Live Programming IoT devices

With Pharo Things

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Section 1

Objective

Objective

- Run Pharo IoT in a Raspberry Pi that has Raspbian already installed.
- Install Pharo IoT and Raspbian from scratch in headless mode (without keyboard/mouse/screen);
- Run and use Pharo IoT IDE on your Linux, Windows or Mac OSX computer.

Section 2

Installation

Install in a Raspberry that has Raspbian

- If you already have Raspbian running on your Raspberry Pi, you can simply use the Pharo IoT zero-conf.
- Open a terminal window in your Rpi (local or remote SSH)

Install in a Raspberry that has Raspbian

- Enter:

```
wget -O - get.pharo/server | bash
```

- $=>$ You will download the server side and extract the files to the pharoiot-server folder

Install in a Raspberry that has Raspbian

- Goto the folder and run pharo server

```
cd pharoiot-server
./pharo-server
```

- If everything is alright, you will see this message: ‘a `TlpRemoteUIManager is registered on port 40423`’.
  - This means that you have TelePharo running on your Raspberry on TCP port 40423.
- Now you can use Pharo IoT on your computer to connect to your Raspberry and create IoT applications remotely.

Install Raspbian and Pharo IoT from scratch (Raspberry Pi Headless Setup)

- There are many options to install Raspbian on your Raspberry. The most common way is to download the ISO image from the official Raspberry website and follow the steps to install it.
  - Basically, they are: copy an ISO image to an SD card, insert it in Raspberry Pi, turn On the Rasp and use a `keyboard/mouse/screen` to use it as a normal computer.
- But we will not use `keyboard/mouse/screen` to install Raspbian and run Pharo IoT! We do not need them.

Install Raspbian and Pharo IoT from scratch (Raspberry Pi Headless Setup)

- We will use a third-party program to perform these tasks automatically:
  - Install Raspbian Full OS
  - Setting the Raspberry Pi hostname
  - Set boot to console
  - Enable the I2C and SPI modules
  - Connect it in your WiFi network
  - Download Pharo IoT (requires Rasberry Pi connected on the internet)
  - and start the Pharo IoT server at every boot

Pibakery

- Download the Pibakery.
- Download the configuration file.

  `http://get.pharoiot.org/pibakeryPharoIoT.xml`

- Write to your Rpi SD card.

Pibakery

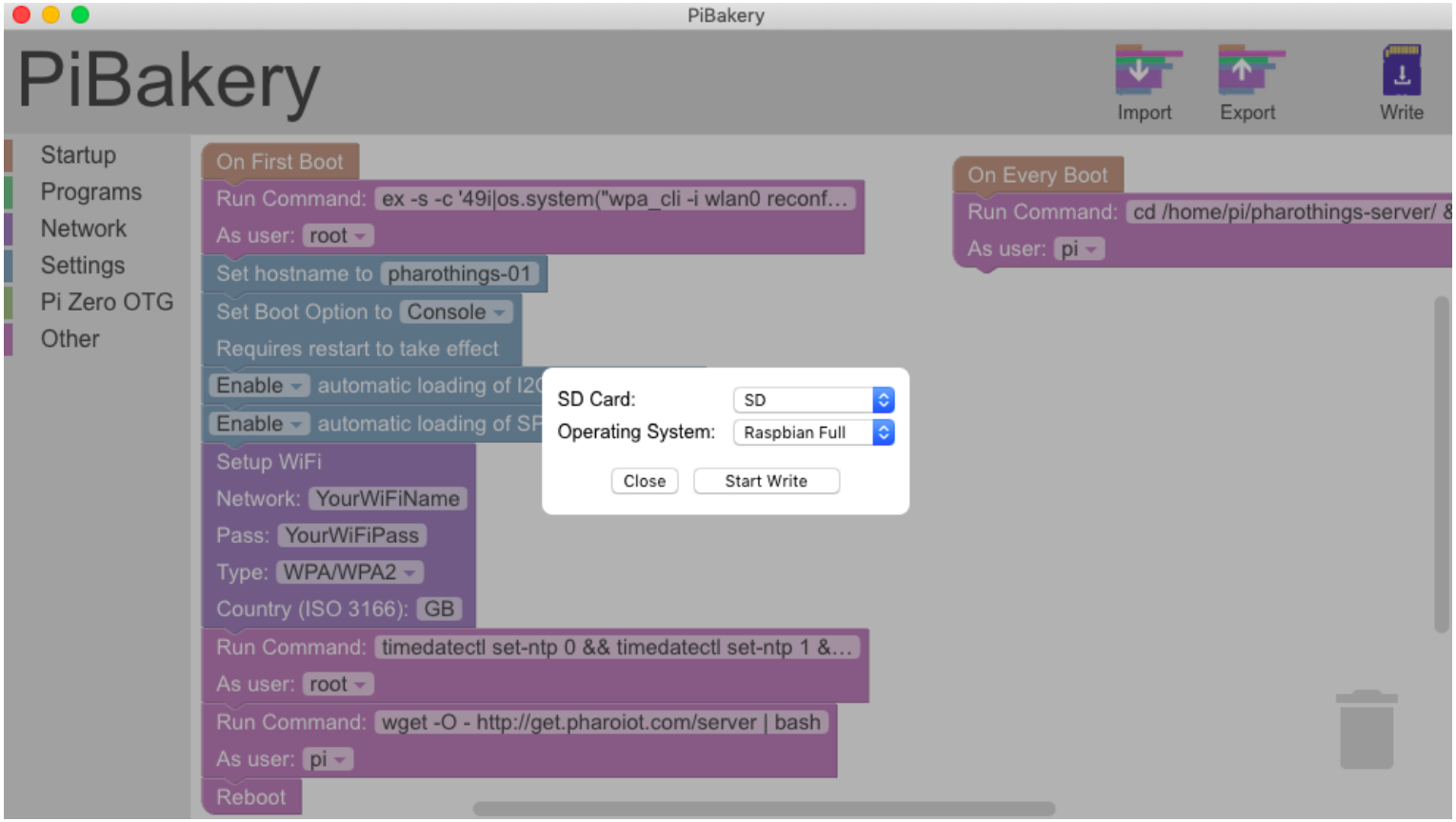


Figure 1: Configuration

Pibakery

- Change your hostname and WiFi configuration in PiBakery;
- Insert the SD card into your machine, click Write and select the Opera- tion System Raspbian Full;
- After the process, insert the SD in the Raspberry and wait about 3 minutes to complete the automatic configuration. Time depends on the speed of your internet;
- You can now find your Raspberry by the Hostname you defined above.
- You do not need to do anything else on your Raspberry Pi. It is already loaded with Pharo IoT starting at every boot on the TCP port 40423

