OS - Phidget SBC

On the Single Board Computer (SBC), Phidgets can be either plugged directly into one of the USB ports or run over a network using the WebService.

Quick Downloads

Unlike our other supported operating systems, the SBC **does not require downloads** unless you are doing something advanced like loading the firmware or developing your own kernel. You will know if you need these downloads, otherwise, the SBC should work as described on the SBC2 Getting Started Guide right out of the box.

- SBC2 Firmware [1]
- SBC2 Kernel Development Package [2] (How-to and patch file)
- Software License
- SBC3 Firmware [3]
- SBC3 Kernel Development Package [4]

Note that, instead of using the firmware to update your SBC, updates should normally be done via the System -> Packages page on your SBC2 web interface. It is rarely necessary to completely re-flash your device.

Getting Started with the Phidget SBC Debian Linux

The Single Board Computer (SBC) is a unique Phidget. It is a computer with a Linux operating system. It can compile code, save files, manage background jobs, host information over the web, and more.

If this is your first time using the Phidget SBC, you will want to start with the Getting Started Guide for the SBC. After that, here we will get you started on topics beyond those in the getting started guide, including how to write Phidget code to run on the SBC. You **do not need this page** if you are simply using the SBC to broadcast data from Phidgets over the network - it does that automatically. We describe how to verify and use this in the Getting Started Guide.

This page will show you how to:

- Install the ability to write and develop code on the SBC itself
- Use the command line for basic coding tasks
- Troubleshoot the SBC's network

It will also give additional specifications, which are useful for doing more advanced things with the SBC hardware and software.

Before reading this page, you should have done the following via the Getting Started Guide:

- Set up networking on your SBC, via either Ethernet or wireless
- Set up an admin password
- Learned the IP address or link local address of the SBC

We will use this information in setting up the libraries and drivers to use the SBC for writing and running code.

Conceivably, you could simply use the SBC like any Linux computer, and do all of your development and compiling of Phidget code on the SBC itself. In practice this gets complicated as the SBC does not have a keyboard or screen. So usually, you will want to develop your code an external computer and copy files and settings over to the SBC via a network. This makes this Getting Started section unique, in that we show you how to set up both computers:

- Your External Development Computer, usually your main desktop or laptop which will transfer files and settings to and from the SBC

- The SBC itself, which needs programming language libraries to use Phidgets.

Getting Started - External Computer

You have two ways to connect to the SBC from an external computer: via the SBC Web Interface and over the more powerful but complex Secure Shell (SSH).

SBC Web Interface

You have already worked extensively with the web interface in the Getting Started Guide for the SBC. This was the tool within a web browser which was opened either via the Phidget Control Panel on Windows, or by simply entering the IP or link local address into an internet browser. It allowed you to set the password, set up internet connectivity, and so on.

This section doesn't have more information on the interface; rather, it simply serves as a reminder that you have the web interface as an available tool. Examples, including screenshots, are placed where appropriate in this document. The web interface will probably stay your initial go-to way to connect to the SBC, especially for tasks that benefit from graphical interaction, like setting up wireless or using the webcam.

SSH

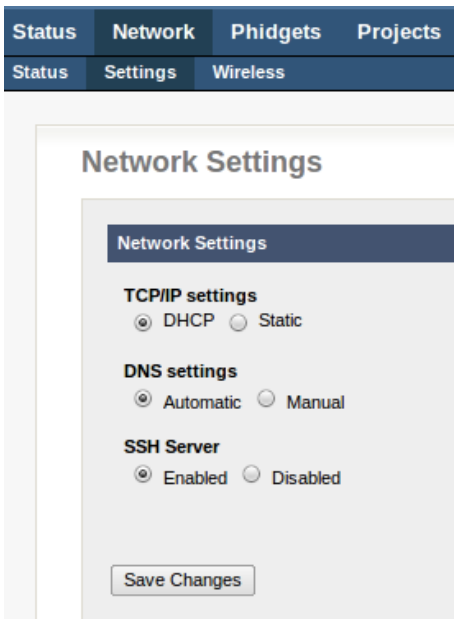
The most flexible way to transfer files and commands to and from the SBC is via a program called **ssh**. The ssh program provides command line text access over a network into the SBC. Using it, you can run programs and give the SBC commands. The ssh program has a companion program called **scp** which can copy files back and forth. If you are unfamiliar with ssh, you can think of it like the command line or a Mac terminal, but with a remote connection to a different computer. It is a minimal yet effective way to interact with a remote computer.

Before connecting over ssh, you will need:

- The **IP address** (such as 168.254.3.0) or **link local address** (such as phidgetsbc.local) of the SBC
- The **admin password** for the SBC

Both of these items can be found by following the steps in the Getting Started Guide for the SBC.

You will also need to enable SSH on the SBC side. This can be done through the Web Interface, under `Network` → `Settings`, by changing the *SSH Server* radio button to *Enabled* and saving your changes:



SSH on Windows

The ssh program is not installed on Windows by default. But, there are a variety of SSH programs available for free. One simple and commonly used program is PuTTY [5], and it has the advantage that the executable doesn't need to install, it just runs.

With PuTTY, when you first run the program it will ask you what to connect to. Enter the IP address or link local address of the SBC, and then click the SSH radio button right below the address, which will change the port to 22. Then click open, and you'll have an ssh connection to the SBC open in a terminal. It will prompt you for a user name (`root`) and password (the admin password).

To copy files back and forth, there is an SCP component to PuTTY, called PSCP, which is available from the same PuTTY download page [5]. Use of PSCP will be similar with the address, username, and password, except that you will be transferring files instead of sending commands.

SSH on Linux and Mac OS

Linux and Mac OS already have ssh installed by default. To run ssh simply open a terminal...

- `Ctrl-Alt-T` on Linux
- `Applications` → `Utilities` → `Terminal` on Mac OS

...and type:

```
ssh root@phidgetsbc.local
```

If you have re-named your SBC, include that name instead of the `phidgetsbc.local` link address. Or, you can use the SBC's IP address, e.g. something like `ssh root@168.254.3.0`

To copy files back and forth, the command follows the form of: `scp from to`

So, to copy a file `/root/data.txt` from the SBC to your local machine, type:

```
scp root@phidgetsbc.local:/root/data.txt .
```

Note the use of the dot **.** to indicate that scp should put the file in the current local directory. If you're not sure what folder the terminal is operating in type `pwd` to print the working directory. Terminals usually start by default in your home folder.

Getting Started - The SBC (Debian Linux)

The SBC runs Linux, which is a full operating system. It is stripped down compared to a full desktop release of Linux, but you can compile code on it, run programs, schedule tasks, create and manage files, run a web server, and much, much more.

At this point you have connected to the SBC via the web interface, and probably also through SSH. This section will help you install libraries and drivers that you probably want - i.e. support for C, Java, and Python. After this section, you'll be well into the depths of using the SBC as a computer, and so you'll probably want to keep the Using SBC Linux section open for reference while you work if you are not already familiar with Linux.

The SBC comes with the following Phidget functionality installed:

- The Phidget C libraries `libphidget21.so`
- The Phidget WebService

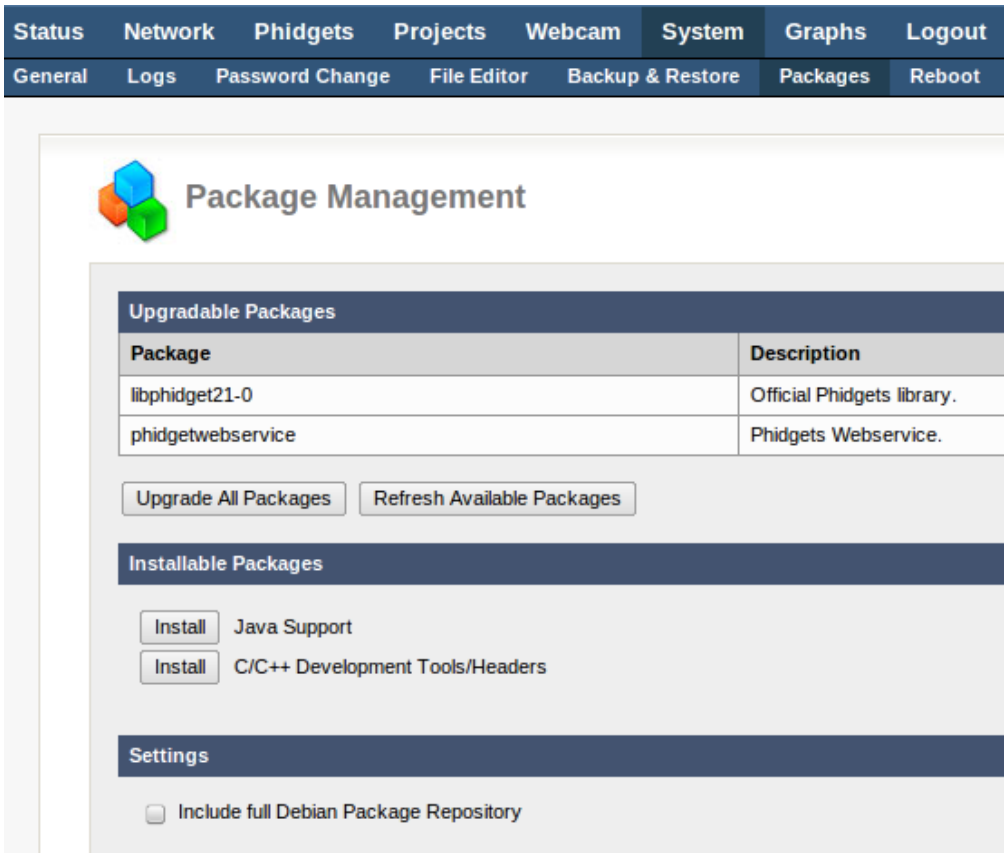
(If you are simply curious what these are and how they get installed, we describe the process on the general Linux page.)

But to compile C programs, or run Java programs, or use Python, you will need to install these languages onto the SBC.

Before installing anything on the SBC, however, (even via a button on the web interface) make sure that the *Include full Debian Package Repository* option is checked in the web interface under `System` → `Packages`.

Installing C/C++ and Java

The simplest way to install C/C++ and Java on the SBC is via the web interface. There is a button under `System` → `Packages` to install C support (including `gcc`) and another button to install Java support:



You have to check that you are running the same version of Java on your development machine (where you plan on compiling the java programs) as the SBC is running. To do this type the following into the terminal on your computer and from ssh on the SBC:

```
Java -version
```

If you need to update the version of Java on your SBC, use the following commands:

```
apt-get install openjdk-7-jre-headless
su
update-alternatives --config java
```

Now you're ready to begin programming. We have programming pages for both C/C++ and for Java. Remember that if you're unfamiliar with Linux, we have help on using files and running programs automatically in the Using SBC Linux section.

If you want to avoid using the SSH interface on the SBC entirely, and you want to write your program in Java and run it continuously from boot (which is the only option if you want to avoid SSH), we have a very in-depth section

on that topic.

Installing Python

Installing Python has two steps. First, you'll need to install the basic ability to run python, and then you'll need to install the Phidget Python module. Both steps (and both options) require that you issue the relevant commands through an SSH terminal.

