Building a Raspberry Pi Office Network Server

By Dave Campbell

Keywords: Raspberry Pi, RPi, small business, office, server, network, Kerberos login, domain, DNS server, DHCP server, Samba server, Active Directory, file and printer sharing, Linux, Raspian, open source.



Figure 1: Raspberry Pi Server Hardware

# Abstract

This document provides step-by-step details for setting up a Raspberry Pi (RPi) to perform the basic services of managing a small office or home network using Raspian Linux and open source tool packages. It includes everything needed to support a basic Active Directory domain controller, including time services, dynamic IP, DNS and DHCP network services, file and printer sharing, Kerberos login, backup, and automation of operational tasks.

Total cost of full feature (headless) hardware, including a 1.2GHz Quad-core Raspberry Pi 3 with 1G RAM, 16G SD Card, case, power adapter, 64G USB flash drive, USB SD Card adapter and second 16G SD Card, runs around $100. Total software cost and licensing is $0.

Setup time following these instructions runs around 2-3 days. After creating a baseline image file, it only requires a matter of a few minutes to rebuild the server. Existing servers have demonstrated uptime and reliability equal to or better than Windows based servers.

# Hardware

This tutorial assumes the following hardware for setup, shown in Figure 1:

* A Raspberry Pi B+ or 2B or 3 (recommended).
* 2A MicroUSB wall wart power supply.
* 16G or larger MicroSD card loaded with NOOBS. (A Raspian only distribution can be used too.)
* Network connection (Ethernet recommended or wireless adapter).
* A 64G or larger USB flash drive for local Linux file and image backup.
* Optional HDMI monitor, keyboard, and mouse (required for setup only).

## Operating System Assumption

This tutorial assumes a general familiarity with Linux or at least some commandline based operating system experience such as DOS. *Appendix A: Linux Jumpstart* provides information on getting started with Linux as well as an explanation of most commands used herein.

### Tips

This tutorial shows tips formatted as green text outlined in green boxes.

### Warnings

This tutorial shows warnings formatted as red text outlined in red boxes.

### Keywords

Keywords appear highlighted inline as example or marked items.

### Code

Code appears as monospaced indented colored text...

# Server Specific Configuration

**For consistency and simplicity of documentation, this tutorial assumes a number of configuration details specific to the tutorial that each particular setup must uniquely define.** These fields, styled as shown below, include:

* Server (aliases): tiny (host), timex (NTP), home, house
* User: pi
* Subnet and mask: 192.168.0.0 or 192.168.0.1 / 255.255.254.0
* IP address(es): 192.168.0.251 (local DNS [DNSMasq], house)

192.168.0.253 (Samba AD DC, home, tiny)

* Registered domain: saranamabq.net
* AD domain (& DNS) name: home.saranamabq.net
* AD Kerberos Realm: HOME.SARANAMABQ.NET
* NetBIOS domain: HOME
* Primary DC (host): tiny.home.saranamabq.net (tiny)
* SMTP admin contact: contact-email
* Domain Admin Account: HOME\Administrator
* Windows admin node: airstream (running RSAT)

# Starting with Raspian Linux

This setup uses the popular Raspian Linux distribution, a Debian Linux derivative specifically optimized for the Raspberry Pi platform. Given the similarity to various other Debian derivatives, nearly all of the setup instructions will work for other configurations as well, such as Ubuntu on an old desktop PC.

The configuration instructions generally follow an order of precedence required for proper changes. That is, you must do certain things before other actions you can complete. Although the order of most things typically does not matter some things may be more easily accomplished based on certain services being available.

The following configuration setup and changes make use of the nano editor included in the default Raspian configuration, but any text editor of user choice may be used. I suggest the user spend some time familiarizing oneself with a basic text editor of choice before attempting server setup. It is always a good idea to work with recovery in mind, so I suggest reviewing the *Appendix A: Linux Jumpstart* section on *Best Practices* before making any edits to configuration setups.

The code examples provided can generally be cut and pasted directly to the Raspberry Pi commandline or into specified files as needed although some edits would be required for user and server specific information as given above.

## New Out Of Box Software (NOOBS)

NOOBS implements an operating system (OS) installer and provides a very convenient way to start building a server. Download the NOOBS installer ISO image from the Raspberry Pi web site (<http://www.raspberrypi.org>) and prepared on an SD card according to instructions there. Once ready, simply insert the SD card and apply power to boot the Raspberry Pi to the NOOBS installer.

NOOBS will load a simple graphical menu to choose one of several OSes for install. Select Raspian and install. When installation completes the raspi-config program should automatically start. Use it to

* Change user (pi) password. (**Document it! If you forget it, you will have to start over**.)
* Make appropriate Internationalization Options changes.
* Advanced Options changes
  + Change Hostname (see password tip below)
  + Adjust memory split to 16M (i.e. server doesn’t need graphics performance)
  + Enable Secure Shell (SSH)   
    See IMPORTANT NOTE ABOUT KEY GENERATION in Remote Secure Shell (SSH) Operation section.
* Update the raspi-config tool (with the command below…

sudo apt-get install raspi-config

Upon reboot, you will be presented a terminal session requesting login credentials. Login as user pi with the password defined above in the raspi-config session.

Password Tip: An administrator password must meet rules for strict passwords. A strict password must include at least one each of upper and lower case letters, digit 0-9, and special characters (i.e. ~!@#$%^&\*\_-+=`|\(){}[]:;"'<>,.?/), be at least 8 characters in length, and it must not contain the username

## Basic Machine Setup

To be useful as a server with remote access you must change a few basic settings. **You may perform all these actions from a terminal window started from an icon on the Desktop, usually as a** superuser**.**

Tip: The sudo command prefix used in the following instructions stands for “superuser do”, explained in Appendix A: Linux Jumpstart. sudo gives you temporary permission to act as an administrator to perform privileged operating system actions. Failure to include sudo will likely result in the familiar “permission denied” message. When performing many successive commands, such as initial setup, you will find it easier to use the su command, which enters a continuous superuser mode. Type exit to return to user mode.

### Machine Reboot and Shutdown

Many operations require rebooting the system afterwards. Simply run:

sudo reboot

Alternate ways to shut down the Raspberry Pi include any of the following:

sudo halt -p

sudo shutdown –h now

sudo poweroff

These commands signal all processes to save state as necessary and stop, unmounts file systems, and then sets the RUNLEVEL=6, which stops execution and makes removing power safe.

Warning: Removing power (from the Raspberry Pi while operating) to initiate a reboot has a tendency to corrupt the SD card. Use the shutdown methods outlined above.

### Set Root Password

Always set the root password to a known value for administrator use by running the command.

sudo passwd root

You must successfully enter the password twice to change it. It may be set the same as user pi since pi has administrator privileges.

### Hostname

The human-friendly machine name, known as the hostname, can be edited using raspi-config or by directly editing the /etc/hostname file with nano. This file contains a single line containing the name of the machine.

sudo nano /etc/hostname

(Enter the desired machine name without a newline)

(Save the file by CTRL-X)

### Host Lookups

The /etc/hosts file relates fixed IP addresses of local machines to their static host names and aliases. Edit the file with

sudo nano /etc/hosts

Add a line for the server itself and a second for the primary domain controller and include all desired aliases as a space delimited list such as

192.168.0.251 house timex

192.168.0.253 tiny home home.saranamabq.net

Tip: See Network Time Protocol (NTP) Service section for use of timex.

### Network Interface Configuration

Edit the /etc/network/interfaces file to change the configuration from DHCP to a fixed IP address. (See *DNS & DHCP Services* section for further understanding.) While a server can function with a DHCP address, it will lead to more problems than it is worth. From a terminal window type

sudo nano /etc/network/interfaces

Change any of the lines

iface eth0 inet dhcp

iface eth0 inet manual

to

#iface eth0 inet dhcp

#iface eth0 inet manual

The # at the beginning of the line disables the configuration of that line. Then add the following lines (in order) after it

auto eth0

iface eth0 inet static

address 192.168.0.251

gateway 192.168.0.1

netmask 255.255.254.0

broadcast 192.168.0.255

network 192.168.0.0

auto eth0:0

iface eth0:0 inet static

address 192.168.0.253

Note: The alias eth0:0 definition creates an alternate address for the same interface to support Samba configuration notions.

Then for “Jesse” and later Raspian versions remove the DHCP client daemon and reboot…

sudo apt-get remove dhcpcd5 raspberrypi-net-mods

sudo reboot

Warning: The DHCP client daemon overrides the traditional /etc/network/interfaces file.

To verify the configuration run the ip command. It should identify to IP addresses for eth0.

ip addr

Tip: 192.168.0.0 is the most common local subnet but you may use other addresses reserved for local use consistent with other hardware setups of the local network.

Tip: Subnets may be joined into a single net by the appropriate configuration of the netmask. For example, a netmask of 255.255.254.0 will combine 192.168.0 and 192.168.1 subnets.

Tip: The IP address must be unique per machine. Recommend numbering servers from the top down of the local subnet. Address 255 represents a reserved broadcast address making the highest possible server address 254. The gateway represents the box that connects the local network to the next network, likely your cable or DSL modem, typically 192.168.0.1.

### Network Time Protocol (NTP) Service

Secure access services use “current time” as a component, so machines not synchronized to a time standard will have difficulty connecting or staying connected. The network time protocol (NTP) service synchronizes a machine’s clock to international standard time. By default, Raspian automatically starts the NTP daemon (ntpd) and configures it to randomly acquire time from a pool of calibrated timeservers.

#### The timex Alias

By default, the server will operate as a local time server. I recommend configuring the server in the /etc/hosts file to have an alias of timex. All other local machines can then sync to timex reducing traffic overhead for timeservers. If in the future you replace the server, giving the new server the same timex alias will allow all the network machines to continue to sync without having to be reconfigured.

### Update Operating System

Before doing much else run the following command string. The first part updates the local copy of the code repository listing and the second then upgrades the OS based on this listing if the first is successful. The -y switches answer yes to questions to suppress interactive queries and automatically run.

sudo apt-get –y update && sudo apt-get –y upgrade

After updating the OS this first time, I recommend rebooting. Simply run:

sudo reboot

Following the reboot, log in and start a new terminal to continue.

If setting up on a **Raspberry Pi B+** for a **Raspberry Pi 2** or **Raspberry Pi 3**, then also run

sudo apt-get dist-upgrade

sudo apt-get install raspberrypi-ui-mods

This way the SD card will work on both platforms interchangeably.

See *Automatic Server Update* section for information on automating updates.

## X Windows Graphical User Interface

Raspian supports the MIT X Windows system as a graphical user interface (GUI). After login to a terminal window, start the Raspberry Pi graphical mode if desired simply by running the command:

startx

## Remote Secure Shell (SSH) Operation

At this point the server is ready for remote operation and all remaining setup can be done remotely either from another machine on the local network or from an off-site Internet location using Secure Shell (SSH). From another Linux box on the local network, use the following command (or a Windows machine using Putty, see *PuTTY* section below).

ssh pi@tiny or ssh [pi@192.168.0.251](mailto:pi@192.168.0.251)

This provides a terminal window on the client machine connected remotely to the server as user pi. If the local network does not recognize the machine name, you may need to use the specified IP address as shown in the alternate command form. (This may be necessary until DNS is established later.) After Internet connection setup the ssh command can provide access from anywhere using the fully qualified domain name.

You can perform all further configuration via SSH without having to be present at the machine. SSH becomes particularly handy when performing maintenance from an off-site location such as home. (Access from the Internet will require some additional setup, discussed later, depending on your Internet Service Provider (ISP).)

SSH access also enables headless operation, meaning a machine operating without a monitor, which saves on server cost.

IMPORTANT NOTE ABOUT KEY GENERATION

When setting up a new SSH installation, especially from a (Noobs) image, you should always run ssh-keygen to create unique keys for the specific installation. For example:

sudo ssh-keygen –t rsa –f /etc/ssh/ssh\_host\_rsa\_key

This will create both /etc/ssh/ssh\_host\_rsa\_key and /etc/ssh/ssh\_host\_rsa\_key.pub

The next login after this change may result in an error. Fix this by deleting the ./.ssh/known\_hosts file on the local machine.

To verify the fingerprint of the remote machine run the command…

ssh-keyscan tiny >/tmp/key; ssh-keygen -lf /tmp/key; rm /tmp/key

### Certificate Based Login

You can use SSH to make machine-to-machine connections too such as one machine backing up another. In this case, login uses a security certificate. It involves using openssl key-gen to generate a *self-signed certificate* and then placing that certificate on both machines. See man ssh for more instructions. Reference [1] gives some examples of setup and use of certificate based login.