Run Pharo IoT IDE on your Linux, Windows or Mac OSX computer

Download Pharo from

`get.pharoiot.com/multi.zip`

Run Pharo IoT IDE on your Linux, Windows or Mac OSX computer

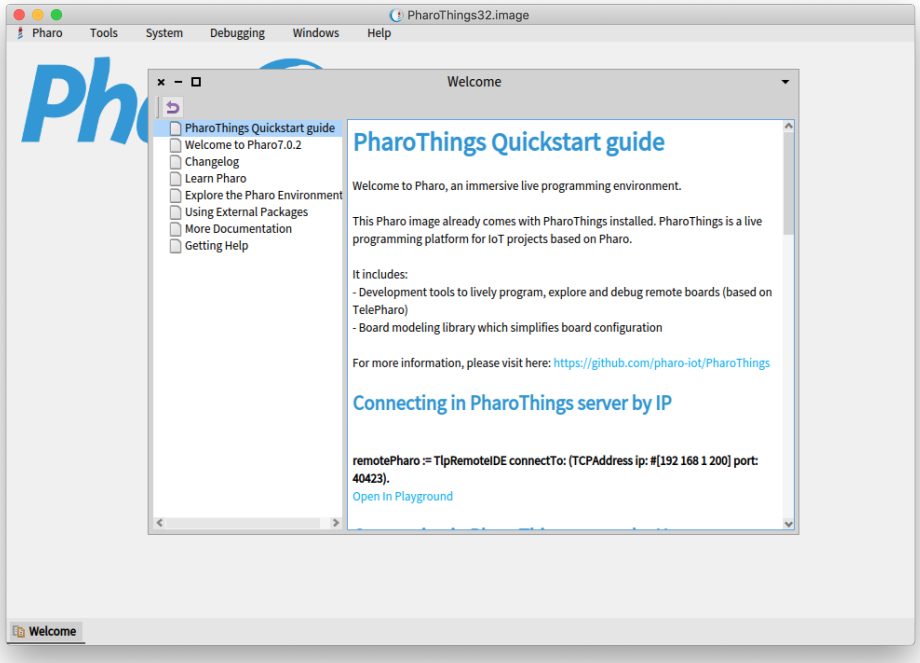


Figure 2: Pharo IDE

Section 3

Get Started

Connecting from your computer to Raspberry Pi

Connecting in Pharo IoT server by Hostname

```
ip := NetNameResolver addressForName: 'pharoiot-01'.

remotePharo := TlpRemoteIDE connectTo:
    (TCPAddress ip: ip port:40423).
```

Connecting in Pharo IoT server by IP

```
remotePharo := TlpRemoteIDE connectTo:
    (TCPAddress ip: #[192 168 1 200] port: 40423).
```

Working remotely

- If you don't receive any error, this means that you are connected.
- Now you can call the Remote Playground, Remote System Browser, and Remote Process Browser.

Remote control

```
remotePharo openPlayground.
remotePharo openBrowser.
remotePharo openProcessBrowser.
```

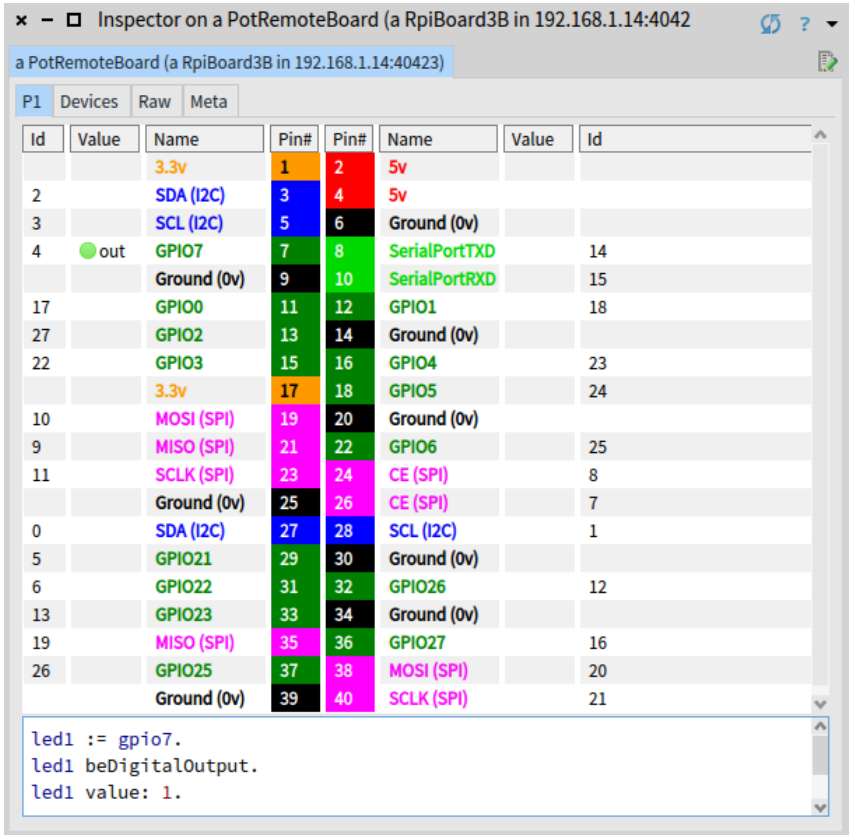
Inspect the remote Raspberry Pi GPIO board

- You can inspect the physical board of your Raspberry Pi.
- For Raspberry, it will be one of the RpiBoard subclasses. Currently, you can use the following classes according to the models:
  - RpiBoardBRev1: Raspberry Pi Model B Revision 1
  - RpiBoardBRev2: Raspberry Pi Model B Revision 2
  - RpiBoard3B: Raspberry Pi Model B+, Pi2 Model B, Pi3 Model B, Pi3 Model B+

With the chosen class evaluate the following code to open an inspector:

```
remoteBoard := remotePharo evaluate: [
    RpiBoard3B current].
remoteBoard inspect.
```

