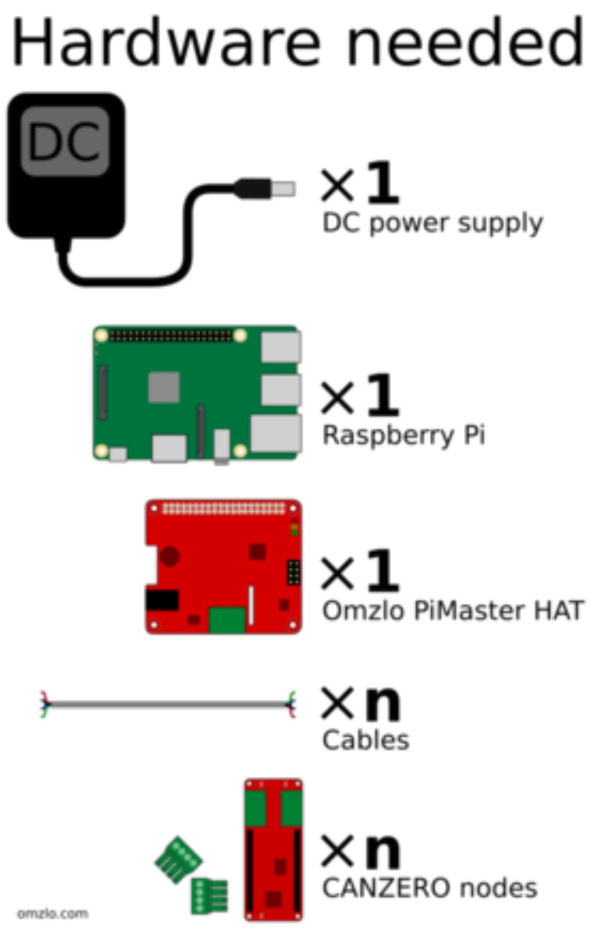
Installing NoCAN: full tutorial

Installing software and hardware for a NoCAN network

1. Hardware

A NoCAN network is composed of a "master" and one or more "CANZERO" nodes. The master is built by combining a Raspberry Pi with the Omzlo PiMaster HAT.



In this tutorial, we will assume that you have the following elements:

- A 12V DC power supply, preferably rated above 24 Watts (any supply between 6V and 24V should be OK).

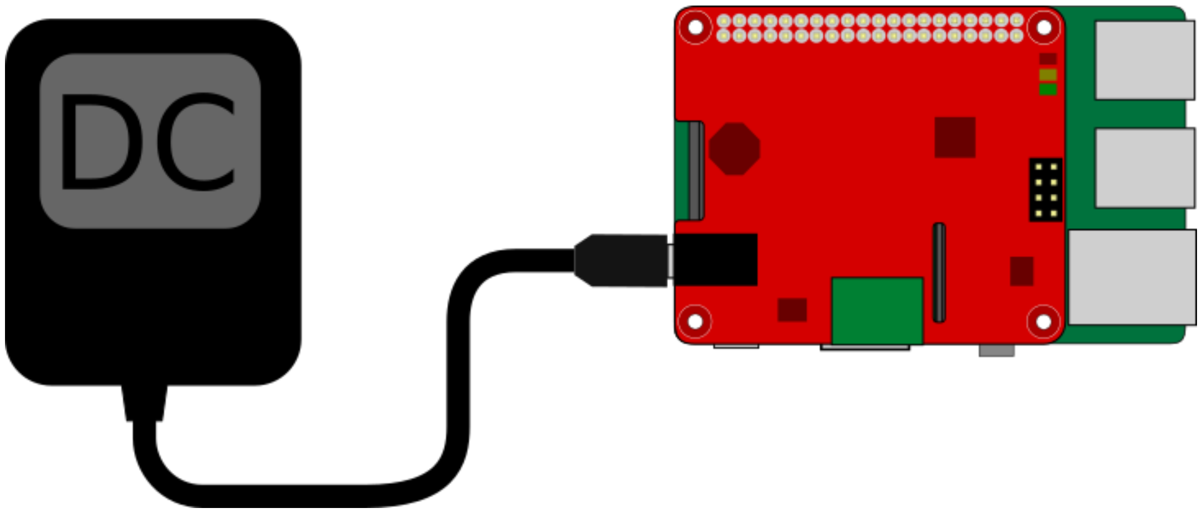
- A working Raspberry Pi to which you are able to have command line access (e.g. through SSH).
- A PiMaster HAT.
- 4-wire cable or 8-wire UTP ethernet cable.
- Two CANZERO nodes.

This starting point provided here in this tutorial is easy to modify to add or remove CANZERO nodes.

1.1 Setting up the PiMaster

To set up the PiMaster, follow these steps:

- Solder the 40-pin GPIO header to the PiMaster HAT (if it is not already soldered).
- Unconnect the Raspberry Pi from any power supply and connect it to the PiMaster HAT with the 40 pin header.
- Plug the 12V DC power jack into the PiMaster HAT.



After completing these steps, the RaspberryPi should boot up, powered by the PiMaster HAT. Right when the power is switched on, the 3 LEDs in the upper left top corner of the PiMaster HAT will get animated briefly. The green LED, marked "A", should stay on.

To further test your setup, you will need to install **nocand** and **nocanc** as described later in this tutorial.

1.2 Adding CANZERO nodes

The first CANZERO node you add to your network will be connected to the PiMaster. The second node will be connected to the first CANZERO node, and so forth, forming a "chain."

A NOCAN network uses four wires:

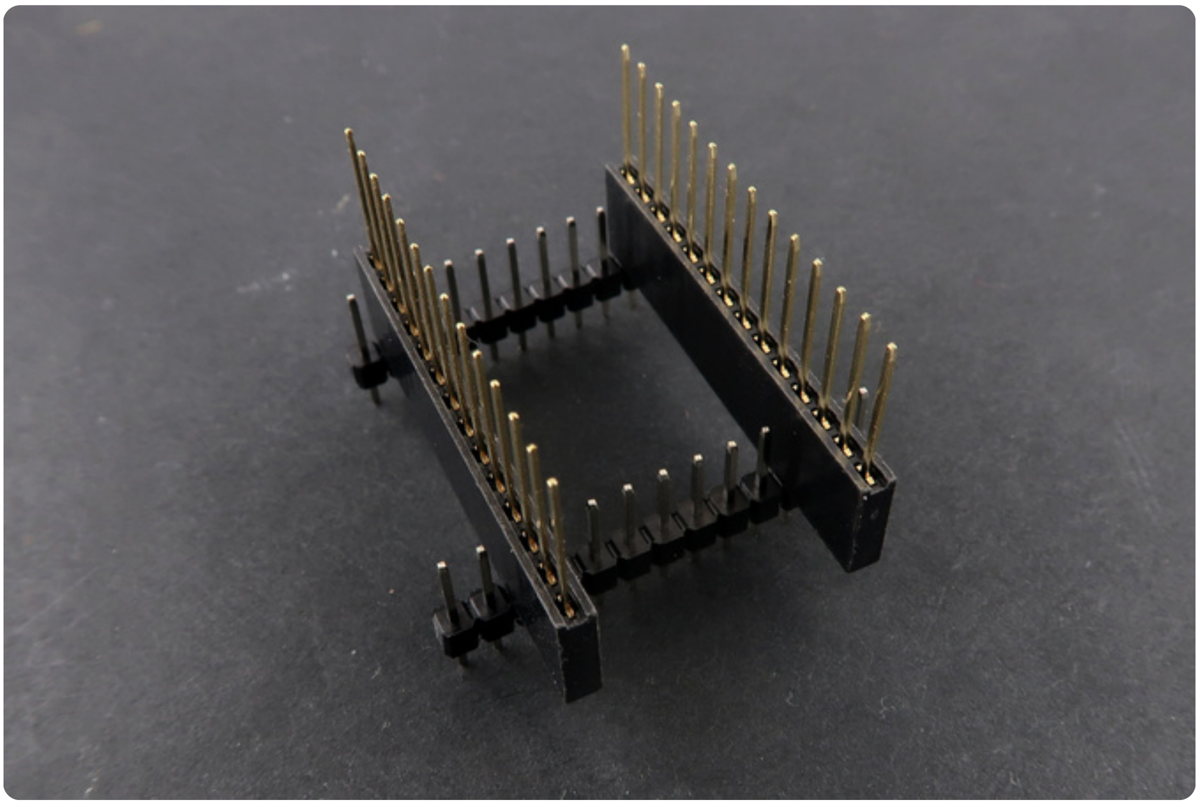
- **GND**: Ground
- **VIN**: DC power (12v or 24v)
- **CAN_L**: CAN bus low signal
- **CAN_H**: CAN bus high signal