### Port Forwarding

In order to use Secure Shell over the Internet, the DSL/cable modem box at the server must enable port forwarding of the WAN port 22 to the LAN SSH server port 22. See port forwarding instructions for your specific model modem.

### PuTTY

If working from an MS Windows machine the PuTTY terminal emulator provides a nice graphical user interface (GUI) based client for connecting to the server. Simply install it on a Windows machine and define a configuration to point to your server. PuTTY will work for both local network connections as well as access from the Internet.

### Tunneling

Secure Shell implements an encrypted link between the two connected machines that means a significant security advantage for connecting across the Internet. This capability extends to any other application based on a procedure called tunneling. Putty provides a convenient way to setup and use SSH for any remote application. By tunneling other applications, all communications occur through a single port (22) without the need to open other ports and increase the server’s vulnerability.

### Virtual Network Computing (VNC) Server

A virtual network computing or VNC server provides a means of seeing a desktop remotely, thus it offers a graphical or GUI alternative to secure shell. To setup VNC perform the following command.

sudo apt-get install tightvncserver

Start the TightVNC server on demand simply by running

tightvncserver &

The & character at the end starts the server running in the background and directly returns control to the local shell.

Or tightvncserver can be configured to always start when the machine boots. First create a script to start and stop the server

sudo nano /etc/init.d/vncserver

(Copy the contents of the /etc/init.d/vncserver script from Appendix B: Custom Scripts)

(Save the file)

sudo chmod 755 /etc/init.d/vncboot

sudo update-rc.d tightvncserver defaults

To use VNC you must also install the TightVNC viewer on the client machine.

#### Tunneling VNC

If using VNC across the open Internet, set it up with SSH tunneling. To do so using Putty, simply enter “L5900 black:590x” into the Connection|SSH|Tunnels list of forwarded ports, where x is the number of the server started by the tightvncserver command.

### Terminal Multiplexer (tmux)

SSH sessions interact with an active terminal window. When SSH disconnects that terminal session stops and any current action such as an executing script will likely terminate and fail. This can be frustrating, for example if you begin compiling something that takes several hours only to have you client machine go to sleep or lose communications and terminate the session before completion. The terminal multiplexer (tmux) program provides an excellent workaround for this. It connects your SSH session to a terminal client/server on the host that stays running even if the connection to the host ends. Additionally, it supports multiple windows and panes from a single SSH session. Server operation does not require tmux, but it greatly helps with managing it. *Appendix D: Terminal Multiplexer Setup and Use* provides install, setup, and useful customization instructions.

## DNS & DHCP Services

Domain naming service (DNS) and dynamic host configuration protocol (DHCP) address assignments implement fundamental services of a working network domain. A server must provide these functions on the local area network (LAN).

DNS resolves the *easily remembered human-form machine names*, such as tiny, into their respective *numerical internet protocol addresses* (IP) like 192.168.0.253. The DNS server provides this service for the local network and queries the next level domain service for this information for addresses outside the local network, such as resolving ***google.com***.

**Machines may have fixed IP addresses or dynamically assigned addresses, but every machine on the local network must have a unique address.** The DHCP service does the work of dynamically assigning addresses. Machines configured for DHCP request an address from an available network DHCP server upon power up. The DHCP server allocates addresses to requests and catalogs who’s who by name and address for use by DNS.

Tip: Running a local DNS server will speed up Internet access and resolve local machine names without burdening the ISP. (Note: without a local server, requests for local machines are forwarded to the ISP, which likely does not know anything about your machines, and timeout after 2 seconds.)

Tip: I recommend configuring servers with fixed addresses and other machines dynamically for minimal problems.

Warning: If running a DHCP service as part of the server, be sure to disable any DHCP service provided by your DSL or cable modems to prevent conflicts.

### Network Utilities

By default, Raspian does not include certain utilities useful to DNS. You may install them using

sudo apt-get install dnsutils

This adds nsupdate, dig and nslookup functions. These utilities provides helpful diagnostics for network problems. For example, nslookup timex may report…

Server: 192.168.0.253

Address: 192.168.0.253#53

Name: timex.saranam

Address: 192.168.0.251

Name: timex.saranam

Address: 192.168.0.250

This indicates that two machines on the local domain both map to timex. Either machine can respond to requests to timex. The dig command gives a bit different diagnostic information but the same IP to name mapping. For example, dig black reports.

; <<>> DiG 9.8.4-rpz2+rl005.12-P1 <<>> black

;; global options: +cmd

;; Got answer:

;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 1198

;; flags: qr aa rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 0

;; QUESTION SECTION:

;black. IN A

;; ANSWER SECTION:

black. 0 IN A 192.168.0.250

;; Query time: 7 msec

;; SERVER: 192.168.0.250#53(192.168.0.250)

;; WHEN: Tue Aug 11 19:41:43 2015

;; MSG SIZE rcvd: 39

Note the only line that does not begin with a semicolon gives the mapping of name to IP address. The response also returns the time it took to resolve the answer useful for diagnosing network delays.

#### Ping

Another useful network utility already installed with Raspian is ping. The receiving machine echos the ping request in the same sense sonar bounces off a ship. For example ping –c 5 tiny may reply…

PING tiny (192.168.0.253) 56(84) bytes of data.

64 bytes from tiny (192.168.0.253): icmp\_req=1 ttl=64 time=0.649 ms

64 bytes from tiny (192.168.0.253): icmp\_req=2 ttl=64 time=0.643 ms

--- tiny ping statistics ---

5 packets transmitted, 2 received, 60% packet loss, time 4005ms

rtt min/avg/max/mdev = 0.643/0.646/0.649/0.003 ms

This sends 5 pings (i.e. -c) to host tiny and reports the results. In this case only 2 echos indicates a poor connection — a significant amount of data loss. Packets that complete echo in under 1 ms.

Note: Not all machines or devices support or honor ping and may not reply at all even with no problem present.

### (NoIP) Dynamic Update Client

Network servers generally have a wide area network (WAN) presence, meaning they connect to the Internet. Just as machines on the LAN require an IP address, the server must have an IP address on the WAN to communicate with other machines. The Internet service provider (ISP) may assign the WAN address statically or by DHCP. A dynamically assigned address may change any time.

This server likely has a registered Internet domain name as well, such as saranam.net. This requires a function to synchronize the server’s domain name to its WAN-IP address as it changes, referred to as a dynamic update client (DUC). The following defines the setup for the No-IP dynamic update client, which assumes the use of the No-IP dynamic addressing hosting service. (For first time setup, first create an account on no-ip.com and define the host.

Download the latest client (assumes 2.1.9) from No-IP to a temporary folder, extract, build, install, and run to create a configuration file...

mkdir /tmp/noip

cd /tmp/noip

wget <http://www.no-ip.com/client/linux/noip-duc-linux.tar.gz>

tar vzxf noip-duc-linux.tar.gz

cd noip-2.1.9-1

sudo make

sudo make install

sudo /usr/local/bin/noip2 -C

Running the client will ask for information, including the No-IP login username and password, on how to update clients. After this setup, rerun the client without the –C option to start it in the background.

Perform the following to make the DUC run each time the Raspberry Pi reboots.

sudo nano /etc/init.d/noip2

(Copy the contents of the NoIP DUC script from Appendix B: Custom Scripts and save)

Make the script executable and set it to run on startup.

sudo chmod 755 /etc/init.d/noip2

sudo update-rc.d noip2 defaults

To start stop or restart the service at any time do…

sudo /etc/init.d/noip2 start

sudo /etc/init.d/noip2 stop

sudo /etc/init.d/noip2 restart

sudo /etc/init.d/noip2 status

To update the configuration at any time, first stop the service then run

/usr/local/bin/noip2 –C

To permanently stop the DUC service run…

sudo update-rc.d noip2 remove

Tip: Create a symbolic link as …  
 sudo ln -s /usr/local/bin/noip2 /usr/local/bin/noip  
and refer to noip anywhere noip2 is used. If the version of noip changes to noip3, just redefine the link and continue referring to noip. This represents a common Linux practice that allows commands to point to the latest version transparent to the user.

After completing the install, reboot the Raspberry Pi with the following line and verify that the noip daemon is still running.

sudo reboot

Tip: Appendix B: Custom Scripts contains a script for pid that can be run to list process IDs matching a string, such as pid noip

### DNSMasq

DNSMasq (short for DNS Masquerade) provides both a simple DNS server and DHCP server in a single setup. For installation, simply run…

sudo apt-get install -y dnsmasq

After installation copy the default configuration to a domain configuration file and edit as in...

sudo cp /etc/dnsmasq.conf /etc/dnsmasq.d/saranam.conf

sudo nano /etc/dnsmasq.d/saranam.conf

The configuration file provides many comments for straightforward setup. Below is the specifics recommended configuration for starting. Many settings simply require removing the # from the start of the line.

# basic domain settings...

domain-needed

bogus-priv

resolv-file=/etc/resolv.dnsmasq

local=/saranam/

expand-hosts

domain=saranam

cache-size=10000

# example of manually associating mac address, name, and IP address...

dhcp-host=00:02:2A:4A:C2:23,ojo,192.168.0.81

# this setting controls dhcp assignment range addresses 51-99

dhcp-range=192.168.0.51,192.168.0.99,12h

# these settings provide WINS server data to Windows machines

dhcp-option=44,192.168.0.253 # WINS server

dhcp-option=46,8 # WINS hybrid node type

dhcp-option=3,192.168.0.1 # gateway

dhcp-option=1,255.255.255.0 # subnet mask

dhcp-authoritative

# identify bogus and non-existent domains

bogus-nxdomain=63.146.68.202

bogus-nxdomain=63.146.68.201

Next build the /etc/resolv.dnsmasq file referenced in the configuration

sudo nano /etc/resolv.dnsmasq

Include a (prioritized) list of servers to query for forwarded DNS requests such as…

# dnsmasq configured to look for forwarding servers here...

# qwest.net...

nameserver 205.171.3.25

nameserver 205.171.2.25

# google public...

nameserver 8.8.8.8

nameserver 8.8.4.4

# openDNS...

nameserver 208.67.222.222

nameserver 208.67.220.220

#gateway...

nameserver 192.168.0.1

Edit the default /etc/resolv.conf file as well for any local services that may make queries.

sudo nano /etc/resolv.conf

Paste the following into the file

domain saranam

search saranam

nameserver 192.168.0.253

Edit the /etc/hosts file to include the names and IP addresses of any static machines.

After configuration or /etc/hosts changes, restart the DNS service to have settings take effect by

sudo service dnsmasq restart

or

sudo /etc/init.d/dnsmasq restart

You can test the server by running a number of local and remote DNS requests with dig or nslookup such as

nslookup google.com

dig google.com

dig tiny

### Uninterruptable Power Supply Daemon (APCUPSD)

The APC uninterruptable power supply (UPS) daemon monitors the data port of an UPS as a background service and notifies the server of power outages and pending power failure. (NOTE: Since the Raspberry Pi does not have a power switch, this service does not actually remove power from the Pi, but does shutdown critical services and hardware for safe power failure and logs the outage. To install simply run

sudo apt-get install apcupsd

Start the UPS and connect to the server. Run the following to identify the device and see that it is recognized

lsusb

It will report something similar to the following:

Bus 001 Device 011: ID 051d:0002 American Power Conversion Uninterruptible Power Supply

Edit the daemon configuration to define the type of UPS and connection.

sudo nano /etc/apcupsd/apcupsd.conf

Also, edit the defaults file

sudo nano /etc/default/apcupsd

You MUST define the following line

ISCONFIGURED=yes

After configuring apcupsd start it using the service command as

sudo service apcupsd start

You can setup the daemon to send alerts for various conditions. See the /usr/local/bin/ups script in *Appendix B: Custom Scripts* and man apcupsd for more info.

## Automating Operations

One of the beauties of the Linux operation system involves the ability to script mundane tasks. This section addresses a number of such routine tasks. Such operations may vary significantly from setup to setup. Information presented here serves more as a skeleton than an actual prescription to provide the notions and mechanisms. Examples here represent a few of the tasks usually handled by any system. Extend as desired.

### Admin Notifications

*Appendix B: Custom Scripts* includes a script for automatically notifying system administrators by email of actions performed by other scripts.

Create the notification script by

sudo nano /usr/local/bin/mailto.py

(Copy the contents of the /usr/local/bin/mailto.py script from Appendix B: Custom Scripts into the file and save.)

