
Building A Pi Based NAS

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1 Colophon

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2 Introduction

This is a guide to building a NAS¹ using a Raspberry Pi SBC.

It is assumed that the reader is familiar with the Linux command line and at least one text editor. Desktop users will need to open a terminal to execute many of the commands in this guide.

While aimed at Raspberry Pi OS, much will apply to any Linux distribution.

2.1 What's Not Covered

- OS installation.
- Networking configuration.
- Active Directory and other professional features and environments such as centralised user management.
- Clients other than Linux and Windows.
- iSCSI, ATAoE, NBD, and other SAN² protocols.
- Use of the NAS as a network boot and/or NFS root server.
- Use of the NAS as a network print server.
- Windows versions other than Windows 10.

2.2 Requirements:

- An internet connection for software update and installation.
- Raspberry Pi (any model) with a configured and working network connection.
- One or more directories on the Pi that you wish to share.
- An understanding of how Linux file/directory owner, group, and permissions work.
- For a headless³ sever, VNC or ssh enabled.

1 Network Attached Storage

2 Storage Area Network

3 I.E. no monitor, mouse, or keyboard connected.

2.3 Conventions

Text like this indicates input to or output from the command line.

Text like this also refers to full or partial commands but is not generally intended to be entered into the command line as is.

“SD card” refers equally to full size and micro SD cards. IF should also be taken to refer to any boot storage medium in use.

Where “pi” occurs as a username, replace as appropriate.

“server” refers to the NAS, “client” to any device that accesses resources provided by the NAS.

“l-space” is a sample hostname. Replace with the actual hostname of your server.

All non system paths used in this guide follow the Filesystem Hierarchy Standard⁴ though this is not mandatory.

2.4 Notes

- The file system in use on the server does not matter to the client. The client is not even aware of what it is.
- Versions of Windows 10 except Home and Pro have guest access to remote shares disabled by default. See <https://docs.microsoft.com/en-us/troubleshoot/windows-server/networking/guest-access-in-smb2-is-disabled-by-default>
- Windows 10 has SMB v1 disabled by default. Network browsing will not see the NAS without this enabled or WSDD installed on the server.
- The version of Samba available for Raspberry Pi OS Bullseye has SMB v1 disabled.
- NAS software (Samba, NFS, etc.) cannot⁵ grant permissions to clients that the server’s file system does not grant to it.
- The SMB/CIFS⁶ protocol does not support Linux owner, group, and permissions. Windows clients don’t use them, Linux clients set them in the driver at mount time.

⁴ https://en.wikipedia.org/wiki/Filesystem_Hierarchy_Standard

⁵ Not strictly true. Clients will think they have the permissions but attempts to exercise them will fail.

⁶ As used by Samba.

2.5 References

<https://www.raspberrypi.com/documentation/>

<https://www.samba.org/>

<https://www.samba.org/samba/docs/current/man-html/smb.conf.5.html>

<https://github.com/thagrol/Guides/blob/main/fstab.pdf>

man pages for `samba`, `smb.conf`, `nfs`, `exports`, `mount`, `fstab`, and `fdisk`.

3 A Minimal NAS

This is about as minimal as it can get on the NAS.

1. Enable ssh:

```
sudo touch /boot/ssh
sudo reboot
```

Clients will need to use an appropriate SFTP program. The server cannot be mapped to a drive letter or browsed to on windows clients. Linux clients may also mount the NAS using sshfs.

Client users will be able to access the server's entire file system subject to permissions granted to their user.

Additional users can be created per section 6.2.1

Note: The default user name and password for Raspberry Pi OS are well know. It is recommended to at least change the password when enabling ssh especially if opening it up to the internet via port forwarding on your router.

3.1 Using sshfs On Linux Clients

Install sshfs:

```
sudo apt update
sudo apt install -y sshfs
```

To mount a server:

```
sshfs user@host:directory mount point
```

Enter password when prompted.

For example:

```
sshfs pi@raspberrypi:/home/pi $HOME/remote
```

To unmount:

```
fusermount -u mount point
```

For example:

```
fusermount -u $HOME/remote
```

Sudo is not required and should not be used.⁷

Key based authentication can be used and is configured in the normal way for ssh.

user@ is optional. If not provided the name of the current user will be used.

⁷ Because: security. It will also likely not work as on Raspberry Pi OS root has no password.

4 Install Server Software

This will install but not configure the required server side software. Samba (SMB/CIFS) is more widely supported than NFS but has significant limitation for Linux clients⁸ due to its origin and age⁹.

While better for Linux clients, NFS is not supported on Home editions of MS Windows.