Basic Python

The base Python functionality can be downloaded and installed in one step with apt (i.e. in a terminal, type):

```
apt-get install python
```

This will give you Python, and now you just have to install the Phidget Python module to gain Phidget functionality.

Install Phidget Python Method 1: Use a USB Key

Copy the Python Libraries [6] onto a USB key. Unpack the zip file into a folder on the USB key. Insert the key into the SBC.

You will have to figure out where the USB key (and the Phidget Python library folder) is now located. We describe how in the general Using USB Data Keys section.

After you know the place where the USB key is mounted, in a terminal go to that directory (e.g. type `cd /media/usb0/`), enter the unpacked Phidget Python Library folder, and run:

```
python setup.py install
```

Now, you're ready to begin writing Python code for the SBC. For more help on writing and using Python with Phidgets, we have an whole page on that topic. Remember that if you're unfamiliar with Linux, we have help on using files and running programs automatically in the Using SBC Linux section.

Install Phidget Python Method 2: Use the Internet

Rather than using a USB key to transfer the file, the SBC can download it directly from the internet. You will need `wget` and `unzip` installed, both of which are small:

```
apt-get install wget
apt-get install unzip
```

Copy the web link address for the Python Libraries [6].

In an SSH terminal to the SBC, type: `wget` http://www.python_library_link where instead of http://www.python_library_link you insert the link you just copied. Copying into a terminal can usually be done via the right-click menu.

This will download the Phidget python libraries to the folder you ran the `wget` command in. Unzip the downloaded file using the command `unzip file`, where file is the filename from `wget`. Or try typing `ls` to list the names of a file in the directory, which should include the unzipped folder. Enter the unzipped folder (e.g. use `cd` to change directory), and install the Phidget Python libraries:

```
python setup.py install
```

Now, you're ready to begin writing Python code for the SBC. For more help on writing and using Python with Phidgets, we have a whole page on that topic. Remember that if you're unfamiliar with Linux, we have help on using files and running programs automatically in the Using SBC Linux section.

Installing Other Languages

You may also be able to program on the SBC using Ruby and C# under Mono, though we do not offer in-depth support for these languages on the SBC. The installation procedures should more or less follow that of installing python on the SBC, except you will be installing Ruby or Mono. Performing package searches using apt cache search can help you find the relevant software.

For C#, as of 2012 the `mono-complete` package is broken on the Debian Squeeze repository. Rather, you have to install the Mono runtime and Mono compiler separately.

To install the runtime package (and its dependencies), use apt:

```
apt-get install mono-runtime
```

Then, to install the C# compiler:

```
apt-get install mono-gmcs
```

Or the Visual Basic compiler:

```
apt-get install mono-vbnc
```

Then, the system and library packages do not link correctly for the version 2.0 of Mono. If this is the case, your code will compile fine, but when you try to run it, you will get an error like:

```
The assembly mscorlib.dll was not found or could not be loaded.
It should have been installed in the `/usr/lib/mono/1.0/mscorlib.dll'
directory.
```

In this case, you need to install these two packages:

```
apt-get install libmono-corlib1.0-cil
apt-get install libmono-system1.0-cil
```

Here we found these packages to work by working through the tree structure. As a general rule, you can find these dependencies by using install (here, `apt-get install mono-complete`) to get a sense of the package tree structure. This will possibly tell you that the packages are broken, but at the same time this will list the dependencies of the packages. Trying to install individual dependencies will show you that although a root-package fails, the sub-packages will sometimes succeed, and install what you need.

If you want to use a specific dll or library that is not available in this reduced version of mono, you can install mono complete by switching from Emdebian+Debian to just Debian. To do this:

In `/etc/apt/preferences` make the following changes:

```
Package: *
Pin: release a=stable
Pin-Priority: 1010
```

In `/etc/apt/sources.list/mutistrap-debian.list` remove the emdebian line.

Apply the changes:

```
apt-get update
apt-get dist-upgrade
```

Many packages will be 'downgraded' from the emdebian to debian versions. Delete the `/etc/apt/preferences` file and install mono-complete:

```
apt-get install monodoc-http mono-complete
```

Choose monodoc-http explicitly, because otherwise the install fails on monodoc-browser.

After this process, you can compile your C# Code.cs Phidget source file the same way as on a generic Linux with Mono system. Please refer to that page on how to obtain the *.dll Phidget resource file and compile your code. On the SBC, however, because you are already running as root (the Super User), you do not need 'sudo' and indeed the SBC will give you an error if you use it. Instead, compiling and running will look like:

```
gmcs Code.cs -r:Phidget21.NET.dll
mono Code.exe
```

Using SBC Linux

Now that you've set up communication with the SBC, and installed whichever programming language support you need, you're probably ready for a short tour of useful tools on the SBC's version of Linux.

First, you will by default be running on the SBC as **root**, which is the super-user. For Linux users, this probably makes you nervous because you know you can overwrite important system files without the system asking for additional permission. As a Windows or Mac OS user - although you may usually run your computer as an administrator - your familiar system usually prompts you to confirm before you do anything really dangerous, and this will **not** happen on the SBC as the root user.

Next, there is no installed help on the SBC. Help on Linux is usually called 'man pages' which is short for 'the manual pages'. On a full Linux system, usually if you need help with any command you can type, for example, `man ls` and it will give you help with the program ls. But these help pages take up significant space, and they are widely available online. So, if you need more help with a certain command, you can always type `man command` into your favourite search engine.

Finally, the SBC has no windowing system. For Linux users, this means no X-windows (Gnome, KDE, etc). And as a Windows or Mac user, you can think of it as running all of your programs and commands through the terminal or DOS prompt command line. The SBC provides all of the functionality of an operating system (e.g. process scheduling, file management, etc) but without any graphical interface. The only exception is the web interface, which gives graphical access to a limited part of what the SBC can do.

Some Useful Commands

If you are doing more with the SBC than simply running pre-written programs in Java to run continuously from boot, you will be interacting with the SBC's Linux operating system over the command line by using SSH. This section discusses useful programs already installed on the SBC, and how to run them on the command line.

ls

The **ls** program lists the contents of a directory.

It will show both files and folders, but not files that start with a "." (these are hidden files on Linux).

- If you also want to show hidden files, use `ls -a`
- If you want more information, such as size and date modified, use `ls -l`
- Commands can be combined, like `ls -al`

cd

The **cd** program changes to a new directory.

For example, `cd /root` changes into the directory at the base of the file tree called *root*.

Note:

- Linux uses forward slashes
- The base of all directories is "/" (not "C:\")
- The tilde symbol (~) is short for your home directory (i.e. when you are root, this is short for "/root")
- The double dot ".." means move one directory higher (for example from `/root/data/` to `/root/`)

pwd

The **pwd** program prints the current directory you are working in. ('P'rint 'W'orking 'D'irectory)

For example:

```
root@phidgetsbc:~# pwd
/root
```

cp, mv, and rm

These programs are copy (**cp**), move (**mv**), and remove (**rm**).

Copy copies a file from one location and pastes it to another.

For example, if you have a file `data.txt`, typing `cp data.txt data_backup.txt` will put a copy of the file `data.txt` into `data_backup.txt`

Move moves a file (this is also useful for renaming files) to a new destination.

For example, if you have a file `data.txt`, typing `mv data.txt data_backup.txt` will put the contents of `data.txt` into `data_backup.txt`, and then will remove `data.txt`.

Remove deletes a file.

For example, typing `rm data.txt` will delete `data.txt`.

Note that **rm** is final. Once you remove a file using `rm`, it is gone forever. There is no recycle bin, no temporary trash, nothing other than backups you may have personally created in the past!

Directories can only be removed with `rmdir`, and then only if they are empty. If you want to remove a directory and all the files in it, use `rm -rf directory` but be **very, very careful** with this command. Trying to remove everything within a directory (e.g. `rm -rf *`) is one of the most dangerous commands you can run on a Linux system, as running it from the wrong directory will result in Linux happily removing everything under that directory -- which could be your entire filesystem.

find

The **find** program does what it says - it finds things.

Unfortunately for the casual user, the find program is very flexible and powerful, and thus not especially intuitive to use. But, here are some examples:

SSH Command	What it Does	Example
`find folder -name file.txt`	Looks for all files in a folder (/ for root - or all - folders) with a certain name (* for wildcard)	`find / -name *.jpg`
`find folder -mtime +X`	Looks for all files in a folder modified less than X days ago	`find /root -mtime +30`

grep

The **grep** program takes text input and searches for a term.

For example, if you type `mount` to view what devices are mounted (e.g. loaded) on your SBC, you will see:

```
root@phidgetsbc:~# mount
tmpfs on /lib/init/rw type tmpfs (rw,nosuid,mode=0755)
proc on /proc type proc (rw,noexec,nosuid,nodev)
sysfs on /sys type sysfs (rw,noexec,nosuid,nodev)
udev on /dev type tmpfs (rw,mode=0755)
tmpfs on /dev/shm type tmpfs (rw,nosuid,nodev)
devpts on /dev/pts type devpts (rw,noexec,nosuid,gid=5,mode=620)
rootfs on / type rootfs (rw)
procbususb on /proc/bus/usb type usbfs (rw)
/dev/sda1 on /media/usb0 type vfat
(rw,noexec,nodev,sync,noatime,nodiratime)
```

This may be a lot of information you don't need. If you are only interested in a USB key attachment (as described in the Using USB Data Keys section), you can use grep to filter that one response:

```
root@phidgetsbc:~# mount | grep sda1
/dev/sda1 on /media/usb0 type vfat
(rw,noexec,nodev,sync,noatime,nodiratime)
```

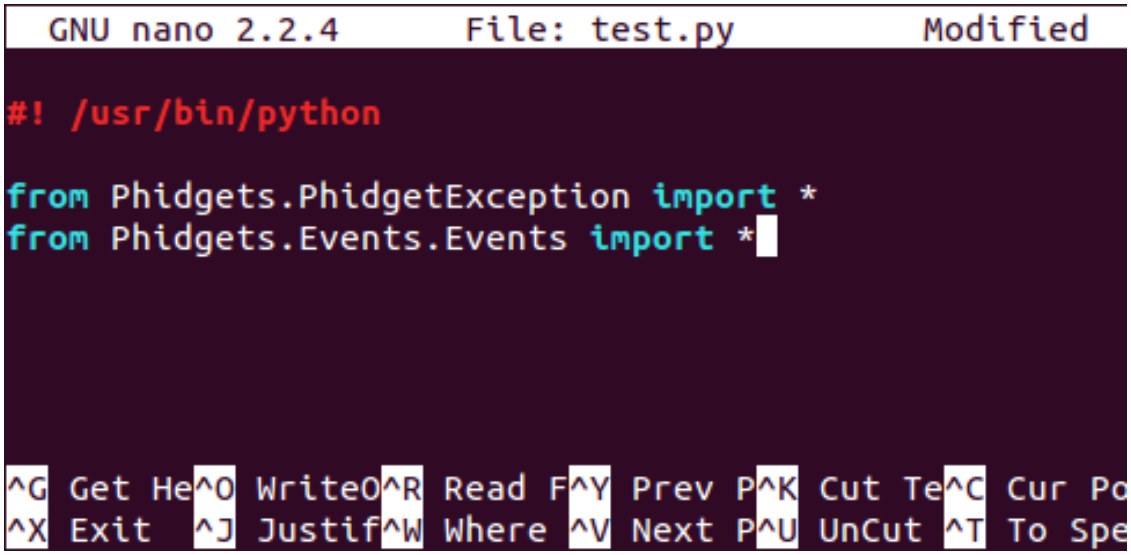
nano

The **nano** program is a small text editor that you can use within an SSH terminal.