Note that this script contains a number of setup specific parameters that you must modify for your network. These include:

*subject: The email subject line.*

*you: The default email recipient(s).*

*me: Identify string for script sender address.*

*server: SMTP server name*

*port: SMTP port*

*username: SMTP login username*

*password: SMTP login password*

WARNING: Normally it is not good practice to embed passwords into scripts. In this case, it simply provides access to an email account (for sending only) so does not involve a serious security issue if compromised, but must still be secured. Be sure to protect the file by setting the permissions to 750 and owner to root:adm with *chmod* and *chown* commands. *See Appendix A: Linux Jumpstart* for help.

To call this script pass it a custom message subject and optional list of recipients as

/usr/local/bin/mailto.py “My Test Script” *email-address* < update.log

The script receives input from stdin so scripts can redirect content directly to it.

### Automatic Server Update

*Appendix B: Custom Scripts* includes an update script for automatically keeping the server up to date.

Create the update script by

sudo nano /usr/local/bin/update

(Copy the contents of the /usr/local/bin/update script from Appendix B: Custom Scripts into the file and save.)

Tip: Save your scripts in /usr/local/bin. The operating system preserves this area on upgrades.

Then establish the cron tasks by

sudo nano /etc/cron.d/sysop

Add these lines

# OS update @ 9:35PM every Friday...

35 21 \* \* 5 root /usr/local/bin/croncall update

See the *Cron Jobs* section of *Appendix A: Linux Jumpstart* for details on how to alter these settings.

Tip: cron processes all files it finds in the /etc/cron.d folder, so you can name it anything. Here sysop denotes system operations.

With this setup, the system will automatically update every Friday at 9:35 PM and send the system administrator an email confirming the operation. The notification email displays a message indicating if the server requires a reboot, captures errors, and includes a log of the updates.

### Backup

#### Server Configuration Files Backup

Backup of server configuration files requires a Linux formatted disk since NTFS and FAT type partitions do not preserve file permissions. This does not require a significant amount of disk space since it amounts to small portion of the SD card, but must be external to the SD card. So this instruction assumes to use of a USB flash drive inserted directly into the Raspberry Pi.

First, prepare a USB flash drive using the fdisk command in (Windows or Linux) to create a single partition on the USB drive.

Then install a Linux file system to the partition by

sudo mkfs.ext4 /dev/sda1 -L usb

Warning: You must determine the correct drive and partition. This can be done by inserting the USB drive, then perform **ls -l /dev/disk/by-id** and look for disk that matches the descriptor of the USB drive. Or look for what changes when the drive is or is not inserted.

Warning: The USB drive may automatically mount in which case it must first be unmounted before creating the file system using the command:

sudo umount /dev/sda1

Either an ext3 or ext4 file system may be used. In the command above ***usb*** is the drive label. The /dev/sda1 field represents the first partition of drive being defined.

Once you have created the file system permanently mount the drive at startup by adding it to the /etc/fstab file. Edit /etc/fstab with

sudo nano /etc/fstab

Add the lines at the end

# configuration usb...

/dev/disk/by-label/usb /mnt/usb ext4 defaults 0 0

Save the file. Then create the mount point and reboot the Raspberry Pi with the following

sudo mkdir /mnt/usb

sudo reboot

Once rebooted run the mount command to list mounted drives, which should include /backup.

mount

Then create needed backup directories as

sudo mkdir /mnt/usb/backup

sudo mkdir /mnt/usb/backup/tiny

sudo mkdir /mnt/usb/backup/tiny/daily

sudo mkdir /mnt/usb/backup/tiny/weekly

sudo mkdir /mnt/usb/backup/tiny/monthly

#### Backup Script

The backup script reads backup instructions, referred to as list files, to perform backup of desired files at specified periodic intervals, typically daily, weekly, monthly, but easily specified as desired.

Create a backup script by

sudo nano /usr/local/bin/backup

(Copy the contents of the /usr/local/bin/backup script from Appendix B: Custom Scripts into the file and save.)

Then using */usr/local/bin/backup.lst.daily as a template create the command lists used by the backup script for daily, weekly, and monthly backups as*

sudo nano /usr/local/bin/backup.lst.daily

(Copy the contents of the /usr/local/bin/backup.lst.daily script from Appendix B: Custom Scripts into the file, edit as appropriate, and save.)

sudo nano /usr/local/bin/backup.lst.weekly

(Copy the contents of the /usr/local/bin/backup.lst.daily script from Appendix B: Custom Scripts or from /usr/local/bin/backup.lst.daily into the file, edit as appropriate, and save.)

sudo nano /usr/local/bin/backup.lst.monthly

(Copy the contents of the /usr/local/bin/backup.lst.daily script from Appendix B: Custom Scripts or from /usr/local/bin/backup.lst.daily into the file, edit as appropriate, and save.)

Tip: The backup script provides for some variable substitution for simplifying porting of backup lists across machines such as the mount point. These can be altered or expanded upon in the /usr/local/bin/backup script.

Then establish the cron tasks to automate backup by

sudo nano /etc/cron.d/sysop

Add these lines

# Backup script run every day @ 11:05PM...

5 23 \* \* \* root /usr/local/bin/croncall backup daily

# Backup script run every Sunday @ 11:10PM...

10 23 \* \* 0 root /usr/local/bin/croncall backup weekly

# Backup script run every month @ 11:15PM...

15 23 1 \* \* root /usr/local/bin/croncall backup monthly

See the *Cron Jobs* section of *Appendix A: Linux Jumpstart* for details on how to alter these settings.

#### Data Backup

Data backup can be accomplished multiple ways depending on the setup.

##### Using The Backup Script

Data backup can use the same backup script used for configuration to back up (server) user data with a few possible exceptions. If backing up Windows data, the destination drive likely needs to be a larger drive and may be better if formatted as a NTFS volume and the mount must include ACLs support to preserve Windows file permissions, best handled with a Windows box.

##### Windows Backup

A number of tools support Windows based backup. Robocopy is a commandline based “robust copy” tool. Richcopy provides a GUI frontend for robocopy; however, it does not support all options. These tools offer much more effective coping and won’t hang or crash on failure.

##### Using Google Drive

If using a shared network drive as a Windows file server, it can be setup as the folder location for Google Drive to automatically sync with online storage. This provides both data backup and off-site reliable safe storage. It simply requires installation of Google Drive and configuration on the Windows machine. As noted in the Samba setup, this provides an alternative to a Samba based file sharing setup. By using a USB drive, it provides a convenient setup easily ported to new machines.

Additionally, the major Google Drive folders could be redundantly backed up to a separate USB drive or even to other normally “hidden” folders within Google Drive.

#### SD Card Backup

Once you have completed a baseline installation clone or copy the SD card for a backup. Do this periodically as well such as once a month or quarter to make server recovery quick and easy. The instructions below identify multiple means to duplicate an SD card.

Warning: SD Cards do not have the same reliability as hard disks. Loss of power or repeated writing of the same location may corrupt an SD card. I recommend routine backup.

##### Cloning

Cloning consists of making an image of the SD card, which copies all of the information from the card into a single image file making it easy to restore. Cloning is a manual process and has some specific issues, namely that the clone must have an equal or larger number of sectors as the original. It may not work in all cases. See *Appendix F: Cloning an SD Card* for the process.

##### Backup using rsync

A second method to backup the SD card uses the system rsync command, essentially the same as done with the backup script but with a bit different setup. Using a mounted USB to SD card adapter, you can automate this method the same as the backup process.

1. Create a second SD card with NOOBS installed as described in section *New Out Of Box Software (NOOBS)*. This card can be of the same capacity or smaller as long it has adequate space to hold everything on the main card.
2. Shutdown the Pi and remove the main SD card.
3. Install this new SD card into the Pi in place of the original card, boot as normal, and install Raspian.
4. Shutdown the Pi and remove the duplicate SD card.
5. Reinstall the original SD card.
6. Start the Raspberry Pi and login.
7. List the disks by using

ls –l /dev/disk/by-id

1. Place the duplicate card in a USB adapter and insert into the Raspberry Pi.
2. Repeat step 7 and identify the USB drive by the new device that appears.
3. Create the *backup\_rpi* script from Appendix C: Custom Scripts

sudo nano /usr/local/bin/backup\_rpi

(copy and paste the contents of the script from the appendix.)

(Edit the clone variable and set it to the value found in step 9.)

(CTRL-X to save)

1. For automatic backup, setup a cron job to run the script periodically. I recommend every 2-3 months to not wear out the SD card. The normal daily, weekly, and monthly backup will capture in between changes.

sudo nano /etc/cron.d/sysop

1. Add these lines

# SD CARD (OS) backup the first of every quarter @ 11:35PM (before updates)...

35 23 1 1,4,7,10 \* root /usr/local/bin/croncall backup\_rpi

See the *Cron Jobs* section of *Appendix A: Linux Jumpstart* for details on how to alter these settings.

Tip: Run this script manually prior to any major server changes such as distribution upgrades.

Tip: Running this script prior to updates ensures a fallback to the previous installation should anything go wrong with the update.

## Admin Tools

### Scanner

Scanner (for Windows) provides a graphical image of disk usage to quickly locate large resource users.

# Dedicated Services

Everything described to this point represent basic network services applicable to any network and server regardless of use. While every server does not necessarily require everything, the mentioned services certainly represents a checklist of things to consider in setting up every server and at least one server on the local network must provide the services. This section describes other specific dedicated services that the network may provide, including:

* (Active Directory) Domain Controller: Handles user login access the network.
* File and Printer Sharing: Provide Windows compatible file and printer sharing services.
* Webserver: Host one or more websites.

Each of these may be optionally setup. Additionally, it may be desirable to use multiple servers for load balancing.

## Samba

Samba provides emulation of the MS Windows SMB protocol, which supports a variety of services with the two of interest being Active Directory Services and file and printer sharing.

Warning: The Samba Team does not presently recommend using an Active Directory server as the file server so the file server may require a second machine if you incur BIND problems.

To start, the repository likely will not have the latest build of Samba. Follow the instructions in *Appendix D: Building Samba* to build it from source, otherwise install from the repository. Do not do this step if you build samba locally.

sudo apt-get –y install samba

Add samba (i.e. /usr/local/samba/bin/ & /usr/local/samba/sbin/) to the PATH by editing /etc/login.defs.

sudo nano /etc/login.defs

(Change PATH as follows…)

#ENV\_SUPATH PATH=/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin

ENV\_SUPATH PATH=/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin \

:/usr/local/samba/sbin/:/usr/local/samba/bin/

(CTRL-X to save)

*NOTE: \ at end of line denotes line continuation.*

You may need to also edit the /etc/profile file as below, comment out the existing PATH definitions and replace with those given.

sudo nano /etc/profile

#PATH="/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin"

PATH="/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin: \  
 /usr/local/samba/sbin:/usr/local/samba/bin"

#PATH="/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin:/usr/local/games: \

/usr/games"

PATH="/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin: \

/usr/local/samba/sbin:/usr/local/samba/bin"

(CTRL-X to save)

Logout and back in the launch a new shell for testing. Then run

sudo samba –V

This should report the version of samba installed as version 4.x.x.

#### Active Directory Server

Directory services function similar to a phonebook by providing network services a means to query about users, machines, devices, etc. ***Active Directory*** is Microsoft’s directory service that works across Windows platforms. The Active Directory service functions as a single point of management of computers and user logins using Kerberos password management.

These directions follow essentially those provided by the Samba 4 Wiki documentation for setup of an Active Directory server with some additional notes and changes. The Active Directory setup uses the following site-specific definitions:

Realm: home.saranamabq.net

Domain: home

Server Role: dc

DNS backend: SAMBA\_INTERNAL

DNS forwarder IP Address: 192.168.0.251

Administrator password: \*\*\*\*\*\*\*\*\*\*\*

AD domain name: home.saranamabq.net

AD DNS name: home.saranamabq.net

AD Kerberos realm: HOME.SARANAMABQ.NET

NetBIOS domain name: HOME

Domain Administrator: HOME\Administrator

AD DC hostname: tiny, tiny.home.saranamabq.net

Samba Server IP address: 192.168.0.253

Once installing Samba, the first step to setting up an Active Directory server involves *provisioning* the server, a kind of initialization process that builds the smb.conf file. The samba-tool suite supports provisioning via an interactive session using the information provided above. Simply run as superuser…

su

samba-tool domain provision --use-rfc2307 --interactive

Copy the (final) output of the provisioning, specifically the SID, into a file named samba\_id\_info.txt for future reference. Perform the setup changes outlined in the *Active Directory DNS Configuration* section below. Then verify that everything works correctly by running the tests from the Samba Wiki: **https://wiki.samba.org/index.php/Setting\_up\_Samba\_as\_an\_Active\_Directory\_Domain\_Controller**

Assuming the tests pass (indicating that Samba, Kerberos, and DNS work properly), see the *Windows Management Tools* section below for setup up the Active Directory.

