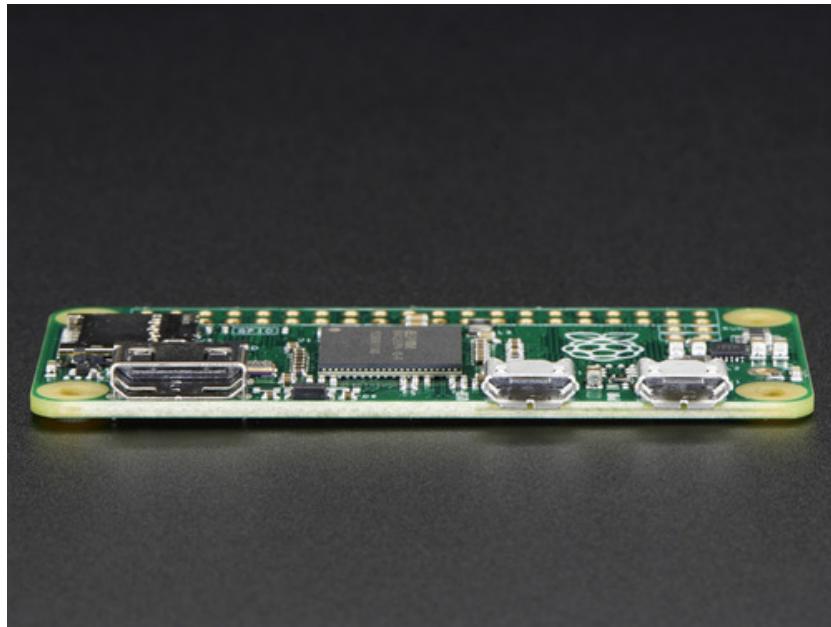




Turning your Raspberry Pi Zero into a USB Gadget

Created by lady ada

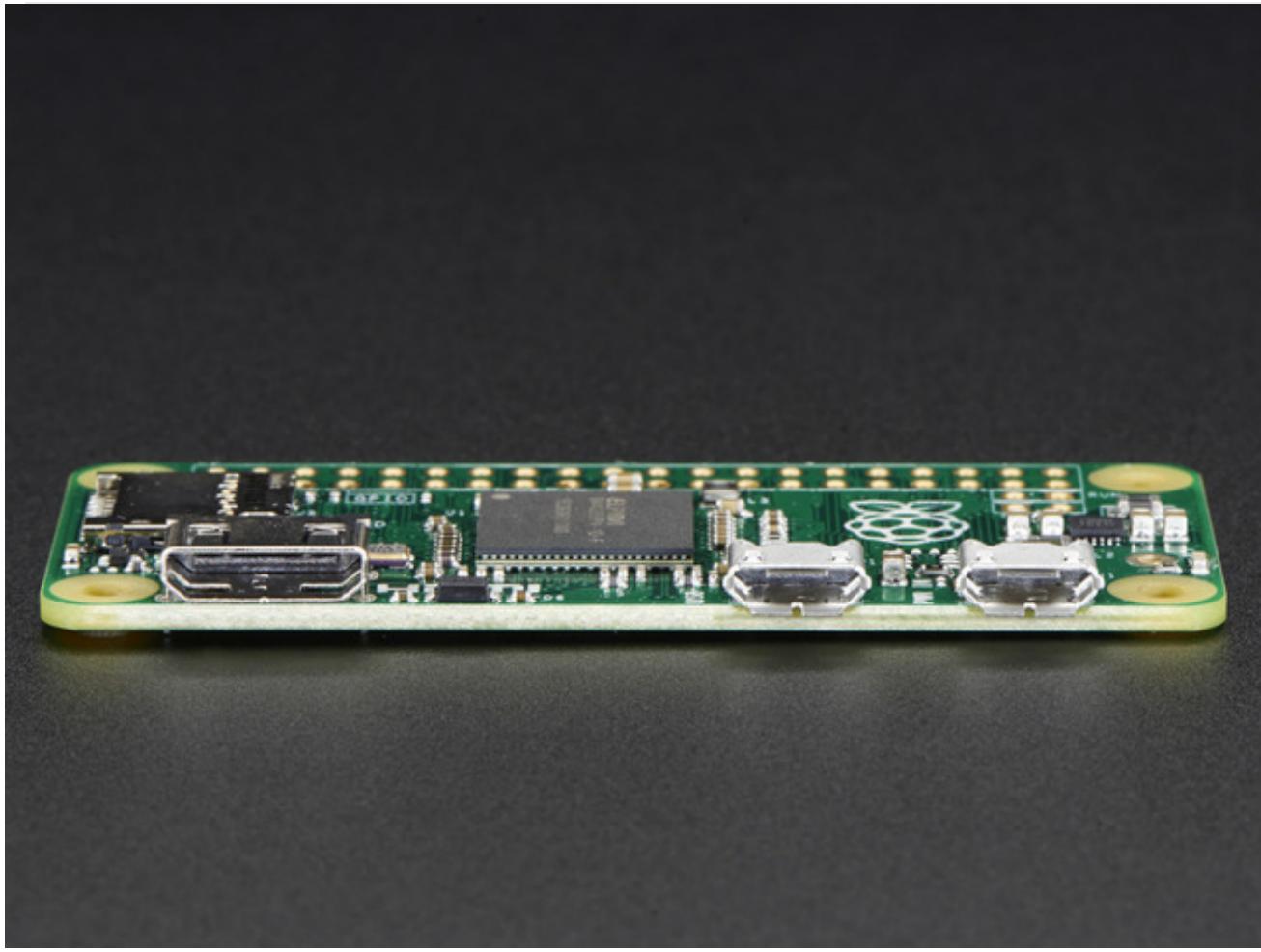


Last updated on 2015-12-27 04:50:10 PM EST

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Overview



When the Pi Zero came out, one of the downsides (!) of the low-cost design was swapping the 'standard' USB A-port for a micro-B port. Now you have to use an 'OTG' cable instead of just plugging in a device.

There was also the matter of, if you didn't have anything connected to USB, and powered up the Pi Zero with an old Raspbian image, you'd get a strange warning (<http://adafru.it/khe>)

`WARN::dwc_otg_handle_mode_mismatch_intr:68: Mode Mismatch Interrupt: currently in Device mode`

Basically, the Pi sorta-trying to become a **usb device** rather than a **usb host**

Some awesome people on github (<http://adafru.it/khf>) sorted out that if you used the DWC2 USB driver, and patched a few files, you could get the Pi to act like a USB device (in linux-land this is called the **USB Gadget** system)

This tutorial is basically just a writeup of how you can follow along and turn your Pi zero into a **USB Serial** device or **Ethernet** device. That's two whole ways of being able to connect to your Pi zero

just by plugging in a micro B cable! You don't even need to power your Pi separately, as power is provided from your computer.

This tutorial is rather bleeding-edge. You'll want a totally fresh new SD card that can be written over with Jessie Lite! Also, this tutorial may change and get updated often: here be drag0ns!

Yeah the gadget system can do a lot more, but these are the two modules we've tested so far. The compiled kernel package has just about every USB gadget compiled in as a module if you'd like to try others

Before You Begin

This tutorial isn't *terribly* difficult but you should have some raspberry Pi experience. In particular you will want to do the following **before anything else**

- [Burn a copy of Rasbian Jessie Lite \(or just plain Jessie\) to a 4G or 8G SD card.](http://adafru.it/dDL) (<http://adafru.it/dDL>)
- [Solder in a 2x20 male header](http://adafru.it/2822) (<http://adafru.it/2822>) or somehow be able to connect a console cable to your Pi Zero
- [Have a USB console cable and be able to log into your Pi over serial from a desktop computer](http://adafru.it/kgF) (<http://adafru.it/kgF>)

While you don't *need* a console cable, it's a lot easier to copy & paste the commands into a terminal than to type into a keyboard + monitor.



Basically, get your Pi zero to a point you can log in. Power it from the Power USB port, leave the Data USB port 'empty'

```
[ 4.797702] systemd[1]: Started Create list of required static device nodes f
or the current kernel.
[ 4.837229] systemd[1]: Started Load Kernel Modules.
[ 4.873911] systemd[1]: Time has been changed
[ 5.002628] systemd[1]: Started udev Coldplug all Devices.
[ 5.237008] systemd[1]: Starting Apply Kernel Variables...
[ 5.259864] systemd[1]: Mounting Configuration File System...
[ 5.300272] systemd[1]: Mounted FUSE Control File System.

Raspbian GNU/Linux 8 raspberrypi ttyAMA0

raspberrypi login: pi
Password:
Linux raspberrypi 4.1.13+ #826 PREEMPT Fri Nov 13 20:13:22 GMT 2015 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.
pi@raspberrypi:~$
```

OK now you can continue!

Serial Gadget

We'll start with Serial Gadget, which is the 'simplest' of the USB gadgets. This one basically makes it so when you plug in the Pi Zero to your computer, it will pop up as a **Serial (COM) Port** - the nice thing about this technique is you can use the pi with any computer and operating system and it doesn't require special drivers or configuration.

Step 0. Download new Kernel Package

Download the following onto your desktop computer:

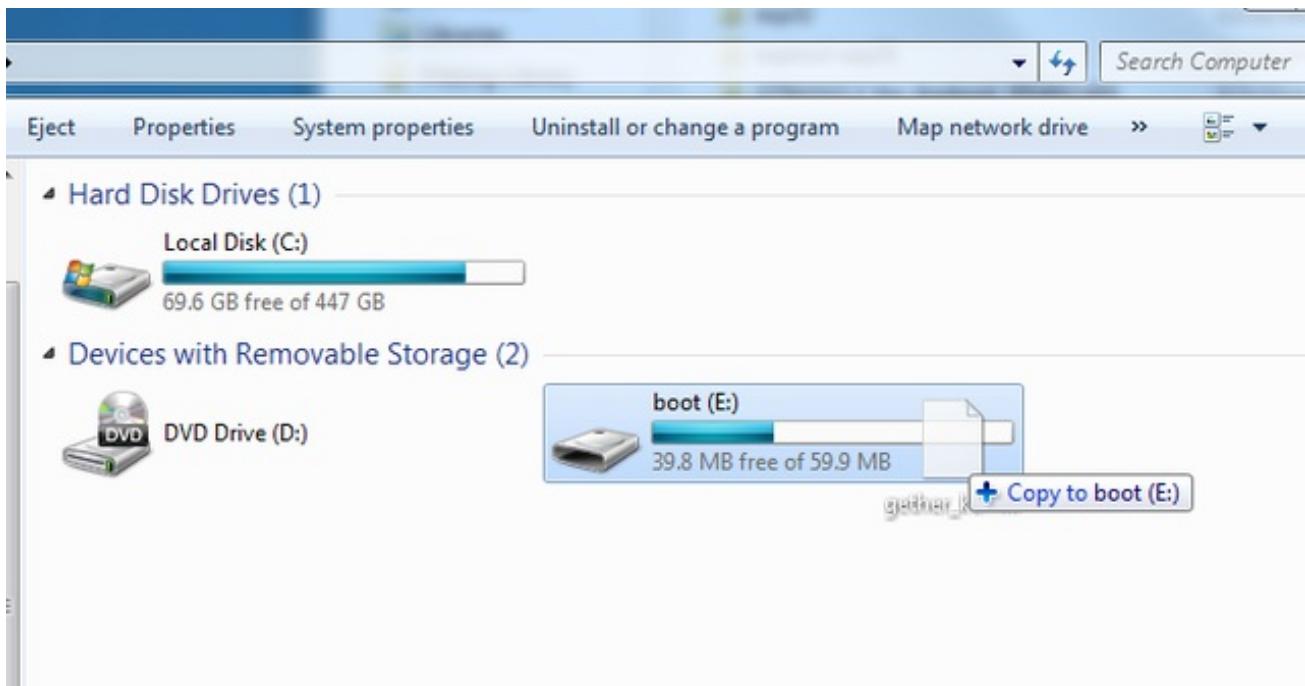
Download the modular Gadget Kernel
TGZ file

<http://adafru.it/klb>

and rename it **gadgetkernel.tgz**

Step 1. Copy New Kernel to SD Card

Copy the new kernel file over to the **boot** directory of the Jessie Lite card. After you're done burning the SD image, don't eject it just yet. Drag the **kernel.tgz** file over to the SD card. This way you can ferry the kernel into your Pi without needing network



Step 2. Log into your Pi Zero

Insert the SD into your Pi Zero, connect the console cable, power the Pi & log into via the USB console.

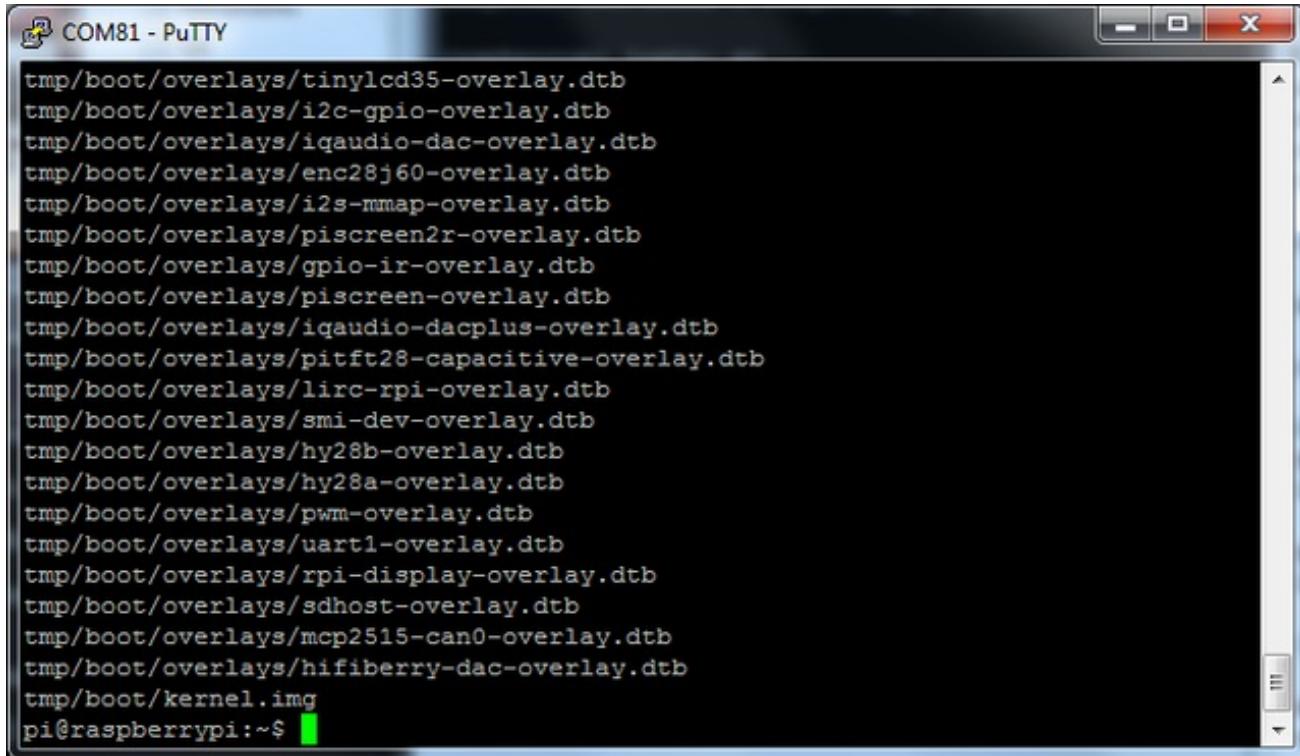
The screenshot shows a PuTTY terminal window titled "COM81 - PuTTY". The terminal displays the boot logs of Raspbian. It starts with systemd services starting, followed by the kernel boot message: "Raspbian GNU/Linux 8 raspberrypi ttyAMA0". A login prompt for "raspberrypi" appears, followed by the kernel version: "Linux raspberrypi 4.1.13+ #826 PREEMPT Fri Nov 13 20:13:22 GMT 2015 armv6l". The standard Debian free software license text follows. Finally, the "Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY" notice is displayed, ending with the prompt "pi@raspberrypi:~\$".

