Community Experience Distilled

Building Networks and Servers Using BeagleBone

Set up and configure a local area network and file server by building your own home-based multimedia server

Bill Pretty Glenn Vander Veer

[PACKT] PUBLISHING open source* community experience distilled

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Over the years, Bill acquired extensive knowledge in the field of technical security and started his own company in 2010. This company is called William Pretty Security Inc. and provides support in the form of research and development to various law enforcement and private security agencies.

Bill has published and presented a number of white papers on the subject of technical security. For a number of years, he was also a guest presenter at the Western Canada Technical Conference, a law enforcement-only conference held every year in western Canada. A selection of these papers is available for download from his website.

There are a number of people that I would like to thank, as without their support, this book would never have been completed. I would also like to thank my good friends at Packt Publishing for having patience and trust in me once again. Thanks to my partner in life, Donna, who never stopped believing in me.

Last but not least, I would like to thank my good friend and fellow code warrior Glenn "the flying Dutchman."

Glenn Vander Veer has been an embedded firmware developer for various microprocessors and microcontrollers for the past 20 years. He has been tinkering with electronics and all types of computers for over 30 years now. His interests lie in computer security, audio and video development, and tinkering with various operating systems. This is Glenn's first book, but definitely not his last.

I would like to thank Bill for bringing me in on this project.

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I would like to thank all the wonderful people that I have been blessed to have in my life, for all the laughter, tears, and everything in between.

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Thanks for giving me the opportunity to join the review process of the book and to the author and coordinator for their contribution to this book. A huge thanks to one of my mentors, Mr. Abe at Info Circus, Inc., because I developed my career with his guidance in the first company where I worked and met him.

Jaime Soriano Pastor was born in Teruel, a small city in Spain. He has always been passionate about technology and sciences. While studying computer science at a university in his hometown, he had his first encounter with Linux and free software, which deeply shaped his career. Later on, he moved to Zaragoza to continue his studies. There, he worked for a couple of companies on different and interesting projects, from operative systems in embedded devices to the cloud, giving him a wide view on several fields of software development as well as some opportunities to travel around Europe. Currently, he lives in Madrid, and automation, configuration management, and continuous integration form a part of his daily work at a well-known technology company.

Justin Smith has a degree in computer science from Tennessee Technological University and is currently a systems and solutions integrator for an industrial IT firm in Nashville, Tennessee. He develops core software to interface with third-party hardware and software and has been introducing the software as modules into LabVIEW of late. Primarily a Java developer, Justin has been using open source tools to allow the code to be run from within LabVIEW.

Growing up around computers in the 80s, Justin has always known that he wanted to pursue a career in computing. Working as an intern in college and spending over a year in Central Mexico for his company, he realized all of the good that can be done by helping improve industrial processes (safety, quality, and efficiency). This made him decide that he wanted to continue working in industrial IT and automation, as he also feels that manufacturing and industry have yet to see the same technological revolutions as other business sectors through advances in companies such as Facebook and Google.

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Norbert Varga has over 5 years experience in the software and hardware development industry, and he is responsible for embedded software development, hardware-software integration, and wireless telecommunication solutions at his current employer, BME-Infokom Innovátor Non-profit Ltd.

He has extensive experience in networking and hardware-software integration; he has engineered advanced systems, including wireless mesh networks and smart metering solutions. He also has a strong background in Linux system administration and software development.

Previously, Norbert worked as a software developer on various projects at the Budapest University of Technology and Economics (Department of Telecommunications), which is the most renowned technical university in Hungary. He played a key role throughout all the development processes, ranging from initial planning through implementation to testing and production support.

He has a personal blog, where he writes about his current projects (`http://nonoo.hu/`).

He has worked on several books by Packt Publishing, such as *BeagleBone for Secret Agents* and *Building a Home Security System with BeagleBone*.

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This book is dedicated to the brave men and women from all corners of the civilized world who watch over us so that we may "sleep peacefully in our beds."

Thank you and stay safe.

-- Bill Pretty

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Preface

Learn how to build and configure your own network based on the BeagleBone. You will do this in a fun and informative way that will not only teach you networking skills but also result in an impressive project.

What this book covers

Chapter 1, *Installing Debian onto Your BeagleBone Black*, introduces how to install Debian onto your BeagleBone. There are two ways to boot the BeagleBone and run the OS.

Chapter 2, *Installing and Configuring Multimedia Server Software*, serves as an installation guide for the software that will be used to store the streamed video and to serve up both the audio and video files to any device on the network, either BB, computers, or tablets/phones.

Chapter 3, *Installing and Configuring Network Monitoring Software*, acts as an installation guide for the software that will be used to monitor the traffic on your local network.

Chapter 4, *Installing and Setting Up a BeagleBone RAID System*, acts as an installation guide for the software that will be used to create a RAID array out of the partitions that you will create on your USB-connected drives.

Chapter 5, *Streaming Videos*, will show you how to set up both live and recorded video streaming, using a web-based application.

Chapter 6, *Setting Up a Wireless Access Point*, shows you how to install and set up a wireless access point or WAP on your BeagleBone system.

What you need for this book

The following is a list of the suggested hardware for those of you who wish to build the entire system described in this book. Additional information has been outlined in the applicable chapters.

- **Two identical USB 2 memory sticks**: These should be at least 2 GB in size. The actual size depends on the amount of multimedia data you intend to store.
- **A Beagle Bone compatible USB 2 WiFi adapter**: There is a list of compatible adapters available at `www.beaglebone.org`.
- **A four-port USB 2 hub**: Depending on the output power of your WiFi adapter, a powered hub may be required.
- **An 8 GB, series 10, uSD card**: This is used to boot the root file system.
- **Win32DiskImager**: This is available with a search engine search. This will install the Debian image onto the uSD card.

Two memory sticks from the same manufacturer and same model number.

Who this book is for

This book is for beginners to intermediate readers who wish to learn more about how Linux networks are configured. You will learn this in a fun and informative way that will provide you with a finished product that you can enjoy and the skills to make improvements if you wish.

Conventions

In this book, you will find a number of text styles that distinguish between different kinds of information. Here are some examples of these styles and an explanation of their meaning.

Code words in text, database table names, folder names, filenames, file extensions, pathnames, dummy URLs, user input, and Twitter handles are shown as follows: "Once `fdisk` is running, enter `p` as the first command."

A block of code is set as follows:

```
### Wireless network name ###
interface=wlan0
### Set your bridge name ###
#bridge=br0
```

When we wish to draw your attention to a particular part of a code block, the relevant lines or items are set in bold:

```
#
DAEMON_CONF="/etc/hostapd/hostapd.conf" ß Add this line

# Additional daemon options to be appended to hostapd command:-
```

Any command-line input or output is written as follows:

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

New terms and **important words** are shown in bold. Words that you see on the screen, for example, in menus or dialog boxes, appear in the text like this: "It will be displayed as an **Open** network."

Warnings or important notes appear in a box like this.

Tips and tricks appear like this.

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1
Installing Debian onto Your BeagleBone Black

In this chapter, you will learn how to install Debian onto your BeagleBone. There are two ways to boot the BeagleBone and run the OS: the first way is to run off the microSD card, and the second is to run off the internal eMMC (flash). BeagleBone has 4 GB of onboard flash, which is not expandable. It is recommended that the microSD be used so that there is ample room left for you to install other programs that will be needed later in the book, and this is what will be shown in this chapter. In order to install the OS, you require a microSD card (an 8 GB card will be fine), an SD card reader (which most laptops have built-in), and the Windows program Win32 DiskImager. This program will write the actual OS image to the SD card, which the BeagleBone will boot from. An archival program, such as WinRAR or 7-Zip, is also needed to extract the OS image from the downloaded archive.

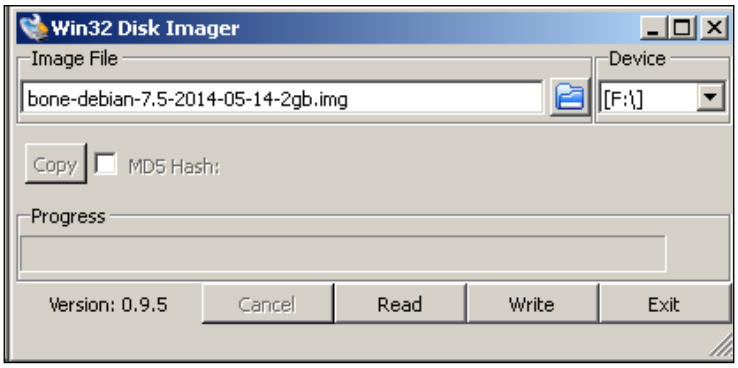
Setting up to install Debian

At this point, you should install Win32 DiskImager and the archival program. This will be used to write the Debian image on the SD card. The archive for the disk image is located at `http://beagleboard.org/latest-images` and `http://debian.beagleboard.org/images/bone-debian-7.8-lxde-4gb-armhf-2015-03-01-4gb.img.xz`.

In order to start the installation, perform the following steps:

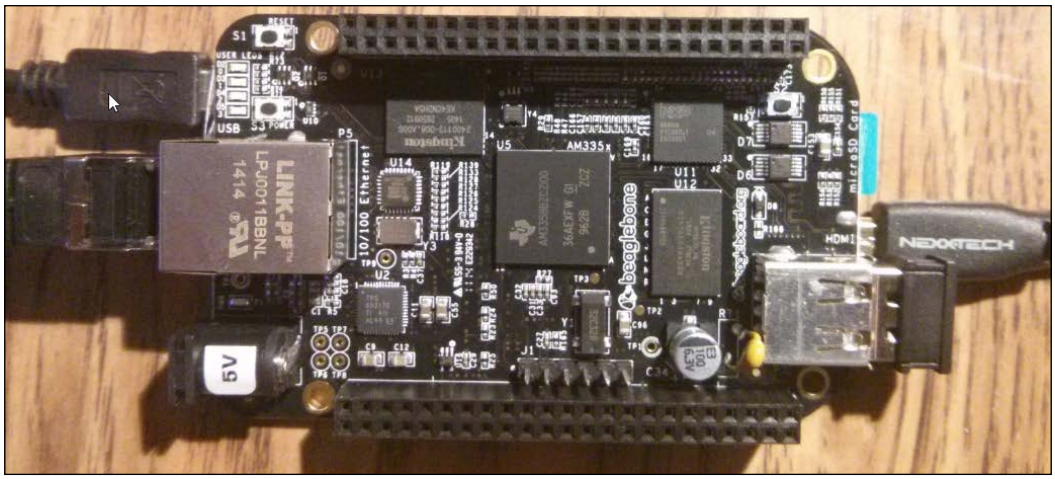
1. Extract the files from this archive and run **Win32 Disk Imager**. If you are using Windows 7 or higher, you will have to run the program as an administrator in order to write the Debian image to the SD card.

2. Select the extracted image file using the blue-colored folder icon, and make sure that the device selected to be written to (`F:\` in the following picture) is your SD card.
3. Click on write and the image will be written to the SD card, as shown in the following screenshot:



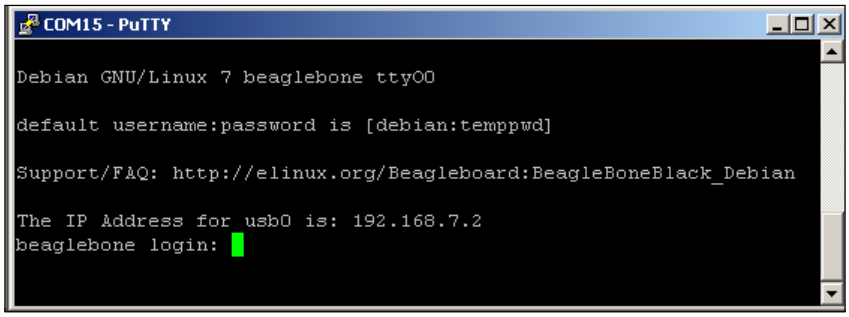
4. Once the image is written to the SD card, remove the card from the PC and insert it into the SD card slot on the BeagleBone.

The following image shows the BeagleBone board with HDMI, Ethernet, and USB installed and an SD card inserted:



At this point, the board is ready to be powered up and to run Debian. The USB cable may not have enough capacity to power the BeagleBone board, so it is strongly suggested that the board be powered by a 5-volt DC power cube with a current output of 2 amps. This will provide sufficient power to the board. Turn on the power to the board. If the board does not power up, press *S3* to enable the power. *S3* is located directly above the Ethernet connection. After about a minute, your screen should display a login prompt. If this does not happen, power off the board and hold down the boot button (located near the top-right corner of the board, close to the SD card); then apply power to the board and don't release the boot button until the user LEDs begin to flicker.

The following screenshot shows the display that you will get after you log in for the first time:



In order to login, the username is `debian` and the password is `temppwd`. The next thing that needs to be done is to get all the updates that are available, and then the image should be resized in order to use the entire 8 GB of the SD card. In order to update, the following commands should be run:

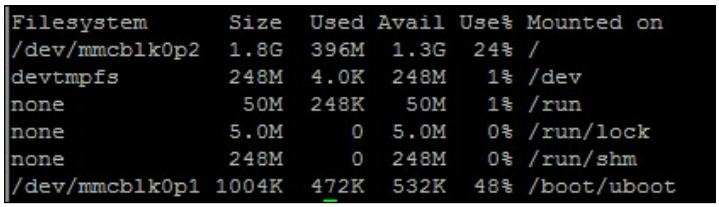
```
sudo apt-get update
sudo apt-get upgrade
sudo apt-get dist-upgrade
```

All of these three commands can be run at the same time by inserting `&&` between each command. After the update is completed, reboot the board (`sudo reboot`) and relogin. At this point, the image will be resized to use the entire size of the SD card.

Before the resizing operation, run the following command to show how much of the SD is being used:

```
df -h
```

The following screenshot shows the output of the `df -h` command:



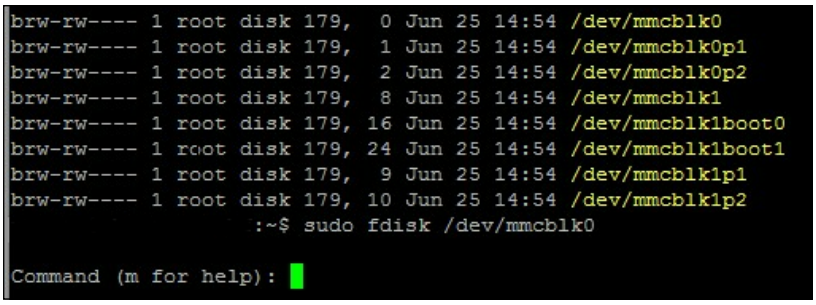
Using the SD card before the resizing operation

First, list the volumes that are available on the SD card by running the following command:

```
ls -l /dev/mmcblk*
```

The output will show all the volumes, as shown in the following screenshot. The volume that will be modified is the first volume in the list, `/dev/mmcblk0`. This is because `mmcblk0` refers to the SD card.

A list of all the available volumes is shown in this screenshot.



At this point, the superuser should be logged in to complete the disk resizing, by executing the following command:

```
sudo su
```

Again, the password is `temppwd`. Once the superuser is active, run `fdisk` on the first volume with the following command (also shown in the preceding screenshot):

```
fdisk /dev/mmcblk0
```

Once `fdisk` is running, enter `p` as the first command. This will display the partition information of the SD. The resizing operation will delete the empty partitions and expand the primary partition to use the entire SD.

First, press `d` for delete and then press `2` for partition 2. Next, press `n` for new, `p` for primary, and `2` for partition 2. Specify the start and end sectors for the new partition—just select the default values by pressing *Enter*. In fact, outside the first `n`, they are all default choices and pressing *Enter* alone to confirm the choice is all that is needed. Select `w` to commit the changes to the SD card. Notice that the partition table in this example was "busy," so a reboot is needed for the changes to be reflected. Reboot by entering `sudo reboot` from the terminal command line, and re-login to update the changes for the next step of resizing the filesystem.

As we can see in the following image, the resized partition is ready to have the file system resized onto it.

```
root@beaglebone:~# fdisk /dev/mmcblk0

Command (m for help): p

Disk /dev/mmcblk0: 8035 MB, 8035237888 bytes
4 heads, 16 sectors/track, 245216 cylinders, total 15693824 sectors
Units = sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disk identifier: 0x00000000

        Device Boot      Start         End      Blocks   Id  System
/dev/mmcblk0p1   *        2048      198655       98304    e  W95 FAT16 (LBA)
/dev/mmcblk0p2          198656     7577599     3689472   83  Linux

Command (m for help): d
Partition number (1-4): 2

Command (m for help): n
Partition type:
   p   primary (1 primary, 0 extended, 3 free)
   e   extended
Select (default p): p
Partition number (1-4, default 2): 2
First sector (198656-15693823, default 198656):
Using default value 198656
Last sector, +sectors or +size{K,M,G} (198656-15693823, default 15693823):
Using default value 15693823

Command (m for help): w
The partition table has been altered!

Calling ioctl() to re-read partition table.

WARNING: Re-reading the partition table failed with error 16: Device or resource
 busy.
The kernel still uses the old table. The new table will be used at
the next reboot or after you run partprobe(8) or kpartx(8)
Syncing disks.
```

Now the file system is ready to be resized. This will take only one command, as follows:

```
resize2fs /dev/mmcblk0p2
```

After this command, the SD card will have all its space available to the OS. Running another `df -h` command will confirm that the new disk size is now much more than 2 GB.

The following screenshot shows the new file system on the SD card, which resulted from running the `resize2fs` command:

```
root@beaglebone:~# sudo resize2fs /dev/mmcblk0p2
resize2fs 1.42.5 (29-Jul-2012)
Filesystem at /dev/mmcblk0p2 is mounted on /; on-line resizing required
old_desc_blocks = 1, new_desc_blocks = 1
The filesystem on /dev/mmcblk0p2 is now 1936896 blocks long.

root@beaglebone:~# df -h
Filesystem      Size  Used Avail Use% Mounted on
rootfs          7.3G  1.8G  5.2G  26% /
udev             10M     0   10M   0% /dev
tmpfs           100M  648K   99M   1% /run
/dev/mmcblk0p2  7.3G  1.8G  5.2G  26% /
tmpfs           249M     0  249M   0% /dev/shm
tmpfs           249M     0  249M   0% /sys/fs/cgroup
tmpfs           100M     0  100M   0% /run/user
tmpfs           5.0M     0  5.0M   0% /run/lock
/dev/mmcblk1p1   96M   72M   25M  75% /media/boot
/dev/mmcblk0p1   96M   64M   33M  67% /media/BEAGLEBONE
/dev/mmcblk1p2  3.4G  1.5G  1.8G  45% /media/rootfs
root@beaglebone:~#
```

Installing Tightvnc

In order to remotely access the BeagleBone, the **Tightvnc** server needs to be installed with the following command:

```
sudo apt-get install tightvncserver
```

Once the server is installed, it needs to be set up as follows:

```
tightvncserver :1
```

This will then ask for a password to access the desktop. Enter a password and verify it. This will be the password used to login to the BeagleBone with the VNC remote viewing client. If a remote connection is needed, to view what is happening on the BeagleBone, a separate password can be entered.

```
root@beaglebone:~# tightvncserver :1

You will require a password to access your desktops.

Password:
Verify:
Would you like to enter a view-only password (y/n)? n
xauth:  file /root/.Xauthority does not exist

New 'X' desktop is beaglebone:1

Creating default startup script /root/.vnc/xstartup
Starting applications specified in /root/.vnc/xstartup
Log file is /root/.vnc/beaglebone:1.log
```

After the server is set up, reboot and re-login. Open a terminal and enter the following command to get the IP address of the BeagleBone:

`ifconfig`

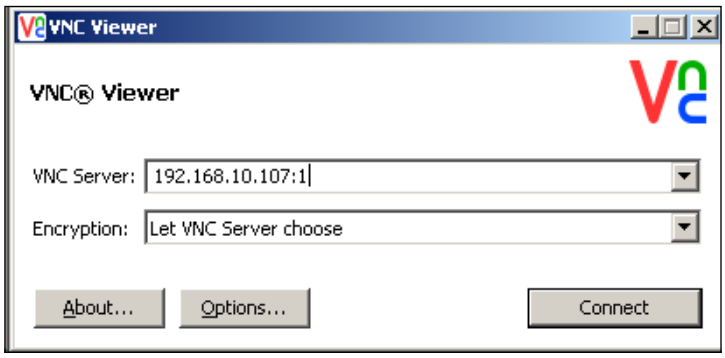
This will be needed on the remote PC to access the system.

```
root@beaglebone:~# ifconfig
eth0      Link encap:Ethernet  HWaddr 1c:ba:8c:96:51:41
          inet addr:192.168.1.13  Bcast:192.168.1.255  Mask:255.255.255.0
          inet6 addr: fe80::1eba:8cff:fe96:5141/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:414 errors:0 dropped:3 overruns:0 frame:0
          TX packets:160 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:71155 (69.4 KiB)  TX bytes:23851 (23.2 KiB)
          Interrupt:40

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: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 62:19:c1:67:36:05
          inet addr:192.168.7.2  Bcast:192.168.7.3  Mask:255.255.255.252
          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)
```

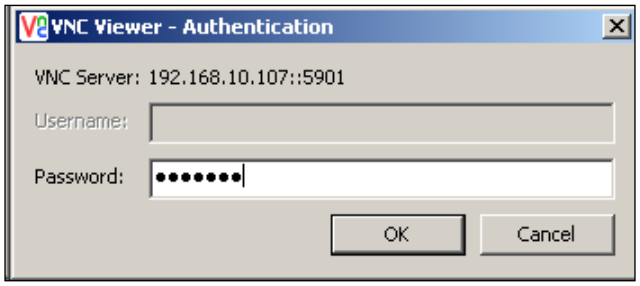
Run the VNC server in order to allow the BeagleBone to start accepting remote connections with the `tightvncserver :1` command.

On the remote computer, a VNC viewer should be installed. There are many options to choose from, which will work. In the remote address, enter the BeagleBone's IP address and add the `:1` at the end and connect to the BeagleBone.

When you run the VNC viewer, you will see a "connection" screen similar to the one shown in the following screenshot:



The default encryption method is to let VNC choose, so just go with the default. The next window that pops up will be the login window, where you have to enter the password that you were prompted for when you installed the VNC Server, as shown in the following screenshot:

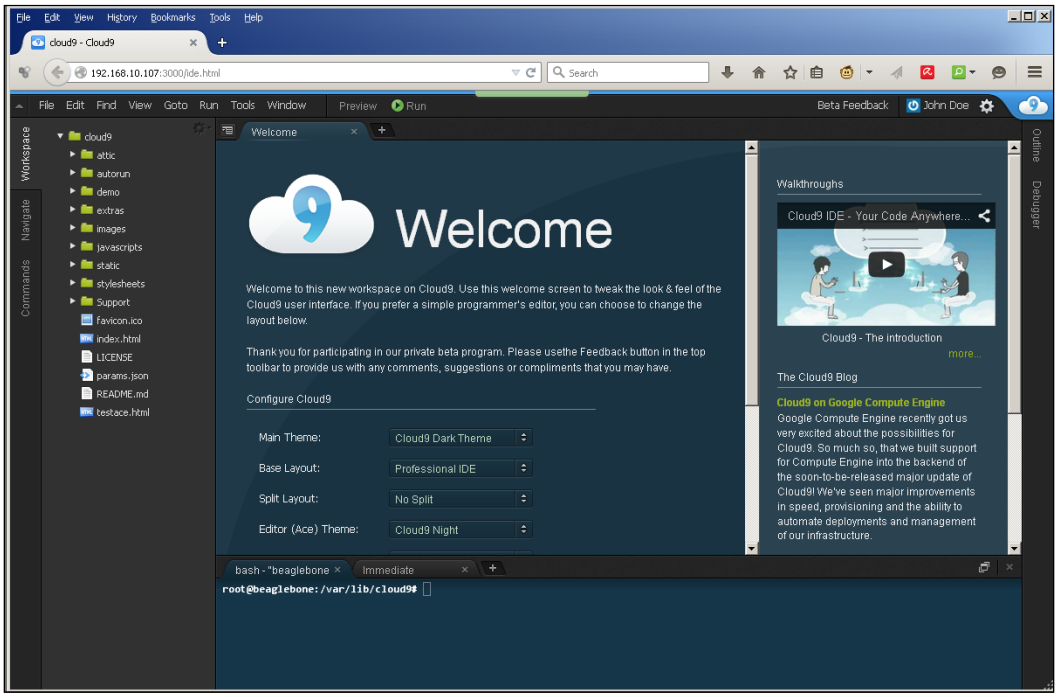


Downloading the example code

You can download the example code files from your account at `http://www.packtpub.com` for all the Packt Publishing books you have purchased. If you purchased this book elsewhere, you can visit `http://www.packtpub.com/support` and register to have the files e-mailed directly to you.

