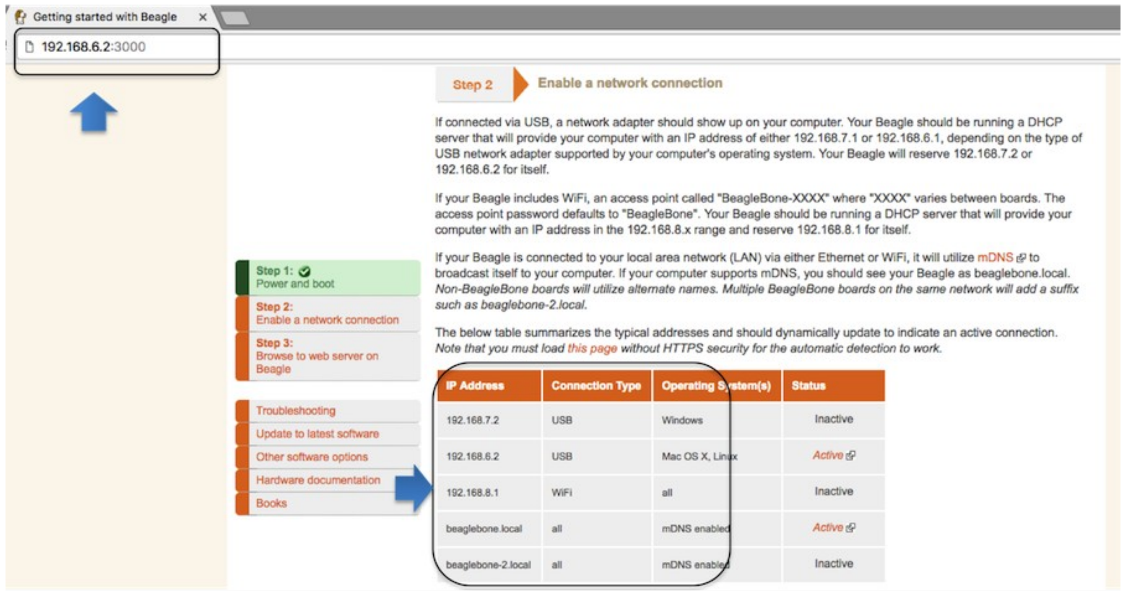
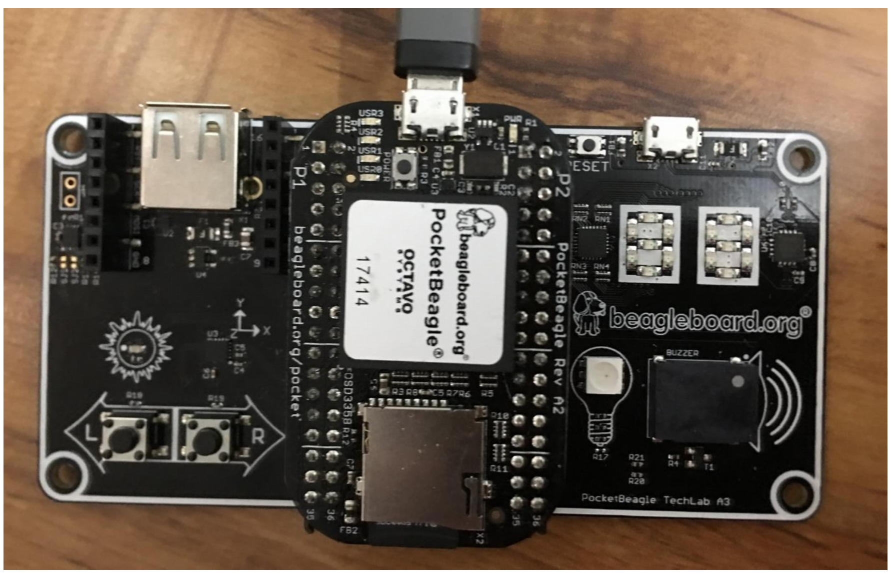
PocketBeagle® TechLab Cape Hands-On Coding Workshop

- MicroSD software image and other materials available from **bbb.io/techlab**

See **bbb.io/start** for instructions on using Etcher.io to write a microSD card

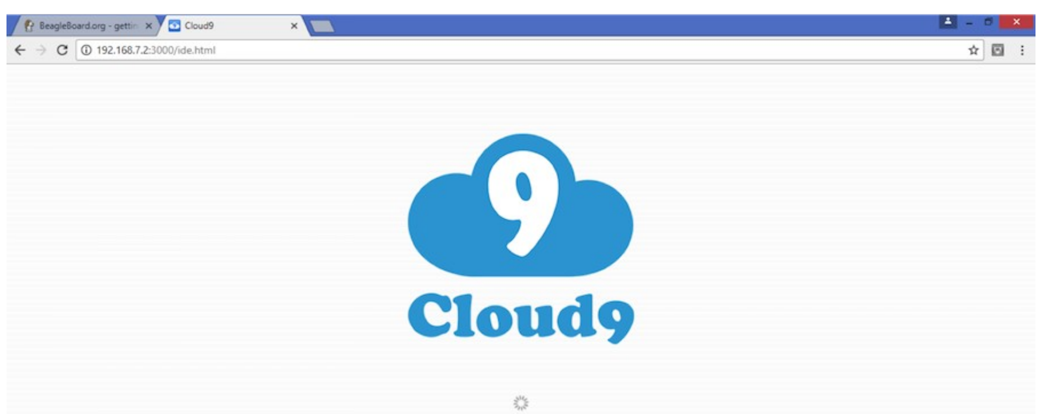




Plug into the microUSB on PocketBeagle to provide power and a network connection. Look for the "heartbeat" pulse on the USR0 LED to know the board has Linux up-and-running.

Get to the Cloud9 IDE

- Served on port 3000
- Windows: http://192.168.7.2:3000
- Linux/Mac: http://192.168.6.2:3000



The **BeagleBoard.org Foundation** is a 501(c)(3) non-profit corporation existing to provide education in and collaboration around the design and use of open-source software and hardware in embedded computing.