Step 3. Uncompress new kernel package

Uncompress and install the **kernel .tgz file**

run the following commands:

- `cd ~`
- `sudo mv /boot/gadgetkernel.tgz .`
- `tar -xvf gadgetkernel.tgz`



```
tmp/boot/overlays/tinylcd35-overlay.dtb
tmp/boot/overlays/i2c-gpio-overlay.dtb
tmp/boot/overlays/iqaudio-dac-overlay.dtb
tmp/boot/overlays/enc28j60-overlay.dtb
tmp/boot/overlays/i2s-mmap-overlay.dtb
tmp/boot/overlays/piscreen2r-overlay.dtb
tmp/boot/overlays/gpio-ir-overlay.dtb
tmp/boot/overlays/piscreen-overlay.dtb
tmp/boot/overlays/iqaudio-dacplus-overlay.dtb
tmp/boot/overlays/pitft28-capacitive-overlay.dtb
tmp/boot/overlays/lirc-rpi-overlay.dtb
tmp/boot/overlays-smi-dev-overlay.dtb
tmp/boot/overlays/hy28b-overlay.dtb
tmp/boot/overlays/hy28a-overlay.dtb
tmp/boot/overlays/pwm-overlay.dtb
tmp/boot/overlays/uart1-overlay.dtb
tmp/boot/overlays/rpi-display-overlay.dtb
tmp/boot/overlays/sdhost-overlay.dtb
tmp/boot/overlays/mcp2515-can0-overlay.dtb
tmp/boot/overlays/hifiberry-dac-overlay.dtb
tmp/boot/kernel.img
pi@raspberrypi:~$
```

You'll see a long stream of file names ending with **tmp/boot/kernel.img**

You may see a bunch of complaints about timestamps being in the future, this is totally OK

Step 4. Backup and Install new Kernel

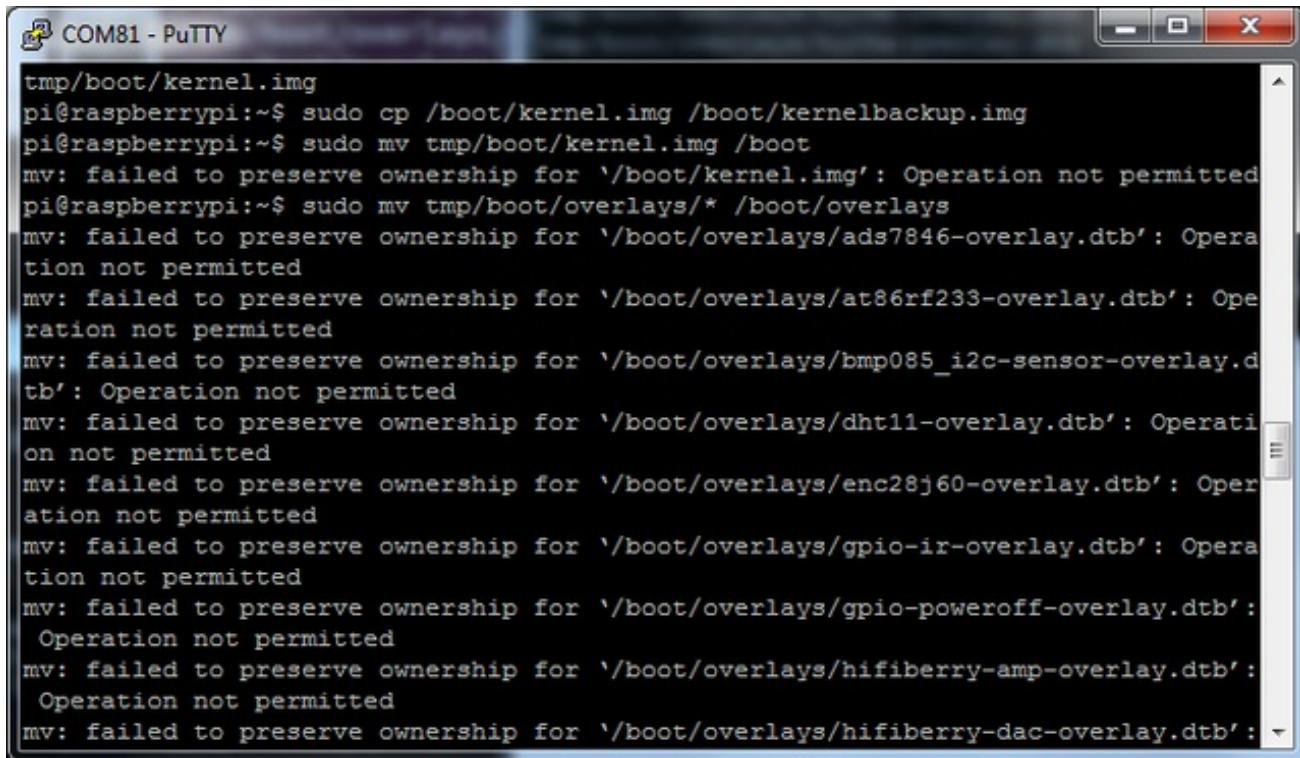
Run

- **sudo mv /boot/kernel.img /boot/kernelbackup.img**

to make a backup of the current kernel. Now run

- **sudo mv tmp/boot/kernel.img /boot**

You may see complaints about preserving ownership, you can ignore them



A screenshot of a PuTTY terminal window titled "COM81 - PuTTY". The window shows a series of Linux commands being run on a Raspberry Pi. The commands include copying the kernel image, moving it to a backup file, and then attempting to move various overlay files from a temporary directory to the boot directory. Most moves fail due to "Operation not permitted" errors.

```
tmp/boot/kernel.img
pi@raspberrypi:~$ sudo cp /boot/kernel.img /boot/kernelbackup.img
pi@raspberrypi:~$ sudo mv tmp/boot/kernel.img /boot
mv: failed to preserve ownership for '/boot/kernel.img': Operation not permitted
pi@raspberrypi:~$ sudo mv tmp/boot/overlays/* /boot/overlays
mv: failed to preserve ownership for '/boot/overlays/ads7846-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/at86rf233-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/bmp085_i2c-sensor-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/dht11-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/enc28j60-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/gpio-ir-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/gpio-poweroff-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/hifiberry-amp-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/hifiberry-dac-overlay.dtb':
```

Step 5. Install Overlays & Modules

Run the commands to install the new overlays & modules

- **sudo mv tmp/boot/overlays/* /boot/overlays**
- **sudo mv tmp/boot/*dtb /boot**
- **sudo cp -R tmp/boot/modules/lib/* /lib**

```
mv: failed to preserve ownership for '/boot/overlays/spi-gpio35-39-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/tinylcd35-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/uart1-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/vc4-kms-v3d-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/vga666-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/wl-gpio-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/wl-gpio-pullup-overlay.dtb': Operation not permitted
pi@raspberrypi:~$ sudo mv tmp/boot/*dtb /boot
mv: failed to preserve ownership for '/boot/bcm2708-rpi-b.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/bcm2708-rpi-b-plus.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/bcm2708-rpi-cm.dtb': Operation not permitted
pi@raspberrypi:~$
```

```
Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/tinylcd35-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/uart1-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/vc4-kms-v3d-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/vga666-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/wl-gpio-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/wl-gpio-pullup-overlay.dtb': Operation not permitted
pi@raspberrypi:~$ sudo mv tmp/boot/*dtb /boot
mv: failed to preserve ownership for '/boot/bcm2708-rpi-b.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/bcm2708-rpi-b-plus.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/bcm2708-rpi-cm.dtb': Operation not permitted
pi@raspberrypi:~$ sudo cp -R tmp/boot/modules/lib/* /lib
pi@raspberrypi:~$
```

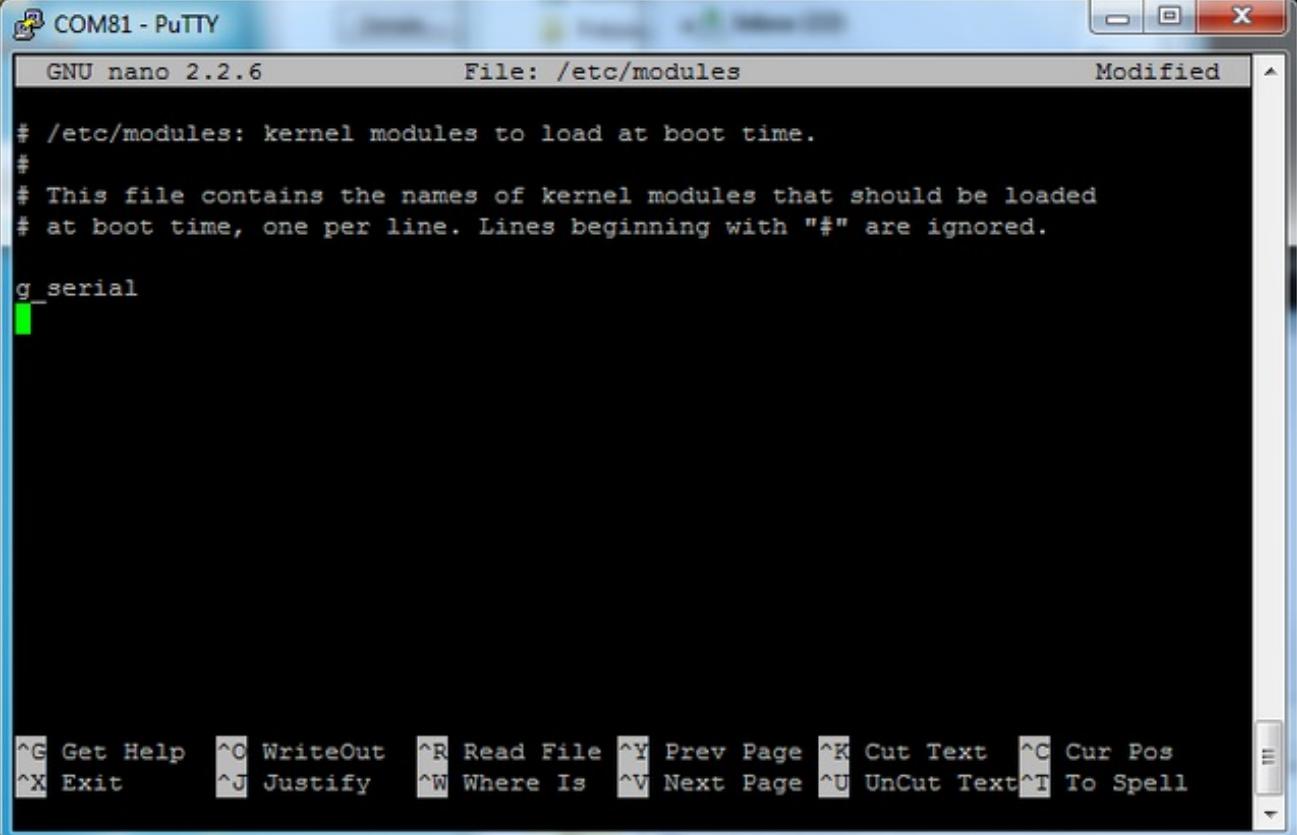
Step 6. Update the Module & Reboot

Now we'll tell the Pi we want to use the `g_serial` module

Run

- **sudo nano /etc/modules**

and add **g_serial** on a single line at the end, then save



```
GNU nano 2.2.6          File: /etc/modules          Modified

# /etc/modules: kernel modules to load at boot time.
#
# This file contains the names of kernel modules that should be loaded
# at boot time, one per line. Lines beginning with "#" are ignored.

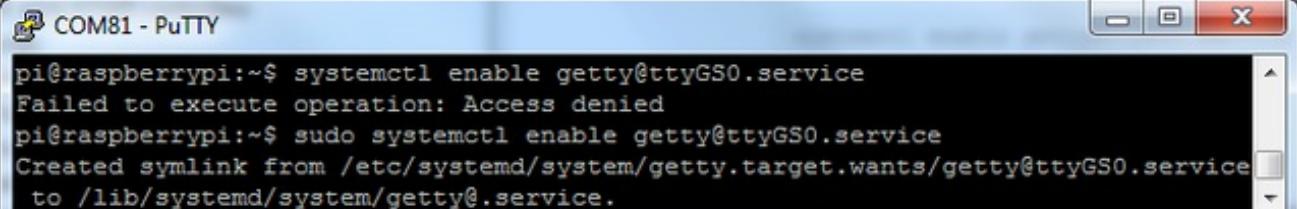
g_serial
```

^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

Step 7. Set up logging in on Pi Zero via Serial Gadget

OK just cuz you have a Serial port doesn't mean you can log in with it *yet*. The Pi knows it has a Serial port but you have to tie it to a console. You can do that very easily with:

- **sudo systemctl enable getty@ttyGS0.service (<http://adafruit.it/khb>)**



```
pi@raspberrypi:~$ sudo systemctl enable getty@ttyGS0.service
Failed to execute operation: Access denied
pi@raspberrypi:~$ sudo systemctl enable getty@ttyGS0.service
Created symlink from /etc/systemd/system/getty.target.wants/getty@ttyGS0.service
to /lib/systemd/system/getty@.service.
```

(don't forget the sudo like i did at first!)

You can then verify its running with

- `sudo systemctl is-active getty@ttyGS0.service`

```
pi@raspberrypi:~$ sudo systemctl is-active getty@ttyGS0.service
active
pi@raspberrypi:~$
```

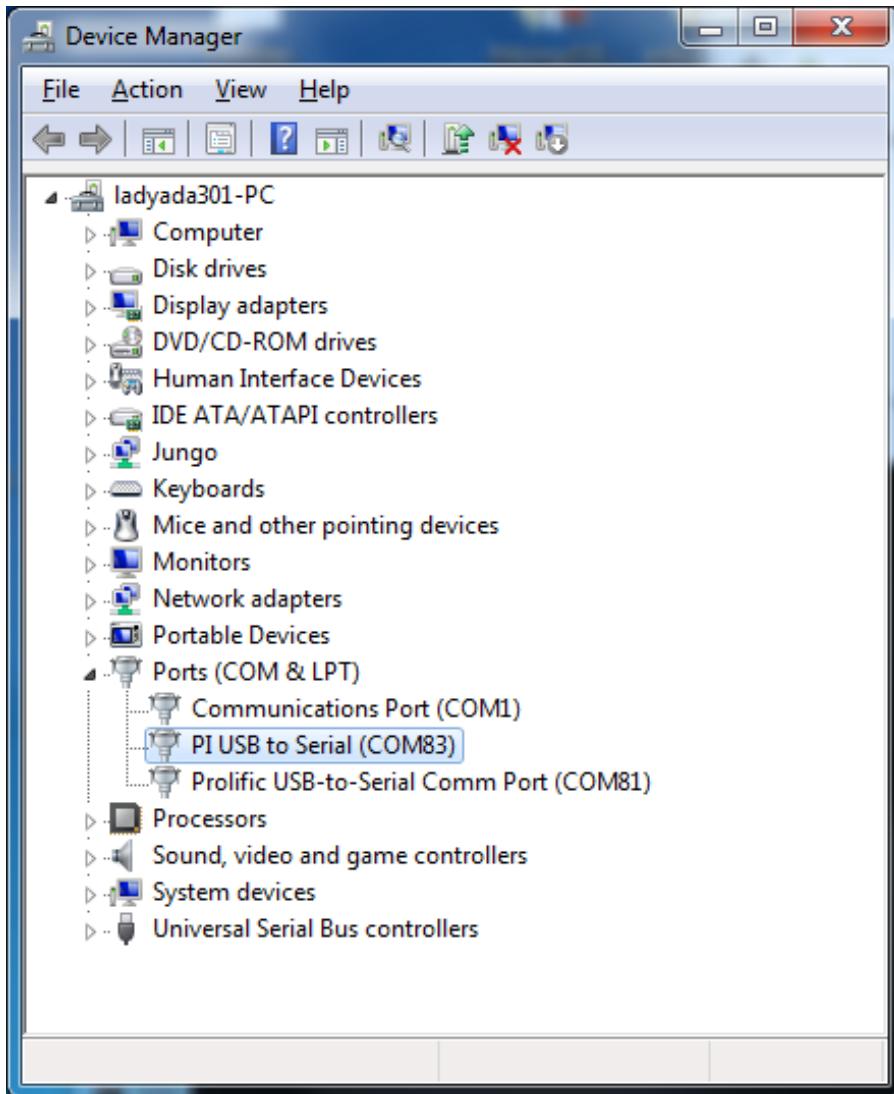
Thats...pretty much it. run `sudo reboot` to start up your Pi Zero. Plug in a USB Micro cable from your computer to the Pi Zero.

```
COM81 - PuTTY
ration not permitted
mv: failed to preserve ownership for '/boot/overlays/uart1-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/vc4-kms-v3d-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/vga666-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/w1-gpio-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/w1-gpio-pullup-overlay.dtb': Operation not permitted
pi@raspberrypi:~$ sudo mv tmp/boot/*dtb /boot
mv: failed to preserve ownership for '/boot/bcm2708-rpi-b.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/bcm2708-rpi-b-plus.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/bcm2708-rpi-cm.dtb': Operation not permitted
pi@raspberrypi:~$ sudo cp -R tmp/boot/modules/lib/* /lib
pi@raspberrypi:~$ sudo reboot
[ 253.747096] reboot: Restarting system
```