#### Active Directory DNS Configuration

Active Directory requires a more sophisticated DNS service than supported by DNSMasq. Samba (internal-DNS) includes the necessary service but the setup requires some modification to the DNSMasq and Samba configurations.

The basic notion involves defining Samba Internal DNS as the primary service. It forwards unknown requests to DNSMasq, which in turn forwards requests to your ISP service. Figure 2 illustrates this arrangement.

In order to achieve the configuration we use a virtual network interface to provide a specific IP address for Samba separate from the host DNSMasq address. (See *DNSMasq* section for details.) Then we bind each specific DNS service on port 53 to only the specific interfaces assigned to the addresses. (Note: DNSMasq automatically binds to the local loopback address, i.e. 127.0.0.1, too!)



Figure 2: Active Directory DNS Configuration

Edit the Samba configuration

sudo nano /usr/local/samba/etc/smb.conf

Add these 2 lines to the [global] section:

interfaces = eth0:0

bind interfaces only = yes

(CTRL-X to save)

Then edit the DNSMasq configuration

sudo nano /etc/dnsmasq.d/saranam.conf

Add these 2 lines:

interface=eth0

bind-interfaces

(CTRL-X to save)

Tip: Note the different interface specifications and keywords for these two configurations.

Restart both services. Run the netstat command to verify that both DNS services have started.

sudo netstat -tapn | grep ":53"

**tcp 0 0 192.168.0.253:53 0.0.0.0:\* LISTEN 20890/samba**

**tcp 0 0 127.0.0.1:53 0.0.0.0:\* LISTEN 18399/dnsmasq**

**tcp 0 0 192.168.0.251:53 0.0.0.0:\* LISTEN 18399/dnsmasq**

tcp6 0 0 ::1:53 :::\* LISTEN 18399/dnsmasq

tcp6 0 0 fe80::ba27:ebff:fe0b:53 :::\* LISTEN 18399/dnsmasq

#### Windows Management Tools

Once you setup and test the Active Directory domain controller, you can manage it remotely using ***Remote Server Administration Tools*** (RSAT) supported across Windows platforms. These tools allow administrators to create user accounts, reset passwords, join machines to the domain and any other services setup normally needed.

##### Download

To acquire the tools go to <http://windows.microsoft.com/en-us/windows/downloads> and search for ***Remote Server Administration Tools***. Select the version of Windows that you wish download.

##### Remote Server Management Setup

1. Install the RSAT tools on a Windows machine.
2. Attach the Windows machine to the same network as the Active Directory server.
3. Log in to the Windows machine as a local administrator.
4. Join the machine to the domain. (Instructions vary specific to Windows version.)
   1. This requires using the Administrator credentials defined when setting up Samba.
5. Reboot.
6. Log into the Windows machine using the domain\Administrator credentials.  
   i.e. home\Administrator
7. Start the Active Directory Users and Computers application.  
   (See *Appendix H: Active Directory Users and Computers* for more instructions.)
8. Select the domain in the left pane, i.e. home.saranamabq.net.
9. From the menu, select Action | New | User and begin adding user accounts.
10. Likewise, select Action | New | Group and define desired groups.
11. Add users to the required groups.

The domain is ready for use. Join other network machines to the network. Users can log in as necessary.

#### Windows File and Printer Sharing

Samba supports a second MS Windows service of file and printer sharing.

Warning: Due to DNS issues, the Samba Team does not recommend running a Windows File and Printer Server on the same device as the Domain Controller; however, any Windows machine on the network can easily provide such services with domain level control.

### Common UNIX Printing System (CUPS)

The common UNIX printing system established a singular way of handling network printing. Once installed, you can add printers easily to the CUPS server via a web interface at port 631. CUPS handles the print queues and access for each printer. After installing, add pi to the lpadmin (i.e. line printer administrators) group too.

sudo apt-get install cups

sudo usermod -a -G lpadmin pi

Then edit the daemon configuration to allow administration from other machines on the local network by adding a line to the listen section as given below:

sudo nano /etc/cups/cupsd.conf

# in the listen section add the line after the following line

# Only listen for connections from the local machines.

**Listen** 192.168.0.0**:631**

(CTRL-X to save)

Then enable remote administration and restart the server

sudo cupsctl –-remote-admin

sudo /etc/init.d/cups restart

Then browse… http://localhost:631

You can add a PDF printer to CUPS by

sudo apt-get install cups-pdf

Then edit /etc/cups/cups.conf and comment out the line that defines where output files get placed and replace with the appropriate line such as follows...

sudo nano /etc/cups/cups-pdf.conf

#Out ${HOME}/PDF

Out /mnt/datos/tmp/PDF

(CTRL-X to save)

Then using a browser on the local network go to http://192.168.0.253:631 or http://tiny:631. Click on Adding Printers and Classes and provide the user pi login credentials. Select local printer CUPS-PDF (Virtual PDF Printer). Click Continue. Edit the descriptions as desired. I recommend placing the output path in the location. Select Share This Printer. Click Continue. Select a Make and Model. (It doesn’t matter really, I use Lexmark, E260DN, same my home printer.) Click Add printer.

You can follow this procedure to add any other network printers and serve them across the network.

#### Avahi

The Avahi service emulates Apple Air Print. If installed on the CUPS server, its printers will be visible to Apple platforms. Install the Avahi service by

sudo apt-get install avahi-daemon

sudo update-rc.d avahi-daemon defaults

## Web Services

The Raspberry Pi easily provides resources necessary for a small/medium webserver for both intranet and Internet use. The spectrum of possibilities itself goes well beyond the scope of configuring a small office server. Nonetheless, the following provides an example of setup to provide basic web services.

WARNING: Web server operation involves significant security issues in protection of information and resources such as the server itself.

Tip: You may not want to run a webserver on the same box as your basic network/domain services as a webserver overload condition may directly impact network all operations.

## Apache

Apache represents the workhorse of web servers running some 80%+ of the Internet. While some have demonstrated running Apache on the Raspberry Pi, Apache uses a significant amount of resources and will not scale well, likely overwhelming the server in short order. Also setting up Apache can be challenging even for the experienced admin. I do not recommend running Apache on the Raspberry Pi.

## Lighttpd

Lighttpd (pronounced light-dee) implements a lightweight web server with basic capabilities including support of Fast-CGI and PHP scripting. It’s open source; it’s free. This probably represents the simplest out of box setup for web services.

## NodeJS

NodeJS provides server side JavaScript for building your own custom web service. See separate document entitled *A Flexible User Configurable NodeJS Web Server* for details.

## SQLite

SQLite implements a simple but very scalable database recommended for use with the NodeJS setup. To install run

sudo apt-get install sqlite3

Then create a pointer by

sudo ln -s /usr/bin/sqlite3 /usr/local/bin/sqlite

You can open any database by the command

sudo sqlite <database\_name>

I recommend using the file extension .sq3 to denote an SQLite 3 database and .sql for SQL syntax files.

1. Linux Jumpstart

## What is Linux?

Linux is an open source operating system (OS) for a computer. The operating system performs basic functions that enable user interaction with the computer as well as interaction with other machines. Raspian represents a version of Linux specifically optimized for the limited resources and hardware of Raspberry Pi. It derives from the Debian kernel, which also provides the kernel of the popular Ubuntu, often referenced in Raspberry Pi tutorials.

### The Linux Shell

Many users confuse the Linux shell with Linux. The shell is simply the program interface to the user that usually supports interaction with the keyboard and/or mouse and video display. Shells come in two forms: textual and graphical. Textual shells utilize a commandline for typing in commands as text strings. Non-Linux users familiar with the once popular DOS shell have already experienced a textual context shell. Linux can provide multiple shell types simultaneously in separate terminal windows. By default the Raspian flavor of Linux uses the *Bourne Again Shell*, commonly called the BASH shell. Graphical User Interfaces (GUI) such as Microsoft Windows or MIT’s X-Windows are nothing more than fancy shells that understand how to interact with a mouse and provide a more visual experience to the user often making it easier for the user to interact. Because network server management generally deal with executing low-level operations, instructions generally involve entering commands in textual shells.

## Some Linux Basics

### Users, Superuser, Root, Groups, and World

We refer to the person actively interacting with the machine as a user who is a member of one or more groups. When a user has successfully logged into the system a text shell will present them with a commandline prompt such as

pi@raspberrypi ~ $

This prompt tells the user the system is ready to take instructions to perform a given task for user *pi*. The ~ character represents shorthand for the user’s home folder, in this case */home/pi*. By default, a user may only perform operations within their own user scope determined by system settings of group membership and ownership.

The user may or may not have special administrative privileges to perform special system wide controlling operations. We refer to a user having these special privileges as a superuser. One specific user called root always has these special privileges. The superuser prompt follows a slightly different format using a hashtag instead of a dollar to distinguish its privilege as a system administrator as in

root@black:/home/pi#

Attempting to perform a superuser command without superuser privileges will give the familiar permission denied response as in

pi@black ~ $ touch /etc/test

touch: cannot touch `/etc/test': Permission denied

pi@black ~ $

Users may temporarily act as a superuser (if allowed by configuration as a member of the sudo group) by prefixing each command with sudo, which stands for “*superuser do*” as in

pi@raspberrypi$ sudo cp /etc/fstab /etc/fstab.save

pi@raspberrypi$

Following the command execution, the same user prompt occurs. This allows for safe use of superuser powers only when needed to prevent accidental action. In some cases one may need to perform multiple successive commands and this practice becomes annoying. In such a case, the user may execute the su login command to turn on superpowers continuously as in

pi@raspberrypi$ su

Password:

root@black:/home/pi#

…

root@black:/home/pi# exit

pi@raspberrypi$ su

The password response prompts the user to enter root’s password. If successful the shell changes to user root. Once complete, typing exit will restore operation to the previous user.

Alternately, a user can run the user’s default shell as root using...

pi@raspberrypi$ sudo -s

*Tip: Most any operation involving installation of software or system configuration will require the use of superuser privileges even if not noted by the instructions.*

As noted, each user may be a member of one or more groups. Members of groups share permissions and authority without having to share credentials.

The term world refers to a *pseudo-group* of all users and groups outside the scope of ownership, but realistically limited to system authenticated users.

#### Ownership and Permissions

Every file or folder has an owner and group owner and specific read, write, and execute (i.e. rwx) permissions assigned to each as well as the world users. This means you can define read, write, and execute operations for any file or directory to the owner or a group or set it open to anyone in the world. For example, a home folder listing (i.e. ls –l /home/pi/bin) gives

-rwxr-xr-- 1 pi staff 0 Mar 6 11:30 /home/pi/bin/test

This shows one file (first character, d for directory) named test with owner rwx, group r-x, and world r-- privileges, commonly referenced by an octal representation, 754. It also shows owner pi and group owner staff. See man page help for chown and chmod commands for altering ownership and permissions, respectively.

Note: Mastering ownership and permissions represents a fundamental element of creating and maintaining a secure system!

## Everything is a File

**First thing to remember in Linux is that everything is a file**, or at least behaves as such. This may sound strange to those unfamiliar, but keeping this perspective in mind will help you learn Linux faster and make you more efficient with commands and resolving issues. With this perspective…

* Files store information, which may include program instructions.
* Files may be readable or not.
* Files may be writable or not.
* Files may be executable or not, as either compiled code or scripts that provide instructions for processing other files.
* Files process information in two modes: by blocks or character-by-character.
* Files support streaming meaning continuous input or output (i.e. reading and writing).
* Files may be containers of information, including containers of other files (i.e. directories or folders).
* Files may be pointers to actual containers, known as links.
* Files may be physical devices that behave as files, sometimes called special files or devices. For example, one can think of a printer as a write-only file.
* Files may be processes. Processes act like files by creating or consuming information, usually in real time, usually by streaming.
* Files may be sockets, special stream processes, which connect to other processes or even other machines for passing information.
* Files have a name, associated owner, group owner, and permissions that define who can use it.

But to the user, these items all look, and act like files!