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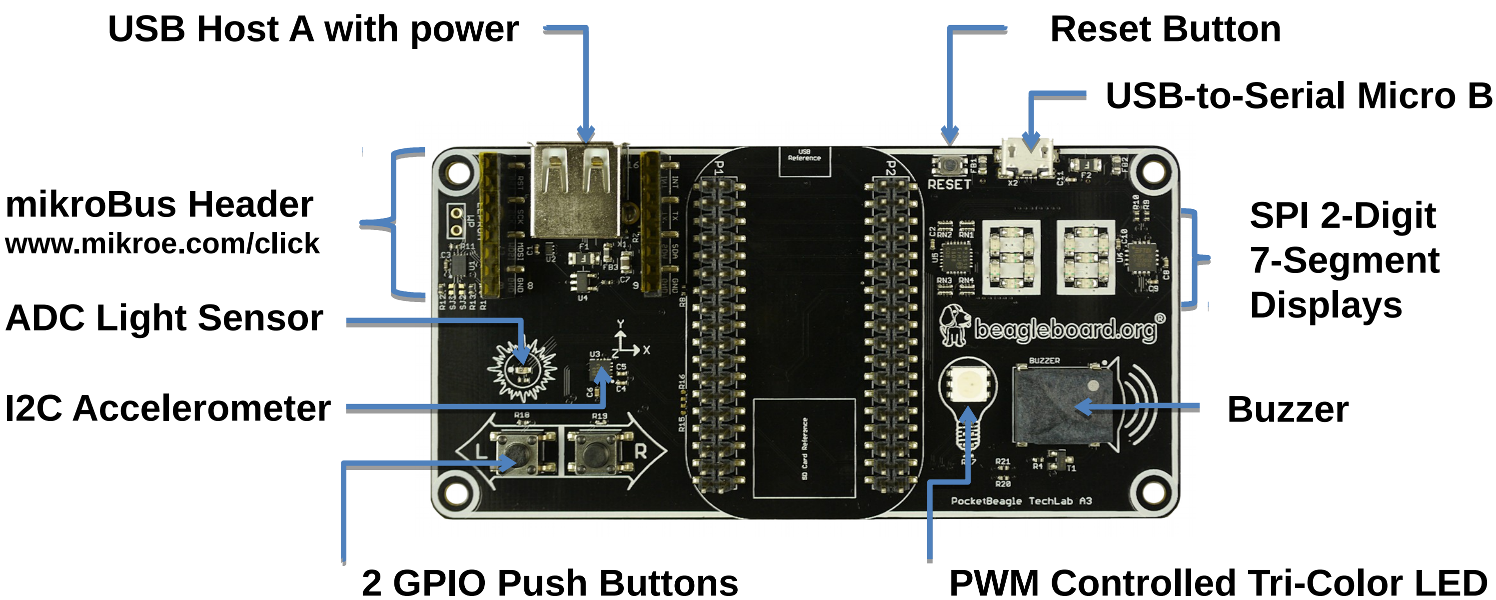
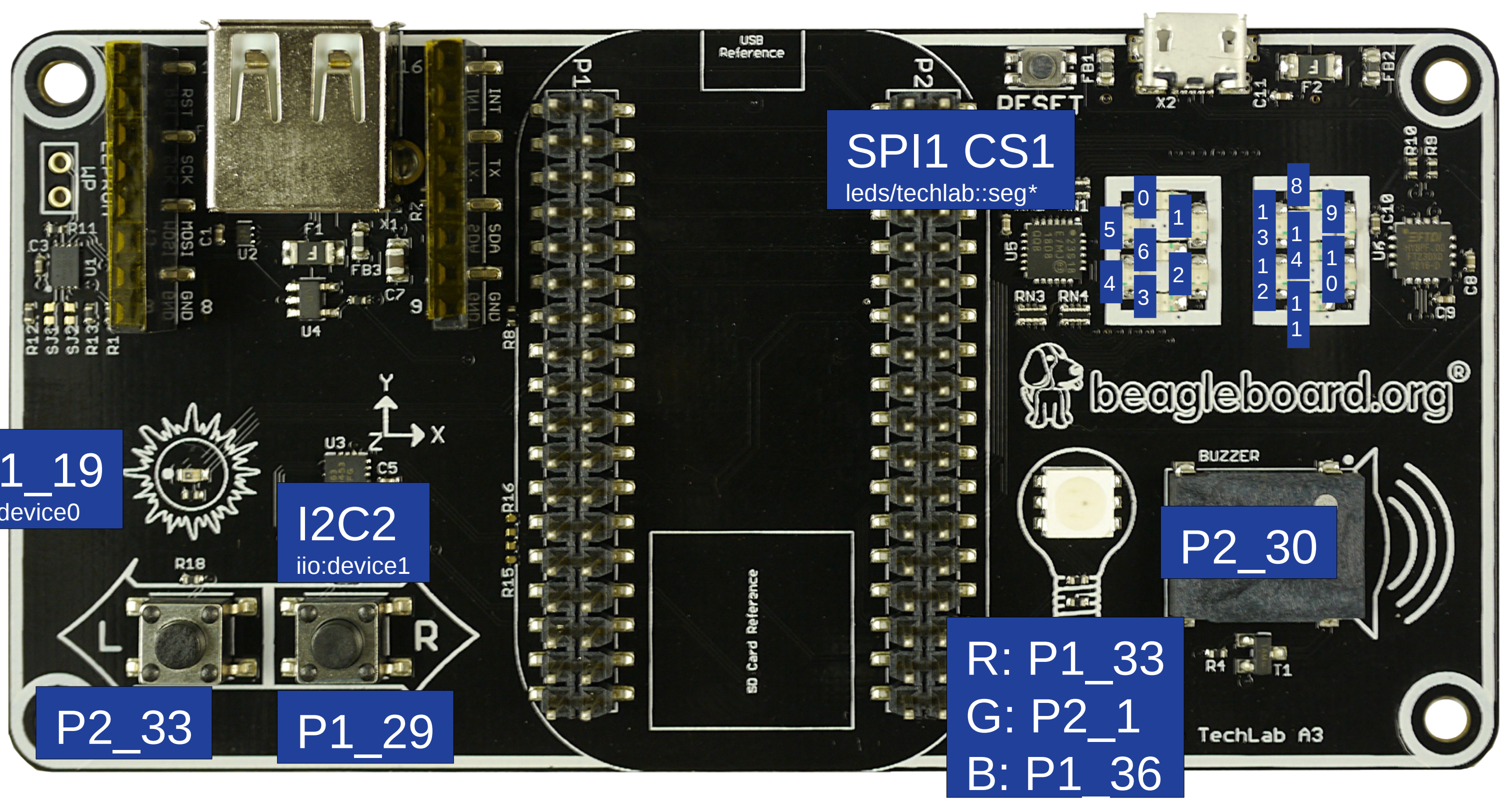
TechLab Pocket Cape



TechLab Wiring Summary



PocketBeagle®

- PocketBeagle® is an ultra-tiny-yet-complete, low-cost, open-source USB-key-fob computer.
- Processor System:
  Octavo Systems OSD3358-SM 21mm x 21mm system-in-package that includes 512MB DDR3 RAM, 1-GHz ARM Cortex-A8 CPU, 2x 200-MHz PRUs, ARM Cortex-M3, 3D accelerator, power/battery management and EEPROM
- 72 expansion pin headers with power and battery I/Os, high-speed USB, 8 analog inputs, 44 digital I/Os and numerous digital interface peripherals
- microUSB host/client and microSD connectors

