detect motion and send email notifications

This course demonstrates how to add one Arduino and one ESP8266 to your Home Automation system. However, you can add as many as you want and extend this project to other rooms in your home.

MODULE 12

Adding Rules and Triggering Events



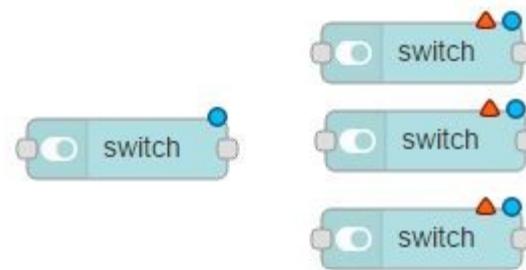
Unit 1 - Creating Master Switches or Modes

In any home automation system, it's useful to create specific modes tailored for your home. For instance, it's handy to press a button that turns on/off all the lights in your home.

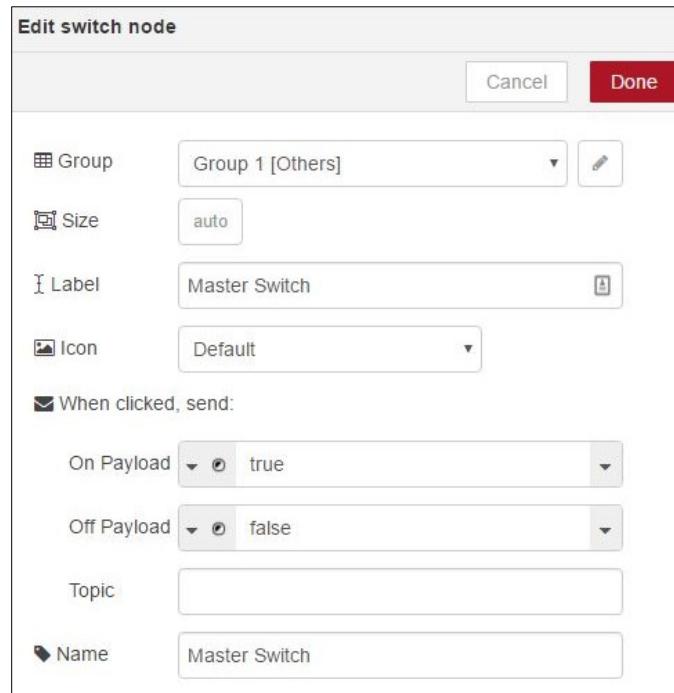
With Node-RED this can be accomplished with what I call a master switch.

Creating Your Flow

First drag 4 **Switch** nodes to your flow:



Open the configuration for one of the **Switches** and call it **Master Switch**.



In this example, I'll be controlling 3 switches. So, I've created 3 other test **Switches** with the following configurations.

For **Switch #1**:

Edit switch node

Cancel Done

Group: Group 1 [Others]

Size: auto

Label: Switch #1

Icon: Default

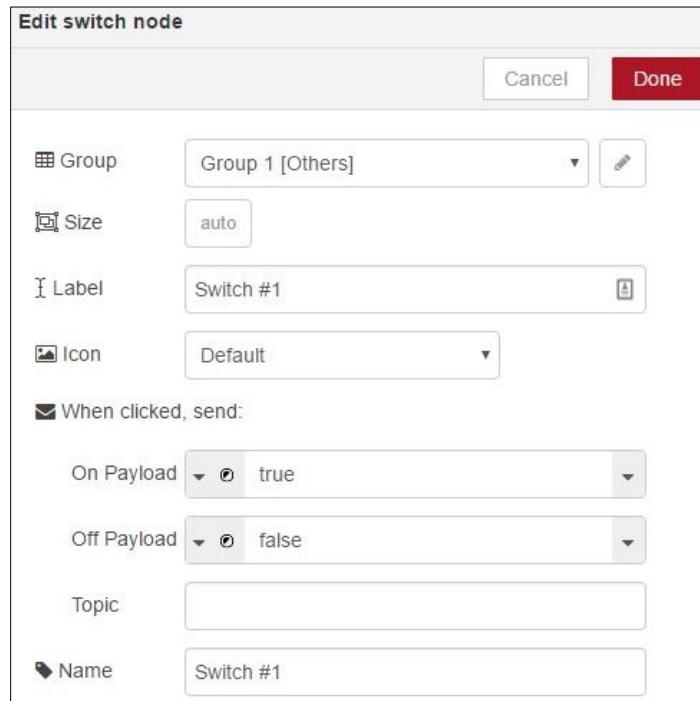
When clicked, send:

On Payload: true false

Off Payload: false true

Topic:

Name: Switch #1



For **Switch #2**:

Edit switch node

Cancel Done

Group: Group 1 [Others]

Size: auto

Label: Switch #2

Icon: Default

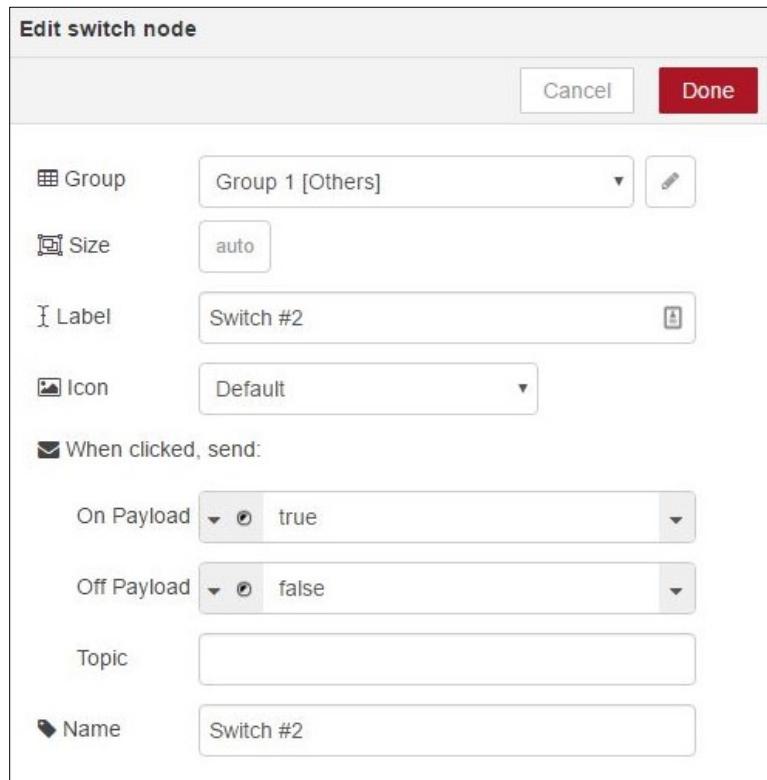
When clicked, send:

On Payload: true false

Off Payload: false true

Topic:

Name: Switch #2



For **Switch #3**:

Edit switch node

Cancel Done

Group: Group 1 [Others]

Size: auto

Label: Switch #3

Icon: Default

When clicked, send:

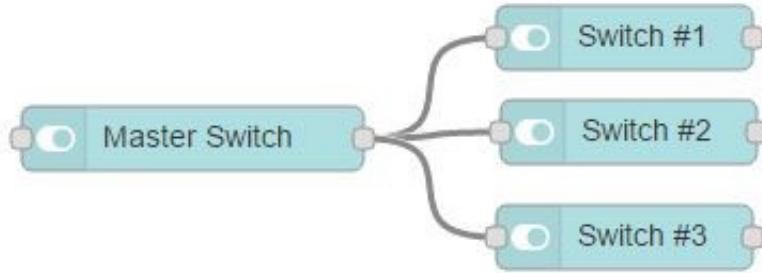
On Payload: true

Off Payload: false

Topic:

Name: Switch #3

Finally, you connect your Master Switch to all the other **Switch** nodes that you want to control, as shown in the following figure:

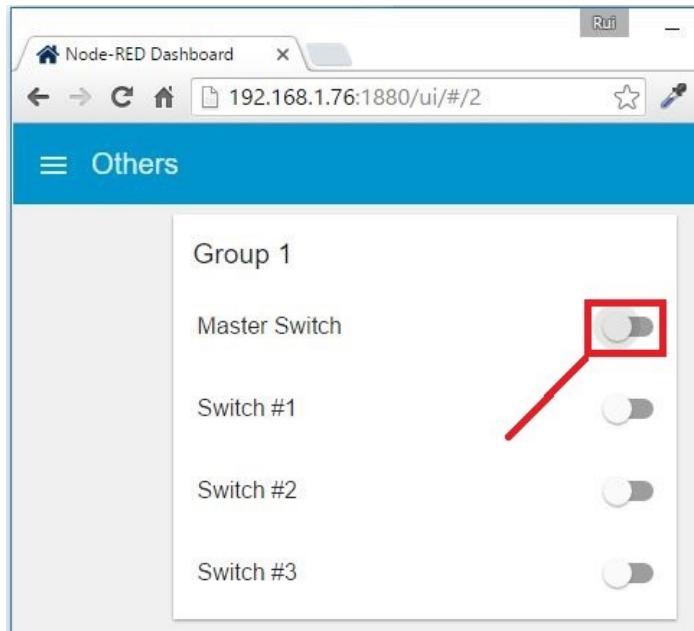


Deploy your application:

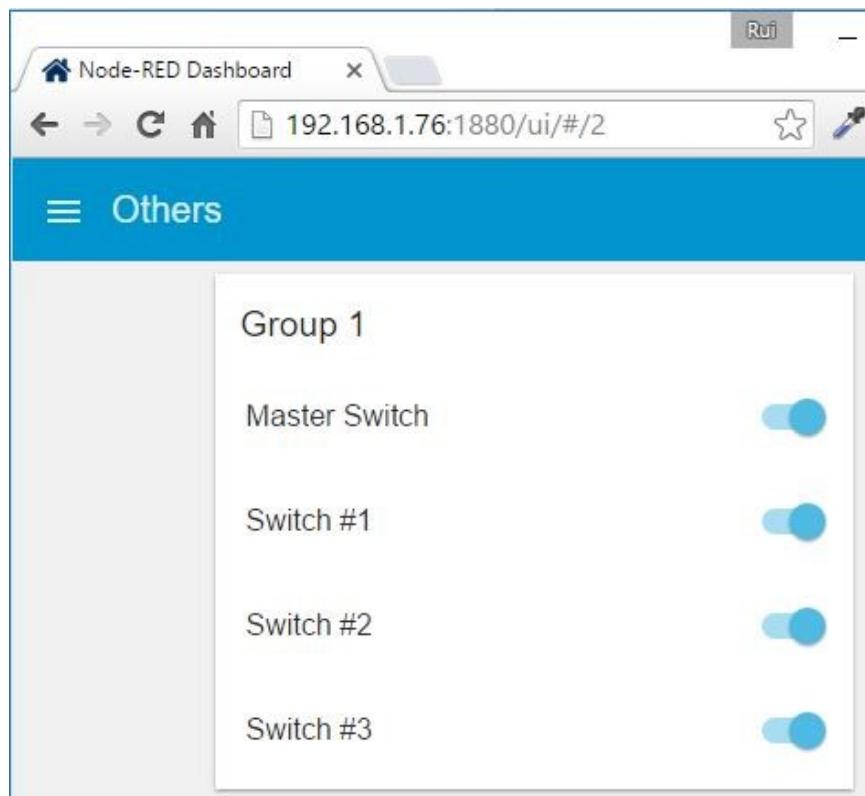


Testing the Master Switch

Open the Node-RED Dashboard tab. If you press the **Master Switch**, you can instantly control all the other **Switches**.



If you press on, it turns on all the other **Switches**.



When you press the **Master Switch** off, it turns off all the other **Switches**.

Note: you can control each **Switch** individually.

This basic concept can be extended to create what I call modes, for example:

- Morning mode: opens your window blinds and disarms the motion sensor
- Evening mode: turns on the living room light, kitchen light and your office light
- Night mode: turns off all lights and arms the motion sensor
- Away mode: turns off all lights and arms the motion sensor

In the next Unit, you're going to learn how you can trigger these modes or any Node-RED node automatically with time-based events.

Unit 2 - Triggering Time-based Events

Having a great home automation system means that you should be able to make something happen without having to touch a single button.

There are certain routines in your home that could be automated. Turning on/off your lights at a certain time, arming/disarming your motion sensor, etc...

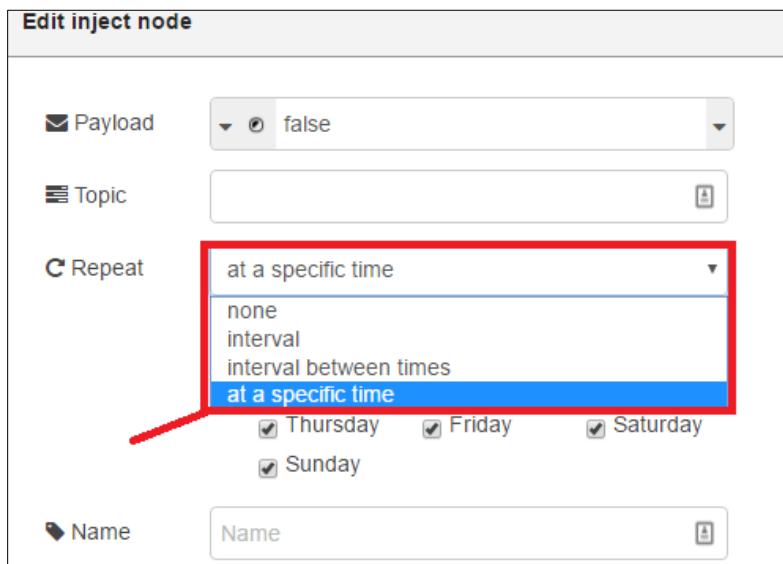
In this Unit, you're going to create events that can occur in a certain day at a specific time. You should add time-based triggers to your home automation system to meet your specific needs.

Creating Your Flow

In this flow, drag 3 nodes: 2 **Inject** nodes and 1 **Switch** node.

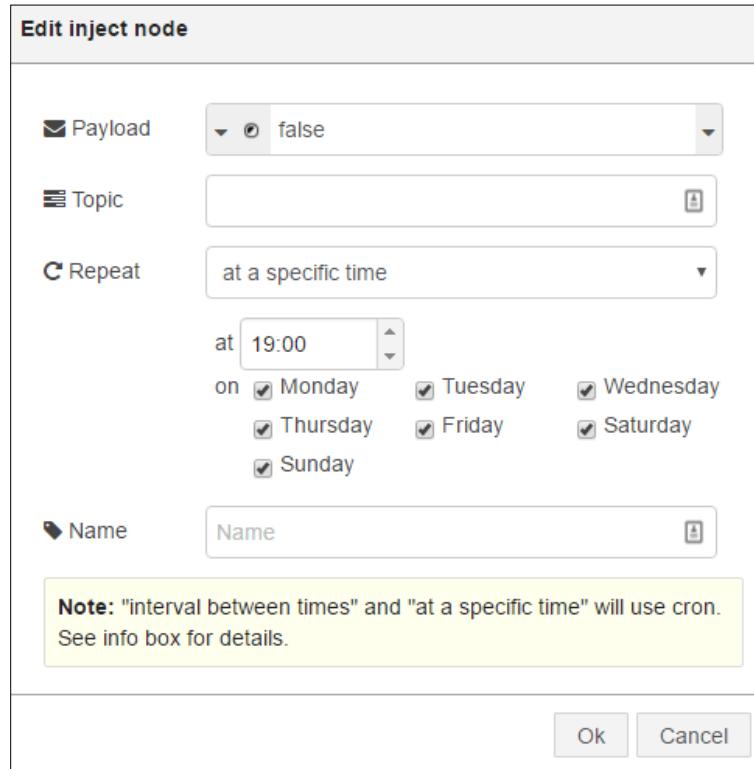


The **Inject** node has a great feature that I haven't covered. It's called "Repeat" and you can set the **Inject** node to be automatically triggered "at a specific time".

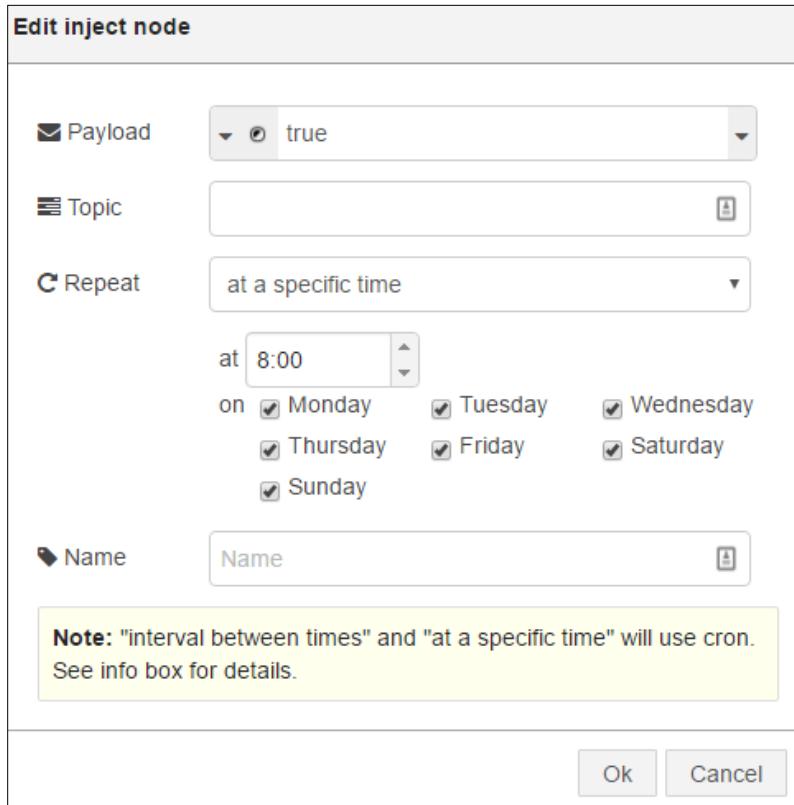


Warning: you should have your Raspberry Pi time zone properly configured. Read the extra Unit called: "Change the Time Zone on Raspberry Pi with Raspbian".