Nano can be surprisingly useful for writing short lengths of code right on the SBC, so there is no need to transfer files and keep track of different file versions on different computers.

Nano has all keyboard commands which are listed at the bottom of the screen at all times as a reminder (Ctrl-O to save, Ctrl-X to exit, these expand with a larger terminal window). And, nano provides what is called 'syntax highlighting', which colours reserved keywords, comments, strings, and so on as appropriate to the programming language you are using. Nano detects the programming language via the extension of the file (`.java` for Java, `.c` for C/C++, and `.py` for Python).

Typing `nano test.py` on an SSH command line and then entering a few lines of Python into the new empty file results in:



apt

The **apt** program allows you to install, uninstall, upgrade, and search software available for the SBC. For a non-Linux user, the apt framework may be daunting at first, but it actually allows you to keep your system up to date and install and manage software quickly, easily, and for free.

Note: Before installing anything on the SBC, make sure that the *Include full Debian Package Repository* option is checked in the web interface under `System` → `Packages`.

SSH Command	What it Does	Example
`apt-cache search term`	Looks for all programs (packages) that have `term` in the title or description	`apt-cache search opencv`
`apt-cache show package`	Shows a lot of data about `package` including size, version, etc	`apt-cache show unzip`
`apt-get update`	Gets the most recent listing of available software	`apt-get update` (No options)
`apt-get install program`	Installs `program` from the internet	`apt-get install python`

mount

The program `mount` shows you all of the mounted devices on your SBC.

For example:

```
root@phidgetsbc:~# mount
tmpfs on /lib/init/rw type tmpfs (rw,nosuid,mode=0755)
proc on /proc type proc (rw,noexec,nosuid,nodev)
sysfs on /sys type sysfs (rw,noexec,nosuid,nodev)
udev on /dev type tmpfs (rw,mode=0755)
tmpfs on /dev/shm type tmpfs (rw,nosuid,nodev)
devpts on /dev/pts type devpts (rw,noexec,nosuid,gid=5,mode=620)
rootfs on / type rootfs (rw)
procbususb on /proc/bus/usb type usbfs (rw)
/dev/sda1 on /media/usb0 type vfat
(rw,noexec,nodev,sync,noatime,nodiratime)
```

For the non-Linux user, the concept of a device may be quite strange. To give a short summary, everything on Linux that you can read or write is a file. Webcams are files (i.e. you can 'read' photos from them), USB keys are files, and each filesystem (tmp storage, the kernel portion, the main filesystem) are also themselves files. These files specify what and how something can be written. These are not necessarily linear, for example, you can see above that the USB key (`/media/usb0` is mounted *within* the root file system `rootfs` which is /.

So mount gives you an idea of what devices have been 'mounted' for reading or writing, and how you can read and write to them. More information on mount (and its various forms, like `umount`) is available widely around the Internet.

which

The program `which` tells you if and where a program is installed.

For example, on a default SBC, typing `which python` will return no results. But after successfully installing python, it will return `/usr/bin/python` as the location of the python program/binary/executable.

Some Useful Commands to Install

These are other programs you may find useful on the command line. Although they are not on the SBC by default, these and other programs can usually be installed simply by using apt-get install, with the exception of gcc. For example, `apt-get install wget` will download and install wget.

Note: This section and the section on pre-installed commands can hardly cover all of the complexities and power of the Linux operating system. There are many excellent tutorials online, and between them and using apt to find and install programs you should be able to learn a lot and perform any number of complex useful tasks.

gcc

The **gcc** program is the C compiler for Linux.

If you are an experienced C/C++ user on Mac or Linux, or if you've already read our C Language page, you might think you need to install gcc via `apt-get` to compile C code. However, gcc is not in the package repository for the SBC, so `apt-get install gcc` will fail. Rather, to install gcc, you can do it via the web interface, as described in the Installing C/C++ and Java section.

After installing it via the SBC web interface, you can use `gcc` normally.

less

The **less** program displays the contents of a text or source code file. When displaying the file, `less` allows you to scroll up and down to read it.

This is useful if you are writing your sensor readings to a data file, and you want to read the data file while it is being written by your main code. If your data file is called `data.txt`, you can type `less data.txt` and see the lines in the file, and what they are.

The `less` program output can also be piped into another program. For example, you can use `less` and the word search program `grep` to find lines within a file with a search term. For instance, if you have a C source code file `Program.c` on the SBC, and you want to see all the lines in `Program.c` that contain a variable name `var`, you can type:

```
less Program.c | grep var
```

wget

The **wget** program allows you to get an online file (over http) and download it to the SBC.

For example, to get the source file (HTML) from the Phidgets home page, you can type:

```
wget http://www.phidgets.com
```

This is most useful for downloading libraries, drivers, or anything (zip, tar, etc) you need from the web which is not available by using apt.

Writing a Phidget Program

We provide two ways to write and upload a Phidget Program:

1. The web interface:
   - This is useful for simple projects written in Java that you want to start only at boot
   - You can also use C projects, but they must be compiled off the SBC for an ARM processor
2. Over SSH, which will allow you to write or transfer source code directly to and from the SBC
   - This is useful for all other projects, such as:
     - Projects that run at scheduled times (e.g. once per minute)
     - Projects that use languages other than Java or ARM-compiled C

Note that you can still run an SSH project at boot, you just have to write and install a startup script. This is a bit complex, but we do have an example that starts the program `phidgetwebservice21` at boot using a script.

Once you know which method you'd like to use, you can continue on to learn how to Program in Java with the Web Interface, or how to Program with SSH using Java, C, or Python. If you are actually typing in source code on the SBC, you'll find our developing code on the SBC section useful.

Program in Java with the Web Interface

To show how to write, compile, and install Java programs on the SBC, we'll use the Java Hello World example code. You can download the HelloWorld example by downloading the whole Java example package [7]. Make sure you have the same version of Java installed on the SBC as you have on your external development machine. Instruction for checking and updating are found on the installation page.

Here's how to get the HelloWorld code running on the SBC. On your external computer:

1. Download the SBC version of the Phidget Java libraries (`phidget21.jar`). You can download this from the web interface, on the page under `Projects` → `Projects`, under the **Notes** section.

2. Place the SBC version of `phidget21.jar` into a directory on your external computer. This will be your working directory that you will use to compile the Java files.

3. Also copy the `HelloWorld.java` file into that working directory.

4. Compile the `HelloWorld.java` file from within that working directory. From the command line prompt on Windows, this will be:

```
javac -classpath .;phidget21.jar HelloWorld.java
```

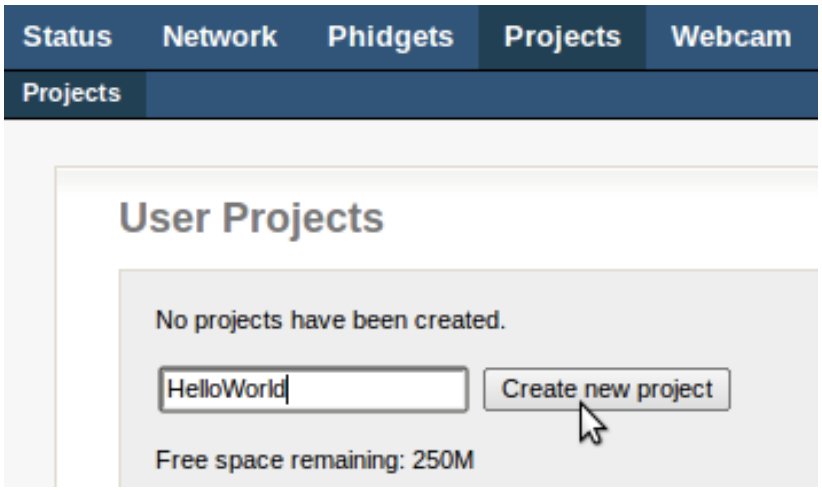
In a terminal on Linux or Mac OS, this will be:

```
javac -classpath .:phidget21.jar HelloWorld.java
```

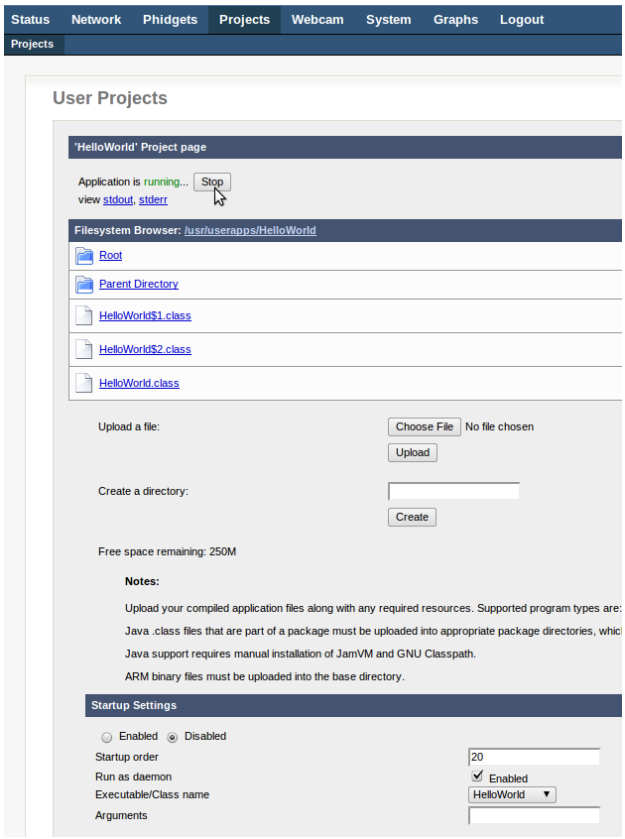
5. You should now have three compiled class files: `HelloWorld.class`, `HelloWorld$1.class`, and `HelloWorld$2.class`. You don't need to try and run them, and if you do you may encounter an error because the SBC `phidget21.jar` may be slightly different than the Phidget support you have installed on your external computer.

Now we move onto the SBC:

6. Create a new project on the SBC, in the web interface under `Projects` → `Projects`. Call it HelloWorld:



7. On the next screen, you will be prompted to upload your files. We will upload the three Java class files, and then click the `Start` button:



8. You'll note that as it runs, there are two links below the `Stop` button: One called `stdout`, which is *Standard Output*, and one called `stderr`, which is *Standard Error*. Usually, when you run a program on the command line, you see both standard out and standard error at the same time - i.e. you get all program output right there in your terminal or command prompt. But when running a program in the background, Linux splits the output up into normal output and error output as this is very useful for debugging (i.e. you can check if standard error is empty).