While the Zero is rebooting you can see that it loads the `g_cdc` module which provides "CDC USB Serial support" ([CDC stands for 'communications device class'](http://adafruit.it/kha) (<http://adafruit.it/kha>))

```
[ 2.856039] dwc2 20980000.usb: DWC OTG Controller
[ 2.860961] dwc2 20980000.usb: new USB bus registered, assigned bus number 1
[ 2.868396] dwc2 20980000.usb: irq 33, io mem 0x00000000
[ 2.878115] usb usb1: New USB device found, idVendor=1d6b, idProduct=0002
[ 2.888942] usb usb1: New USB device strings: Mfr=3, Product=2, SerialNumber=
1
[ 2.900180] usb usb1: Product: DWC OTG Controller
[ 2.908820] usb usb1: Manufacturer: Linux 4.4.0-rc5+ dwc2_hsotg
[ 2.918676] usb usb1: SerialNumber: 20980000.usb
[ 2.928293] hub 1-0:1.0: USB hub found
[ 2.936192] hub 1-0:1.0: 1 port detected
[ 2.945109] usbcore: registered new interface driver usb-storage
[ 2.955996] g_serial gadget: Gadget Serial v2.4
[ 2.964402] g_serial gadget: g_serial ready
[ 2.975583] dwc2 20980000.usb: bound driver g_serial
[ 2.988011] mousedev: PS/2 mouse device common for all mice
[ 2.999009] bcm2835-cpufreq: min=700000 max=1000000
[ 3.008464] sdhci: Secure Digital Host Controller Interface driver
[ 3.018685] sdhci: Copyright(c) Pierre Ossman
[ 3.105606] mmc0: sdhost-bcm2835 loaded - DMA enabled (>1)
[ 3.135629] sdhci-pltfm: SDHCI platform and OF driver helper
[ 3.146065] ledtrig-cpu: registered to indicate activity on CPUs
[ 3.166458] hidraw: raw HID events driver (C) Jiri Kosina
[ 3.183225] usbcore: registered new interface driver usbhid
```

On your computer you'll see a new Serial port is created. Check the Windows device driver:

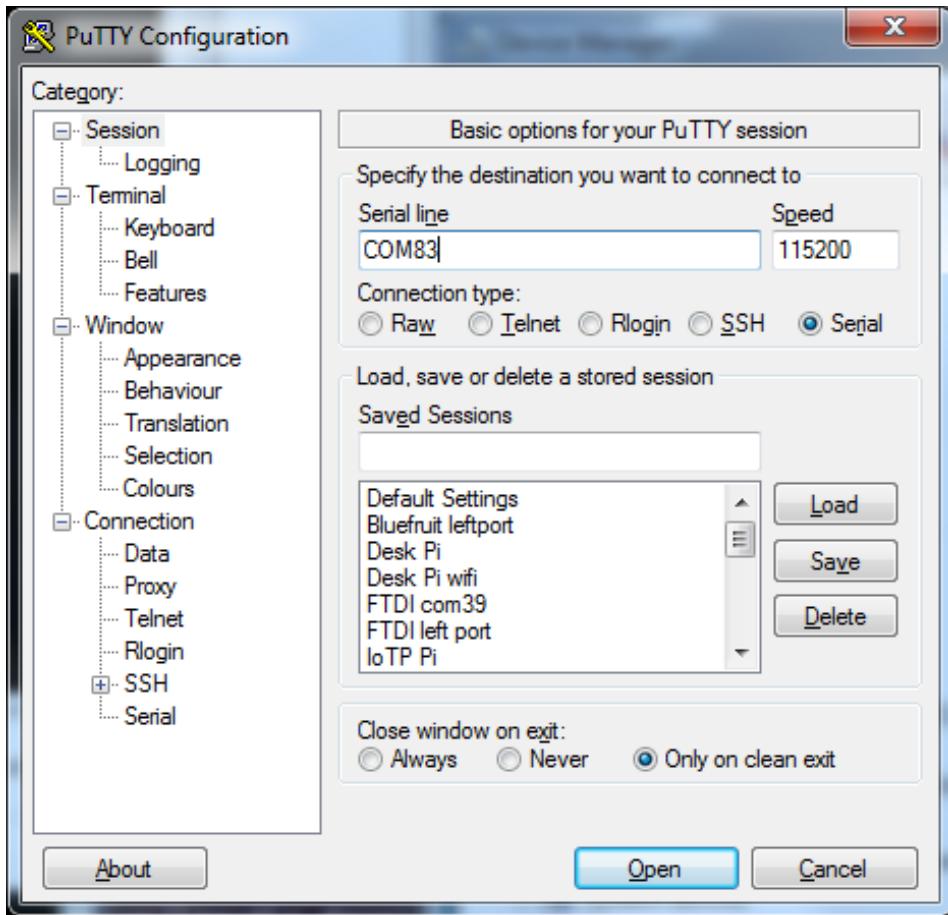


On mac, it will be a new device called `/dev/tty.usbmodemNNNN` where NNNN can be any number

```
ladyada — bash — 80x24
[pts-MacBook-Air:~ ladyada$ ls /dev/tty.usbmodem*
/dev/tty.usbmodem1423
pts-MacBook-Air:~ ladyada$ ]
```

Step 8. Log into your Pi using Serial Port Software

OK now that your Pi is rebooted and you get that USB serial device again, you can connect to it at **115200** baud (8N1 8-bit No-parity 1-stop if you need to set that)



you can disconnect the console cable, so you dont mix up the USB console cable and the direct-console connection (since they both have COM/Serial ports)

You can also remove the power cable to the 'power USB' port, since the desktop computer will be powering the Pi thru the USB gadget port.

```
7^[[6~^[[6~  
Login incorrect  
raspberrypi login:  
Password:  
  
Login incorrect  
raspberrypi login: pi  
Password:  
Last login: Thu Dec 24 18:45:52 UTC 2015 on ttyAMA0  
Linux raspberrypi 4.4.0-rc5+ #4 PREEMPT Thu Dec 24 13:25:56 EST 2015 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.  
pi@raspberrypi:~$
```

You may have to hit return a few times to get it to come up with the login prompt. But that's it! You're now connected to your Pi Zero directly

Ethernet Gadget

The Ethernet Gadget is a little more difficult to set up, but is a lot more powerful because you can tunnel networking, VNC, ssh and scp files, etc. Basically you get the ability to log in to the console as well as anything else you could want to do over a network connection

Note that even though it's called "Ethernet Gadget" you do not use an Ethernet cable! The only cable is the USB micro-B cable from your computer to your Pi Zero. The Pi 'appears' like an Ethernet device.

You can even share your desktop computer's network setup so your Pi can access the internet through your computer via the USB cable! Cool huh?

Step 0. Download New Kernel Package

Download the following onto your desktop computer:

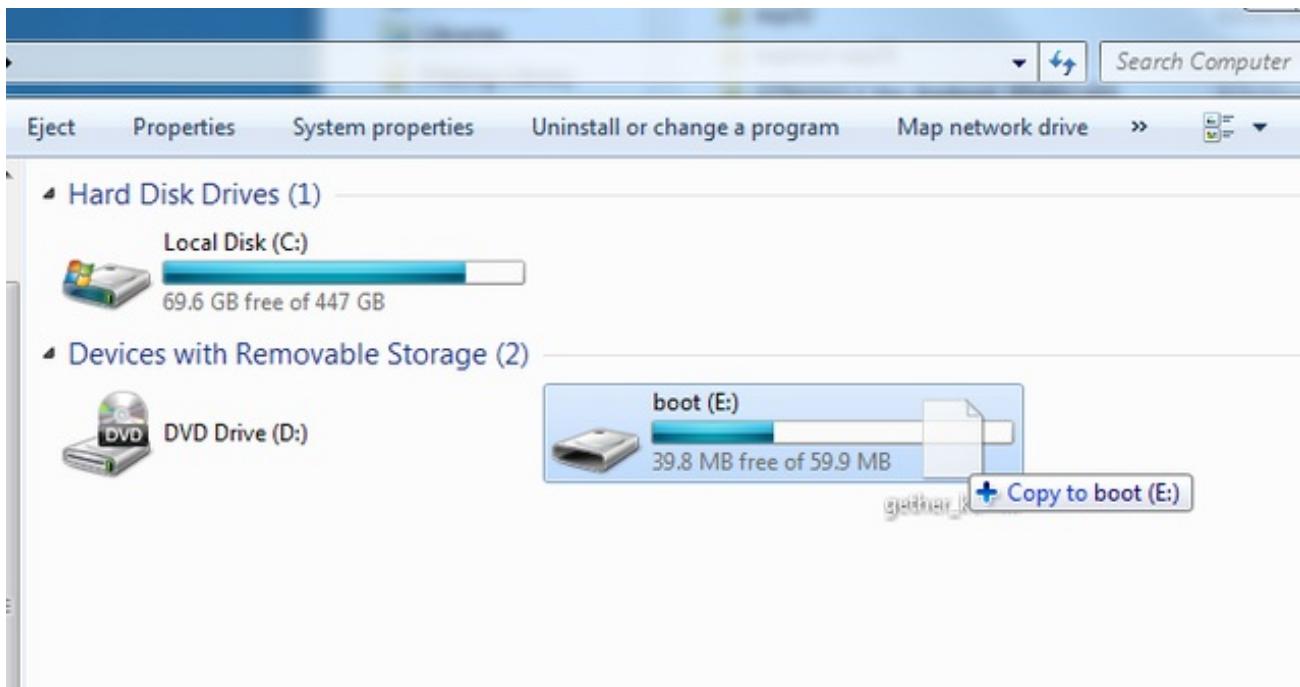
Download the modular Gadget Kernel
TGZ file

<http://adafru.it/klb>

and rename it **gadgetkernel.tgz**

Step 1. Copy New Kernel to SD Card

Copy the new kernel file over to the **boot** directory of the Jessie Lite card. After you're done burning the SD image, don't eject it just yet. Drag the **kernel.tgz** file over to the SD card. This way you can ferry the kernel into your Pi without needing network



Step 2. Log into your Pi Zero

Insert the SD into your Pi Zero, connect the console cable, power the Pi & log into via the USB console.

```
[ 4.797702] systemd[1]: Started Create list of required static device nodes f
or the current kernel.
[ 4.837229] systemd[1]: Started Load Kernel Modules.
[ 4.873911] systemd[1]: Time has been changed
[ 5.002628] systemd[1]: Started udev Coldplug all Devices.
[ 5.237008] systemd[1]: Starting Apply Kernel Variables...
[ 5.259864] systemd[1]: Mounting Configuration File System...
[ 5.300272] systemd[1]: Mounted FUSE Control File System.

Raspbian GNU/Linux 8 raspberrypi ttyAMA0

raspberrypi login: pi
Password:
Linux raspberrypi 4.1.13+ #826 PREEMPT Fri Nov 13 20:13:22 GMT 2015 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.
pi@raspberrypi:~$
```

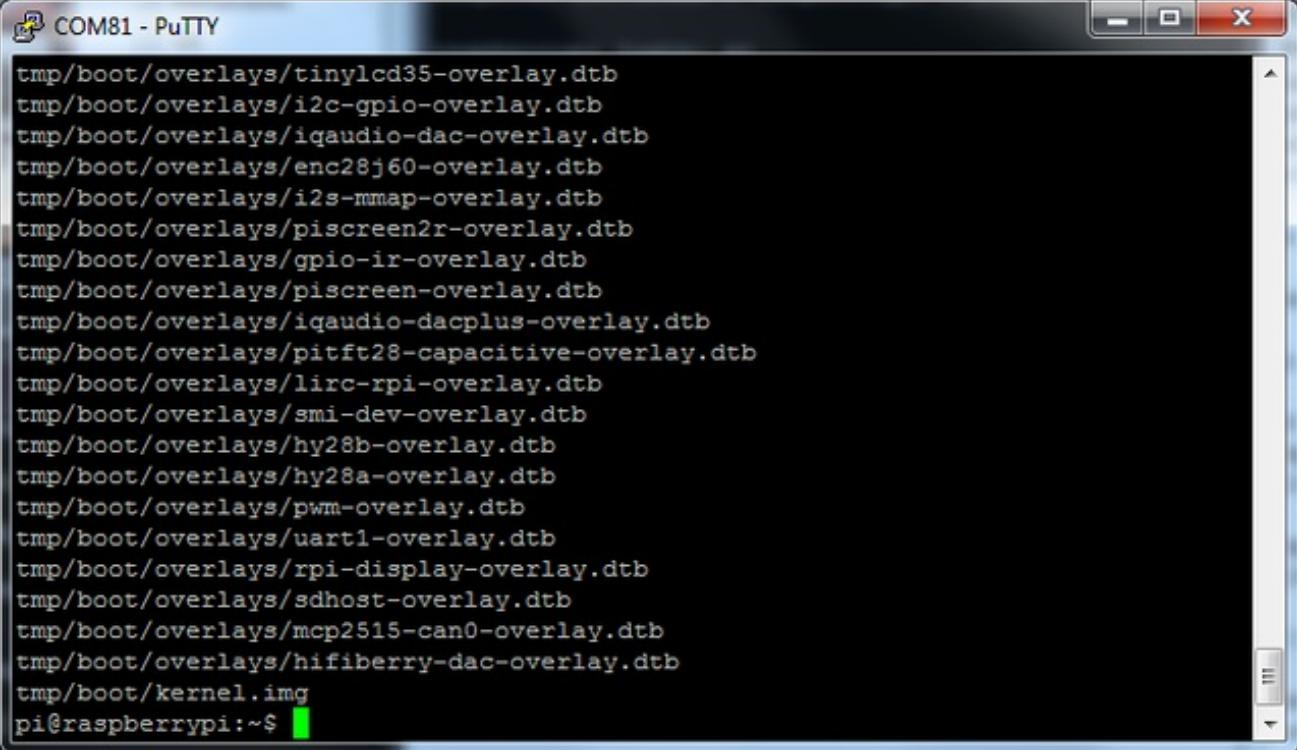
A screenshot of a PuTTY terminal window titled 'COM81 - PuTTY'. The window displays the Raspbian boot logs. It starts with kernel initialization messages like 'Started Create list of required static device nodes' and 'Started Load Kernel Modules'. It then shows the mounting of file systems and the configuration of the system. Finally, it reaches the login prompt 'raspberrypi login: pi'. The user enters 'pi' as the username and is prompted for a password. The terminal then shows the kernel version 'Linux raspberrypi 4.1.13+ #826 PREEMPT Fri Nov 13 20:13:22 GMT 2015 armv6l'. It displays a copyright notice from the Debian project, followed by a warning about the lack of warranty, and ends with the prompt 'pi@raspberrypi:~\$'.

Step 3. Uncompress new kernel package

Uncompress and install the **kernel .tgz** file

run the following commands:

- **cd ~**
- **sudo mv /boot/gadgetkernel.tgz .**
- **tar -xvzf gadgetkernel.tgz**



```
tmp/boot/overlays/tinylcd35-overlay.dtb
tmp/boot/overlays/i2c-gpio-overlay.dtb
tmp/boot/overlays/iqaudio-dac-overlay.dtb
tmp/boot/overlays/enc28j60-overlay.dtb
tmp/boot/overlays/i2s-mmap-overlay.dtb
tmp/boot/overlays/piscreen2r-overlay.dtb
tmp/boot/overlays/gpio-ir-overlay.dtb
tmp/boot/overlays/piscreen-overlay.dtb
tmp/boot/overlays/iqaudio-dacplus-overlay.dtb
tmp/boot/overlays/pitft28-capacitive-overlay.dtb
tmp/boot/overlays/lirc-rpi-overlay.dtb
tmp/boot/overlays/smi-dev-overlay.dtb
tmp/boot/overlays/hy28b-overlay.dtb
tmp/boot/overlays/hy28a-overlay.dtb
tmp/boot/overlays/pwm-overlay.dtb
tmp/boot/overlays/uart1-overlay.dtb
tmp/boot/overlays/rpi-display-overlay.dtb
tmp/boot/overlays/sdhost-overlay.dtb
tmp/boot/overlays/mcp2515-can0-overlay.dtb
tmp/boot/overlays/hifiberry-dac-overlay.dtb
tmp/boot/kernel.img
pi@raspberrypi:~$
```