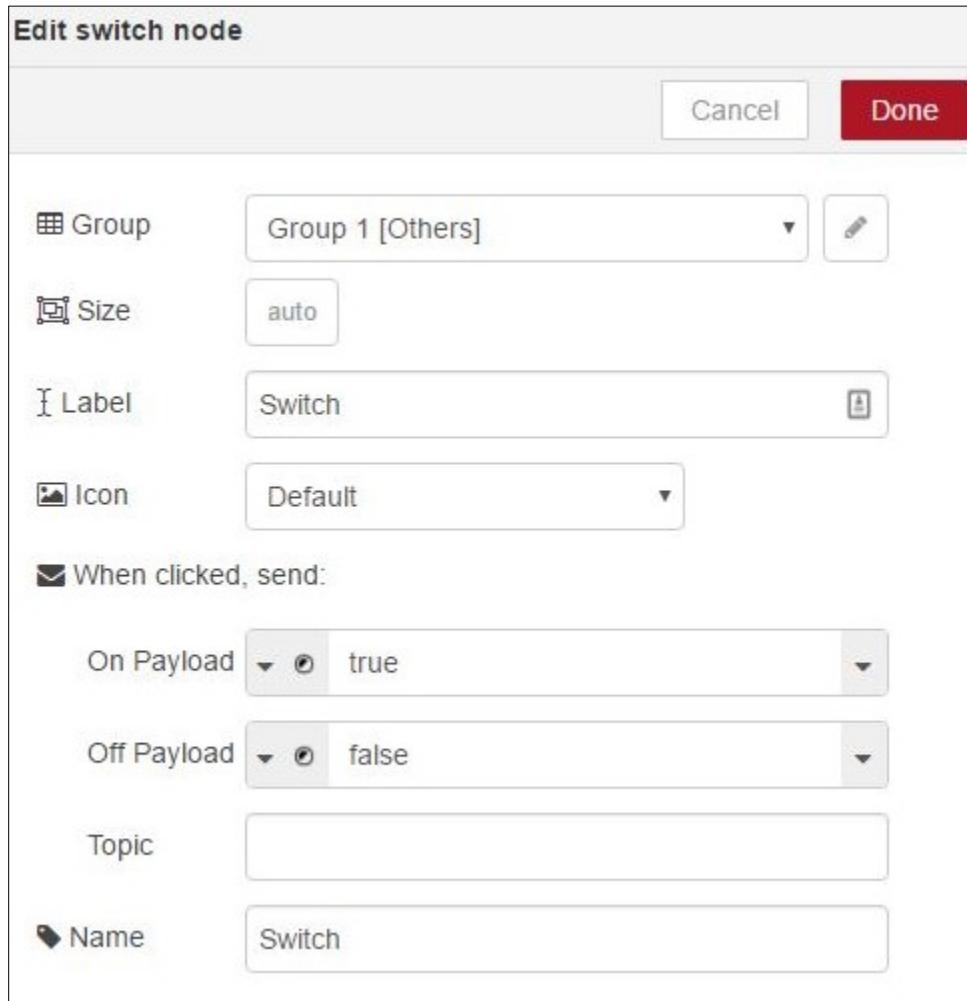
In my case, I'll be setting the **Inject** node to trigger the **false** value everyday at 19:00 (that's 7PM).



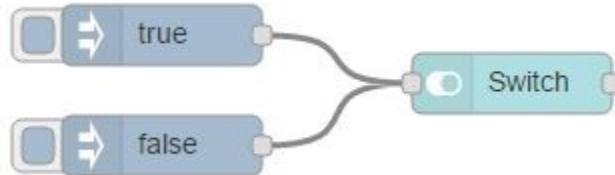
For the other **Inject** node, it will trigger the **true** value everyday at 8:00 (that's 8AM).



Finally, you add a **Switch** node to a Node-RED Dashboard tab:



Connect your 3 nodes as shown in the following figure:

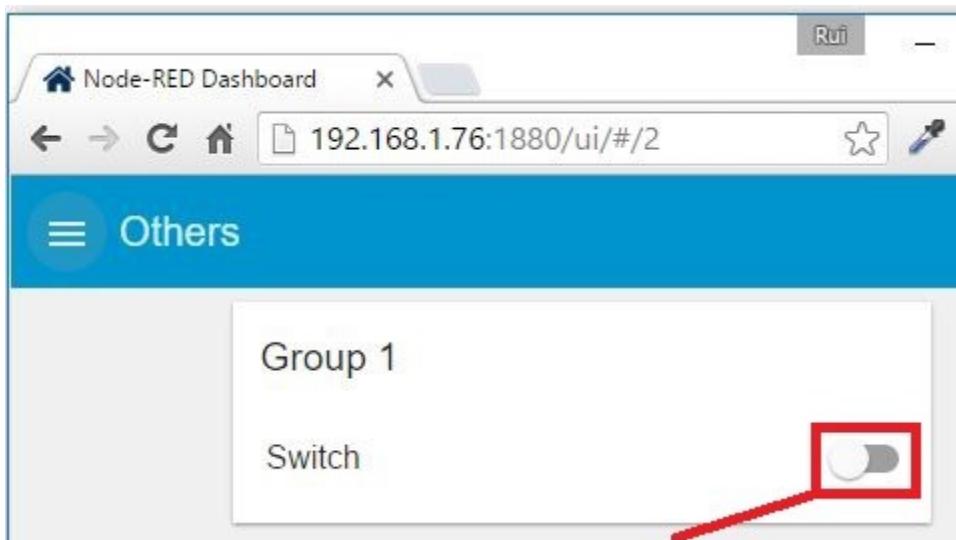


Deploy your application.

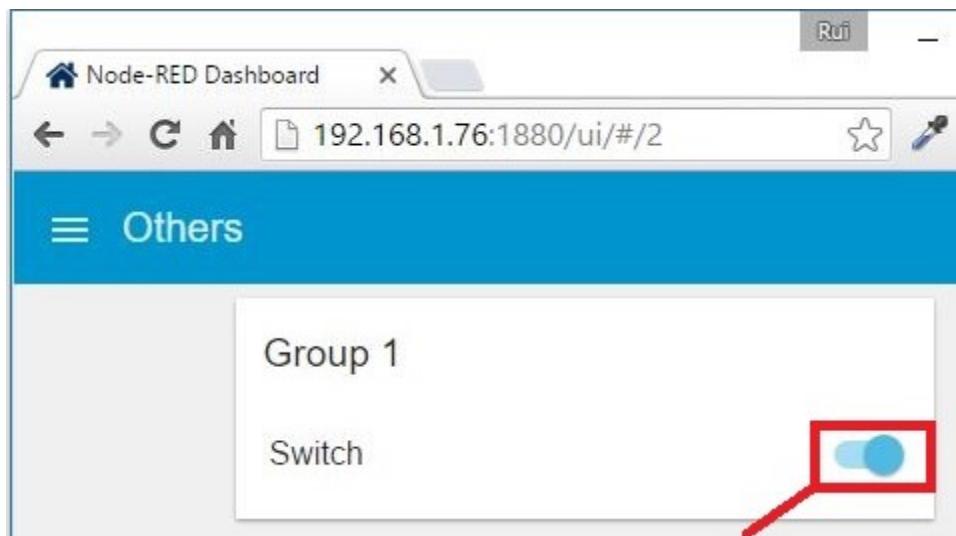


Testing the Flow

The **Switch** node starts off by default. When it reaches 19:00 (that's 7PM).



It will automatically turn on your **Switch**.



Your **Switch** will be automatically turned off at 8:00 (8AM).

This exact same concept can be applied to:

- Control outlets at a certain day and hour
- Arm or disarm sensors
- Trigger notifications or reminders
- Control master switches
- Anything that is time-based

Unit 3 - Sending Notifications to All Your Mobile Devices

In this Unit you're going to send notifications to all your mobile devices with Node-RED.

In order to accomplish this task you have to sign up for a free service called IFTTT which stands for "If This Then That".

IFTTT is a platform that gives you creative control over dozens of products and apps.

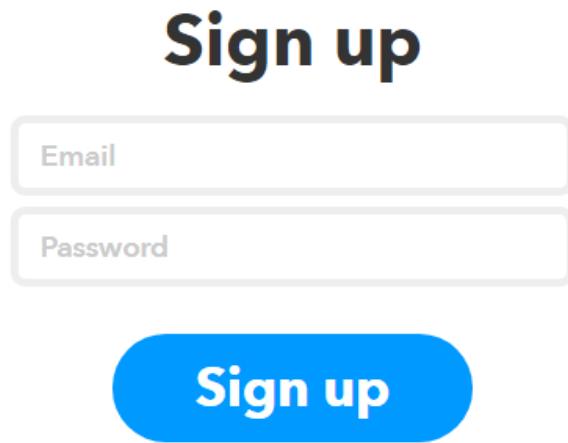
You can make apps work together. For example, when you send a request to IFTTT, it triggers an Applet that sends an email alert or notification.

Creating Your IFTTT Account

Creating an account on IFTTT is free!

Go the official site: <https://ifttt.com> and click the "Sign Up" button in the middle of the page.

Complete the form with your information (see figure below) and create your account.



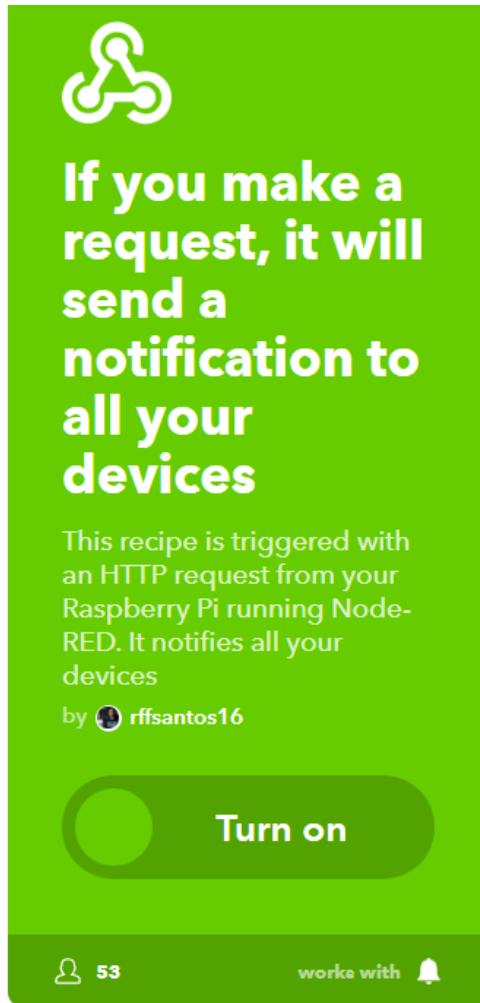
After creating your account, follow their getting started tutorial.

Open the Applet

I've created an Applet that you can use that integrates perfectly in this project. If you're logged in at IFTTT and you open this URL:

<https://ifttt.com/applets/425179p-if-you-make-a-request-it-will-send-a-notification-to-all-your-devices>

Press the “Turn on” button:



Next, you need to grant access permissions:

IFTTT needs permission to access:



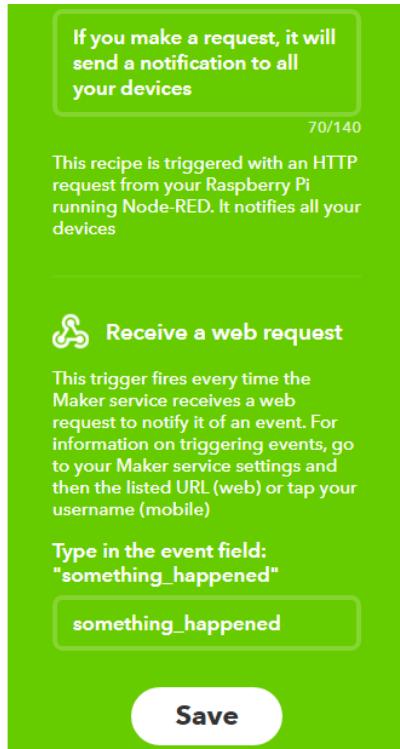
Maker Webhooks

Grant access permission to your IFTTT account. A new page loads when you press the “Ok” button.

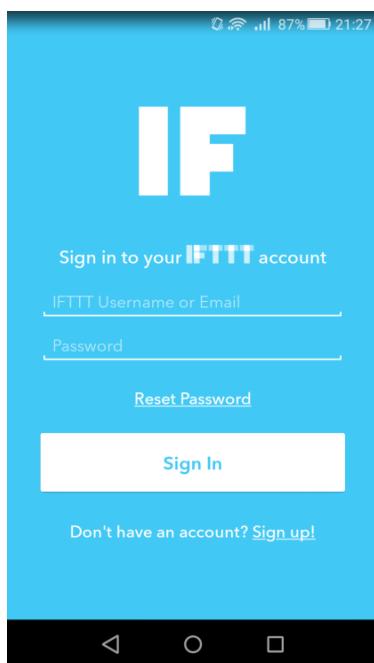
Complete the Applet

Fill the Applet with your own information. Follow these instructions:

- 1) Type “**something_happened**” without the quotes in your event field name

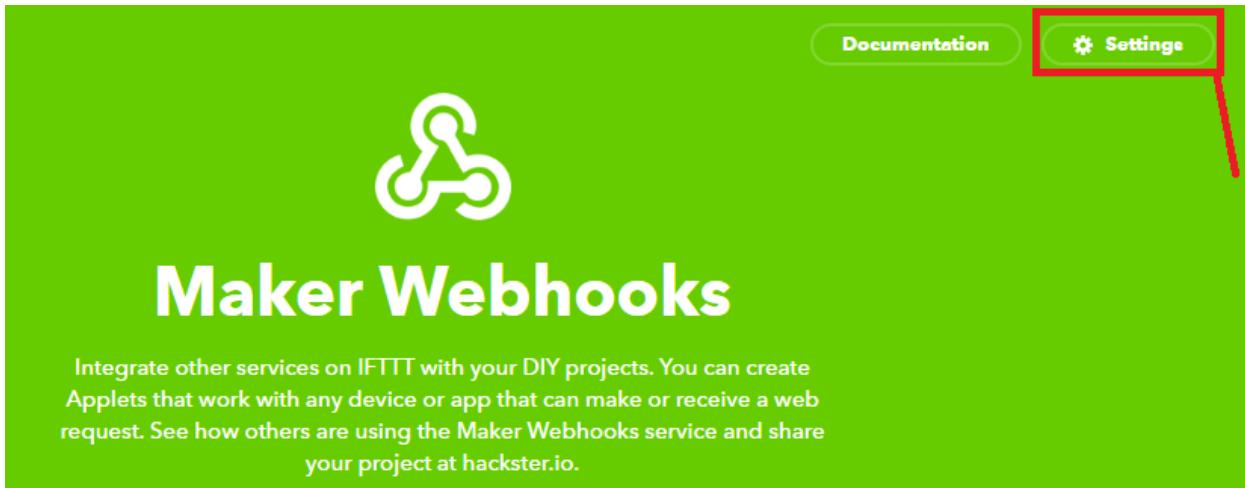


- 2) Go to the [Google Play Store](#) or [App Store](#), install the IFTTT app in your smartphone and sign in with your account.



Testing Your Applet

Now, go to this URL: https://ifttt.com/maker_webhooks and open the "Settings" tab.