Here, however, if you're not sure whether the program will run correctly, you should first check `stderr` to see if any errors were generated, and then check `stdout` to see if the output looks as expected.

To write your own Java program, follow the same process but use your own source code instead of the `HelloWorld.java` example.

Now that you have a running program, we offer additional help on running a program automatically using the web interface.

Program with SSH

Similarly to starting a program via the web interface, we use the Phidget Java `HelloWorld` example here.

Make sure you have Java installed on the SBC. To compile and run the `HelloWorld` example:

1. Open an SSH terminal to the SBC

2. Download the Phidget Java Examples [7] to the SBC, using wget (you may need to install `wget` using apt.)

3. Unpack the examples using unzip (you may need to install `unzip` using apt.)

4. The location of `phidget21.jar` on the SBC is `/usr/share/java/phidget21.jar`. Within the unzipped example directory, compile the `HelloWorld.java` example:

```
javac -classpath .:/usr/share/java/phidget21.jar HelloWorld.java
```

5. To run the `HelloWorld` program, use:

```
java -classpath .:/usr/share/java/phidget21.jar HelloWorld
```

Now that you have a running program, you'll probably want to learn to run this Java program automatically.

Permissions Note: If you're used to using Linux with Phidgets already, you'll probably notice that you don't need to switch into root using `sudo` on the SBC in order to run programs. This is because you already are running as root, not because the udev rules are set up. So if you set up another user, or run a cron job as anything other than root or system, you'll need to add permission for the Phidget program to run in your udev rules.

Developing Code on the SBC

When you're not just using pre-written source code, and you're writing code actually on the SBC itself, you'll probably want to use nano. Other terminal editors on the SBC include `vi` which is already installed, and `emacs`, which you can install using apt. Both `vi` and `emacs` are much more efficient for the experienced user, but they contain modes and keyboard shortcuts that can seem strange or almost hindering to the casual user.

Regardless of which editor you choose to use, some of your keyboard habits may not transfer well. For example, in the Linux command line, the command `Ctrl-C` means *stop the currently running program*, (i.e. your open editor) not copy. Within most SSH terminals, you can copy and paste using the right-mouse button, and on some terminals (and all native Linux terminals) you can copy by simply highlighting text, and you can paste it using the middle (scroll) mouse button. On the other hand, if you write a program that hangs on the command line, `Ctrl-C` can actually be useful to terminate it.

Also `Ctrl-Z` does not mean *undo*, rather it means *run the current program in the background*. This is useful because running a program in an SSH terminal simply hangs your SSH input until the program is done. So typing `Ctrl-Z` while the program is running frees up the command line for more input. But if you accidentally hit `Ctrl-Z` while running an editor like nano, the editor will immediately exit to the command line. Don't worry though, it will not stop or lose your work. You can bring it back up by using the `fg` (e.g. 'foreground') command, like `fg nano`, and this will automatically bring your nano process back to the front.

Running a Program Automatically

For testing your program, you will certainly want to run it via SSH or via the `Start` button on the project page on the web interface until you are quite sure it runs well. However, eventually you will probably want the program to run without your input, either continuously, and starting at boot, or via a task scheduled to run to completion at certain times.

Both have their advantages and disadvantages. Usually, you would want to use the continuous, from-boot methods for event driven code that has to handle a wide variety of user input that could occur at any time. You would want to use the scheduled method when the SBC needs to perform a repeated task (e.g. reading sensor data) again and again. The main difference is:

- With the continuous (boot) method you can have any Phidgets (including sensors, LEDs, input switches, etc) attached and giving events to your code all the time, and
- With the scheduled (cron) method you have much less of a chance to run into long-term memory management and instability problems with any code you write, because your program runs for only a short time before exiting and getting cleaned up.

Via the Web Interface

To use this method, you must have created the program you want to run as a Java or ARM-compiled C project in the web interface. If you would like to use another language, or another way of uploading your project, but you still want to start at boot and run continuously, you will need to use a boot script.

In the web interface, go to the `Projects` tab, and click on the project you would like to run. Near the bottom of the project page (the one with the `Start` and `Stop` buttons at the top), there will be a section called `Startup Settings`. You can see a screenshot of the whole project page, including these settings, in the web interface project section.

Select the `Enabled` radio button. The other defaults should be fine, unless you specifically know otherwise:

- For *Boot Order*, lower numbers boot first. Booting later means more programs are available for use, booting earlier means other programs can use your program.
- *Run as a daemon* starts the program as a daemon, which is a program that runs in the background. Unless you have *explicitly* written your program as a daemon, leave this checked. (If you don't know what a daemon is, don't worry, you haven't written one, so leave it checked.) *Un*checking this when your program is a normal program will cause the SBC to hang while booting.
- The *Executable or Class* name should be automatically sensed to be your main Java class
- *Arguments* are any command line arguments you need, just as you would type them into the command line

Note: Your program must be very, very stable to run properly via the web interface. Imagine your program running continuously for days, or months on end. Any memory leaks, over time, will render your program (and the SBC) unusable until a reboot. Counts or other variables that increase within your program and never reset may create a segmentation fault eventually.

If, for stability purposes, you want your program to start, run for a little while, and then exit so that the SBC operating system can clean up the memory each time, you'll probably want to use Cron to run your program instead.

Via Cron

Cron can automatically schedule programs - known as 'jobs', or 'cron jobs' - at most once per minute. Less often than that, it is very flexible, allowing you to run it on certain months, weekdays, hours, etc. Cron simply reads a special file (your `crontab`) and runs whatever programs are listed, with whatever timing they are listed with. The cron program runs all the time in the background, making it what is known as a Linux *daemon*, but the programs it starts as jobs run only as long as they naturally would, and then they exit.

If you need your program to run more often than once per minute, have the program schedule itself while still running. For example, to run every five seconds, run a fast loop, and sleep for five seconds. Do this twenty times and exit. Then schedule this once per minute using cron, and your program will in essence run every five seconds.

Setting up a cron job simply entails editing your `crontab` file.

First, you'll probably want to specify your default editor to be nano. Otherwise it will default to `vi` and you'll have to figure out `vi` in order to add lines to your crontab:

```
export EDITOR=nano
```

Then, to edit your crontab file, simply type:

```
crontab -e
```

Each line of the crontab file is one scheduled job. Lines that start with a hash "#" are comments and are ignored. There is an example line in the crontab, and a reminder line at the very end. Essentially, each line should contain:

```
minute hour dayOfMonth month dayOfWeek  command
```

Where:

- `command` is the program you want to run (with absolute path, and arguments)
  - For example, `./myprogram argument1` won't work, but `/root/code/myprogram argument1` will
- Each time argument is either a number, a list of numbers separated by commas, or an asterisk
  - For example, * * * * * means every minute for all days and months, 0,30 * * * * means every thirty minutes (i.e. at the top of the hour and at 30 minutes in) for all days and months

If you already have jobs scheduled, you'll see them in the file that comes up. You can edit, add, or delete.

After you save, you'll see a little message back in the terminal that says the new crontab file was installed, and it is now scheduled! Cron always starts every boot, and so if you have edited and installed your crontab as above, the scheduling of your program will start properly even after a reboot of the SBC. However, if you are having strange scheduling problems, you may want to familiarize yourself with the software details of how the SBC as a whole determines the current date and time.

My Cron Job Doesn't Work!

It is actually very common for a script or program to work on the command line but then *not* work as a cron job. The most common reason for this, by far, is that you specify *relative* paths in your program to access files rather than *absolute* paths. For example:

- `code/project.c` is a relative path (bad for cron)
- `/root/code/project.c` is an absolute path (good for cron)

The cron jobs are *not* executed from your home directory, or your code directory, so they will not be using the same location you may be using to test your code. So always use absolute paths.

Another common reason is you may be using environment variables or other settings that are true in a terminal but are *not* true by default in the raw system. You can end up taking many things for granted in a shell, for example the shortcut "~" means home directory in a shell, but not by default in the raw system. The things that get loaded for a shell (but which are not present in the raw system) are:

- The settings loaded by `/etc/profile`
- Any settings in `~/.bashrc`, which is nothing by default on the SBC

On a full Linux operating system, you would use the logs written to by cron to find the error output and debug it. On the SBC, however, cron does not write logs (otherwise, these logs would eat up the SBC memory very quickly even for routine jobs). For short-term debugging, you can write output from your program to a file, and read that file afterwards to figure out what your program is doing.

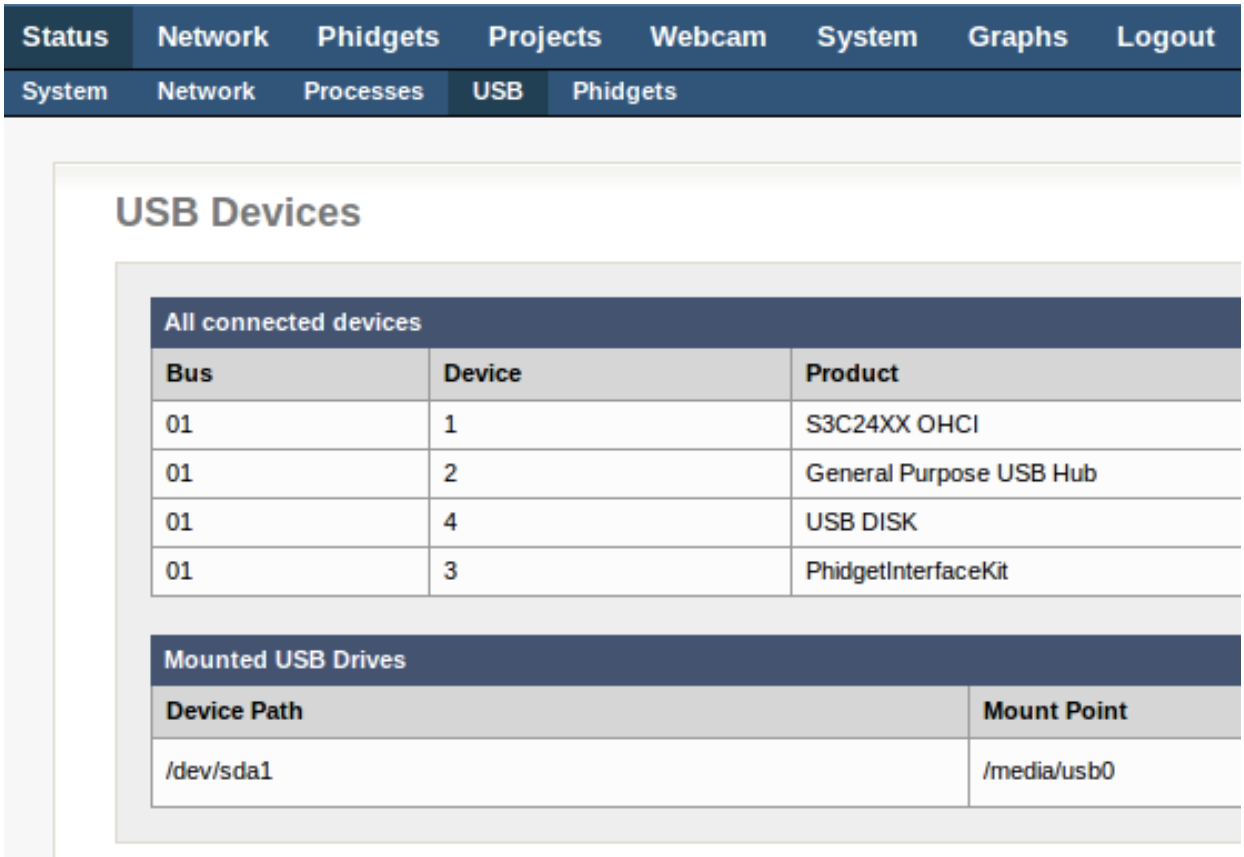
Via a Boot Script

If you want to run your program constantly and for it to start at boot like the web interface would do, you can install your program into the boot order using a script. This is a somewhat involved process, and you should be familiar with shell programming in Linux. For this process, we only offer a similar example which installs and runs the program `phidgetwebservice21` within the boot sequence.