1.2.1 Soldering the headers

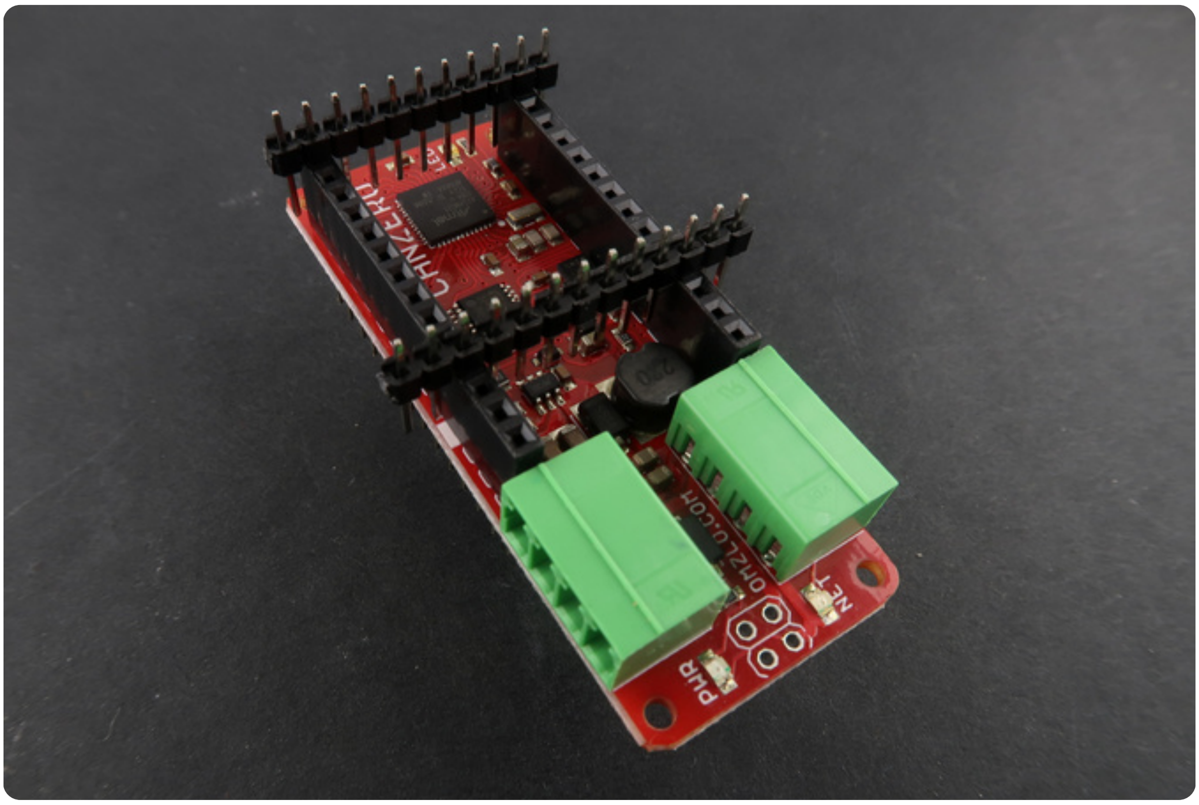
If your CANZERO comes with pre-soldered headers, you may skip the following paragraphs.

If you need to solder a pair of 14-pin "Arduino-MKR style" headers to your CANZERO, you can use the procedure below.

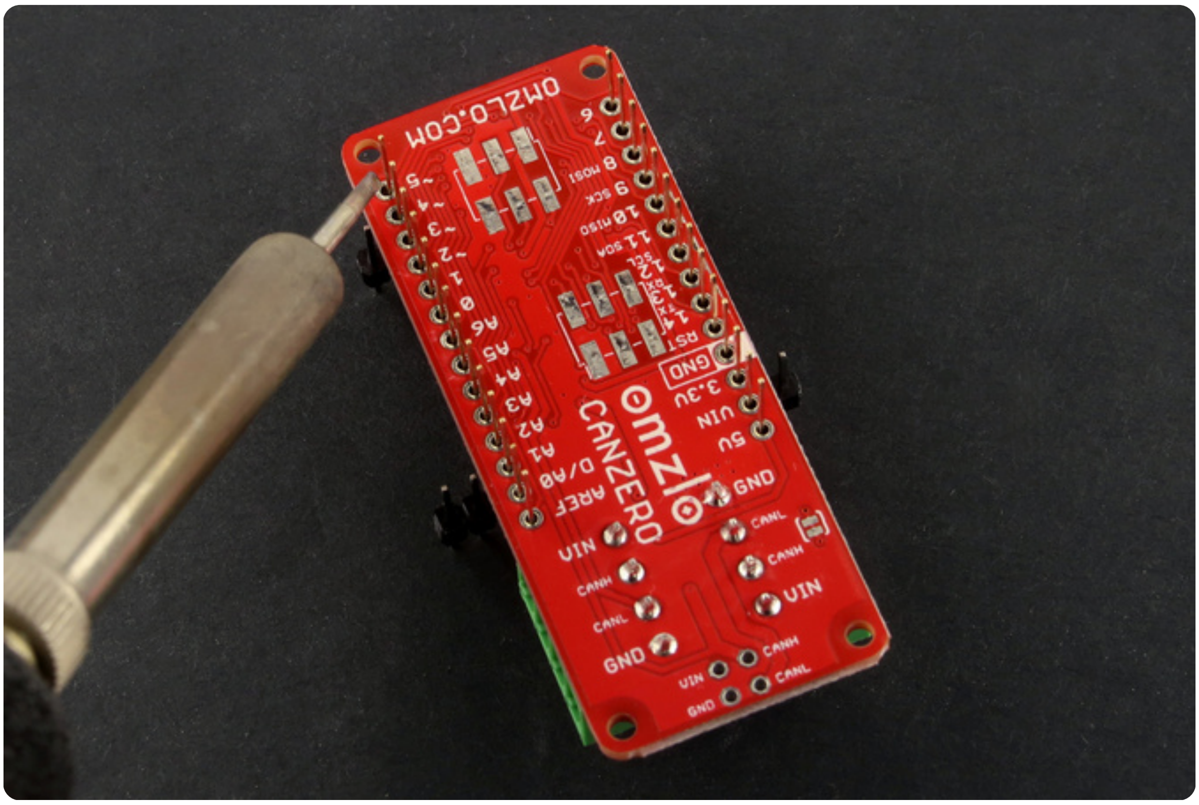
The trick is to use a pair of additional break-apart male headers to create a stable rectangular jig to solder the CANZERO on top, as shown below.