Copy your secret key to a safe place (you'll need them later in this Unit). In my example, my secret key is: **b6eDdHYbIEv2Sy32qLwe**



Maker Webhooks settings

[View activity log](#)

Account Info

Connected as: rffsantos16

URL: <https://maker.ifttt.com/use/b6eDdHYbIEv2Sy32qLwe>

Status: **active**

[Edit connection](#)

Testing Your Applet

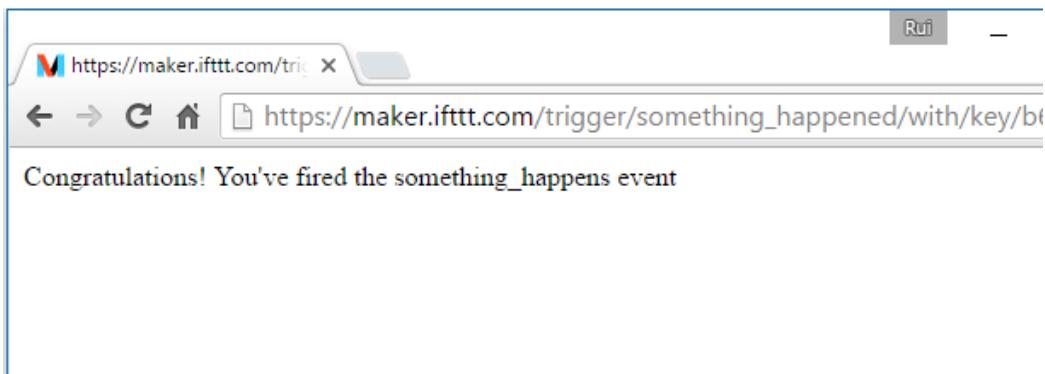
Let's test if your request is working properly. Replace YOUR_API_KEY from the following URL:

https://maker.ifttt.com/trigger/something_happened/with/key/YOUR_API_KEY

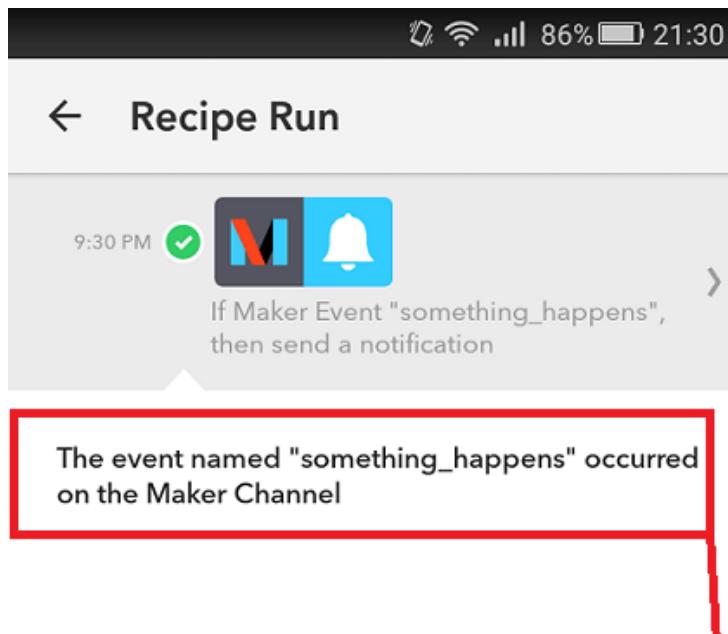
With your **API KEY**:

https://maker.ifttt.com/trigger/something_happened/with/key/b6eDdHYbIEv2Sy32qLwe

Open your URL with your API KEY in your browser.



You should see something similar to the preceding figure. Then, go to your smartphone and a new notification should be there.

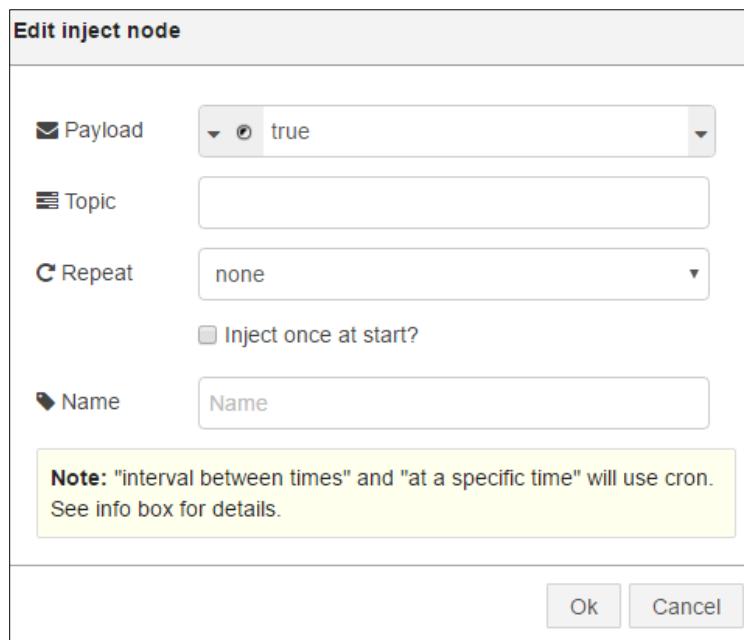


Creating Your Flow

In this flow, you're going to create a request to trigger the IFTTT notification with Node-RED. Drag 3 nodes to your flow: **Inject** node, **HTTP request** node and **Debug** node.

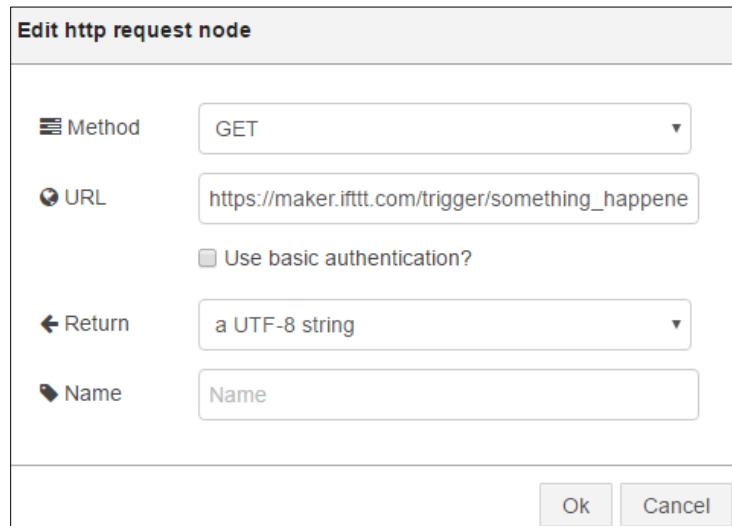


Double-click the **Inject** node and follow these instructions:

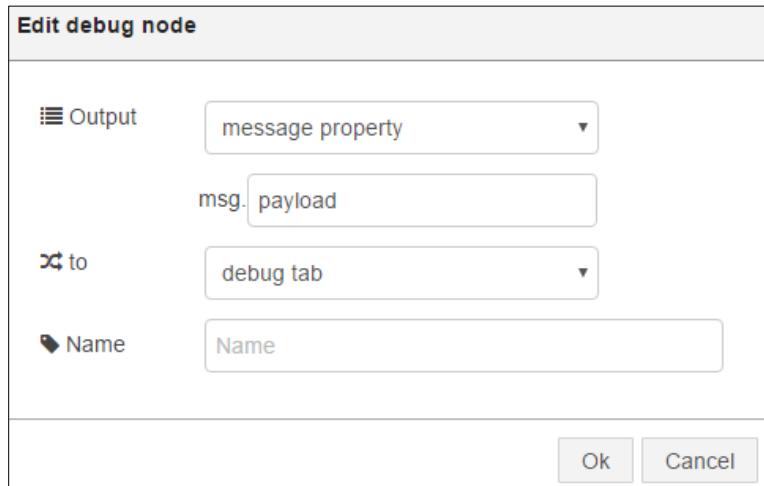


Edit the **HTTP request** node, select the **GET** in the method field and in the **URL** field enter (replace with your actual API key):

https://maker.ifttt.com/trigger/something_happened/with/key/YOUR_API_KEY



You can leave the default settings for the **Debug** node.



Connect the three nodes as shown in the following figure:

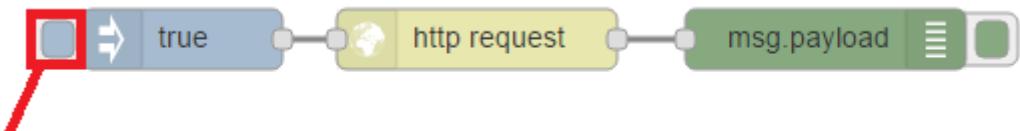


Deploy your application.



Triggering IFTTT Notifications

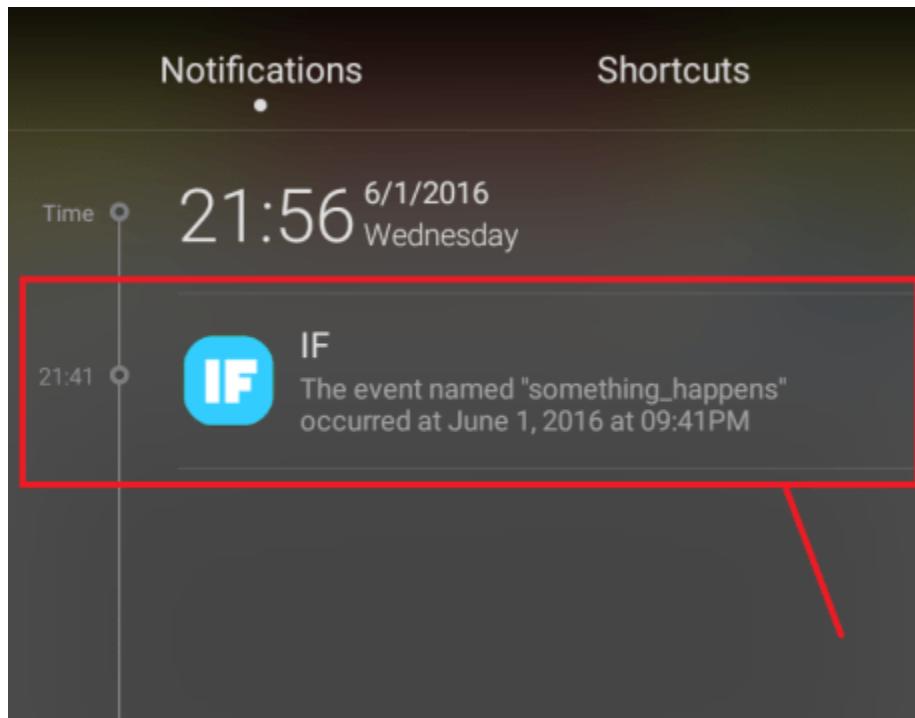
Press the square of the **Inject** node to trigger the flow:



In the **debug** window, you should see a message saying "Congratulations! You've fired...".



Your smartphone instantly receives a notification with the event name and when it happened:



This basic concept can be easily extended and applied to any sensor that you're monitoring in your home automation system. When something happens, you make a request to the IFTTT service to send a notification.

Unit 4 - Wrapping Up and Taking It Further

Congratulations for completing the course!

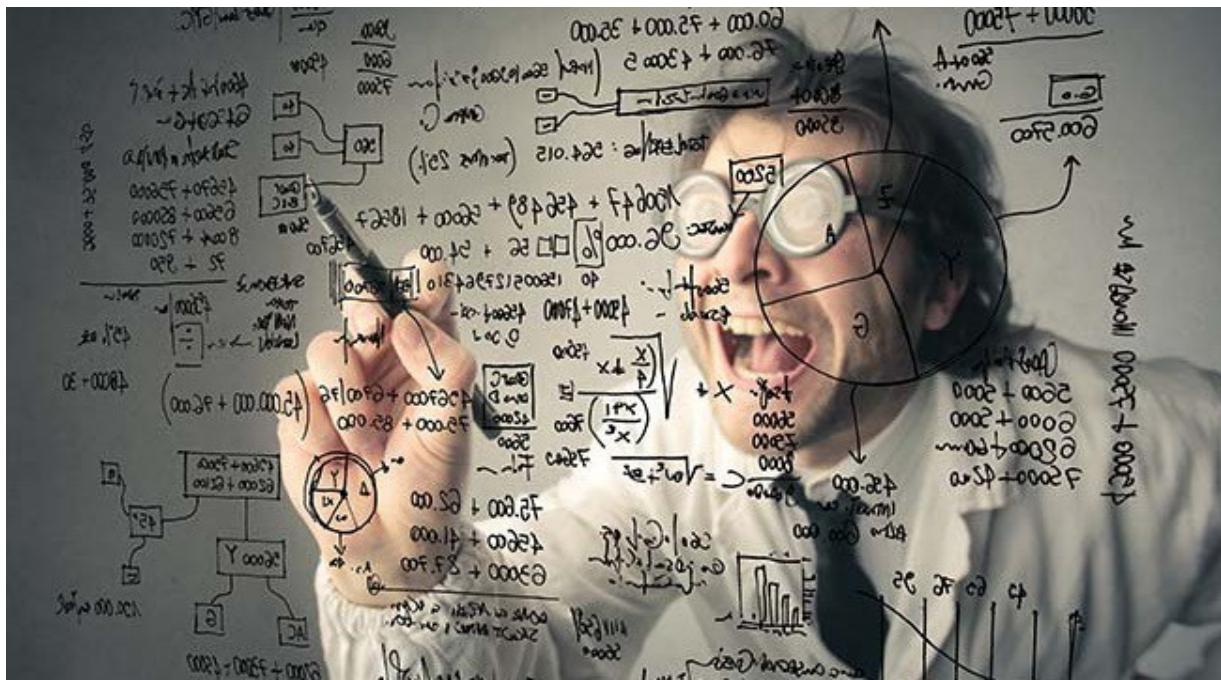
If you've followed all Modules presented throughout this course, you now have the knowledge to build your Home Automation system using the Raspberry Pi, ESP8266 and Arduino boards.

Wrapping Up

Let's see the main things that you've accomplished. You know how to:

- Use Raspberry Pi, ESP8266 and Arduino board
- Use Node-RED, Node-RED Dashboard and Linux commands
- Establish an MQTT connection with multiple devices in your network
- Control any device, outlet or lamp
- Read sensor data (temperature, humidity, luminosity and more)
- Trigger events based on sensor data
- Display your data in gauges and charts
- Build a smoke detection system
- Make a user interface password protected and accessible from anywhere in the world
- Build a motion detection system with email notifications
- Create time-based events
- Set modes for your home

It's Your Time to Experiment



Now, I encourage you to add multiple ESP8266s and Arduinos around your home and build up on the snippets of code presented in this course to fit your own projects and specific needs.

I honestly feel like we've covered all the important subjects, but there's always room for improvement and here's a handful of ideas:

- Surveillance camera
- Controlling TV with Arduino
- Voice commands recognition
- RFID door lock system
- RGB LED strip light controller
- Garage door controller
- Control window blinds

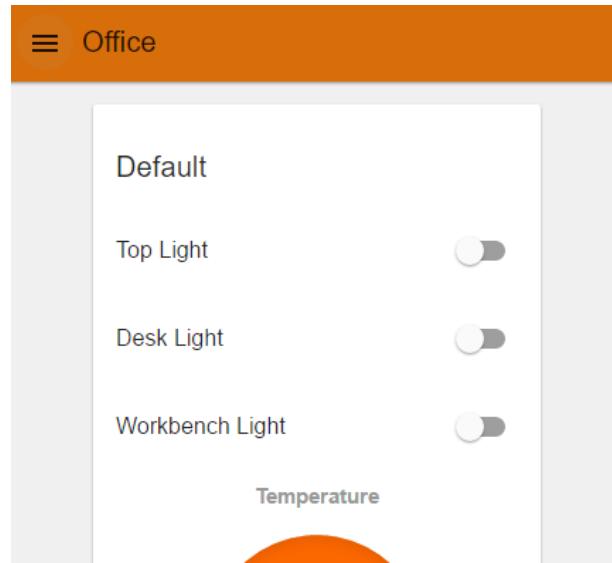
I hope you had fun following all these projects! If you have something you would like to share, let me know in the Facebook group ([join the Facebook group here](#)).

Good luck with all your projects,

-Rui Santos

MODULE 13

Extra #1 - Information that might be useful for this course

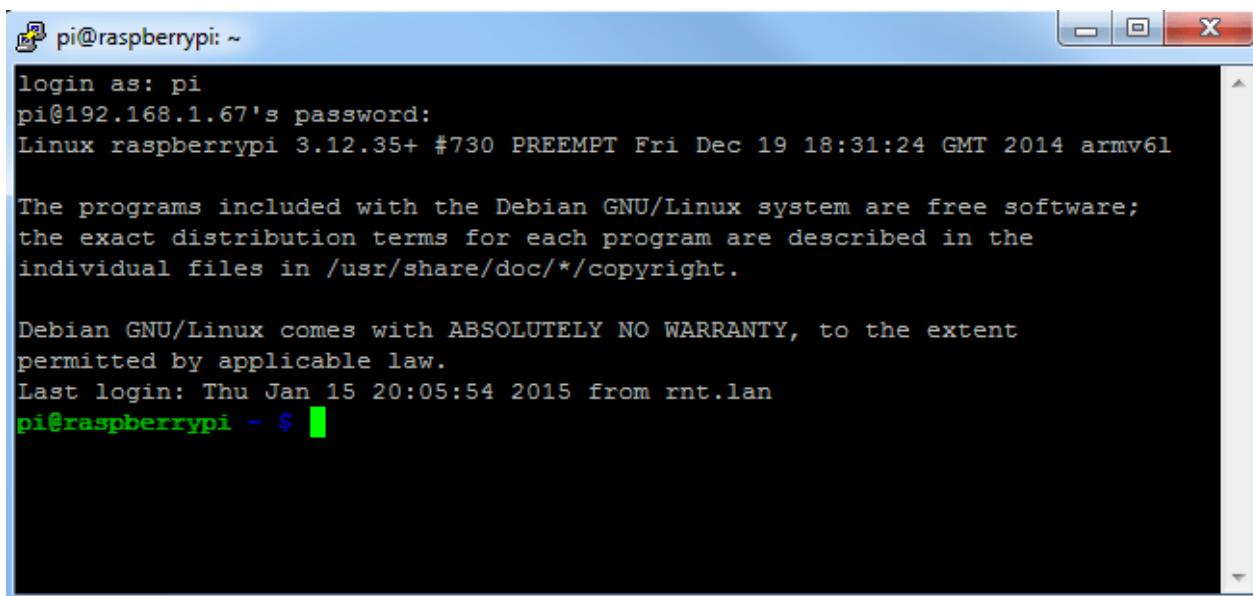


Unit 1 - How to Configure WiFi on Your Raspberry Pi

Here's how to configure WiFi on your Raspberry Pi through the command line.