You'll see a long stream of file names ending with **tmp/boot/kernel.img**

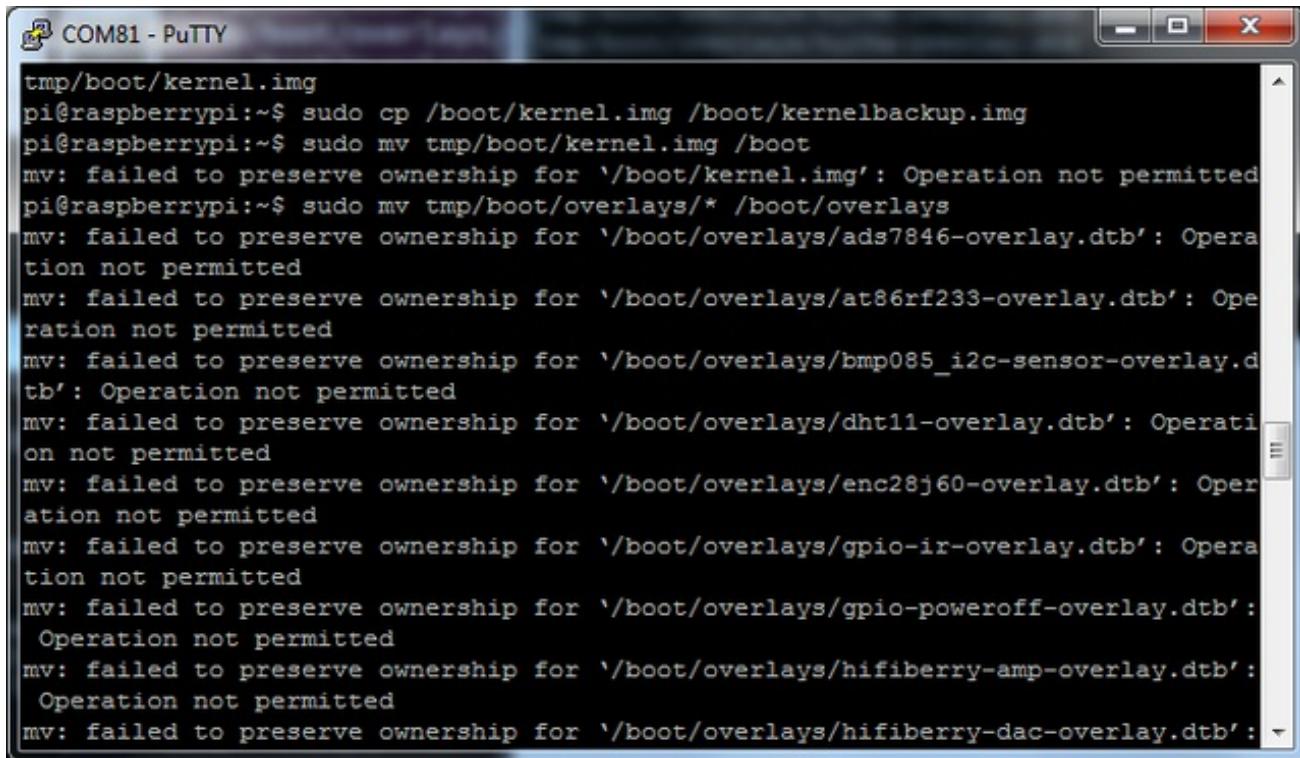
Step 4. Backup and Install new Kernel

Run

- **sudo mv /boot/kernel.img /boot/kernelbackup.img**

to make a backup of the current kernel. Now run

- **sudo mv tmp/boot/kernel.img /boot**



A screenshot of a PuTTY terminal window titled "COM81 - PuTTY". The window shows a series of Linux commands being run on a Raspberry Pi. The commands include copying the kernel image, moving it to a backup file, and then attempting to move various boot overlays and device tree blobs (dtb files) from a temporary directory to the /boot directory. Most of these moves fail with the error message "mv: failed to preserve ownership for ...: Operation not permitted".

```
tmp/boot/kernel.img
pi@raspberrypi:~$ sudo cp /boot/kernel.img /boot/kernelbackup.img
pi@raspberrypi:~$ sudo mv tmp/boot/kernel.img /boot
mv: failed to preserve ownership for '/boot/kernel.img': Operation not permitted
pi@raspberrypi:~$ sudo mv tmp/boot/overlays/* /boot/overlays
mv: failed to preserve ownership for '/boot/overlays/ads7846-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/at86rf233-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/bmp085_i2c-sensor-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/dht11-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/enc28j60-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/gpio-ir-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/gpio-poweroff-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/hifiberry-amp-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/hifiberry-dac-overlay.dtb':
```

Step 5. Install Overlays & Modules

Run the commands to install the new overlays & modules

- **sudo mv tmp/boot/overlays/* /boot/overlays**
- **sudo mv tmp/boot/*dtb /boot**
- **sudo cp -R tmp/boot/modules/lib/* /lib**

```
mv: failed to preserve ownership for '/boot/overlays/spi-gpio35-39-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/tinylcd35-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/uart1-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/vc4-kms-v3d-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/vga666-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/wl-gpio-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/wl-gpio-pullup-overlay.dtb': Operation not permitted
pi@raspberrypi:~$ sudo mv tmp/boot/*dtb /boot
mv: failed to preserve ownership for '/boot/bcm2708-rpi-b.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/bcm2708-rpi-b-plus.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/bcm2708-rpi-cm.dtb': Operation not permitted
pi@raspberrypi:~$
```

```
Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/tinylcd35-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/uart1-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/vc4-kms-v3d-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/vga666-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/wl-gpio-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/wl-gpio-pullup-overlay.dtb': Operation not permitted
pi@raspberrypi:~$ sudo mv tmp/boot/*dtb /boot
mv: failed to preserve ownership for '/boot/bcm2708-rpi-b.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/bcm2708-rpi-b-plus.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/bcm2708-rpi-cm.dtb': Operation not permitted
pi@raspberrypi:~$ sudo cp -R tmp/boot/modules/lib/* /lib
pi@raspberrypi:~$
```

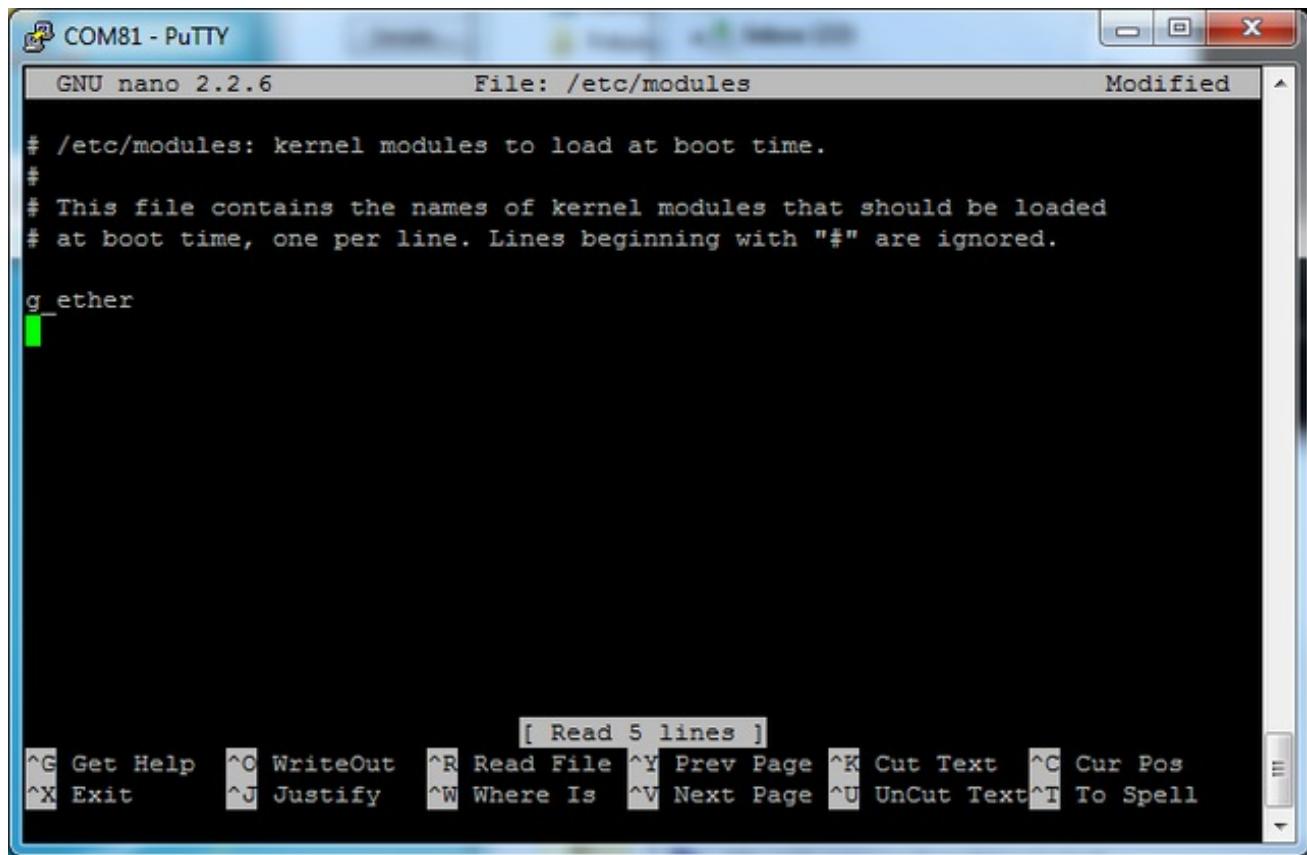
Step 6. Update the Module & Reboot

Now we'll tell the Pi we want to use the `g_serial` module

Run

- **sudo nano /etc/modules**

and add **g_ether** on a single line at the end, then save



```
GNU nano 2.2.6          File: /etc/modules          Modified

# /etc/modules: kernel modules to load at boot time.
#
# This file contains the names of kernel modules that should be loaded
# at boot time, one per line. Lines beginning with "#" are ignored.

g_ether
```

[Read 5 lines]

^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

Thats...pretty much it. run **sudo reboot** to start up your Pi Zero. Plug in a USB Micro cable from your computer to the Pi Zero.

```
ration not permitted
mv: failed to preserve ownership for '/boot/overlays/uart1-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/vc4-kms-v3d-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/vga666-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/w1-gpio-overlay.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/overlays/w1-gpio-pullup-overlay.dtb': Operation not permitted
pi@raspberrypi:~$ sudo mv tmp/boot/*dtb /boot
mv: failed to preserve ownership for '/boot/bcm2708-rpi-b.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/bcm2708-rpi-b-plus.dtb': Operation not permitted
mv: failed to preserve ownership for '/boot/bcm2708-rpi-cm.dtb': Operation not permitted
pi@raspberrypi:~$ sudo cp -R tmp/boot/modules/lib/* /lib
pi@raspberrypi:~$ sudo reboot
[ 253.747096] reboot: Restarting system
```

While the Zero is rebooting you can see that it loads the **g_ether** module which provides USB ethernet support

```
[ 2.888968] usb usb1: New USB device strings: Mfr=3, Product=2, SerialNumber=1
[ 2.900184] usb usb1: Product: DWC OTG Controller
[ 2.908845] usb usb1: Manufacturer: Linux 4.4.0-rc5+ dwc2_hsotg
[ 2.918717] usb usb1: SerialNumber: 20980000.usb
[ 2.928362] hub 1-0:1.0: USB hub found
[ 2.936274] hub 1-0:1.0: 1 port detected
[ 2.945193] usbcore: registered new interface driver usb-storage
[ 2.955711] using random self ethernet address
[ 2.964021] using random host ethernet address
[ 2.973222] usb0: HOST MAC de:1e:d3:e2:fe:d4
[ 2.981708] usb0: MAC de:bb:0c:8b:b4:f9
[ 2.989519] using random self ethernet address
[ 2.997823] using random host ethernet address
[ 3.006139] g_ether gadget: Ethernet Gadget, version: Memorial Day 2008
[ 3.016605] g_ether gadget: g_ether ready
[ 3.027459] dwc2 20980000.usb: bound driver g_ether
[ 3.039809] mousedev: PS/2 mouse device common for all mice
[ 3.050521] bcm2835-cpufreq: min=700000 max=1000000
[ 3.059713] sdhci: Secure Digital Host Controller Interface driver
[ 3.069743] sdhci: Copyright(c) Pierre Ossman
[ 3.155608] mmc0: sdhost-bcm2835 loaded - DMA enabled (>1)
[ 3.165201] sdhci-pltfm: SDHCI platform and OF driver helper
[ 3.195672] ledtrig-cpu: registered to indicate activity on CPUs
[ 3.215939] hidraw: raw HID events driver (C) Jiri Kosina
[ 3.232561] usbcore: registered new interface driver usbhid
[ 3.241926] usbhid: USB HID core driver
[ 3.251303] Initializing XFRM netlink socket
[ 3.261191] NET: Registered protocol family 10
```

You can now log in and check that you have a new network device called **usb0**

- **sudo ifconfig -a**

```
Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
pi@raspberrypi:~$ ifconfig -a
lo      Link encap:Local Loopback
        inet addr:127.0.0.1  Mask:255.0.0.0
              inet6 addr: ::1/128 Scope:Host
                     UP LOOPBACK RUNNING  MTU:65536  Metric:1
                     RX packets:192 errors:0 dropped:0 overruns:0 frame:0
                     TX packets:192 errors:0 dropped:0 overruns:0 carrier:0
                     collisions:0 txqueuelen:0
                     RX bytes:15552 (15.1 KiB)  TX bytes:15552 (15.1 KiB)

sit0    Link encap:IPv6-in-IPv4
        NOARP  MTU:1480  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)

usb0    Link encap:Ethernet  HWaddr de:bb:0c:8b:b4:f9
        inet6 addr: fe80::4306:c050:a099:d4af/64 Scope:Link
              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)

pi@raspberrypi:~$
```

Try plugging the Pi Zero into your computer now. For example, on a Mac, we plugged it in

```
pi@raspberrypi:~$ ifconfig usb0
usb0      Link encap:Ethernet HWaddr 9a:38:21:15:53:6e
          inet6 addr: fe80::d8dc:6ae8:cb4b/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1
          RX packets:43 errors:0 dropped:0 overruns:0 frame:0
          TX packets:11 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:5850 (5.7 KiB)  TX bytes:1506 (1.4 KiB)

pi@raspberrypi:~$ ifconfig usb0
usb0      Link encap:Ethernet HWaddr 9a:38:21:15:53:6e
          inet addr:169.254.248.219 Bcast:169.254.255.255 Mask:255.255.0.0
          inet6 addr: fe80::d8dc:6ae8:cb4b/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1
          RX packets:48 errors:0 dropped:0 overruns:0 frame:0
          TX packets:29 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:6912 (6.7 KiB)  TX bytes:5149 (5.0 KiB)

pi@raspberrypi:~$
```

As you can see above, between the first ifconfig and second, the network came up with an address. The problem this is a arbitrary (DHCP) address, and we dont want to have to guess it.

We can configure this device to have a fixed address (this makes it easier to find on a network!)

- **sudo nano /etc/network/interfaces**

and add at the end

```
allow-hotplug usb0
iface usb0 inet static
    address 192.168.7.2
    netmask 255.255.255.0
    network 192.168.7.0
    broadcast 192.168.7.255
    gateway 192.168.7.1
```

This will give the **Raspberry Pi the IP Address 192.168.7.2**

you can change this to a different address but unless you're sure that 192.168.7.* is unavailable, keep it as above for now.

COM81 - PuTTY

GNU nano 2.2.6 File: /etc/network/interfaces

```
allow-hotplug wlan1
iface wlan1 inet manual
    wpa-conf /etc/wpa_supplicant/wpa_supplicant.conf

allow-hotplug usb0
iface usb0 inet static
    address 192.168.7.2
    netmask 255.255.255.0
    network 192.168.7.0
    broadcast 192.168.7.255
    gateway 192.168.7.1
```

[Read 28 lines]

^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

Save the file and run

- **sudo ifdown usb0** (this may fail, its fine)
- **sudo ifup usb0**
- **ifconfig usb0**

to verify it now has the 192.168.7.2 address

COM81 - PuTTY

[Wrote 26 lines]

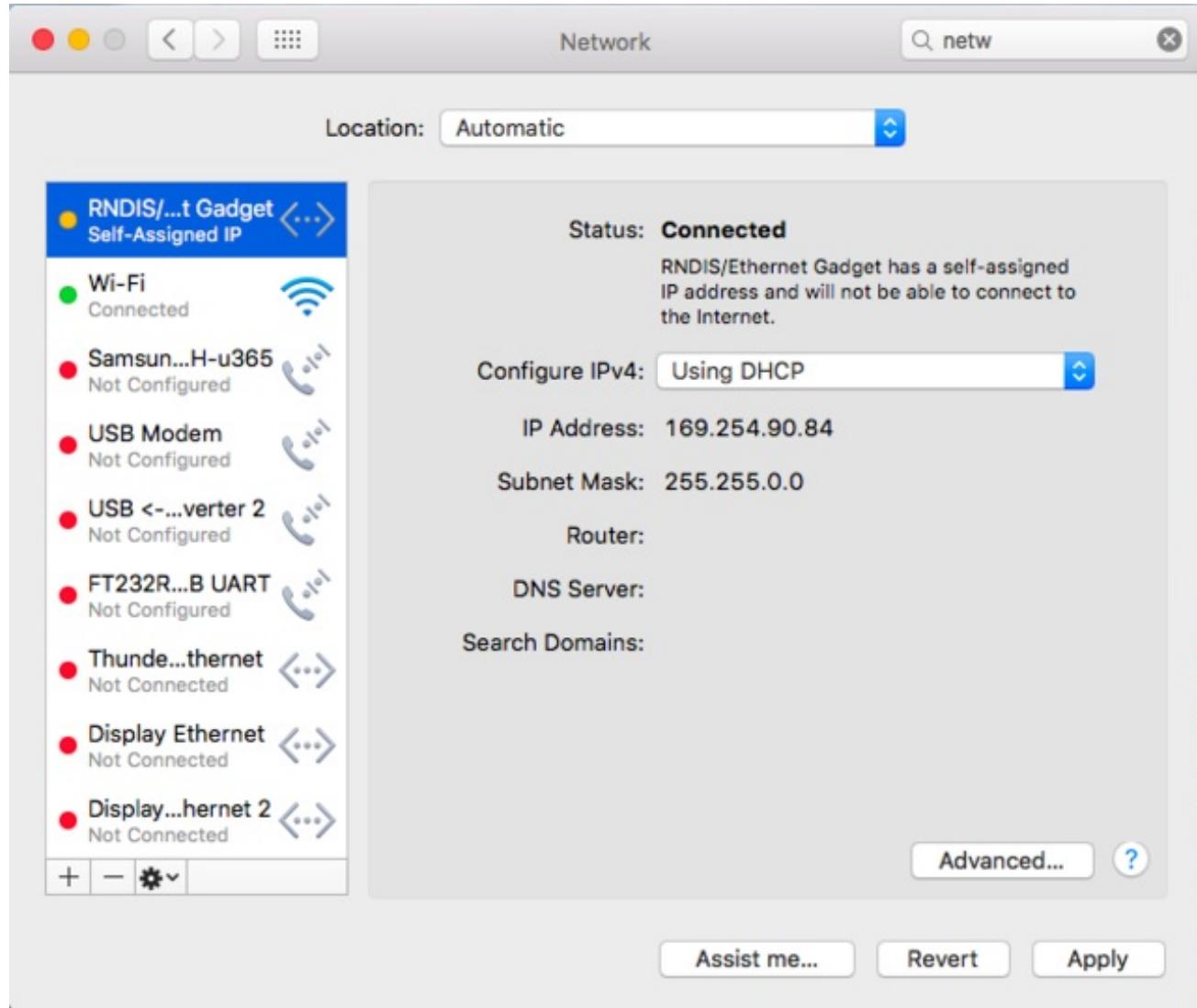
```
pi@raspberrypi:~$ sudo ifdown usb0
ifdown: interface usb0 not configured
pi@raspberrypi:~$ sudo ifup usb0
pi@raspberrypi:~$ ifconfig usb0
usb0      Link encap:Ethernet HWaddr de:bb:0c:8b:b4:f9
          inet addr:192.168.7.2 Bcast:192.168.7.255 Mask:255.255.255.0
          inet6 addr: fe80::4306:c050:a099:d4af/64 Scope:Link
          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)

pi@raspberrypi:~$
```

Now on your **computer** you'll need to set it up as well.