Remote GPIO inspector



Id	Value	Name	Pin#	Pin#	Name	Value	Id
		3.3v	1	2	5v		
2		SDA (I2C)	3	4	5v		
3		SCL (I2C)	5	6	Ground (0v)		
4	out	GPIO7	7	8	SerialPortTXD		14
		Ground (0v)	9	10	SerialPortRXD		15
17		GPIO0	11	12	GPIO1		18
27		GPIO2	13	14	Ground (0v)		
22		GPIO3	15	16	GPIO4		23
		3.3v	17	18	GPIO5		24
10		MOSI (SPI)	19	20	Ground (0v)		
9		MISO (SPI)	21	22	GPIO6		25
11		SCLK (SPI)	23	24	CE (SPI)		8
		Ground (0v)	25	26	CE (SPI)		7
0		SDA (I2C)	27	28	SCL (I2C)		1
5		GPIO21	29	30	Ground (0v)		
6		GPIO22	31	32	GPIO26		12
13		GPIO23	33	34	Ground (0v)		
19		MISO (SPI)	35	36	GPIO27		16
26		GPIO25	37	38	MOSI (SPI)		20
		Ground (0v)	39	40	SCLK (SPI)		21

Figure 3: Remote GPIO inspector

GPIOs

- A live tool which represents the current pins state.
- The evaluation pane in the bottom of the inspector provides bindings to gpio pins which you can script by #doIt/printIt commands
- Digital pins are shown with green/red icons which represent high/low (1/0) values.
- Able to togge the value.

Saving the remote image

```
remotePharo saveImage.
```

Disconnect all remote sessions

```
TlpRemoteIDE disconnectAll.
```

Section 4

Lesson 1 – Turning LED on/off

Lesson 1 – Turning LED on/off

Components

- 1 Raspberry Pi connected to your network (wired or wireless)
- 1 Breadboard
- 1 LED
- 1 Resistor (330 ohms)
- Jumper wires

Experimental procedure

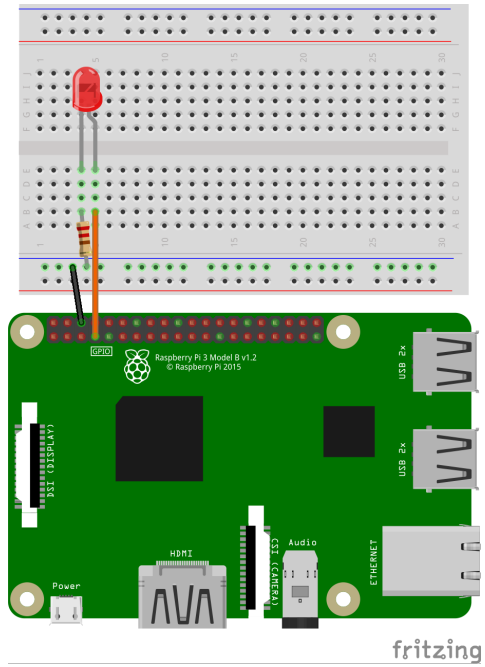


Figure 4: Physical connection LED

* The circuit consists of an LED that lights up when power is applied, a resistor to limit current and a power supply (the Rasp).

Physical connection LED detail

- Connect the Ground PIN from Raspberry in the breadboard blue rail (-). Raspeberry Pi models with 40 pins has 8 GPIO ground pins. You can connect with anyone. In this experiment we will use the PIN6 (Ground);
- Then connect the resistor from the blue rail on the breadboard (-) to a column on the breadboard
- Now push the LED legs into the breadboard, with the long leg (with the kink) on the right;
- And insert a jumper wire connecting the rigth column and the PIN7 (GPIO7).

Experimental code

Connecting remotely

- Run this code in Playground:

```
remotePharo := TlpRemoteIDE connectTo: (TCPAddress ip:
    #[193 51 236 167] port: 40423)
GTInspector enableStepRefresh

remoteBoard := remotePharo evaluate: [ RpiBoard3B
    current].

remoteBoard inspect.
```

$\Longrightarrow$ Make a new connection to your Rpi and Open the *Remote Playground*

Experimental code

- To control the LED we first introduce the named variable #led which we assigned to GPIO7 pin instance:

```
led := gpio7.
```

- Then we configure the pin to be in digital output mode and set the value:

```
led beDigitalOutput.
led value: 1.
```

$\Longrightarrow$ It turns the LED on.

Experimental code

- You can **notice** that gpio variables are not just numbers/ids.
- They are real **objects** with behaviour.
- For example you can ask pin to toggle a value:

```
led toggleDigitalValue.
```