1) Establish an SSH communication with your Pi

Boot your Raspberry Pi with the WiFi adapter plugged in. You also need to connect Ethernet cable connection to ensure that you can open an SSH client like PuTTY to establish an SSH communication.



```
pi@raspberrypi: ~
login as: pi
pi@192.168.1.67's password:
Linux raspberrypi 3.12.35+ #730 PREEMPT Fri Dec 19 18:31:24 GMT 2014 armv6l

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Thu Jan 15 20:05:54 2015 from rnt.lan
pi@raspberrypi ~ $
```

2) Checking if your RPi recognizes your WiFi adapter

There are several ways to check if your WiFi adapter has been recognized. You can type:

```
pi@raspberry:~ $ ifconfig
```

And your wireless adapter named as **wlan0** should appear as shown in the figure below.

```
pi@raspberrypi: ~
pi@raspberrypi - $ ifconfig
eth0      Link encap:Ethernet HWaddr b8:27:eb:e0:2a:a5
          UP BROADCAST MULTICAST MTU:1500 Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

lo       Link encap:Local Loopback
          inet addr:127.0.0.1 Mask:255.0.0.0
          UP LOOPBACK RUNNING MTU:65536 Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

wlan0    Link encap:Ethernet HWaddr e8:de:27:13:2d:4e
          inet addr:192.168.1.76 Bcast:192.168.1.255 Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1
          RX packets:303 errors:0 dropped:2 overruns:0 frame:0
          TX packets:318 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:86410 (84.3 KiB)  TX bytes:59261 (57.8 KiB)

pi@raspberrypi - $
```

If you don't see your WiFi adapter listed, you might have to install drivers for your particular WiFi adapter. I'm using the [TL-WN725N](#) and by default Raspbian doesn't support my WiFi adapter. So I've followed this [thread](#) to install my drivers.

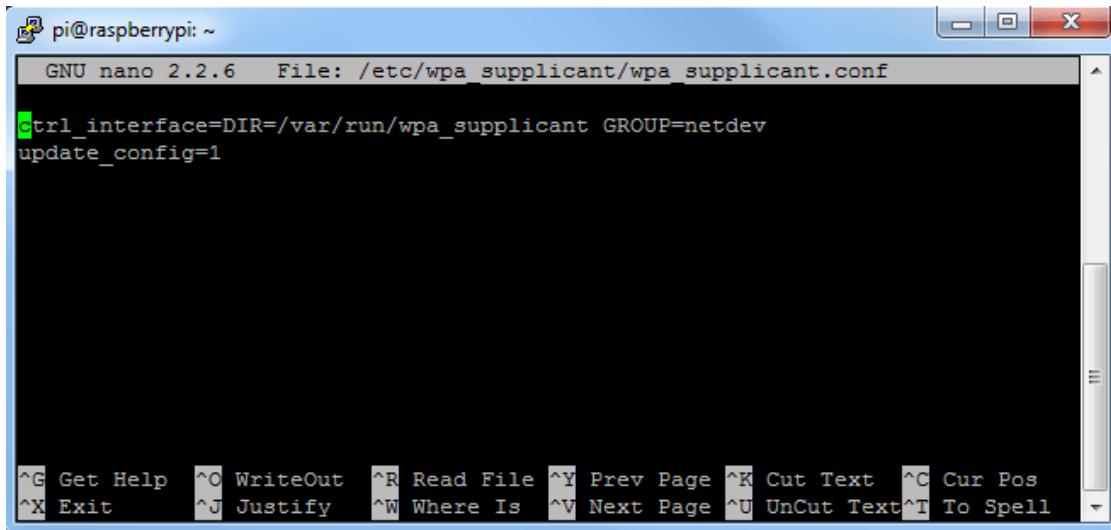
If you don't have a WiFi adapter yet, I highly recommend purchasing the [Edimax EW 7811UN](#). This is a good option, because Raspbian comes with its drivers installed out of the box, that ensures that your RPi recognizes that WiFi adapter.



3) Opening configuration file

Type the following command to open your configuration file:

```
pi@raspberry:~ $ sudo nano /etc/wpa_supplicant/wpa_supplicant.conf
```

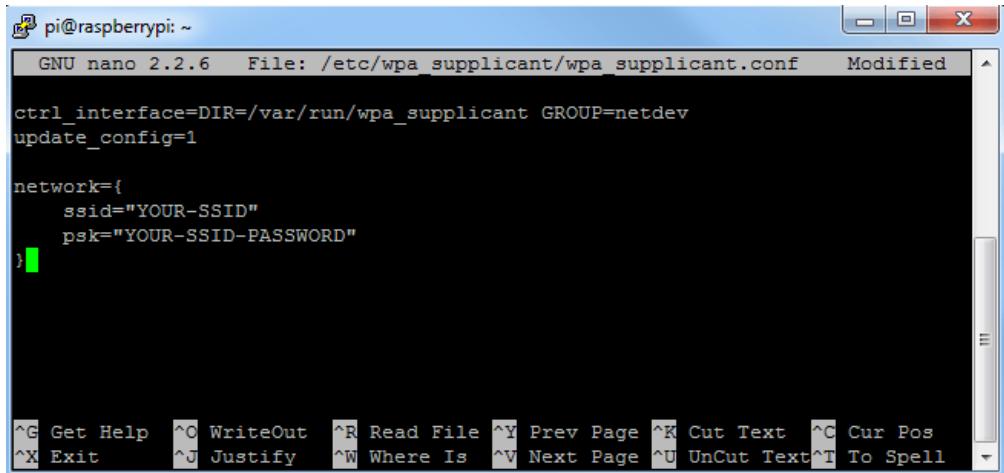


```
pi@raspberrypi: ~
GNU nano 2.2.6  File: /etc/wpa_supplicant/wpa_supplicant.conf
ctrl_interface=DIR=/var/run/wpa_supplicant GROUP=netdev
update_config=1
```

^G Get Help ^O WriteOut ^R Read File ^Y Prev Page ^K Cut Text ^C Cur Pos
^X Exit ^J Justify ^W Where Is ^V Next Page ^U UnCut Text^T To Spell

4) Adding your network details

Go to the bottom of your configuration file wpa_supplicant.conf and add your network details as shown below. Replace “**YOUR-SSID**” and “**YOUR-SSID-PASSWORD**” with the details of your WiFi connection.



```
pi@raspberrypi: ~
GNU nano 2.2.6  File: /etc/wpa_supplicant/wpa_supplicant.conf  Modified
ctrl_interface=DIR=/var/run/wpa_supplicant GROUP=netdev
update_config=1

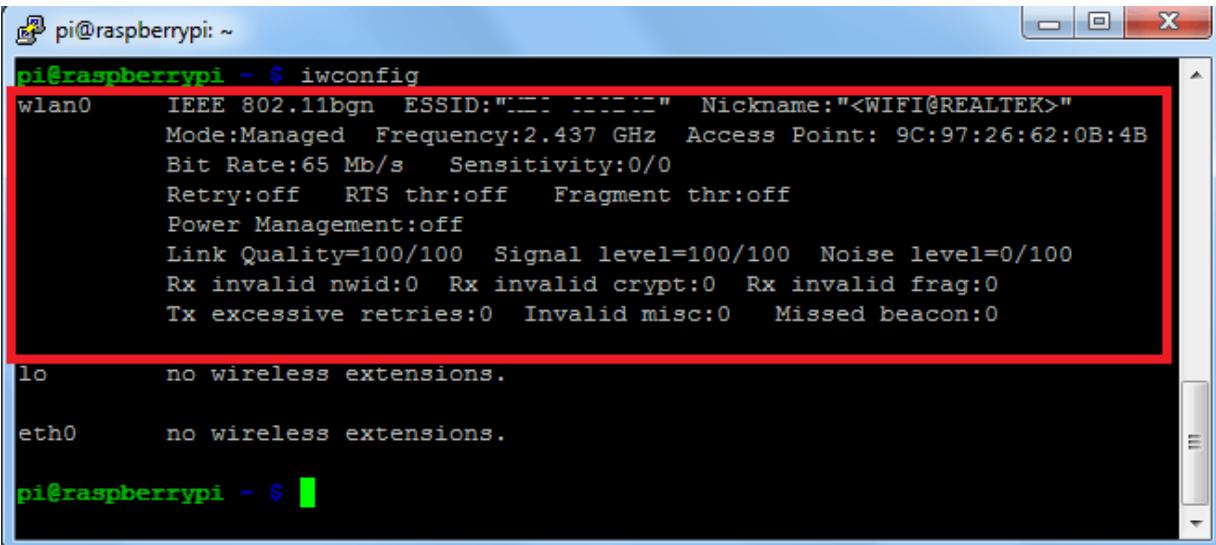
network={
    ssid="YOUR-SSID"
    psk="YOUR-SSID-PASSWORD"
}
```

^G Get Help ^O WriteOut ^R Read File ^Y Prev Page ^K Cut Text ^C Cur Pos
^X Exit ^J Justify ^W Where Is ^V Next Page ^U UnCut Text^T To Spell

Now save your file by pressing **Ctrl+x** then **y**, then finally press **Enter**.

5) Testing your connection

You can check the status of the wireless connection using `ifconfig` (to see if `wlan0` has acquired an IP address) and `iwconfig` to check which network the wireless adapter is using.



```
pi@raspberrypi: ~
pi@raspberrypi - $ iwconfig
wlan0      IEEE 802.11bgn  ESSID:"__-__-__-__"  Nickname:<WIFI@REALTEK>
            Mode:Managed  Frequency:2.437 GHz  Access Point: 9C:97:26:62:0B:4B
            Bit Rate:65 Mb/s  Sensitivity:0/0
            Retry:off  RTS thr:off  Fragment thr:off
            Power Management:off
            Link Quality=100/100  Signal level=100/100  Noise level=0/100
            Rx invalid nwid:0  Rx invalid crypt:0  Rx invalid frag:0
            Tx excessive retries:0  Invalid misc:0  Missed beacon:0

lo        no wireless extensions.

eth0      no wireless extensions.

pi@raspberrypi - $
```

Unit 2 - Change the Time Zone on Raspberry Pi with Raspbian

You can quickly change the time zone of your Raspberry Pi with one command.

First, you have to check if your time zone is already correct. Use the date command:

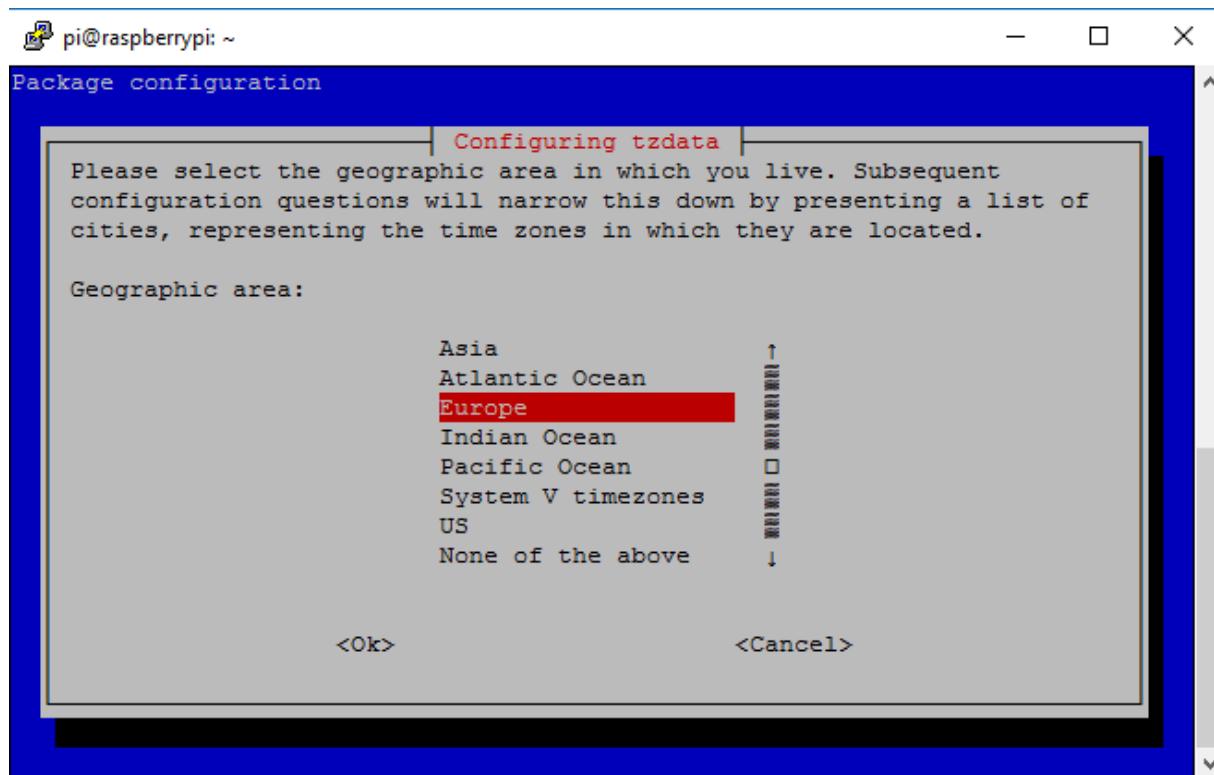
```
pi@raspberrypi:~ $ date  
Mon 30 May 09:54:40 UTC 2016
```

If the hour is correct, you don't have to do anything else. In my case, I need to change the time zone from UTC to WEST.

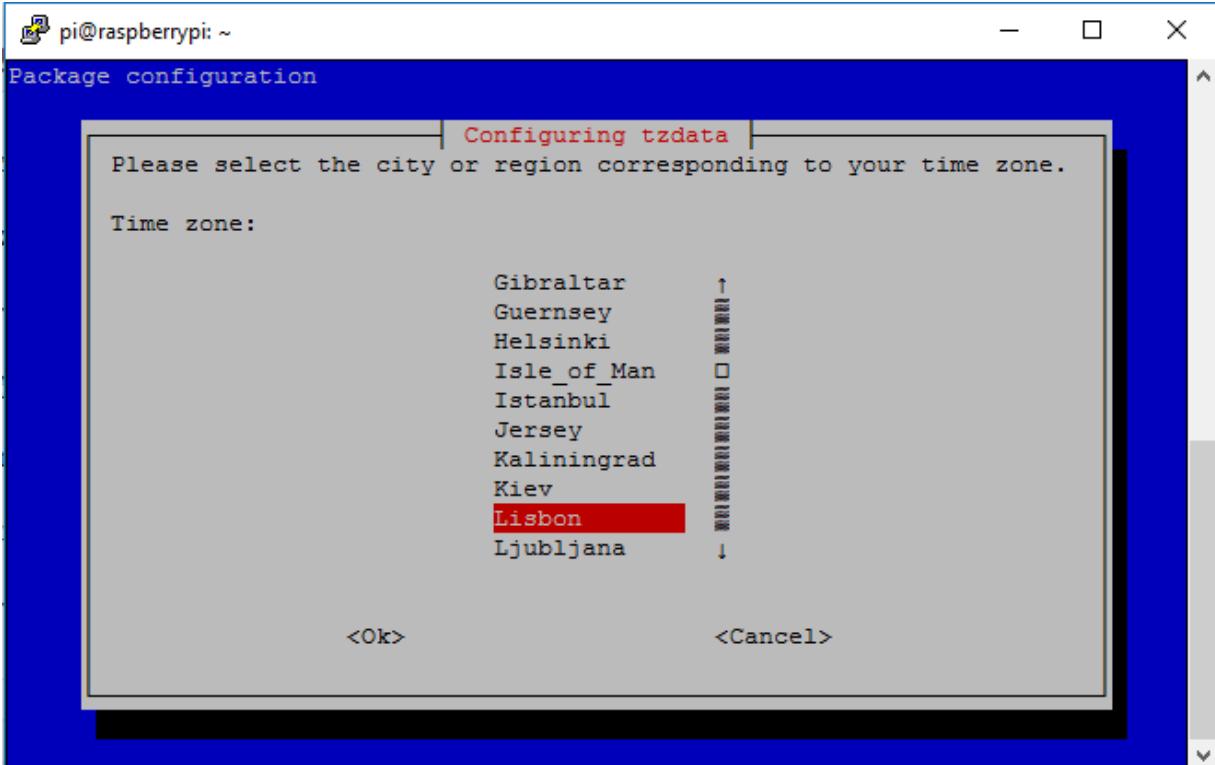
Run this command:

```
pi@raspberrypi:~ $ sudo dpkg-reconfigure tzdata
```

Select your geographic area (it's Europe for me) and click "**Ok**":



Select the national capital or state where you are located (I live in Portugal, so it's Lisbon for me). Click "**Ok**".