PocketBeagle Expansion Header Pin-out

P1

SYS					VIN	1	2	87	GPIO	6	AIN 3.3V	9	PRU1
USB1	V_EN			GPIO	109	3	4	89				11	
USB1					VBUS	5	6	5		CS	SPI0	TX	PRU
					VIN	7	8	2		CLK		RX	UART2
					DN	9	10	3		MISO		TX	
					DP	11	12	4		MOSI		RX	PRU
					ID	13	14	3.3V	SYS				
					GND	15	16	GND					
					REF-	17	18	REF+	AIN 1.8V				
AIN 1.8V					0	19	20	20	GPIO			16(in)	PRU0
					1	21	22	GND	SYS				
					2	23	24	VOUT					
					3	25	26	12	GPIO	SDA	I2C2	TX	CAN0
					4	27	28	13		SCL		RX	
PRU0	7	QEP0	STRB	GPIO	117	29	30	43		TX	UART0	15	PRU1
	4		A		114	31	32	42		RX		14	
	1	PWM0	B		111	33	34	26					
PRU1	10				88	35	36	110		A	PWM0	0	PRU0

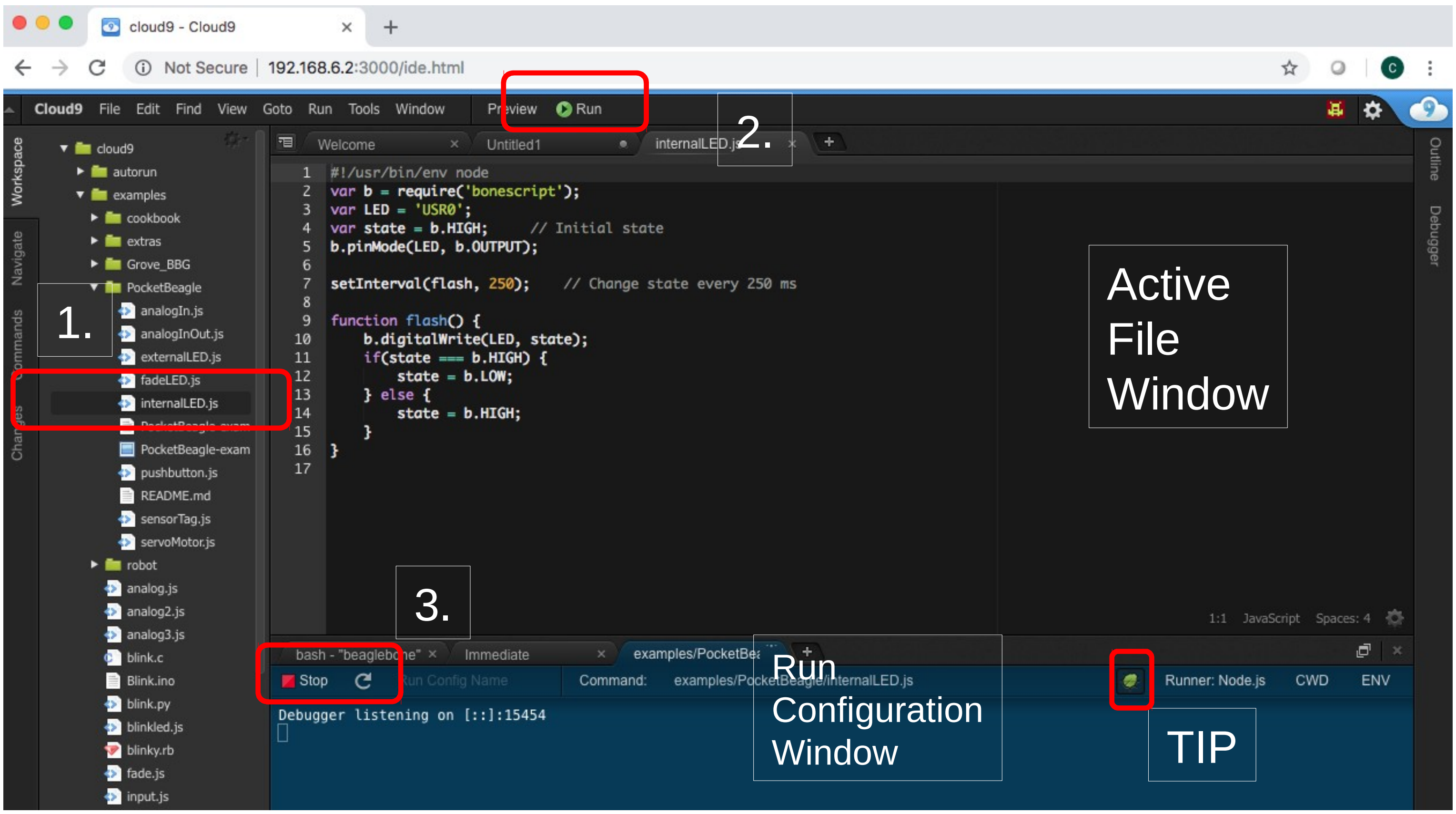
P2

		PWM1	A	GPIO	50	1	2	59	GPIO				
		PWM2	B		23	3	4	58					
		UART4	RX		30	5	6	57					
			TX		31	7	8	60					
CAN1	RX	I2C1	SCL		15	9	10	52					
	TX		SDA		14	11	12	PWR BTN	SYS				
				SYS	VOUT	13	14	VIN	BAT				
					GND	15	16	TEMP					
				GPIO	65	17	18	47	GPIO	STRB	QEP2	15i	PRU0
					27	19	20	64					
				SYS	GND	21	22	46		IDX	QEP2	14(in)	PRU0
					3.3V	23	24	44		A		14(out)	
CAN1	RX	SPI1	MOSI	GPIO	41	25	26	NRST	SYS				
	TX		MISO		40	27	28	116	GPIO	IDX	QEP0	6	PRU0
PRU	eCAP		CLK		7	29	30	113				3	
PRU1	16(in)		CS		19	31	32	112				2	
PRU0	15(out)	QEP2	B		45	33	34	115		B	QEP0	5	
PRU1	8	AIN 3.3V	5		86	35	36	7	AIN 1.8V				