- Or ask a pin for current value if you want to check it:

```
led value.
```

Result

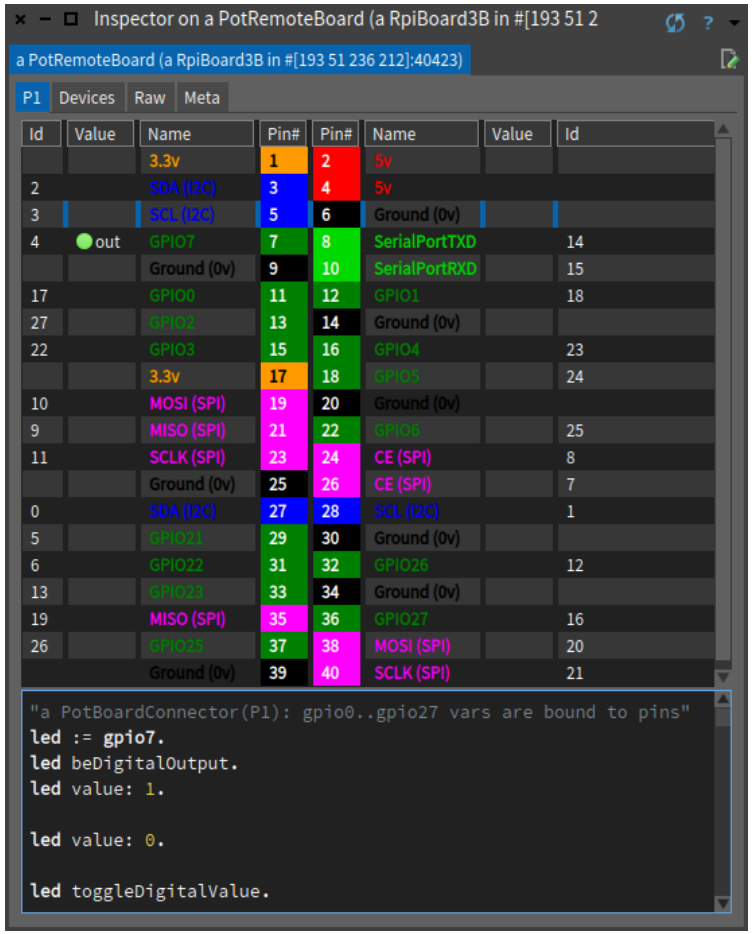


Figure 5: Remote Board Inspector

Section 5

Lesson 2 - Blinking LED

Experimental code

Connecting remotely

- Run this code in Playground:

```
remotePharo := TlpRemoteIDE connectTo: (TCPAddress ip:
    #[193 51 236 212] port: 40423)
GTInspector enableStepRefresh.

remoteBoard := remotePharo evaluate:
    [ RpiBoard3B current].

remoteBoard inspect.
```

$\Longrightarrow$ Make a new connection to your Rpi and Open the *Remote Playground*

Experimental code

- We still assigned the LED pin to GPIO7 pin:

```
led := gpio7.
led beDigitalOutput.
```

- To blink the LED, we create a loop to change the value of LED by time.
- We use the method *toggleDigitalValue* as previously.
- For example we blink the LED every 1 second by 10 times.

```
[ 10 timesRepeat: [
  led toggleDigitalValue.
  (Delay forSeconds: 1) wait
] ] forkNamed: 'BlinkerProcess'.
```

$\Longrightarrow$ Your LED is blinking now!

Section 6

Lesson 3 - Introduce to Pharo object-oriented

Blinking LED using OOP

Experimental code

```
|blinker|
blinker := Blinker new.
blinker timesRepeat: 10 waitForSeconds: 1.
```

Experimental code

- We declare the variable *blinker* in the first line.
- We will use this variable to create an object using the Blinker class.
- In the second line, we instantiate the Blinker class in the *blinker* variable
- In the third line, we send some messages to the blinker object to controll the times.

$\Longrightarrow$ This will make the GPIO behave according to the parameters

Create your own class remotely

- To create a class, we need first to create a package.
- In your local playground, call the Remote System Browser of your Raspberry Pi

```
remotePharo := TlpRemoteIDE connectTo: (TCPAddress ip:
    #[193 51 236 212] port: 40423).
remotePharo openBrowser.
```

Create a package

- Using the Remote Browser to create.
- *Right-click* the package area and enter the package name.
- For example, we create a package named *PharoThings-Lessons*

Create a class

- Edit the default class template by changing the *#NameOfSublass* to the name of new class
- For example, let's create the class *#Blinker*
- The class name begin with hash symbol (#) and a calpital leter.

```
Object subclass: #Blinker
instaceVariableNames: 'led'
classVariableNames: ''
package: 'PharoThings-Lessons'
```

- Right click on the code and select *Accept* option.
  $\Longrightarrow$ The class is compiled and added to the system.

Create a protocol

- Create a new protocol to organize the methods.
- The first protocol: `initialization`

Create a protocol

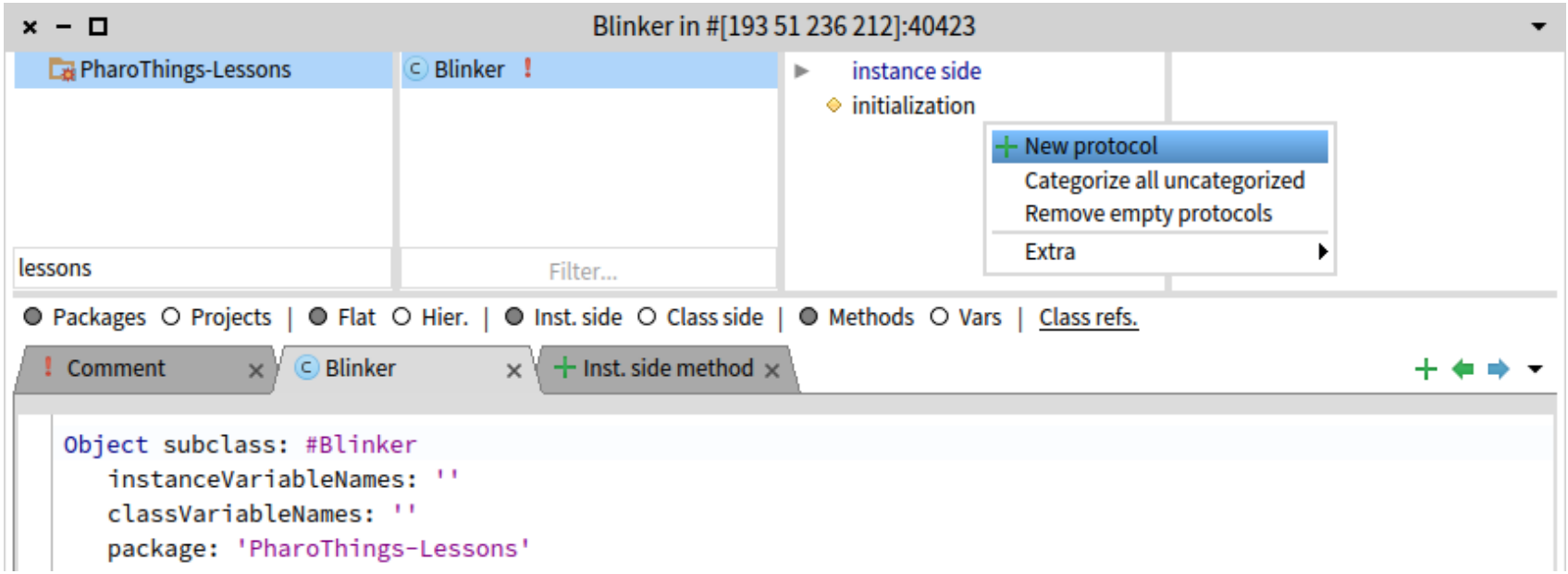


Figure 6: Creating a package remotely.