#### File Structure

Linux uses a prescribed file directory or folder structure, actually several. Linux evolved from an amalgamation of several UNIX operating systems, including AT&T System 5, Berkeley Software Distribution (BSD), and even Linux original notions. As a result, the file system has elements sometimes overlapping all of them. Table 1 lists the normal Linux file system installed by Raspian. Users can only access files and folders owned by root with superuser permissions.

Folders denoted with an \* represent pseudo or virtual folders such as external or temporary file system mount points that have special purpose and behavior. These folders do not need backed up for system restore and may in fact cause problems if backed up.

#### Links

Links, similar to MS Windows *shortcuts*, point to files. Links may be hard links, which represent multiple path references to the same physical file within the file system, but more typically symbolic, which simply add a pointer to the primary file reference. Use the ln command to create links. Listing a folder (ls) with the –l option will show the source of defined links. Hard and symbolic links behave differently for copy, move, and backup operations.

Table 1: Linux Filesystem

|  |  |  |  |
| --- | --- | --- | --- |
| Folder |  | Owner | Use |
| /bin |  | root | System binaries storage, i.e. programs available to all users. |
| /boot |  | root | Holds boot files.  (On RPi this mounts to the boot partition.) |
| /dev | \* | root | Pseudo folder that maps hardware devices |
| /etc |  | root | System configuration data. Many subfolders specific to various programs such as /etc/samba |
| /home |  | <users> | Stores each user’s profile, except root.  (Equivalent to ~/ shortcut.) |
| /lib |  | root | Code libraries for compiling |
| /lost+found |  | root | Storage for disk error recovery fragments. |
| /media | \* | root | Removeable media, i.e. floppy and USB, (auto) mount point. |
| /mnt | \* | root | Network drive mount point. |
| /opt |  | root | Legacy system folder that holds optional packages. |
| /proc | \* | root | Pseudo folder for processes |
| /root |  | root | Home folder for root. |
| /run | \* | root | Pseudo folder for running programs state data. |
| /sbin |  | root | System binaries, storage, i.e. programs, with root access only. |
| /selinux | \* | root | “Secure Linux” hold over. (empty) |
| /srv | \* | root | System services data folder. (empty) |
| /tmp | \* | - | Temporary storage open to all users. (Usually a mount to a temporary file system (i.e. tmpfs) such as a ram disk. It is erased or cleared on reboot.) |
| /usr |  | root | Machine specific program storage. /usr/local subfolder does not get overridden by OS updates ans so is generally used to store user customized scripts. |
| /var | \* | root | Program variables data storage, such as logs, cache files, file locks, run states, and process info. |

#### The Console

The keyboard and video screen or terminal window make up the *computer console* that provides the mechanism for user interaction. The keyboard refers to a special read-only file. The video screen or terminal window of the console represents a write-only file (although screen capture may provide a pseudo-read capability). The commandline refers to the input line of the terminal window where the user types commands to execute.

#### Newline Character(s)

The newline character refers to the character(s) terminating a line of text in a file, thus delineating the start of a newline. Pressing the Enter or (Carriage) Return key sends the newline character(s). The new line character differs across operating systems. Linux uses \n (character 0x0A); DOS and MS Windows uses \r\n (characters 0x0D 0x0A); Apple systems use \r (character 0x0D). While usually handled automatically and generally transparent to most operations across platforms, be aware it will matter in some cases.

Tip: Linux scripts expect Linux newlines only. They will fail otherwise, so be careful with MS Windows to Linux copy-paste operations in particular.

#### Escape Character

Some characters in a command may have special behavior such as regular expression patterns or strings. In such cases, it may be necessary to “escape” the characters by prefixing with the \ character to turn off their special behavior.

For example, the escape character in the single quoted string 'john\'s home' means ignore the string ending meaning of the second ' character to treat it as part of the value, as in “john’s home”.

Alternately, the \ character, as used above in the newline description, may designate the following character as having special meaning. That is, it escapes the character’s normal default meaning. The notation \n indicates a special newline character, not the normal letter *n* character.

## Basic Commands and Syntax

### Commands and Scripts

Commands refer to input entered at the commandline of a terminal or console to perform various actions, such as copying a file. These can be compiled programs or interpreted scripts. Compiled programs generally run faster and keep their contents proprietary while scripts generally exist as simple text files written in some specific scripting language such as Perl, Python, Bash shell, etc. Unlike MS Windows where the file extension specifies the type of file and associated program for execution, the first line of a script, somethings called the hash bang because of the first two characters, references the interpreter used to run the script as in the following:

#!/bin/bash

Table 1 lists some commonly used BASH commands, their common options or switches, and their arguments. See each command’s man page for complete information.

#### Syntax example…

command –switch <arg1> [<arg2>]

The line above illustrates syntax used throughout this document and commonly applied across tutorials. Each space delimited string is referred to a token or field. The command itself occurs first on the line. The order of the remaining fields depends on the specific command but usually doesn’t matter, except for multiple arguments. The –switch term represents a command switch or option, usually prefixed by a – character. Switches alter the commands default behavior. Generally switches immediately follow the command. Most commands allow aggregated switches, meaning “-l -a” is the same as “-la” or even “‑al”. Arg1 and arg2 represent the command arguments such as filenames. The <> characters around these terms mean the name stands for the actual content rather than the literal string. For example, the argument <path> would expect an actual file path, not the word path. The [] characters identify optional arguments. For the example given, <arg1> would be required, but <arg2> is optional.

#### Compound Commands

You can concatenate Commands in various ways to simplify typing and extend operations from one command to the next. Table 1 gives a summary of common command operations. Note that virtually any combination of thee sequences may be used to perform very complex operations such as controlling a script with control input from a file, piping its output to a second script such as a filter whose output is redirected to a second file.

Table 2: Linux Command Operations

|  |  |  |  |
| --- | --- | --- | --- |
| Character | Operator | Function | Example |
| & | Background | Executes current command in the background and returns to command prompt immediately. | run\_a\_test & |
| | | Pipe | Takes output of one command into the input of the next. | ls | grep “pi” |
| < | Input Redirect | Redirects a file into a commands input. | grep “pi” < /tmp/list |
| > | Output Redirect | Redirects a command output into a file. | ls > /tmp/list |
| >> | Append Redirect | Redirects a command output to append to a file. | ls >> /tmp/list |
| 2>&1 | Redirect All | Redirect a commands error to output stream. |  |
| 2>&1| | Pipe All | Pipe a command’s error and output. |  |
| ; | Command separator | Concatenates a series of command in the same line | cd /tmp; ls |
| () | Group | Treat commands as a group with respect to input and output. | (pwd; ls –l) > out |

#### Strings

Because the commandline parses by space between tokens, fields containing spaces must be quoted. Often, it does not matter whether using single quotes or doubles quotes, but as a rule, generally the shell (i.e. parser) cannot see inside single quotes but can see inside double quotes. This means variable substitutions inside strings generally require double quotes and to protect again misinterpreting content as special requires single quotes and/or escaping.

#### Comments

Commands prefixed with a # character represent comments for Bash shell operations. While not common for interactive use, comments commonly occur throughout scripts to document actions of the script.

Tip: Other scripting languages may define a different specific comment character.

### Man Pages – Linux Help

The Linux manual exists online for access interactively while working from the commandline.

man cat

Typing man followed by a command as in this example will open the help pages for that command in the current shell terminal. The user can scroll or page up and down to move around. When finished type Q or q to quit and return to the shell. You can also access man pages online from any of a number of web sites.

### Program Installation

#### apt-get

The apt-get command, short for aptitude get where aptitude represents the name of the code Linux code repository installer, installs or removes pre-packaged software builds. It also implements commands to update code references and upgrade already installed packages.

### Cron Jobs

The Linux cron command provides an extremely flexible and powerful way to run tasks on schedule, such as periodic backups and OS updates. All files placed in the /etc/cron.d folder will be treated as cron jobs by the OS. Each task has parameters for the time to run, the owner, the command to execute, and any parameters for the command.

Run time parameters use whitespace delimited fields for min, hour, day\_of\_month, month, and day\_of\_week (where Sunday=0 or 7). A \* wildcard may be used to match any time. For example,

# OS update @ 9:35PM every Friday...

35 21 \* \* 5 root /usr/local/bin/croncall update

(Here /usr/local/bin/croncall just represents a wrapper that logs cron calls and is not required.)

Time fields may also use a comma delimited list of parameters. For example, the day\_of\_month could be specified as 1,15 (note, no whitespace between numbers) to run on the 1ST and 15TH of the month.

Some special predefined terms specify certain run conditions such as @reboot to run a job every time the machine starts. See man cron for more information.

## Client/Server Model

The client server model defines a common communications model between two machines. The client machine represents the machine making or initiating requests for information and the server represents the machine fulfilling the request. For example, a machine running a web browser represents a client. The machine responding to that request represents the web server.

## Daemons

In Linux Daemons are processes that usually run in the background to provide services needed for operation of the server, clients, and network. Examples include DNS, DHCP server, NTP, … These daemons often run with representative names suffixed with the letter d, for example, ntpd provides the NTP daemon service.

A special process starts and stops a daemon so that it continues to run after the interactive session that started the daemon stops. Most any process may be turned into a daemon, which allows users to create custom services. Raspian typically uses a SYS5 (i.e. AT&T UNIX) style init script to start, stop, restart, or check the status of a daemon as in …

sudo /etc/init.d/daemonx start

sudo /etc/init.d/daemonx status

sudo /etc/init.d/daemonx restart

sudo /etc/init.d/daemonx stop

Alternately, the process may use the Ubuntu style service command as in…

sudo service daemonx start

## Best Practices

### Backup and Updates

Obviously, keeping data backed up and the OS up to date stand as two of the most important system administrator tasks. Automating such important tasks makes sure they occur on a timely basis. See the *Automatic Server Update* and *Backup* sections for how-to details.

### Configuration Changes

Before making any configuration changes always backup what you plan to change. For files a copy can be made of the original file with an altered name such as

pi@raspberrypi$ sudo cp /etc/network/interfaces /etc/network/interfaces.orig

This copies the original file into a backup with a .orig suffix. It the event of a problem you can restore the original settings by reversing the operation and copying the backup file to the configuration file.

Most configuration files recognize the # or other character as a comment. So when editing configurations a good practice involves commenting out an existing line and replacing with a new line such that record of the previous configuration remains in the file.

When multiple individuals work on the same configuration, it is useful to date and comment by user the changes made.

### Dates

I recommend using YYYY-MM-DD [HR-MN-SS] format for dates, which sort chronologically and removes month/day ambiguity. For example, appending a date string such as “.20150814” to files will result in an ordered directory listing making it easier to sort out the latest version. It also provides an ordered historical record for recovery.

Note: Do not use colons in date strings in filenames since it will not port to MS Windows.

### Change Log

Administrators should keep a change log for servers. This helps links symptoms and causes when someone notes problems. It is particularly helpful for situations involving multiple administrators as a way of communicating who is doing what.

# References

|  |  |
| --- | --- |
| [1] | B. Ward, How Linux Works, No Starch Press, ISBN 1-59327-035-6, 2004.  Provides a very good overview of many Linux operations and internal workings. |
| [2] | J. Kemp, Linux System Administration Recipes, Apress, ISBN 978-1-4302-2448-5, 2009.  Provides solutions to many common administrative tasks. |

Table 3: Some Common (BASH) Linux Commands

|  |  |  |  |
| --- | --- | --- | --- |
| Command | Switches | Parameters | Description |
|  |  |  |  |
| alias |  | aka=command | Create a command alias |
| apt-get |  |  | Tool to install or remove software. |
| cat |  | list of files | Concatenate (stream, print) files to standard output. |
| cd |  | folder | Change directory to specified folder. |
| chown | -R | owner:group path | Change owner and group for file or folders (recursively) |
| chmod | -R | permissions | Change file permissions for file or folder (recursively)  Permissions owner-group-world, read=4,write=2,execute=1 |
| cp | -R | source dest | Copy a file from the source location to destination. |
| df |  | disk | Display the amount of disk space used. |
| echo |  | prompt | Print prompt to standard output. |
| exit |  |  | Terminate the current shell. |
| ln | -s | source link | Creates a symbolic link for specified source. |
| ls | -alR | [<path>] | List contents of a folder, optionally specified by <path>. |
| man |  | command | Help manual for the specified command. |
| mkdir |  | folder | Create a folder. |
| more |  |  | Paginate standard input to standard output (pipe to more) |
| mv |  | source dest | Move a file from the source location to destination. |
| nano (vi) |  | file | Text editor |
| nslookup (dig) |  | node | Lookup the IP address for a specified machine (node). |
| passwd |  | user | Change the passwd for the specified (or current) user. |
| ps | -aux |  | List process IDs. |
| reboot |  | now | Reboot the machine. |
| rm | -R | source | Remove a file |
| rmdir |  | Source folder | Remove a folder. (Must be empty.) |
| rsync |  |  | Remote sync or backup command. |
| shutdown |  |  | Halt the machine. |
| Ssh |  | user@node | Secure shell remote login to user at a specific machine. |
| su |  |  | Start a superuser shell |
| sudo |  |  | Run next command as superuser |
| tar (bzip) |  |  | Archive command. |
| uname |  |  | Display the name of the current OS. |

See also Appendix C: Custom Scripts for useful “embellished” commands, such as pid, strip, update.