Great getting started information is at beagleboard.org/pocket

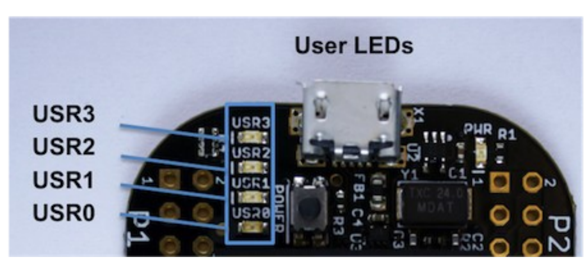
Blink PocketBeagle on-board USRx LED

Goal: Blink USR3 LED on PocketBeagle.
Overview: BoneScript is a Node.js library customized for the Beagle family and featuring familiar Arduino function calls. Here we will use it to blink an LED built into your PocketBeagle.
Do this in the Cloud9 IDE:
1. Navigate to **TechLab/internalLED.js** and double-click on it.
2. Click the Run button in the toolbar to execute the script in the active file window
3. You will see the run configuration window open with a Stop button. Click the Stop button to halt the program.
4. Try changing the LED or blink time, save the program and run again.
TIP: Click the green bug to disable the debugger and begin execution quicker.



internalLED.js

```
#!/usr/bin/env node
var b = require('bonescript');
var LED = 'USR3';
var state = b.HIGH;     // Initial state
b.pinMode(LED, b.OUTPUT);

setInterval(flash, 250); // Change state every 250 ms

function flash() {
    b.digitalWrite(LED, state);
    if(state === b.HIGH) {
        state = b.LOW;
    } else {
        state = b.HIGH;
    }
}
```

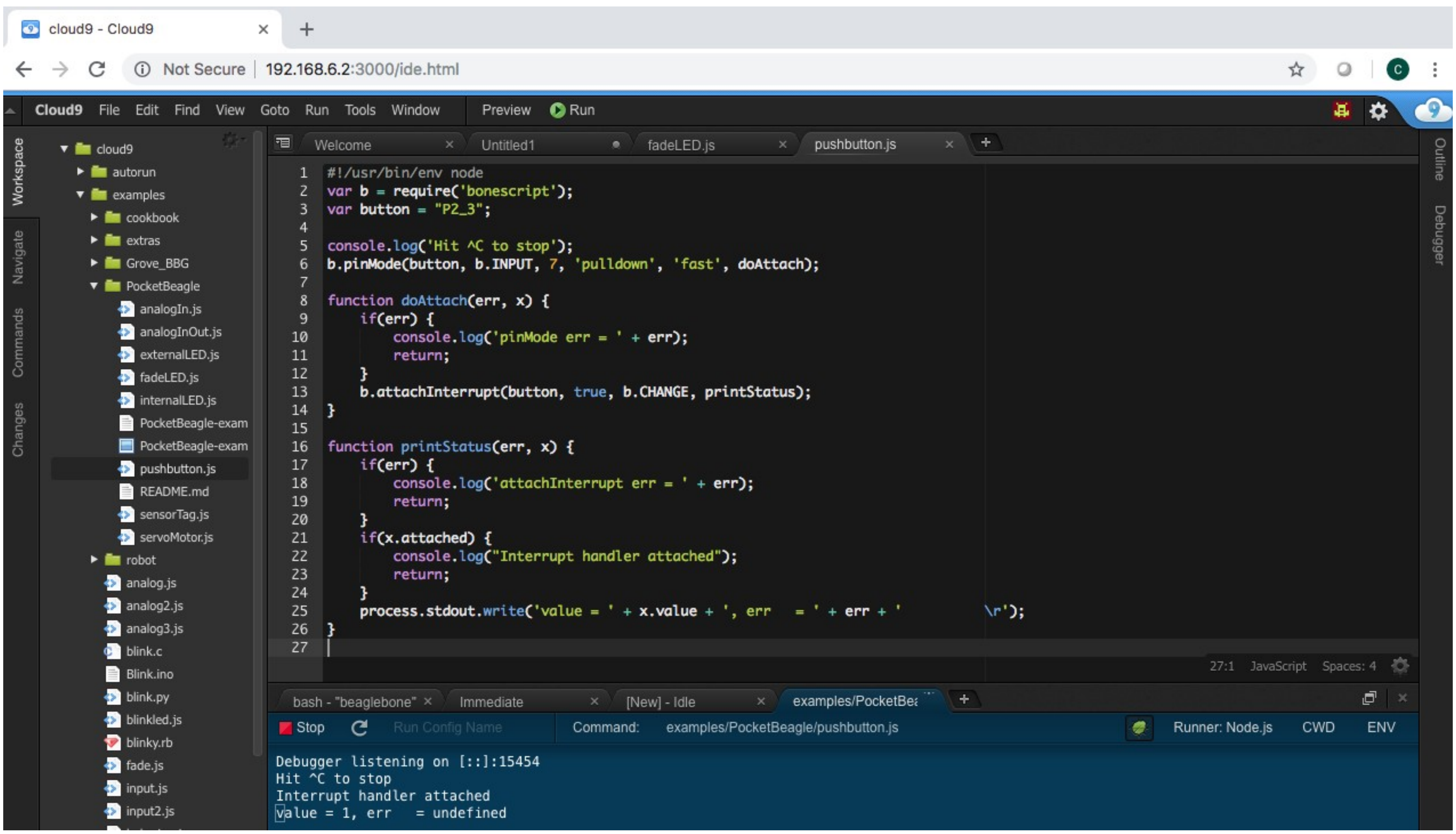


Read a button

Goal: Sense the external world by reading a digital input.
Overview: Reading a switch attached to a GPIO (general purpose input/output) port is as easy as configuring the port as an input and attaching an interrupt handler to it. Note the buttons are “active low”.
Do this in the Cloud9 IDE:

1. Navigate to **TechLab/pushbutton.js** and double-click on it.
2. Click the Run button in the toolbar to execute the script in the active file window
3. Press the “L” button on TechLab and check the output (Value=1 or Value=0) in the configuration window. Click the Stop button on the IDE to halt the program.

Challenge #1: Can you modify the program to read from the “R” button?
Challenge #2: Can you modify the program to toggle the USR3 LED?
Challenge #3: Can you modify the program to turn the USR3 LED on with the “L” button and off with the “R” button?