To do this, first, place the two 14 pin headers through the CANZERO board. Then place a pair of break-apart male headers across the 14 pin headers as shown below.



Next, flip around the board and start soldering. It's best to solder first the 4 corners (5V, AREF, Pin 5 and Pin 6) and then the rest of the pins. Note that the pin marked GND will take a little more time to solder because it takes longer to heat up.

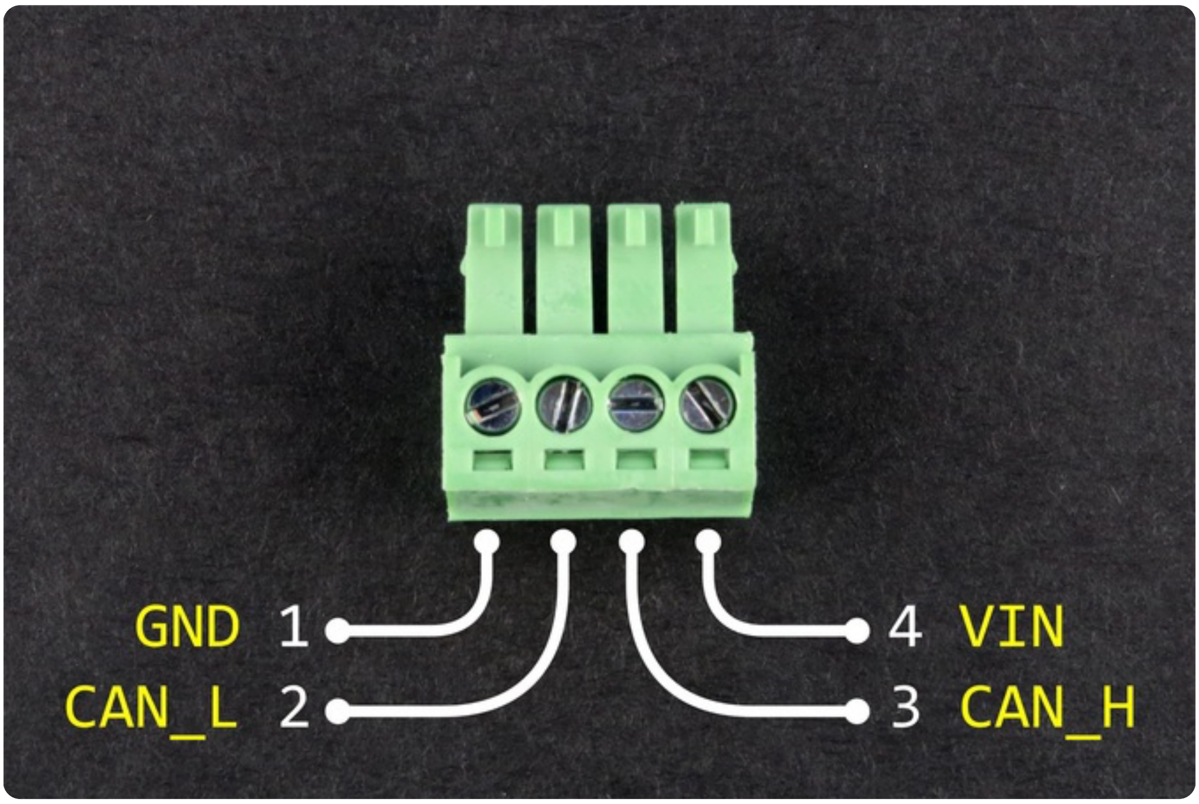


After soldering, remove the break-apart male headers and you are done.

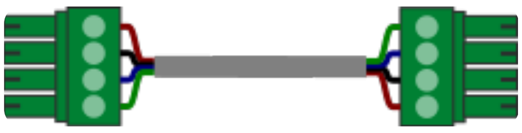
1.2.2 Making cables

The first step is to create cables using the 3.5mm 4-pin pluggable headers that come with the CANZERO. For short distances (a few meters), any cable with four wires will do. For longer distances, cables with twisted pairs provide better robustness. A simple solution is to use Ethernet cable (UTP Cat 5): they can be found for cheap almost anywhere.

The picture below shows pinout used for the 3.5mm pluggable headers.



To make cables, connect pin 1 of the first 3.5mm plug to pin 1 of the second 3.5mm, then do the same for pin 2, pin3 and pin 4. You should obtain a result similar to the illustration below:



As explained here, if you prefer to use Ethernet cables, which are formed with eight wires, you will have better performance if you use three wires for ground, one wire for CAN low (CAN_L), one wire for CAN high (CAN_H) and three wires for VIN.

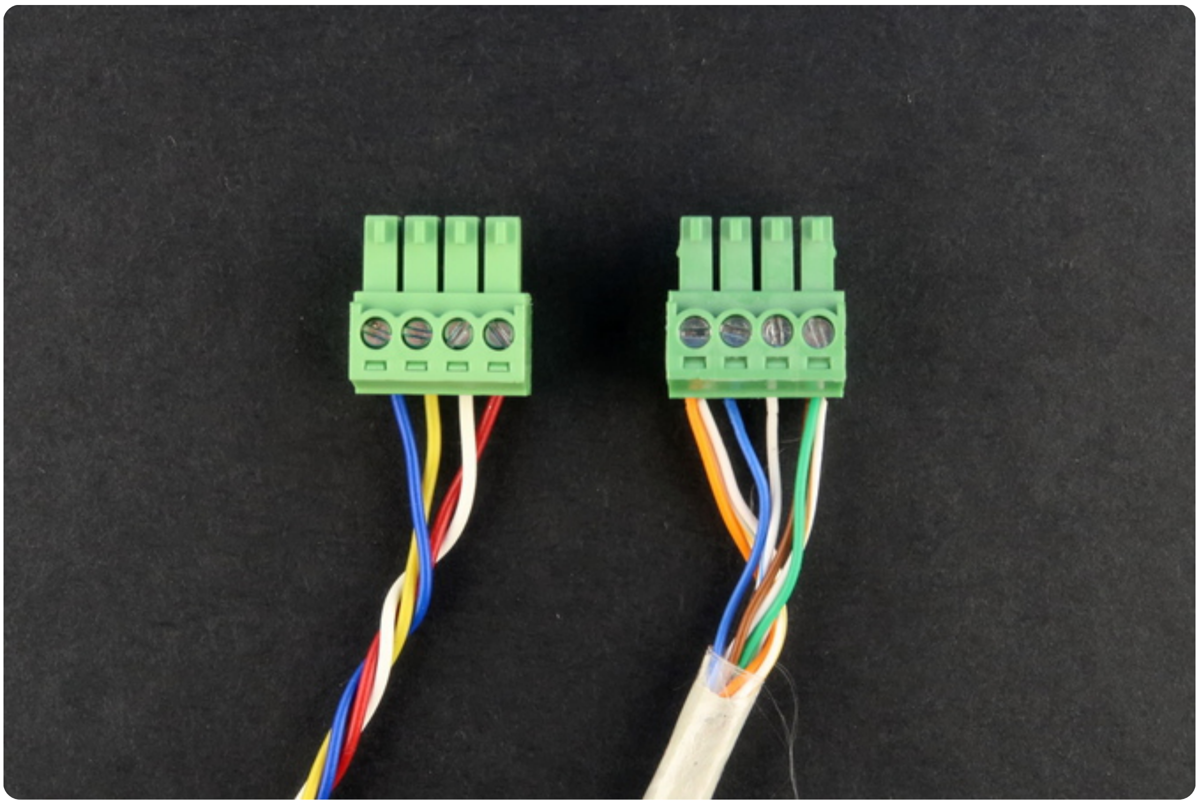
WARNING: it's easy to misconnect these 3.5mm plugs by accidentally fitting wires below the slot where they are supposed to be inserted. Always visually inspect the connections carefully.