If you are using a Mac as the Host Computer

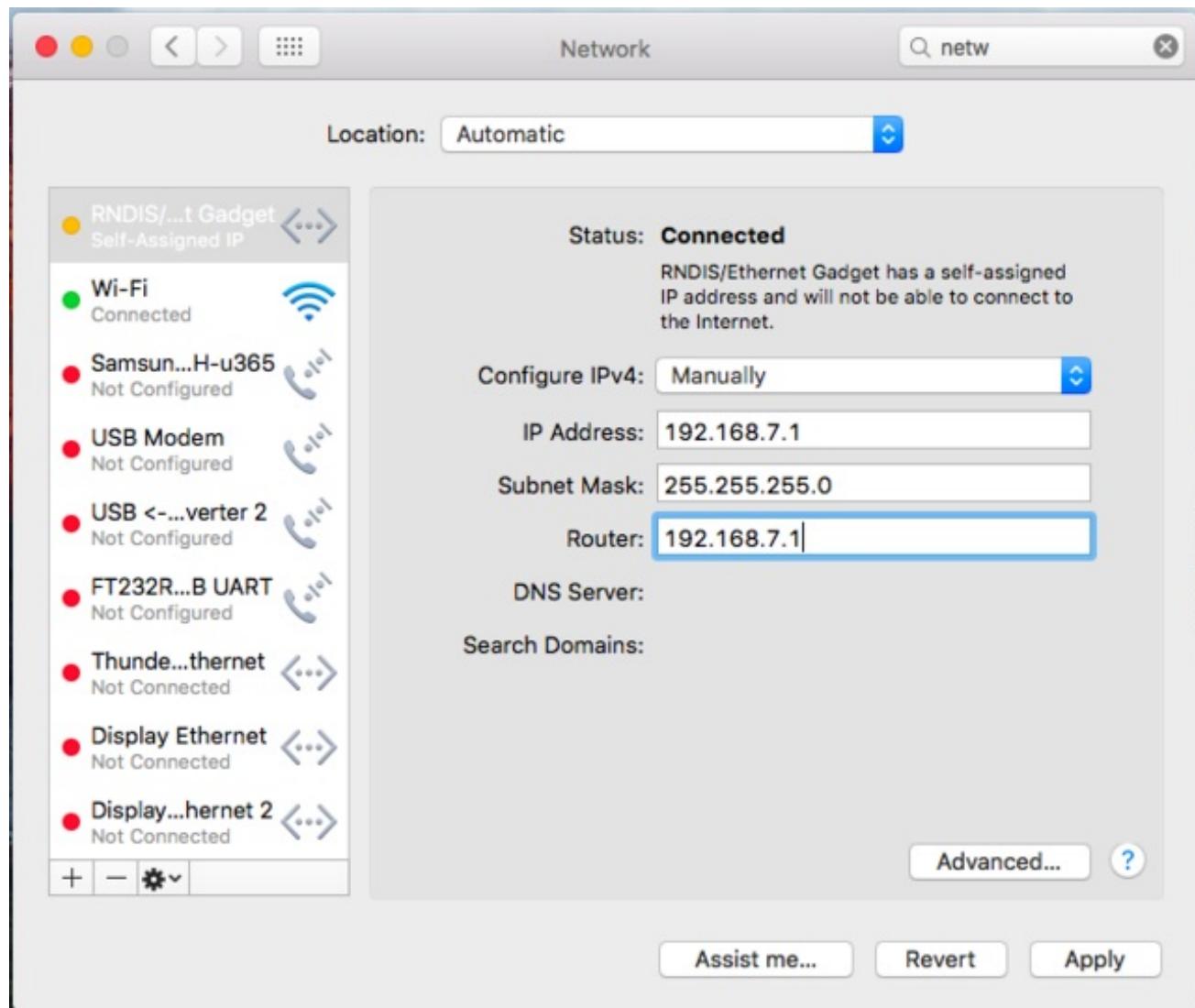
On a Mac OS X machine, open up the **System Preferences -> Network** box.



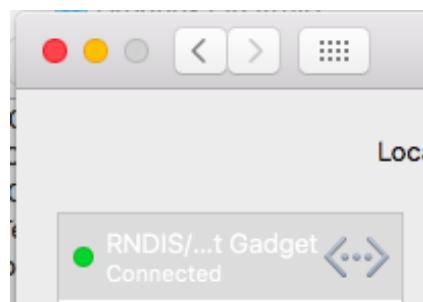
You'll see the device show up as an RNDIS/Ethernet Gadget. it'll probably be set up for DHCP by default so change it to **Configure IP4 Manually**

- For the IP address pick **192.168.7.1** (note that this is not the same as the Pi Zero's address!)
- For the subnet mask, use **255.255.255.0** (same as Pi)
- For the router/gateway use **192.168.7.1** (same as Pi)

If you didn't use our suggested netconfig above on the Pi, you may have to adjust this one to match



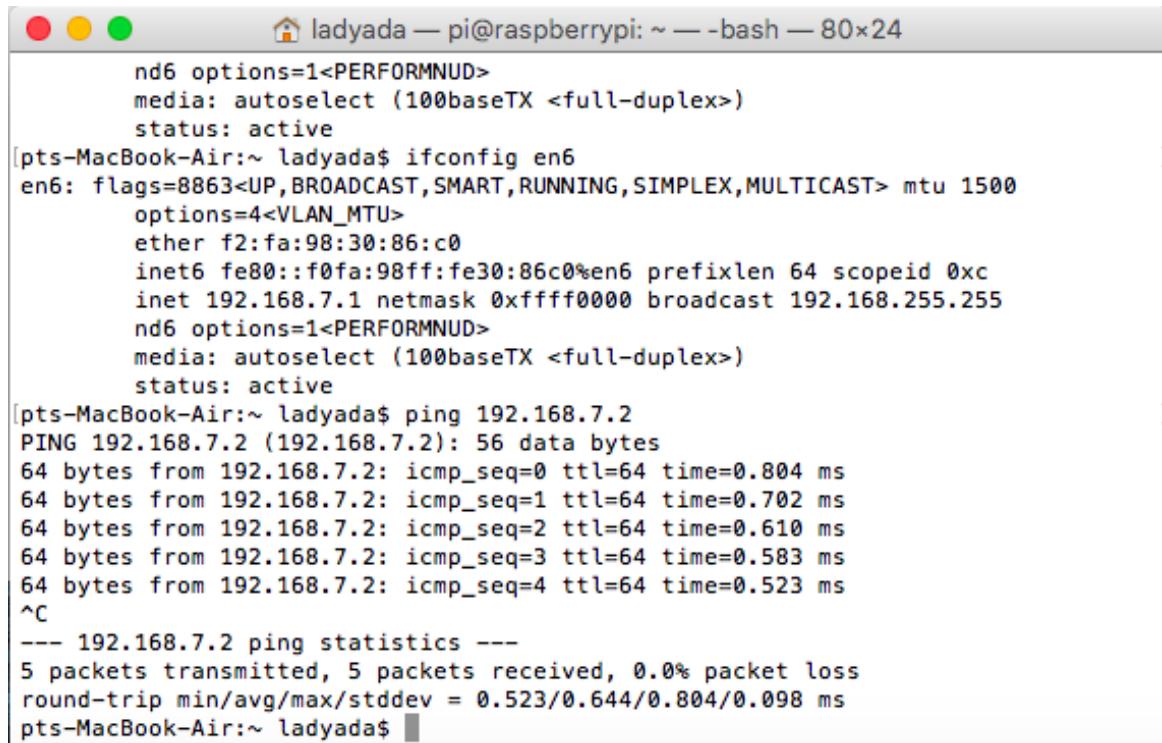
Click **Apply** when done, and wait a minute or so.



You can use a terminal on the computer to check the IP address was set, your device will be called **enX** where X is some number, use **ifconfig -a** to see a list of all devices, chances are the Pi is the last one.

Once you can see that the IP address is set, try pinging the pi with

- ping 192.168.7.2



```
ladyada — pi@raspberrypi: ~ — -bash — 80x24
nd6 options=1<PERFORMNUD>
media: autoselect (100baseTX <full-duplex>)
status: active
[pts-MacBook-Air:~ ladyada$ ifconfig en6
en6: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
    options=4<VLAN_MTU>
    ether f2:fa:98:30:86:c0
    inet6 fe80::f0fa:98ff:fe30:86c0%en6 prefixlen 64 scopeid 0xc
        inet 192.168.7.1 netmask 0xffff0000 broadcast 192.168.255.255
    nd6 options=1<PERFORMNUD>
    media: autoselect (100baseTX <full-duplex>)
    status: active
[pts-MacBook-Air:~ ladyada$ ping 192.168.7.2
PING 192.168.7.2 (192.168.7.2): 56 data bytes
64 bytes from 192.168.7.2: icmp_seq=0 ttl=64 time=0.804 ms
64 bytes from 192.168.7.2: icmp_seq=1 ttl=64 time=0.702 ms
64 bytes from 192.168.7.2: icmp_seq=2 ttl=64 time=0.610 ms
64 bytes from 192.168.7.2: icmp_seq=3 ttl=64 time=0.583 ms
64 bytes from 192.168.7.2: icmp_seq=4 ttl=64 time=0.523 ms
^C
--- 192.168.7.2 ping statistics ---
5 packets transmitted, 5 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 0.523/0.644/0.804/0.098 ms
pts-MacBook-Air:~ ladyada$
```

To be honest, I rebooted the Pi after setting up the network config file, so if it doesn't work at first, try that.

Next up you can ssh into your pi from your Mac!

- ssh pi@192.168.7.1

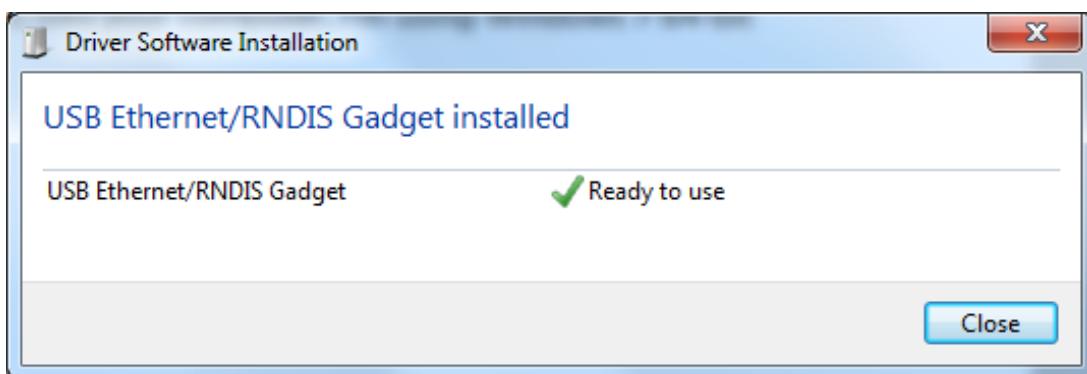
```
ladyada — pi@raspberrypi: ~ — ssh pi@192.168.7.2 — 80x24
64 bytes from 192.168.7.2: icmp_seq=115 ttl=64 time=0.607 ms
64 bytes from 192.168.7.2: icmp_seq=116 ttl=64 time=0.535 ms
64 bytes from 192.168.7.2: icmp_seq=117 ttl=64 time=0.590 ms
64 bytes from 192.168.7.2: icmp_seq=118 ttl=64 time=0.612 ms
64 bytes from 192.168.7.2: icmp_seq=119 ttl=64 time=0.547 ms
^C
--- 192.168.7.2 ping statistics ---
120 packets transmitted, 119 packets received, 0.8% packet loss
round-trip min/avg/max/stddev = 0.435/8.955/996.622/90.922 ms
[pts-MacBook-Air:~ ladyada$ ssh pi@192.168.7.2
The authenticity of host '192.168.7.2 (192.168.7.2)' can't be established.
ECDSA key fingerprint is SHA256:gFkMFfWcI607SRFvkxxy6pa0+gq3wd6wJ/vrebsPegM.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '192.168.7.2' (ECDSA) to the list of known hosts.
[pi@192.168.7.2'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.

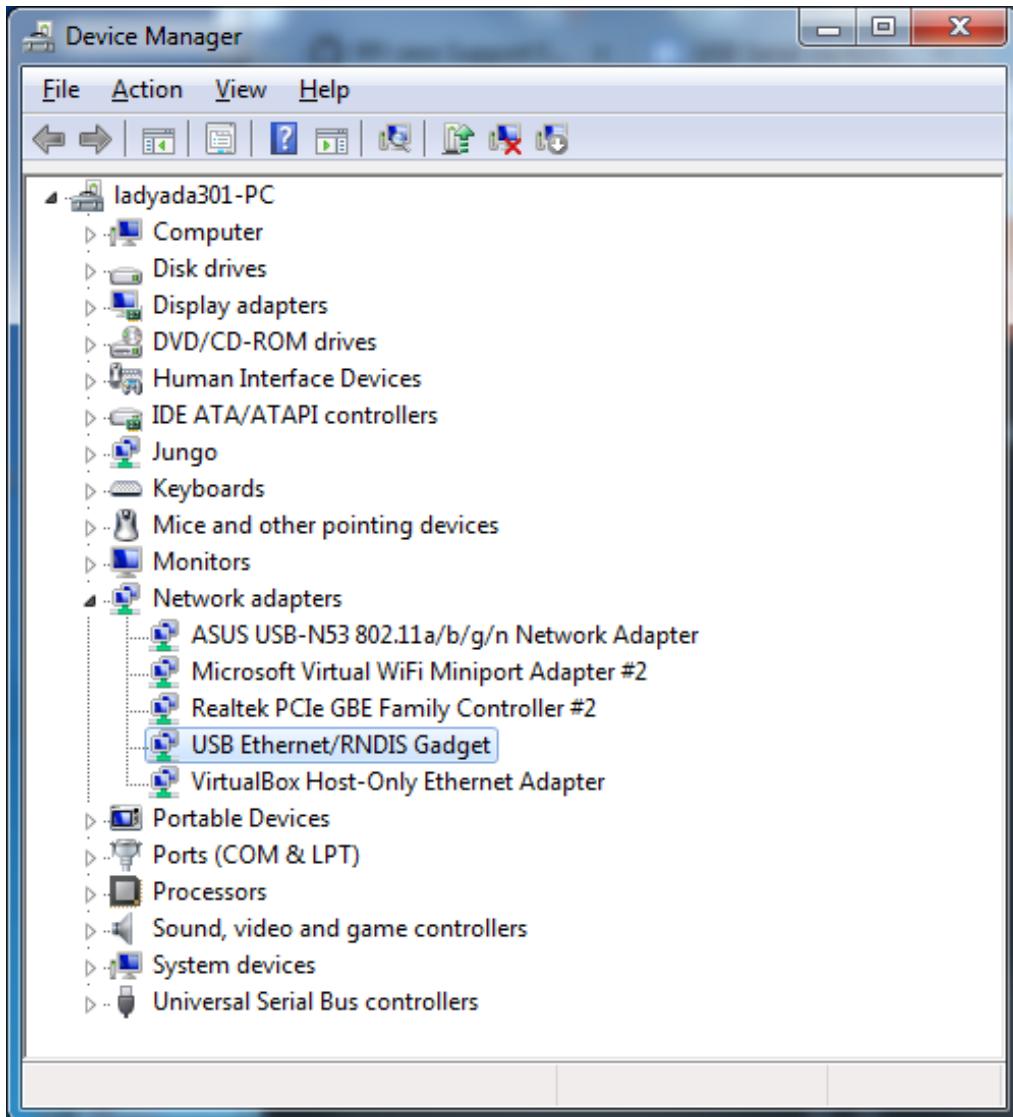
Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Sat Nov 21 22:18:07 2015
pi@raspberrypi:~ $ ]
```