1. Linux User Tips

## .bashrc

The .bashrc file in each user’s home folder (i.e. /home/<user> or ~/) can be edited to add or change personal preferences to the shell experience that become permanent each time the user logs in.

Tip: In Linux, files prefixed with a . character become hidden files. Use ls -a to see them.

Tip: In Linux ~/ defines a shortcut to a user’s home folder, same as /home/$USER.

### Alias

At the end of the .bashrc file are a list of predefined aliases using the bash alias command. Add the following to make shortcuts for a long listing and to list all files.

alias ll=’ls -l --color=auto’

alias la=’ls -a --color=auto’

## /etc/profile

The /etc/profile file defines system wide bash shell setup. Changes to it will apply to all users. Changes to the /etc/profile require a reboot to take effect.

## /etc/login.defs

The /etc/login.defs file defines login defaults. Use it to make changes to the PATH for users or superuser. Changes to the /etc/login.defs require a reboot or re-login to take effect.

## Environment Variables

Environment variables get inherited by users and processes to pass configuration information as needed. Environment variables get defined in a number of locations by the precedence of /etc/login.defs, /etc/environment, /etc/profile, and ~/.bashrc with each later location overriding the previous. The first locations apply to all users while the .bashrc applies only to the specific user in whose home directory it is located.

### PATH

The PATH variable defines the search order and locations that the shell uses to locate commands. The /etc/login.defs file initializes the path for both users and superuser. Override in /etc/environment and /etc/profile for all users, or in ~/.bashrc for user specific changes.

You can (conditionally) add a local user ~/bin to the path by including this at the end of the .bashrc file.

# add local user path if exists...

if [ -e ~/bin ]; then

PATH=$PATH:~/bin

fi

#### type

Sometimes in may be confusing as to where the system locates a particular executable. The type command provides a means of querying a bash shell to trace the path for locating any command, for example

type tmux

reports

tmux is /usr/local/bin/tmux

This indicates that the current user retrieves the tmux executable from the /usr/local/bin folder.

## TAB TAB

When you cannot remember the exact name of a command starting the command name and typing the TAB key twice will recall all available commands matching the pattern. Typing

raspi TAB TAB

For example, will return

raspi-config raspistill raspivid raspiyuv

## Suggested “Tiny” Links

You will find that system operations often involve using a few particular folders repeatedly. As such, it becomes useful to create simple links as typing shortcuts, such as listed in Table 3.

Table 4: Suggested Shortcuts

|  |  |  |  |
| --- | --- | --- | --- |
| Link | Folder | Command | Example Use |
|  |  |  |  |
| /u | /usr/local/bin | ln -s /usr/local/bin /u | sudo nano /u/update |
| /i | /etc/init.d | ln -s /etc/init.d | /i/dnsmasq start |

1. Custom Scripts

Tip: When copying scripts be sure to paste as simple test, not Windows Rich Text Format. Characters such as quotes and hypens get mangled.

NOTE: When creating scripts in Linux you must set the file permissions using chmod, typically 755 for root execute, and you may have to change the owner too using chown. Otherwise, the scripts will not execute even if defined correctly.

## /usr/local/bin/backup

Script to run backup “lists” and notify admin. Lists consist of a series of rsync commands specifying files and folders backed up from a source area to a destination area.

#!/bin/bash

# linux backup script called from croncall...

# script variables

# exported variables and environment variables can be substited in list files

e=`date +%s`

logRoot=/tmp/backup.log

log="$logRoot.$e"

list=${1:-daily}

export host=`cat /etc/hostname`

export mnt=${2:-/mnt/usb/backup}

export backup="$mnt/$host"

export day=`date +%A`

export mday=`date +%d`

export week=$((10#`date +%W` % 4))

export month=`date +%B`

export year=`date +%Y`

if [ "$list" = "daily" ]; then

flist=/usr/local/bin/backup.lst.daily

fi

if [ "$list" = "weekly" ]; then

flist=/usr/local/bin/backup.lst.weekly

fi

if [ "$list" = "monthly" ]; then

flist=/usr/local/bin/backup.lst.monthly

fi

if [ "$list" = "test" ]; then

flist=/usr/local/bin/backup.lst.test

fi

#echo "LIST: $list"

echo "### [$USER] BACKUP BEGUN: `date`" >> $log 2>&1

echo "# HOST: $host" >> $log 2>&1

echo "# LIST: $list ($flist)" >> $log 2>&1

echo >> $log 2>&1

# handle mounting of backup drive...

mounted=0

try=6

n=0

if [ $mnt = "offline" ]; then

disk="/dev/disk/by-label/offline"

else

# assume using an existing locally mounted drive.

mounted=-1

fi

echo "# DRIVE: $disk" >> $log 2>&1

echo "# MOUNT: $mnt" >> $log 2>&1

if [ $mounted -eq 0 ]; then

while [ $n -lt $try ];

do

#mount backup drive

mount -t ext4 $disk $mnt >> $log 2>&1

sleep 1

if ! grep -qs "$mnt" /etc/mtab

then

# failed to mount, retry

(( n = $n + 1 ))

#echo "### BACKUP DRIVE[$disk] failed to mount on attempt $n."

echo "### BACKUP DRIVE[$disk] failed to mount on attempt $n." >> $log 2>&1

sleep 9

else

#echo "### BACKUP DRIVE[$disk] mounted."

echo "### BACKUP DRIVE[$disk] mounted." >> $log 2>&1

sleep 1

ls -l $mnt >> $log 2>&1

(( n=$try ))

mounted=1

fi

done

fi

if [ $mounted -eq 0 ]; then

echo "### BACKUP DRIVE[$disk] NOT READY: BACKUP ABORTED!" >> $log 2>&1

else

echo "### BACKUP DRIVE[$disk] ready as $mnt." >> $log 2>&1

# backup.lst.\* contains list of specific backup operations

while read line;

do

# ignore comments lines...

line=`echo "$line" |sed "s/[ ^I]\*#.\*//"`

if [ -z "$line" ]; then continue; fi

# variable substitutions...

line=`echo $line | envsubst`

if ! [[ $line =~ "echo" ]]; then

echo "EXECUTING '$line' ..." >> $log 2>&1

fi

`$line >> $log 2>&1`

printf "\n\n" >> $log 2>&1

done < $flist

fi

e2=`date +%s`

echo "### BACKUP completed $d2" >> $log 2>&1

elapsed=`expr $e2 - $e`

echo "### ELAPSED TIME: $(date -d "1970-01-01 $elapsed sec" +%H:%M:%S)" >> $log 2>&1

# save log....

cp $log $mnt/$list.log

# unmount offline backup area...

if [ $mounted -eq 1 ]; then

# umount drive

ls -l $mnt >> $log 2>&1

sleep 2

umount $mnt

echo "### UMOUNTED DRIVE $disk" >> $log 2>&1

fi

#cleanup tmp files

find $logRoot.\* -mtime +30 | 2>/dev/null xargs -r rm -- >> $log 2>&1

# report log...

cp $log $logRoot

cat $log | /usr/local/bin/mailto.py "BACKUP[$host] -> $list"

### /usr/local/bin/backup.lst.daily

Example backup list executed by /usr/local/bin/backup script. Shows how to call a list of rsync calls that perform the backup. Note the variable substitutions defined in /usr/local/bin/backup, Other commands may be called as well, such as the example echo.

#!/bin/bash

# updated: 20170228 dvc

# syntax: rsync options source destination

# common rsync options

# a = rlptgoD

# recursive, links, permissions, times, groups, owner, devices.

# v -> verbose

# z -> compress transfer

# R -> relative paths

# -no- -> turn off any options

echo "DAILY BACK UP SCRIPT..."

# system configuration files...

rsync -avzR /etc $backup/daily/$day/

# custom local scripts and cnfiguration...

rsync -avzR /usr/local/bin $backup/daily/$day/

rsync -avzR /usr/local/bin $backup/daily/$day/

rsync -avzR /usr/local/etc $backup/daily/$day/

# web code and databases...

rsync -avzR /home/js/bin $backup/daily/$day/

rsync -avzR /home/js/logs $backup/daily/$day/

rsync -avzR /home/js/restricted $backup/daily/$day/

rsync -avzR /home/js/sites $backup/daily/$day/

rsync -avzR /home/js/change.log $backup/daily/$day/

echo "... BACKUP COMPLETE"

## /usr/local/bin/backup\_rpi

This script does a backup of the sections of the boot (/boot) and root (/) partitions of the Raspberry Pi main SD card to a “clone” SD card. It assumes a NOOBS setup and partitions on the clone card as built from an existing image. *See SD Card Backup* section for details.

#!/bin/bash

# Raspberry Pi SD Card backup script...

# define default paramaters -- must be customized per installation!!!

# Assumes a usb mounted SD card with Raspian installed for backup as...

clone="usb-Generic\_Mass-Storage-0:0"

# with two mount points...

clone\_mnts***=***"/mnt/os\_clone"

boot="/mnt/os\_clone/boot"

root="/mnt/os\_clone/root"

# define default paramaters

e=`date +\_%Y%m%d\_%H%M%S`

logRoot="/tmp/sd\_backup"

logBase="$logRoot.log"

log="$logRoot$e.log"

### backup procedure...

echo "### [$HOSTNAME] SC CARD BACKUP BEGUN: `date`" > $log 2>&1

echo $0 >> $log 2>&1

echo >> $log 2>&1

# check mountpoints exist

if [ ! -d $clone\_mnts ]

then

mkdir $clone\_mnts

echo clone mountpoint $clone\_mnts created!

fi

if [ ! -d $boot ]

then

mkdir $boot

echo boot clone mountpoint $boot created!

fi

if [ ! -d $root ]

then

mkdir $root

echo boot clone mountpoint $root created!

fi

# mount the boot and root partitions of the clone, assumes NOOB partitions

echo "mounting clone partitions..." >> $log 2>&1

mount /dev/disk/by-id/$clone-part6 $boot >> $log 2>&1

mount /dev/disk/by-id/$clone-part7 $root >> $log 2>&1

echo >> $log 2>&1

# mirror the /boot partition of the main sd card to the clone partition

echo "mirroring /boot partition..." >> $log 2>&1

rsync -aHv --delete /boot/\* $boot/ >> $log 2>&1

echo >> $log 2>&1

# mirror the / partition (root) of the main sd card to the clone partition

echo "mirroring / \(i.e. root\) partition..." >> $log 2>&1

# exclude root areas: /backup, /boot, /dev /lost+found, /media, /mnt, /proc, /run, /sys, /tmp

echo >> $log 2>&1

echo "# mirroring /bin..." >> $log 2>&1

rsync -aHv --delete /bin/ $root/bin/ >> $log 2>&1

echo >> $log 2>&1

echo "# mirroring /etc..." >> $log 2>&1

rsync -aHv --delete /etc/ $root/etc/ >> $log 2>&1

echo >> $log 2>&1

echo "# mirroring /home..." >> $log 2>&1

rsync -aHv --delete /home/ $root/home/ >> $log 2>&1

echo >> $log 2>&1

echo "# mirroring /lib..." >> $log 2>&1

rsync -aHv --delete /lib/ $root/lib/ >> $log 2>&1

echo >> $log 2>&1

echo "# mirroring /man..." >> $log 2>&1

rsync -aHv --delete /man/ $root/man/ >> $log 2>&1

echo >> $log 2>&1

echo "# mirroring /opt..." >> $log 2>&1

rsync -aHv --delete /opt/ $root/opt/ >> $log 2>&1

echo >> $log 2>&1

echo "# mirroring /root..." >> $log 2>&1

rsync -aHv --delete /root/ $root/root/ >> $log 2>&1

echo >> $log 2>&1

echo "# mirroring /sbin..." >> $log 2>&1

rsync -aHv --delete /sbin/ $root/sbin/ >> $log 2>&1

echo >> $log 2>&1

#echo "# mirroring /selinux..." >> $log 2>&1

#rsync -aHv --delete /selinux/ $root/selinux/ >> $log 2>&1

echo >> $log 2>&1

echo "# mirroring /srv..." >> $log 2>&1

rsync -aHv --delete /srv/ $root/srv/ >> $log 2>&1

echo >> $log 2>&1

echo "# mirroring /usr..." >> $log 2>&1

rsync -aHv --delete /usr/ $root/usr/ >> $log 2>&1

echo "# mirroring /var..." >> $log 2>&1

rsync -aHv --delete /var/ $root/var/ >> $log 2>&1

echo >> $log 2>&1

echo >> $log 2>&1

echo "checking mounts..." >> $log 2>&1

rsync -lptgodv --delete /mnt/\* $root/mnt/ >> $log 2>&1

echo "checking symbolic links..." >> $log 2>&1

for s in $( find / -maxdepth 1 -type l ); do

if [ ! -e $root$s ]; then

echo "creating symbolic link: $root$s" >> $log 2>&1

ln -s $(readlink -f $s) $root$s

fi

done

# unmount partitions...

echo "unmounting partitions..." >> $log 2>&1

umount $boot >> $log 2>&1

umount $root >> $log 2>&1

echo >> $log 2>&1

#cleanup tmp files

find $logRoot\* -mtime +30 | 2>/dev/null xargs -r rm -- >> $log 2>&1

# report log...

cp $log $logBase

cat $log | /usr/local/bin/mailto.py "SD CARD BACKUP[$HOSTNAME]"

## /usr/local/bin/croncall

Wrapper script for calling scripts form cron that simply logs the action, mainly for debug.