Create a method

- Inside this protocol, create an `initialize` method.
  $\Longrightarrow$ Everytime a new object was created using Blinker class, this method will be executed to define some variable in the new object.
- Let's use the instance variable `led`.
- The instance variable is private to the object and accessible by any methods inside this class.
- These methods can access this variable to get or set any value to it.

initialize

```
initialize
    led := PotClockGPIOPin id: 4 number: 7.
    led board: RpiBoard3B current; beDigitalOutput
```

Creating the initialize method

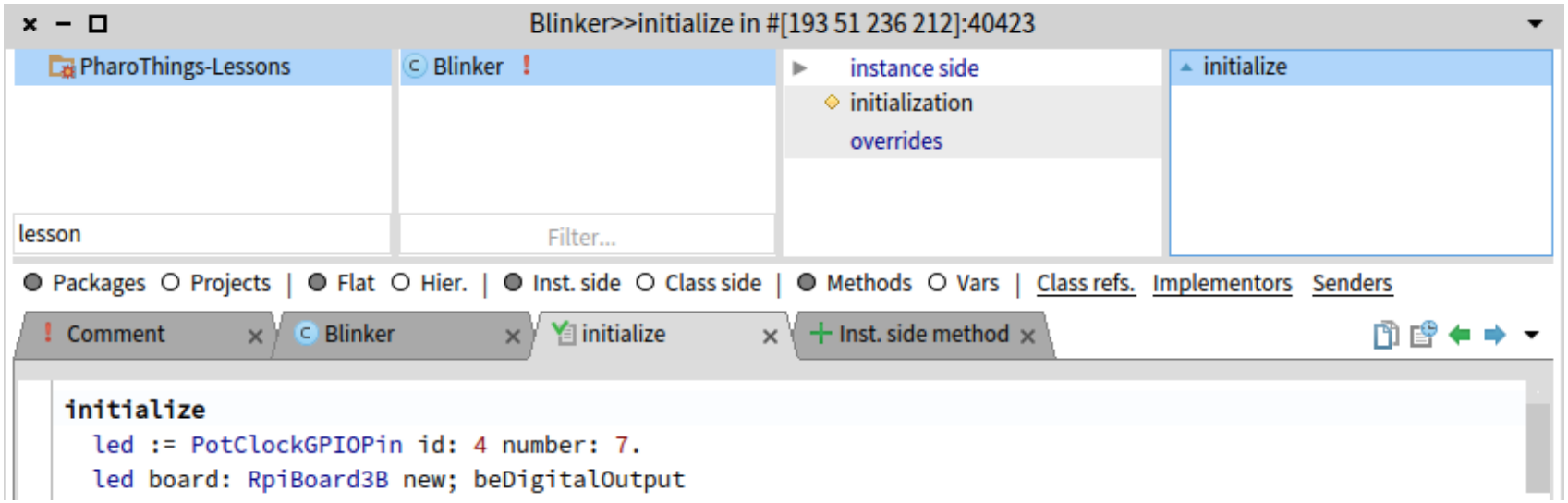


Figure 7: Creating the initialize method

Explanation

Explanation

- The first line defines the name of the method;
- In the second line, we configure the GPIO that we wanna use. Note that we need the GPIO number and ID. The ID is required to communicate with WiringPi Library. You can seethe ID and GPIO number in PotRemoteBoard inspector.
- In the third line, we define the model of the Raspberry board and con- figure this GPIO as beDigitalOutput. This means that when the GPIO change to `value:1`, the power will go out of the GPIO to power the LED.
- Compile your code (cmd + S) and the method will be shown in the remote browser.

Create a method to do actions

- Let's create a method to control the object led inside the class Blinker.
- Create a protocol `operations` and inside this protocol, create the following method

Method

```
timesRepeat: anInteger waitForSeconds: aNumber
        [ anInteger timesRepeat: [
            led toggleDigitalValue.
            (Delay forSeconds: aNumber) wait
        ] ] forkNamed: 'BlinkerProcess'.
```

Explanation

Explanation

- In the first line, we define the message with `timesRepeat:` and wait `ForSeconds:`. We inform the kind of value will be received, creating 2 variables: aNumber and anInteger;
- We replace these variables in the code and now we have the control to say how many times repeat and for how many seconds;
- We finished the code by putting everything inside a fork to create a process in Pharo. While the process is running, you can open the Remote Process Browser (remotePharo openProcessBrowser) and see the process. This is useful when you wanna kill the remote process.

Using the new class

- Now we can use the class that we created, the Blinker class. To do this, let's open the Remote Playground:

```
remotePharo openPlayground
```

Call blinker class

```
|blinker|
    blinker := Blinker new.
    blinker timesRepeat: 10 waitForSeconds: 1.
```

Save your work

Don't forget to save your work remotely. To do this, run this command on your local playground:

```
remotePharo saveImage.
```

Section 7

Lesson 4 - LED Flowing Lights

What do we need

Components

- 1 Raspberry Pi connected to your network (wired or wireless)
- 1 Breadboard
- 8 LEDs
- 8 Resistors 330ohms
- Jumper wires