Using USB Data Keys

After plugging the USB key in, it won't just appear on your desktop, so to speak, so you'll need to figure out where you can read and write to it within the SSH directory structure.

The web interface program can help with this. After you plug a USB key in, it will show up under `Status` → `System`. Or, the USB key and all other attached devices can be seen at `Status` → `USB`:



In the screenshot above, you can see that the USB key is located in `/media/usb0`.

Alternately, you can use the SSH command `mount`, and the searching program `grep` which will filter the response of `mount` and only return the lines with your search term (`usb`):

```
root@phidgetsbc:~# mount | grep usb
/dev/sda1 on /media/usb0 type vfat
(rw,noexec,nodev,sync,noatime,nodiratime)
```

In this case, the USB key can be written to and read from using the `/media/usb0` directory. Copying a file to `/media/usb0` will copy a file to the USB key. The same goes for removing, renaming, opening files within your

program, etc.

Note: Mount points like `/media/usb0` should not be hard-coded into any of your programs. (See the Common Problems and Solutions section for more information.) If you need to obtain the mount point for a freshly mounted USB key within your code, have your code obtain the mount tables and search on the *device* (e.g. `/dev/sda1` or `/dev/sdb1`) and obtain the corresponding mounted `/media/usbN` location, where N is a number 0-9.

Saving and Retrieving Data

This section covers getting data on and off of the SBC. There are two main methods of simply moving data on and off the SBC - via a USB key, and via copy over the network - and a third method for moving and installing data when it concerns backing up lower level system data.

Via a USB Key

After plugging in a USB data key, first you need to find out the location where that data key was mounted.

Let's say the location of the USB key is `/media/usb0/`, and we want to copy the file `data.txt` to the USB key. Your SSH session might look something like this, using ls and mount:

```
root@phidgetsbc:~# ls
data.txt
root@phidgetsbc:~# mount
tmpfs on /lib/init/rw type tmpfs (rw,nosuid,mode=0755)
proc on /proc type proc (rw,noexec,nosuid,nodev)
sysfs on /sys type sysfs (rw,noexec,nosuid,nodev)
udev on /dev type tmpfs (rw,mode=0755)
tmpfs on /dev/shm type tmpfs (rw,nosuid,nodev)
devpts on /dev/pts type devpts (rw,noexec,nosuid,gid=5,mode=620)
rootfs on / type rootfs (rw)
procbususb on /proc/bus/usb type usbfs (rw)
/dev/sda1 on /media/usb0 type vfat
(rw,noexec,nodev,sync,noatime,nodiratime)
root@phidgetsbc:~# cp data.txt /media/usb0/
```

The **cp** program copies data from a source to a destination. The syntax is `cp from to`, where here we are copying from `data.txt` to `/media/usb0/`.

Caution: Even if there is no USB key mounted at `/media/usb0/`, this use of `cp` will still work *with no errors*! This is because there is still a file called `/media/usb0/`, there is just no USB key file system *mounted* to that point. So be sure to run mount or use some other method of determining that there is, in fact, a USB data key attached and where it is mounted to.

Over the Network (SCP)

SCP is a command line program already installed on Linux and Mac OS, and downloadable for free on Windows. We discuss it and give examples in the SSH section, but remember it here when you're trying to get data on and off of the SBC. With SSH or a terminal already open, you'll probably find it to be much faster and easier than dealing with a USB key.

Backing Up Your Data

For the web interface, you can save and restore all web interface settings under the `System` → `Backup & Restore` tab.

To save the settings of what packages are installed for later re-installation, you can type:

```
dpkg --get-selections > installedPrograms.txt
```

Then save the file `installedPrograms.txt` externally. If you have to completely wipe the SBC, you can just reinstall the whole list by moving the `installedPrograms.txt` file back onto the SBC, and then typing:

```
dpkg —set-selections < installedPrograms.txt
apt-get dselect-upgrade
```

Also remember to externally save:

- Your `~/.bashrc` settings file if you've changed it
- Your `crontab` file if you've edited it
- Any data files or code you've created

It is important to save these settings often, and at points where you know the system is running well. It may be tempting to create a backup right before you wipe the SBC and start from scratch, but often the reason you are having problems then is some setting or change, and backing these up and reinstalling them will only reinstall the problem.

To truly back the files up, you must copy them to an external computer or location using either a USB Key or over the network. Then they can be copied back if needed later.

If you are looking to restore data on an SBC that will not boot properly, you'll want to be in the partial recovery portion of our Troubleshooting section.

Troubleshooting

The SBC can be quite tricky to debug, because it is a complex and flexible computer. Common problems and solutions include:

- You can't find the SBC on the network at all - refer to the Initial Internet Setup section
- You have changed some setting or file such that the SBC doesn't run anymore, or doesn't run as expected - refer to the Recovery section

If you are having trouble using Phidgets on the SBC, you should go through the Troubleshooting section on the general Linux page. Some of the problems on the Linux page (such as library problems) are easier to fix by simply working through the Recovery section when they occur on the SBC.

Namely, it often helps to simply perform a factory reset on the SBC (save your files and installed program list first, as described here). Sometimes you change a file or setting within the operating system when you are trying to get something up and running, and this unintentionally affects other programs too. Performing a factory reset starts you with a clean slate.

If your problem doesn't seem to be fixed by these steps, or the information within this guide, please ask us!

Initial Internet Setup

To set up the SBC, you almost always need a *wired* Ethernet connection with DHCP (Dynamic Host Configuration Protocol), and without a firewall. This connection should be to a *router*, not directly plugged in to your computer.

Even if you do not have this type of a connection at home, these types of connections are very common at both offices and universities. On a Windows or Mac OS computer, you can bring up the Phidget Control Panel as described in the SBC's Getting Started Page. Failing this, or on a Linux computer, we discuss some alternate setup methods in this section. Keep in mind that without a wired, open DHCP connection these setup methods can be difficult and fickle.

No Wired-Only Connection

Sometimes it can work to plug the SBC, using Ethernet, directly into an Ethernet port on your home wireless router. Do not plug it directly into your computer! (Although in some instances, a direct connection can be made to work on Linux, see the No DHCP section below)

This direct-router method is a very picky process, however, and can fail because:

- Some home and office routers place a firewall between wireless connections (clients) and wired connections (the local area network)
- Some home and office routers do not by default allow both Ethernet DHCP and wireless DHCP.
- Some routers and DHCP hubs only provide access to an internet connection, and do not provide local area network inter-connections (this is common on mobile device tethering hubs)

Routers are quite complex, and even with admin privileges it can be a painstaking process to find all the right firewall settings to turn off in order to allow two computers on the network to talk to one another, rather than just connect to the internet. This is why university or office networks are often ideal for the purpose of setting up the SBC, because these institutions depend on computers on a local network being able to talk together. University libraries in particular can be a good source of wired DHCP connection ports.

Covering all of the different router configuration possibilities here, and how to change them to make the SBC work, is essentially impossible. If you try using the SBC at home or at work, the SBC does not work on the first try when plugged directly into the router via Ethernet, and you want to make that connection work rather than seeking out an alternate for the initial setup, you should find documentation specific to your router (usually available online) and properly configure it.

The good news is that if you can find an Ethernet DHCP connection *just once* for a short time, you can use that connection to configure the SBC to work on your home wireless network. During that initial connection, you can enable wireless and set up as many wireless DHCP connections (with passwords) that you need. Once wireless is enabled and set up, you can take the SBC home to your wireless router and the SBC will automatically seek out and connect to its remembered networks as they appear. At that point, you can also use wireless like a normal internet, web interface, and SSH connection.

No Link Local Addressing

If you have a wired DHCP connection, no firewall, and no link local addressing (e.g. bonjour or avahi is not installed) then you will need access to the DHCP router logs. From the router logs, you should see the connection (or attempted connection) by the SBC within the logs. From that log entry, you should either be able to determine the IP address for the SBC, or see what happens when the router blocks access. The IP address can be used in place of the link local address for both the web interface and for SSH.

No DHCP

The SBC will first try to use DHCP, but then it will revert to responding to a link local address under bonjour and avahi. If you are depending on this, please wait **at least three minutes** after the SBC boots for the SBC to fail in obtaining a DHCP connection and properly revert to link local addressing.

If you have a static IP setup, and want to use link local addressing rather than accessing the router logs, this should usually work by default on Windows and Mac OS (e.g. type the address such as `phidgetsbc.local` into a web browser). If it doesn't work automatically, there is not much you can do and you should seek out a wired DHCP connection elsewhere.

On Linux, it also should work by default, but you have the additional option of explicitly adding routes that look within the default network settings for the SBC. From a terminal (as root), type:

- `route add -net 169.254.0.0 netmask 255.255.0.0 dev eth0 metric 99`
- `route add default dev eth0 metric 99`

You can also compile and use the `phidgetsbclist.c` example (use the provided Makefile, don't use gcc) in the Phidget Linux Libraries [8] package, under the `examples` folder. This will allow you to see if the SBC is detected on the network at all. Note that to use this option you must have the Phidget Libraries and the Phidget WebService installed on your Linux computer - in-depth instructions to do this are on the main Linux page.

Recovery System

You can either boot the SBC into recovery mode and attempt to recover files and settings, or you can completely wipe the SBC by performing a factory reset. If the LEDs do not turn on normally (red on constantly, green on at first start, then off, then on when fully booted) then you'll want to read the hardware issues section.

Partial Recovery

The recovery system can be entered in two ways:

1. From the `System` → `Backup & Restore` web interface page.
2. By holding down the reset button for 20+ seconds - until the green light has switched from flashing slowly to flashing quickly.

The recovery system runs an SSH server where the username and password both are `root`.

If the main filesystem has been damaged/misconfigured in such a way that it won't boot, you may be able to fix the issue or recover important files before running a full factory reset. From an SSH connection to the recovery system, you can mount the main root filesystem with the following commands (assuming it's not damaged):

```
ubiattach /dev/ubi_ctrl -m 6
mount -t ubifs /dev/ubi0_0 /mnt
```

Factory Reset

This restores the kernel and root filesystem from backup, overwriting any changes that may have been made and *completely wiping the system* to the state that it got shipped in. (You can save your files and installed program list first, as described here.) This can be enacted one of two ways.