Read a button

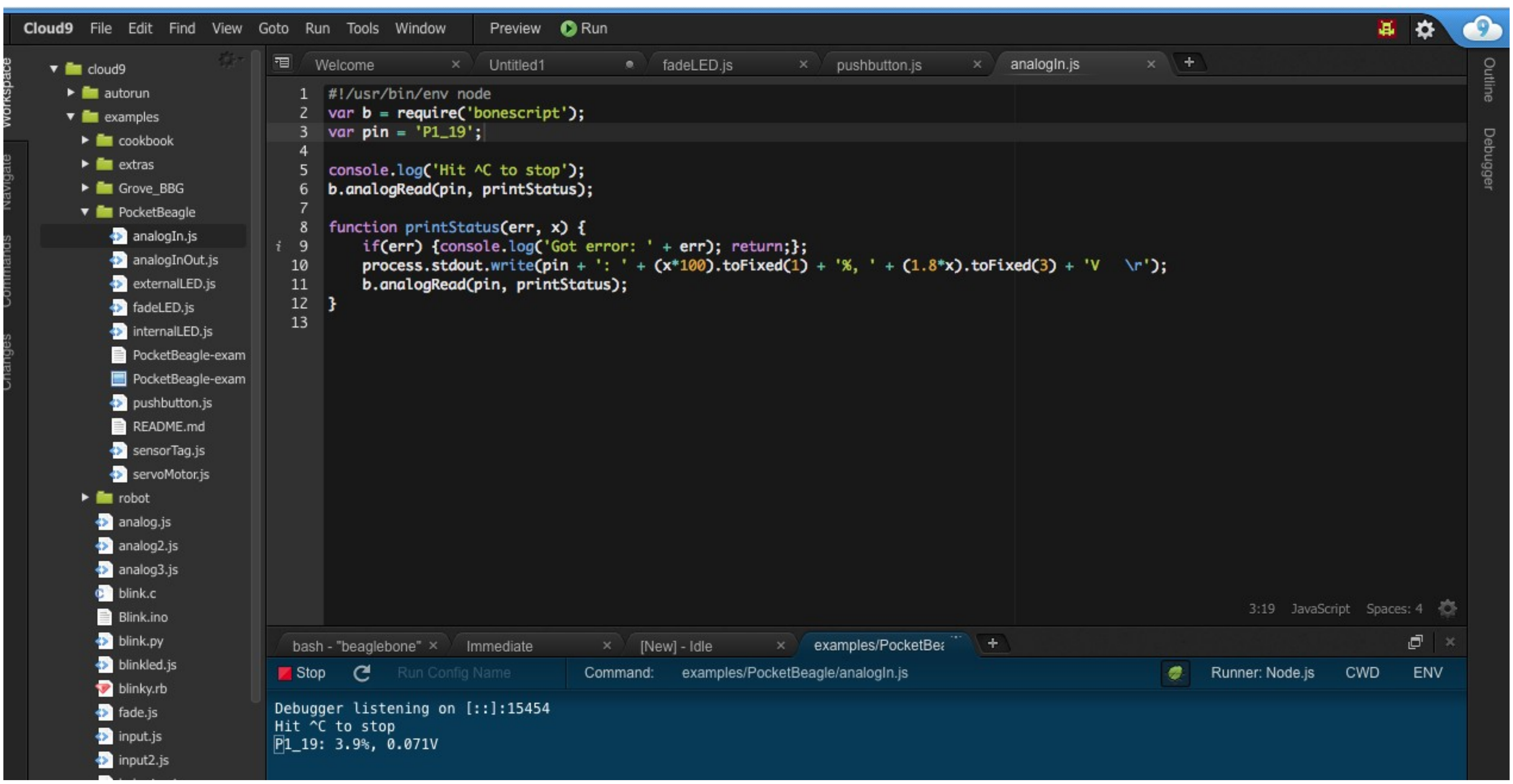
pushbutton.js

```
#!/usr/bin/env node
var b = require('bonescript');
var button = "P2_33";

console.log('Hit ^C to stop');
b.pinMode(button, b.INPUT, 7, null, null, doAttach);

function doAttach(err, x) {
  if(err) {
    console.log('pinMode err = ' + err);
    return;
  }
  b.attachInterrupt(button, true, b.CHANGE, printStatus);
}

function printStatus(err, x) {
  if(err) {
    console.log('attachInterrupt err = ' + err);
    return;
  }
  if(x.attached) {
    console.log("Interrupt handler attached");
    return;
  }
  process.stdout.write('value = ' + x.value + '          \r');
}
```

Read an analog sensor

Goal: Sense the external world by reading a variable analog input
Overview: Reading a light sensor attached to an analog input pin.
Do this in the Cloud9 IDE:
1. Navigate to **TechLab/analogIn.js** and double-click on it.
2. Click the Run button in the toolbar to execute the script in the active file window
3. Cover the light sensor and check the output in the configuration window. Click the Stop button to halt the program.

Challenge #1: Can you change how often the light sensor is read? What happens and why?
Challenge #2: Can you activate the USR3 LED based upon a voltage threshold from the light sensor?
Challenge #3: **(Advanced Coding Lab)**
Try using the I2C accelerometer input from /sys/bus/iio/devices/iio:device1/in_accel_x_raw.
Hint: use b.readTextFile()