We strongly suggest using the following wiring convention when using Ethernet cables. This will facilitate debugging and interoperability with other NoCAN networks:

NoCAN 3.5mm pin	Ethernet wire color codes

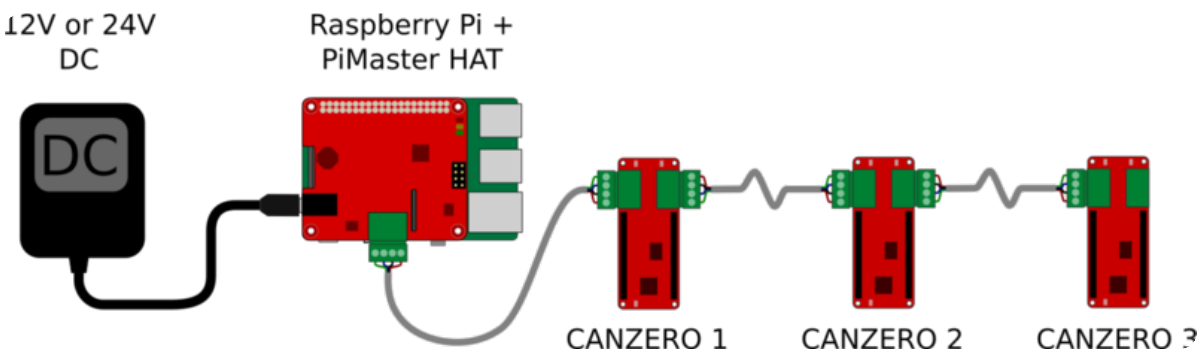
1 (GND)	Orange, Orange/White, Green/White
2 (CAN_L)	Blue
3 (CAN_H)	Blue/White
4 (VIN)	Brown, Brown/White, Green

The picture below shows two wiring examples: on the left, a simple set of 4 wires, and on the right an Ethernet cable wired according to the convention described above.



1.2.3 Connecting to the PiMaster

Once your cables are ready, you can use them to connect your CANZERO nodes to the PiMaster, as illustrated below.



For large networks which run over 100 meters (330 feet) or with many nodes, it may be necessary to add a termination resistor on the last CANZERO node in the network. For this purpose, get a 120-ohm leaded resistor and screw it into pins 2 and 3 of a 3.5mm 4-pin pluggable header. Next, plug this "terminator" in the last CANZERO node in your network.

The network will not be powered and active until you launch **nocand** as detailed in the next section.

2. Software

2.1 Installing nocand

nocand is the server that manages a NoCAN network. It assigns node IDs to each node in the network and keeps track of open channels used to communicate through the network. It also acts as a gateway between the network and the outside world.

nocand needs SPI to be enabled on the Raspberry Pi and the wiringpi library to be installed.

To check if you have already installed *wiringpi*, simply type `gpio -v` in a shell terminal on your Raspberry Pi that is connected to the PiMaster HAT. If you get something you are all set. Otherwise, you will need to install *wiringpi*. On recent versions of Raspbian, you simply need to type:

```
sudo apt-get install wiringpi
```

If that doesn't work on your system, you can install the latest version of *wiringpi* directly by following the instructions provided at http://wiringpi.com/download-and-install/ .

Next, to enable *SPI*, launch the `raspi-conf` utility by typing:

```
sudo raspi-config
```

In the menu select **Interfacing Options**, then **SPI** and finally answer **yes** to the question **Would you like the SPI interface to be enabled?**. Note that not all versions of `raspi-config` have the same layout, so you might need to search for the SPI option in a different sub-menu (e.g. older versions of raspi-config have SPI in the **Advanced Options** menu).

You are now ready to install `nocand`. To do this, open a shell terminal on the Pi and first download the nocand application. You can do this by typing:

```
wget -N http://omzlo.com/downloads/nocand-linux-arm.tar.gz
```

Untar the archive to extract the executable `nocand` by typing `tar xvf nocand-linux-arm.tar.gz`. Put `nocand` in a convenient directory, potentially adding that directory to your path (e.g. edit the `PATH` variable in `~/.profile`).

Next, to make your life easier, you should create a configuration file called `config` in a subdirectory named `.nocand` of your home directory, using your favorite editor (e.g. `mkdir ~/.nocand` followed by `nano ~/.nocand/config`), and providing the following content:

```
auth-token = "yoursupersecretpassword"
```

The AuthToken value ("yoursupersecretpassword") will be used to authenticate connections from the **nocanc** tool to your **nocand** server. You should change the value provided in the example above to a secret password of your choice.

Testing your network with nocand

You are now ready to test your setup, by typing `./nocand server` in the directory where you stored the `nocand` executable. If everything is OK, you should see the following output on the screen.

```
22018/04/25 19:05:14 INFO Connected to driver using SPI interface
2018/04/25 19:05:14 INFO Reseting driver
2018/04/25 19:05:14 DEBUG+ (0) SPI SEND 3: 010200 (SPI_OP_RESET)
2018/04/25 19:05:14 DEBUG+ (0) SPI RECV 3: ffa000
2018/04/25 19:05:14 DEBUG+ Waiting for TX line to be HIGH
2018/04/25 19:05:17 DEBUG+ TX line is HIGH
2018/04/25 19:05:17 DEBUG+ (1) SPI SEND 19: 0200000000000000000000
2018/04/25 19:05:17 DEBUG+ (1) SPI RECV 19: 0043414e3000011d001000
2018/04/25 19:05:17 INFO Firmware version 0.1, signature='CAN0',
2018/04/25 19:05:17 INFO Driver signature verified
2018/04/25 19:05:17 DEBUG+ (2) SPI SEND 2: 0401 (SPI_OP_SET_POWER)
2018/04/25 19:05:17 DEBUG+ (2) SPI RECV 2: 00a0
2018/04/25 19:05:17 DEBUG+ (3) SPI SEND 11: 0300000000000000000000
2018/04/25 19:05:17 INFO Listening for clients at [::]:4242
2018/04/25 19:05:17 DEBUG+ (3) SPI RECV 11: 8040003e050000f705030
2018/04/25 19:05:17 DEBUG+ Driver voltage=11.9, current sense=0 (
[...]
```

When **nocand** launches, it resets the PiMaster HAT and the 3 LEDs in the right top corner of the board with blink briefly a few times. The network will power up and both the Green and Orange LEDs labeled 'A' and 'B' will remain on. If the red LED switches on, you likely have a short circuit in your network, typically as the result of a cabling misconfiguration.

If the application blocks for more than a 10 seconds on the line "*DEBUG+ Waiting for TX line to be HIGH*" the PiMaster is likely in an undefined state: restarting the Raspberry Pi should fix this. If you get a message saying "*panic: SPI driver signature check failed.*", it likely means that the PiMaster HAT is damaged.

You can stop **nocand** at any time by pressing `ctrl` + `C`.

The last line in the logs above also gives some useful information:

```
2018/04/25 19:05:17 DEBUG+ Driver voltage=11.9, current sense=0 (
```

Driver voltage indicates the detected DC voltage that powers the Raspberry Pi and your network. The *status(40)=+powered* shows that everything seems powered correctly without any electrical faults.