1. Use the reset button:
    1. Enter the recovery mode by holding down the reset button for 20+ seconds as above (until fast flashing)
    2. Wait for a full boot (i.e. you can see it on the Phidget Control Panel, or can SSH with username and password as `root`)
    3. Hold down the reset button again, but this time for only 10 seconds (until slow flashing)

4. Wait for the SBC to fully reset and reboot (at least three minutes) - the LED will turn off and on again when this occurs
    - Note that after a factory reboot the SSH server will be disabled
    - Also note that after a factory reboot the SBC creates new SSH keys, and reverts to the `phidgetsbc.local` address
2. Via the web interface, under `System` → `Backup & Restore` → `Go button`, where you can follow the instructions

Hardware Issues

The LEDs are an indicator of the hardware working properly. The normal boot process is:

- Red LED: Turns on from moment of power being applied.
- Green LED: Turns on momentarily when power applied, then turns off momentarily, then turns on and stays on when booted.

If the green status LED never turns on (or fails to turn on the second time), the boot process is failing somewhere. This could be due to:

- A damaged OS - Try performing a Factory Reset
- If this fails, it is likely hardware damage (very difficult to diagnose, please contact us)

If neither LED turns on, hardware damage is even more likely. Unless the path to the red LED is the one thing that has been damaged, the device is likely not receiving and using power.

- Try performing a Factory Reset, and if that does not work please contact us

USB Issues

On the Phidget SBC2, there is a hardware issue that is unrelated to the LEDs. It is a USB problem, and manifests in many ways:

- Strange behaviour when some devices but not others are plugged in to the SBC
- Strange behaviour with combinations of devices
- Failure (or intermittent failure) to see Phidgets on the USB hub, or USB keys on the hub

This problem is fixable, either on your own or by sending your SBC back to Phidgets. For an in-depth solution, see the SBC2 Hub Fix Page.

Updating Your SBC

If you've owned your SBC for a while and want to update your packages, you can run:

```
apt-get update
apt-get upgrade
```

...to *update* your software source list and then *upgrade* to the latest version of all installed software. If you are used to Mac OS or Windows, note that this does not just update the non-kernel parts of the operating system, it updates every additional piece of software you have installed.

To update the SBC software itself (e.g. the kernel), it is easiest to use the web interface, under `System` → `Backup & Restore` → `Go button`, to enter a page that will give you the option to update. You will need to have an update file on a USB key inserted into the SBC, of type:

- UBI Image (system_ubi.img), or
- Kernel image (uImage), or
- Phidget Upgrade package containing both UBI and Kernel images (phidgetsbc*.bin)

These are either obtained from the Phidgets website, or are a custom kernel / filesystem that you can create yourself, if you are experienced.

The reason why this information is in troubleshooting is that you should certainly back up your system before trying this. And, it is quite rare to need to upgrade the kernel or filesystem on the SBC, so something serious should be going on before you attempt it. Try using the recovery system first.

Programming Languages

Now that you have the basic libraries installed, you can pick your language and begin programming!

If you are not using the webservice to control a Phidget over a network, your next step will be to delve into the use of your specific language. Each page has its own set of specific libraries, code examples, and setup instructions.

On SBC Linux, we recommend the following languages:

- C/C++
- Java
- Python

These languages may also run on the SBC, but we do not yet directly offer SBC support for them:

- Ruby
- C# (using Mono)

You can probably figure out how to install and use them by a combination of the language pages linked above, and the section on installing other languages on the SBC.

WebService

The SBC comes with the Phidget WebService installed, and the SBC automatically starts the WebService at boot.

To practice using the WebService, and to learn more about it, we have hands-on examples on the general Linux page, starting in the using the WebService section.

Advanced Uses

Shutting off USB ports to save power

The SBC3 has an on-board USB hub that can control power to the ports. To do this unbind and rebind the USB drivers.

To turn off the ports `echo "1-1" >/sys/bus/usb/drivers/usb/unbind`

To turn on the ports `echo "1-1" >/sys/bus/usb/drivers/usb/bind`

These will also cause detach and attach events for the Phidget devices, respectively. While the drivers are unbound, you will not get any hot plug events for any devices on USB.

Using a Touchscreen

Please note that this will ONLY work with an SBC3 since it has a USB 2.0 hub:

Using a touchscreen with the SBC is a great way to get user input and visual feedback from an SBC otherwise devoid of visual output. The SBC does not have any conventional display ports such as VGA, DVI, or HDMI but it does have a number of USB ports and USB displays do exist. With the upgrade to a USB 2.0 hub on the SBC3 from the earlier models which had USB 1 hubs the SBC now has enough capability to operate a screen over USB. We don't recommend running a standard desktop environment since the processor is too slow to really keep up with a typical desktop it does make for an excellent interface for a kiosk, instrumentation control panel or other, similar use

case. This document is going to go through the process of enabling support for a typical USB display as well as installing a fairly compact desktop environment called xfce on the SBC.

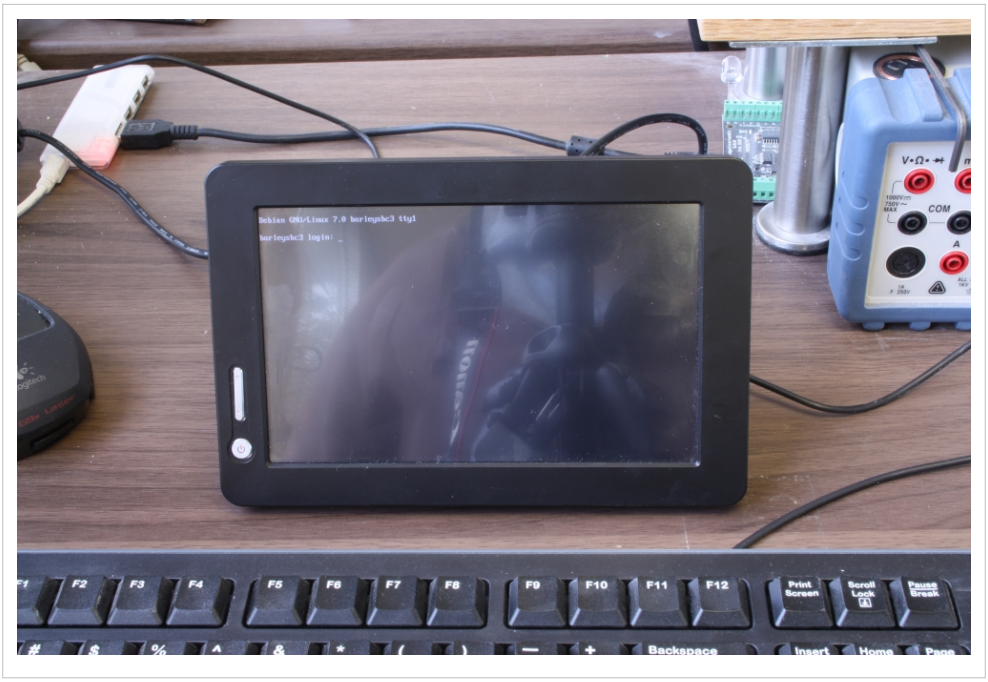
The screen I will be using is from a company called Lilliput [9]. Specifically a UM-70 model. Before you begin, please make sure that you have the screen plugged into the SBC, it will also be useful to have a spare USB keyboard and mouse handy as you will need them once you are no longer using an SSH terminal to communicate with the SBC.

Getting the display to function

Begin by logging into the web configuration page for your SBC and upgrading all of the packages on the SBC. Be sure to include the full Debian package repository. For more information on how to do this refer to the getting started section of the Phidget SBC documentation. Once you are fully up to date open an SSH session with the SBC and navigate to the "/etc" folder. Open inittab with a terminal-based text editor such as nano and add the following to the bottom of the file, just above the `T0:23:respawn:/sbin/getty -L ttyAMA0 115200 vt100` line:

```
1:2345:respawn:/sbin/getty 38400 tty1
2:23:respawn:/sbin/getty 38400 tty2
3:23:respawn:/sbin/getty 38400 tty3
4:23:respawn:/sbin/getty 38400 tty4
5:23:respawn:/sbin/getty 38400 tty5
6:23:respawn:/sbin/getty 38400 tty6
```

Now reboot your system. After a few minutes you should see the LCD screen come up with a standard Linux terminal interface and a login prompt. This is all well and good but this isn't really appreciably better than simply using an SSH session to communicate with the SBC.



Setting up Xfce

In order to get a traditional windowing environment we still need to install a desktop manager as well as a number of supporting packages. Log in and make sure everything is still up to date with:

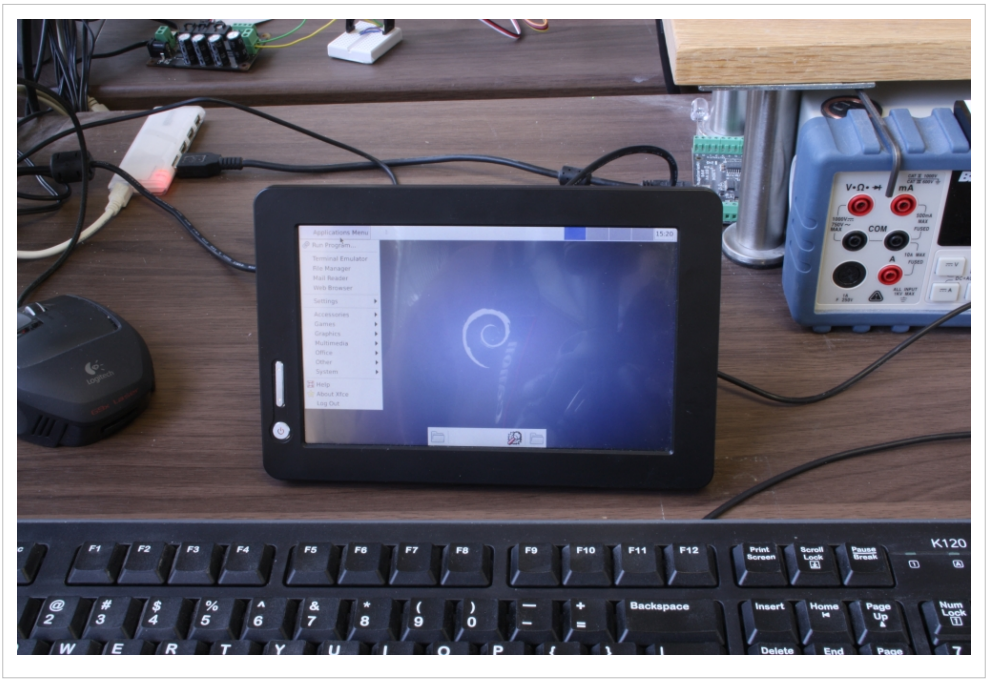
```
apt-get update
```

Then install the following packages:

```
apt-get install xserver-xorg lxde xfce4
```

If the SBC asks you if you want to continue, just type "Y" and press enter.