Read an analog sensor

analogIn.js

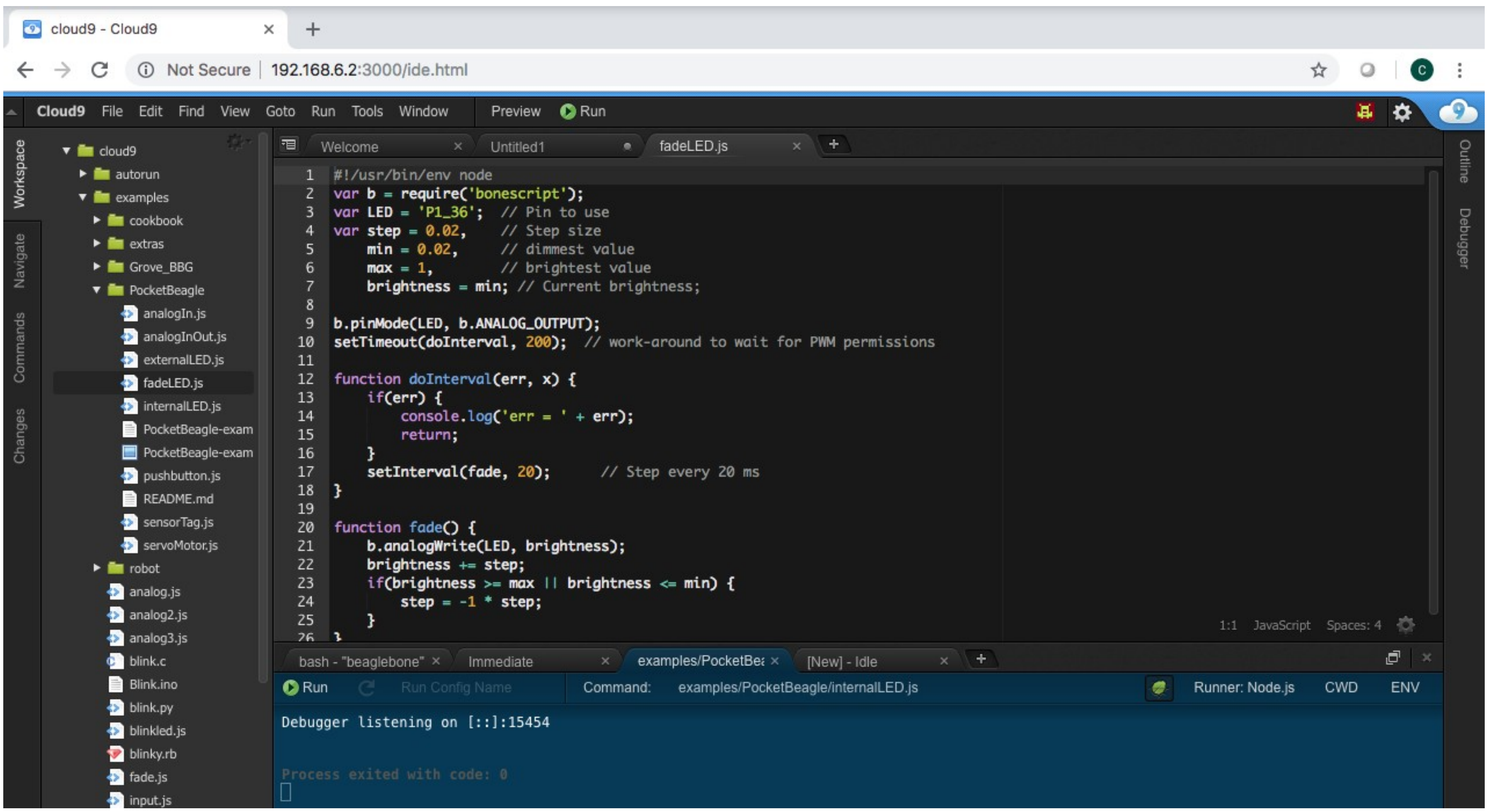
```
#!/usr/bin/env node
var b = require('bonescript');
var pin = 'P1_19';

console.log('Hit ^C to stop');
doAnalogRead();

function printStatus(err, x) {
  if(err) {console.log('Got error: ' + err); return;};
  process.stdout.write(pin + ': ' + (x*100).toFixed(1) +
    '%, ' + (1.8*x).toFixed(3) + 'V   \r');
  setTimeout(doAnalogRead, 100);
}

function doAnalogRead() {
  b.analogRead(pin, printStatus);
}
```

Fade an LED

Goal: Utilize a hardware pulse-width-modulator (PWM) to light an LED with variable brightness
Overview: Linux provides LED drivers that understand how to utilize PWM drivers, making use of PocketBeagle's built-in PWM hardware. They are controlled with simple text files where you can set the brightness.
Do this in the Cloud9 IDE:

1. Navigate to **TechLab/fadeLED.js** and double-click on it.
2. Click the Run button in the toolbar to execute the script in the active file window
3. You will see the run configuration window open with a Stop button. Click the Stop button to halt the program.

Challenge #1: Try changing the fade interval, save the program and run again.
Challenge #2: Try using the light sensor input to set the LED brightness.
Challenge #3: **(Advanced Coding Lab)**
Try using the I2C accelerometer input for all 3 color LEDs..