The next step is to check that the CANZERO nodes are connected correctly. If at least the first CANZERO node is connected correctly the logs will continue to display information similar to the lines below:

```
[...]
2018/04/25 19:05:19 DEBUG+ (4) SPI SEND 15: 090000000000000000000
2018/04/25 19:05:19 DEBUG+ (4) SPI RECV 15: 180d9014010008080b0643
2018/04/25 19:05:19 DEBUG+ (5) SPI SEND 2: 0a00 (SPI_OP_RECV_ACK)
2018/04/25 19:05:19 DEBUG+ (5) SPI RECV 2: 0080
2018/04/25 19:05:19 DEBUG++ RECV FRAME EXT@90140100 8: 08 0b 06 43
2018/04/25 19:05:19 DEBUG ** Received <nocan-sys-address-request r
2018/04/25 19:05:19 INFO Device 08:0b:06:43:4d:54:03:1f has been r
2018/04/25 19:05:19 DEBUG+ ** Sending <nocan-sys-address-configure
[...]
```

The line *INFO Device 08:0b:06:43:4d:54:03:1f has been registered as node N1* indicates that a first CANZERO node has been correctly registered in the network. You should get a similar message for each node in the network (identified as N1, N2, N3, etc.).

You may see a **WARNING** saying that `message of type nocan-sys-channel-subscribe` ... `was not processed`. This warning can be safely ignored.

After a few seconds, you will also power status messages such as the following:

```
2018/04/25 19:12:17 DEBUG+ Driver voltage=11.9, current sense=7 (~
```

Here, the value of *current sense* gives a very rough estimate of the power consumption of the nodes in the network. When this value is 0, it means that the network is likely disconnected. This value will increase as you add nodes. If this value goes above a specific limit (approx. 4A by default), the PiMaster will cut off the power provided to the network as a safety measure.

Another way to check for potential connection issues is to visually inspect the green LEDs of the CANZERO nodes. During normal bootup, the green LED marked "NET" on the CANZERO will blink with regular frequency for 10 seconds and then stay fully on, once the node is registered with the PiMaster and fully booted. In case of an issue, this LED will blink twice rapidly and then stay off for a short while, before starting again to blink twice rapidly. This blinking pattern is typically the sign that the power connection to the board is correct but that the CAN bus is itself not correctly connected: it worth checking pins 2 and 3 on every cable for misconnections.

Once you have installed **nocanc**, as described in the next section, you will be able to check the correct configuration of the network more simply.

Once your setup is more stable, and you want to run **nocand** permanently, you can try to use the screen utility. This way you can connect and disconnect from your Pi, while **nocand** is running. Alternatively, you may want to put nocand into a *systemd startup script* so the server starts up automatically each time your raspberry pi boots up.

2.2 Installing nocanc

nocanc is the application that enables you to interact with your NoCAN network. For example, you can use **nocanc** to send a message to nodes or upload an Arduino sketch to a node. You are free to install **nocanc** on a different machine than the one that runs **nocand**. In fact, it often makes sense to do so, by running **nocanc** on the same machine that runs the Arduino IDE that is used to develop the sketches that will be uploaded to various nodes.

2.2.1 On Linux or Mac OS X

First, download the `nocanc` executable that corresponds to your platform:

- On Mac OS X, download nocanc-darwin-amd64.tar.gz

- On Linux/Amd64, download nocanc-linux-amd64.tar.gz
- On Linux/Arm (Raspberry Pi), download nocanc-linux-arm.tar.gz

Untar and uncompress the downloaded archive and extract the `nocanc` executable in a directory of your choice. Optionally, for greater ease of use, you can add that directory to your PATH environment variable.

Next, to simplify your life, use your favorite text editor to create a simple configuration file named `.nocanc.conf` and place it in your home directory (e.g. `nano ~\.nocanc.conf`).

The content of this file should look as follows:

```
event-server = "192.168.2.112:4242"
auth-token = "yoursupersecretpassword"
```

You will need to replace `192.168.2.112:4242` with the actual address of your Raspberry Pi machine running **nocand**. Similarly, you will need to replace `yoursupersecretpassword` with the same password selected for **nocand** on the Raspberry Pi.

Assuming all is set up correctly, you can test the connection by typing the following command at the command prompt, in the directory where you extracted the `nocanc` tool:

```
./nocanc monitor
```

The tool should output messages similar to these:

```
EVENT   bus-power-status-update-event   #6  Driver voltage=11.9, c
EVENT   bus-power-status-update-event   #6  Driver voltage=11.9, c
```

If the connection fails, you will see *Error: dial tcp :4242: getsockopt: connection refused*. Please check your setup. If you see *Error: Request failed, code 2* it probably means that the AuthToken value is incorrect.

2.2.2 On MS-Windows

First, download nocanc-windows-amd64.zip, and extract the executable `nocanc.exe` inside the zip file. As a good starting point for experimenting, you can put it in your user directory: if your windows username is "Foobar," then your user directory will typically be "C:\Users\Foobar\". This directory is also defined as the windows environment variable `%userprofile%`.

Next, to simplify your life, use your favorite text editor to create a simple configuration file named `_nocanc.conf` that will be placed in the user directory (e.g. `Notepad.exe C:\Users\Foobar\_nocanc.conf` or `Notepad.exe %userprofile%\_nocanc.conf`).

The content of this file should look as follows:

```
event-server = "192.168.2.112:4242"
auth-token = "yoursupersecretpassword"
```

You will need to replace `192.168.2.112:4242` with the actual address of the `nocand` server running on your Raspberry Pi. Similarly, you will need to replace `yoursupersecretpassword` with the same password selected for `nocand` on the Raspberry Pi.

Assuming all is set up correctly, you can test the connection by opening a Windows shell (search for "cmd.exe" in the windows launch menu) and typing the following command:

```
nocanc.exe monitor
```

The tool should output messages similar to these:

```
EVENT   bus-power-status-update-event   #6  Driver voltage=11.9, c
EVENT   bus-power-status-update-event   #6  Driver voltage=11.9, c
```

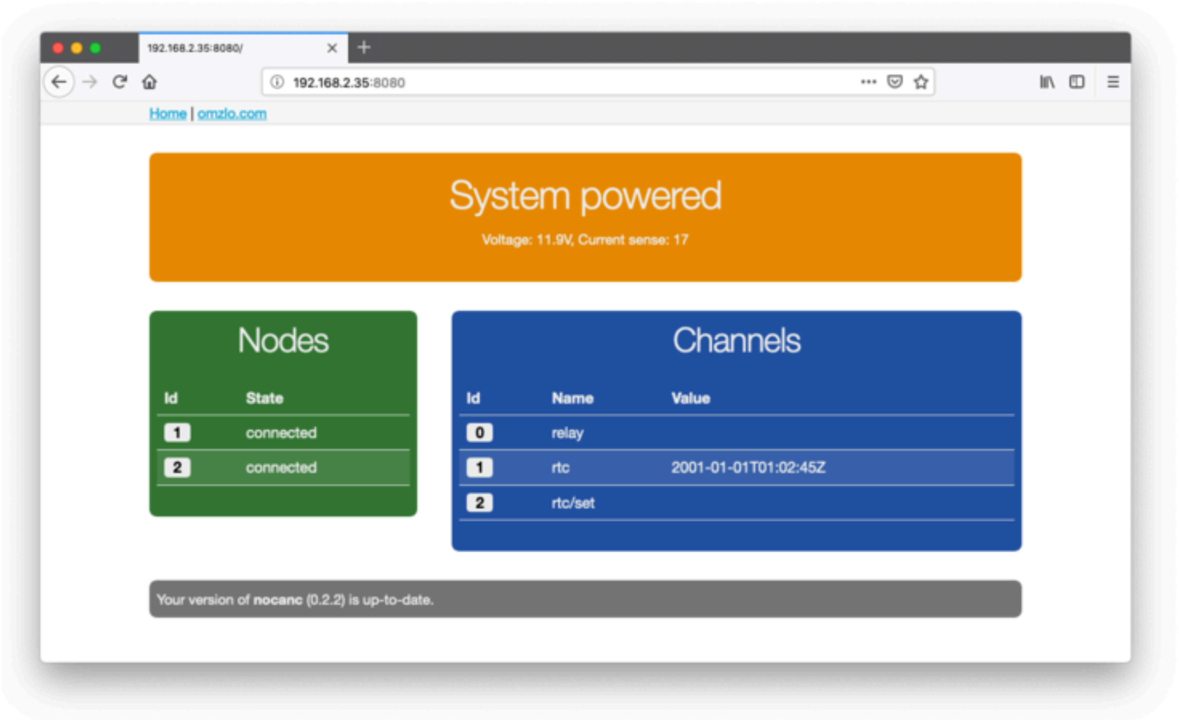
If the connection fails, you will see *Error: dial tcp :4242: getsockopt: connection refused*. Please check your setup. If you see *Error: Request failed, code 2* it probably means that the AuthToken value is incorrect.