Now, your RPi should be set for the correct time zone.

Enter the date command again and it should output the right hour for your location.

```
pi@raspberrypi:~ $ sudo dpkg-reconfigure tzdata
Current default time zone: 'Europe/Lisbon'
Local time is now:      Mon May 30 10:58:43 WEST 2016.
Universal Time is now:  Mon May 30 09:58:43 UTC 2016.

pi@raspberrypi:~ $ date
Mon 30 May 10:58:49 WEST 2016
```

Reboot your RPi to ensure that Node-RED updates the time zone.

```
pi@raspberrypi:~ $ sudo reboot
```

Unit 3 - ESP-01 with Arduino IDE

This Extra Unit shows:

1. How to configure the ESP-01 with the Arduino IDE
2. How to upload code with FTDI programmer to the ESP-01

There are a variety of development environments that can be used to program the ESP8266.

The ESP8266 community created an add-on for the Arduino IDE that allows you to program the ESP8266 using the Arduino IDE and its programming language.

Downloading Arduino IDE

First download the Arduino IDE to ensure that you have the latest software version (some older versions won't work), visit the following URL: <https://www.arduino.cc/en/Main/Software>.

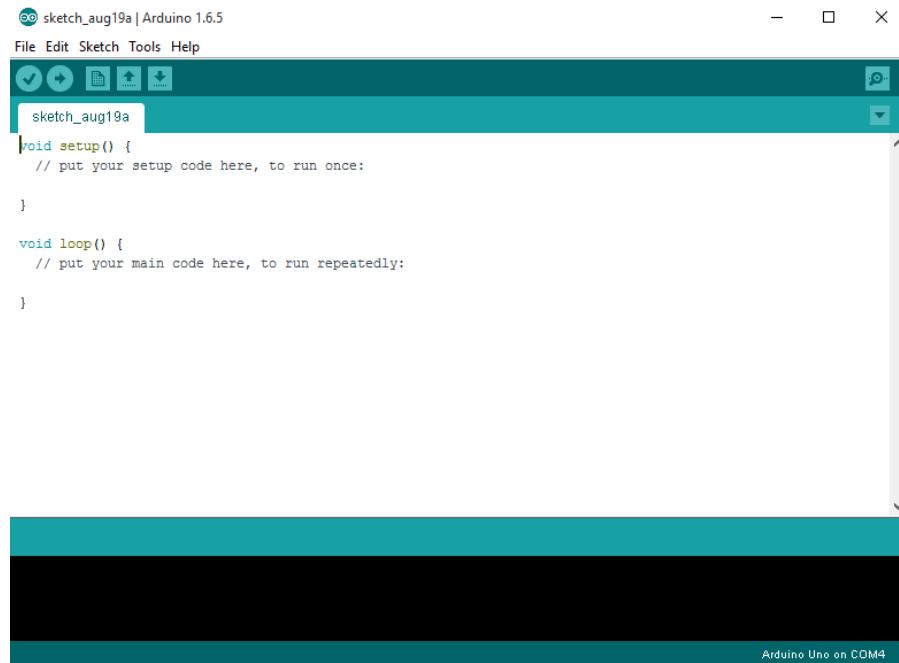
Then select your operating system and download the latest software release of the Arduino IDE.

Installing Arduino IDE

Grab the file that you have just downloaded and open the Arduino IDE application file (see Figure below).

Name	Date modified	Type
dist	13/08/2015 20:53	File folder
drivers	13/08/2015 20:53	File folder
examples	13/08/2015 20:54	File folder
hardware	13/08/2015 20:54	File folder
java	13/08/2015 20:57	File folder
lib	13/08/2015 20:59	File folder
libraries	11/09/2015 13:38	File folder
reference	13/08/2015 21:03	File folder
tools	13/08/2015 21:03	File folder
arduino	14/08/2015 17:42	Application

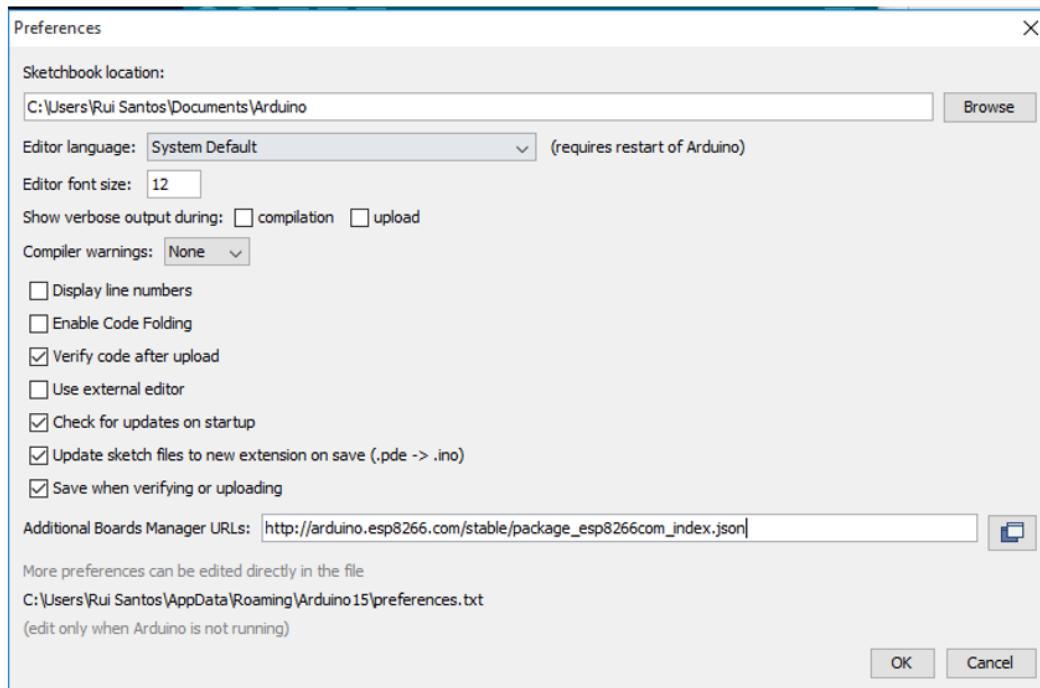
When the Arduino IDE first opens, this is what you should see:



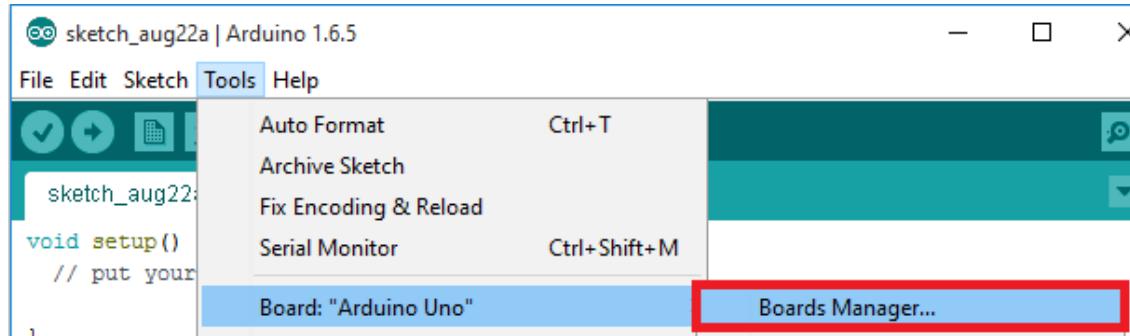
Installing the ESP8266 Board

To install the ESP8266 board in your Arduino IDE, follow these next instructions:

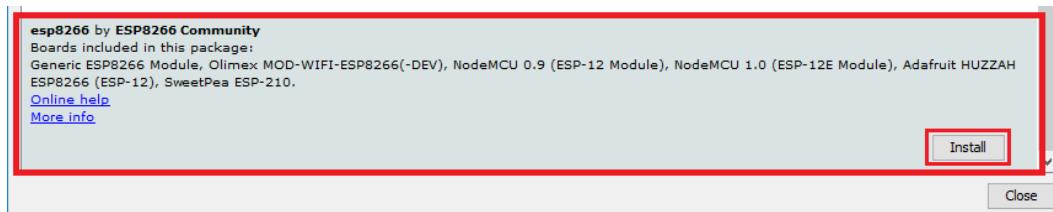
- 1) Open the preferences window from the Arduino IDE. Go to **File > Preferences**
- 2) Enter http://arduino.esp8266.com/stable/package_esp8266com_index.json into **Additional Board Manager URLs** field and click the "**OK**" button



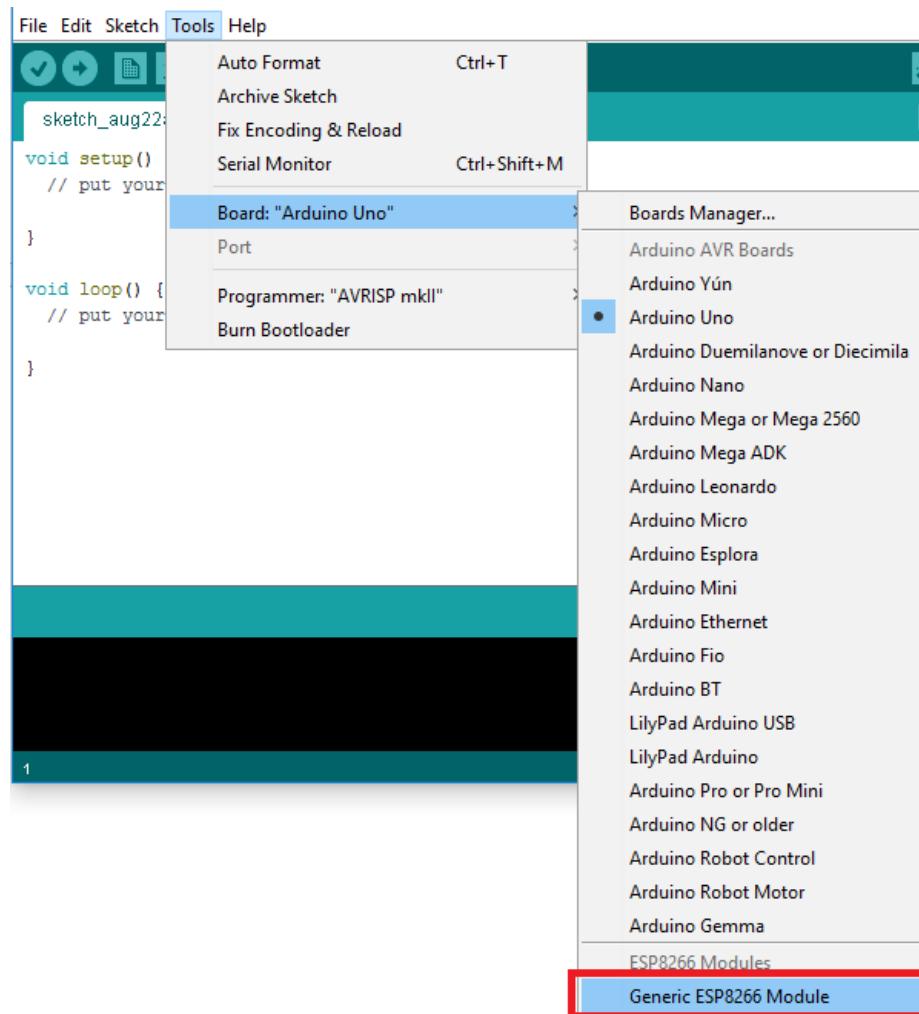
3) Open boards manager. Go to Tools > Board > Boards Manager...



4) Scroll down, select the ESP8266 board menu and install “esp8266 platform”



5) Choose your ESP8266 board from Tools > Board > Generic ESP8266 Module



6) Finally, re-open your Arduino IDE

Testing the Installation

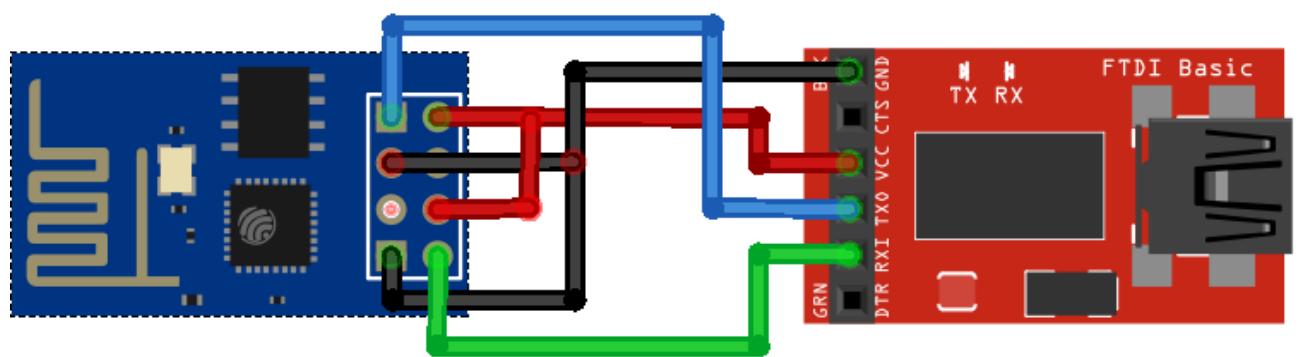
To test the ESP8266 add-on installation, let's see if we can blink an LED with the ESP8266 using the Arduino programming language. Here's the hardware that you need to complete this project:

- [ESP-01 Wi-Fi Module](#)
- [FT232RL FTDI Programmer](#)



How to Upload a Sketch

To upload code to your ESP follow these schematics:



Then upload the sketch below to your ESP using the Arduino IDE. You should see "Done Uploading" after a few seconds.

```
*****
Rui Santos
Complete project details at http://randomnerdtutorials.com
*****/

int pin = 2;

void setup() {
  // initialize GPIO 2 as an output.
  pinMode(pin, OUTPUT);
}
```

```
// the loop function runs over and over again forever
void loop() {
    digitalWrite(pin, HIGH); // turn the LED on (HIGH is the voltage level)
    delay(1000); // wait for a second
    digitalWrite(pin, LOW); // turn the LED off by making the voltage LOW
    delay(1000); // wait for a second
}
```

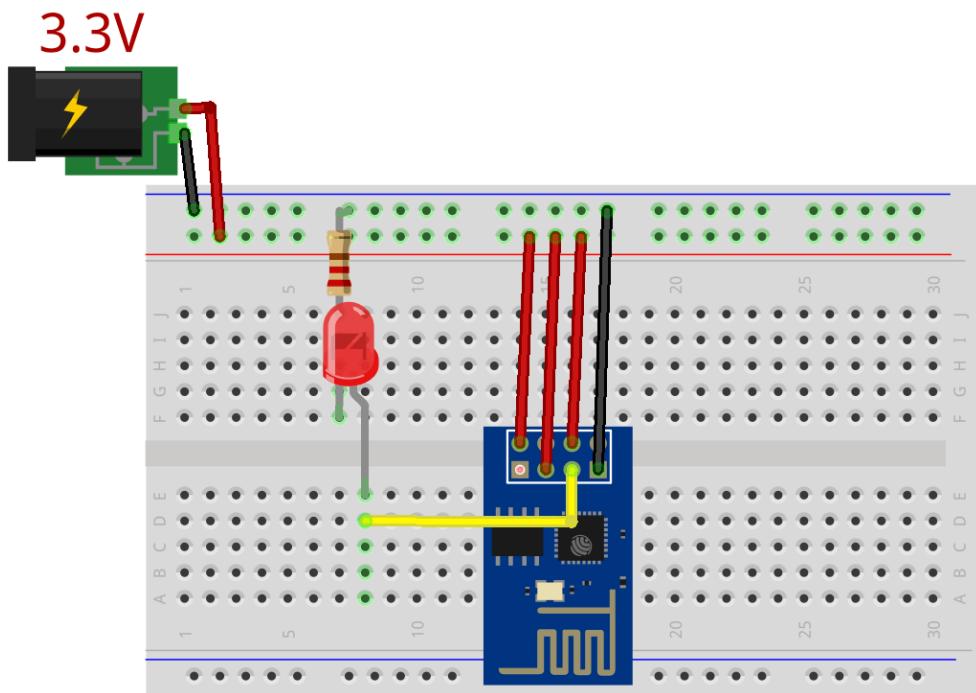
[DOWNLOAD SOURCE CODE](#)

https://github.com/RuiSantosdotme/Home-Automation-Course/blob/master/code/blink_led_esp8266.ino

Note: You have to select your FTDI's port number under the Tools > Port menu of the Arduino IDE.

Demonstration

Now assemble this simple circuit and add an LED to your ESP. Your LED should be blinking every 1 second.



Now you can continue the Home Automation using Raspberry Pi course with the ESP-01:

1. Installing the PubSubClient Library
2. Connecting the ESP8266 to the Node-RED Nodes

Unit 4 - ESP-12E – Pinout Reference

This page provides a quick pinout reference for [ESP8266-12E NodeMCU Kit](#) that has built-in programmer.