This will install the xfce desktop environment and any other necessary programs on the SBC. When it's done, restart the SBC. When it boots back up it should boot directly to a login screen instead of the terminal interface. Log in, and you are good to go. It won't be particularly fast, but don't worry, the SBC does not have a dedicated video processor on it so it's perfectly normal for it to be slow. What's important is that it works.



Calibrating the touch screen

Unfortunately, by default the screen is calibrated to believe the bottom of the screen is on the right hand side. This has the effect of making the touch functionality more or less useless until it has been properly calibrated. To do this, install the following package:

```
apt-get install xinput-calibrator
```

Now use xinput calibrator to measure the parameters of your screen. Launch xinput calibrator (called Calibrate Touchscreen in the programs menu) and follow the instructions on the screen. The screen should now be functioning at full potential.

Using a Different Wireless Adapter

The support for the wireless adaptor that Phidgets sells is written into the SBC kernel. Hence, we do not support using other adaptors.

However, Linux is very flexible, and it is possible (though not easy) to write a custom kernel for the SBC and add support for a new wireless adaptor. We can't help you with this, but we do provide some basic guidelines for building your own kernel. You can also have a look at our thoughts on our own experience with choosing a Wifi adapter: Alternative Wi-Fi Adapters on the SBC.

Using a Different Webcam

In addition to the webcam that Phidgets sells, you have the option to use many different webcams with the SBC. There is a long list [10] of compatible webcams.

The common thread for these webcams is that they use UVC - the USB Video Class - drivers for Linux. You can then use mount to find out what video device your webcam is mounted under.

Taking Pictures With the Webcam

Probably the most straightforward way to use a webcam for pictures rather than video is to use the `opencv` library. You can get it by:

```
apt-get install libcv2.1
```

If there is no `libcv2.1` package, you can perform `apt-cache search libcv` to find the current version.

The opencv libraries can also be used within Python, by installing the link between them:

```
apt-get install python-opencv
```

Then taking pictures from within code becomes quite simple. For example, in Python, taking and saving an image is four lines:

```
#! /usr/bin/python

import cv

# The webcam is located at /dev/video0
# OpenCV only needs the number after video
webcam = cv.CaptureFromCAM(0)

frame = cv.QueryFrame(webcam)

cv.SaveImage("image.jpg", frame)
```

For the complete OpenCV documentation, see The OpenCV Reference [11], and specifically the section on Reading and Writing Images [12].

Note: The SBC is probably not as powerful for image processing and transport when compared to your desktop computer. Try running your image processing code on the SBC from an early point in development. During those test runs, you can visit the first System page of the SBC Web Interface to check the processor and memory use. For more information on processor power, check the specification for your SBC (on the product page on our main website [13]) as well as our discussion of pushing processor limits below.

Checking System Logs

The SBC maintains two logs: a kernel log and a system log.

The kernel log is for low-level occurrences, such as devices attaching and leaving the USB hub, recording what drivers are being used, and so on.

The system log (syslog) is for normal chatter from the operating system. Any program with the right permissions can use it (though you need to know the method to write to it, information all around the Internet can help) and it contains everything from the Ethernet going up and down, to webserver requests, and so on. If you don't run many programs or services on the SBC, the syslog will essentially be a mirror of the kernel log, because the kernel is the only thing talking.

You can check these logs by using the web interface in the `System` → `Logs` tab.

Or you can perform more powerful filtering and displaying via an SSH terminal. For example, `dmesg` is the command to display the kernel log, and `tail` prints the last ten lines of input. So, if you are trying to see if you can get a device to be detected on USB, you can run `dmesg | tail` to print the latest ten lines of kernel log data.

The actual locations of the log files (for filtering and reading) are:

- `/var/log/syslog`
- `/var/log/dmesg`

But don't edit them directly! Always follow the advice and procedures around the Internet on how to properly log items to syslog.

X Forwarding

Although most tasks can be done using the SBC Web Interface or SSH, you can also set up X11 forwarding on the SBC. X11 is the window manager base, which provides a graphical windowing system on the SBC. Although you probably won't connect directly to the X11 manager (i.e. by plugging a screen directly into the SBC), X11 also gives a user the ability to forward graphical windows over SSH. You will need the following packages installed:

- `x11-common`
- `xbase-clients`

After installing, make sure that the line in `/etc/ssh/sshd_config` has a line that says:

```
X11Forwarding yes
```

Then log out and log back into the SBC. This second time you log in, use the `-X` switch to turn on X forwarding for that connection:

```
ssh -X root@phidgetsbc.local
```

Then you should be able to run programs that launch a window, and it will launch remotely and appear on the computer you have the SSH connection from.

Pushing Processor Limits

The SBC, though more powerful than many embedded computers out there, is probably about as powerful as your smartphone. If you hook up 1 ms Phidget sampling devices to all six of its USB ports, events and packets will probably get lost. The exact data rates you can accomplish depend on:

- What else is running on the SBC
- How efficient your code is for external operations (like File I/O)
- Other minor details (e.g. the temperature of the SBC, etc)

If you want to achieve data rates as fast as possible, try these tips:

- Program in C, not in an interpreted language (Python, Java, .NET)

- Perform file I/O as little as possible. Locally cache data, manage your writing to a file in a separate thread, and use low-level write calls.
- Change the filesystem to a faster, non-compressed file system.
  - Alternatively, use a high-data-rate USB key.
- Keep other running processes to a minimum.
  - If you are running code locally right on the SBC, turn off the Phidget WebService.

Custom Kernel and Filesystem

You can compile your own kernel and flash it to the board. It is left up to the user to configure an appropriate cross-compiler for kernel development. You may also be able to compile a new kernel on-board. We have a kernel development kit, complete with patch file and README:

- SBC Kernel Development Package [2]

Compiling a new, custom kernel is somewhat complex. If the SBC is your first experience with Linux, writing a custom kernel will be difficult. However, it will probably also be very rewarding because you can put whatever you like into it. We might be able to offer additional suggestions, but ultimately you're on your own here.

You may be able to write a custom kernel right on the SBC, but the easiest way is to develop the kernel on an external computer. And the easiest way to develop on an external computer is for that computer to also be Linux, even just in a Virtual Machine. The time spent loading a copy of Linux into a virtual machine (such as VirtualBox, which is free) onto your computer will probably be less time than setting up a standard compiler on Windows to cross-compile.

On your external Linux system, you will need:

- A cross-compiling toolchain for the ARM processor, which we briefly describe on the main Linux page, and
- The SBC Kernel Development Package [2] from the Phidgets website.

The kernel development kit has a brief README file which describes how to obtain the proper kernel and patch, configure, customize, and build it.

We have an application guide in progress, which walks through building a custom kernel to add Bluetooth support to the SBC. Please contact us if you would like more information. Even if you are trying to add support for hardware other than a bluetooth modem, or wondering if support even exists in the kernel for your modem (3G, alternate wireless, etc) you will probably find the application guide helpful. Follow it up to the point where you run the program `menuconfig` (you don't need an SBC to do this), which will give you a menu of all drivers you can enable in the SBC kernel.

After making your new kernel, you should have a uImage and modules target for your Makefile. At this point you can transfer your kernel files onto the SBC, make their targets, and transfer them into the nand memory. This involves erasing the old kernel, flashing the new kernel, installing the new kernel modules, and rebooting. From the SBC, in the kernel directory:

```
make uImage; make modules
flash-eraseall /dev/mtd3
nandwrite -p /dev/mtd3 arch/arm/boot/uImage
make modules-install
reboot
```

Custom kernels can also be flashed from the Recovery System.

If you need to create a root filesystem image, the filesystem type is UBIFS, and the commands to create it are:

For SBC2:

```
mkfs.ubifs -m 2KiB -e 126KiB -c 4050 -r $ROOTFS/ system_ubifs.img
ubinize -o system_ubi.img -m 2KiB -p 128KiB -s 512 ubinize.cfg
```

Where `ubinize.cfg` contains:

```
# Section header
[rootfs]
# Volume mode (other option is static)
mode=ubi
# Source image
image=system_ubifs.img
# Volume ID in UBI image
vol_id=0
# Volume size
vol_size=64128KiB
# Allow for dynamic resize
vol_type=dynamic
# Volume name
vol_name=rootfs
# Autoresize volume at first mount
vol_flags=autoresize
```

For SBC3:

```
mkfs.ubifs -F -m 4KiB -e 248KiB -c 4000 -r $ROOTFS/ system_ubifs.img
ubinize -o system_ubi.img -m 4KiB -p 256KiB ubinize.cfg
```

Where `ubinize.cfg` contains:

```
# Section header
[rootfs]
# Volume mode (other option is static)
mode=ubi
# Source image
image=system_ubifs.img
# Volume ID in UBI image
vol_id=0
# Volume size
vol_size=83MiB
# Allow for dynamic resize
vol_type=dynamic
# Volume name
vol_name=rootfs
# Autoresize volume at first mount
vol_flags=autoresize
```

You then flash 'system_ubi.img' (not 'system_ubifs.img') from the recovery system.

Again, like the custom kernel creation, the need to create a custom root filesystem is essentially non-existent except for those advanced users who already know they need it... and furthermore, you are almost entirely on your own.

Saving a file system to flash to multiple SBC's

You may want to create a complete backup of your SBC root filesystem, which can then be flashed to other SBCs. This is how it could be done:

You will need a USB flash drive - at least 2GB is recommended. Make sure it's empty, as it will be reformatted.

All of these commands are executed on your SBC, while logged in over SSH.

First, re-format the USB drive as ext3. Assuming the USB drive is sda and has a single partition:

```
umount /dev/sda1
mkfs.ext3 /dev/sda1
mount -t ext3 /dev/sda1 /media/usb0
```

Then, remount / as readonly, so it doesn't change as we're copying it. To do this, we need to kill all running processes except sshd:

```
service udev stop
service ifplugd stop
service rsyslog stop
service avahi-daemon stop
service phidgetwebservice stop
service ntp stop
service busybox-httpd stop
service dbus stop
service cron stop
pkill dhclient
mount -o remount,ro /
```

If the remount says that / is busy, do a 'ps auxww' and 'pkill' anything else that may be running until it remounts properly.