2.2.3 Using nocanc to test your network

The simplest way to check the status of your network is to use nocanc's web interface:

- Type the command `./nocanc webui`.
- Open a browser window and type `localhost:8080` in the address bar.

You should get access to a web interface like the one below:



System powered

Voltage: 11.9V, Current sense: 17

Nodes

Id	State
1	connected
2	connected

Channels

Id	Name	Value
0	relay	
1	rtc	2001-01-01T01:02:45Z
2	rtc/set	

Your version of **nocanc** (0.2.2) is up-to-date.

You will be able to see how many nodes are connected, what channels have been created.

2.2.4 Playing with nocanc

The web interface described in the previous paragraph should provide you with all that is needed to get started. However, it's good to know that you can also get information directly from the command line with `nocanc` (so worries, if you don't like using the command line, you can skip this section).

The following examples assume that `nocanc` is running on Linux or MacOS. To translate the examples for Windows, simply replace all instances of `./nocanc` with `nocanc.exe`

Typing `./nocanc list-nodes` will provide a list of connected nodes in the network such as in the example below, which shows a two-node network.

```
$ ./nocanc list-nodes
# Nodes:
#1  08:0b:06:43:4d:54:03:1f connected
#2  07:01:06:43:4d:54:03:1f connected
```

By default, CANZERO nodes ship with a very simple default firmware that creates a channel named **led*x*** where *x* is the node number. You can check this with the command `./nocanc list-channels`, as in the example below:

```
$ ./nocanc list-channels
# Channels:
UPDATED #1  led1    ""
UPDATED #2  led2    ""
```

From this point on, you can switch the orange user LED on or off on any connected CANZERO node. For example by typing `./nocanc publish led1 1` you will switch on the orange user LED on node 1, while typing `./nocanc publish led1 0` will switch it off.

Of course, once you upload your sketches to a CANZERO node, this user LED "demo" will stop working. Creating your own Arduino sketches for the CANZERO is the topic of the final part of this tutorial.

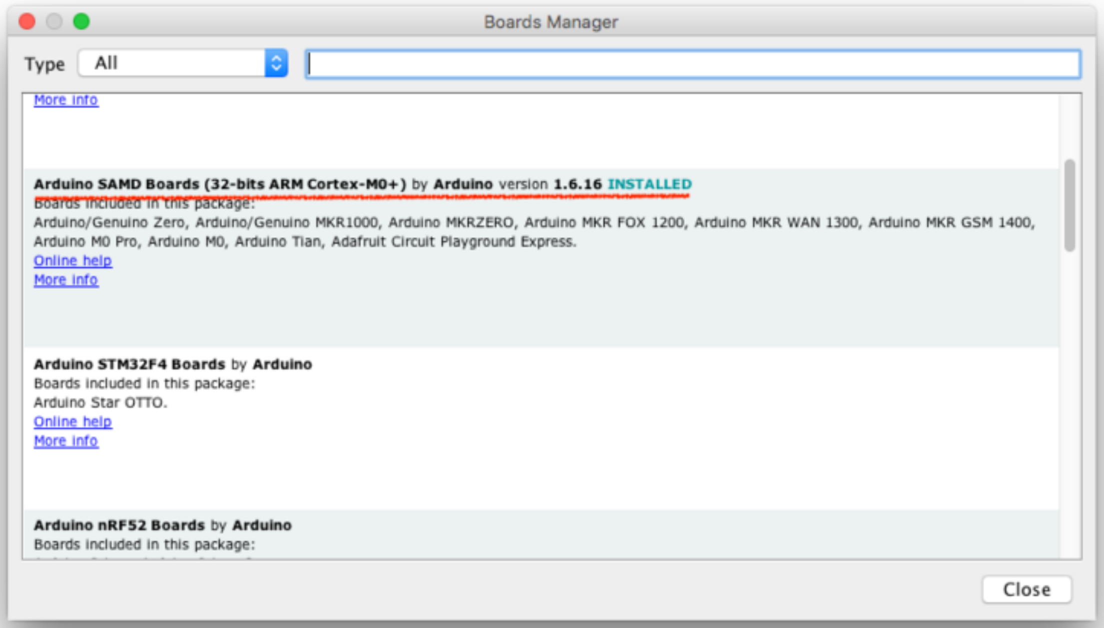
To learn more about `nocanc` command line options, simply type `nocanc help`.

2.3 Configuring Arduino

For the most user-friendly experience, it is recommended to use Arduino version 1.8.9 or above.

To be able to use the Arduino IDE to create sketches for CANZERO nodes, you will need to install some additional components. This is a typical process needed to add non-native "Arduino-compatible" boards to the Arduino IDE. You can see for example the Sparkfun Tutorial describing how to install their SAMD21 board.

The first step is to add the native Arduino SAMD board definitions. This provides us with the necessary tools needed to compile Arduino sketches that target Atmel SAMD21 Arm Cortex M0+ boards, like the Omzlo CANZERO. To do this navigate to the board manager: **Tools > Board > Board Manager**. Then select **Arduino SAMD Boards (32-bits ARM Cortex-M0+) by Arduino**, and click on **install**.