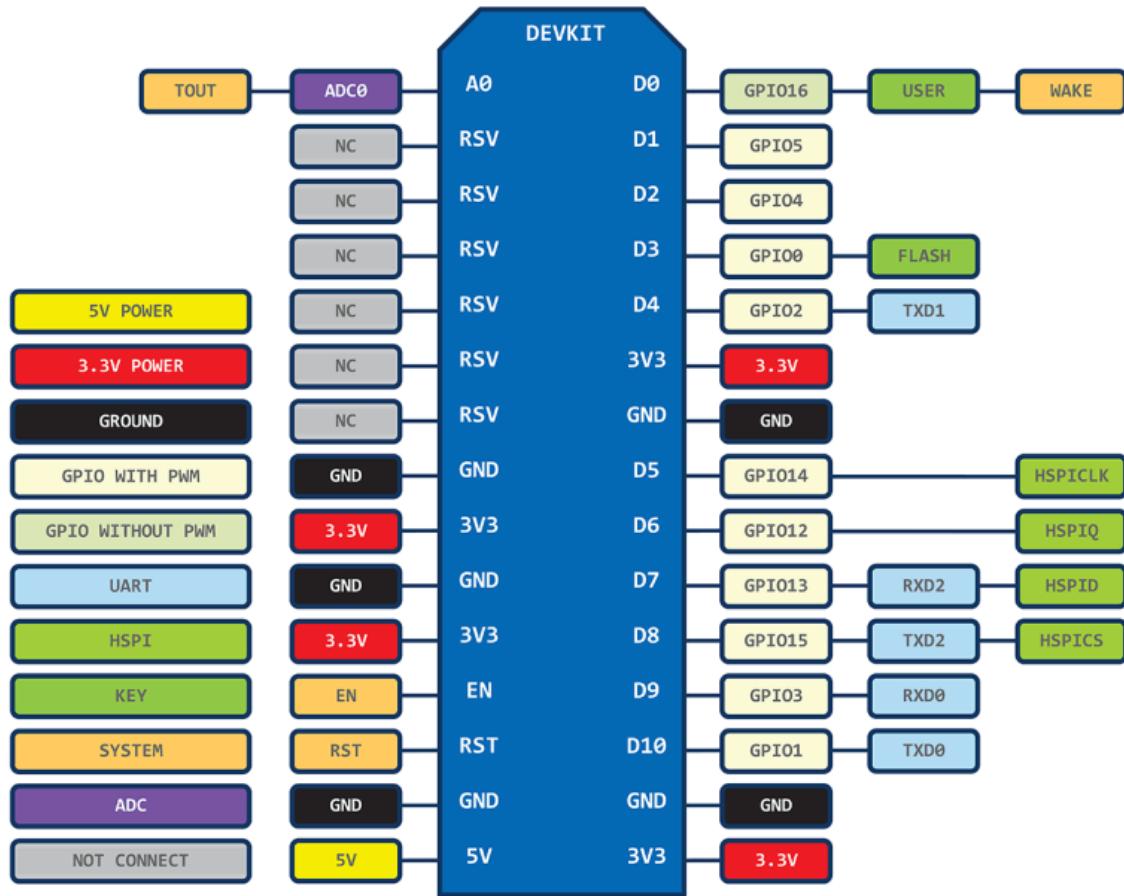


ESP-12E Pinout

Use this table below for a quick reference on how to assign the Arduino GPIOs in the Arduino code (first column):

IO index (Arduino code)	ESP8266 GPIO	ESP-12E
0	GPIO 0	D3
1	GPIO 1	D10
2	GPIO 2	D4
3	GPIO 3	D9
4	GPIO 4	D2
5	GPIO 5	D1
12	GPIO 12	D6
13	GPIO 13	D7
14	GPIO 14	D5
15	GPIO 15	D8
16	GPIO 16	D0
A0	ADC 0	A0

Here's the location for each pin in the actual board:



Unit 5 - MQTT Authentication with Username and Password

In this Unit, I'm going to show you how to setup an authentication mechanism with MQTT. I will use basic authentication with username and password. You could potentially setup a full encrypted secured connection with TLS, but it is a bit more complicated and it's not the purpose of this tutorial.

Configuring Mosquitto

Before running this command, replace the username part with the actual username that you desire:

```
pi@raspberry:~ $ sudo mosquitto_passwd -c  
/etc/mosquitto/username
```

I'll be using **rui** as my username:

```
pi@raspberry:~ $ sudo mosquitto_passwd -c  
/etc/mosquitto/username rui
```

Then you will be prompted to enter a password twice. That will be the password required to connect to the server with the username that you just chose. Run this command to configure the permissions to write in that directory:

```
pi@raspberry:~ $ sudo sh -c 'zcat  
/usr/share/doc/mosquitto/examples/mosquitto.conf.gz >  
/etc/mosquitto/conf.d/mosquitto.conf'
```

Then edit Mosquitto configuration file:

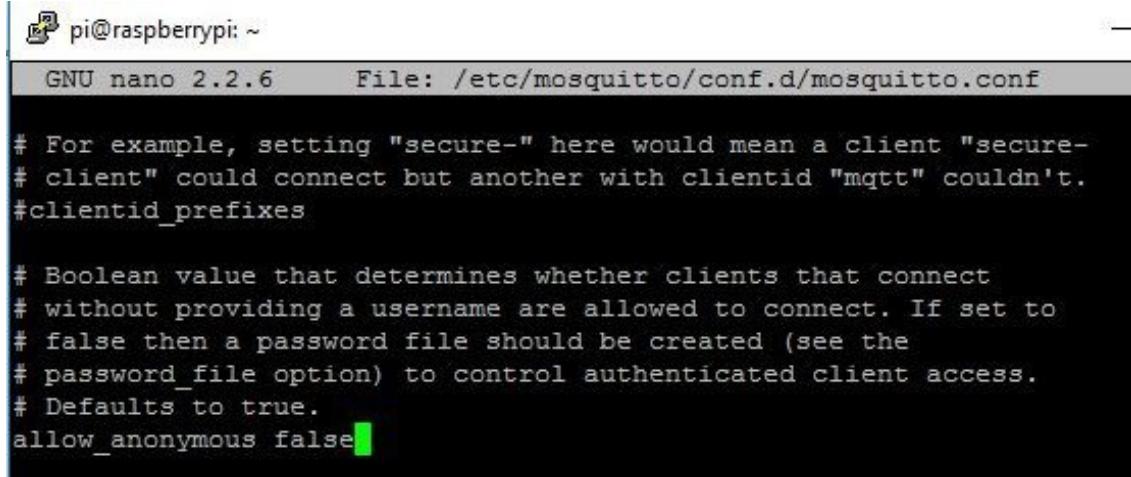
```
pi@raspberry:~ $ sudo nano /etc/mosquitto/conf.d/mosquitto.conf
```

Scroll and find the line containing **#allow_anonymous**:

1. remove the # to uncomment it
2. set the parameter to false

This how it should look like:

```
allow_anonymous false
```



```
pi@raspberrypi: ~
GNU nano 2.2.6      File: /etc/mosquitto/conf.d/mosquitto.conf

# For example, setting "secure-" here would mean a client "secure-
# client" could connect but another with clientid "mqtt" couldn't.
#clientid_prefixes

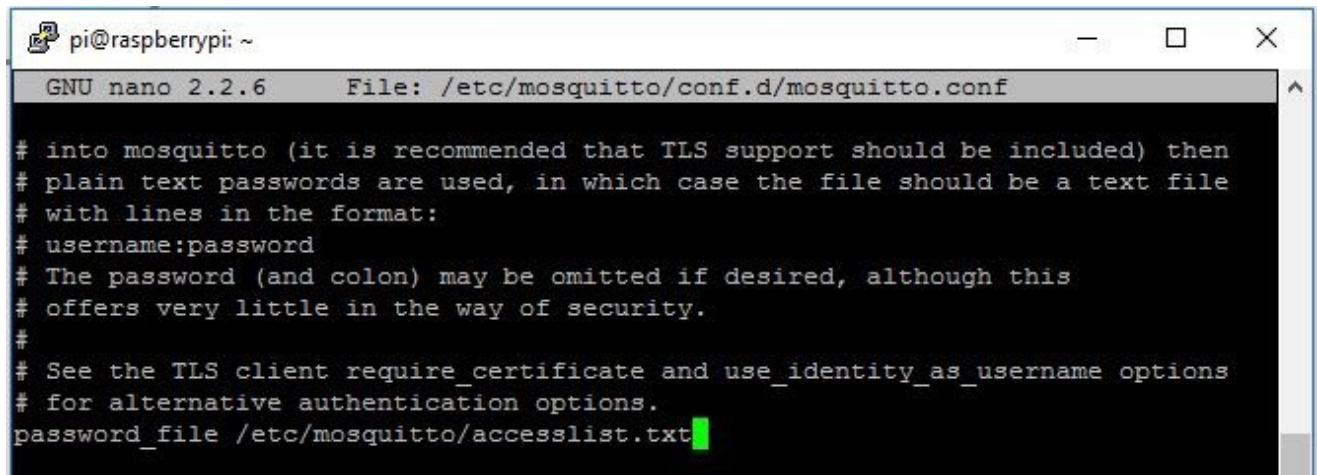
# Boolean value that determines whether clients that connect
# without providing a username are allowed to connect. If set to
# false then a password file should be created (see the
# password_file option) to control authenticated client access.
# Defaults to true.
allow_anonymous false
```

Lastly find the line containing “**#password_file**”:

1. remove the # to uncomment it
2. set the parameter to the path of the password file previously created

The line becomes:

```
password_file /etc/mosquitto/accesslist.txt
```



```
pi@raspberrypi: ~
GNU nano 2.2.6      File: /etc/mosquitto/conf.d/mosquitto.conf

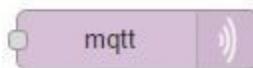
# into mosquitto (it is recommended that TLS support should be included) then
# plain text passwords are used, in which case the file should be a text file
# with lines in the format:
# username:password
# The password (and colon) may be omitted if desired, although this
# offers very little in the way of security.
#
# See the TLS client require_certificate and use_identity_as_username options
# for alternative authentication options.
password_file /etc/mosquitto/accesslist.txt
```

Now the server is properly configured, restart the service and you're up to go:

```
pi@raspberry:~ $ sudo service mosquitto restart
```

Editing the MQTT Broker

First drag an MQTT output node to the flow.



You need to connect Node-RED to your MQTT broker. Double-click the MQTT output node.

Click the **Add new mqtt-broker** option.

Edit mqtt in node

<input type="radio"/> Server	<input type="text" value="Add new mqtt-broker..."/>	<input type="button" value=""/>
<input type="radio"/> Topic	<input type="text" value="Topic"/>	
<input type="radio"/> Name	<input type="text" value="Name"/>	
<input type="button" value="Ok"/> <input type="button" value="Cancel"/>		

Go to the **Security** tab, Enter your username and password.

Edit mqtt-broker config node

<input type="radio"/> Connection	<input checked="" type="radio" value="Security"/>	<input type="radio"/> Birth Message	<input type="radio"/> Will Message
<input type="text" value="Username"/> rui			
<input type="text" value="Password"/>	<input type="button" value=""/>		
<input type="checkbox"/> Enable secure (SSL/TLS) connection			
<input checked="" type="checkbox"/> Verify server certificate			
<input type="radio"/> 2 nodes use this config		<input type="button" value="Delete"/>	<input type="button" value="Update"/>
		<input type="button" value="Cancel"/>	

Then go to the Connection tab, type **localhost** in the server field and I'll the other settings are configured properly by default.

Add new mqtt-broker config node Flow 1 ▾

Connection Security Birth Message Will Message

Server localhost Port 1883

Client ID Leave blank for auto generated A

Keep alive time (s) 60 Use clean session

Use legacy MQTT 3.1 support

Add Cancel

Press **Add** and the MQTT output node automatically connects to your broker.

Now only devices with username and password can connect to your MQTT broker.

Unit 6 - Exporting Node-RED Nodes

This Unit shows how to export your Node-RED Nodes.

This is useful if you need to:

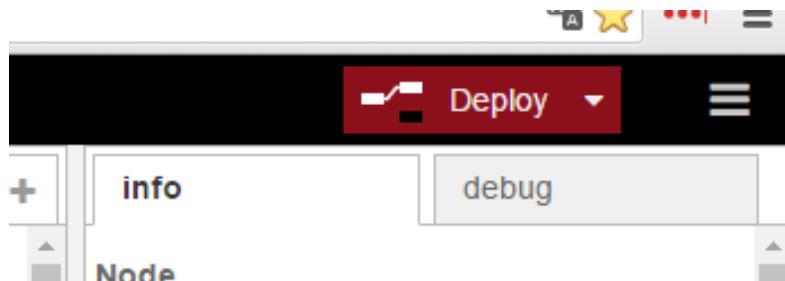
- **Backup** your Node-RED flow
- **Move** your flow to another Raspberry Pi (or machine)
- **Share** your Node-RED project with others

Example

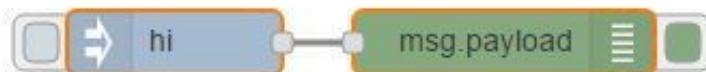
Imagine that you had the following nodes in your flow:



You would need to click the deploy button on the top-right corner to save your application.

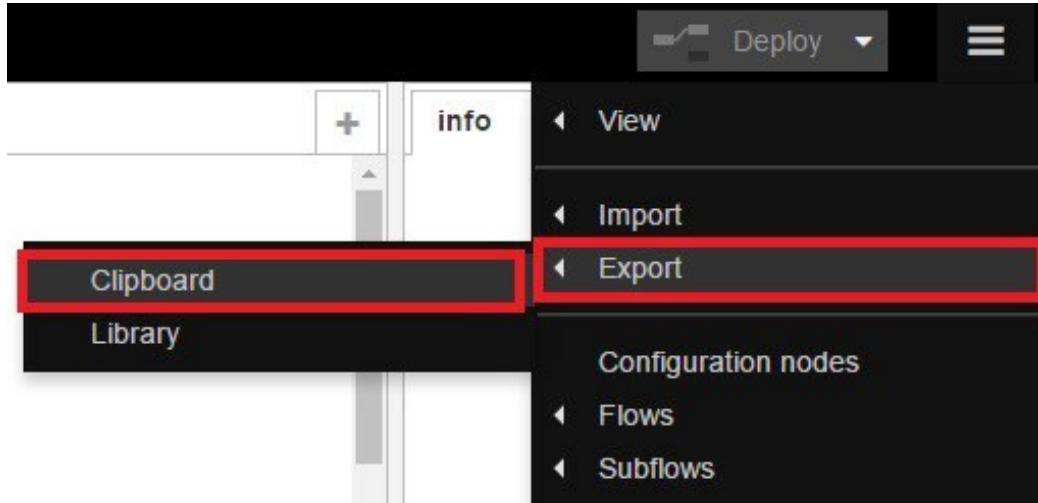


Then you would select with your mouse all the nodes that you wish to export and they would be highlighted in orange (as shown below):

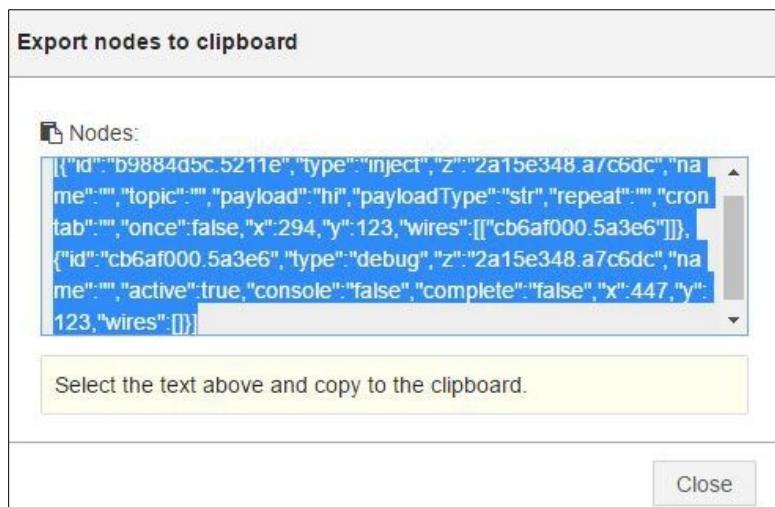


Exporting

Now with the nodes highlighted, you open the **top Menu**, go to **Export** and select **Clipboard**.



A new window opens. Copy the text that appears and save it.