#!/bin/bash

# wrapper script to call and log cron jobs

d=`date`

log='/tmp/croncall.log'

vlog='/var/log/croncall.log'

echo "[$d] $\*" >> $log 2>&1

# set a working path since cron does not run in a shell...

PATH="/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin:$PATH"

#echo " PATH: $PATH" >> $log 2>&1

# save a truncated version (as tmp clears on power cycle)

tail –n 40 $log > $vlog

# call the task script with any parameters...

# $\* = $1 ...

$\*

## /usr/local/bin/gotmux

Shortcut “GOT MUX” (or GO TMUX) command that attaches a user to their predefined tmux session with $USER session name. See *~/.tmux.init* for info on starting a user specific session.

#!/bin/bash

# start user specific tmux session

who=${1-$USER}

echo "WHO: '$who'"

if [ "$who" == "$USER" ]; then

tmux attach-session -t $who

else

su $who -c "tmux attach-session -t $who"

fi

## /usr/local/bin/mailto.py

Script called from other scripts that emails log files and other information based on system actions.   
Be sure to change the user and server specific information below highlighted in red.

#!/usr/bin/python

import sys

import smtplib

from email.mime.multipart import MIMEMultipart

from email.mime.text import MIMEText

# compose fields...

subject = "SARANAM CASITA SCRIPT: " + sys.argv[1]

if len(sys.argv)>2:

you = ','.join(sys.argv[2:])

else:

you = "email-address"

me = "email-address"

server = "mail.noip.com"

port = "465"

username = "username"

pw = "\*\*\*\*\*\*\*\*\*\*"

message = ''

for line in sys.stdin:

message += line

# Create message container - the correct MIME type is multipart/alternative.

msg = MIMEMultipart('alternative')

msg['Subject'] = subject

msg['From'] = me

msg['To'] = you

# Create the body of the message (a plain-text and an HTML version).

text = "Automatic script ..."

html = """\

<html>

<head></head>

<body>

<p>%s</p>

<pre>%s</pre>

</body>

</html>

""" % (subject,message)

# Record the MIME types of both parts - text/plain and text/html.

part1 = MIMEText(text, 'plain')

part2 = MIMEText(html, 'html')

# Attach parts into message container.

# According to RFC 2046, the last part of a multipart message, in this case

# the HTML message, is best and preferred.

msg.attach(part1)

msg.attach(part2)

# Send the message via local SMTP server.

s = smtplib.SMTP\_SSL(server,port)

s.login(username,pw)

# sendmail function takes 3 arguments: sender's address, recipient's address

# and message to send - here it is sent as one string.

s.sendmail(me, you, msg.as\_string())

s.quit()

## /etc/init.d/noip2

Script to start and stop No-IP Dynamic Update Client (DUC) daemon.

#! /bin/sh

# /etc/init.d/noip2

# Supplied by no-ip.com

### BEGIN INIT INFO

# Provides: noip2

# Required-Start: networking

# Required-Stop:

# Should-Start:

# Should-Stop:

# Default-Start: 2 3 4 5

# Default-Stop: 0 1 6

# Short-Description: Start noip2 at boot time

# Description: Start noip2 at boot time

### END INIT INFO

DAEMON=/usr/local/bin/noip2

NAME=noip2

test -x $DAEMON || exit 0

case "$1" in

start)

echo -n "Starting dynamic address update: "

start-stop-daemon --start --exec $DAEMON

echo "noip2."

;;

stop)

echo -n "Shutting down dynamic address update:"

start-stop-daemon --stop --oknodo --retry 30 --exec $DAEMON

echo "noip2."

;;

restart)

echo -n "Restarting dynamic address update: "

start-stop-daemon --stop --oknodo --retry 30 --exec $DAEMON

start-stop-daemon --start --exec $DAEMON

echo "noip2."

;;

status)

echo -n "NOIP DUC status..."

$DAEMON -S

;;

\*)

echo "Usage: $0 {start|stop|restart|status}"

exit 1

esac

exit 0

## /usr/local/bin/pid

Utility script to find running process by a given identifier string. For example pid noip will show any running No‑IP DUC services.

#!/bin/bash

# list processes by name

report=$(ps aux | sed -n -e 1p -e "/$1/I"p | grep -v $0 | grep -v sed)

echo "$report"

## /usr/local/bin/samba

Init script for samba.

#!/bin/bash

# script to setup samba (AD DC)

# can't get /etc/init.d/samba-ad-dc to run ???

### BEGIN INIT INFO

# Provides: samba

# Required-Start:

# Required-Stop:

# Should-Start:

# Should-Stop:

# Default-Start: 2 3 4 5

# Default-Stop: 0 1 6

# Short-Description: Start and Stop Samba

# Description: samba initialization script

### END INIT INFO

# parameters...

NAME=samba

PROMPT="${NAME} Version 4"

SCRIPT=/usr/local/samba/sbin/samba

KILL="killall"

RC=/usr/sbin/update-rc.d

case "$1" in

start)

echo "Starting $PROMPT ($SCRIPT) service..."

$SCRIPT

sleep 3

$0 status

;;

stop)

echo "Shutting down $PROMPT service..."

$KILL $NAME

sleep 3

$0 status

;;

status)

STATUS=$(ps auxf | sed -n -e 1p -e "/$NAME/I"p | grep -v $0 | grep -v sed)

echo "$STATUS"

;;

restart)

$0 stop

sleep 1

$0 start

;;

auto)

case "$2" in

start)

$RC $NAME defaults

;;

stop)

$RC $NAME remove

;;

\*)

$0

;;

esac

;;

\*)

echo "Usage: $0 start|stop|status|restart|(auto start|auto)|stop"

exit 1

;;

esac

## /usr/local/bin/strip

Useful little script to strip and report only meaningful lines from configuration files.

#!/bin/bash

# strip comments and blank lines from configuration files.

# Usage: strip <configuration\_file>

grep "^[^#;\*].\*$" $1

## /etc/init.d/tmux

Script to launch tmux for a specific user.

#!/bin/bash

# script to setup terminal multiplexer with session for multiusers

# each user defines their setup in /home/$USER/.tmux.init

# session named for user

### BEGIN INIT INFO

# Provides: tmux-$USER

# Required-Start:

# Required-Stop:

# Should-Start:

# Should-Stop:

# Default-Start: 2 3 4 5

# Default-Stop: 0 1 6

# Short-Description: Start and Stop

# Description: tmux initialization script

### END INIT INFO

# parameters...

NAME=tmux

SCRIPT=/usr/local/bin/tmux

XARGS="kill-server"

# find users with .tmux.init

declare -a who

for u in $( ls /home ); do

if [ -e /home/$u/.tmux.init ]; then

who[${#who}]=$u

fi

done

case "$1" in

start)

echo "Starting $SCRIPT service..."

for u in $who; do

su $u -c "$SCRIPT -c /home/$u/.tmux.init"

echo "Started: /home/$u/.tmux.init"

done

sleep 1

$0 status

;;

stop)

echo "Shutting down $SCRIPT service..."

su $USER -c "$SCRIPT $XARGS"

$0 status

;;

status)

STATUS=$(ps aux | sed -n -e 1p -e "/$NAME/I"p | grep -v $0 | grep -v sed)

echo "$STATUS"

;;

restart)

$0 stop; $0 start

;;

auto)

case "$2" in

start)

/usr/sbin/update-rc.d $NAME defaults

;;

stop)

/usr/sbin/update-rc.d $NAME remove

;;

\*)

$0

;;

esac

;;

\*)

echo "Usage: $0 start|stop|status|restart[|auto start|auto stop"

exit 1

;;

esac

## /usr/local/bin/update

Script to automatically make server OS updates and notify admin of action, errors, and pending reboot. Note: Accesses /etc/motd (message of the day shown at login) to query reboot.

#!/bin/bash

# script to make OS updates

e=`date +%s`

d=`date`

logRoot='/tmp/update'

tmp="$logRoot.tmp"

log="$logRoot.$e"

host=`cat /etc/hostname`

echo "$0 RUN $d with $PATH" > $log 2>&1

echo "" >> $log 2>&1

# run system update...

apt-get update -y > $tmp 2>&1

apt-get upgrade -y >> $tmp 2>&1

echo "" >> $tmp 2>&1

echo "" >> $tmp 2>&1

# remove logs over 30 days old...

find $logRoot.\* -mtime +30 | 2>/dev/null xargs -r rm -- >> $tmp 2>&1

echo "" >> $tmp 2>&1

# is restart required...

msg=$(grep "restart required" /etc/motd)

check=$(grep -c "restart required" /etc/motd)

echo "MSG: $msg" >> $log 2>&1

if [ $check -ne 0 ]

then

echo "REBOOT" >> $log 2>&1

else

echo "OK" >> $log 2>&1

fi

echo "" >> $log 2>&1

echo "Errors?..." >> $log 2>&1

grep -i "error" $tmp >> $log 2>&1

echo "-- END OF ERRORS --" >> $log 2>&1

echo "" >> $log 2>&1

echo "Update Log..." >> $log 2>&1

cat $tmp >> $log

cp $log "$logRoot.log"

cat $log | /usr/local/bin/mailto.py "$host update script..."

## /usr/local/bin/ups

Script called from apcupsd daemon to notify admin of UPS state changes such as lost power. Links must be added to /etc/apcupsd folder to point to this script for each desired power state warning. For example

sudo ln –s /usr/local/bin/ups /etc/apcupsd/doshutdown

This causes an apcupsd doshutdown event to call /usr/local/bin/ups. Other states include mainsback, offbattery, onbattery, powerout, etc. See man apcupsd for details.

#!/bin/bash

# script to report UPS state changes...

e=`date +%s`

d=`date`

logRoot='/var/log/ups'

log="$logRoot.$e"

host=`cat /etc/hostname`

echo "$0 $\* RUN $d" > $log 2>&1

echo "" >> $log 2>&1

# dump apcupsd log...

tail /var/log/apcupsd.events >> $log 2>&1

echo "" >> $log 2>&1

# remove logs over 30 days old...

find $logRoot.\* -mtime +30 | 2>/dev/null xargs -r rm -- >> $log 2>&1

# move log to base file and email to sysop...

cp $log "$logRoot.log"

cat $log | /usr/local/bin/mailto.py "$host UPS script..."

## /etc/init.d/vncserver

Script to control operation of tightvncserver.