Then, copy / to the flash drive:

```
mkdir /media/usb0/root
mount --bind / /mnt/
cp -a /mnt/* /media/usb0/root/
```

Then, clean up the copy - removing files specific to this board. We also remove the APT cache to save space.

```
find /media/usb0/root/var/log -type f -print0 | xargs -0 rm -f
rm -rf /media/usb0/root/var/lib/apt/lists/*
mkdir /media/usb0/root/var/lib/apt/lists/partial
rm -f /media/usb0/root/var/cache/apt/*.bin
rm /media/usb0/root/etc/udev/rules.d/70-persistent-net.rules
rm /media/usb0/root/etc/ssh/ssh_host_*
```

then, create the ubinize.cfg file:

For SBC3:

```
cd /media/usb0
cat > ubinize.cfg << EOF
[rootfs]
mode=ubi
image=/media/usb0/system_ubifs.img
vol_id=0
vol_size=83MiB
vol_type=dynamic
vol_name=rootfs0
vol_flags=autoresize
EOF
```

For SBC2:

```
cd /media/usb0
cat > ubinize.cfg << EOF
[rootfs]
mode=ubi
image=/media/usb0/system_ubifs.img
vol_id=0
vol_size=64128KiB
vol_type=dynamic
vol_name=rootfs
vol_flags=autoresize
EOF
```

NOTE: you may need to increase vol_size if your filesystem is larger.

then, create the UBI image from the copy:

For SBC3:

```
mkfs.ubifs -F -m 4KiB -e 248KiB -c 4000 -r /media/usb0/root
/media/usb0/system_ubifs.img
ubinize -o /media/usb0/system_ubi.img -m 4KiB -p 256KiB ubinize.cfg
```

For SBC2:

```
mkfs.ubifs -m 2KiB -e 126KiB -c 4050 -r /media/usb0/root
/media/usb0/system_ubifs.img
ubinize -o /media/usb0/system_ubi.img -m 2KiB -p 128KiB -s 512
ubinize.cfg
```

Then, you can remove the /root/ folder and system_ubifs.img. system_ubi.img can be flashed to other SBCs using the recovery system.

Software Details

For even more advanced uses of the SBC, it may help to know the gritty details of the SBC software system.

Operating System

Debian/GNU Linux

Kernel 2.6.X or higher (generally kept up to date with latest releases, use `uname -r` to check the kernel version)

Main Filesystem (rootfs)

UBIFS (a raw flash type of file system)

Mounted in a 460 MB Nand partition (in Read/Write mode)

Kernel

uImage format

Has its own 3MiB partition on bare Nand

Web Interface Scripts and Configuration Data

Located in `/etc/webif`

Modifying these scripts can be done; however, it is very easy to enter invalid data that could cause the system to behave unexpectedly or not boot.

User Applications uploaded through Web Interface

Located in `/usr/userapps`

Webcam Device Location

`/dev/video0`

Numbers increase with more webcams

Date and Time

Set using ntp (network time protocol) at boot

The ntp daemon continues to run in the background and will periodically update the clock

The network keeps the SBC very close to real time

Also there is a real-time clock with battery backup which will preserve date/time across reboots, power removal

The real-time clock is synced to system time during reboot/shutdown

If power is unplugged suddenly, and the network not restored, the real-time clock may not have the correct time

Wireless Networking System

Wireless adapter support for the wireless adapter that Phidgets sells is written into the kernel

It supports WEP and WPA

It is best configured through the configuration interface.

Nand Layout

The board contains 512MiB on Nand. This nand is split into 7 partitions as follows:

0: u-boot size: 256K Read Only

1: u-boot_env size: 128K Read Only

2: recovery_kernel size: 2M Read Only

3: kernel size: 3M Writable

4: flashfs size: ~3.625M Read Only

5: recovery_fs size: ~ 43M Read Only

6: rootfs size: ~ 460M Writable

The final size of flashfs/recovery_fs/rootfs depends on the image size at production, and on the number/location of bad blocks in the NAND.

Note: U-Boot and recovery kernel and filesystem cannot be written from Linux - this is a safety measure.

Boot Loader

U-Boot is used for setting up the processor and booting Linux, and is only accessible via a serial connection.

Normal users will not need to use or modify it.

Be very careful when modifying the u-boot partition. If it is damaged or overwritten, it is difficult to fix.

When using U-Boot, a prompt will appear via serial shortly after power on.

The environment variables will help you determine how to boot Linux on the SBC

You can also refer to the U-Boot documentation [14]

Boot Process

From power on...

1. Processor loads first 4 bytes from NAND into Steppingstone and runs it.

2. Steppingstone sets up RAM, copies u-boot from NAND into RAM and runs U-Boot.

3. U-Boot initializes the processor, sets GPIO state, etc., copies the linux kernel into RAM, sets up the kernel command line arguments, checks that the kernel image is valid, and boots it.

4. Linux boots, bringing up USB, Networking, NAND, etc. and then mounts the rootfs NAND partition on /.

5. init gets run as the parents of all processes, as uses the /etc/inittab script to bring up the system. This includes mounting other filesystems, settings the hostname, and running the scripts in /etc/init.d, among other things.

6. inittab then turns the green LED on.

7. inittab then sets up a getty on the first serial port, ready for interfacing using the debug board.

Common Problems and Solutions

PHP Curl: Curl doesn't install smoothly

There is an issue with the embedded version of PHP5.3, try forcing it to install the specific version that you need. This can be done with the following command:

```
apt-get install php5-common=5.3.3-7+squeeze14
```

FTDI Errors: FTDI adapters do not appear to work with the SBC

The 3.1.6 version of the Linux kernel which is used on some versions of the SBC has a bug that causes issues with FTDI drivers and makes them malfunction. To solve this problem you must upgrade the kernel to a newer version. You can find the files here.

USB Memory Key mounting: Sometimes USB Memory Keys mount at more than one location

When you insert a memory key, the SBC will load it as a device (e.g. `/dev/sda1`) and it will also *mount* the key for reading and writing within the `/media/` directory. The `/media/` directory version will be called something like `usb0`. At times, an inserted memory key will get mounted in more than one location. You can observe if this occurs by checking the currently mounted devices with the command `mount`:

```
root@phidgetsbc:~# mount
tmpfs on /lib/init/rw type tmpfs (rw,nosuid,mode=0755)
proc on /proc type proc (rw,noexec,nosuid,nodev)
sysfs on /sys type sysfs (rw,noexec,nosuid,nodev)
udev on /dev type tmpfs (rw,mode=0755)
tmpfs on /dev/shm type tmpfs (rw,nosuid,nodev)
devpts on /dev/pts type devpts (rw,noexec,nosuid,gid=5,mode=620)
rootfs on / type rootfs (rw)
procbususb on /proc/bus/usb type usbfs (rw)
/dev/sda1 on /media/usb0 type vfat
(rw,noexec,nodev,sync,noatime,nodiratime)
/dev/sda1 on /media/usb1 type vfat
(rw,noexec,nodev,sync,noatime,nodiratime)
```

You will note that the same device (`/dev/sda1`) is now mounted at *both* `/media/usb0` and `/media/usb1`. To fix this problem as it occurs, you can use `umount` (notice there is no letter 'n') to unmount the second instance:

```
root@phidgetsbc:~# umount /media/usb1
```

In practice, this should not be a problem, because writing to or reading from either `usb0` or `usb1` will have the same effect on the memory key. However, if you hard-code a media location into your program (i.e. expecting `/media/usb0` to be the first USB key you insert and `/media/usb1` to be the second key) your program will sometimes work and sometimes fail.

To get around this within code, find the mount point for each device as it appears. The devices, such as `/dev/sda1` will always refer to the actual memory key. But, they cannot be written to directly without being mounted, so you will have to parse the mount table (what is returned from `mount`) within your code to find the device and its corresponding mount point.

This is a problem with the standard embedded Debian automount program, and we have no known fix.

Perl Locale Errors on SSH: No Locales Installed

By default, no locales are installed on the SBC. If you use apt a lot to install and manage your software on the SBC, you will get messages like this:

```
perl: warning: Setting locale failed.
perl: warning: Please check that your locale settings:
      LANGUAGE = (unset),
      LC_ALL = (unset),
      LANG = "en_CA.UTF-8"
    are supported and installed on your system.
perl: warning: Falling back to the standard locale ("C").
locale: Cannot set LC_CTYPE to default locale: No such file or
directory
locale: Cannot set LC_MESSAGES to default locale: No such file or
directory
locale: Cannot set LC_ALL to default locale: No such file or directory
```

To squelch these messages, you should install and reconfigure your locale like this:

```
apt-get install locales
dpkg-reconfigure locales
```

The last command will show you a long list from which you should pick your location, by language. For example, en_CA is english_Canada. Here in Calgary, we use en_CA.UTF-8 and so for the first question we would input locale "114" and for the second (system) question we would input `en_CA` for the locale.

This might give you a locale undefined error, in which case you can generate the locale (for us, again, it is en_CA):

```
locale-gen en_CA
```

References

[1] http://www.phidgets.com/downloads/libraries/phidgetsbc2.bin
[2] http://www.phidgets.com/downloads/libraries/phidgetsbc2-kerneldev.tar.gz
[3] http://www.phidgets.com/downloads/libraries/phidgetsbc3_1.0.0.20121213.bin
[4] http://www.phidgets.com/downloads/libraries/phidgetsbc3-kerneldev_1.0.0.20121213.tar.gz
[5] http://www.chiark.greenend.org.uk/~sgtatham/putty/download.html
[6] http://www.phidgets.com/downloads/libraries/PhidgetsPython.zip
[7] http://www.phidgets.com/downloads/examples/JavaJNI.zip
[8] http://www.phidgets.com/downloads/libraries/libphidget.tar.gz
[9] http://lilliputweb.net/
[10] http://www.ideasonboard.org/uvc/#devices
[11] http://opencv.willowgarage.com/documentation/index.html
[12] http://opencv.willowgarage.com/documentation/reading_and_writing_images_and_video.html
[13] http://www.phidgets.com
[14] http://www.denx.de/wiki/DULG/Manual

Article Sources and Contributors

OS - Phidget SBC *Source*: http://www.phidgets.com/wiki/index.php?title=OS_-_Phidget_SBC *Contributors*: Burley, Cora, Djrudiak, Kat, Mparadis, Patrick, 2 anonymous edits

Image Sources, Licenses and Contributors

File:icon-Linux.png *Source*: http://www.phidgets.com/wiki/index.php?title=File:Icon-Linux.png *License*: unknown *Contributors*: Djrudiak
File:sbc_turn_on_ssh.png *Source*: http://www.phidgets.com/wiki/index.php?title=File:Sbc_turn_on_ssh.png *License*: unknown *Contributors*: Cora
File:sbc_packages_web.png *Source*: http://www.phidgets.com/wiki/index.php?title=File:Sbc_packages_web.png *License*: unknown *Contributors*: Cora
File:sbc_nano_python.png *Source*: http://www.phidgets.com/wiki/index.php?title=File:Sbc_nano_python.png *License*: unknown *Contributors*: Cora
File:sbc_create_project.png *Source*: http://www.phidgets.com/wiki/index.php?title=File:Sbc_create_project.png *License*: unknown *Contributors*: Cora
File:sbc_web_run_project.png *Source*: http://www.phidgets.com/wiki/index.php?title=File:Sbc_web_run_project.png *License*: unknown *Contributors*: Cora
File:sbc_mounted_devices.png *Source*: http://www.phidgets.com/wiki/index.php?title=File:Sbc_mounted_devices.png *License*: unknown *Contributors*: Cora
File:lilliputoff.jpg *Source*: http://www.phidgets.com/wiki/index.php?title=File:Lilliputoff.jpg *License*: unknown *Contributors*: Burley
File:lilliputlogin.jpg *Source*: http://www.phidgets.com/wiki/index.php?title=File:Lilliputlogin.jpg *License*: unknown *Contributors*: Burley
File:lilliputdesktop.jpg *Source*: http://www.phidgets.com/wiki/index.php?title=File:Lilliputdesktop.jpg *License*: unknown *Contributors*: Burley