Schema connection 8 LEDs

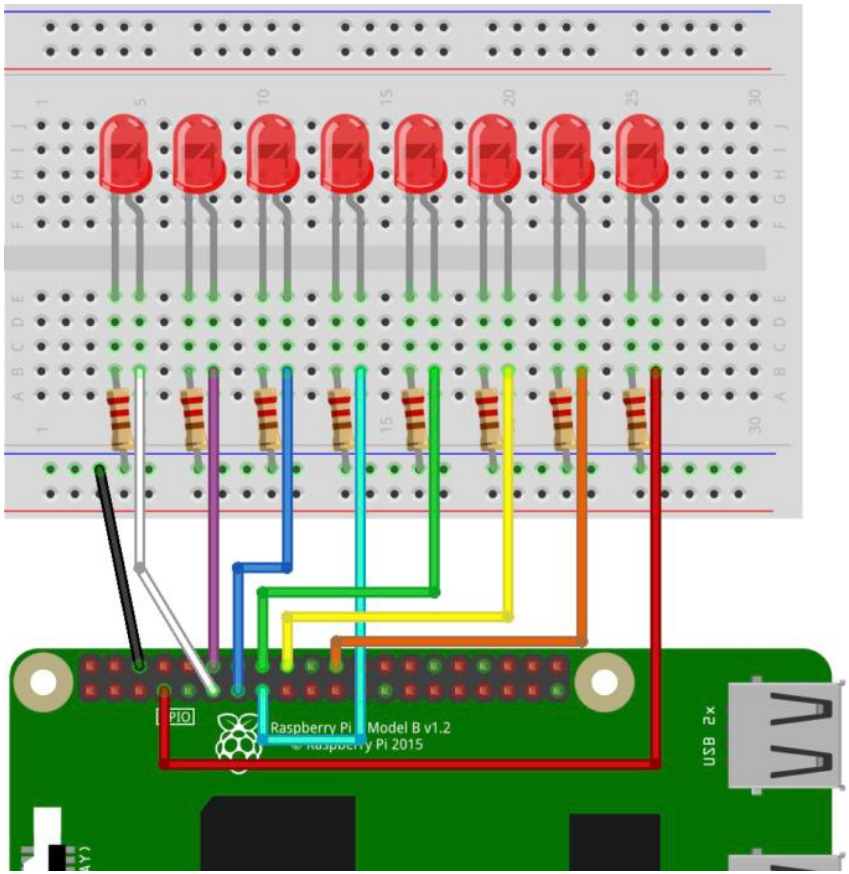


Figure 8: Schema connection 8 LEDs

Physical connection 8 LEDs

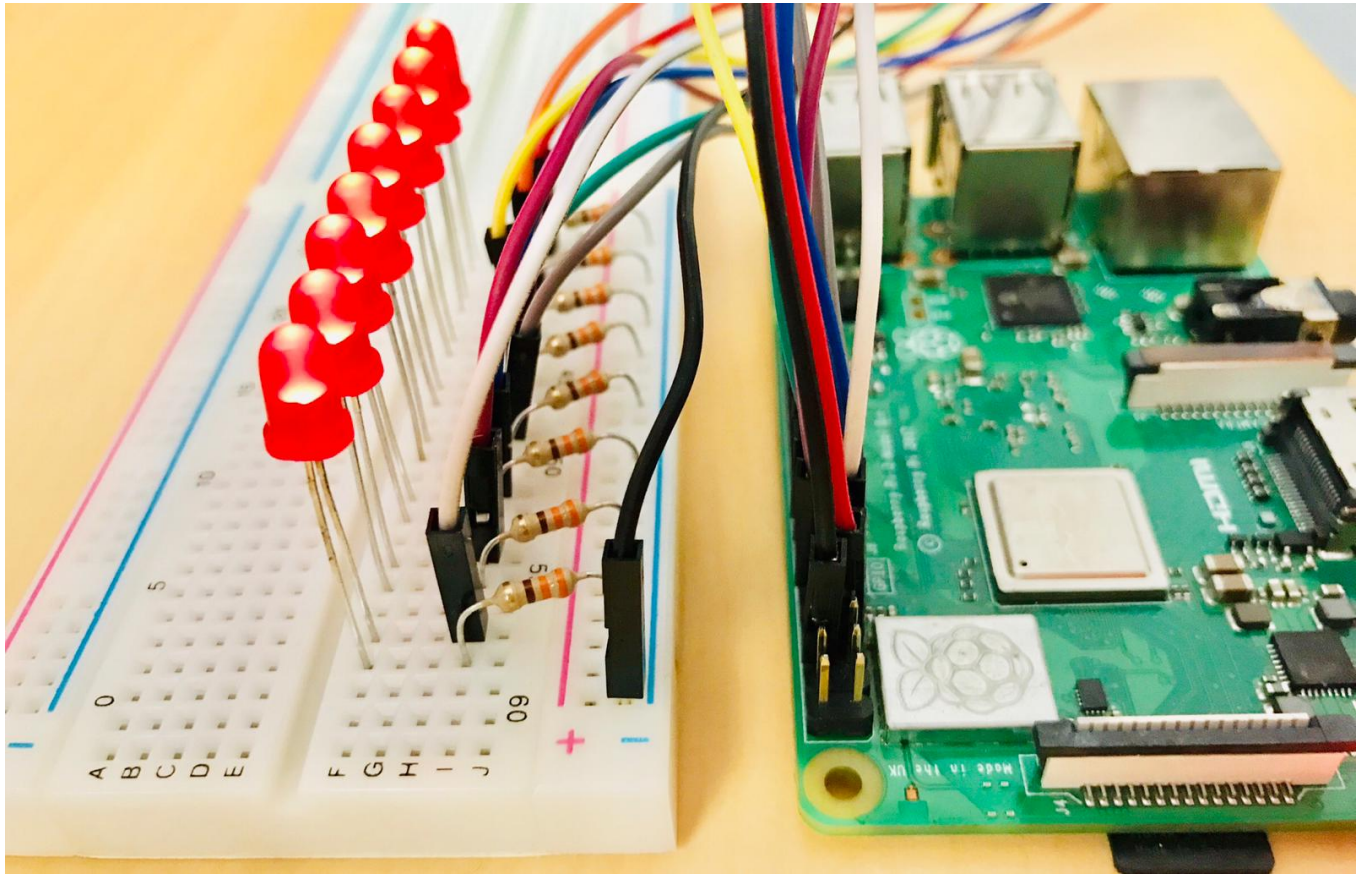


Figure 9: Physical connection 8 LEDs

Experimental process

- Connect the Ground PIN from Raspberry in the breadboard blue rail (-).
- Then connect the 8 resistors from the blue rail (-) to a column on the breadboard.
- Now push the LED legs into the breadboard, with the long leg (with the kink) on the right.
- And insert the jumper wires connecting the right column of each LED to GPIO from 0 to 7.

Connecting remotely

```
remotePharo := TlpRemoteIDE connectTo: (TCPAddress ip:
    #[193 51 236 212] port: 40423)
GTInspector enableStepRefresh.
remoteBoard := remotePharo evaluate: [ RpiBoard3B current]
    remoteBoard inspect.
```

Experimental code

- Let's create an array and initialize the 8 LEDs, putting each one in a position of the array.

```
gpioArray := { gpio0. gpio1. gpio2. gpio3.
    gpio4. gpio5. gpio6. gpio7 }.
gpioArray do: [ :item | item beDigitalOutput ].
```

Experimental code

- In the previous lesson, we use `toggleDigitalValue` to change the value of the object (Led value)

```
gpioArray do: [ :item | item toggleDigitalValue ].
```

Experimental code

- Let's put a Delay after changing the led value, to wait a bit time before to changethenextLEDvalue. Let's also put this inside a process using the method `forkNamed:`

```
[
    gpioArray do: [ :item | item toggleDigitalValue.
    (Delay forSeconds: 0.3) wait ].
] forkNamed: 'FlowingProcess'.
```

Result

- Execute this code and... cool! Now your LEDs are on by flowing an ordering!