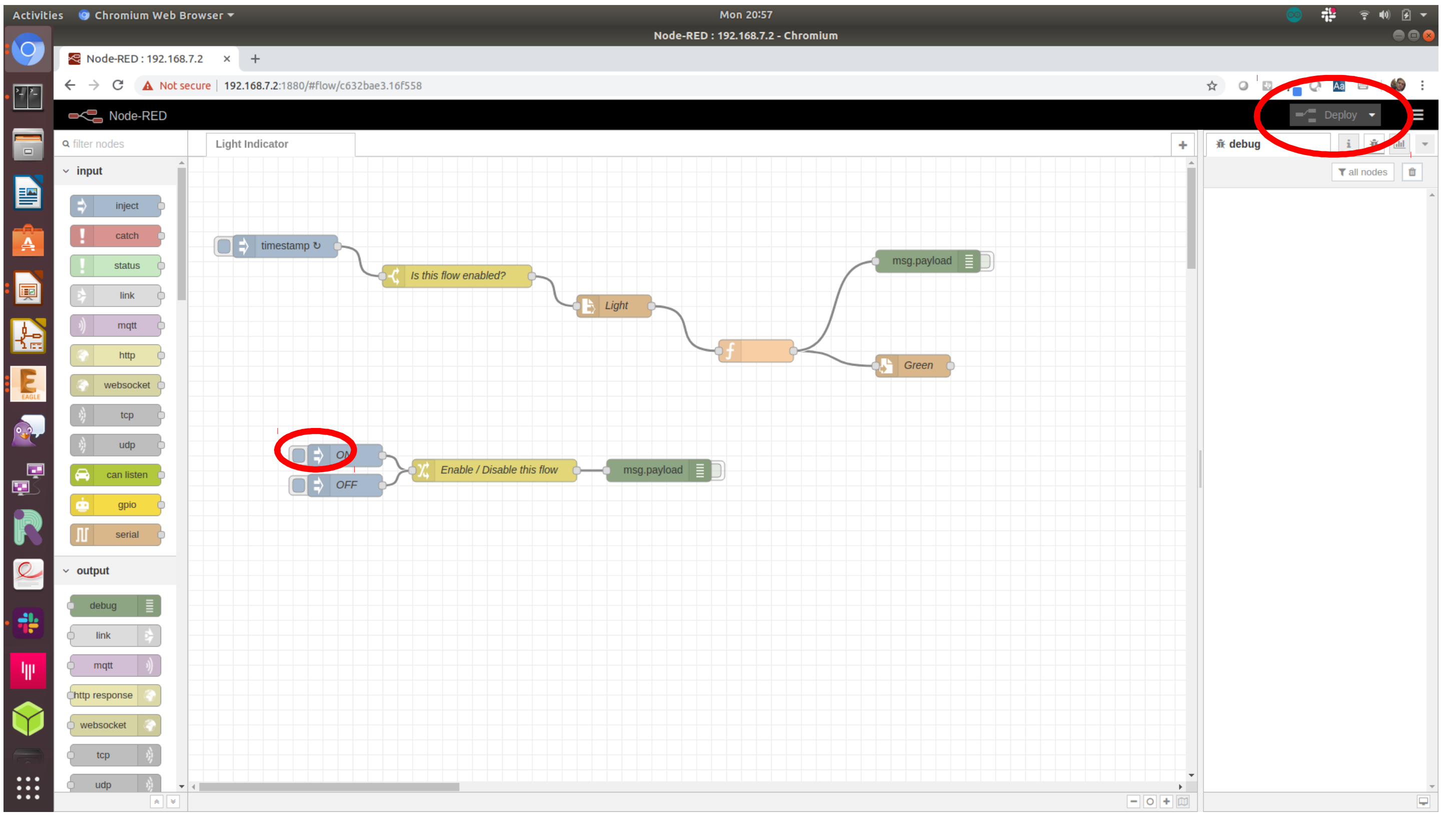
Fade an LED

fadeLED.js

```
#!/usr/bin/env node
var b = require('bonescript');
var LED = '/sys/class/leds/techlab::blue/brightness';
var step = 10,      // Step size
    min = 0,        // dimmest value
    max = 255,      // brightest value
    brightness = min; // Current brightness;

doInterval();

function doInterval(err, x) {
    if(err) {
        console.log('err = ' + err);
        return;
    }
    setInterval(fade, 20);      // Step every 20 ms
}

function fade() {
    b.writeTextFile(LED, brightness);
    brightness += step;
    if(brightness >= max || brightness <= min) {
        step = -1 * step;
    }
}
```

Using Node-RED to read and write files

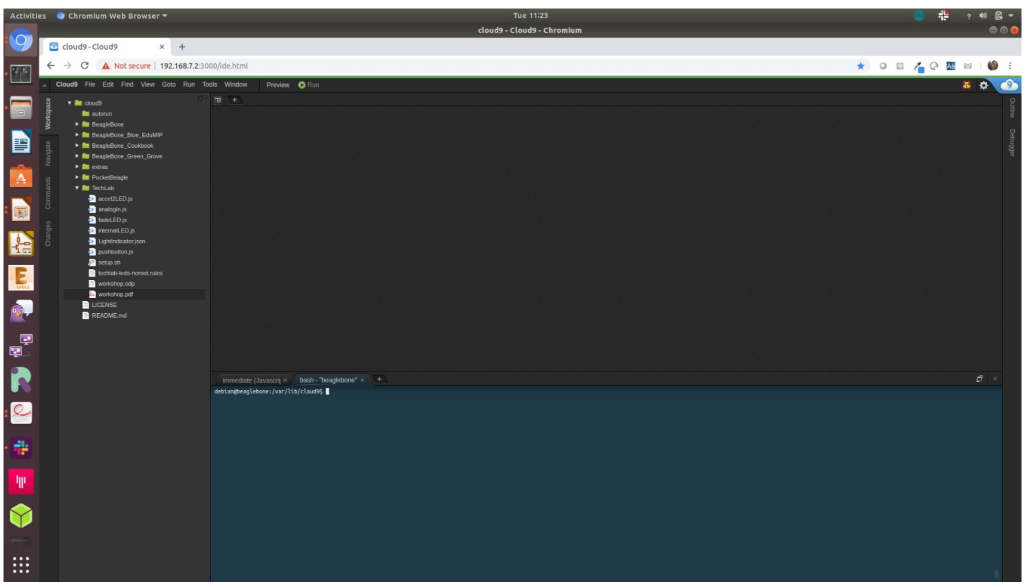
Goal: Read light sensor data and output to green LED brightness
Overview: Node-RED is a flow-based development tool developed originally by IBM for wiring together hardware devices, APIs and online services as part of the Internet of Things. Node-RED provides a browser-based flow editor, which can be used to create JavaScript functions. Linux turns devices into virtual files, making Node-RED well suited to interacting with the physical world.
Do this:
1. Open Node-RED by pointing your browser to **http://192.168.7.2:1880**



2. Make sure the big “DEPLOY” button in the top right corner is greyed-out by clicking it. This makes sure any changes you’ve made have been started on your PocketBeagle. The program will run continuously.
3. Click the highlightable button to the left of the “ON”. Cover the light sensor to notice the brightness of the green LED adjust.
4. Try double-clicking on each node to see the parameters used for the demo.
5. Click the highlightable button to the left of the “OFF” to stop adjusting the brightness of the green LED.
6. Explore
Challenge #1: Try updating the blue LED rather than the green LED. Remember to click the “DEPLOY” button to save and run your changes.
Challenge #2: Try reading from the I2C accelerometer rather than the light sensor.
Challenge #3: Use a “gpio in” node to use the status of the “L” or “R” buttons to update the LED.

Explore the Linux command line

Goal: Learn to send several basic commands to the shell
Overview: The true power of Linux to automate many aspects of your life cannot be achieved without some utilization of the command line shell. The Cloud9 IDE makes it easy to access this directly from your web browser. Another great resource for learning is **linuxcommand.org**.
Do this in the Cloud9 IDE:
1. Click in the terminal window at the bottom half of the IDE. You can also open a new terminal by clicking the "+" in the window tabs and selecting "New Terminal".
2. Try typing in the "commands to try". Press <ENTER> after each command. Take note of how the prompt changes to show you the current active directory. Use the up and down arrows to cycle through commands you've typed before, in case you want to repeat any.
Challenge #1: Can you repeat the last command below that prints GPIO values and change the values?
Challenge #2: Using the "watch" command, can you monitor the I2C accelerometer status?
Challenge #3: Can you use the "config-pin" command to switch the red LED to a GPIO, set it high and low and then switch it back to PWM mode? What happens if the red LED is in GPIO mode and you change the brightness with the "/sys/class/leds" entry?



commands to try

```
cd /sys/class/leds
ls
echo 1 > techlab\:\:seg0/brightness
config-pin p1.33 pwm
echo 10 > techlab\:\:red/brightness

cd /sys/class/gpio
config-pin p1.29 gpio
cat gpio45/value gpio117/value
```

Some useful commands
pwd - show current directory
cd - change current directory
ls - list directory contents
chmod - change file permissions
chown - change file ownership
cp - copy files
mv - move files
rm - remove files
mkdir - make directory
rmdir - remove directory
cat - dump file contents
less - progressively dump file
vi - edit file (complex)
nano - edit file (simple)
head - trim dump to top
tail - trim dump to bottom
echo - print/dump value
env - dump environment variables
export - set environment variable
history - dump command history
grep - search dump for strings
man - get help on command
apropos - show list of man pages
find - search for files
tar - create/extract file archives
gzip - compress a file
gunzip - decompress a file
du - show disk usage
df - show disk free space
mount - mount disks
tee - write dump to file in parallel
hexdump - readable binary dumps