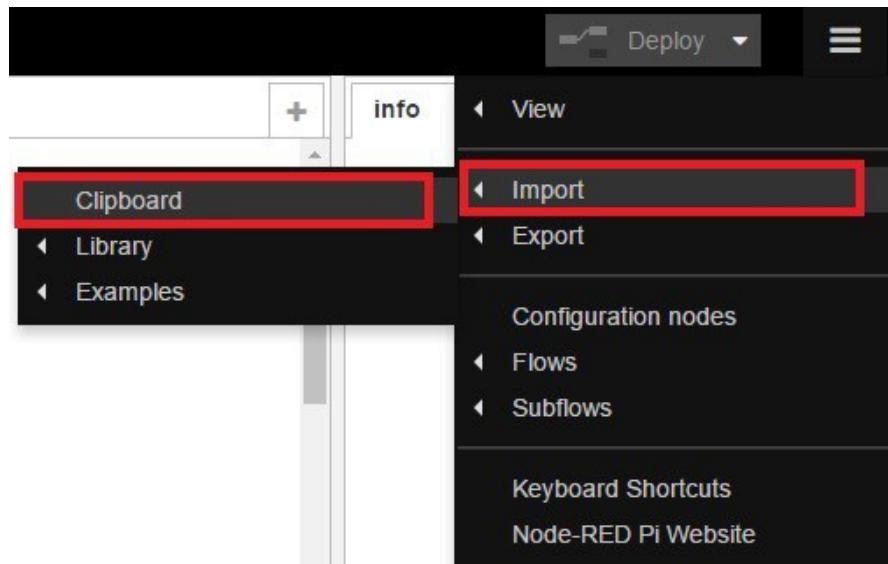
This is how the text looks for the flow demonstrated in this example:

```
[{"id": "b9884d5c.5211e", "type": "inject", "z": "2a15e348.a7c6dc", "name": "", "topic": "", "payload": "hi", "payloadType": "str", "repeat": "", "crontab": "", "once": false, "x": 294, "y": 123, "wires": [ ["cb6af000.5a3e6"] ]}, {"id": "cb6af000.5a3e6", "type": "debug", "z": "2a15e348.a7c6dc", "name": "", "active": true, "console": "false", "complete": "false", "x": 447, "y": 123, "wires": []}]
```

Importing

Now you could go to another Raspberry Pi or a machine that has Node-RED installed and you could simply import your flow.

You only have to go to the **Import** menu and paste your nodes in text format (as show below).



Important: If you have previously installed extra nodes (for example Node-RED Dashboard), you'll also have to install those nodes in your new machine, otherwise the Import process will not work.

Unit 7 - Sending Linux Commands Through the Node-RED Dashboard

Sometimes you don't want to open the terminal and establish an SSH communication to power off your Raspberry Pi.

So, It would be useful to send the `poweroff` and the `reboot` commands through the Node-RED Dashboard with a button press. That's exactly what you are going to learn in this extra Unit.

Creating the Flow

Follow these 7 steps to create a flow:

1 – Drag Nodes



2 – Poweroff Button in Config tab

Edit button node

Cancel Done

Group	Group 1 [Config]
Size	auto
Icon	optional icon
Label	Poweroff
Color	optional text/icon color
When clicked, send:	
Payload	a ₂
Topic	
Name	Poweroff

3 – poweroff Command

Edit exec node

Cancel Done

Command /usr/bin/sudo

Append msg.payload
poweroff

Use spawn() instead of exec()?

Timeout optional seconds

Name poweroff

4 – Reboot Button in Config tab

Edit button node

Cancel Done

Group Group 1 [Config]

Size auto

Icon optional icon

Label Reboot

Color optional text/icon color

When clicked, send:

Payload

Topic

Name Reboot

5 – reboot Command

Edit exec node

Cancel Done

Command /usr/bin/sudo

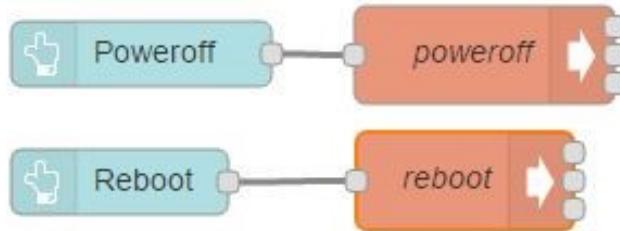
Append msg.payload
reboot

Use spawn() instead of exec()?

Timeout optional seconds

Name reboot

6 – Final Flow



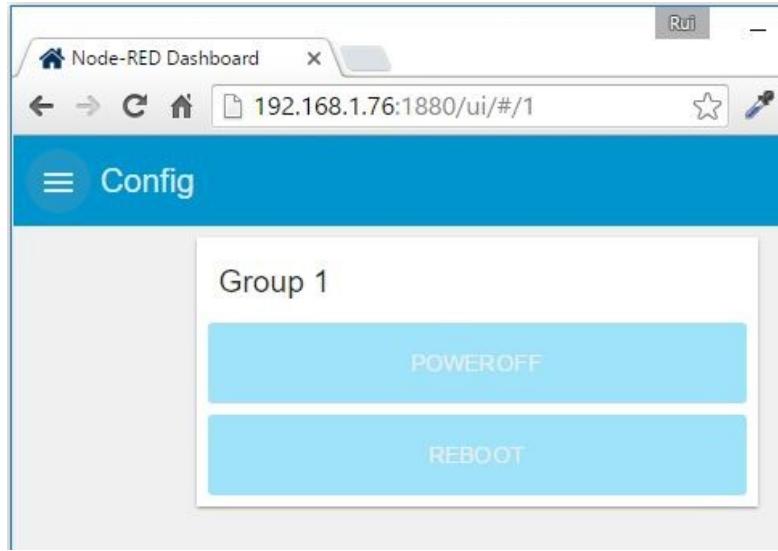
7 – Deploy Your Application



Open Node-RED Dashboard

When you go to the **Config** tab in the UI, it shows two new buttons.

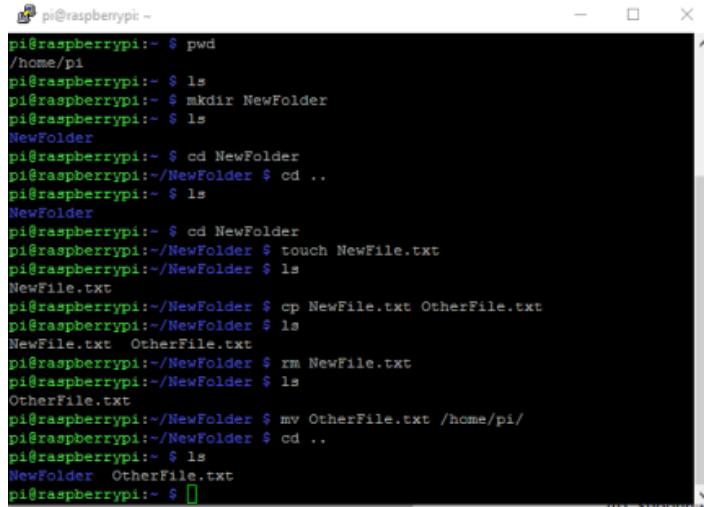
If you press the first button your Raspberry Pi immediately powers off safely and when you click the second button the RPi reboots.



You can apply this method to send almost any other Linux command to your Raspberry Pi through the UI.

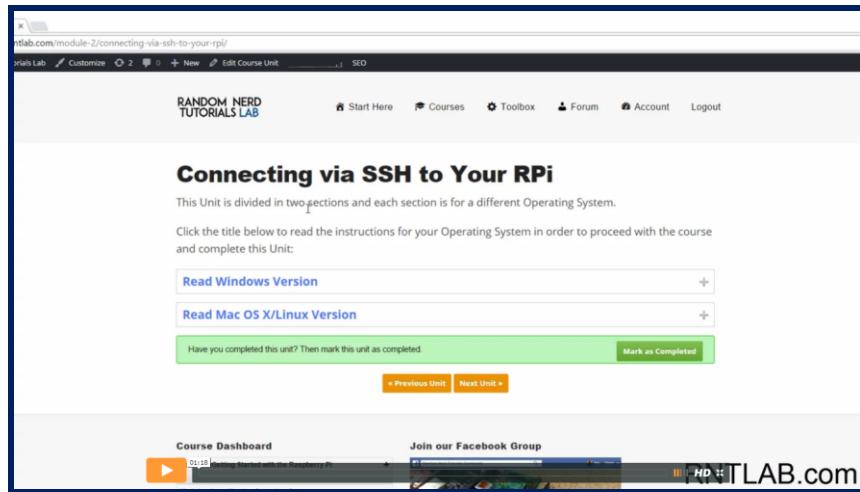
MODULE 14

Extra #2 - Getting Started with Linux

A screenshot of a terminal window titled "pi@raspberrypi ~". The window shows a series of Linux commands being run. The commands include pwd, ls, mkdir, cd, touch, cp, rm, and mv. The output shows the creation of a folder named "NewFolder", the creation of a file named "NewFile.txt" within it, the copying of "NewFile.txt" to "OtherFile.txt", the deletion of "NewFile.txt", and finally moving "OtherFile.txt" back to the root directory at "/home/pi".

```
pi@raspberrypi:~ $ pwd
/home/pi
pi@raspberrypi:~ $ ls
pi@raspberrypi:~ $ mkdir NewFolder
pi@raspberrypi:~ $ ls
NewFolder
pi@raspberrypi:~ $ cd NewFolder
pi@raspberrypi:/NewFolder $ cd ..
pi@raspberrypi:~ $ ls
NewFolder
pi@raspberrypi:~ $ cd NewFolder
pi@raspberrypi:/NewFolder $ touch NewFile.txt
pi@raspberrypi:/NewFolder $ ls
NewFile.txt
pi@raspberrypi:/NewFolder $ cp NewFile.txt OtherFile.txt
pi@raspberrypi:/NewFolder $ ls
NewFile.txt OtherFile.txt
pi@raspberrypi:/NewFolder $ rm NewFile.txt
pi@raspberrypi:/NewFolder $ ls
OtherFile.txt
pi@raspberrypi:/NewFolder $ mv OtherFile.txt /home/pi/
pi@raspberrypi:/NewFolder $ cd ..
pi@raspberrypi:~ $ ls
NewFolder OtherFile.txt
pi@raspberrypi:~ $
```

Unit 1 - Learning Basic Linux Commands



Video # 28 - <https://rntlab.com/watch-has-videos>

A big part of using a Raspberry Pi is also using the terminal. The terminal is something that a lot of people try to avoid, because they feel like it is a bit hard to use.

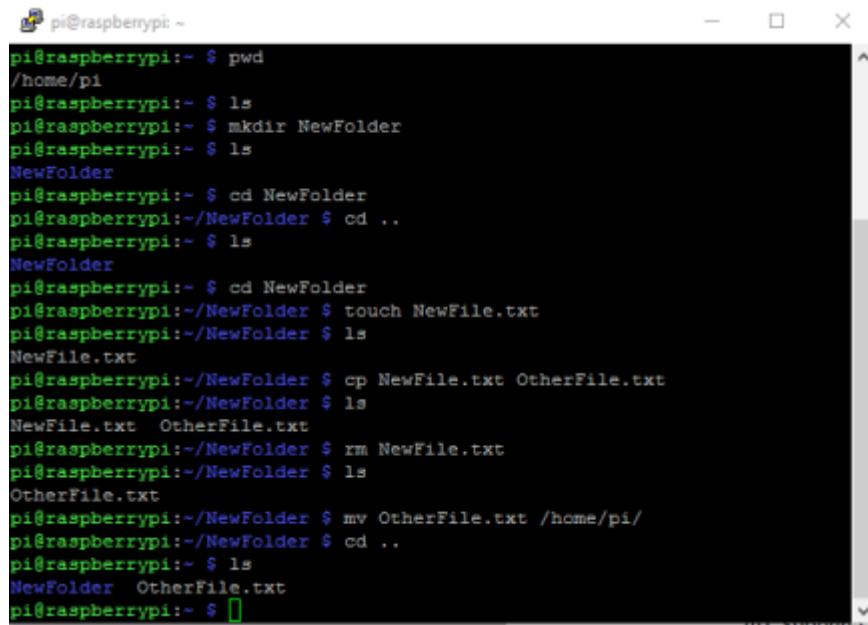
But it doesn't need to be that way, because in reality we can break it down to just a few basic commands that you need to know to do everything. After you learn these commands you'll hopefully feel really comfortable using the terminal.

In Module 2, I've shown how to establish an SSH communication with your RPi. Having that connection still on, you can now install software on your Pi remotely, create files or folders and run any scripts directly from your computer.

Follow the next few Units that will teach you how to use the command line in a few easy steps. You'll be comfortable in no time. You also don't need to know all these commands by heart, you can always access this Module as a reference to remind how to do something.

Important: If there are commands that you need to run to do something, I'll post them in that Module or Unit so you don't get lost.

Unit 2 - Exploring the Linux File System



```
pi@raspberrypi: ~
pi@raspberrypi:~ $ pwd
/home/pi
pi@raspberrypi:~ $ ls
pi@raspberrypi:~ $ mkdir NewFolder
pi@raspberrypi:~ $ ls
NewFolder
pi@raspberrypi:~ $ cd NewFolder
pi@raspberrypi:~/NewFolder $ cd ..
pi@raspberrypi:~ $ ls
NewFolder
pi@raspberrypi:~ $ cd NewFolder
pi@raspberrypi:~/NewFolder $ touch NewFile.txt
pi@raspberrypi:~/NewFolder $ ls
NewFile.txt
pi@raspberrypi:~/NewFolder $ cp NewFile.txt OtherFile.txt
pi@raspberrypi:~/NewFolder $ ls
NewFile.txt OtherFile.txt
pi@raspberrypi:~/NewFolder $ rm NewFile.txt
pi@raspberrypi:~/NewFolder $ ls
OtherFile.txt
pi@raspberrypi:~/NewFolder $ mv OtherFile.txt /home/pi/
pi@raspberrypi:~/NewFolder $ cd ..
pi@raspberrypi:~ $ ls
NewFolder OtherFile.txt
pi@raspberrypi:~ $ [ ]
```

It's time to play around with the command line.

For starters, type `pwd`, which means print working directory:

```
pi@raspberry:~ $ pwd
/home/pi
```

The output is `/home/pi`. Forward slashes are always used to indicate folders and files within other folders. In this case, the current working directory is `pi`, which is inside `home`, which is inside the root of the file system. Here, `pi` is the username with which you are logged in.

Note: The commands in Linux are case-sensitive, which means that `PWD`, `PwD`, `pWd`, and any other variations are completely different from `pwd`. The same holds true for all other commands and for any code written in the programming languages addressed in this course.

Navigating the file system

The most frequent commands you will use are `ls` (list) and `cd` (change directory). They are used for listing the contents of a directory and moving from one directory to another.

When you first open the terminal, it will open up in your home folder (as you've seen with the `pwd` command). You can display exactly what kind of files or folders are in working directory with `ls`:

```
pi@raspberry:~ $ ls
```

Right now your directory is empty, so you won't see anything when you try to list your files and folders. Want to create a new folder? Use `mkdir` followed by the name you want to give the folder:

```
pi@raspberry:~ $ mkdir NewFolder  
pi@raspberry:~ $ ls  
NewFolder
```

To navigate, we'll be using the `cd` command, followed by the location you want to move to. This can be done like so:

```
pi@raspberry:~ $ cd NewFolder  
pi@raspberry:~/NewFolder $
```

This moved you to the `NewFolder` directory that you just created.

Here's one trick you can use so you don't have to remember the exact name of the path – the command line or terminal will try to autocomplete the phrase if you press the Tab key while something is only partially typed. Try the `cd` command again (use `cd ..` to move up one directory):

```
pi@raspberry:~/NewFolder $ cd ..  
pi@raspberry:~ $ ls  
NewFolder
```

Now start writing your `cd` command again...

```
pi@raspberry:~ $ cd NewF
```

... by pressing **Tab** when you've only written '`NewF`' It will autocomplete the file path:

```
pi@raspberry:~ $ cd NewFolder
```

Finally, there are some quick commands you can use to manipulate files. Create a new file with the `touch` command:

```
pi@raspberry:~/NewFolder $ touch NewFile.txt  
pi@raspberry:~/NewFolder $ ls  
NewFile.txt
```

Individual files can be copied using the command `cp`, followed by the file name and you can also use this to rename files by doing:

```
pi@raspberry:~/NewFolder $ cp NewFile.txt OtherFile.txt  
pi@raspberry:~/NewFolder $ ls  
NewFile.txt OtherFile.txt
```

The original file can then be deleted by using the `rm` command followed by the file name:

```
pi@raspberry:~/NewFolder $ rm NewFile.txt  
pi@raspberry:~/NewFolder $ ls  
OtherFile.txt
```

You can move files using the `mv` command:

```
pi@raspberry:~/NewFolder $ mv OtherFile.txt /home/pi  
pi@raspberry:~/NewFolder $ cd ..  
pi@raspberry:~/NewFolder $ ls  
NewFolder OtherFile.txt
```

There's a lot more you can do with the command line, but these are the very basics.

As you use Linux more and more, you'll be confronted with tasks that need the command line, and through this process you'll learn just how much can be accomplished when you work using the command line to manipulate files.

Unit 3 - Editing Files using the Terminal

Nano is an easy to use text editor that is installed by default in Raspbian distribution and many other Linux distributions.

Using nano

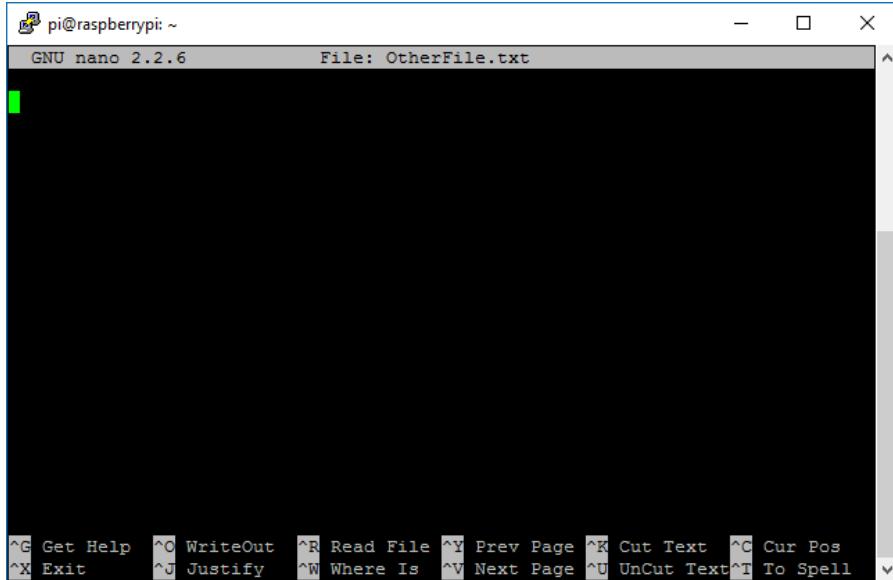
You can run nano by just typing in `nano` at the command prompt.