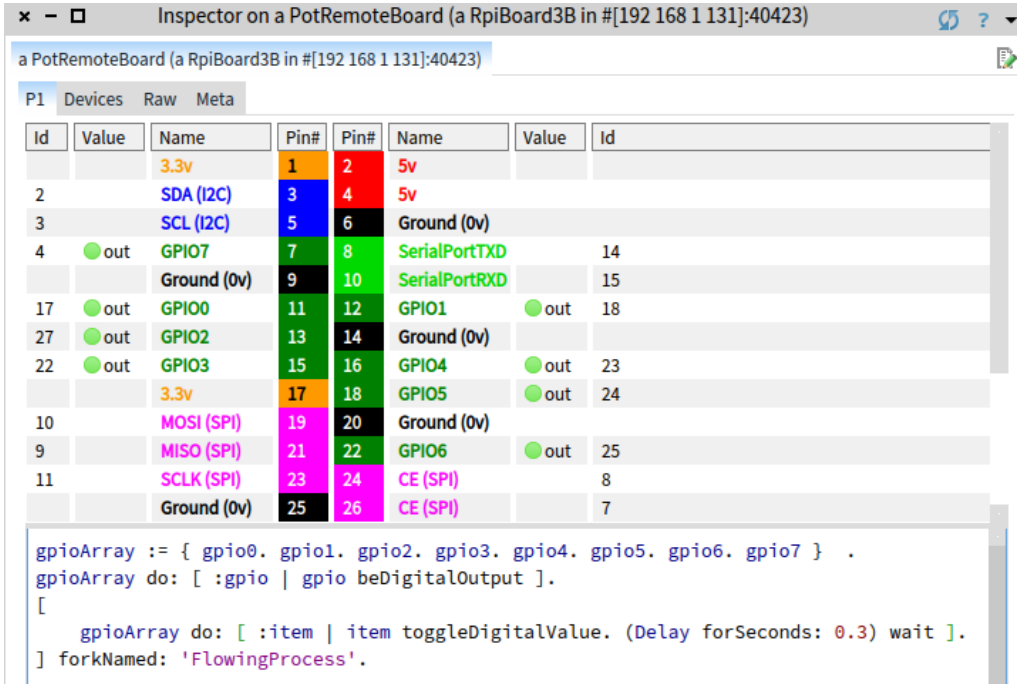


Figure 10: Code on Inspector

Result

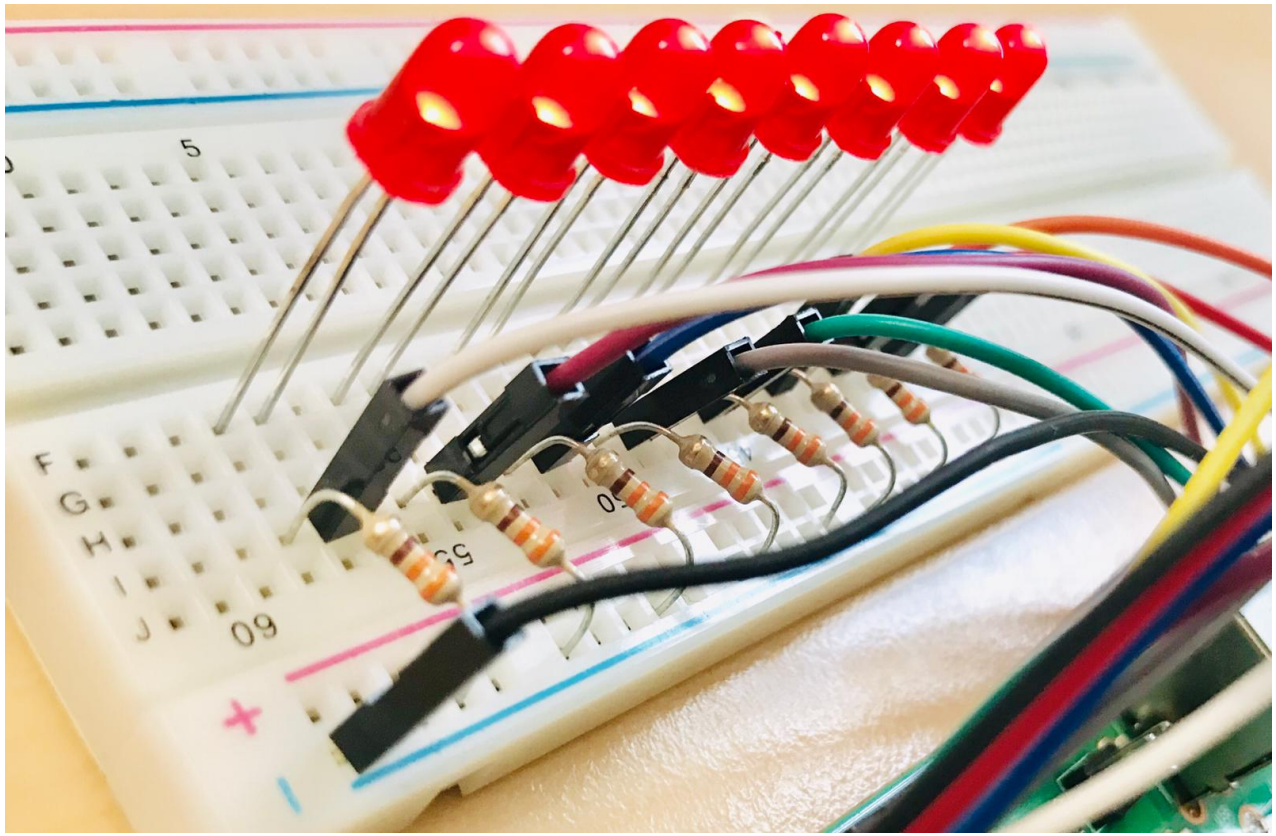


Figure 11: LEDs turn On.