Running the Cloud9 IDE

Fortunately for us, the good folks who maintain the Debian image files have included the Cloud9 IDE in the standard image. For those of you who don't know what an IDE is, the letters stand for **Integrated Development Environment**. Cloud9 allows you to write and debug various types of source code. In order to access Cloud9, you have to simply enter the IP address of the BeagleBone in your favorite web browser followed by `:3000`, because Cloud9 uses port 3000.



Summary

In this chapter, the BeagleBone was set up to run Debian on a resized SD card. The image was also updated to get the latest upgrades available. Then, the LXDE desktop environment was installed. Finally, the Cloud9 IDE was set up and run. Now, the BeagleBone is ready to build the applications needed to control the devices discussed in the later chapters. In the next chapter, we will talk about the software that will be used to store streamed video, and serve up both audio and video files to any device on the network.

2
Installing and Configuring Multimedia Server Software

This chapter will serve as an installation guide for the software that will be used to store streamed videos and to serve up both the audio and video files to any device on the network, either BB or computers or tablets/phones. However, first some "housekeeping" needs to be done to the packages that were installed in the last chapter. For this, we will do the following:

- Set up the BeagleBone to have a static IP.
- Start the VNC server as soon as the BeagleBone is powered on.
- Set the time and date to their proper values and to automatically update via NTP time servers.
- After the housekeeping, download and set up Samba for the BeagleBone. Samba is going to be used because it is easy to configure and maintain. This will be used to load the MP3 files into their proper shared directory and for the video streaming to store the video files for playback later.
- Download and set up the DLNA server software for the BeagleBone. This will allow the audio and video files to be browsed and *served* to other devices on the network.

Setting up a static IP on the BeagleBone

First, display the contents of the `/etc/network/interfaces` file. Run the following command:

```
cat /etc/network/interfaces
```

If the board is configured to use DHCP services (the default configuration), `dhcp` appears at the end of the following line:

```
iface eth0 inet dhcp
```

If the board is configured to use static IP settings, `static` appears at the end of the line instead of `dhcp`.

The following screenshot shows the output of the `cat /etc/network/interfaces` command:

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

# loopback network interface
auto lo
iface lo inet loopback

# primary network interface
auto eth0
iface eth0 inet dhcp
#hwaddress ether DE:AD:BE:EF:CA:FE

# wireless network interface
#auto wlan0
#iface wlan0 inet dhcp
#   wpa-ssid "my_wifi_name"
#   wpa-psk  "my_wifi_pass"
```

Now, create a backup of the `/etc/network/interfaces` file by running the following command:

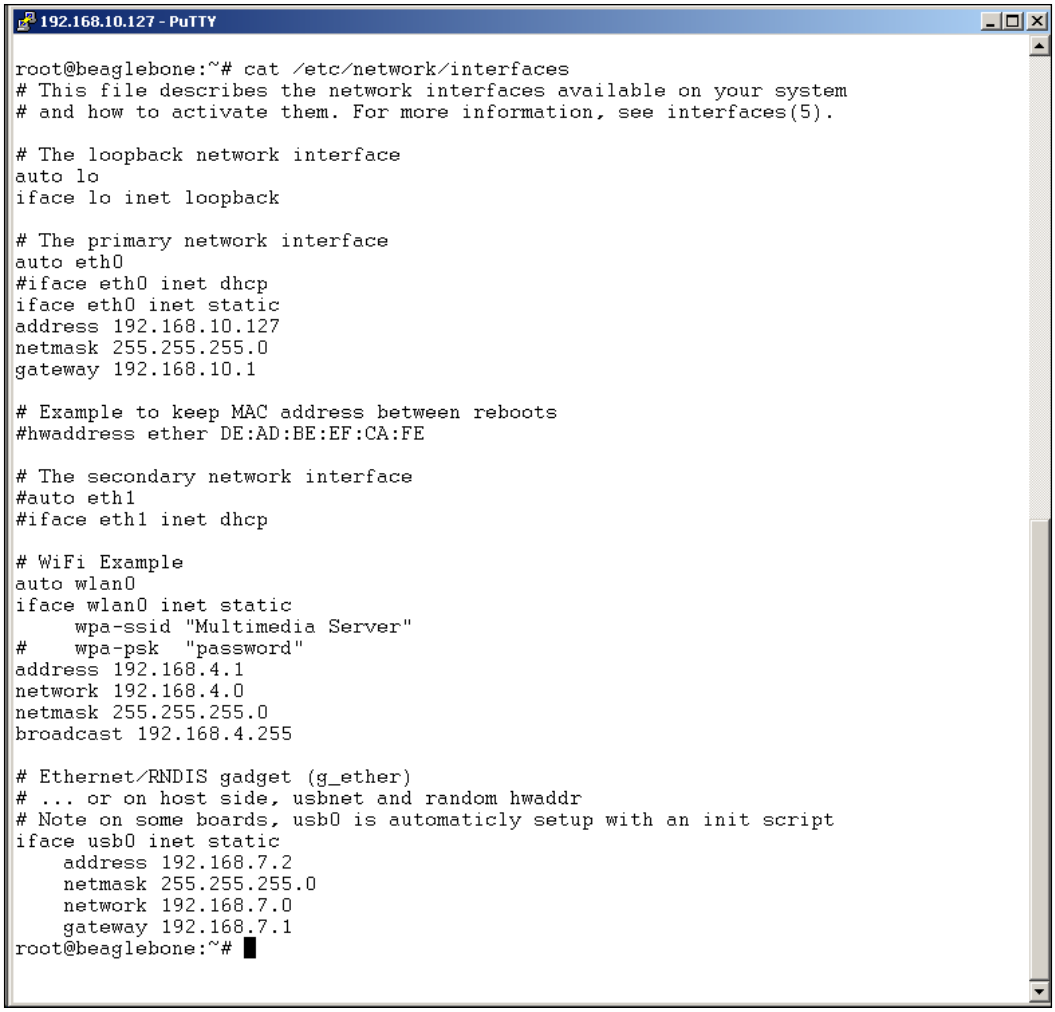
```
sudo cp /etc/network/interfaces /etc/network/interfaces.backup
```

Now, edit the `interfaces` file with nano, as follows:

```
iface eth0 inet dhcp
```

Change the preceding command line to this:

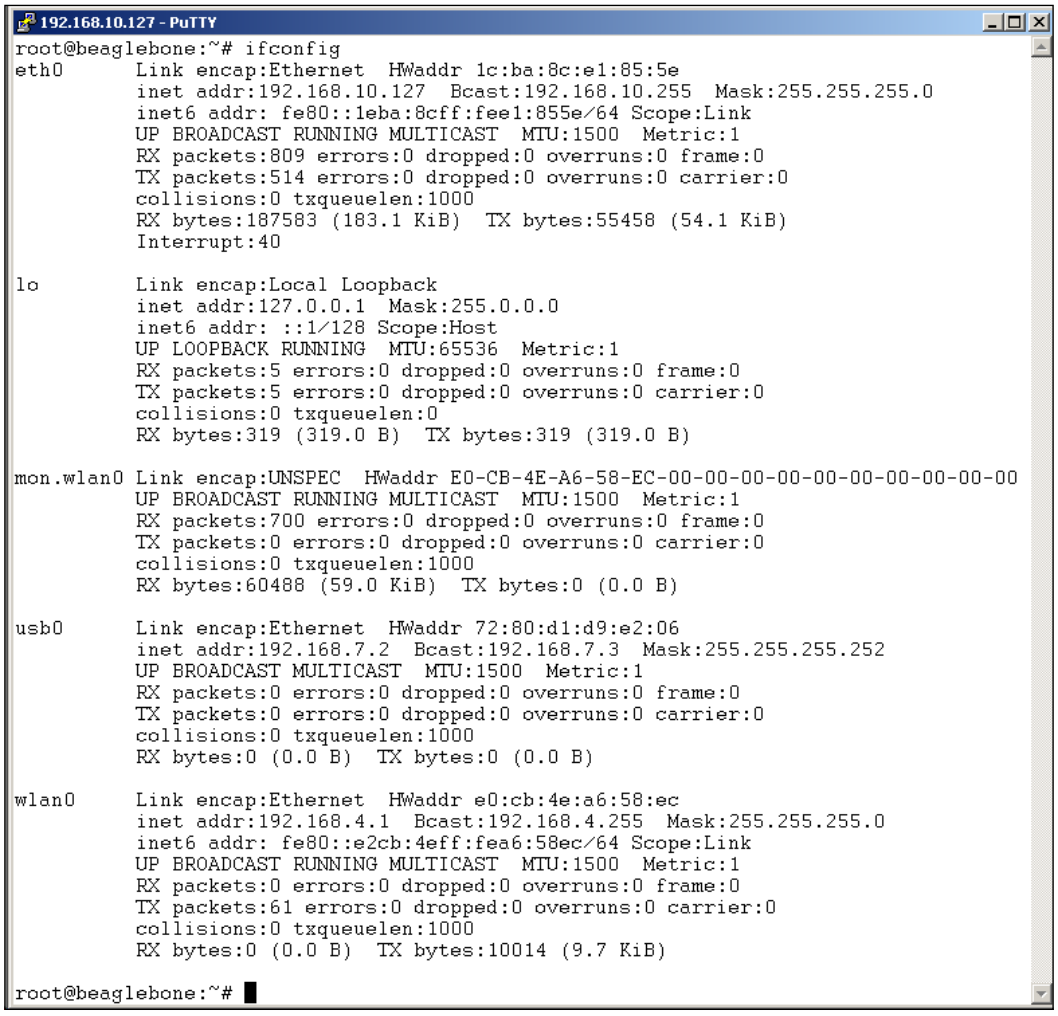
```
iface eth0 inet static
```



Now, enter the following command in the terminal:

```
ifconfig
```

On the command line, you will see something similar to what is shown in the following screenshot:

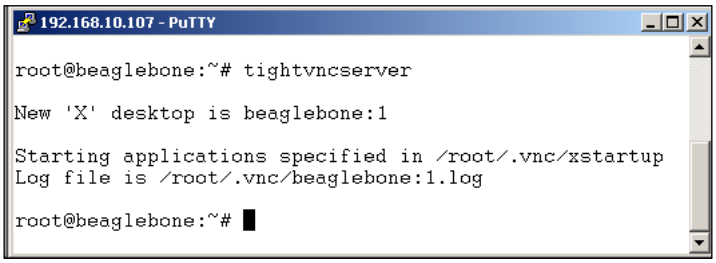


Starting the VNC server

To start the VNC server after booting and logging in, we just SSH to the multimedia server and enter the following command:

```
tightvncserver
```

The terminal will display the following response:



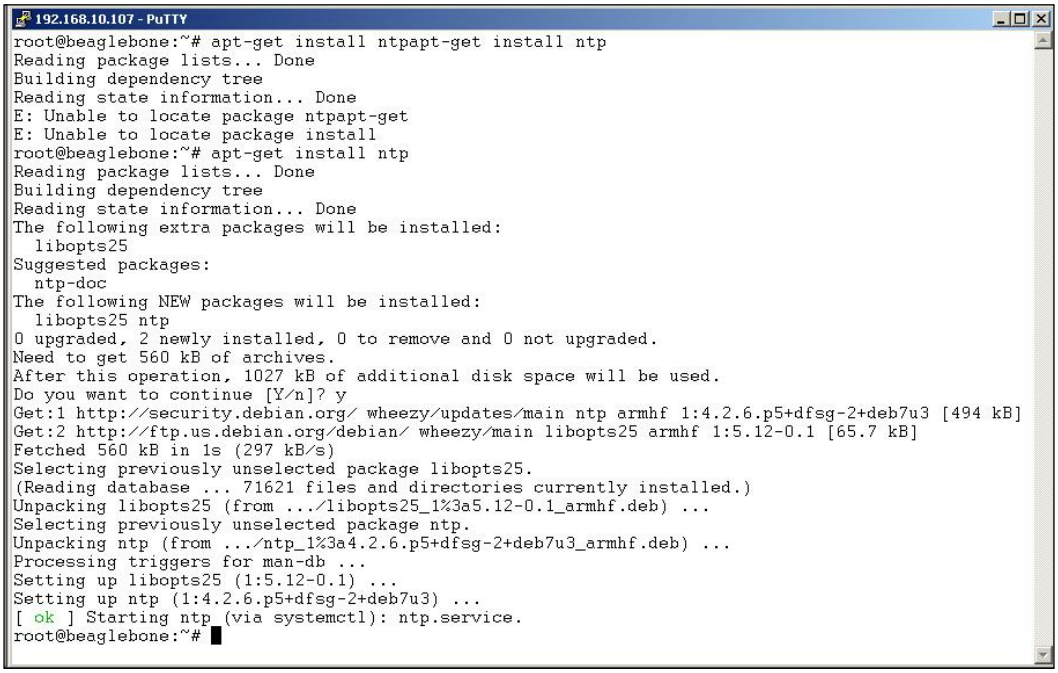
You can now access the multimedia server's desktop from your PC or Mac.

Installing NTP

Every time the board is powered, the clock is reset. This can be inconvenient when using a source code repository; therefore, the **Network Time Protocol** (**NTP**) will be installed and set up so that the board updates to the current time and date on power up. To install NTP, run the following command:

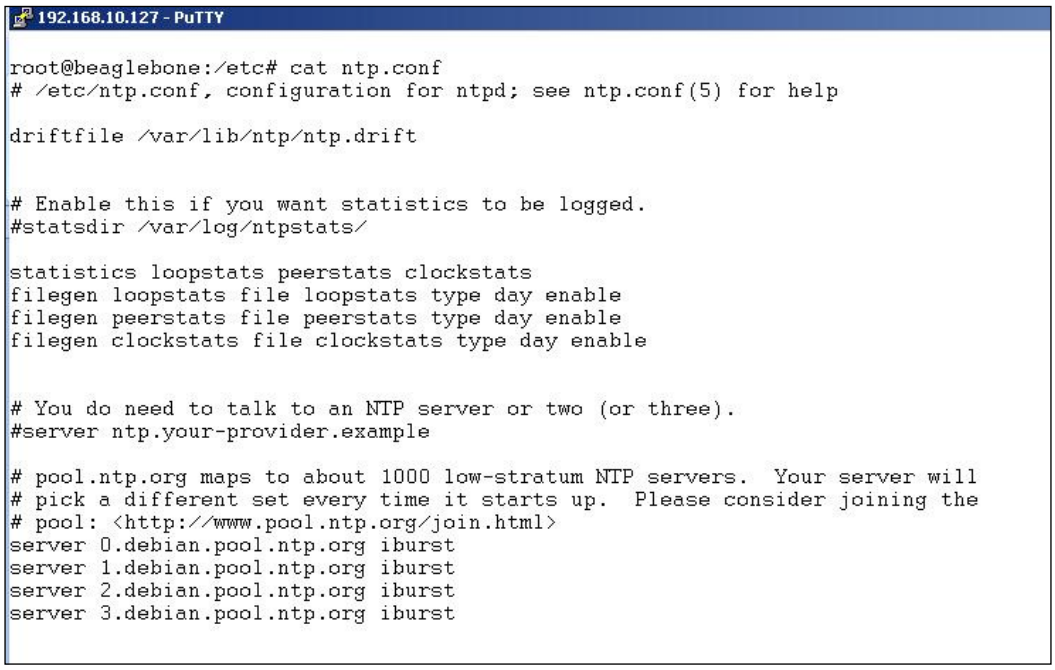
```
sudo apt-get install ntp
```

Here's the output of the NTP `install` command:



Setting the local time zone

Once NTP is installed, a local time server should be set to offload the requests from global time servers. This is done by editing the `/etc/ntp.conf` file and replacing one or more of the default servers with a local time server that can be found via a web search. The following is an example `ntp.conf` file:

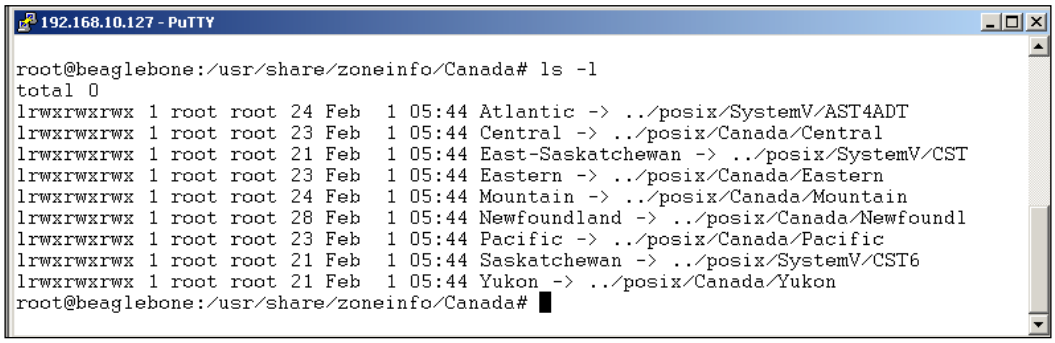


The local time zone should be set as well, and there are two ways of achieving this. First, by running this command:

```
sudo dpkg-reconfigure tzdata
```

This will set the time zone, or by making a symbolic link to the proper time zone settings file, which is located in `/usr/share/zoneinfo`.

This is what the time zone data for Canada looks like:



To set the local time zone, first remove the default `localtime` file with the following command:

```
sudo rm /etc/localtime
```

Then, create a link to the `localtime` file that is closest to the time zone that you are in, with the following command:

```
sudo ln -s /usr/share/zoneinfo/Canada/Eastern /etc/localtime
```

This finishes up the housekeeping that needs to be done. Reboot the BeagleBone to get the new setup.

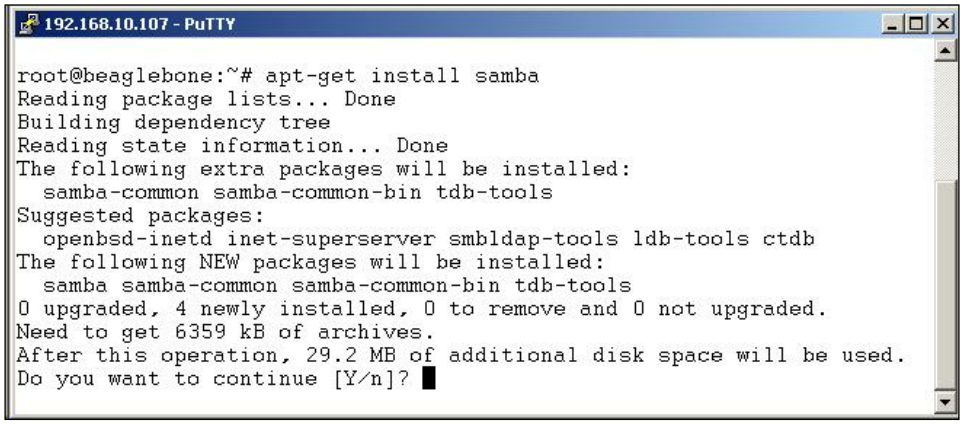
Installing and configuring Samba

Samba is a very convenient application to have running for a home media server, as it allows easy access to files from other computers on the local network. Here, Samba is configured to be used with authentication and authorization. In other words, a username and password must be used in order to access Samba's shared folders from any network connection. In order to access the folders, they will be *mapped* to a local drive on the non-BeagleBone system. Then, the Samba share will appear as a local drive on the non-BeagleBone system, even though it is actually a folder on the BeagleBone. On the Windows operating system, this is easily accomplished by the **map network drive** option. This option is available by right-clicking on the shared folder in a **File Explorer** window.

To install samba, use the following command:

```
sudo apt-get install samba
```

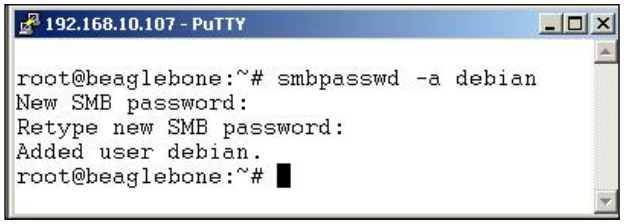
Sometimes, there are extra packages that need to be installed in addition to the package you want to install. After reading the details of these packages, select `Y` to continue, as shown in the following screenshot:



Now, a password is needed to access the server from other remote clients. The user will be the default user (`debian`). To set the password, run the following command:

```
sudo smbpasswd -a debian
```

The following screenshot shows how to set the **SMB password** for the debian user:



Now, `/etc/samba/smb.conf` will be changed to increase security and remove some unnecessary settings.

First, ensure that the Samba shares can only be accessed by devices on the local network by restricting the IP addresses that Samba will respond to. This is done by adding the following lines in the `#### Networking ####` section:

```
hosts allow = 127.0.0.1 192.168.1.0/24
hosts deny = 0.0.0.0/0
```

Make sure that the `hosts allow` line reflects your local network settings. Your local subnet may be different from the `X.X.1.0/24`, as shown in the previous command.

Next, make sure that the following line is present and uncommented in the `#######` `Authentication` `#######` section:

```
security = user
```

This will ensure that the only people who can access Samba shares are those who have a valid Debian account on the BeagleBone.

Now, you need to comment out any of the lines pertaining to `printers` because the BeagleBone is not going to be attached to any.

Anything in the `;[printers]` section should be commented out with a ";".

Later on in *Chapter 4*, *Installing and Setting Up a BeagleBone RAID System*, when the external **RAID array** is attached, the `smb.conf` file will need to be edited and the Raid array will need to be entered in to allow access over Samba.

This entry will then become the "mapping" point on the non-BeagleBone system and will appear as a local drive. This will be where the video, audio, and pictures will be stored.

To do this, the following lines are entered:

```
#Share for the Raid array
[media]
  Comment= Raid array connected to BeagleBone
  path = /media/<Raid mount point>
  read only = no
  browseable = yes
  valid users = <debian>
```

Now, enter the `reboot` command to restart Linux.

Installing the DLNA server

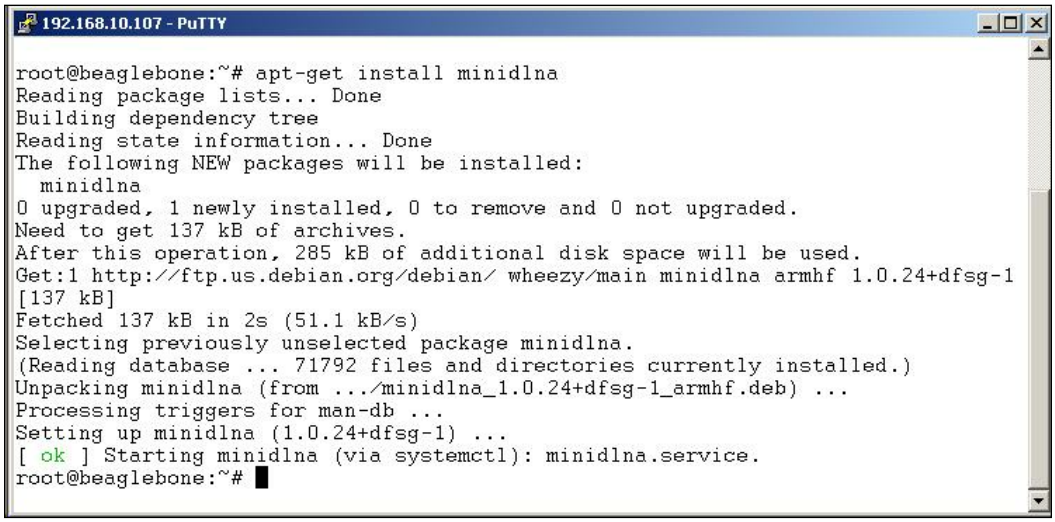
Digital Living Network Alliance (**DLNA**), which is a group of organizations that have created an industry-wide standard, enables all DLNA devices to share media over a home network. Once a device is connected to a DLNA server, media content can be accessed with minimum hassle so that movies, music, or digital photos are available to be played on game consoles, tablets, mobile phones, and televisions.

This content will be loaded by remote machines using the Samba shares that have been mapped as part of their filesystem. Once the network and server is set up, content can be added and viewed at anytime, anywhere on the local network.

Now, the DLNA server will be installed with the following command:

```
sudo apt-get install minidlna
```

Installing the DLNA server will have extra packages that need to be installed in addition to the package you want to install. After reading the details of these packages, select `y` to continue, as shown in the following screenshot:



Once the server is installed, its settings can be modified by editing `/etc/minidlna.conf`. Once again, the entries in this file will be done later on when the external Raid array is set up and attached. This last section of the chapter should be bookmarked so that it can be easily found when that time comes.

Edit the file to add the `media` directories; at the end, it will have the uncommented lines, which might look like this:

```
$ grep -o "^[a-z].*" /etc/minidlna.conf
port=8200
media_dir=V,/home/user/media/Movies
media_dir=A,/home/user/media/Music
media_dir=P,/home/user/media/Pictures
friendly_name=BeagleBone DLNA Server
```

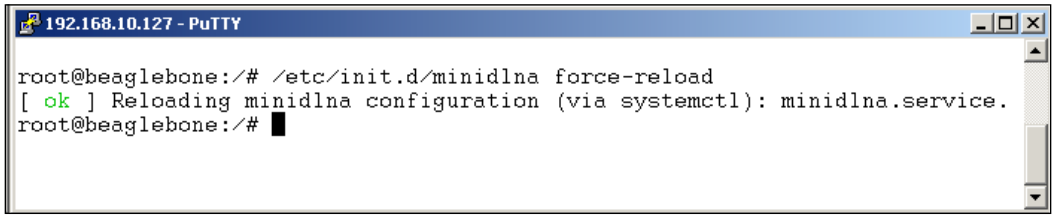
```
album_art_names=Cover.jpg/cover.jpg/AlbumArtSmall.jpg/albumartsmall.jpg/
AlbumArt.jpg/albumart.jpg/Album.jpg/album.jpg/Folder.jpg/folder.jpg/
Thumb.jpg/thumb.jpg
inotify=yes
enable_tivo=no
strict_dlna=no
notify_interval=900
serial=12345678
model_number=1
```

The `media` directory entries will be the entries that are changed to match the mounted directories on the Raid array.

After saving the `.conf` file, the DLNA server needs to be forced into rescanning the new folder locations for media files. This is done with the following command:

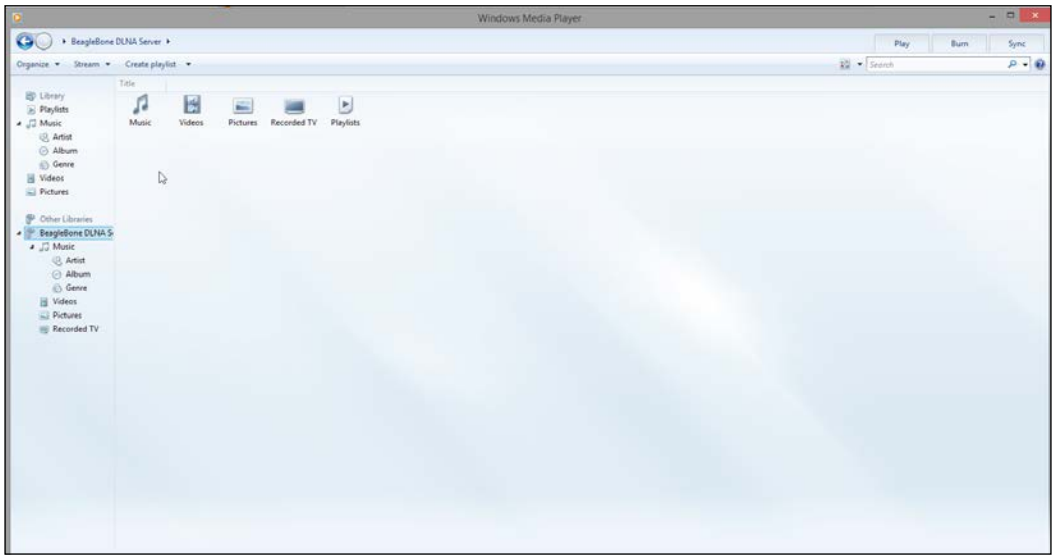
```
sudo /etc/init.d/minidlna force-reload
```

The following screenshot shows the `force-reload` command to refresh the server:



Now, the DLNA server is running and can be browsed with any DLNA-aware device or media player. All that is needed now is the Raid array to store the media files and the content to fill up the array.

Here's the BeagleBone displayed in **Windows Media Player**:



Summary

In this chapter, the BeagleBone was set up to update the time and date via NTP. It was also configured to automatically start the VNC server so that an external keyboard, mouse, and display will not be needed to control the BeagleBone. Next, Samba was installed to allow access to the yet to be connected Raid array, and a DLNA server was installed in order to serve up audio, video, and pictures to the properly authenticated user.

In the next chapter, we will talk about the software needed to secure the network from any unauthorized use.

3
Installing and Configuring Network Monitoring Software

This chapter will serve as an installation guide for the software that will be used to monitor the traffic on your local network. These utilities can help determine which devices on your network are hogging the bandwidth, which slows down the network for other devices on your network. Here are the topics that we are going to cover in this chapter:

- Installing **traceroute** and **My Trace Route** (MTR or Matt's Traceroute): These utilities will give you a real-time view of the connection between one node and another
- Installing **Nmap**: This utility is a network scanner that can list all the hosts on your network and all the services available on those hosts
- Installing **iptraf-ng**: This utility gathers various network traffic information and statistics

Installing Traceroute

Traceroute is a tool that can show the path from one node on a network to another. This can help determine the ideal placement of a router to maximize wireless bandwidth in order to stream music and videos from the BeagleBone server to remote devices. Traceroute can be installed with the following command:

```
apt-get install traceroute
```

```
root@beaglebone:~# apt-get install mtr
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following NEW packages will be installed:
  mtr
0 upgraded, 1 newly installed, 0 to remove and 1 not upgraded.
Need to get 57.4 kB of archives.
After this operation, 130 kB of additional disk space will be used.
Get:1 http://ftp.us.debian.org/debian/ wheezy/main mtr armhf 0.82-3 [57.4 kB]
Fetched 57.4 kB in 0s (106 kB/s)
Selecting previously unselected package mtr.
(Reading database ... 59626 files and directories currently installed.)
Unpacking mtr (from .../archives/mtr_0.82-3_armhf.deb) ...
Processing triggers for man-db ...
Setting up mtr (0.82-3) ...
```

Once Traceroute is installed, it can be run to find the path from the BeagleBone to any server anywhere in the world. For example, here's the route from my BeagelBone to the Canadian Google servers:

```
root@beaglebone:~# traceroute google.ca
traceroute to google.ca (74.125.225.23), 30 hops max, 60 byte packets
 1  WNDR4500v2.local (192.168.1.1)  1.936 ms  2.915 ms  2.872 ms
 2  10.149.206.1 (10.149.206.1)  15.335 ms  17.319 ms  17.232 ms
 3  dtr01bxtrmn-tge-0-0-0-3.bxtr.mn.charter.com (96.34.26.56)  17.207 ms  16.719 ms  28.205 ms
 4  dtr01alxnmn-tge-0-1-0-1.alxn.mn.charter.com (96.34.27.90)  31.484 ms dtr01alxnmn-tge-0-1-0-0.alxn.
mn.charter.com (96.34.27.20)  31.422 ms dtr01alxnmn-tge-0-1-0-1.alxn.mn.charter.com (96.34.27.90)  31.
236 ms
 5  dtr02stcdmn-tge-0-5-0-10.stcd.mn.charter.com (96.34.27.46)  31.850 ms  32.602 ms  31.379 ms
 6  crr02stcdmn-bue-6.stcd.mn.charter.com (96.34.27.108)  32.092 ms  17.880 ms  43.844 ms
 7  bbr01stcdmn-bue-3.stcd.mn.charter.com (96.34.2.136)  43.599 ms  23.363 ms  23.721 ms
 8  bbr02chcgil-bue-1.chcg.il.charter.com (96.34.1.149)  38.412 ms  38.351 ms  37.565 ms
 9  prr01chcgil-bue-4.chcg.il.charter.com (96.34.3.11)  37.084 ms  36.368 ms  41.885 ms
10  96-34-152-30.static.unas.mo.charter.com (96.34.152.30)  39.268 ms  38.911 ms  37.289 ms
11  209.85.244.1 (209.85.244.1)  38.857 ms  38.579 ms  29.242 ms
12  72.14.237.109 (72.14.237.109)  31.330 ms  32.095 ms  27.483 ms
13  ord08s12-in-f23.1e100.net (74.125.225.23)  31.330 ms  38.031 ms  42.130 ms
```

Now, it is time to decipher all the information that is presented. This first command line tells traceroute the parameters that it must use:

```
traceroute to google.ca (74.125.225.23), 30 hops max, 60 byte
packets
```

This gives the hostname, the IP address returned by the DNS server, the maximum number of hops to be taken, and the size of the data packet to be sent. The maximum number of hops can be changed with the `-m` flag and can be up to `255`. In the context of this book, this will not have to be changed.

After the first line, the next few lines show the trip from the BeagleBone, through the intermediate hosts (or hops), to the `Google.ca` server. Each line follows the following format:

```
hop_number  host_name  (host IP_address)  packet_round_trip_times
```

From the command that was run previously (specifically hop number `4`):

```
2  10.149.206.1 (10.149.206.1)  15.335 ms  17.319 ms  17.232 ms
```

Here's a breakdown of the output:

- The hop number `2`: This is a count of the number of hosts between this host and the originating host. The higher the number, the greater is the number of computers that the traffic has to go through to reach its destination.
- `10.149.206.1`: This denotes the hostname. This is the result of a reverse DNS lookup on the IP address. If no information is returned from the DNS query (as in this case), the IP address of the host is given instead.
- `(10.149.206.1)`: This is the actual host IP address.
- Various numbers: This is the round-trip time for a packet to go from the BeagleBone to the server and back again. These numbers will vary depending on network traffic, and lower is better.

Sometimes, the traceroute will return some asterisks (`*`). This indicates that the packet has not been acknowledged by the host. If there are consecutive asterisks and the final destination is not reached, then there may be a routing problem. In a local network trace, it most likely is a firewall that is blocking the data packet.

Installing My Traceroute

My Traceroute (**MTR**) is an extension of traceroute, which probes the routers on the path from the packet source and destination, and keeps track of the response times of the hops. It does this repeatedly so that the response times can be averaged.

Now, install `mtr` with the following command:

```
sudo apt-get install mtr
```

After it is run, `mtr` will provide quite a bit more information to look at, which would look like the following:

```
                                 My traceroute  [v0.82]
beaglebone (0.0.0.0)                                          Sat Apr 11 23:14:59 2015
Keys:  Help   Display mode   Restart statistics   Order of fields   quit
                                                      Packets               Pings
 Host                                                Loss%   Snt   Last   Avg  Best  Wrst StDev
 1. 192.168.1.1                                       0.0%    14    1.5   6.1   1.4  11.8   3.6
 2. 10.149.206.1                                      0.0%    14   22.1  16.8   9.6  23.7   4.6
 3. dtr01bxtrmn-tge-0-0-0-3.bxtr.mn.charter.com       0.0%    14   20.9  16.1   9.2  21.3   4.1
 4. dtr01alxnmn-tge-0-1-0-1.alxn.mn.charter.com       0.0%    14   19.6  18.3  11.4  25.6   4.5
    dtr01alxnmn-tge-0-1-0-0.alxn.mn.charter.com
 5. dtr02stcdmn-tge-0-5-0-8.stcd.mn.charter.com       0.0%    14   36.9  23.1  15.0  36.9   6.9
    dtr02stcdmn-tge-0-5-0-10.stcd.mn.charter.com
 6. crr02stcdmn-bue-6.stcd.mn.charter.com             0.0%    14   28.0  27.6  20.4  44.6   7.1
 7. bbr01stcdmn-bue-3.stcd.mn.charter.com             7.1%    14   47.3  31.3  20.2  47.3   9.6
 8. bbr02chcgil-bue-1.chcg.il.charter.com             0.0%    14   39.0  45.3  33.5  70.6  10.6
 9. prr01chcgil-bue-4.chcg.il.charter.com             0.0%    14   36.8  42.6  31.1  63.5   9.4
10. 96-34-152-30.static.unas.mo.charter.com           7.7%    13   33.4  42.3  31.7  63.0  10.0
11. 209.85.244.1                                      0.0%    13   35.2  45.4  31.3  81.4  16.7
12. 72.14.237.109                                     0.0%    13   33.2  37.1  32.9  43.1   3.3
13. ord08s12-in-f15.1e100.net                         0.0%    13   33.0  36.1  32.0  42.2   3.1
```

While the output may look similar, the big advantage over traceroute is that the output is constantly updated. This allows you to accumulate trends and averages and also see how network performance varies over time.

When using traceroute, there is a possibility that the packets that were sent to each hop happened to make the trip without incident, even in a situation where the route is suffering from intermittent packet loss. The `mtr` utility allows you to monitor this by gathering data over a wider range of time.

Here's an `mtr` trace from my BeagleBone to my Android smartphone:

```
                                 My traceroute  [v0.82]
beaglebone (0.0.0.0)                                          Sat Apr 11 23:16:38 2015
Keys:  Help   Display mode   Restart statistics   Order of fields   quit
                                                      Packets               Pings
 Host                                                Loss%   Snt   Last   Avg  Best  Wrst StDev
 1. 192.168.1.2                                       0.0%     4   46.4 304.0   6.0 950.2 440.1
```

Here's another trace, after I changed the orientation of the antennae of my router:

```
                                 My traceroute  [v0.82]
beaglebone (0.0.0.0)                                          Sat Apr 11 23:17:41 2015
Keys:  Help   Display mode   Restart statistics   Order of fields   quit
                                                      Packets               Pings
 Host                                                Loss%   Snt   Last   Avg  Best  Wrst StDev
 1. 192.168.1.2                                       6.7%    15   97.9 189.7   5.0 470.5 164.1
```

As you can see, the original orientation was almost 100 milliseconds faster for ping traffic.

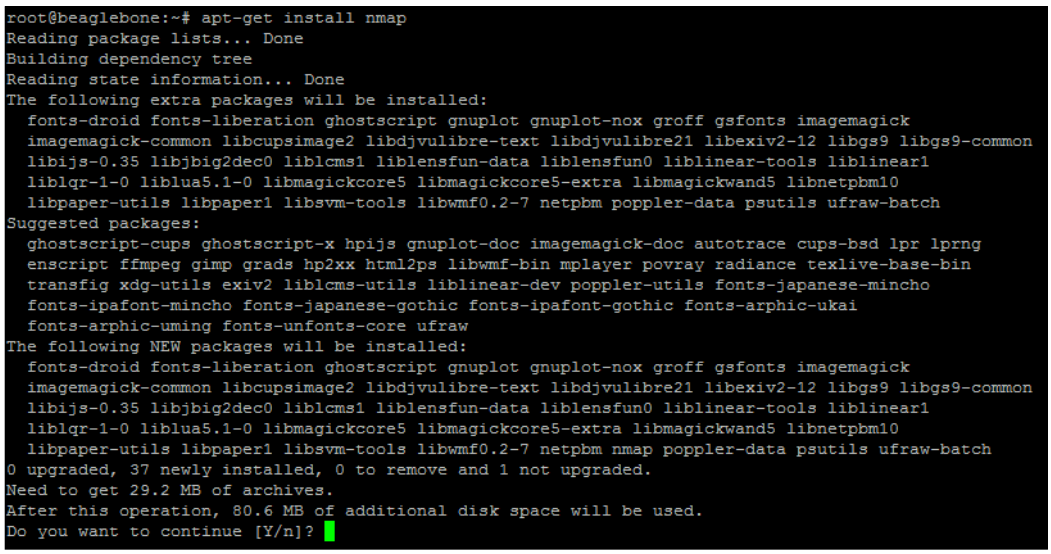
Installing Nmap

Nmap is designed to allow the scanning of networks in order to determine which hosts are up and what services are they offering. Nmap supports a large number of scanning options, which are overkill for what will be done in this book.

Nmap is installed with the following command:

```
sudo apt-get install nmap
```

Answer `Yes` to install Nmap and its dependent packages.



Using Nmap

After it is installed, run the following command to see all the hosts that are currently on the network:

```
nmap -T4 -F <your_local_ip_range>
```

The option `-T4` sets the timing template to be used, and the `-F` option is for fast scanning. There are other options that can be used and found via the Nmap manpage.

Here, `your_local_ip_range` is within the range of addresses assigned by your router.

Here's a node scan of my local network. If you have a lot of devices on your local network, this command may take a long time to complete.

```
root@beaglebone:~# nmap -T4 -F 192.168.1.0-255

Starting Nmap 6.00 ( http://nmap.org ) at 2015-04-11 23:25 UTC
Nmap scan report for 192.168.1.1
Host is up (0.017s latency).
Not shown: 96 closed ports
PORT     STATE SERVICE
53/tcp   open  domain
80/tcp   open  http
548/tcp  open  afp
5000/tcp open  upnp
MAC Address: C4:04:15:2D:2B:D5 (Unknown)

Nmap scan report for 192.168.1.3
Host is up (0.033s latency).
Not shown: 94 filtered ports
PORT     STATE SERVICE
135/tcp  open  msrpc
139/tcp  open  netbios-ssn
445/tcp  open  microsoft-ds
5357/tcp open  wsdapi
5800/tcp open  vnc-http
5900/tcp open  vnc
MAC Address: 9C:4E:36:8E:46:A4 (Intel Corporate)

Nmap scan report for 192.168.1.5
Host is up (0.0047s latency).
All 100 scanned ports on 192.168.1.5 are closed
MAC Address: 00:11:22:5E:FC:CB (Cimsys)

Nmap scan report for 192.168.1.9
Host is up (0.0055s latency).
Not shown: 97 filtered ports
PORT    STATE SERVICE
135/tcp open  msrpc
139/tcp open  netbios-ssn
445/tcp open  microsoft-ds
MAC Address: 70:5A:B6:15:9C:A4 (Compal Information (kunshan) CO.)
```

Now, I know that I have more nodes on my network, but they don't show up. This is because the command we ran didn't tell Nmap to explicitly query each IP address to see whether the host responds but to query common ports that may be open to traffic.

Instead, only use the `-Pn` option in the command to tell Nmap to scan all the ports for every address in the range. This will scan more ports on each address to determine whether the host is active or not.

```
root@beaglebone:~# nmap -Pn 192.168.1.0-20

Starting Nmap 6.00 ( http://nmap.org ) at 2015-04-11 23:26 UTC
Nmap scan report for 192.168.1.1
Host is up (0.0038s latency).
Not shown: 994 closed ports
PORT      STATE SERVICE
53/tcp    open  domain
80/tcp    open  http
548/tcp   open  afp
5000/tcp  open  upnp
8200/tcp  open  trivnet1
20005/tcp open  btx
MAC Address: C4:04:15:2D:2B:D5 (Unknown)

Nmap scan report for 192.168.1.3
Host is up (0.017s latency).
Not shown: 992 filtered ports
PORT     STATE SERVICE
135/tcp  open  msrpc
139/tcp  open  netbios-ssn
445/tcp  open  microsoft-ds
902/tcp  open  iss-realsecure
912/tcp  open  apex-mesh
5357/tcp open  wsdapi
5800/tcp open  vnc-http
5900/tcp open  vnc
MAC Address: 9C:4E:36:8E:46:A4 (Intel Corporate)

Nmap scan report for 192.168.1.9
Host is up (0.0062s latency).
Not shown: 995 filtered ports
PORT      STATE SERVICE
135/tcp   open  msrpc
139/tcp   open  netbios-ssn
445/tcp   open  microsoft-ds
2869/tcp  open  icslap
49167/tcp open  unknown
MAC Address: 70:5A:B6:15:9C:A4 (Compal Information (kunshan) CO.)
```

Here, we can see that there are definitely more hosts registered in the router device table. This scan will attempt to scan a host IP address even if the device is powered off.

Resetting the router and running the same scan will scan the same address range, but it will not return any device names for devices that are not powered at the time of the scan.

You will notice that after scanning, Nmap reports that some IP addresses' ports are closed and some are filtered. Closed ports are usually maintained on the addresses of devices that are locked down by their firewall. Filtered ports are on the addresses that will be handled by the router because there actually isn't a node assigned to these addresses.

Here's a part of the output from an Nmap scan of my Windows machine:

```
root@beaglebone:~# nmap -A -T4 192.168.1.3

Starting Nmap 6.00 ( http://nmap.org ) at 2015-04-11 23:34 UTC
Nmap scan report for 192.168.1.3
Host is up (0.0074s latency).
Not shown: 992 filtered ports
PORT     STATE SERVICE         VERSION
135/tcp  open  msrpc           Microsoft Windows RPC
139/tcp  open  netbios-ssn
445/tcp  open  netbios-ssn
902/tcp  open  ssl/vmware-auth VMware Authentication Daemon 1.10 (Uses VNC, SOAP)
912/tcp  open  vmware-auth     VMware Authentication Daemon 1.0 (Uses VNC, SOAP)
5357/tcp open  http            Microsoft HTTPAPI httpd 2.0 (SSDP/UPnP)
|_http-title: Service Unavailable
|_http-methods: No Allow or Public header in OPTIONS response (status code 503)
5800/tcp open  vnc-http?
5900/tcp open  vnc             VNC (protocol 3.8)
| vnc-info:
|   Protocol version: 3.8
|   Security types:
|     VNC Authentication
|_    Tight
1 service unrecognized despite returning data. If you know the service/version, please submit the foll
owing fingerprint at http://www.insecure.org/cgi-bin/servicefp-submit.cgi :
SF-Port5800-TCP:V=6.00%I=7%D=4/11%Time=5529AF7A%P=armv7l-unknown-linux-gnu
SF:eabi%r(GetRequest,171,"HTTP/1\.0\x20200\x20OK\r\n\r\n<HTML>\n\x20\x20<H
SF:EAD><TITLE>TightVNC\x20desktop\x20\[beast2\]</TITLE></HEAD>\n\x20\x20<B
SF:ODY>\n\x20\x20\x20\x20<APPLET\x20ARCHIVE=\"tightvnc-jviewer\.jar\"\x20C
SF:ODE=\"com\.glavsoft\.viewer\.Viewer\"\x20WIDTH=1\x20HEIGHT=1>\n\x20\x20
SF:\x20\x20\x20\x20<PARAM\x20NAME=\"PORT\"\x20VALUE=\"5900\">\n\x20\x20\x2
```

Here's a part of the output of a scan of the BeagleBone:

```
root@beaglebone:~# nmap -A -T4 192.168.1.13

Starting Nmap 6.00 ( http://nmap.org ) at 2015-04-11 23:38 UTC
Nmap scan report for 192.168.1.13
Host is up (0.00026s latency).
Not shown: 995 closed ports
PORT     STATE SERVICE       VERSION
22/tcp   open  ssh           OpenSSH 6.0p1 Debian 4+deb7u2 (protocol 2.0)
| ssh-hostkey: 1024 83:54:25:48:68:04:85:b8:e4:cd:27:a9:bc:88:ad:14 (DSA)
|_2048 05:21:e3:4a:84:76:a4:e6:a0:83:33:b7:ff:f0:55:2b (RSA)
80/tcp   open  http?
|_http-methods: No Allow or Public header in OPTIONS response (status code 404)
|_http-title: Bone101
3000/tcp open  ppp?
3389/tcp open  ms-wbt-server xrdp
8080/tcp open  http          Apache httpd 2.2.22 ((Debian))
|_http-title: Index of /
2 services unrecognized despite returning data. If you know the service/version, please submit the fol
lowing fingerprints at http://www.insecure.org/cgi-bin/servicefp-submit.cgi :
==============NEXT SERVICE FINGERPRINT (SUBMIT INDIVIDUALLY)==============
SF-Port80-TCP:V=6.00%I=7%D=4/11%Time=5529B080%P=armv7l-unknown-linux-gnuea
SF:bi%r(GetRequest,B1A,"HTTP/1\.1\x20200\x20OK\r\nX-Powered-By:\x20Express
SF:\r\nAccept-Ranges:\x20bytes\r\nETag:\x20\"2552-1425244362000\"\r\nDate:
SF:\x20Sat,\x2011\x20Apr\x202015\x2023:38:40\x20GMT\r\nCache-Control:\x20p
SF:ublic,\x20max-age=0\r\nLast-Modified:\x20Sun,\x2001\x20Mar\x202015\x202
SF:1:12:42\x20GMT\r\nContent-Type:\x20text/html;\x20charset=UTF-8\r\nConte
SF:nt-Length:\x202552\r\nConnection:\x20close\r\n\r\n---\nlayout:\x20bare\
SF:n---\n<!DOCTYPE\x20html>\n<html>\n\n\x20\x20<head>\n\x20\x20\x20\x20<me
SF:ta\x20charset='utf-8'\x20/>\n\x20\x20\x20\x20<meta\x20http-equiv=\"X-UA
SF:-Compatible\"\x20content=\"chrome=1\"\x20/>\n\x20\x20\x20\x20<meta\x20n
SF:ame=\"description\"\x20content=\"Bone101\x20:\x20Presentation\x20web\x2
```

Installing iptraf-ng

Iptraf-ng is a utility that monitors traffic on any of the interfaces or IP addresses on your network via custom filters. Because iptraf-ng is based on the `ncurses` libraries, we will have to install them first before downloading and compiling the actual iptraf-ng package. To install `ncurses`, run the following command:

```
sudo apt-get install libncurses5-dev
```

Here's how you will install `ncurses` and its dependent packages:

```
root@beaglebone:~# sudo apt-get install libncurses5-dev
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following extra packages will be installed:
  libtinfo-dev
Suggested packages:
  ncurses-doc
The following NEW packages will be installed:
  libncurses5-dev libtinfo-dev
0 upgraded, 2 newly installed, 0 to remove and 1 not upgraded.
Need to get 277 kB of archives.
After this operation, 1038 kB of additional disk space will be used.
Do you want to continue [Y/n]?
```

Once `ncurses` is installed, download and extract the iptraf-ng **tarball** so that it can be built.

At the time of writing this book, iptrf-ng's version 1.1.4 was available. This will change over time, and a quick search on Google will give you the latest and greatest version to download. You can download this version with the following command:

```
wget https://fedorahosted.org/releases/i/p/iptraf-ng/iptraf-ng-
<current_version_number>.tar.gz
```

The following screenshot shows how to download the iptraf-ng tarball:

```
root@beaglebone:~# wget https://fedorahosted.org/releases/i/p/iptraf-ng/iptraf-ng-1.1.4.tar.gz
--2015-04-11 23:43:47--  https://fedorahosted.org/releases/i/p/iptraf-ng/iptraf-ng-1.1.4.tar.gz
Resolving fedorahosted.org (fedorahosted.org)... 140.211.169.199
Connecting to fedorahosted.org (fedorahosted.org)|140.211.169.199|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 583306 (570K) [application/x-gzip]
Saving to: `iptraf-ng-1.1.4.tar.gz'

100%[======================================================>] 583,306      720K/s   in 0.8s

2015-04-11 23:43:57 (720 KB/s) - `iptraf-ng-1.1.4.tar.gz' saved [583306/583306]
```

After we have completed the downloading, extract the tarball using the following command:

```
tar -xzf iptraf-ng-<current_version_number>.tar.gz
```

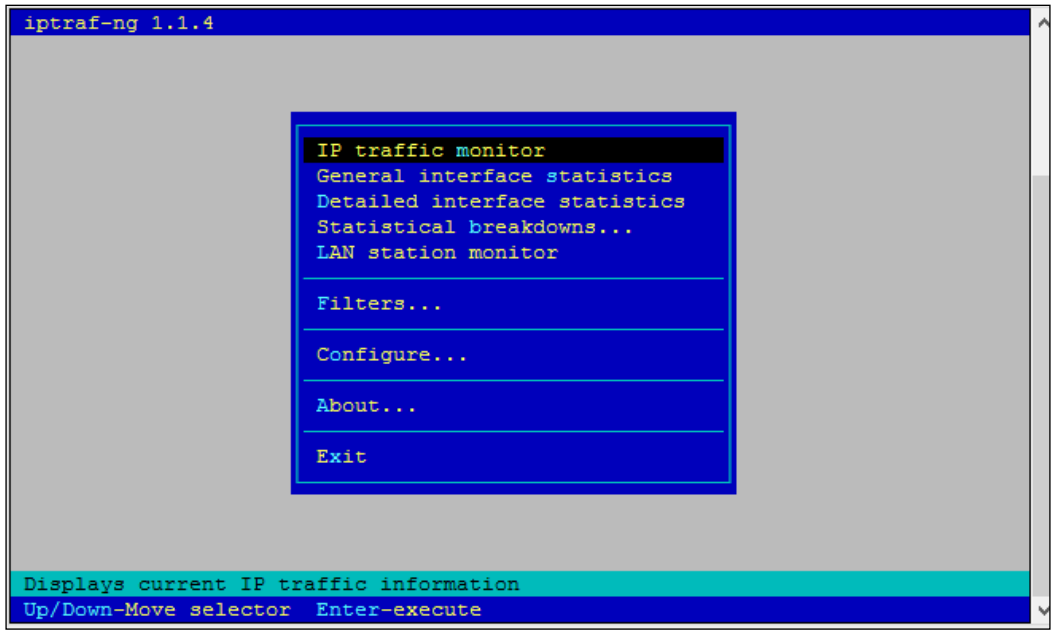
Navigate to the iptraf-ng directory created by the `tar` command and issue the following commands:

```
./configure
make
sudo make install
```

After these commands are complete, iptraf-ng is ready to run, using the following command:

```
sudo iptraf-ng
```

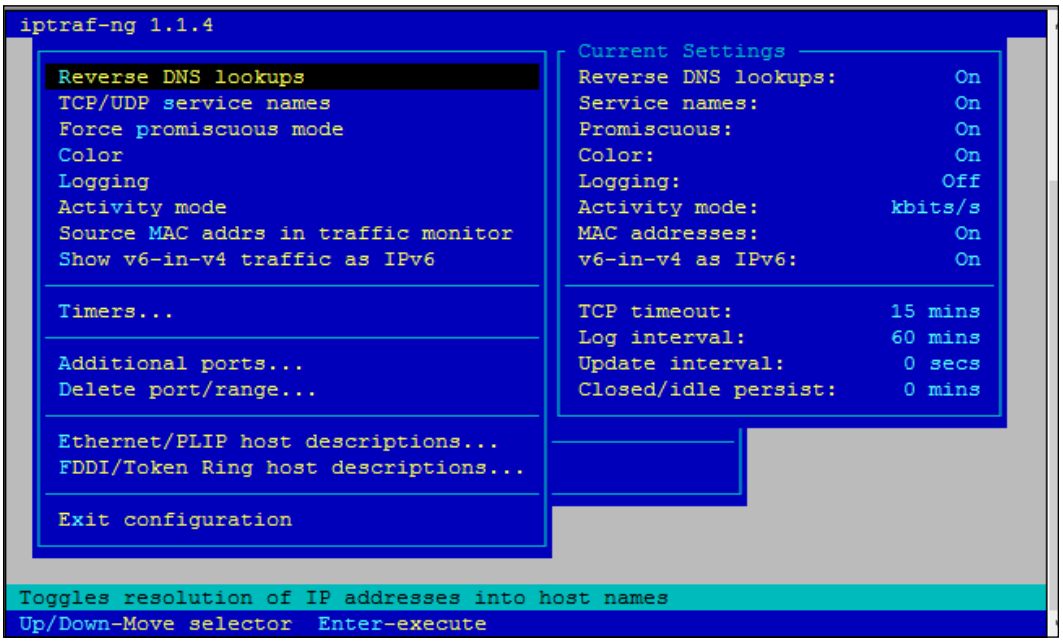
When the program starts, you will be presented with the following screen:



Configuring iptraf-ng

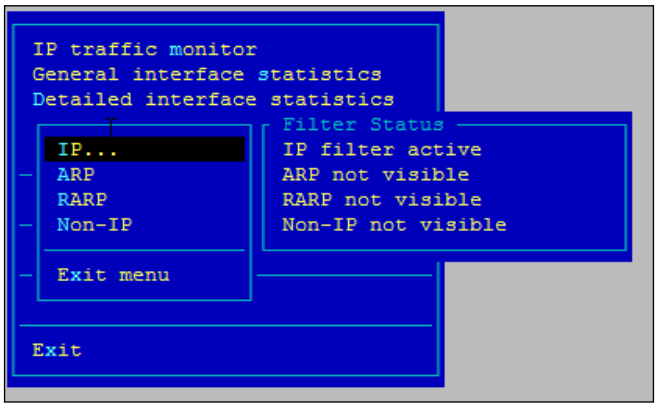
As an example, we are going to monitor all incoming traffic to the BeagleBone. In order to do this, iptraf-ng should be configured.

Selecting the **Configure...** menu item will show you the following screen:

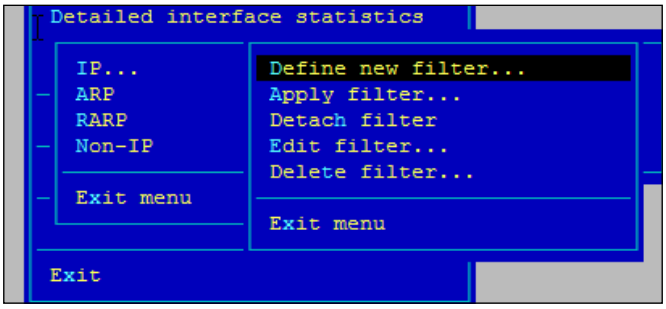


Here, settings can be changed by highlighting an option in the left-hand side window and pressing *Enter* to select a new value, which will be shown in the **Current Settings** window. In this case, I have enabled all the options except **Logging**. Exit the configuration screen and enter the **Filter Status** screen. This is where we will set up the filter to only monitor traffic coming to the BeagleBone and from it.

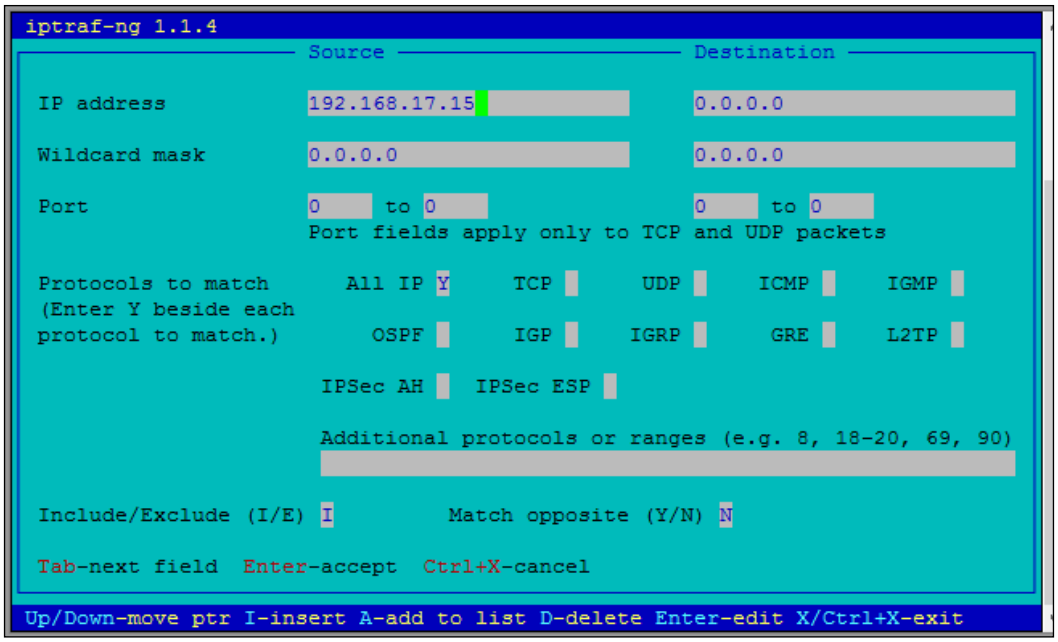
Then, the following screen will be presented:



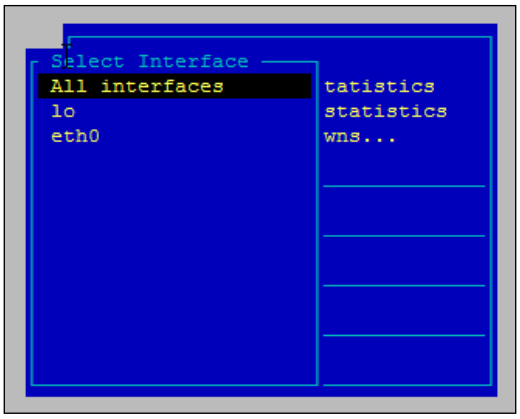
Selecting **IP...** will create an IP filter, and the following subscreen will pop up:



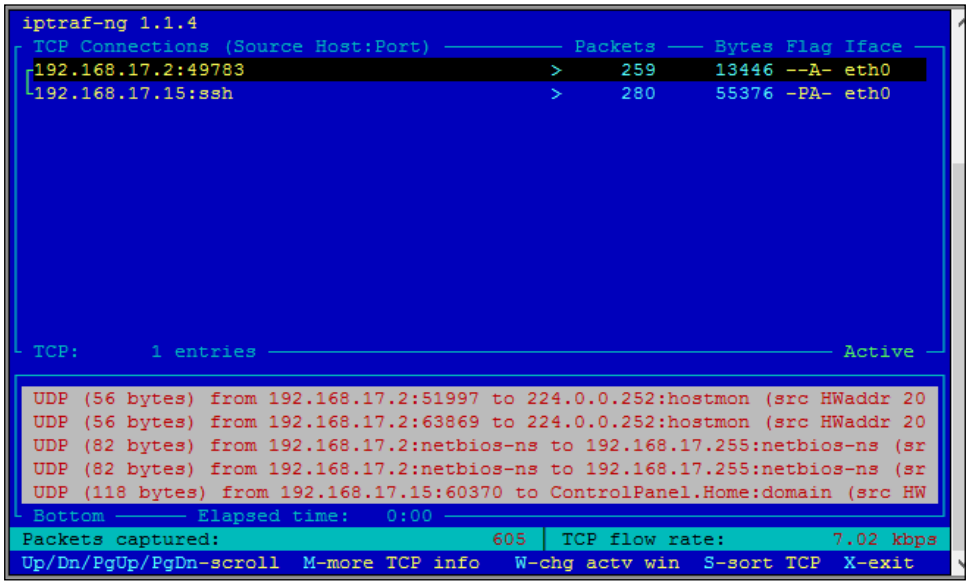
Selecting **Define new filter...** will allow the creation and saving of a filter that will only display traffic for the IP address and the IP protocols that are selected, as shown in the following screenshot:



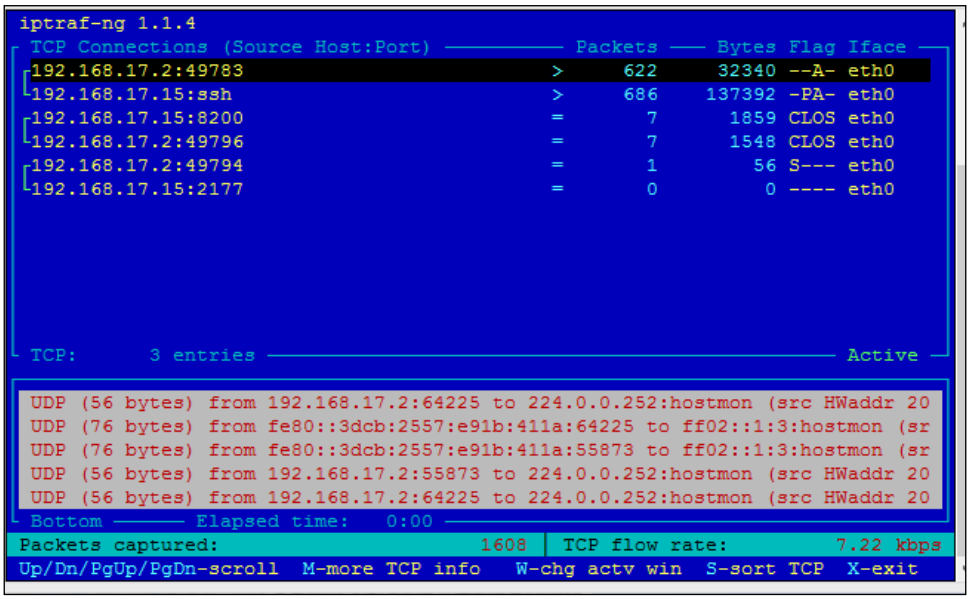
Here, I have put in the BeagleBone's IP address, and to match all IP protocols. Once saved, return to the main menu and select **IP traffic monitor**. Here, you will be able to select the network interfaces to be monitored. Because my BeagleBone is connected to my wired network, I have selected **eth0**. The following screenshot should shows us the options:



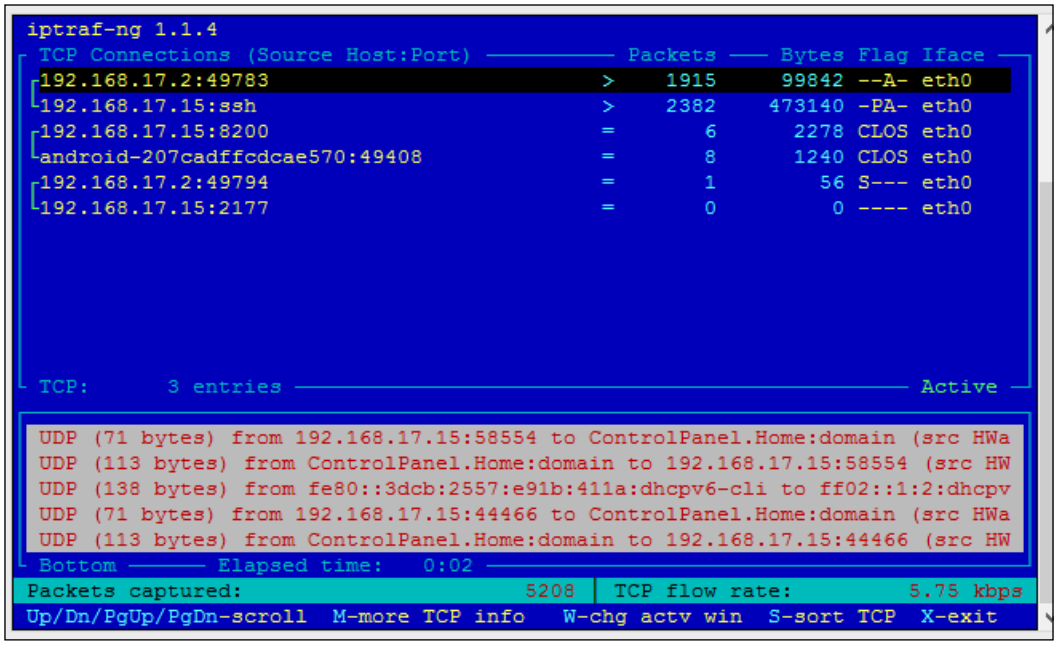
If all went well with your filter, you should see traffic to your BeagleBone and from it. Here are the entries for my PuTTy session; `192.168.17.2` is my Windows 8 machine, and `192.168.17.15` is my BeagleBone:



Here's an image of the traffic generated by browsing the DLNA server from the Windows Explorer:



Moreover, here's the traffic from my Android smartphone running a DLNA player, browsing the shared directories that were set up in *Chapter 2*, *Installing and Configuring Multimedia Server Software*:



Summary

In this chapter, you saw how to install and configure the software that will be used to monitor the traffic on your local network. With these programs and a bit of experience, you can determine which devices on your network are hogging the bandwidth and find out whether you have any unauthorized users.

In the next chapter, you will see how to add the RAID subsystem to the BeagleBone and how to load it up with content.

4

Installing and Setting Up a BeagleBone RAID System

This chapter will serve as an installation guide for the software that will be used to create a RAID array out of the partitions that you will create on your USB-connected drives. This storage array will then hold all your media files (pictures, videos, and audio) in one drive instead of being spread out over several drives.

For the basics of RAID systems, take a look at `http://en.wikipedia.org/wiki/RAID`.

I don't want to discuss the basics because it is beyond the scope of this book, and other people have done a better job of explaining them than I can ever do. It is, however, important to understand that we will be building a "software" type of RAID array. There are two basic types of RAID arrays (not to be confused with *modes*, as in mode 0, mode 1, and so on).

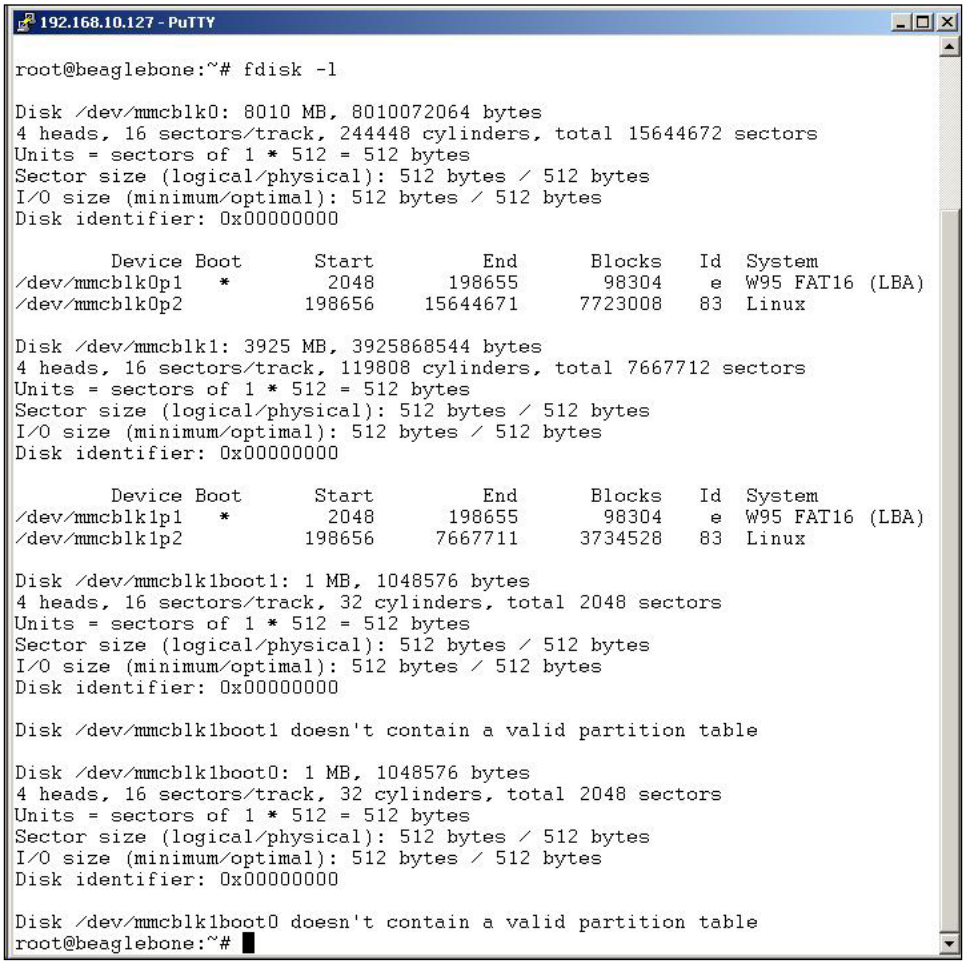
The first type is called a **hardware RAID**, which as the name suggests, has specialized hardware that makes the array appear as one hard drive to the operating system.

The second type is the type that we will be creating here. This is called a **software RAID** because it uses a software program (`mdadm`) to create a RAID array using discrete drives attached to system.

Determining the available partitions

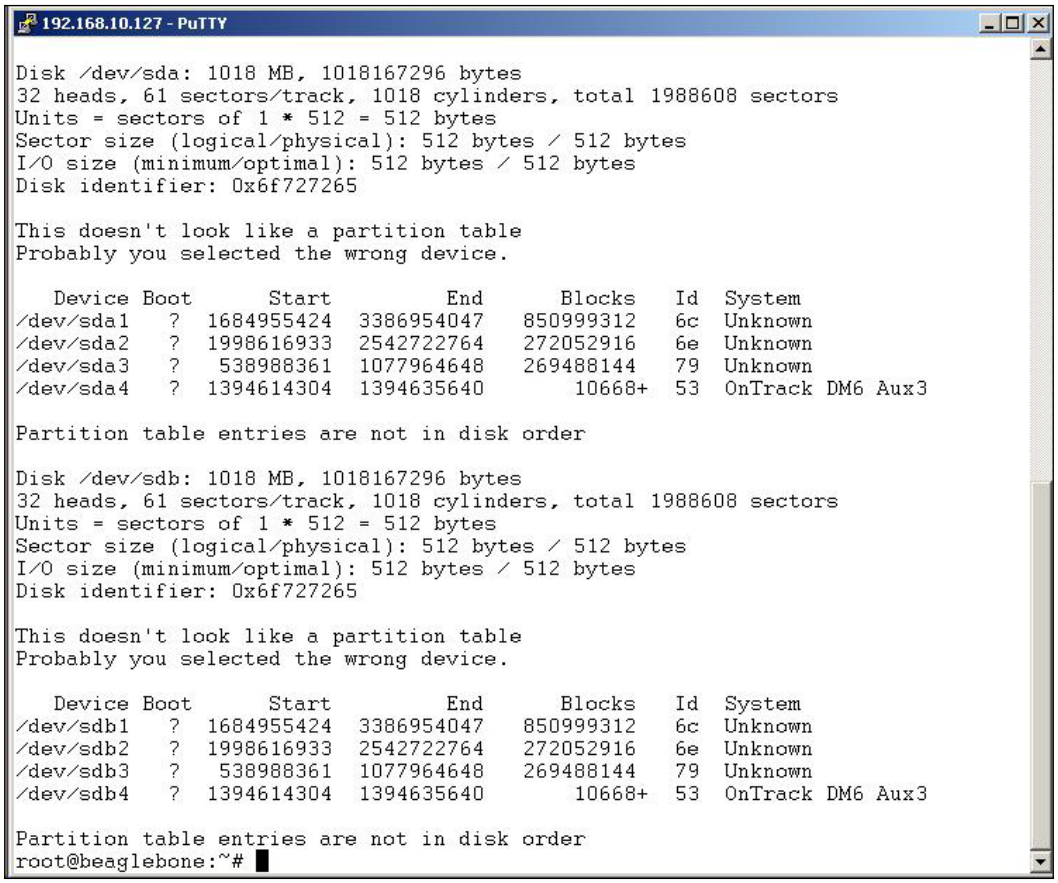
The first thing that we have to do is to determine the volumes that the Kernel thinks are available to it. We do this using the `fdisk -l` command.

Here's the output of the `fdisk -l` command before you've attached the USB hub and USB disks; the reader should note that only block devices (`mmcblk`) appear in the listing:



If you connect the USB flash drives one at a time to your hub, you can label them as `sda` and `sdb` in case they are ever removed.

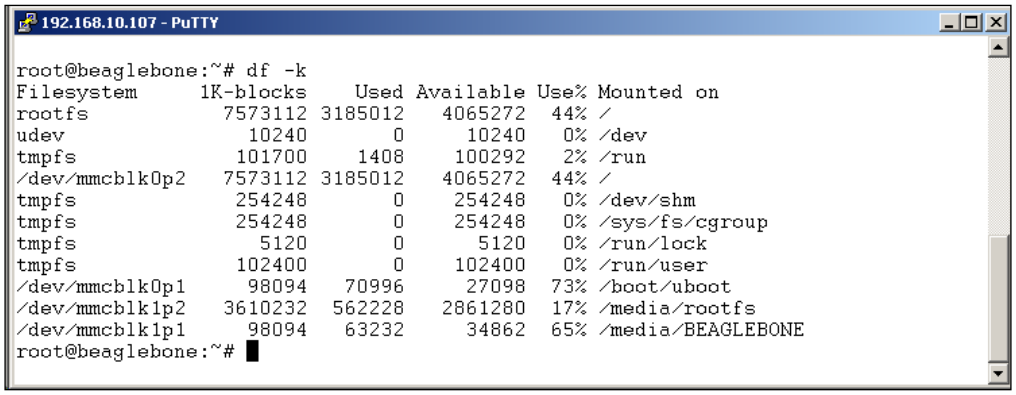
Moreover, here's the output of the command after you've attached the disks. Note that several new devices have appeared now. Rather that block devices, these devices appear as `/dev/sda1` and so on.