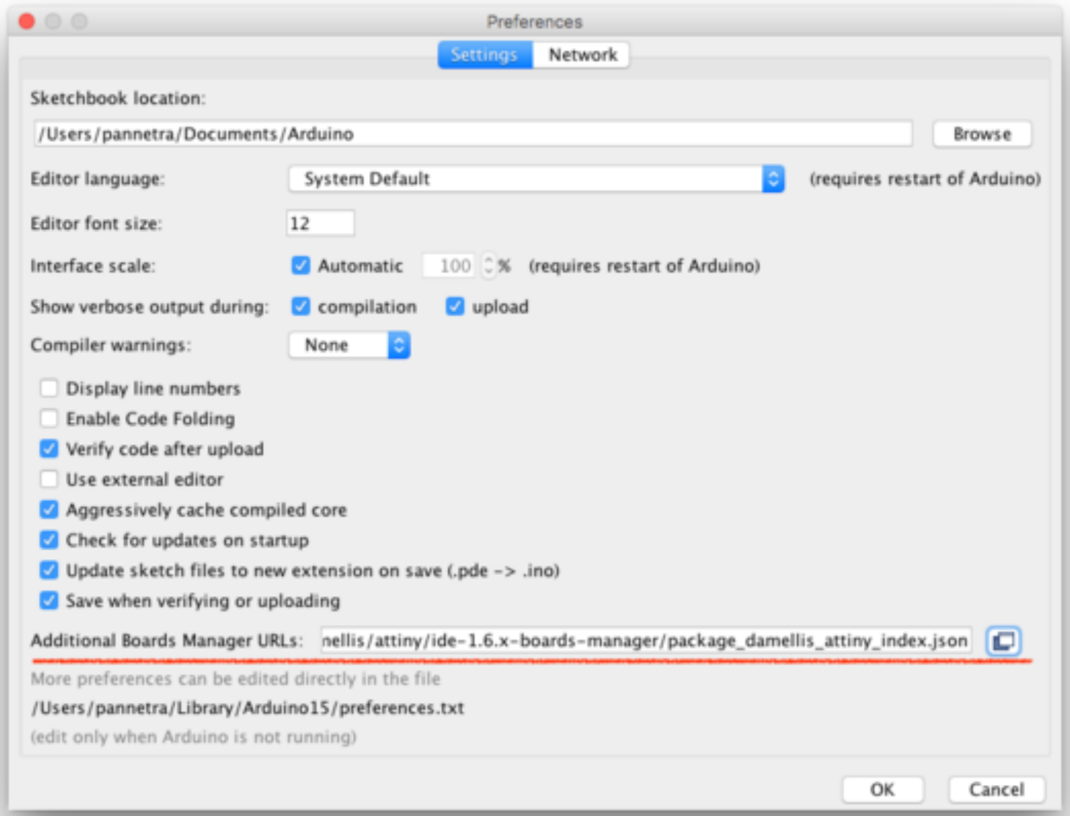
More info

Arduino SAMD Boards (32-bits ARM Cortex-M0+) by **Arduino** version **1.6.16** INSTALLED
Boards included in this package:
Arduino/Genuino Zero, Arduino/Genuino MKR1000, Arduino MKRZERO, Arduino MKR FOX 1200, Arduino MKR WAN 1300, Arduino MKR GSM 1400, Arduino M0 Pro, Arduino M0, Arduino Tian, Adafruit Circuit Playground Express.
Online help
More info

Arduino STM32F4 Boards by **Arduino**
Boards included in this package:
Arduino Star OTTO.
Online help
More info

Arduino nRF52 Boards by **Arduino**
Boards included in this package:

Next, navigate to **Preferences** and locate the **Additional Boards Manager URLs** field and click on the small icon on the right.



Sketchbook location:
/Users/pannetra/Documents/Arduino

Editor language: System Default (requires restart of Arduino)

Editor font size: 12

Interface scale: ✓ Automatic 100 % (requires restart of Arduino)

Show verbose output during: ✓ compilation ✓ upload

Compiler warnings: None

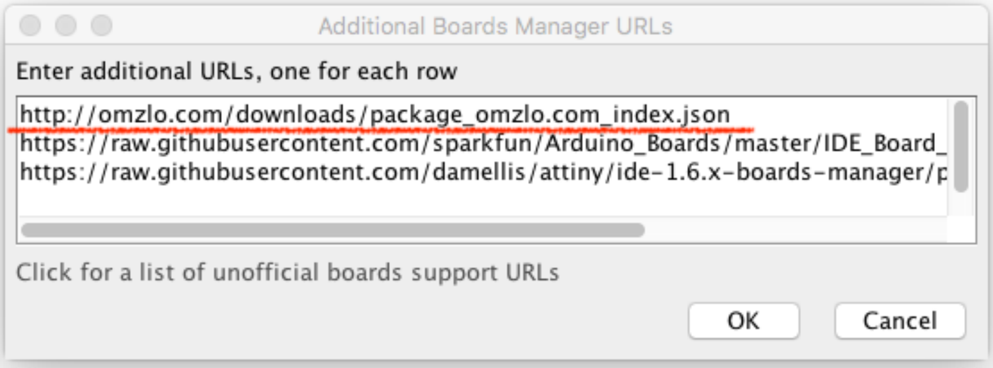
- ☐ Display line numbers
- ☐ Enable Code Folding
- ✓ Verify code after upload
- ☐ Use external editor
- ✓ Aggressively cache compiled core
- ✓ Check for updates on startup
- ✓ Update sketch files to new extension on save (.pde -> .ino)
- ✓ Save when verifying or uploading

Additional Boards Manager URLs: nellis/attiny/ide-1.6.x-boards-manager/package_damellis_attiny_index.json

More preferences can be edited directly in the file
/Users/pannetra/Library/Arduino15/preferences.txt
(edit only when Arduino is not running)

There you should add the following URL to the list, as shown below.

```
http://omzlo.com/downloads/package_omzlo.com_index.json
```



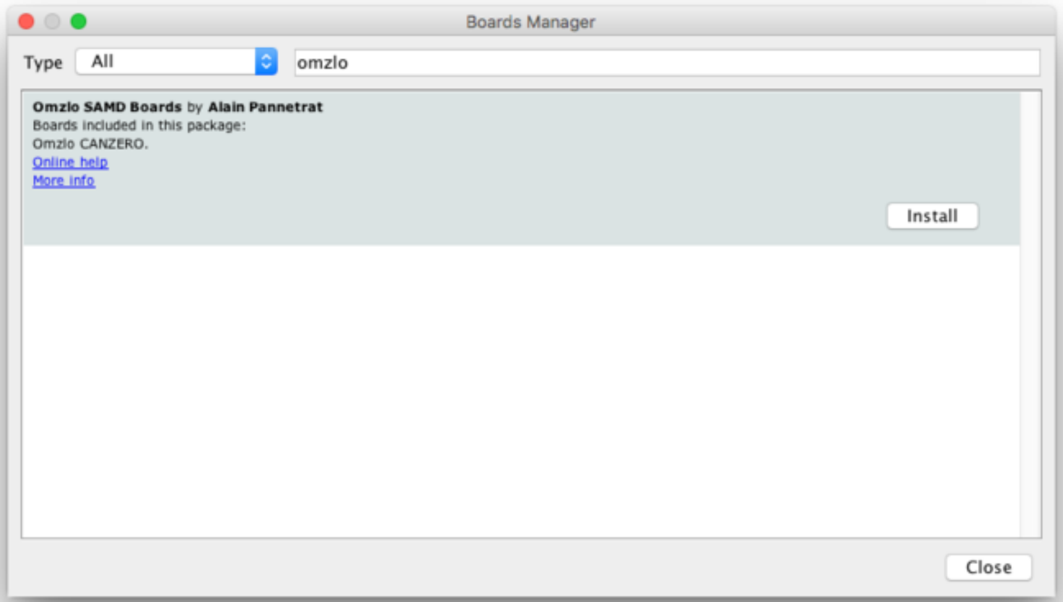
Enter additional URLs, one for each row

```
http://omzlo.com/downloads/package_omzlo.com_index.json
https://raw.githubusercontent.com/sparkfun/Arduino_Boards/master/IDE_Board_
https://raw.githubusercontent.com/damellis/attiny/ide-1.6.x-boards-manager/p
```

Click for a list of unofficial boards support URLs

Finally, navigate back to the board manager: **Tools > Board > Board**

Manager. Then select **Omzlo SAMD boards** and click **install**.



Omzlo SAMD Boards by **Alain Pannetrat**
Boards included in this package:
Omzlo CANZERO.

Note: If the *Omzlo SAMD boards* does not appear in the list the first time, please try again a few seconds later, to give the Arduino IDE enough time to download the board description.

2.4 Creating and uploading Arduino sketches

2.4.1 Starting with a very simple sketch

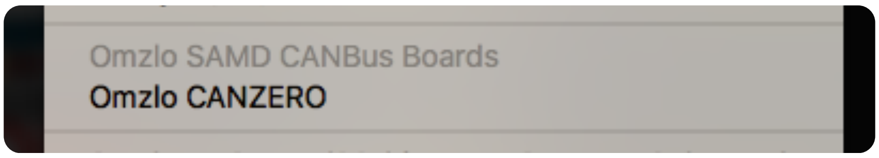
As a starting point, we will write the classic Arduino equivalent of "hello world": a blinking LED, using the builtin orange user LED. The corresponding sketch provided below four you to copy and paste:

```
void setup() {
  pinMode(LED_BUILTIN, OUTPUT);
}

void loop() {
  digitalWrite(LED_BUILTIN, HIGH);
  delay(100);
  digitalWrite(LED_BUILTIN, LOW);
  delay(100);
}
```

That sketch is very simple. In fact, it's so simple that it does not showcase any of the communication capabilities of the CANZERO. That's OK for now: it's just a test.