Adding features

Control loop time?

```
[ 2 timesRepeat: [
    gpioArray do: [ :item | item toggleDigitalValue.
    (Delay forSeconds: 0.1) wait ].
] ] forkNamed: 'FlowingProcess'.
```

Adding features

Reversing the flow

```
[ 2 timesRepeat: [
  gpioArray reverseDo: [ :item | item toggleDigitalValue.
  (Delay forSeconds: 0.1) wait ].
] ] forkNamed: 'FlowingProcess'.
```

Terminating the process

- Call the **Remote Process Browser**

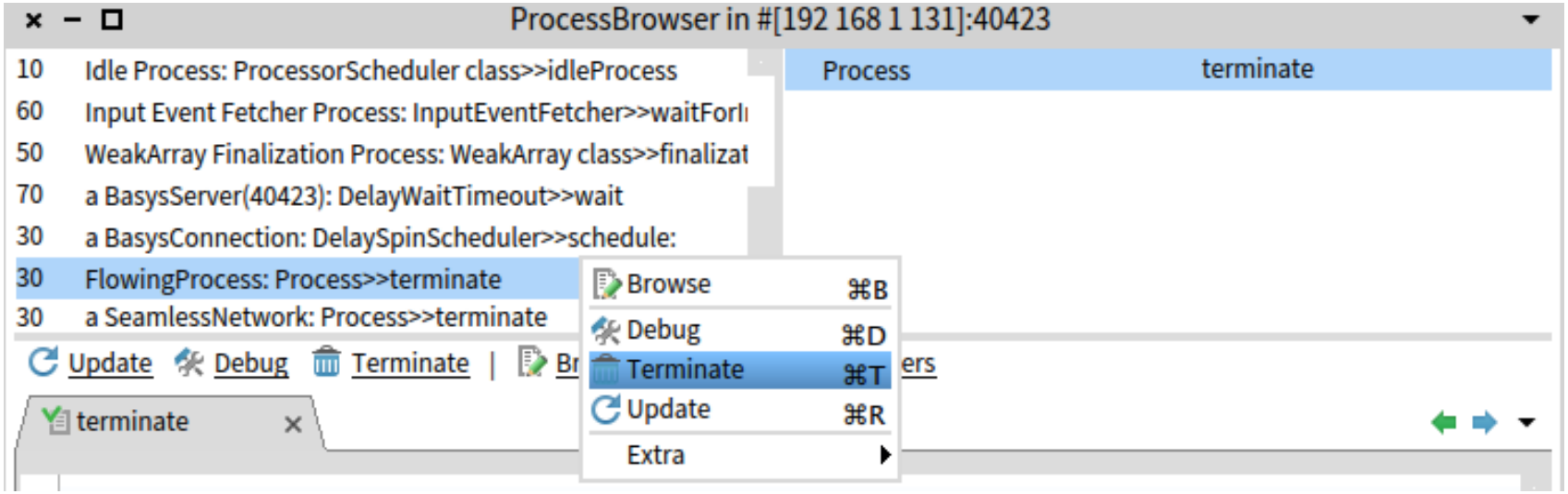


Figure 12: Remote Process Browser

Section 8

Lesson 5 - I2C Sensors (Temperature, Humidity, Acellerometer)

Lesson 5 - I2C Sensors (Temperature, Humidity, Acellerometer)

Let's start using some sensors to interact automat- ically with the real world, taking the temperature, air pressure and humidity This kind of sensor use the I2C protocol to communicate.

Components

- 1 Raspberry Pi connected to your network (wired or wireless).
- 1 Breadboard.
- 1 BME280 temperature, humidity and pressure sensor.
- 1 ADXL345 accelerometer sensor.
- Jumper wires.

The I2C protocol

How I2C works?

- Each device has set an ID or a unique address. Then the master device can choose which device to communicate with.
- The two wires are called Serial Clock (or SCL) and Serial Data (or SDA).
  - SDA: synchronize the data transfer between devices on the i2C bus and is generated by the master device.
  - SCL: Carries the date.

Devices connected using I2C bus

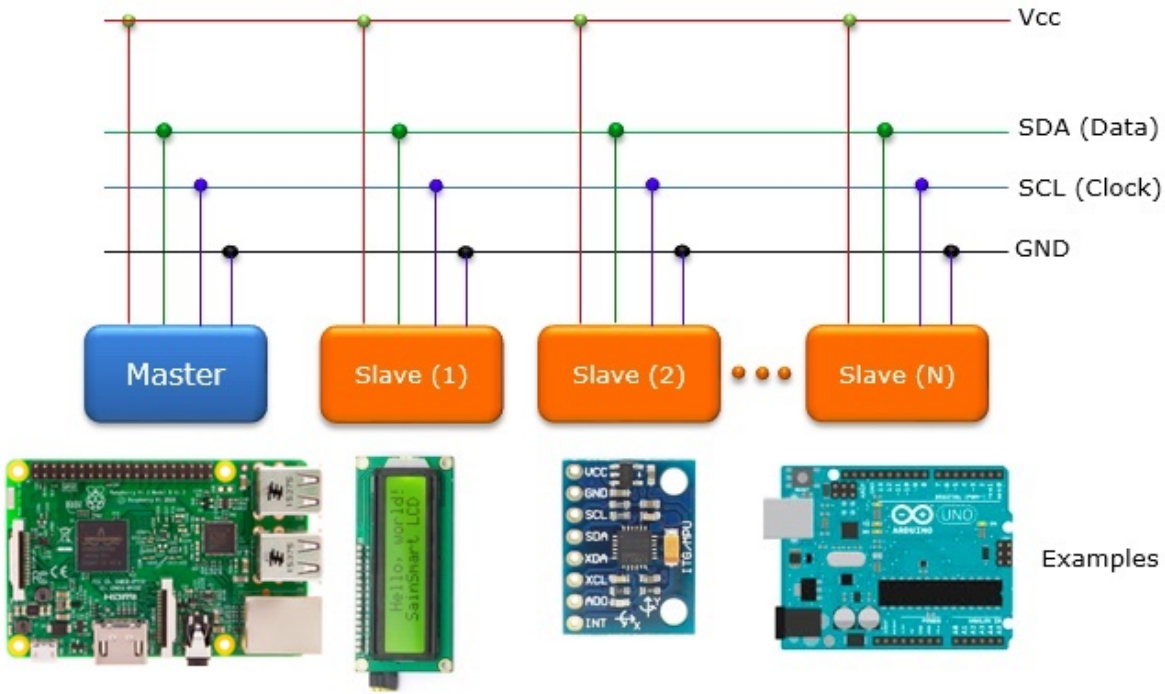


Figure 13: Devices connected using I2C bus