```
192.168.10.127 - PuTTY

Disk /dev/sda: 1018 MB, 1018167296 bytes
32 heads, 61 sectors/track, 1018 cylinders, total 1988608 sectors
Units = sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disk identifier: 0x6f727265

This doesn't look like a partition table
Probably you selected the wrong device.

   Device Boot      Start         End      Blocks   Id  System
/dev/sda1   ?  1684955424  3386954047   850999312   6c  Unknown
/dev/sda2   ?  1998616933  2542722764   272052916   6e  Unknown
/dev/sda3   ?   538988361  1077964648   269488144   79  Unknown
/dev/sda4   ?  1394614304  1394635640       10668+  53  OnTrack DM6 Aux3

Partition table entries are not in disk order

Disk /dev/sdb: 1018 MB, 1018167296 bytes
32 heads, 61 sectors/track, 1018 cylinders, total 1988608 sectors
Units = sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disk identifier: 0x6f727265

This doesn't look like a partition table
Probably you selected the wrong device.

   Device Boot      Start         End      Blocks   Id  System
/dev/sdb1   ?  1684955424  3386954047   850999312   6c  Unknown
/dev/sdb2   ?  1998616933  2542722764   272052916   6e  Unknown
/dev/sdb3   ?   538988361  1077964648   269488144   79  Unknown
/dev/sdb4   ?  1394614304  1394635640       10668+  53  OnTrack DM6 Aux3

Partition table entries are not in disk order
root@beaglebone:~#
```

The term *mount* is a leftover from the "good old days" when a techie had to physically mount a disk or magnetic tape on a drive.

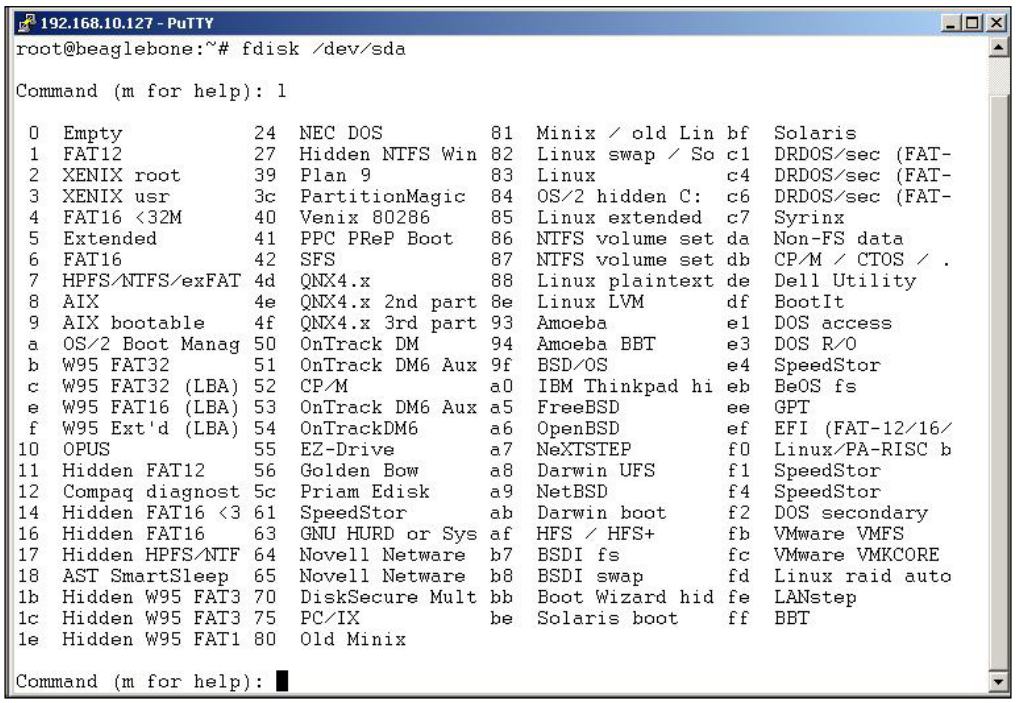
If you use the the `df -k` command, it will show you the filesystems that are mounted and their mount points.



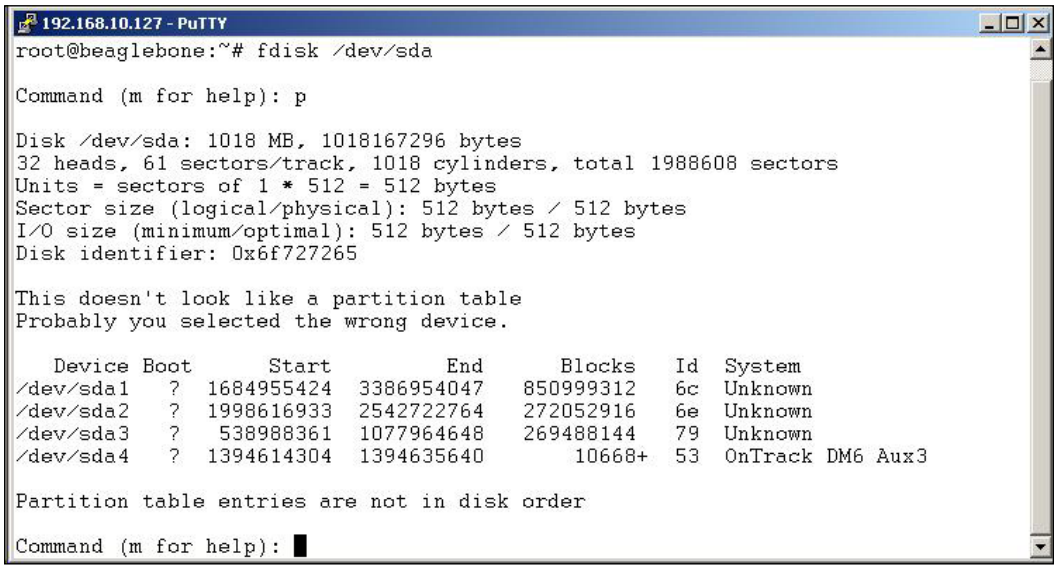
Preparing the partitions with fdisk

Each partition in the RAID set must be set to the type **Linux raid auto**.

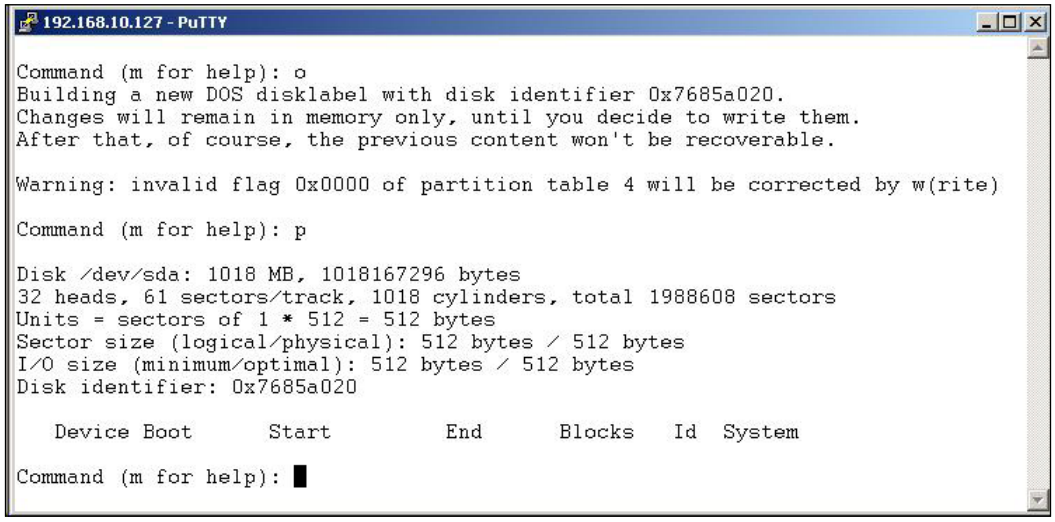
1. We will be doing this using `fdisk` again, as shown in the following screenshot:



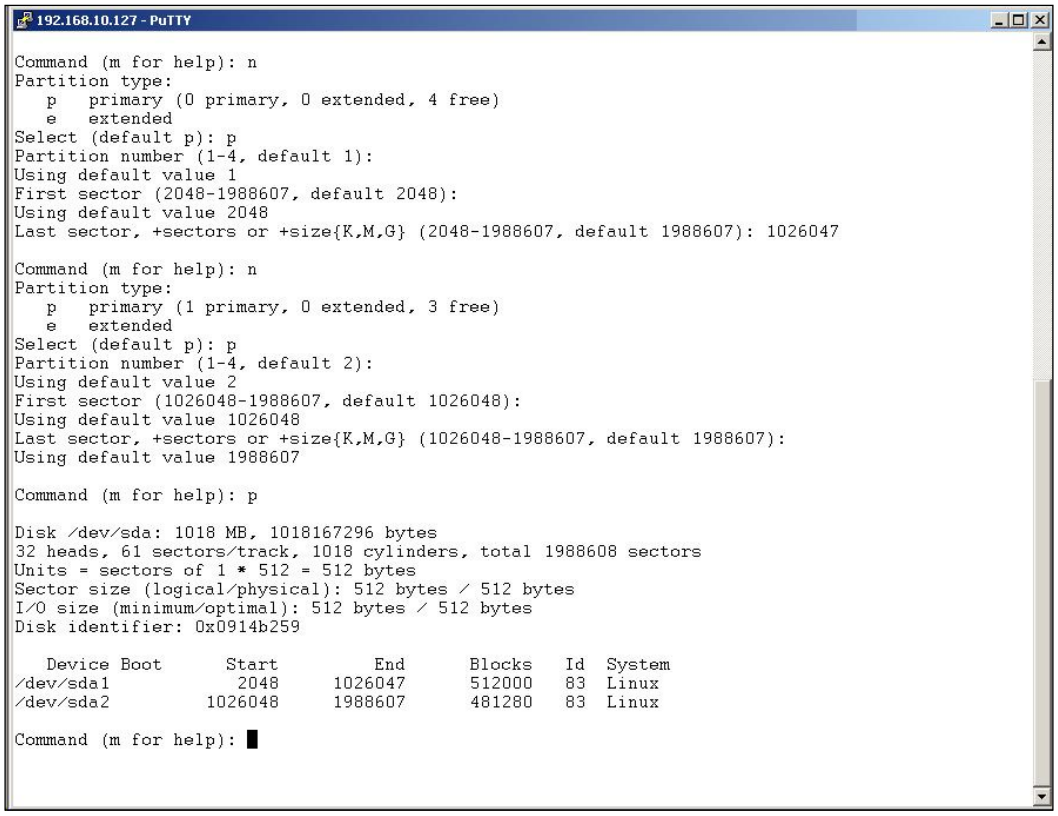
2. Your disk may come with a number of partitions, as shown here:



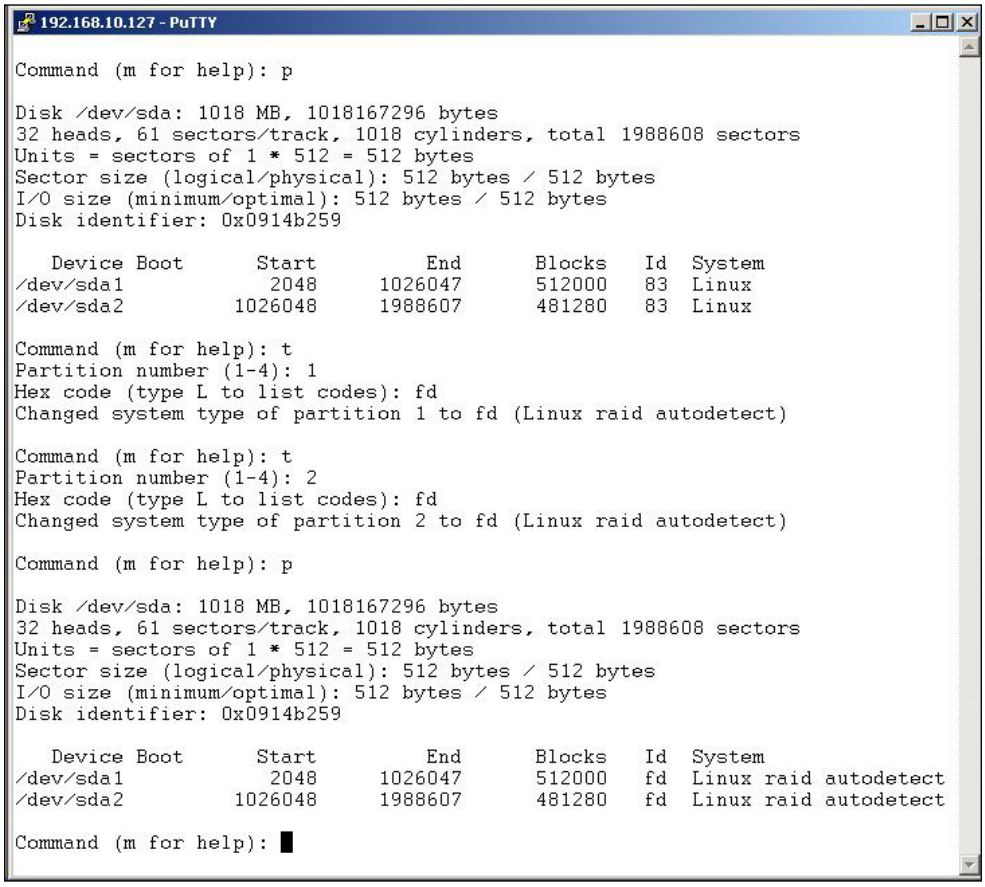
3. First, we must get rid of any existing partitions using the o command, as shown in the following screenshot:



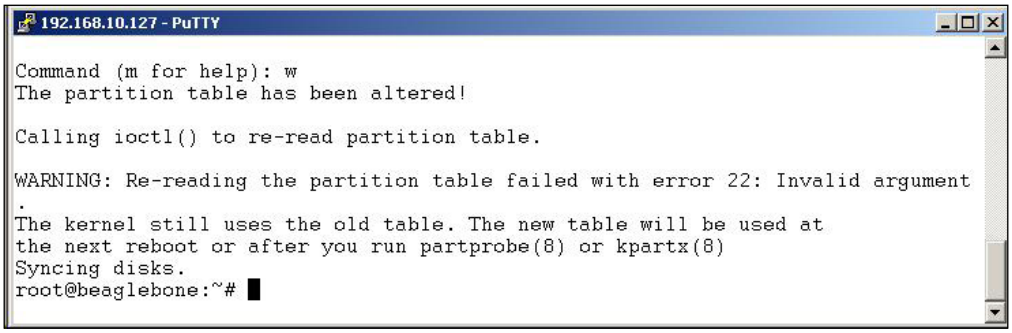
4. Now that we have removed the unwanted partitions, we can create our own using the `n` command:



5. Select a partition and modify its type using the `t` command and specify the partition number and type code. Then, use the `p` command to get the new proposed partition table, as shown here:



6. Use the `w` command to permanently save the changes to the `/dev/sda` disk:



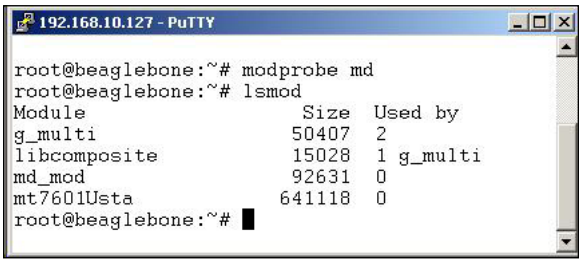
We will not cover the process for the other partitions. It's enough to know that the steps to change the IDs for `/dev/sdb1` and `/dev/sdb2` are very similar.

Now that we have our RAID drives initialized, it is time to install **Linux Mdadm**, which stands for **Multiple Disk Administrator**.

Installing Mdadm

The first step in the installation of Mdadm is actually the loading of the `md` module, which the installation software will check for. If it does not find the software, you will get an error message, but Mdadm will definitely not be installed properly.

The following screenshot shows the result of the `modprobe md` command:

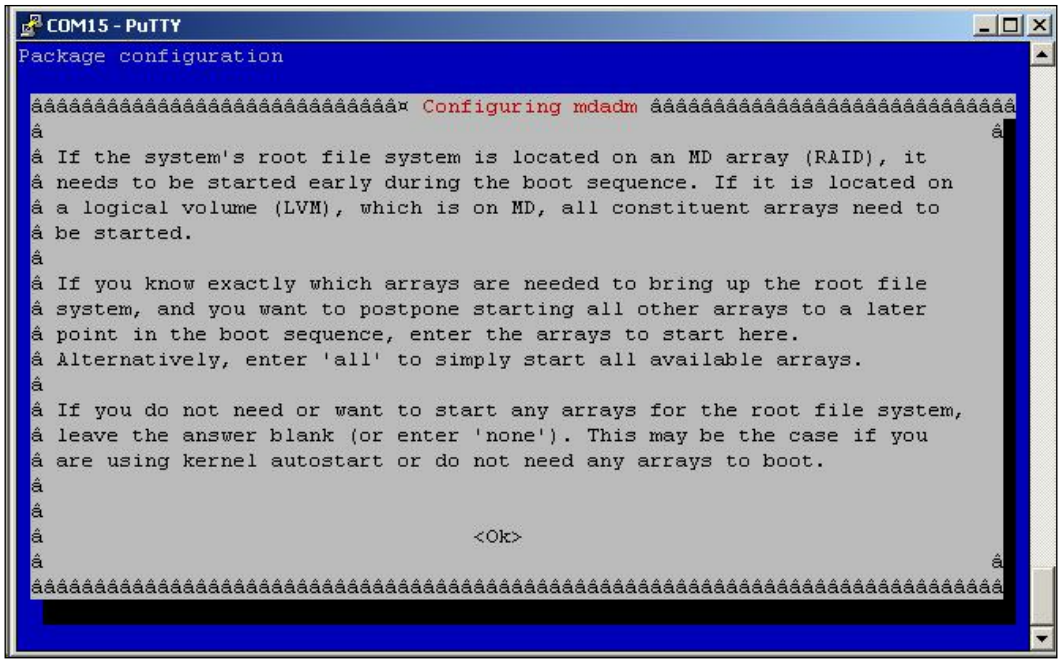


Now that the `md` module is loaded, the next step in the installation process is to download and install the Mdadm software using the `apt` command:

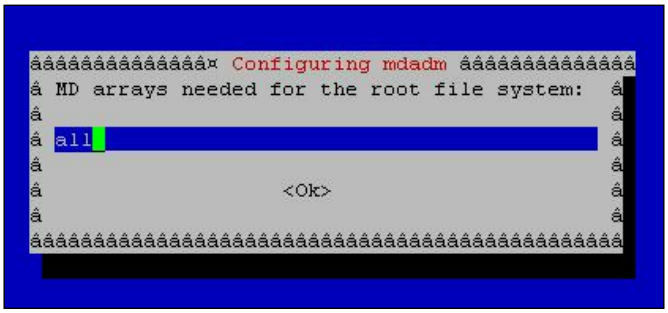
```
apt-get install mdadm
```

The installation procedure will display the following screens:

That's why we formatted the drives first. This way the installer does all the heavy lifting for us!



The first thing that the installer will ask you is whether you want to use all the automatically-detected RAID drives in the same array. We want to keep things simple, so we will tell Mdadm to use all the drives we formatted by entering **all**:



Mdadm will now go off and build our RAID array for us.

Preparing the RAID set

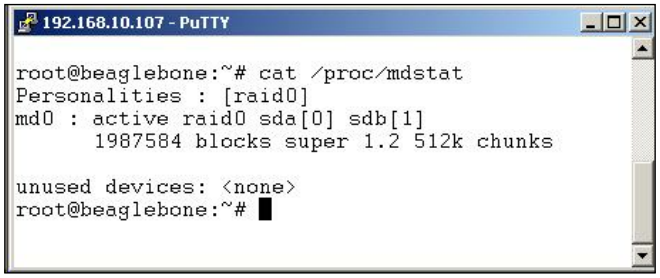
In this section, we will build the actual software RAID drive from our previously prepared and formatted physical drives.

Confirming whether RAID is correctly initialized

The `/proc/mdstat` file is a dynamically modified log file, which provides the current status of all the RAID devices on the system. We can confirm that the initialization is complete by displaying the file, with the following command:

```
cat /proc/mdstat
```

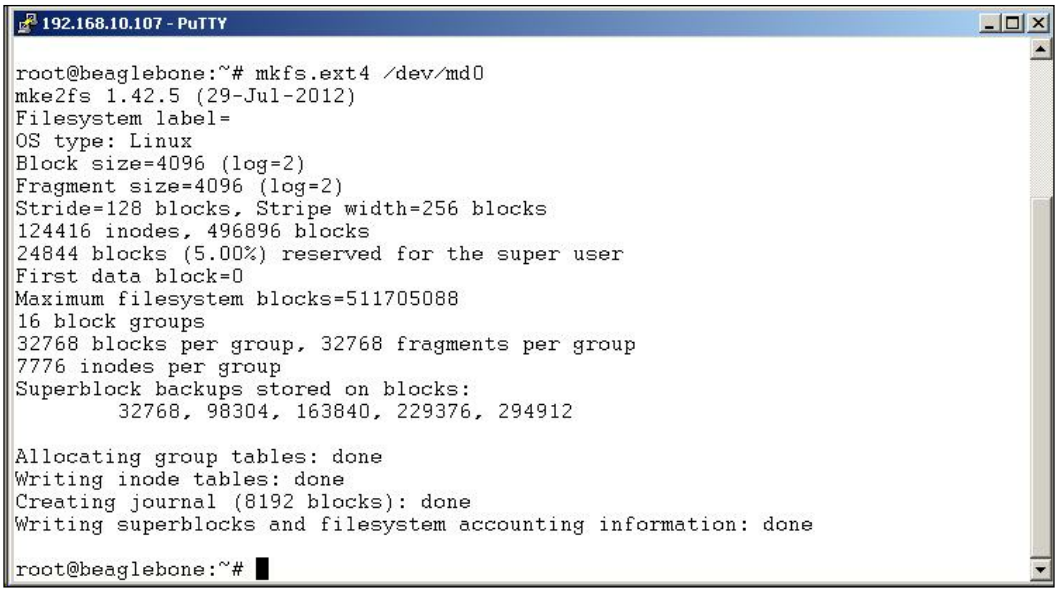
This may take some time to complete, depending on the size of the attached drives.



The preceding screenshot shows the result of this command. You will notice that our array is called `md0` and that it consists of two physical drives, called `sda` and `sdb`.

It's now time to format the drives in our RAID array. We will use the `mkfs.ext4` command to do this, as shown in the screenshot that follows the command line:

```
mkfs.ext4 /dev/md0
```



Creating the Mdadm.conf configuration file

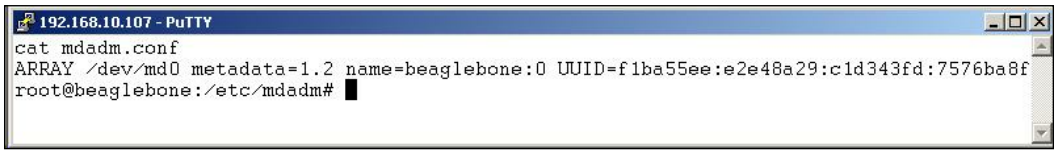
The new Mdadm installer creates an `mdadm.conf` file in the `/etc/mdadm` directory.

All the partitions will be given a UUID label that contains four sets of eight numbers and letters. The `mdadm.conf` file makes sure that this mapping is remembered when you reboot.

Here, we export the screen's output to create the configuration file by adding a pipe to the `mdadm.conf` file:

```
mdadm --detail --scan /dev/md0 > /etc/mdadm.conf
```

The following screenshot shows the contents of `mdadm.conf`:



Creating a mount point for the RAID set

We proceed further by creating a mount point for `/dev/md0`. In this case, we'll create one called `/mnt/raid`, which will then be used to store all your media files.

First, we will create a mount point in the `/mnt` subdirectory of the root file system:

```
mkdir /mnt/raid
```

Then, we will use `mdadm` to assign this point to `/dev/md0`:

```
mount /dev/md0 /mnt/raid
```

We then tell `mdadm` to create the array, as follows:

```
root@beaglebone: mdadm --create --verbose /dev/md0 --level=0 --raid-
devices=2 /dev/sda /dev/sdb
```

This command tells `mdadm` to create a RAID array called device, `md0` and to use our preformatted drives `sda` and `sdb`:

```
mdadm: chunk size defaults to 512K
mdadm: /dev/sda appears to be part of a raid array:
       level=raid0 devices=2 ctime=Wed Jan 28 00:44:42 2015
mdadm: partition table exists on /dev/sda but will be lost or
       meaningless after creating array
mdadm: /dev/sdb appears to be part of a raid array:
       level=raid0 devices=2 ctime=Wed Jan 28 00:44:42 2015
mdadm: partition table exists on /dev/sdb but will be lost or
       meaningless after creating array
Continue creating array? y
mdadm: Defaulting to version 1.2 metadata
mdadm: array /dev/md0 started.
```

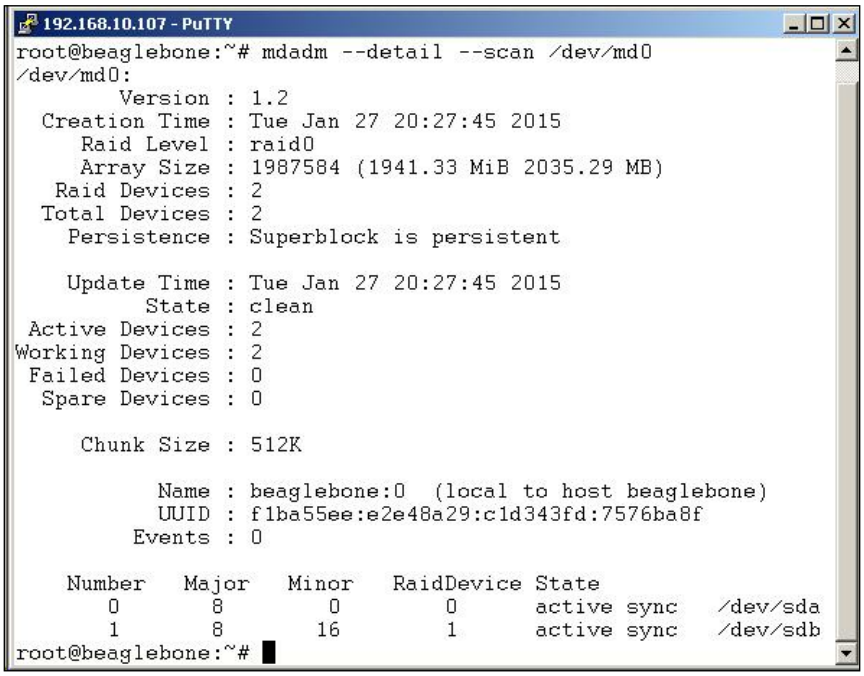
The command also creates a configuration file called `mdadm.conf`, which will be used by Mdadm when we reboot, as shown here:

```
root@beaglebone:/etc/mdadm# cat mdadm.conf
ARRAY /dev/md0 metadata=1.2 name=beaglebone:0
UUID=f1ba55ee:e2e48a29:c1d343fd:7576ba8f
```

If you have set up your RAID properly, then enter this command:

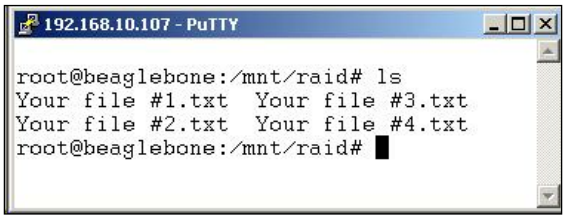
```
mdadm --detail --scan /dev/md0
```

This will produce the following output (a properly configured RAID array):



This tells us that the array has been mounted properly on the device `md0` and that it is a RAID devices `/dev/sda` and `/dev/sbd`. Both these devices are active and synced so that the OS can access both the devices simultaneously (RAID `0`).

We then copy some simple text files to the RAID array in order to make sure that it is working. A directory listing is shown in the following screenshot:



Configuring Samba

Back in *Chapter 2*, *Installing and Configuring Multimedia Server Software*, when Samba was installed, I told you that you will have to make an entry into the `smb.conf` file in order to add the RAID array. Now, you can do this so that the RAID array is visible to all the network devices connecting to your BeagleBone. If you have not already done so in *Chapter 2*, *Installing and Configuring Multimedia Server Software*, edit `smb.conf` and add the following lines.

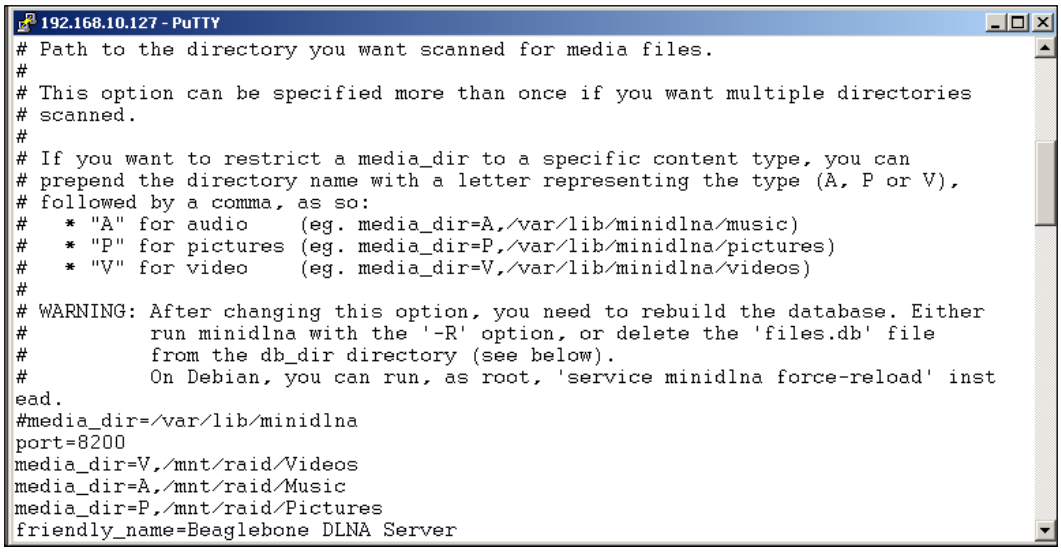
```
#Share for the Raid array
[media]
  Comment= Raid array connected to BeagleBone
  path = /media/<Raid mount point>
  read only = no
  browseable = yes
  valid users = <debian>
```

What we are doing here is explained in the following points:

1. We tell Samba the path to the RAID array with the `path=` statement.
2. We make the directory writeable by telling Samba that it is *NOT* read-only. For security reasons, many Linux settings deny access rather than grant it by default.
3. We then tell Samba which users are allowed to browse the directory. In this case, the default *debian* user. If we had a user called *guest*, we will add them here.
4. You will also have to add the RAID array to the `/etc/minidlna.conf` so that you can stream your files to any `dlna` device on your network:

   ```
   #media_dir=/var/lib/minidlna
   port=8200
   media_dir=V,/mnt/raid/Videos
   media_dir=A,/mnt/raid/Music
   media_dir=P,/mnt/raid/Pictures
   friendly_name=Beaglebone DLNA Server
   ```

The functions of these entries are shown in the following screenshot:



Summary

In this chapter, we created a software RAID array using the Mdadm administrator tool, which we downloaded and configured. We then used `fdisk` to set up and format an array of drives.

In the next chapter, we will be setting up a streaming video server using our new RAID array.

5
Streaming Videos

In this chapter, we are going to set up both live and recorded video streaming, using a web-based application. What this means for the user is that they can access either their recorded videos or a live stream from their home IP video camera, from their smartphone, or their tablet while being logged on to their home network.

In order to do this, we have to install some additional software on our BeagleBone. The instructions explained in this chapter are based on an excellent tutorial from HowtoForge:

`https://www.howtoforge.com/installing-lighttpd-with-php5-php-fpm-and-mysql-support-on-debian-wheezy`

Installing MySQL5

The first package that we are going to install is called **MySQL5**.

All these instructions assume that you have logged in as `Root` and your network IP address is 192.168.10.127.

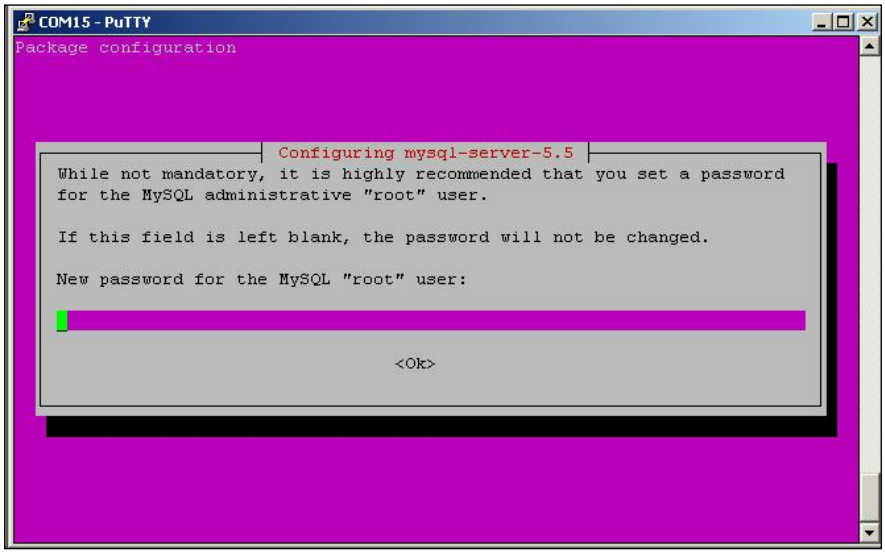
To do this, we enter the following command into a terminal (or SSH) window:

```
apt-get install mysql-server mysql-client
```

Once the software has finished installing, the first thing we have to do is set up a root user password.

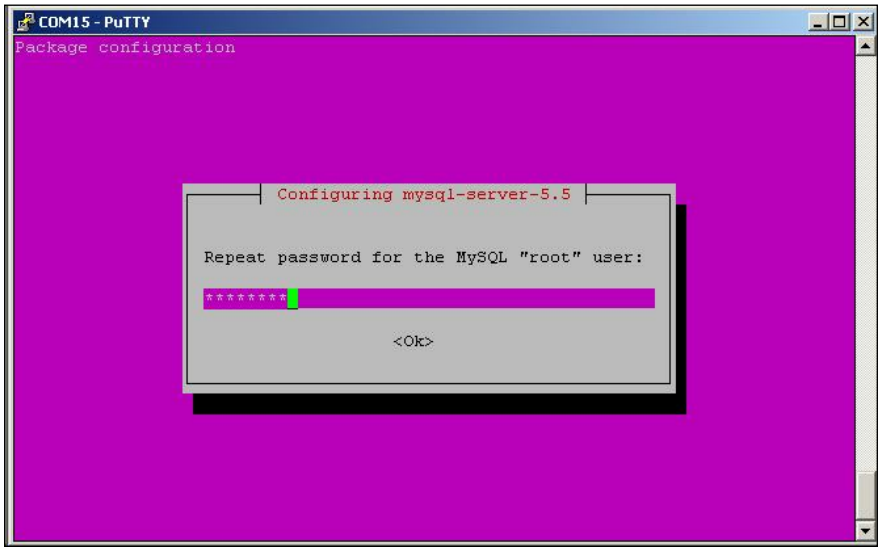
In the terminal window, enter p. The following message will appear in the window, as shown in the following screenshot:

New password for the MySQL "root" user:



You will then be asked to repeat the password with the following message, as shown here:

Repeat password for the MySQL "root" user:



That's it; we are done with MySQL for now.

Installing Lighttpd

The next piece of software that we will be installing is the actual web server software, called **Lighttpd**. This is a server package that has been optimized for embedded applications. It has all the functionality that we will need and consumes relatively few computing resources. For a better reference, refer to `http://www.lighttpd.net/`

> *"With a small memory footprint compared to other web-servers, effective management of the cpu-load, and advanced feature set (FastCGI, SCGI, Auth, Output-Compression, URL-Rewriting and many more) lighttpd is the perfect solution for every server that is suffering load problems. And best of all it's Open Source licensed under the revised BSD license."*

To bring about the installation, we enter the following command in the terminal window:

```
apt-get install lighttpd
```

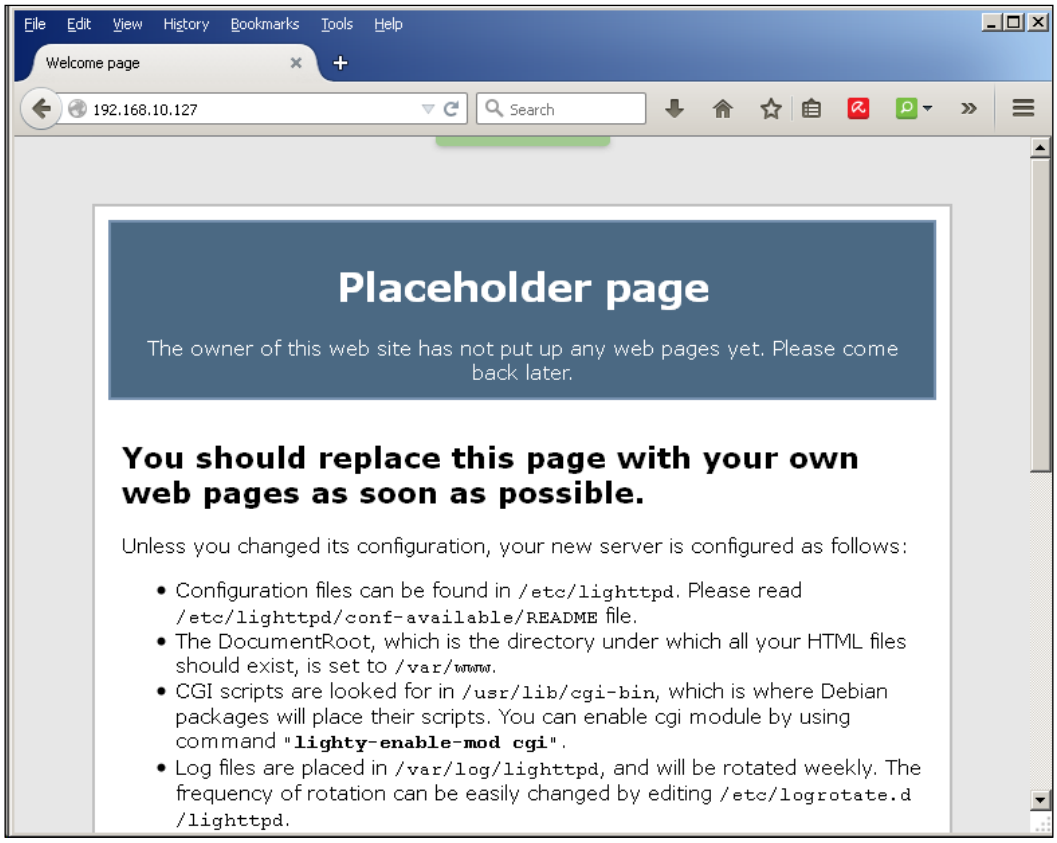
Disabling Cloud9 services

To prevent the Cloud9 IDE from interfering with your web server, you must disable these services:

```
systemctl disable cloud9.service
systemctl disable bonescript.service
systemctl disable bonescript.socket
systemctl disable bonescript-autorun.service
```

Even with these services disabled, you will still be able to use the Cloud9 IDE to develop code.

If you now enter the IP of the BeagleBone, you will see the Lighttpd placeholder page:



If you get `Error 404`, then you've forgotten to perform `apt-get update` as I suggested. So, you can either do the update now or try using `index.html` instead.

Installing PHP5

Our web-based file browser is a PHP application. Therefore, our next task is to install **PHP5** and **PHP-FPM**. PHP-FPM is a daemon process that runs a **FastCGI** server on port 9000. The `init` script for this application is stored at `/etc/init.d/php5-fpm/php.ini`.

To install these two programs, enter the following command:

```
apt-get install php5-fpm php5
```

Configuring Lighttpd and PHP5

To enable PHP5 in Lighttpd, we must modify `/etc/php5/fpm/php.ini` and uncomment the line `cgi.fix_pathinfo=1`:

```
;http://php.net/cgi.fix-pathinfo
;cgi.fix_pathinfo=1
```

Remove the semicolon present at the beginning of the previous line.

The Lighttpd configuration file for `PHP /etc/lighttpd/conf-available/15-fastcgi-php.conf` is suitable for use with `spawn-fcgi`. However, we want to use PHP-FPM; therefore, we create a backup of the file (named `15-fastcgi-php-spawnfcgi.conf`) and modify `15-fastcgi-php.conf`, as follows:

1. `cd /etc/lighttpd/conf-available/`
2. `cp 15-fastcgi-php.conf 15-fastcgi-php-spawnfcgi.conf`
3. `nano 15-fastcgi-php.conf`

We then add the following code to the `config` file:

```
# /usr/share/doc/lighttpd/fastcgi.txt.gz
# http://redmine.lighttpd.net/projects/lighttpd/wiki/Docs:Configuration
Options#mod_fastcgi-fastcgi
## Start an FastCGI server for php (needs the php5-cgi package)
fastcgi.server += ( ".php" =>
        ((
                "socket" => "/var/run/php5-fpm.sock",
                "broken-scriptfilename" => "enable"
        ))
)
```

Lighttpd has a number of different modules that can be enabled by running the `lighttpd-enable-mod <module>` command.

To enable the `fastcgi` configuration, run the following command:

```
lighttpd-enable-mod fastcgi
```

As a result of running the command, the following messages are displayed in the terminal:

```
Available modules: auth accesslog cgi evasive evhost expire fastcgi
flv-streaming no-www proxy rrdtool simple-vhost ssi ssl status userdir
usertrack fastcgi-php-spawnfcgi fastcgi-php debian-doc
Already enabled modules:
Enabling fastcgi: ok
```

```
Run /etc/init.d/lighttpd force-reload to enable changes
```

We proceed further by running the following command:

```
lighttpd-enable-mod fastcgi-php
```

The messages displayed in the terminal will look like the following:

```
Available modules: auth accesslog cgi evasive evhost expire fastcgi
flv-streaming no-www proxy rrdtool simple-vhost ssi ssl status userdir
usertrack fastcgi-php-spawnfcgi fastcgi-php debian-doc
Already enabled modules: fastcgi
Enabling fastcgi-php: ok
```

This creates the `symlinks /etc/lighttpd/conf-enabled/10-fastcgi.conf`, which points to `/etc/lighttpd/conf-available/10-fastcgi.conf`, and `/etc/lighttpd/conf-enabled/15-fastcgi-php.conf`, which points to `/etc/lighttpd/conf-available/15-fastcgi-php.conf`.

Now, enter the following command:

```
cd /etc/lighttpd/conf-enabled
ls –l
```

You will see the following messages in the terminal:

10-fastcgi.conf -> ../conf-available/10-fastcgi.conf

fastcgi-php.conf -> ../conf-available/15-fastcgi-php.conf

We then force a reload, as follows:

```
root@beaglebone: /etc/init.d/lighttpd force-reload
```

This causes the terminal to display the following:

*** Reloading web server configuration lighttpd [OK]**

Testing PHP5

The document root of the default website is `/var/www`. We will now create a small PHP file (`info.php`) in this directory and call it in a browser:

```
nano Info.php
<?php
phpinfo();
?>
```

The following screenshot shows how `Info.php` looks in a browser:

The file will display lots of useful details about our PHP installation, such as the installed PHP version, as shown here:

PHP5 is working, and it's working through FPM/FastCGI, as shown in the **Server API** line. If you scroll down further, you will see all the modules that are already enabled in PHP5. MySQL is not listed here, which means that we don't have MySQL support in PHP5 yet.

Setting up MySQL support in PHP5

To get MySQL support in PHP, we can install the `php5-mysql` package. It's a good idea to install some other PHP5 modules as well, as you might need them for your applications. You can search for available PHP5 modules as follows:

```
root@beaglebone:/apt-cache search php5
```

You will see the following messages being displayed:

```
php5-curl - CURL module for php5
php5-dbg - Debug symbols for PHP5
php5-dev - Files for PHP5 module development
php5-gd - GD module for php5
php5-gmp - GMP module for php5
php5-ldap - LDAP module for php5
php5-mysql - MySQL module for php5
php5-odbc - ODBC module for php5
```

Pick the modules you need and install them. These are the ones that I installed:

```
apt-get install php5-mysql php5-curl
```

Xcache is a PHP opcode cacher for caching and optimizing PHP intermediate code. Xcache can be installed as follows:

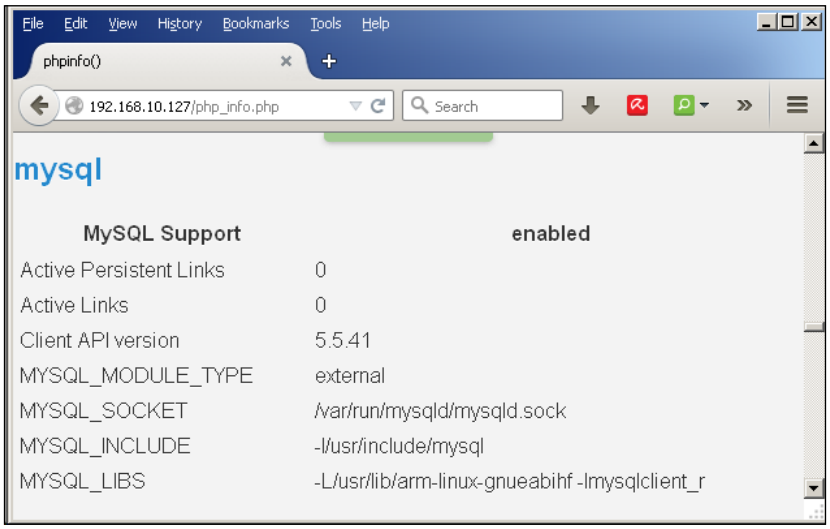
```
apt-get install php5-xcache
```

Reload the PHP-FPM service:

```
/etc/init.d/php5-fpm reload
```

Now, reload `http://192.168.10.127/info.php` in your browser and scroll down to the modules section again.

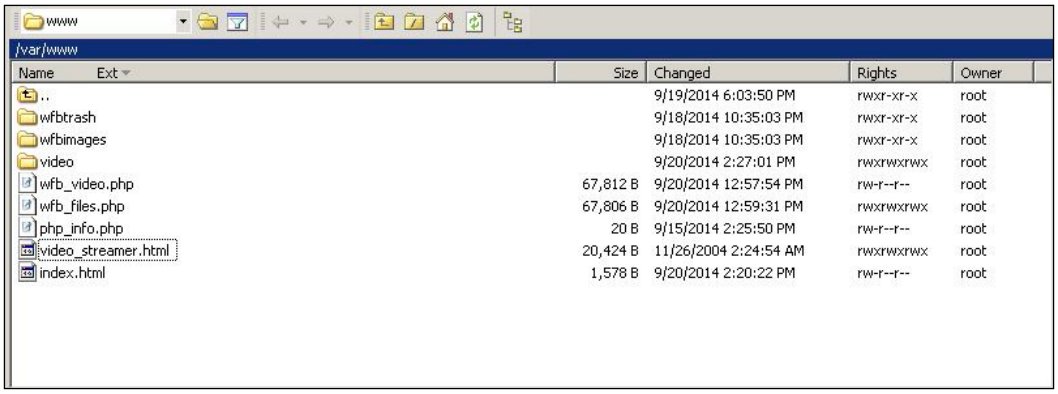
You should now find lots of new modules here, including the **mysql** module:



Creating your own home page

Now that we have the required software installed and configured, it is time to install our own software. We will start by installing our home page, called `index.html`, in the directory where Lighttpd expects to find it.

The directory name is `/var/www`, as shown here:



The software uses a modified version of `wfb.php`, which is a web-based file browser written in PHP. It is available for download at `http://cgdave.github.io/webfilebrowser/`.

There are three subdirectories:

- The `wfbtrash` directory is used by `wfb` to store deleted files. This directory must have write privileges enabled or the delete button on the form will not be available.
- The `wfbimages` directory is where the icons for the form are stored. If you want to use your own icons, this is where you will put them.
- The `video` directory is where we will store all our pre-recorded videos. This directory is the cleanest way of keeping our video files separate from the program files.

Creating two modified PHP files

What I have done is created two versions of `wfb.php` and changed the `base directory` information in each file.

The following is the code for `wfb_video.php`:

```
$basedir = "video";// Base directory = custom directory
$filelinks = true;// Links on files enabled
$basevirtualdir = "video" //video directory
```

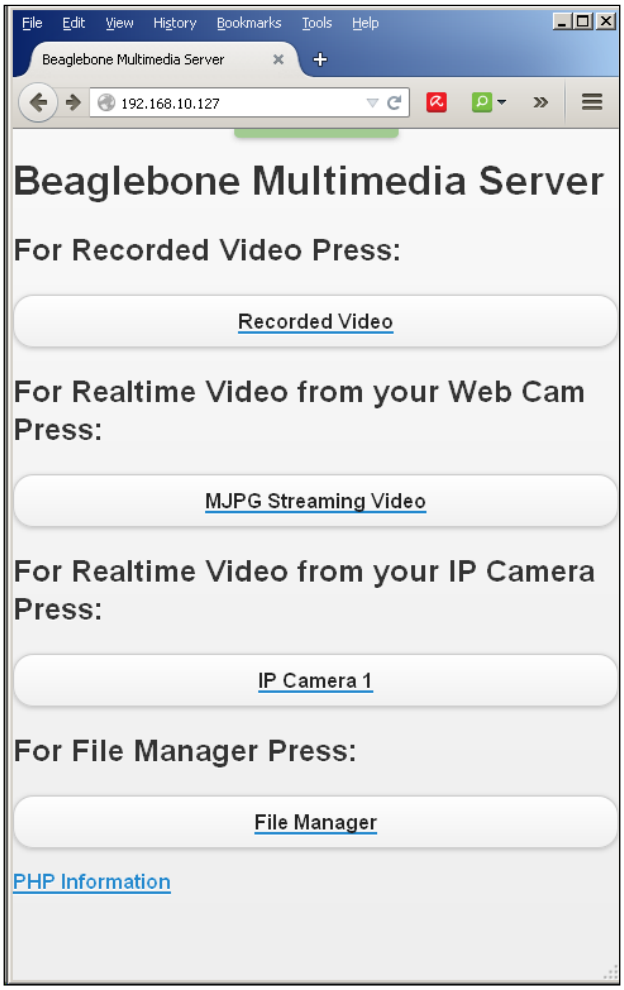
File links are enabled so that when the user clicks on a given link, the video will automatically start playing, assuming that the required codecs are installed in the browser.

The following is the code for `wfb_files.php`:

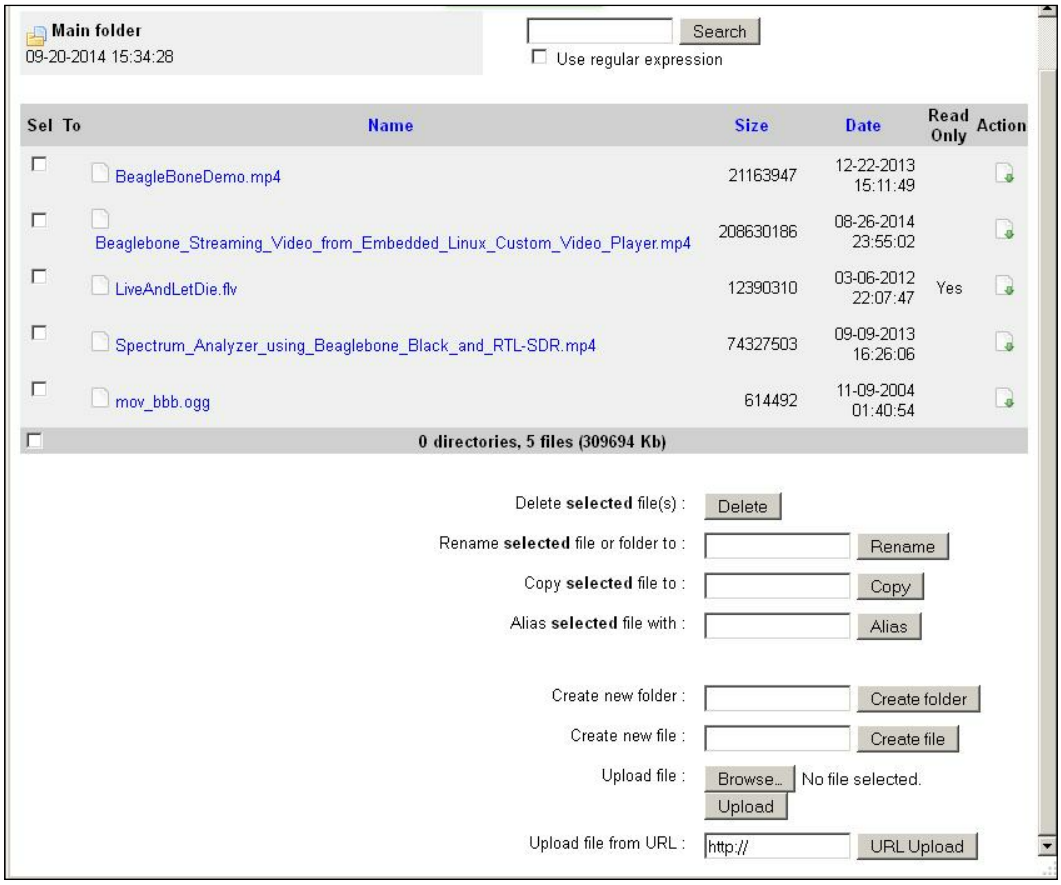
```
$basedir = "/";   // Base directory = custom directory
$filelinks = true;// Links on files enabled
$basevirtualdir = "/"; // root directory
```

In this case, the root directory of the file system can be accessed. There doesn't appear to be any way to pass directory information to the PHP code, so we need a different `wfb.php` file for each location.

When the user enters the location of the media server into their browser, they will be directed to `index.html` on the BeagleBone (in my case, `192.168.10.127`).

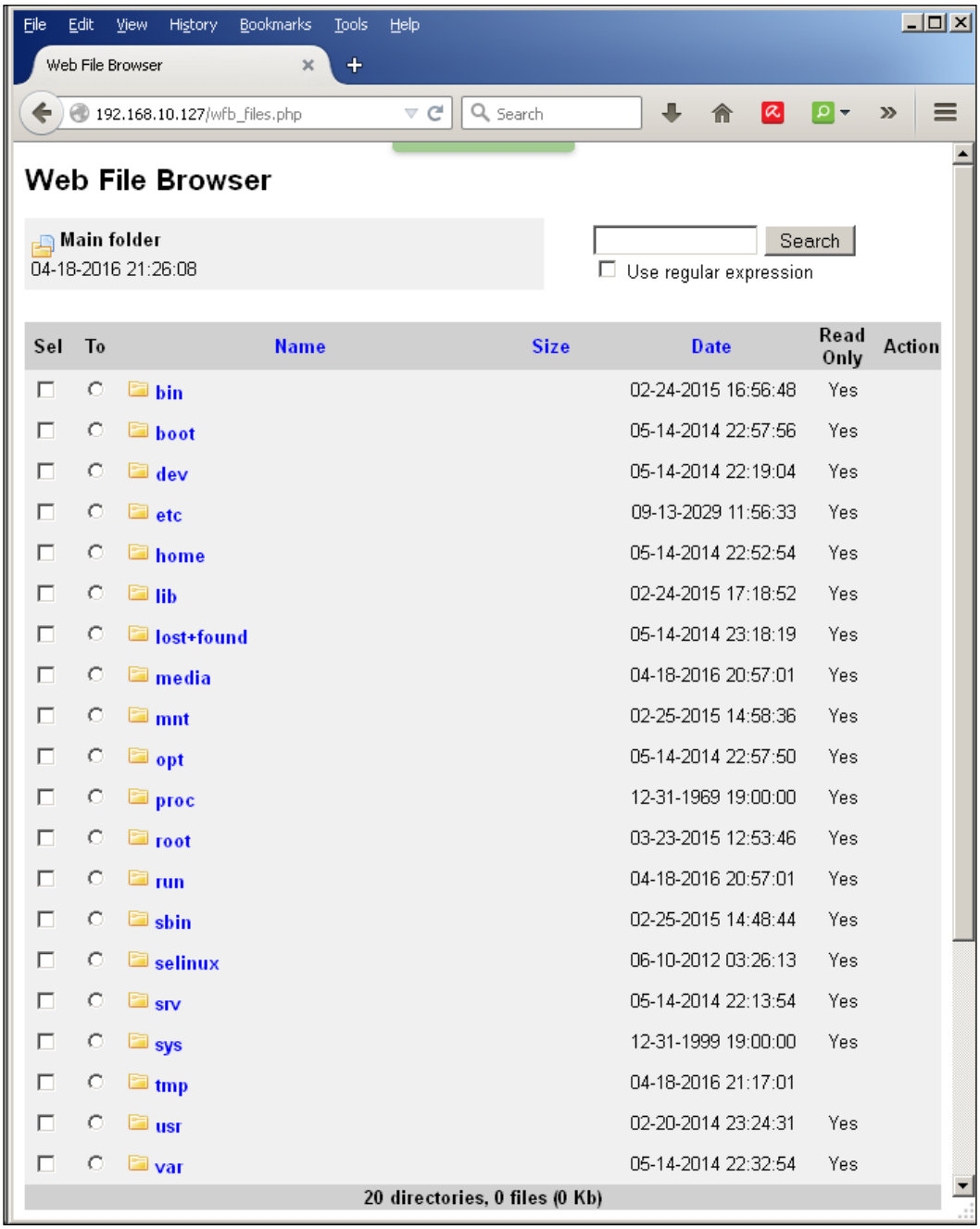


When the user presses the **Recorded Video** button, the following custom file browser screen appears:

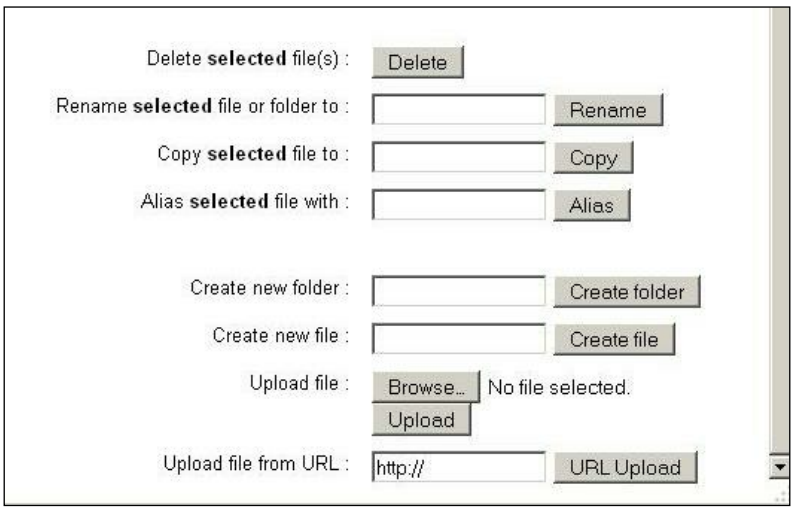


The **File Manager** interface is pretty much the same, except that the browser is now pointing to the root directory of the BeagleBone. This version of the PHP file should have password access enabled in order to keep normal users from damaging things.

As we can see in the following screenshot, we have **Root File System Access**:



In both cases, there is an additional area at the bottom of the page that allows the user to do many of the things that they can do in a graphical user interface based system, including uploading files from the Internet.



The user is also able to access the IP cameras that are connected to their local network. In this case, the HTML code of `index.html` must be modified so that it points to the user's camera.

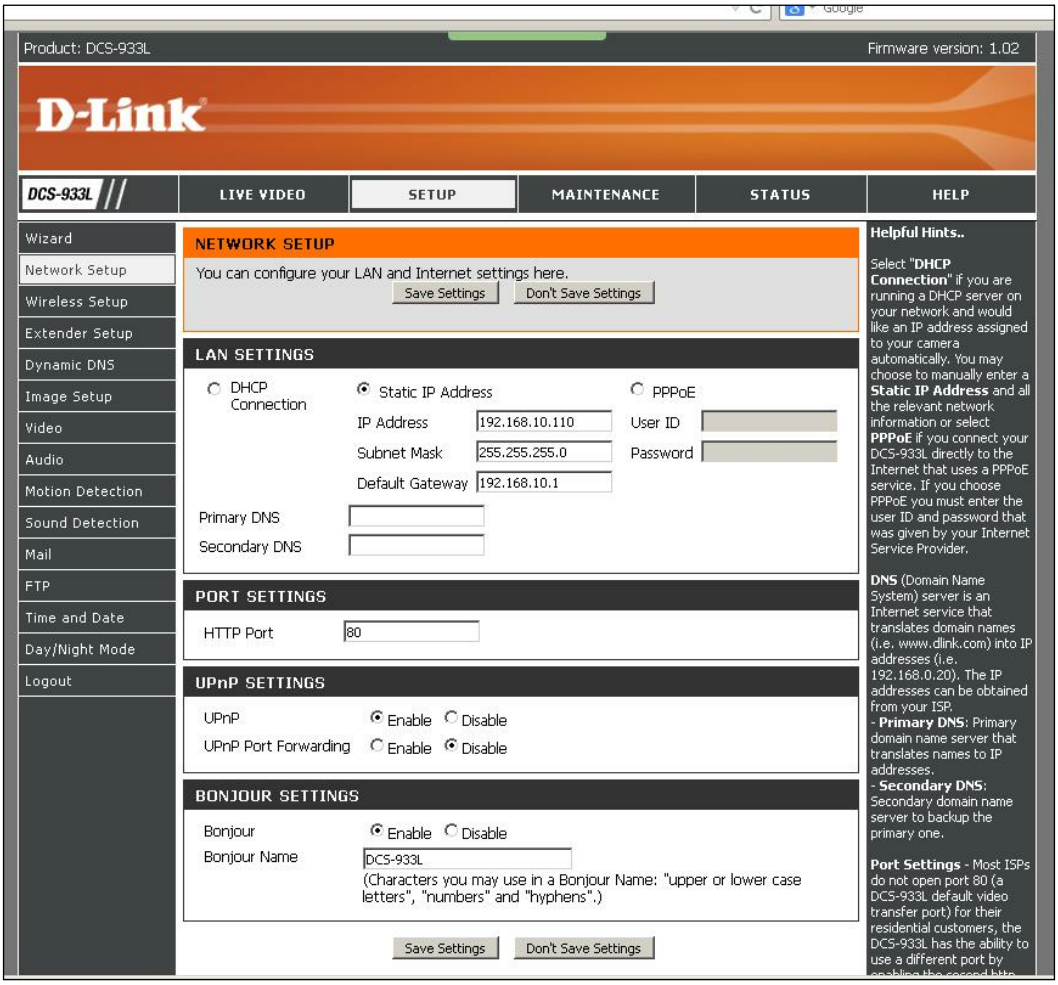
In this case, the IP address is `192.168.10.110` and the default page to view is `jview.htm`. The reader's IP address and default page will probably be different. This information is for a D-Link DCS-933L camera, which requires the user to log in before accessing the video.