Toggle LED based on a button press using a PRU

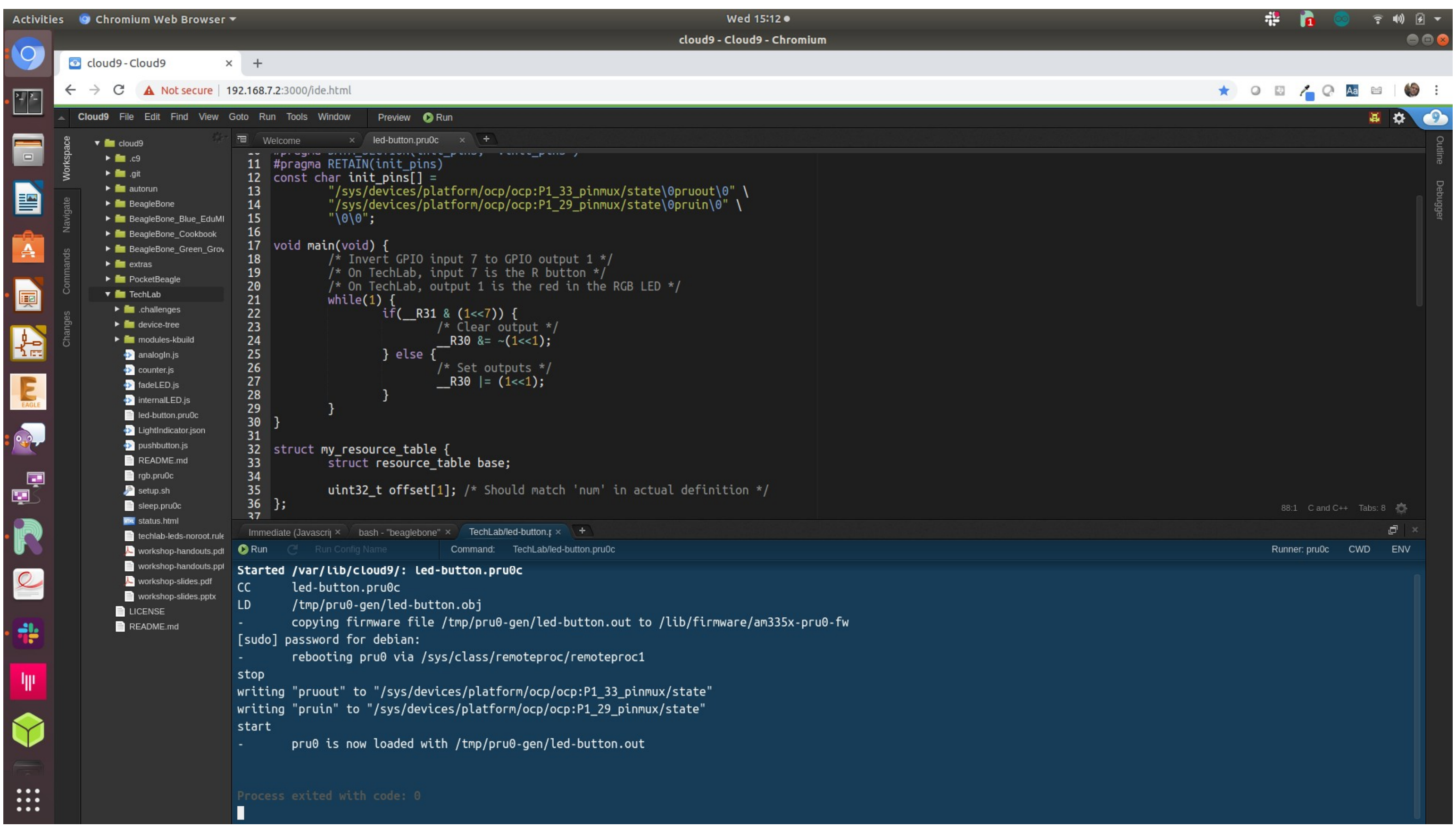
Goal: Utilize a programmable real-time unit (PRU) to read and set GPIOs.
Overview: A PRU is a microcontroller built into the PocketBeagle that can be programmed in C or assembly and controlled by the main ARM processor that runs Linux. Some pins can be directly mapped to PRU registered for the lowest possible latency, but other GPIOs can be utilized via the on-chip-peripheral (OCP) bus inside the processor. Here we'll learn to execute an example written in C to access the direct-mapped PRU GPIOs.
Do this in the Cloud9 IDE:

1. Navigate to **TechLab/led-button.pru0c** and double-click on it.
2. Click the Run button in the toolbar to execute the script in the active file window.
3. Click the run configuration window and type 'temppwd' when prompted for the password.

Note: The program will keep running until you execute a different program or reboot.

4. Press the 'R' button to note the red RGB LED light up.

Challenge #1: The buzzer is on PRU0 output 3 (P2_30). Try setting its output at the same time as the LED.
Challenge #2: Try toggling the buzzer with a `for` loop when the button is pressed. You can use the '__delay_cycles' function to add a delay. Each delay cycle should be 5ns, so 800Hz is 250000 cycles, a reasonable number to try.
Challenge #3: **(Advanced Coding Lab)**
Run **TechLab/rgb.pru0c** and note how the on-chip-peripherals are accessed as well as how a fade effect can be done easily creating a software pulse-width-modulator.



Fade LEDs using a PRU

led-button.pru0c

```
#include <stdint.h>
#include <pru_cfg.h>
#include <pru_ctrl.h>
#include <stddef.h>
#include <rsc_types.h>

volatile register unsigned int __R30;
volatile register unsigned int __R31;

#pragma DATA_SECTION(init_pins, ".init_pins")
#pragma RETAIN(init_pins)
const char init_pins[] =
     "/sys/devices/platform/ocp/ocp:P1_33_pinmux/state\0pruout\0" \
     "/sys/devices/platform/ocp/ocp:P1_29_pinmux/state\0pruin\0" \
     "\0\0";

void main(void) {
     /* Invert GPIO input 7 to GPIO output 1 */
     /* On TechLab, input 7 is the R button */
     /* On TechLab, output 1 is the red in the RGB LED */
     while(1) {
          if(__R31 & (1<<7)) {
               /* Clear output */
               __R30 &= ~(1<<1);
          } else {
               /* Set outputs */
               __R30 |= (1<<1);
          }
     }
}

struct my_resource_table {
        struct resource_table base;

        uint32_t offset[1];
};

#pragma DATA_SECTION(pru_remoteproc_ResourceTable, ".resource_table")
#pragma RETAIN(pru_remoteproc_ResourceTable)
struct my_resource_table pru_remoteproc_ResourceTable = {
        1,      /* we're the first version that implements this */
        0,      /* number of entries in the table */
        0, 0,   /* reserved, must be zero */
        0,      /* offset[0] */
};
```