You can use the following commands to edit the `OtherFile.txt` created in the previous Unit:

```
pi@raspberry:~ $ cd  
pi@raspberry:~ $ nano OtherFile.txt
```

Nano will follow the path and open that file if it exists. If it does not exist, it'll start a new buffer with that file name in that directory.

Let's take a look at the default nano screen:

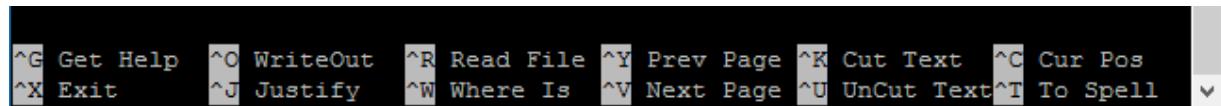


At the top row, you'll see the name of the program version number, the name and extension of the file you're editing, and whether the file has been modified since it was last saved.

Note: If you have a new file that isn't saved yet, you'll see "New Buffer."

Next, you'll see the contents of your file.

Lastly, the final two rows at the bottom are the shortcut lines (as shown below).



Shortcuts

Program functions are referred to as “shortcuts” in nano, such as saving, quitting, searching, etc. The most common ones are listed at the bottom of the screen (as shown in the preceding Figure), but there are many more that aren’t.

Warning: nano does not use the Shift key in shortcuts. All shortcuts use lowercase letters and unmodified number keys, so Ctrl+G is NOT Ctrl+Shift+G.

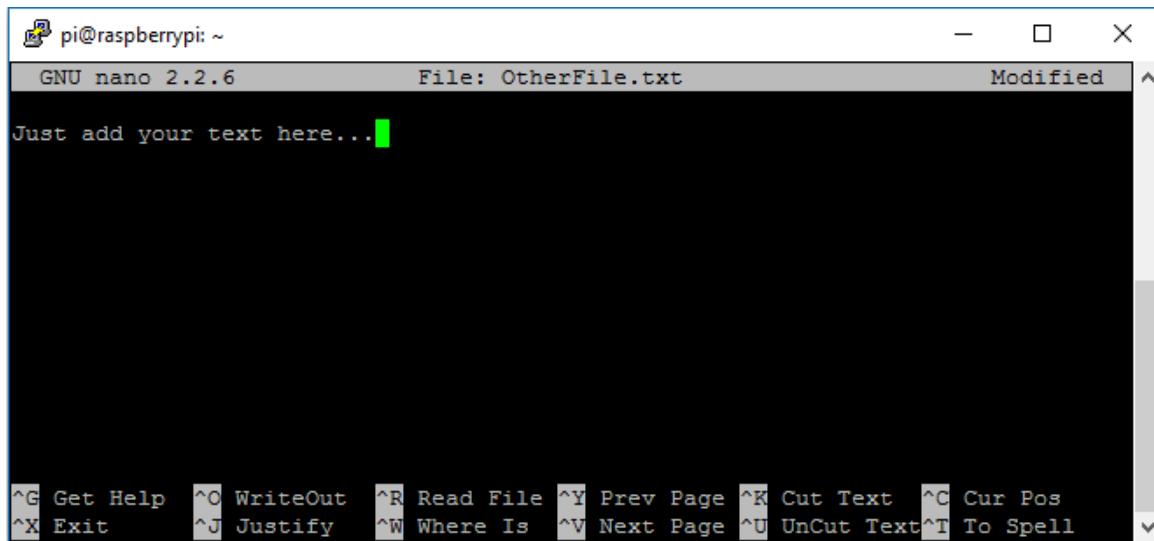
Press Ctrl+G to bring up the Help menu and scroll down with your arrow keys to see a list of valid shortcuts.

```
Main nano help text

The nano editor is designed to emulate the functionality and ease-of-use of the UW Pico text editor. There are four main sections of the help text: file operations, editing operations, search operations, and other operations. The first section describes how to save or exit the editor. The second section describes how to insert another file into the current one. The third section describes how to search for a string or regular expression. The fourth section describes how to use the cutbuffer, display cursor position, invoke spell checker, and go to specific lines or columns. The fifth section describes how to copy and paste text, indent and unindent lines, move characters and words, and navigate through the document. The sixth section describes how to scroll through the document and switch between buffers. The seventh section describes how to insert tabs and newlines, and delete characters.
```

When you're done looking at the list, hit Ctrl+X to exit Help menu.

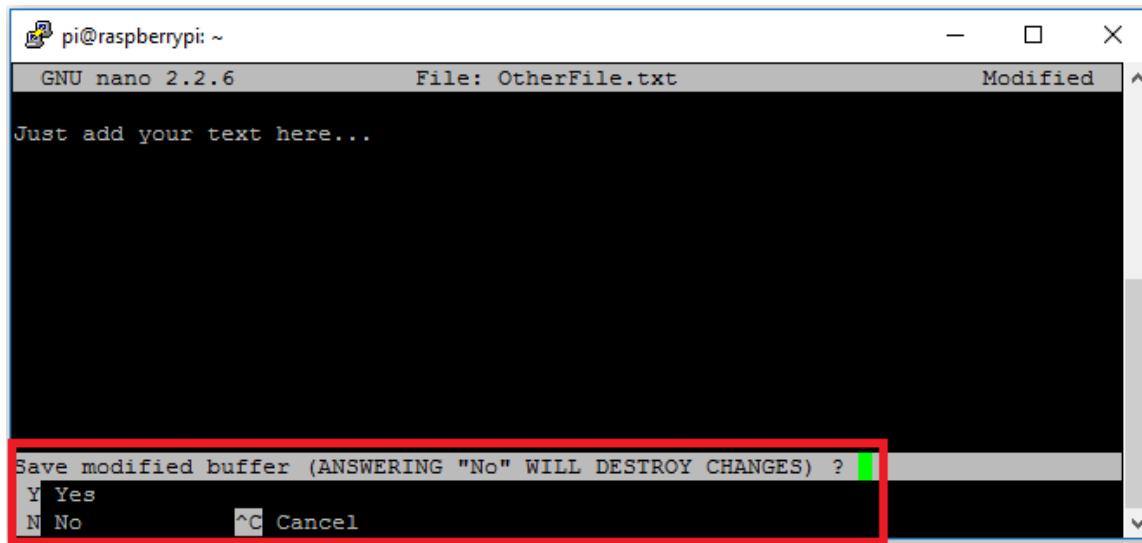
Now let's say you're working on your text file and you want to save it and exit nano. This is executed by pressing Ctrl+X.



A screenshot of the nano text editor window. The title bar says "pi@raspberrypi: ~" and "GNU nano 2.2.6". The status bar shows "File: OtherFile.txt" and "Modified". The main area contains the text "Just add your text here...". The bottom status bar lists various keyboard shortcuts. A red box highlights the status bar area.

Nano will ask you if you want to save the changes, you can type:

- Y, then Enter – to save all your changes
- N, then Enter- to cancel any changes



A screenshot of the nano text editor window. The title bar says "pi@raspberrypi: ~" and "GNU nano 2.2.6". The status bar shows "File: OtherFile.txt" and "Modified". The main area contains the text "Just add your text here...". A red box highlights a modal dialog at the bottom with the message "Save modified buffer (ANSWERING \"No\" WILL DESTROY CHANGES) ?". Below the message are three options: "Y Yes", "N No", and "^C Cancel".

This is a very brief tutorial that shows how to edit a file and save it using the nano program.

The nano is way more powerful and has a lot of shortcuts that you can use to your advantage, but those go beyond what you need to know to complete this course. You can always refer to the official documentation or use the built-in Help menu.

Unit 4 - Managing Software on Your Raspberry Pi

When you know your way around the command line, downloading and installing new software on a computer or device running the Linux OS is quite easy and straightforward.

The software comes in what are called packages — software programs that can be downloaded from the Internet and installed simply by typing a command in the prompt.

To download and install these packages, you normally use a package manager, which downloads and installs not only the software you requested, but also all other required software, known as dependencies.

The Raspbian distribution uses a package manager called `apt`.

To manage your software, you need the authorization of the administrator, whom you already know as the superuser. To do so, type `sudo` (superuser do) before a command.

Updating and Upgrading

First and foremost, you have to update the list of available package versions that your package manager is aware of. (The package manager keeps such a list in the Raspberry's file system.) Type the following command:

```
pi@raspberry:~ $ sudo apt-get update
```

You need to be connected to the Internet for this command to work. Text scrolls by after you type the command, giving information about the newest listings.

Next, you should update the software, which you can achieve by commanding `apt` to upgrade. This command upgrades all the packages you've installed to their most recent versions:

```
pi@raspberry:~ $ sudo apt-get upgrade
```

In terms of wording, the difference between updating and upgrading is subtle, but what they do is quite different (even though they're usually done together).

`sudo apt-get update` updates the list of available package versions but doesn't install or upgrade any of them, whereas `sudo apt-get upgrade` updates the packages themselves, checking the list to do so. For that reason, you should always run update before upgrade.

Installing software

To install a package for which you already know the name, you have to type the following command:

```
pi@raspberry:~ $ sudo apt-get install <desired application name>
```

Running software

To run programs directly from the prompt, simply type their names, as shown in the following command:

```
pi@raspberry:~ $ python
```

This opens the python interpreter that we are going to explore in the next Module.

Removing software

To remove software from your RPi, you resort once more to the apt package manager. Here's an example:

```
pi@raspberry:~ $ sudo apt-get remove <desired application name>
```

This command, however, leaves behind files that are somehow related to the software, such as configuration files and logs. If you don't intend to use those files in any way, you can remove everything by using purge:

```
pi@raspberry:~ $ sudo apt-get purge <desired application name>
```

Do not remove any package that you didn't install yourself unless you're absolutely certain that you know what it's for. It may be a necessary package that comes with the Linux OS, and removing it may lead to a system crash.

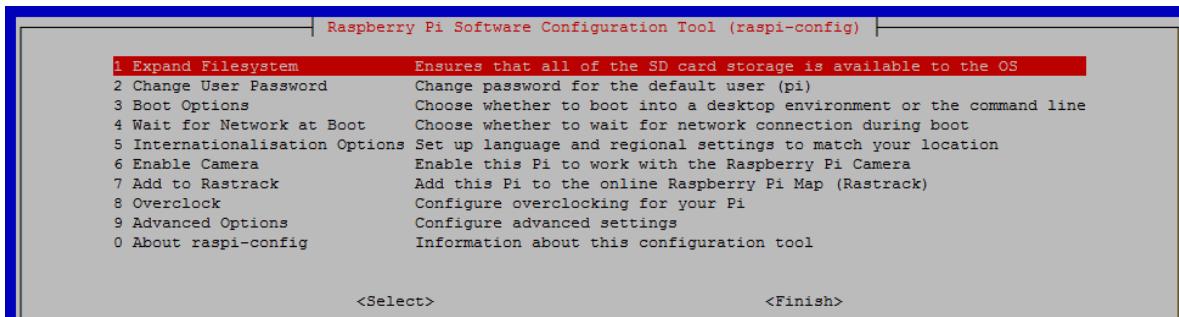
Unit 5 - Changing the Raspberry Pi Settings

To change the the Raspberry Pi configurations you can use a tool written by Alex Bradbury. To open the configuration tool, simply run the following from the command line:

```
pi@raspberry:~ $ sudo raspi-config
```

The sudo is required, because you will be changing files that you do not own as the pi user.

You should see a blue screen with options in a grey box in the center:



raspi-config aims to provide the functionality to make the most common configuration changes. keep in mind that some options require a reboot to take effect. If you changed any of those, raspi-config will ask if you wish to reboot now when you select the <Finish> button.

It has the following options available:

1. Expand Filesystem
2. Change User Password
3. Boot Options
4. Wait for Network at Boot
5. Internationalisation Options
6. Enable Camera
7. Add to Rastrack
8. Overclock
9. Advanced Options
10. About raspi-config

Most configurations are pretty self-explanatory and for this course you only need to change one setting (as shown in the next section).

Expanding your file system

I recommend expanding your file system.

Choosing option 1 from the raspi-config menu will expand your installation to fill the rest of the microSD card, giving you more space to use for files.

Note: you will need to reboot the Raspberry Pi to make this available. Note there is no confirmation; selecting the option begins the partition expansion immediately (as shown in the Figure below).



Right now, you don't need to change anything else.

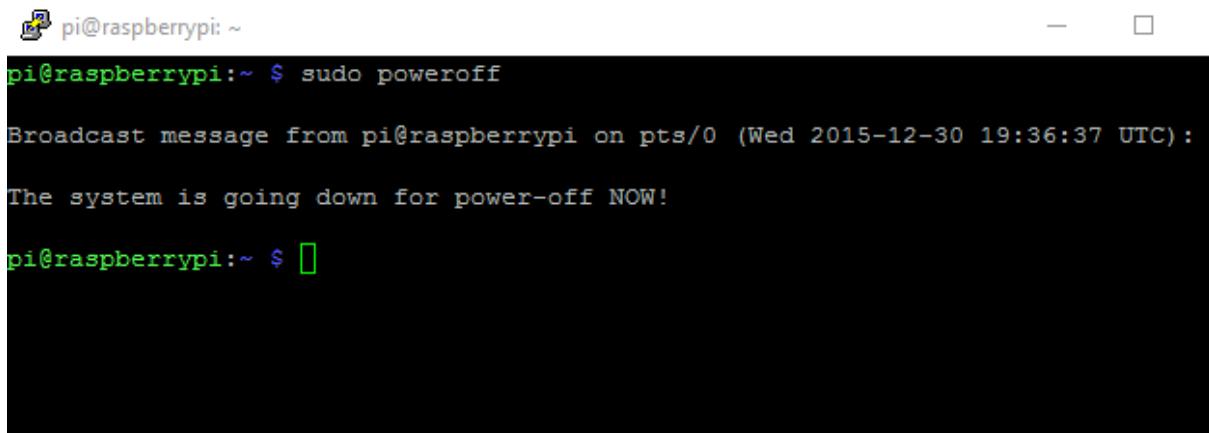
Unit 6 - Shutting Down and Rebooting

There are better ways to shut down and reboot your Raspberry Pi than simply unplugging it. Unplugging your RPi is the equivalent of shutting down your computer by pressing the power button or even removing its power source, which can lead to file corruption.

To shut down your Raspberry Pi, simply type this command on the command line:

```
pi@raspberry:~ $ sudo poweroff
```

You see the following information after you use the shutdown command:



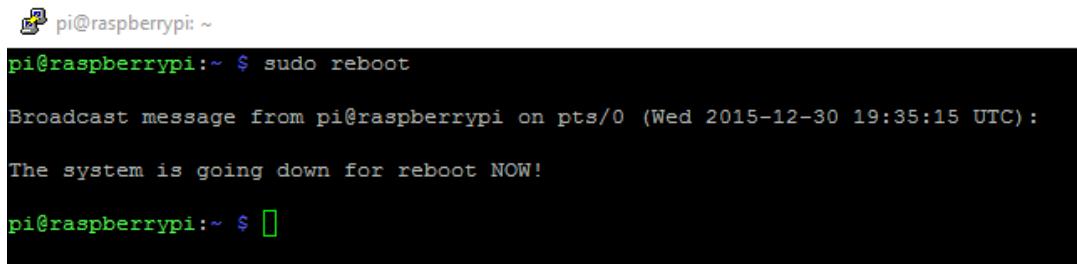
A screenshot of a terminal window titled "pi@raspberrypi: ~". The window shows the command "sudo poweroff" being run, followed by a broadcast message indicating the system is going down for power-off. The terminal then goes black, indicating the system has shutdown.

```
pi@raspberrypi:~ $ sudo poweroff
Broadcast message from pi@raspberrypi on pts/0 (Wed 2015-12-30 19:36:37 UTC):
The system is going down for power-off NOW!
pi@raspberrypi:~ $
```

To reboot, type this:

```
pi@raspberry:~ $ sudo reboot
```

This is the result:



A screenshot of a terminal window titled "pi@raspberrypi: ~". The window shows the command "sudo reboot" being run, followed by a broadcast message indicating the system is going down for reboot. The terminal then goes black, indicating the system has rebooted.

```
pi@raspberrypi:~ $ sudo reboot
Broadcast message from pi@raspberrypi on pts/0 (Wed 2015-12-30 19:35:15 UTC):
The system is going down for reboot NOW!
pi@raspberrypi:~ $
```

You need to log in again through SSH after rebooting.

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Good luck with all your projects,

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