```
<h2>For Realtime Video from your IP Camera Press:</h2>

<p>
<a href="http://192.168.10.110/jview.htm" target="_parent"><button>IP
Camera 1</button></a>
</p>
```

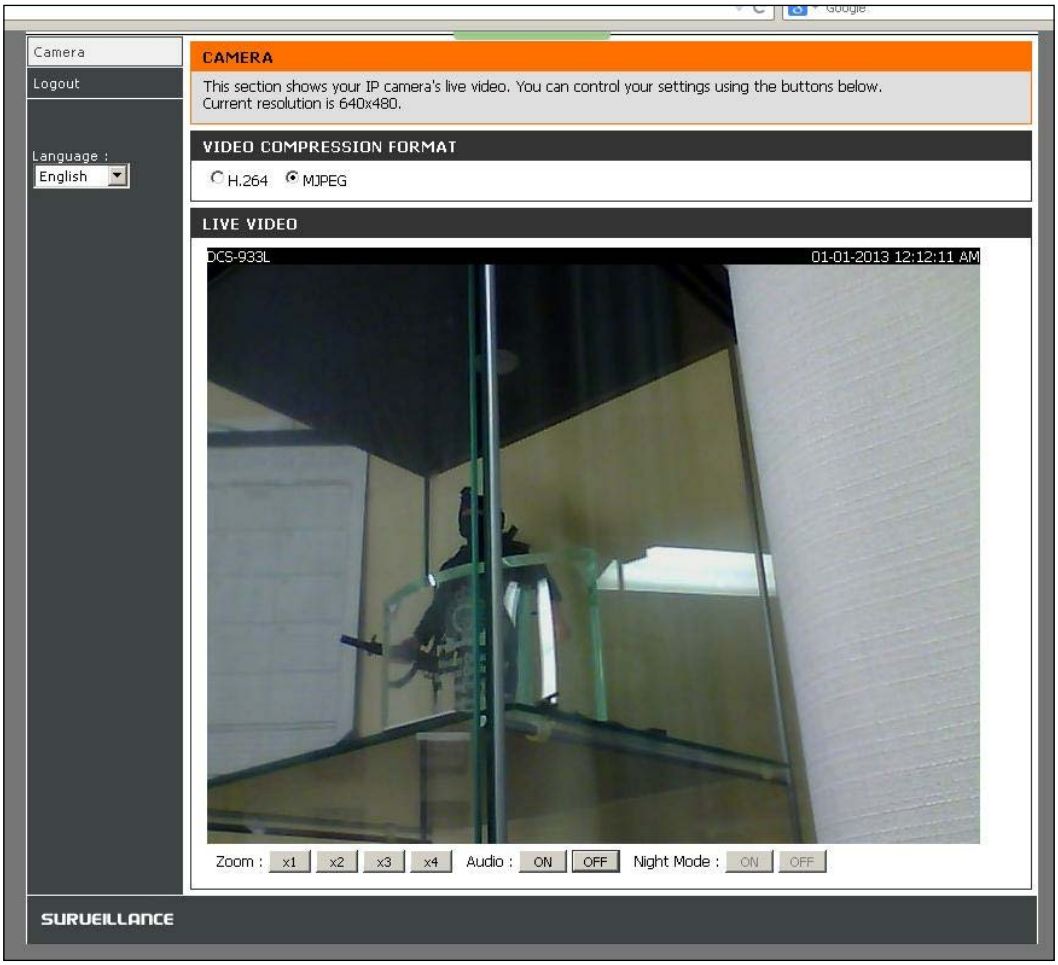
Most, if not all, IP cameras have a built-in web server with a configuration page. What you can *configure* varies from camera to camera, but the most important part is the camera's IP address. In the following screenshot, you will see that I have configured the camera to use a static IP address. This is so that our home page will always be able to find the camera. My network uses the IP addresses `192.168.10.xxx`, so I set up the camera at `192.168.10.110` in the LAN settings. My default gateway is `192.168.10.1`; yours may be different.

When you access the camera, you must first enter a username and password. The username is `admin` and the password field is blank. You should probably change this in the settings menu.

As you can see in the following screenshot, this particular camera has a number of features that can be **SETUP** for security monitoring:



Once this is done, the user can access the camera from the web application by clicking on the **LIVE VIDEO** button at the top of the screen, as shown here:



There are several buttons at the bottom of the video's window, which allows the user to (digitally) zoom in and out, turn the sound on and off, and enable **Night Mode**. In night mode, the camera will automatically detect when the light level drops and will turn on the Infrared LEDs. Other IP cameras will, of course, have different controls, such as pan, tilt, and optical zoom.

Configuring a streaming video

In order to provide video streaming from a USB device in our multimedia setup, we have to first install some software that will allow the BeagleBone to act as a server. The software that I chose to use is called **MJPG Streamer**. If you want to add more functionality than I have here, the instructions are available at `http://shrkey.com/installing-mjpg-streamer-on-beaglebone-black/` and at Sourceforge (`http://sourceforge.net/projects/mjpg-streamer/`).

The first thing we have to do is install the tools and dependencies that we will need to compile the software.

I make it a habit to always do an `apt-get update` to make sure that all the repositories are up to date. The following commands will install the required tools and dependencies. If your tools are already installed and up to date, they will not be overwritten. All the commands assume that you are logged in as root:

1. Run the following command:

   ```
   apt-get install g++ curl pkg-config libv4l-dev libjpeg-dev
   build-essential libssl-dev vim cmake
   ```

2. Then, run this:

   ```
   apt-get install imagemagick
   ```

3. Next, we have to get the code from the website I mentioned earlier:

   ```
   wget https://github.com/shrkey/mjpg-streamer/raw/master
   /mjpg-streamer.tar.gz
   ```

4. Now that we have the tar ball, we can expand it in the directory of our choice:

   ```
   tar -xvf ./mjpg-streamer.tar.gz
   ```

5. The next step is to compile the `mjpg-streamer` code:

   ```
   cd mjpg-streamer


   make USE_LIBV4L2=true


   make install
   ```

6. Now, from the directory that we compiled in, we can run a quick test by typing the following:

   ```
   /mjpg_streamer -i "./input_uvc.so" -o "./output_http.so -w
   ./www"
   ```

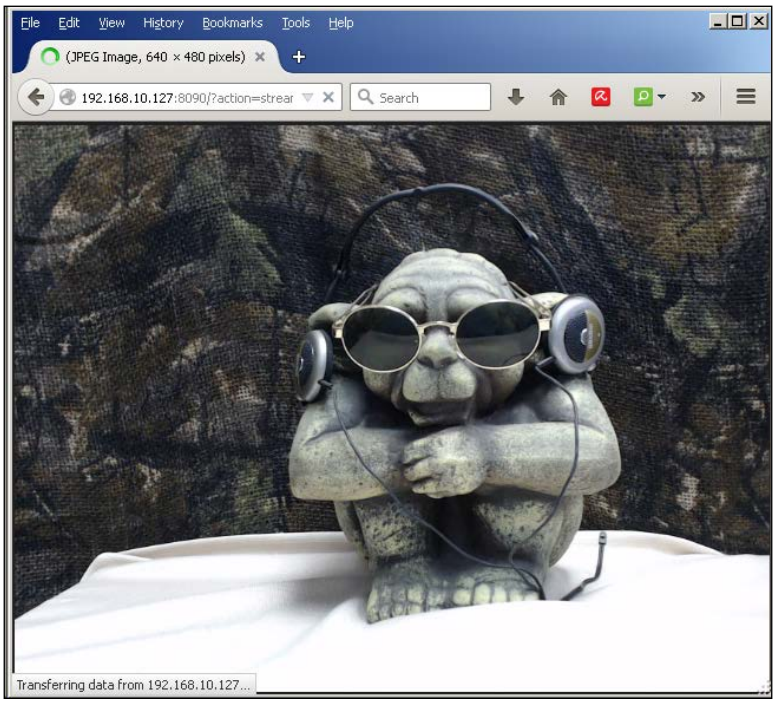
This will start the server running from port `8080` of the BeagleBone. The `input_uvc.so` file is the input device driver used by `mjpg_streamer`, and `output_http.so` is the output device driver. The final argument is the directory, where the web page is located, that the video should be sent to.

You will see a screen much like what is shown in the following screenshot; the actual messages shown will depend on the capabilities of your particular camera:

```
MJPG Streamer Version: svn rev:
    i: Using V4L2 device.: /dev/video0
    i: Desired Resolution: 640 x 480
    i: Frames Per Second.: 5
    i: Format............: MJPEG
    o: www-folder-path...: ./www/
    o: HTTP TCP port.....: 8080
    o: username:password.: disabled
    o: commands..........: enabled
```

If you now go to the web interface described earlier and click on the **Streaming Video** button, you should see the output of your webcam.

The following screenshot is from a cheap dollar store camera (it came with an exercise video for about $3.00):



Summary

In this chapter, we installed and set up our web server software as well as support for PHP scripting and SQL.

We also installed the web page that will allow you to view both recorded video on your file server and live video from IP and USB cameras. The web page also features a web-based file browser, similar to those available with graphical user interfaces.

In the next chapter, we will be setting up a Wi-Fi server so that you can connect to your multimedia server from anywhere within its range.

6
Setting Up a Wireless Access Point

In this chapter, we will be installing and setting up a **Wireless Access Point** (**WAP**) on our BeagleBone system. In the first phase of the installation, our media server will be wide open. Once we have things running smoothly, we will add layers of security.

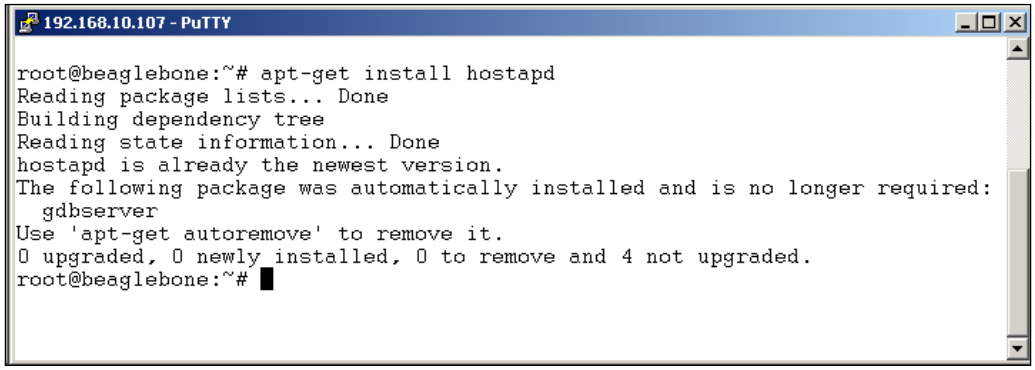
We will do this by installing and configuring the following programs:

- **hostapd**: This will install the access point software
- **DHCP**: This will provide the user with a local IP address

Installing hostapd

The first thing that we have to do is to make sure that we have the latest version of `hostapd`, and we can do this with the following commands:

```
apt-get update
apt-get install hostapd
```



As you can see in the previous screenshot, we have the latest version installed.

Now that we know we have the latest version installed, it is time to edit the `/etc/default/hostapd` configuration file, as follows:

```
nano /etc/default/hostapd
```

We need to add the following line to the file:

```
DAEMON_CONF="/etc/hostapd/hostapd.conf"
```

This is how your `hostapd` file should look:

```
# Defaults for hostapd initscript
#
# See /usr/share/doc/hostapd/README.Debian for information about
alternative
# methods of managing hostapd.
#
# Uncomment and set DAEMON_CONF to the absolute path of a hostapd
configuration
# file and hostapd will be started during system boot. An example
configuration
# file can be found at
/usr/share/doc/hostapd/examples/hostapd.conf.gz
#
DAEMON_CONF="/etc/hostapd/hostapd.conf" ß Add this line

# Additional daemon options to be appended to hostapd command:-
#   -d   show more debug messages (-dd for even more)
#   -K   include key data in debug messages
#   -t   include timestamps in some debug messages
#
# Note that -B (daemon mode) and -P (pidfile) options are
automatically
# configured by the init.d script and must not be added to
DAEMON_OPTS.
#
#DAEMON_OPTS=""
```

Now that we have referenced the `hostapd`it, the next file that we have to create is the `hostapd.conf` file.

You can create and empty the file with the following command:

```
touch /etc/hostapd/hostapd.conf
```

Next, we edit the empty file and add the following text:

```
### Wireless network name ###
interface=wlan0
### Set your bridge name ###
#bridge=br0

#driver
driver=nl80211
country_code=US
## The name of your server##
ssid=Beaglebone Media Server
## Channel to use
channel=7
hw_mode=g
#############Security Starts Here#########################
# # Static WPA2 key configuration
# #1=wpa1, 2=wpa2, 3=both
# #wpa=2
## wpa_passphrase=yourpassword
## Key management algorithms ##
## wpa_key_mgmt=WPA-PSK
#
## Set cipher suites (encryption algorithms) ##
## TKIP = Temporal Key Integrity Protocol
## CCMP = AES in Counter mode with CBC-MAC
wpa_pairwise=TKIP
#rsn_pairwise=CCMP
#
## Shared Key Authentication ##
auth_algs=1
## Accept all MAC address ###
macaddr_acl=0
#enables/disables broadcasting the ssid
ignore_broadcast_ssid=0
# Needed for Windows clients
eapol_key_index_workaround=0
```

As I mentioned earlier, security is disabled at this point. At the risk of stating the obvious, a laptop or a tablet with Wi-Fi capability will come in really handy while performing the following steps.

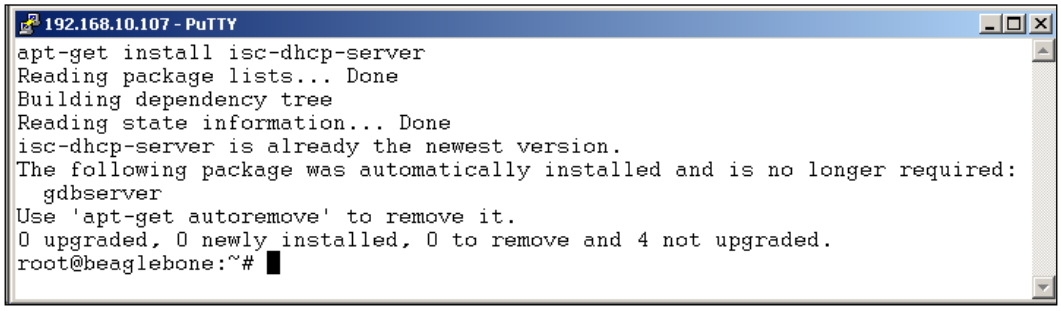
If you turn on your laptop or tablet and "search for available networks," you should see your BeagleBone server on the list. It will be displayed as an **Open** network, because we have not turned on security yet. If you try to connect, your device will say something such as *acquiring a network address* and then hang. This is normal because we haven't set up DHCP yet. We do know, however, that hostapd is alive and well.

Installing DHCP

The **Dynamic Host Control Protocol** (**DHCP**) is how your computer, tablet, or smartphone gets an IP address when you log on to a network or an access point at your favorite coffee shop.

The first thing to do, once again, is to make sure that we have the latest version of the software installed, with the following commands:

```
apt-get update
apt-get install isc-dhcp-server
```



As you can see in the previous screenshot, we have the latest version installed.

Next, we have to edit the configuration file for the DHCP server. For this, we run the following command:

```
nano /etc/dhcp/dhcpd.conf
```

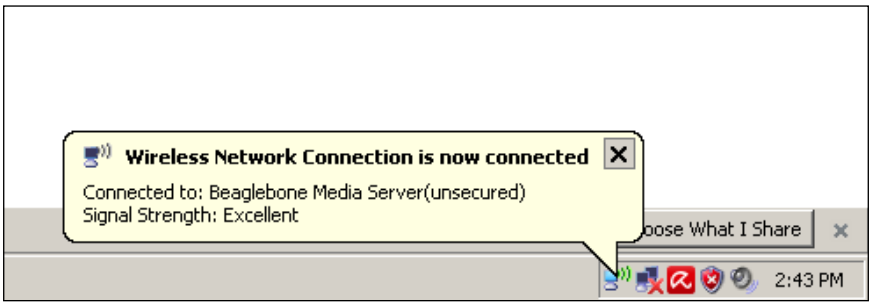
Then, we add the following lines:

```
subnet 192.168.4.0 netmask 255.255.255.0 {
  range 192.168.4.2 192.168.4.10;
}
```

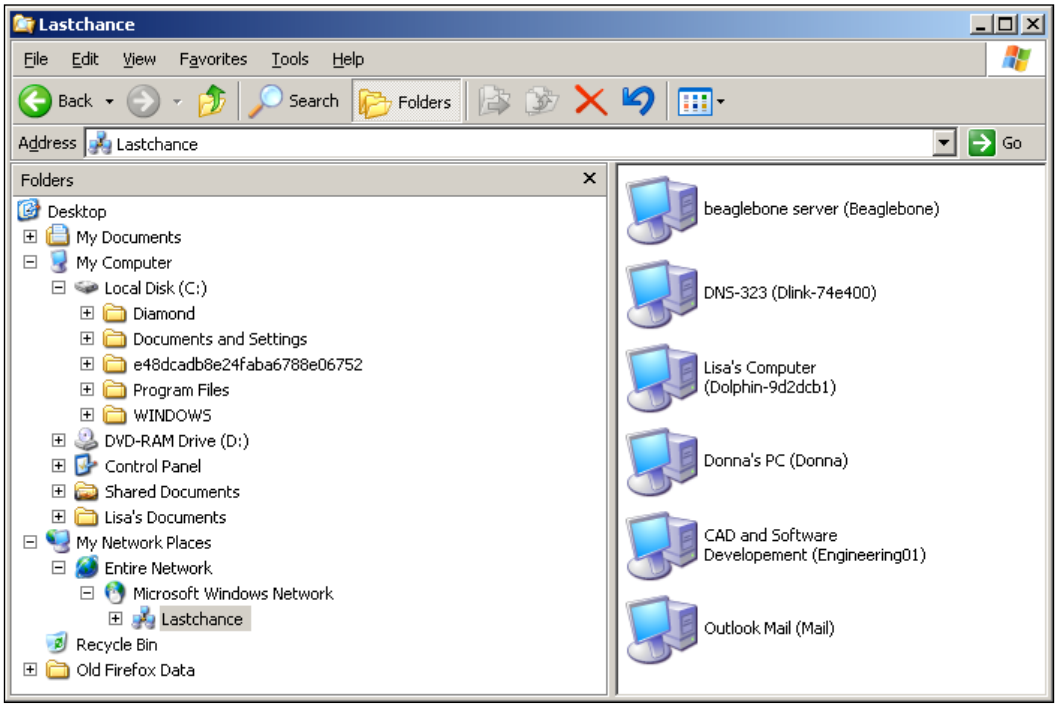
This is how your `dhcp.conf` file will look:

```
#
# Sample configuration file for ISC dhcpd for Debian
#
#
.
.
.
.
subnet 192.168.4.0 netmask 255.255.255.0 {
  range 192.168.4.2 192.168.4.10;
}
```

Now that we have DHCP configured, we can reboot our BeagleBone and can try to connect to it wirelessly, as shown here:



Because we previously installed **Samba**, your media server will also show up in the networks list of your control panel. Depending on your version of Windows, it may look different from the following screenshot:



The following screenshot is a screen grab from my Windows XP laptop, which has connected wirelessly to my multimedia server. We can now play music and stream various kinds of videos to the laptop. (Note the IP address shown in the address bar.)

Enabling Wi-Fi security

Now that we have everything up and running, it is time to add some wireless security to our media server. This isn't absolutely necessary, if your server will not be permanently connected to your home network, but I highly recommend that you do it.

The following portion of `hostapd.conf` shows the security part of the file:

```
#############Security Starts Here#########################
# # Static WPA2 key configuration
# #1=wpa1, 2=wpa2, 3=both
# #wpa=2
## wpa_passphrase=yourpassword
## Key management algorithms ##
## wpa_key_mgmt=WPA-PSK
```

The first few lines are where we enable `WPA/WPA2`:

For more information on WEP/WPA/WPA2, just follow `http://en.wikipedia.org/wiki/Wi-Fi_Protected_Access`.

```
## Set cipher suites (encryption algorithms) ##
## TKIP = Temporal Key Integrity Protocol
## CCMP = AES in Counter mode with CBC-MAC
wpa_pairwise=TKIP
#rsn_pairwise=CCMP
#
## Shared Key Authentication ##
auth_algs=1
```

For information on TKIP, check out `http://en.wikipedia.org/wiki/Temporal_Key_Integrity_Protocol`.

Next, we can set up MAC address filtering:

```
## Accept all MAC address ###
macaddr_acl=0
```

Finally, we can choose to broadcast our SSID.

This option is a bit strange. What we are saying is *don't ignore broadcasting the SSID*; in other words, broadcast the SSID. It is a kind of double negative:

```
#enables/disables broadcasting the ssid
ignore_broadcast_ssid=0

# Needed for Windows clients
eapol_key_index_workaround=0
```

I will suggest that you enable these features one at a time and check the operation between changes.

The hardware

This is the final section of this chapter and of this book as well. The following is a list of the devices that I used when I was writing this book; I hope you will find them useful:

- **Wi-Fi dongle**: ASUS - WL167G (the following image is an example of it)

- **USB flash drive**: 8 GB USB Flash drive from Dollarama ($3.00 CDN)
- **Four-port hub**: Targus non-powered from Dollarama ($3.00 CDN) (I will recommend that you use a powered hub if you experience problems or are using a high-power Wi-Fi adapter)

- **12 Volt USB charger**: From Dollarama (~$3.00 CDN)

Dollarama is a local chain store that sells cheap Chinese-made goods for under $5.00

By using the USB charger shown previously, you can power your multimedia server from any 12 Volt source, such as a car, boat, or RV. With one of the many rechargeable battery packs, you can also take it to the beach.

Summary

In this chapter, we added Wi-Fi connectivity to our multimedia server. You also saw how to secure the access point.

If you have completed all or most of the tasks in the previous chapters, you should now have a portable or fixed multimedia server, which is capable of simultaneously streaming music and MP4 videos to any WiFi-enabled device, any device on your home wired network, or of any other combination.

I hope that this book has been both informative and entertaining and that you enjoy your new multimedia device as much as we enjoyed writing this book.

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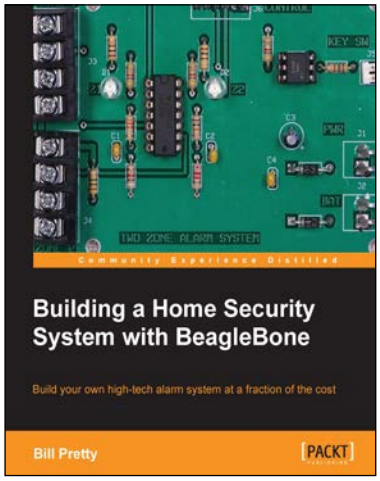

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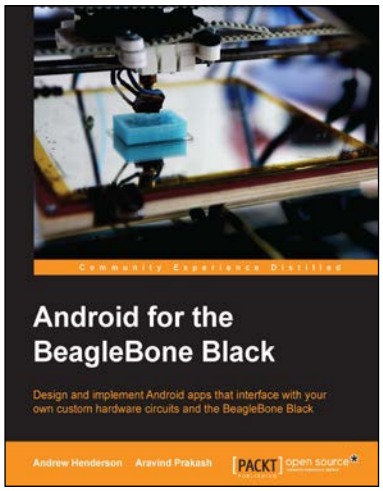

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