#!/bin/sh

### BEGIN INIT INFO

# Provides: vncboot

# Required-Start: $remote\_fs $syslog

# Required-Stop: $remote\_fs $syslog

# Default-Start: 2 3 4 5

# Default-Stop: 0 1 6

# Short-Description: Start VNC Server at boot time

# Description: Start VNC Server at boot time.

### END INIT INFO

USER=root

HOME=/root

export USER HOME

case "$1" in

start)

echo "Starting VNC Server"

#Insert your favoured settings for a VNC session

/usr/bin/vncserver :0 -geometry 1280x800 -depth 16 -pixelformat rgb565

;;

stop)

echo "Stopping VNC Server"

/usr/bin/vncserver -kill :0

;;

\*)

echo "Usage: /etc/init.d/vncboot {start|stop}"

exit 1

;;

esac

exit 0

1. Terminal Multiplexer (tmux), Install, Setup, and Use

Terminal multiplexer creates a nice environment for multi-terminal remote server operation. You can configure it to start automatically after login and users can highly customize the operating experience.

To install, run the following, which installs tmux in /usr/local/bin

sudo apt-get install tmux

Run terminal multiplexer with a predefined window/pane configuration (see .tmux.init) located in the user’s home folder such as

tmux –c ~/.tmux.init

Once started a tmux session will run indefinitely. To reconnect after logging out and back in run

tmux attach

or if multiple sessions are running run the following:

tmux attach-session –t <session\_name>

## ~/.tmux.init

This defines an example shell-command file called by tmux that establishes a tmux session with a default set of windows running various processes. The user can easily modify the number of windows, names, and purpose of each window by editing this file, which uses BASH syntax.

#!/bin/bash

# preloaded session...

/usr/local/bin/tmux new-session -d -s $USER

# define a set of windows and launch specific commands

# to make windows remain if initial command terminates append a "bash -i" command

# web server

/usr/local/bin/tmux new-window -c /home/js/bin -n server '/usr/bin/nodejs ./homebrew.js ../restricted/config.json; bash -i'

# interactive node shell

/usr/local/bin/tmux new-window -c /home/js/bin -n node-bin '/usr/bin/nodejs; bash -i'

# interactive node shell

/usr/local/bin/tmux new-window -c /tmp -n node-tmp '/usr/bin/nodejs; bash -i'

# general purpose bash shell

/usr/local/bin/tmux new-window -c /home/js/bin -n bash-bin

# general purpose bash shell

/usr/local/bin/tmux new-window -c /home/js -n bash-home

# interactive python window

/usr/local/bin/tmux new-window -c /home/js/bin -n python-bin '/usr/bin/python; bash -i'

## ~/.tmux.conf

The ~/.tmux.conf file allows each user to uniquely configure tmux to their preferred style. Configuration options exceed the scope of this document but the example below provides a starting point. See tmux documentation for more information.

This configuration:

* Redefines the hot-key “prefix” as CTRL-A.
* Binds the PREFIX-r key to reload the configuration file.
* Sets some basic window appearance features: titles, white text on black, …
* Defines some mouse defaults.

# tmux configuration 20140522...

# change the prefix hot-key to more useable CTRL-A

set -g prefix C-a

unbind C-b

bind C-a send-prefix

# binding for the config file

bind r source-file ~/.tmux.conf

# window look and feel...

set -g set-titles on

set -g status-utf8 on

set -g status-fg black

set -g status-bg white

set -g status-interval 5

# enable mouse to allow window scrolling...

set-window-option -g mode-mouse on

set-option -g mouse-select-pane on

set-option -g mouse-resize-pane on

set-option -g mouse-select-window on

# toggle mouse-mode with prefix m or prefix M...

bind m \

set -g mode-mouse on \;\

set -g mouse-resize-pane on \;\

set -g mouse-select-pane on \;\

set -g mouse-select-pane on \;\

set -g mouse-select-window on \;\

display 'Mouse: ON'

bind M \

set -g mode-mouse off \;\

set -g mouse-resize-pane off \;\

set -g mouse-select-pane off \;\

set -g mouse-select-pane off \;\

set -g mouse-select-window off \;\

display 'Mouse: OFF'

1. Building Samba or Other Packages

Building Samba or any Linux system code follows a relatively straightforward process, which is the same flow for any package just deviating in the package details and dependencies.

Create a temporary folder (under user pi) for the build.

mkdir samba

cd samba

Before building Samba, first install its dependencies. The list may change from version to version but should include …

sudo apt-get -y install dnsutils

sudo apt-get -y install acl

sudo apt-get -y install attr

sudo apt-get -y install krb5-user

sudo apt-get -y install python-dev

sudo apt-get -y install libgnutls28-dev

sudo apt-get -y install libgnutlsxx28

sudo apt-get –y install libldap2-dev

sudo apt-get -y install cups

Tip: You can install multiple packages in a single command, but if one fails it likely will not install any. Doing one at a time is a little easier to watch and debug what is happening.

Tip: To find missing packages try apt-cache search <package>, where <package> defines a simple name string such as libgnutls.

Then get the Samba source (~20M) with the following commands. This may take a while to download depending on connection speed.

wget <https://www.samba.org/samba/ftp/samba-latest.tar.gz>

tar vzxf samba-latest.tar.gz

cd samba-x.y.z

Now the steps to compile. This will take over 5 hours on a Raspberry Pi B+.

./configure --enable-debug --enable-selftest

make

Note: The configure step above could fail based on missing dependencies. If so, simply Google information as to where to find and how to install each missing dependency until configure no longer reports any errors. You can then proceed with the make operation.

If make completes successfully then install with

sudo make install

If make install completes successfully, the compiled version of samba should be installed. At this point, exit from the su shell or continue with other samba configuring operations. See Samba Wiki.

## Notes

1. You may remove the build directory at this point.
2. You may also want to add /usr/local/samba to the path variable. *See Appendix C: Linux User Tips*.
3. Run update-rc.d command for packages that you wish to start automatically at startup.
4. Cloning a Disk or SD Card

Tip: The Raspian Desktop GUI now includes a new SD card copier (under Accessories) to backup an SD card, even on a running system, supports both Raspian and NOOBS builds, and can copy to a smaller or larger card as long as the card have enough room for files.

Cloning a disk or SD card makes an exact copy sector by sector to a single image file (.img). Creating an image stores all disk data including free space. To restore the image file requires a disk having an equal or larger number of sectors as the original card.

Note: All SD cards of the same size do not have the same capacity, that is, you may not be able to restore an 8G image to an 8G card if it has slightly less sectors.

1. Shut down or halt the Pi and remove the SD card.   
   (You cannot reliably copy the SD card while mounted as the root file system.)
2. Insert the SD card into your computer.
3. For Windows …
   1. Start up Win32DiskImager.
   2. In the "Image File" box, enter the path for the image file being created, such as  
      C:\data\images\tiny.img
   3. Under the "Device" box, select the disk representing the SD card.
   4. Click the "Read" button to create the image file from the card.
   5. When done, eject the SD card.

Use this process in reverse to build an SD card from an image file.

For Linux …

1. Mount the SD card as a secondary disk (i.e. non-booting) in another machine.
2. Use the dd command to copy as:

sudo dd if=</dev/sdx> of=</path/to/image>

Where x of sdx is the letter signifying the SD card disk device.

Or redirect to gzip for compression...

dd if=</dev/sdx> | gzip > </path/to/image.gz>

Or a live update to another Linux box…

ssh root@raspberrypi dd if=/dev/mmcblk0 | gzip -c > img.gz

1. Replace the SD card in the Raspberry Pi and power it back on.

Keep the backup IMG file in a safe place. For immediate server restoration, copy the image to a second backup SD card using Win32DiskImager or Linux dd command in reverse or directly using 7Zip to extract an img file to an SD card.

For non-NOOBS installs, <https://github.com/billw2/rpi-clone> offers a way to clone Raspberry Pi SD cards in-situ.

The script /usr/local/bin/backup\_rpi keeps a cloned SD card up to date. Run it after periodic updates (i.e. /usr/local/bin/update).

1. Google Drive

A number of services provide efficient, secure, and online/offsite file storage with backup. This setup assumes the use of Google Drive because of its direct integration with Gmail in use by the example installation and other services such as Google+, Google Photos, and Chrome, as well as being low cost for additional storage. Every Google account automatically includes 15G of storage aggregated across Gmail and all other Google Apps, including Drive.

Tip: See the PowerPoint presentation entitled Using Google Drive for more details.

## Google Drive Web Interface

Google Drive provides a web-interface using the Chrome browser to completely access and manage using the following link:

https://drive.google.com/drive/my-drive

From Chrome, you can simply type drive in the address bar. ***You must log into your Google Account first.*** Through the web interface you can upload, download, move, delete, share, and manage file versions, even on machines without a Google Drive installation.

## Drive Installation

Additionally, you can install the Drive app on a local machine, Windows or Mac or mobile devices, to provide automatic file synchronizing with a local folder. Download Drive from

<https://www.google.com/drive/download/>

Simply click on the downloaded file to install. This will create a Google Drive folder under your user area (i.e. c:\Users\dvc\Google Drive) that will appear in the Quick access list found in the top left pane of the Windows Explorer window as seen below.



Figure 3: Google Drive Quick Access Link

### Documents Backup and Offsite Access

Note: This will not work for installations using folder redirection for roaming profiles.

A nice feature Windows and a Google Drive installation involves the direct mapping of one’s Document folder to the Google Drive folder. This provides automatic backup of Documents to Google Drive.

Warning: Before doing this setup I recommend backing up your Documents folder. This can be done my making a temporary copy to c:\temp\Documents for example.

Tip: For older versions of Windows prior to Windows 10, reference the My Documents folder instead of Documents.

To setup, in Windows Explorer click on This PC in the left-hand pane to expand its subfolders. Write click on the Documents folder and click on Properties.... In the dialog window select the Location tab. Click Move and browse for the Google Drive folder. Select the Select Folder button. Windows will move the files in the Documents folder to the Google Drive folder and point to that folder for future file operations. Drive will automatically sync files to the Google account storage.

## Selective Copying

Google Drive supports selective copying from your Google account to a local machine (but not vice versa). As such, you can conserve disk space on your local machine but syncing only specific subfolders located within the Google account. To do so right-click on the Google Drive folder in Windows Explorer and select the Google Drive item and then Preferences. Alternately, click on the Google Drive icon in the System Tray on the lower right Taskbar area. Then click the 3 vertical dots in the upper right of the popup and then select Preferences. Then chose the folders you wish to sync with Google Drive.

## Common Shared Area with Local Drive Mapping

Drive also has value as a common file share resource. This case uses a separate standalone Gmail account, such as shared-gmail-address. Given the greater storage needs you can purchase additional storage space as needed. Share trees within the common share with users and then each user can “Add to my drive” to have direct access.

1. Active Directory Users and Computers

Windows Remote Server Administration Tools (RSAT) provide an interface to the Active Directory server. The Active Directory Users and Computers plugin supports managing both domain users and computers. This runs on one or more Windows machines attached to the domain to enable GUI-based management without having to execute commandline commands directly on the server itself.

## Adding a Computer

You can add computers to the domain most easily from the specific machine following these steps.

1. Click on the Windows icon (at the lower left of the desktop).
2. Type **join**. Select **Rename your PC or join a domain** from the list of choices.
3. Click **Join a Domain** from the Settings dialog.  
   (You must first disconnect from any other domain.)
4. Type **saranam** and click **Next**.
5. Enter admin credentials to authorize the join.

## Adding a Group

To add a group follow these steps…

1. Select Users in the left pane under the domain. Right-click and select New → Group.
2. Enter the group name.
3. Use the default global security group settings. Click OK.
4. Click on the created group and open its property dialog and add a description.

## Managing Users

### Adding a User

To add a user follow these steps…

1. Select Users in the left pane under the domain. Right-click and select New → User or click on the Add New User Icon on the toolbar.
2. Complete the appropriate information in the dialog and click Next.
3. Define a default password for the account and OK.  
   (Note: the “User must change password on next login” checkbox will be set automatically.)  
   (Note: the “Password never expires” may be set on admin accounts.)
4. Acknowledge the user account creation.

Some additional user definition not supported by the initial dialog needs to be completed.

1. Right-click on the user account and select Properties or click the Properties icon on the taskbar. This will open a detailed multi-tab dialog box to change any user setting.
2. On the General tab add a description consistent with previous descriptions (i.e. Admin Account, Saranam Staff, Instructors, Clients, …).  
   (Change display name if desired. This defines the users identity shown on the Windows desktop.
3. Click on the MemberOf tab and add the user to the appropriate groups.  
   (Note: the group must be pre-defined.  
   (Note: to list available groups, click **Advanced**, then click **Find now**.)
4. Edit any other information as desired.

### Terminating Users

When terminating a user, best practice involves simply **disabling** the account rather than deleting the account. This keeps the account in tact but prevents user login, which allows recovery in the future if necessary.