If you are using Windows as the Host Machine

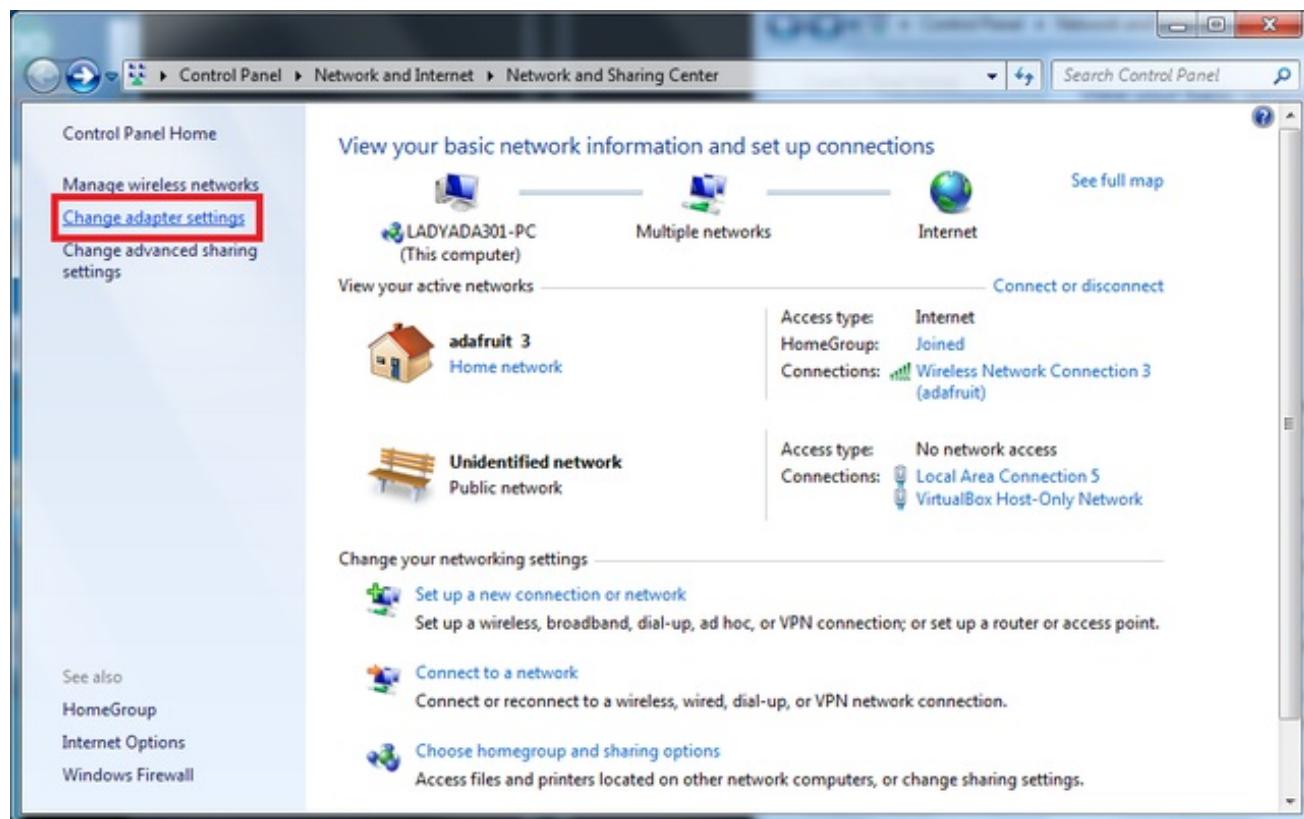
Plug in the Pi Zero into your computer, I'm using Windows 7 64-bit. It will automatically download and install the RNDIS Ethernet drivers



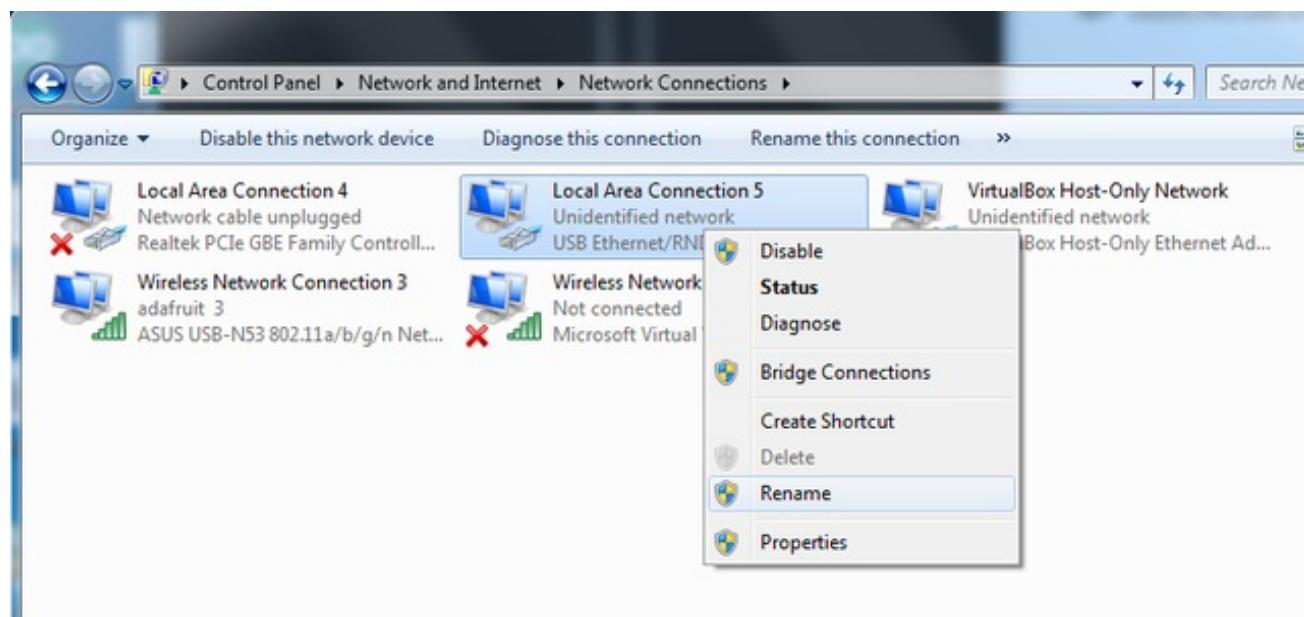
Check the Device Manager to check that it is a new network adapter



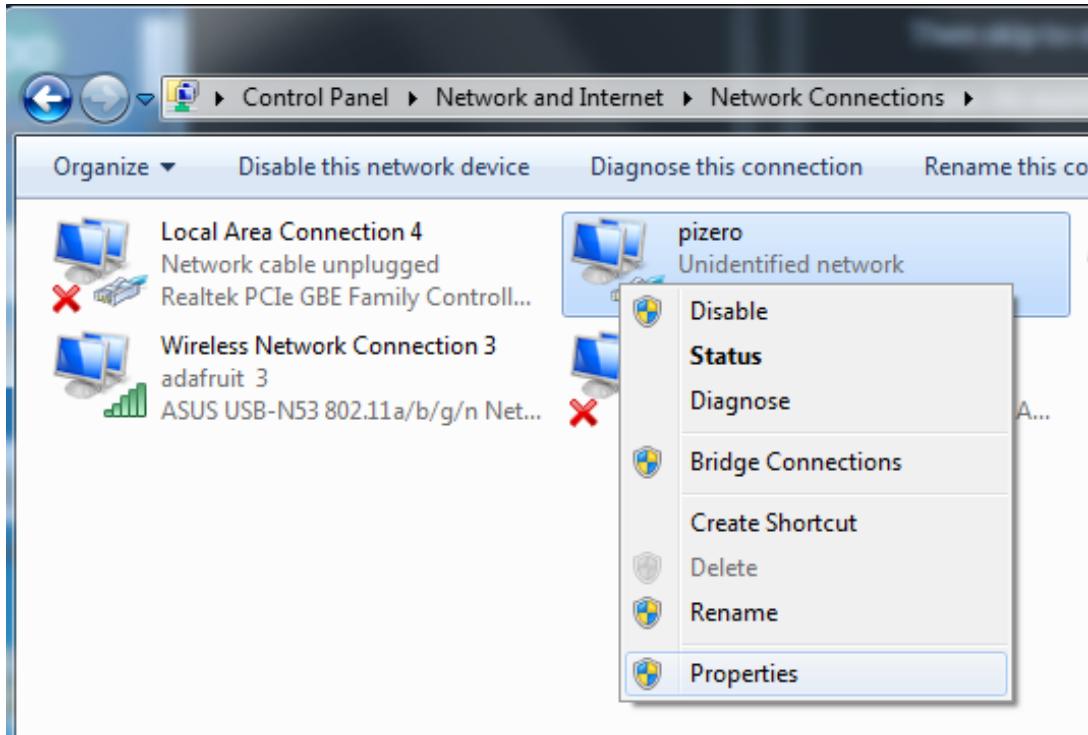
Open up **Network and Sharing Center** and click on **Change Adapter Settings**



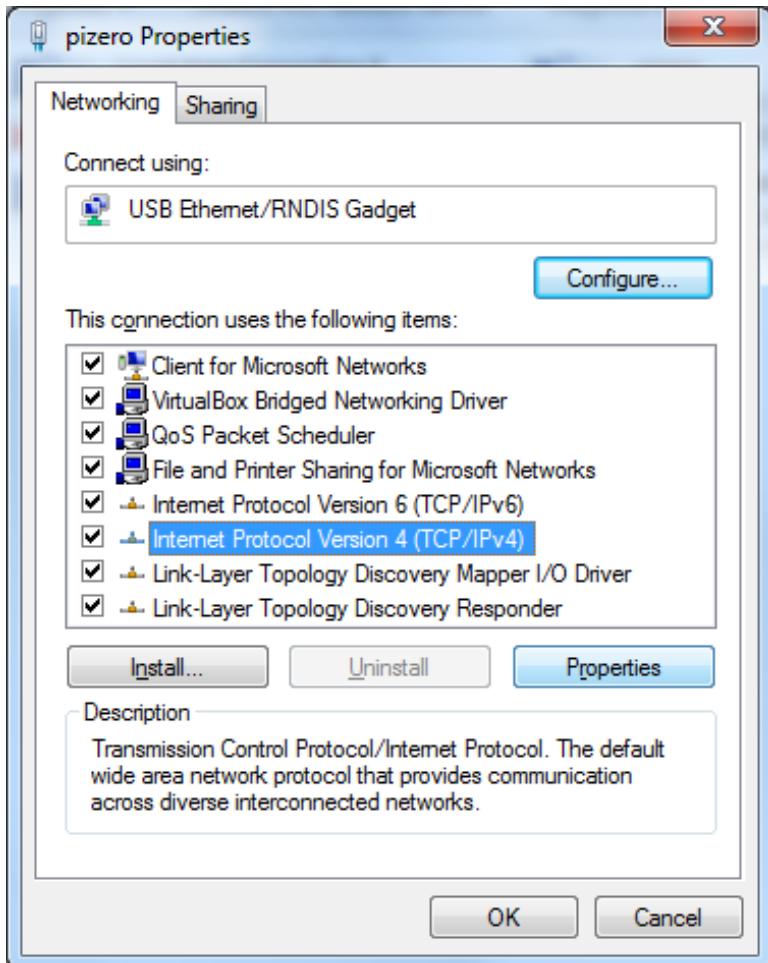
You'll see a list of all the myriad adapters you have. I have a lot but you'll likely only have 2 or 3. Find the RNDIS adapter and rename it **pizero** (makes it easier to find)



Then right-click and select **Properties...**

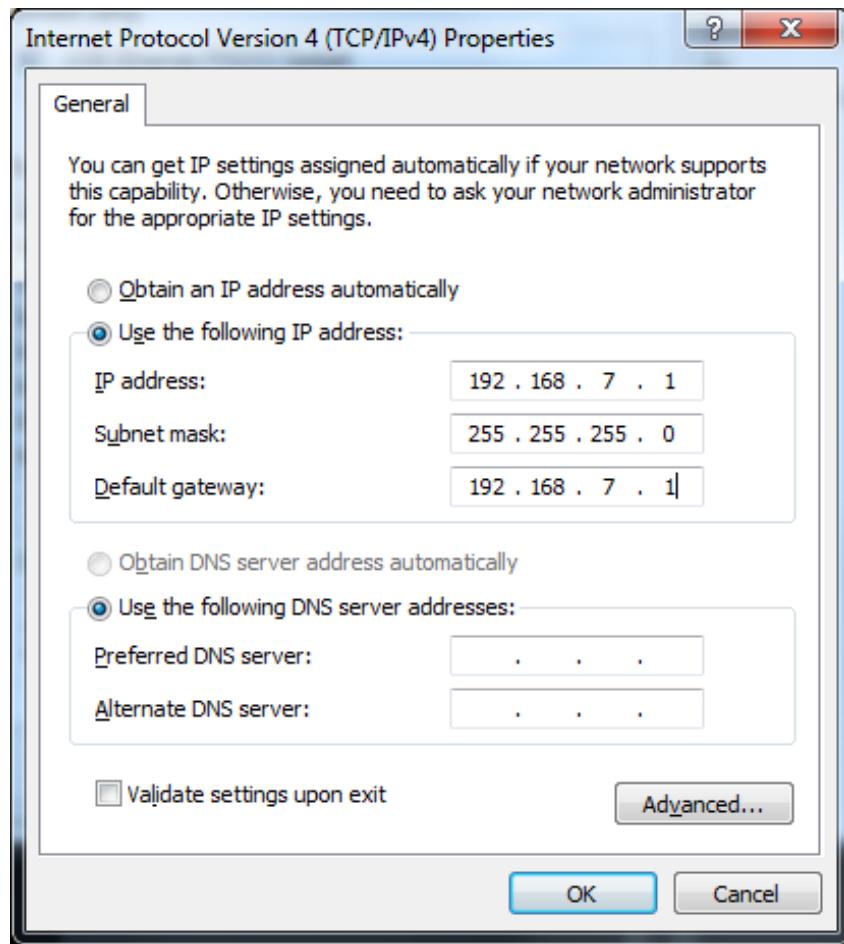


And select the **Internet Protocol Version 4 (TCP/IPv4)** from the connection list and click **Properties**

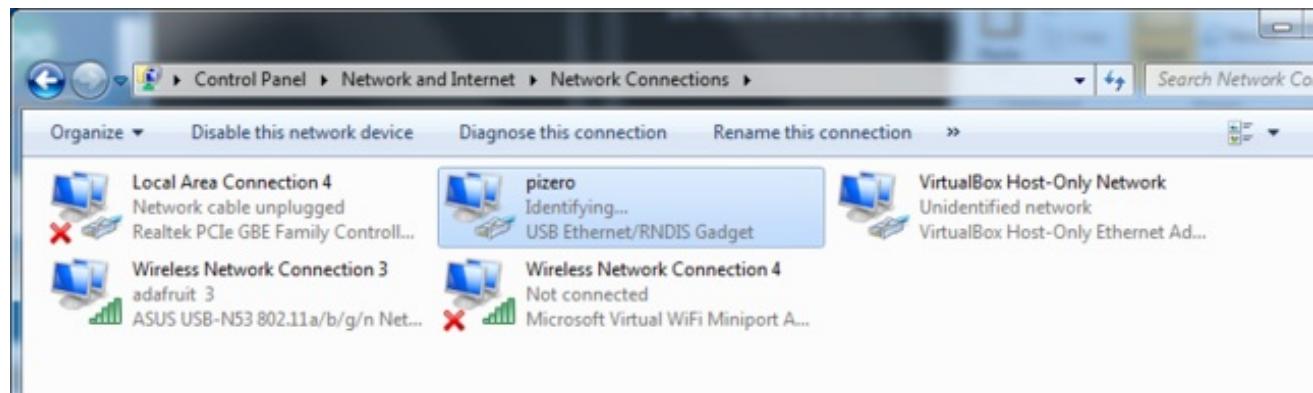


Enter in **192.168.7.1** as the computer's IP address and gateway (the gateway got erased later, I think Windows just automatically uses the IP address if they're the same) the subnet mask is **255.255.255.0** same as the Pi's

There's no DNS address



I unplugged & replugged in the Pi Zero, Windows will then identify the network.