To prepare the sketch for compilation, navigate the Arduino IDE to **Tools > Boards** and select **Omzlo CANZERO**, as shown below.



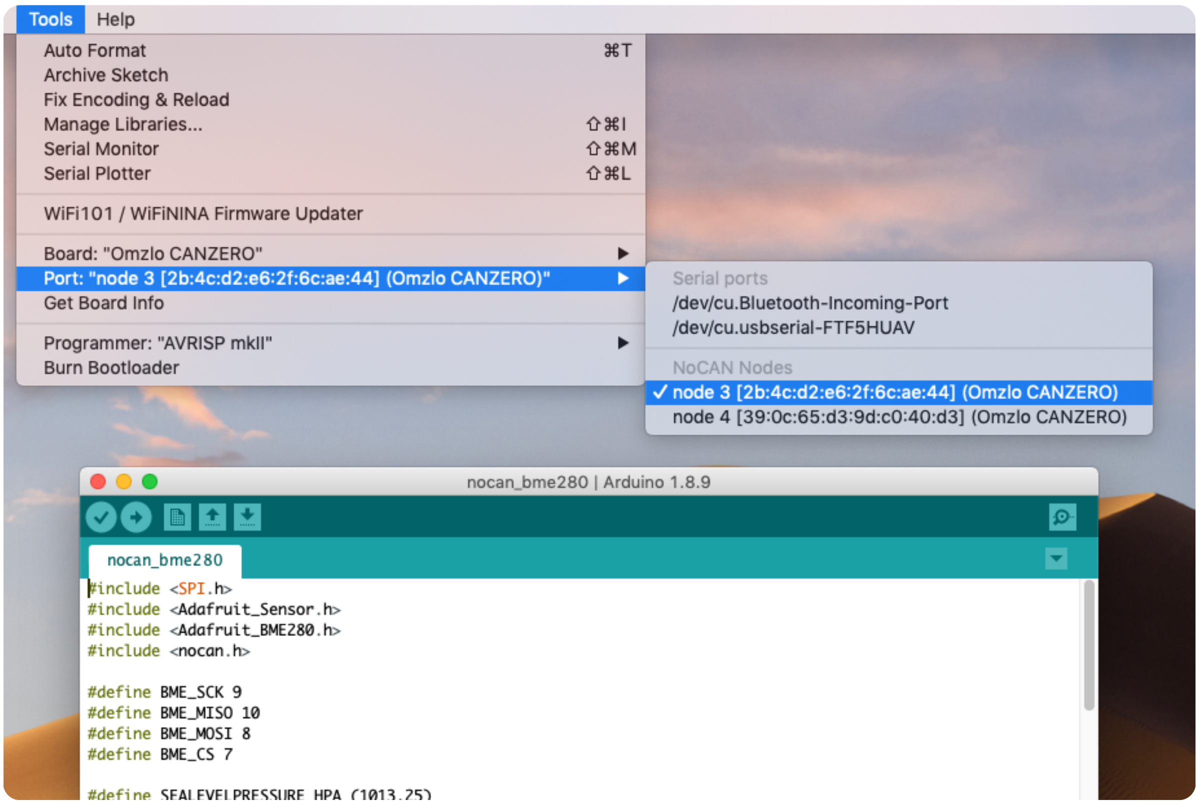
The following steps will depend on your installation. Read on.

2.4.2 Uploading Arduino sketches the easy way

Let's assume that:

- You have Arduino version 1.8.9 or above
- On the same machine that runs Arduino, you have created a configuration file for `nocanc` as indicated previously

Congratulations! Uploading sketches will be super simple. Navigate the Arduino IDE to **Tools > Port** and select the node you want to upload to, as shown on the screenshot example below:


Tools
Help
Auto Format ⌘T
Archive Sketch
Fix Encoding & Reload
Manage Libraries... ⇧⌘I
Serial Monitor ⇧⌘M
Serial Plotter ⇧⌘L
WiFi101 / WiFiNINA Firmware Updater
Board: "Omzlo CANZERO"
Port: "node 3 [2b:4c:d2:e6:2f:6c:ae:44] (Omzlo CANZERO)"
Get Board Info
Programmer: "AVRISP mkII"
Burn Bootloader
Serial ports
/dev/cu.Bluetooth-Incoming-Port
/dev/cu.usbserial-FTF5HUAV
NoCAN Nodes
✓ node 3 [2b:4c:d2:e6:2f:6c:ae:44] (Omzlo CANZERO)
node 4 [39:0c:65:d3:9d:c0:40:d3] (Omzlo CANZERO)
nocan_bme280 | Arduino 1.8.9
nocan_bme280

```
#include <SPI.h>
#include <Adafruit_Sensor.h>
#include <Adafruit_BME280.h>
#include <nocan.h>

#define BME_SCK 9
#define BME_MISO 10
#define BME_MOSI 8
#define BME_CS 7

#define SEALEVELPRESSURE_HPA (1013.25)
```

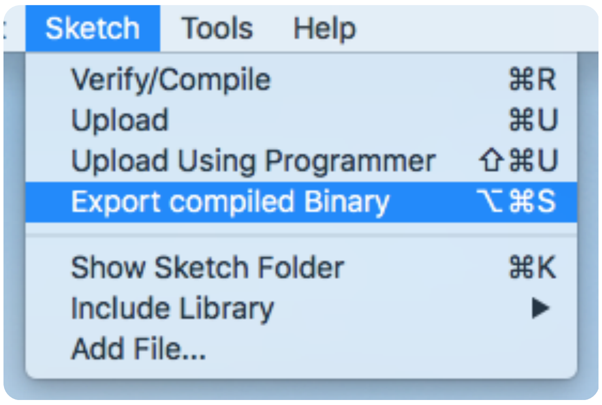
Then simply click on the "upload" icon, and you're done!

Once the upload has completed, after a few seconds the LED of the selected CANZERO node will blink rapidly.

2.4.3 Uploading Arduino sketches manually

If you have an older version of Arduino, will need to upload your sketches "manually".

To do that, navigate to **Sketch > Export compiled Binary**. This will create a compiled version of your sketch, which is a file ending with the extension `.hex`.



Now you can use **nocanc** to upload your compiled sketch to the node of your choice. For example, if you want to upload the compiled binary `canzero_hello_world.ino.omzlo_canzero.hex` which is in the directory `/Users/Omzlo/Arduino/canzero_hello_world`, you would type the following command on a Mac OS X machine.

```
./nocanc upload /Users/Omzlo/Arduino/canzero_hello_world/canzero_h
```

On an MS-Windows machine, the command will look more like this:

```
nocanc.exe upload C:\Users\Omzlo\Documents\Arduino\canzero_hello_w
```

Once the upload has completed, after a few seconds the LED of the selected CANZERO node will blink rapidly.

What's next

You are now ready to explore the communication possibilities of the NoCAN network. As a start, you can look at the relay example provided in the introduction to the NoCAN platform as well as the examples provided in the NoCAN API description

Note: All logic on the CANZERO is 3.3V, like the Arduino MKR ZERO or the ESP8266 for example. Level shifting will be necessary to interface with legacy 5V circuits.

INFORMATION

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