Now you can use a command box to run **ipconfig /all** if you want to check out the stats on the connection

```
C:\Users\ladyada\Desktop\shared>ipconfig /all
Windows IP Configuration

Host Name . . . . . : ladyada301-PC
Primary Dns Suffix . . . . . :
Node Type . . . . . : Hybrid
IP Routing Enabled . . . . . : No
WINS Proxy Enabled . . . . . : No
DNS Suffix Search List. . . . . : fios-router.home

Ethernet adapter pizero:

Connection-specific DNS Suffix . . . . . :
Description . . . . . : USB Ethernet/RNDIS Gadget
Physical Address. . . . . : AE-E2-D8-52-92-11
DHCP Enabled. . . . . : No
Autoconfiguration Enabled . . . . . : Yes
Link-local IPv6 Address . . . . . : fe80::1160:2ef:e097:c2c7%56(Preferred)
IPv4 Address. . . . . : 192.168.7.1(Preferred)
Subnet Mask . . . . . : 255.255.255.0
Default Gateway . . . . . : 0.0.0.0
DHCPv6 IAID . . . . . : 950985432
DHCPv6 Client DUID. . . . . : 00-01-00-01-17-BD-FD-BC-80-EE-73-36-FC-61

DNS Servers . . . . . : fec0:0:0:ffff::1%1
                         fec0:0:0:ffff::2%1
                         fec0:0:0:ffff::3%1
NetBIOS over Tcpip. . . . . : Enabled

Ethernet adapter Local Area Connection 4:

Media State . . . . . : Media disconnected
Connection-specific DNS Suffix . . . . . :
```

and ping 192.168.7.2 (the pi)

```
MHV AVR Tools 20121007
DHCP Enabled . . . . : No
Autoconfiguration Enabled . . . . : Yes

C:\Users\ladyada\Desktop\shared>ping 192.168.7.1

Pinging 192.168.7.1 with 32 bytes of data:
Reply from 192.168.7.1: bytes=32 time<1ms TTL=128

Ping statistics for 192.168.7.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\ladyada\Desktop\shared>
```

and even **ssh**!

```
^C
MHV AVR Tools 20121007 - ssh pi@192.168.7.2
C:\Users\ladyada\Desktop\shared>ping 192.168.7.2

Pinging 192.168.7.2 with 32 bytes of data:
Reply from 192.168.7.2: bytes=32 time<1ms TTL=64
Reply from 192.168.7.2: bytes=32 time<1ms TTL=64

Ping statistics for 192.168.7.2:
    Packets: Sent = 2, Received = 2, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms
Control-C
^C
C:\Users\ladyada\Desktop\shared>ssh pi@192.168.7.2
The authenticity of host '192.168.7.2 (192.168.7.2)' can't be established.
ECDSA key fingerprint is 22:1f:a4:76:55:56:a1:c4:82:c1:13:ec:5d:26:20:58.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '192.168.7.2' (ECDSA) to the list of known hosts.
pi@192.168.7.2'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 Nov 21 22:22:16 2015 from 192.168.7.1
pi@raspberrypi:~ $ _
```

Ethernet Tweaks

Using mDNS/Bonjour Naming

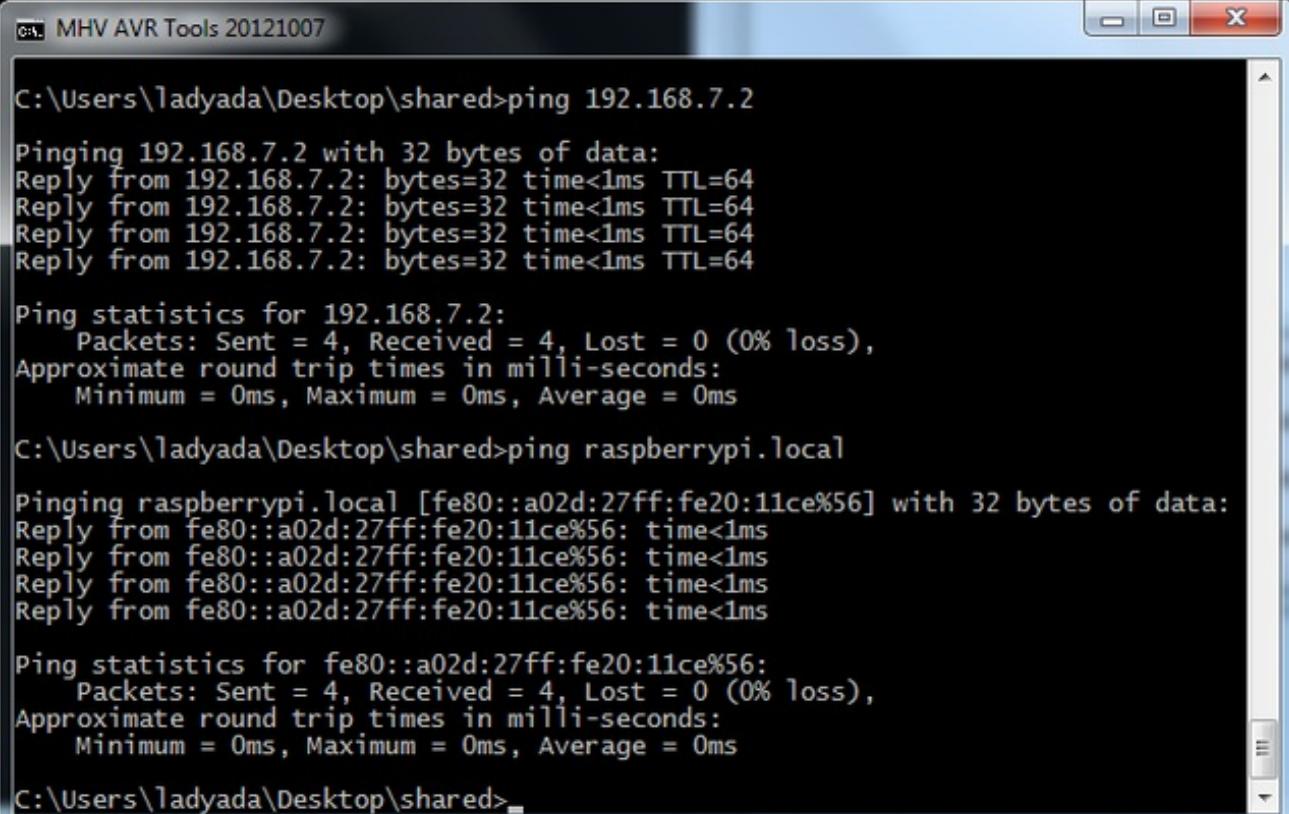
If you don't want to have to remember your Pi's IP address, you don't have to! Jessie Lite includes and automatically enables **avahi** which lets you use names like **raspberrypi.local**

If for some reason its not activated, we have a full tutorial that will help you get set up.
(<http://adafru.it/khB>)

Don't forget, Windows doesn't have native Bonjour support, so download & install Bonjour Print Services!

(check the tutorial above for a link on where/how to install, you only have to do it once)

So, after you get ping'ing working...try **ping raspberrypi.local**



```
C:\Users\ladyada\Desktop\shared>ping 192.168.7.2
Pinging 192.168.7.2 with 32 bytes of data:
Reply from 192.168.7.2: bytes=32 time<1ms TTL=64

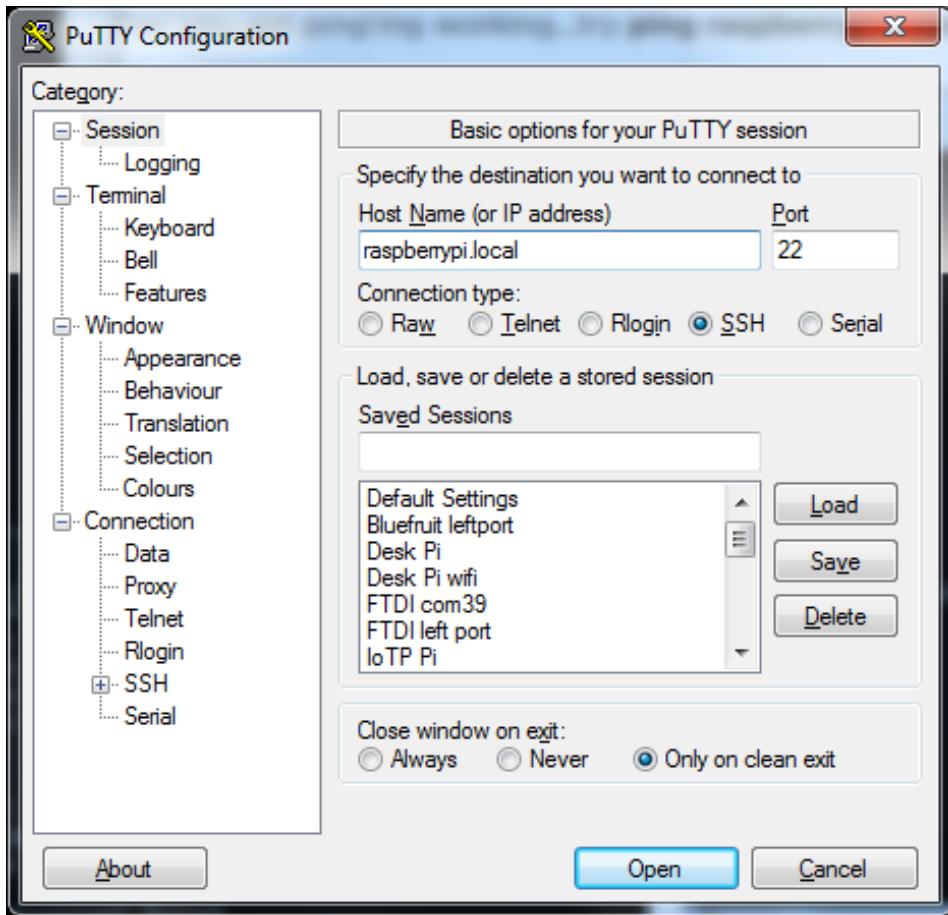
Ping statistics for 192.168.7.2:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\ladyada\Desktop\shared>ping raspberrypi.local
Pinging raspberrypi.local [fe80::a02d:27ff:fe20:11ce%56] with 32 bytes of data:
Reply from fe80::a02d:27ff:fe20:11ce%56: time<1ms
Reply from fe80::a02d:27ff:fe20:11ce%56: time<1ms
Reply from fe80::a02d:27ff:fe20:11ce%56: time<1ms
Reply from fe80::a02d:27ff:fe20:11ce%56: time<1ms

Ping statistics for fe80::a02d:27ff:fe20:11ce%56:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms

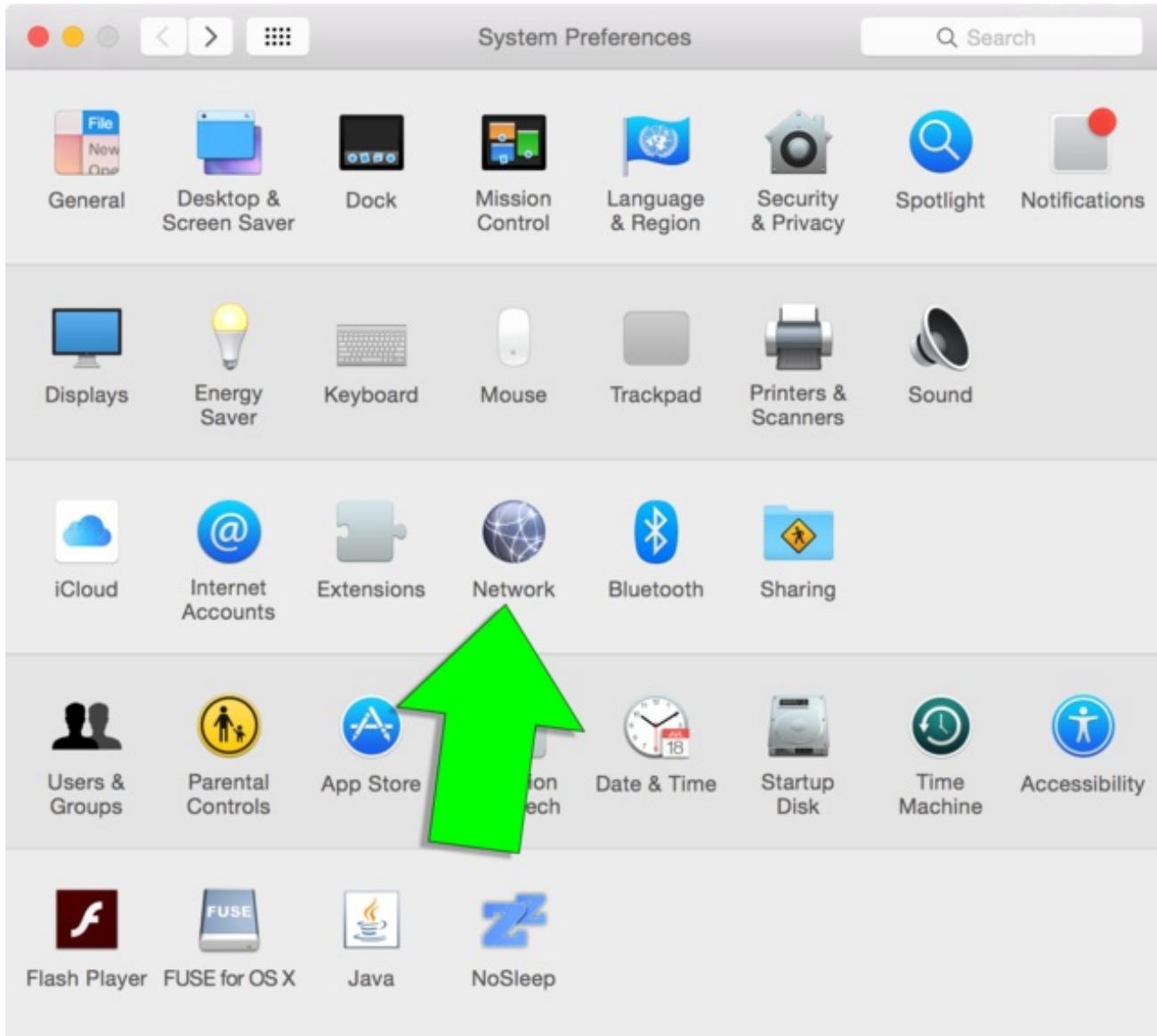
C:\Users\ladyada\Desktop\shared>
```

Or for ssh, it's also perfectly fine:

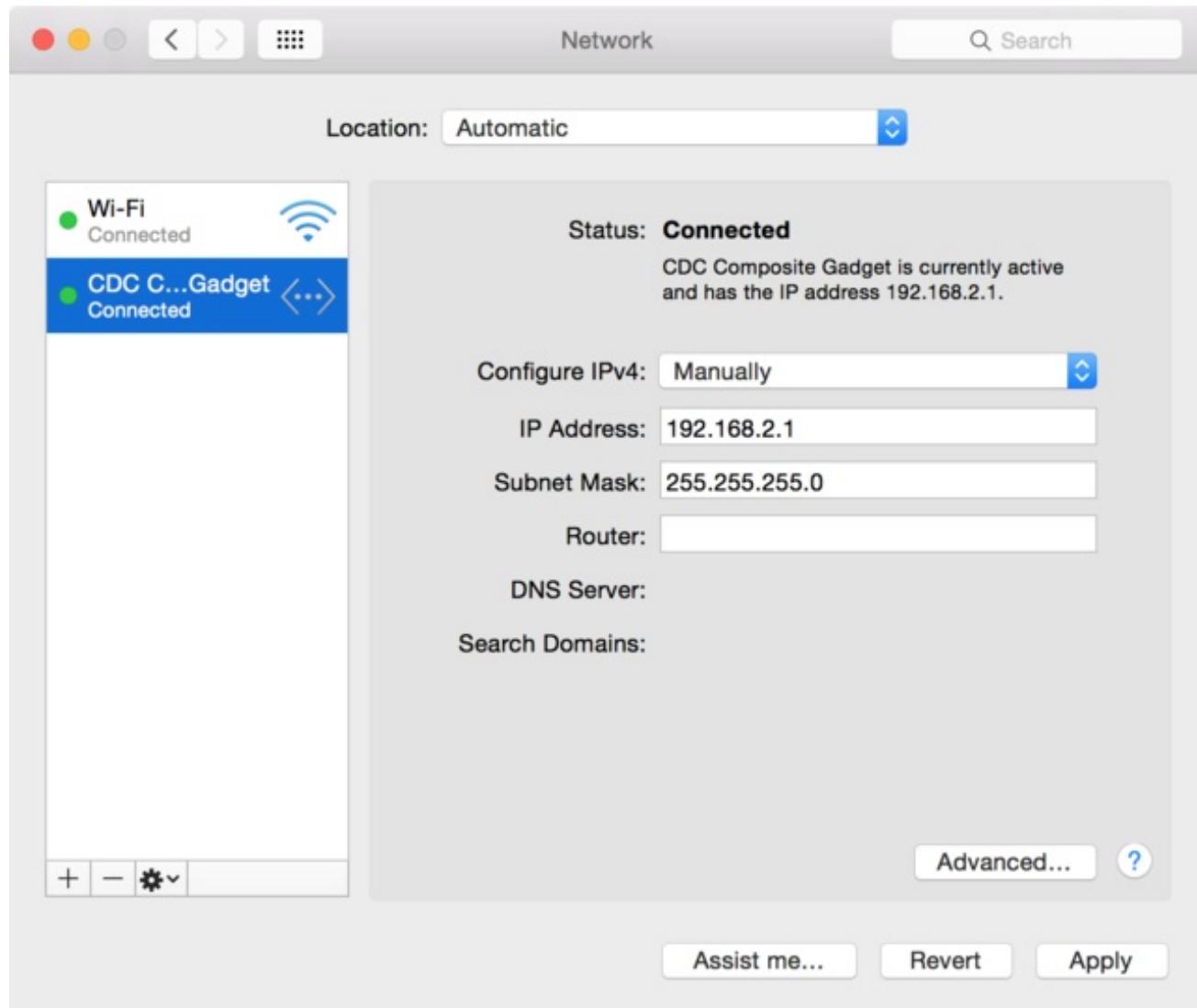


Sharing Network Access to Your Pi

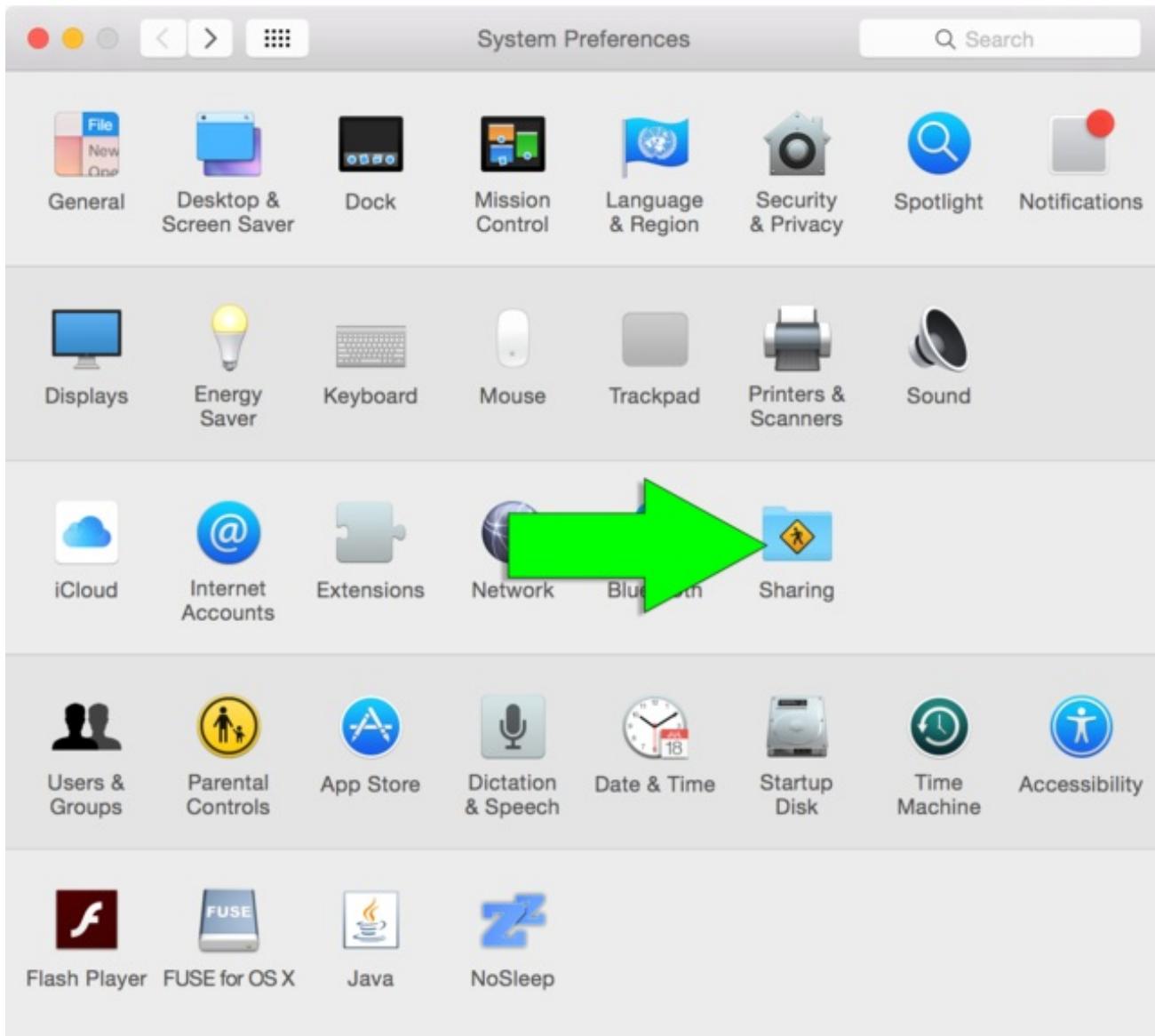
On OS X, open the **Network** tab of System Preferences.



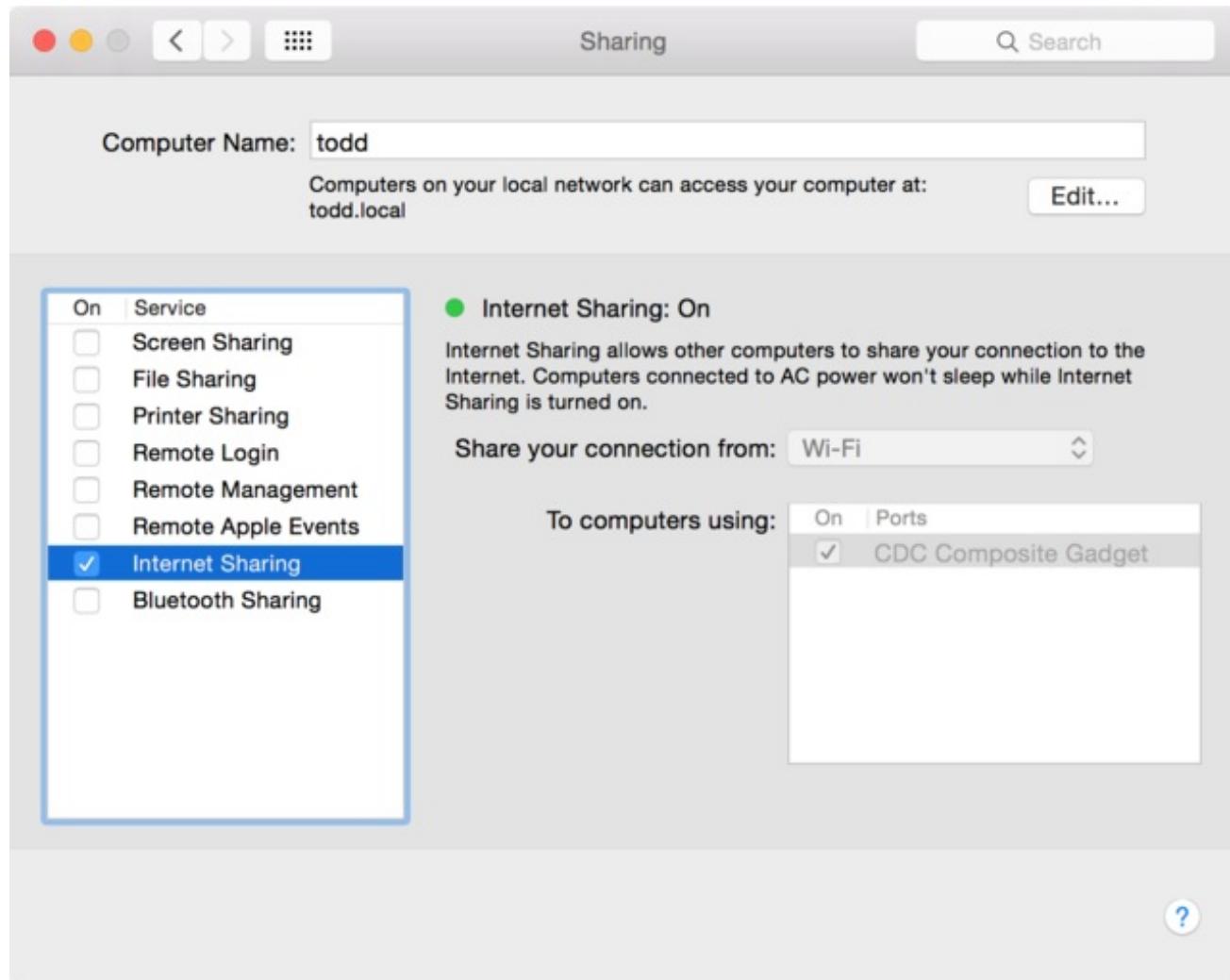
Select the existing **CDC** or **RNDIS** USB connection to your Raspberry Pi by selecting **Manually** from the *Configure IPv4* menu. Use **192.168.2.1** for the *IP Address*, and **255.255.255.0** for the *Subnet Mask*. Click **Apply** to save your changes.



Then, open the **Sharing** tab in System Preferences.



Turn on **Internet Sharing** to share your existing internet connection from Wi-Fi or ethernet with the **CDC** or **RNDIS** Raspberry Pi connection.



Edit your /etc/network/interfaces file on your Pi to match the one below.

```
# interfaces(5) file used by ifup(8) and ifdown(8)

# Please note that this file is written to be used with dhcpcd
# For static IP, consult /etc/dhcpcd.conf and 'man dhcpcd.conf'

# Include files from /etc/network/interfaces.d:
source-directory /etc/network/interfaces.d

auto lo usb0
iface lo inet loopback

iface eth0 inet manual

allow-hotplug wlan0
iface wlan0 inet manual
    wpa-conf /etc/wpa_supplicant/wpa_supplicant.conf

allow-hotplug wlan1
iface wlan1 inet manual
    wpa-conf /etc/wpa_supplicant/wpa_supplicant.conf

allow-hotplug usb0
iface usb0 inet manual
```

The important lines are:

```
auto lo usb0
```

and also:

```
allow-hotplug usb0
iface usb0 inet manual
```

Restart your Pi using **sudo reboot**, and SSH back in to it using **ssh pi@raspberrypi.local**. You can then attempt to **ping google.com**.

```
$ ping -c 5 google.com
PING google.com (216.58.219.238): 56 data bytes
64 bytes from 216.58.219.238: icmp_seq=0 ttl=55 time=20.975 ms
64 bytes from 216.58.219.238: icmp_seq=1 ttl=55 time=20.904 ms
64 bytes from 216.58.219.238: icmp_seq=2 ttl=55 time=20.646 ms
64 bytes from 216.58.219.238: icmp_seq=3 ttl=55 time=20.401 ms
64 bytes from 216.58.219.238: icmp_seq=4 ttl=55 time=20.379 ms

--- google.com ping statistics ---
5 packets transmitted, 5 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 20.379/20.661/20.975/0.247 ms
```

Other Modules!

Serial and Ethernet are the easiest to get going but they are far from the *only* gadgets the Linux kernel supports. You can also try such options as:

- **Mass storage** (you can have the Pi appear as a 'USB key' disk drive) - note, we didn't get this up and running smoothly, it enumerated but disk access to the backing file didn't work on our windows machine
- **MIDI** - shows up as a 'native' USB CDC MIDI device
- **HID** - appear to the host computer as a mouse/keyboard/joystick
- **Audio** - Show up as an audio/speaker device & line in as well?
- **Composite** - a mix of serial/ethernet/mass storage composite devices is available. Note that this may work on a Mac or Linux but for windows you'd need a custom driver
- **Printer, webcam, etc** - There's about a dozen more options

For more details, check out the [USB gadget API framework page](http://adafru.it/klc) (<http://adafru.it/klc>)

Sunxi also has a handy page (<http://adafru.it/kld>)

We compiled all of the available USB gadget modules into the December 25, 2015 (or later) kernel tgz. You can enable them by using **modprobe** or editing the **/etc/modules** file to enable. If they need options, creating a new file for those options in **/etc/modprobe.d/usbgadget.conf** or similar

In particular, here's the modules that are available:

```
#  
# USB Peripheral Controller  
#  
# CONFIG_USB_FUSB300 is not set  
# CONFIG_USB_FOTG210_UDC is not set  
# CONFIG_USB_GR_UDC is not set  
# CONFIG_USB_R8A66597 is not set  
# CONFIG_USB_PXA27X is not set  
# CONFIG_USB_MV_UDC is not set  
# CONFIG_USB_MV_U3D is not set  
# CONFIG_USB_M66592 is not set  
# CONFIG_USB_BDC_UDC is not set  
# CONFIG_USB_NET2272 is not set  
# CONFIG_USB_GADGET_XILINX is not set  
# CONFIG_USB_DUMMY_HCD is not set  
CONFIG_USB_LIBCOMPOSITE=m  
CONFIG_USB_F_ACm=m  
CONFIG_USB_F_SS_LB=m  
CONFIG_USB_U_SERIAL=m  
CONFIG_USB_U_ETHERP=m
```

```
CONFIG_USB_U_ETHER=m
CONFIG_USB_F_SERIAL=m
CONFIG_USB_F_OBEX=m
CONFIG_USB_F_NCM=m
CONFIG_USB_F_ECM=m
CONFIG_USB_F_EEM=m
CONFIG_USB_F_SUBSET=m
CONFIG_USB_F_RNDIS=m
CONFIG_USB_F_MASS_STORAGE=m
CONFIG_USB_F_FS=m
CONFIG_USB_F_UAC1=m
CONFIG_USB_F_UAC2=m
CONFIG_USB_F_UVC=m
CONFIG_USB_F_MIDI=m
CONFIG_USB_F_HID=m
CONFIG_USB_F_PRINTER=m
CONFIG_USB_CONFIGFS=m
CONFIG_USB_CONFIGFS_SERIAL=y
CONFIG_USB_CONFIGFS_ACM=y
CONFIG_USB_CONFIGFS_OBEX=y
CONFIG_USB_CONFIGFS_NCM=y
CONFIG_USB_CONFIGFS_ECM=y
CONFIG_USB_CONFIGFS_ECM_SUBSET=y
CONFIG_USB_CONFIGFS_RNDIS=y
CONFIG_USB_CONFIGFS_EEM=y
CONFIG_USB_CONFIGFS_MASS_STORAGE=y
CONFIG_USB_CONFIGFS_F_LB_SS=y
CONFIG_USB_CONFIGFS_F_FS=y
CONFIG_USB_CONFIGFS_F_UAC1=y
CONFIG_USB_CONFIGFS_F_UAC2=y
CONFIG_USB_CONFIGFS_F_MIDI=y
CONFIG_USB_CONFIGFS_F_HID=y
CONFIG_USB_CONFIGFS_F_UVC=y
CONFIG_USB_CONFIGFS_F_PRINTER=y
CONFIG_USB_ZERO=m
CONFIG_USB_AUDIO=m
# CONFIG_GADGET_UAC1 is not set
CONFIG_USB_ETH=m
CONFIG_USB_ETH_RNDIS=y
CONFIG_USB_ETH_EEM=y
# CONFIG_USB_G_NCM is not set
CONFIG_USB_GADGETFS=m
CONFIG_USB_FUNCTIONFS=m
CONFIG_USB_FUNCTIONFS_ETH=y
CONFIG_USB_FUNCTIONFS_RNDIS=y
CONFIG_USB_FUNCTIONFS_GENERIC=y
CONFIG_USB_MASS_STORAGE=m
```

```
CONFIG_USB_G_SERIAL=m
CONFIG_USB_MIDI_GADGET=m
CONFIG_USB_G_PRINTER=m
CONFIG_USB_CDC_COMPOSITE=m
CONFIG_USB_G_ACm_MS=m
CONFIG_USB_G_MULTI=m
CONFIG_USB_G_MULTI_RNDIS=y
CONFIG_USB_G_MULTI_CDC=y
CONFIG_USB_G_HID=m
CONFIG_USB_G_DBGP=m
# CONFIG_USB_G_DBGP_PRINTK is not set
CONFIG_USB_G_DBGP_SERIAL=y
CONFIG_USB_G_WEBcAM=m
# CONFIG_USB_LED_TRIG is not set
# CONFIG_UWB is not set
CONFIG_MMc=y
# CONFIG_MMc_DEBUG is not set
```

Compiling your own kernel? Here's the
v4.4 .config we used

<http://adafru.it/kle>

You'll also have to patch the 'common' rpi overlay as shown here (<http://adafru.it/khf>)