1. Ensure your OS installation is up to date:

```
sudo apt update && sudo apt upgrade -y
```

2. Install samba

```
sudo apt install -y samba samba-common-bin smbclient cifs-utils
```

3. Install the NFS server:

```
sudo apt install -y nfs-kernel-server
```

⁸ More on this later.

⁹ c.1992 with Windows 3.11 (Windows for Workgroups) though first designed in 1983 at IBM.

5 A Quick, Dirty, and Insecure Samba Server

Quick because it's a minimal configuration. Dirty because it's a minimal configuration and because samba is not ideal for Linux clients. Insecure because it gives all permissions to all users and does not require login.

That said, this may be good enough in some circumstances – where security is not required and all remote users and devices are trusted.

If you have not already done so, install Samba per section 4.

5.1 Configure Samba

1. Stop the samba server:

```
sudo systemctl stop smbd nmbd
```

2. If it does not exist, create a directory to share:

```
sudo mkdir -p /srv/shared
```

3. Open permissions on it:

```
sudo chmod 777 /srv/shared
```

4. Backup your current smb.conf:

```
sudo cp /etc/samba/smb.conf /etc/samba/smb.bak
```

5. Open /etc/samba/smb.conf in your preferred text editor. You will need to be root or use sudo.

6. Replace its contents with the following:

```
[global]
    log file = /var/log/samba/log.%m
    server role = standalone
    map to guest = bad user

[shared]
    path = /srv/shared
    read only = no
    guest ok = yes
    force create mode = 666
    force directory mode = 777
```

See section 5.4 for a brief explanation of the above smb.conf.

7. Save and close.

8. Verify smb.conf:

```
testparm
```

9. Fix any errors and reverify.

10. Start the samba server:

```
sudo systemctl start smbd nmbd
```

5.2 Client Access

5.2.1 Linux Command Line

Remote shares can be made available via the mount command this normally requires root privileges. For example:

```
sudo mount -t cifs -o guest,rw,file_mode=666,dir_mode=777 //l-space/shared /mnt
```

l-space is the name or IP address of the NFS server. /shared is the share name as defined in the server's smb.conf.

Remote shares may also be added to /etc/fstab. For example¹⁰:

```
//l-space/shared /mnt cifs  
defaults,nofail,_netdev,guest,rw,file_mode=666,dir_mode=777 0 0
```

As with the share definition, above, these mount options will allow full access by all users on the client though files and directories will appear to be owned by root.

The meaning of the mount options are:

guest	Use guest access. Do not prompt for password.
rw	Mount read/write.
file_mode=666	Override default file permissions.
dir_mode=777	Override default directory permissions.
defaults	Use default mount options
nofail	Allow boot to continue if the mount fails. Only useful; in fstab with auto (and defaults) mounts.
_netdev	Flag to the system that the mount requires the network to be up.

For further mount options refer to the documentation for the mount and mount.cifs commands.

For further information on /etc/fstab please refer to its documentation or to my guide at <https://github.com/thagrol/Guides>.

5.2.2 Linux Desktop

Mounts made via the command line or /etc/fstab will be available via the chosen mount point.

Most file managers can access shares by entering smb://server/share e.g. smb://ankh/shared in the address field.

Network browsing may be functional but only if both the server and client have the SMB v1 protocol enabled.

Please refer to the documentation for your chosen file manager for more details.

¹⁰ An fstab entry must be on a single line. That may not be apparent here due to document formatting.

5.2.3 Microsoft Windows

Shares can be accessed by entering `\\server\\share` e.g. `\\l-space\shared` into the address field of File Explorer or This PC. Shares may be assigned a drive letter via “Map network drive”.

Network browsing may be functional but only if both the server and client have the SMB v1 protocol enabled or the server has wsdd installed (see 13.2.2). SMB v1 is disabled by default on Windows 10.

Please refer to the documentation for your version of Windows and to section 2.4.

5.3 Adding a User's Home Directory

It may be desirable to allow access to a user's home directory. As with the rest of this section, the method below is insecure as any remote user can access the share with full permissions and without login.

- 1 Backup your `smb.conf`. You may wish to rename any existing backup first so it is not lost.
- 2 Open `/etc/samba/smb.conf` in your preferred text editor. You will need to be root or use `sudo`.
- 3 Add the following to the end of the file.

```
[pi]
  path = /home/pi
  read only = no
  guest ok = yes
  force user = pi
  force group = pi
```

- 4 Save and close
- 5 Verify your new `smb.conf`:

```
testparm
```

- 6 Fix any errors and reverify.
- 7 Restart the samba server:

```
sudo systemctl restart smbd nmbd
```

Unlike the shared directory, above, this share definition does not force a set of permissions for new files and directories. Instead it forces all file system access to use the Linux user and group specified by `force user` and `force group`.

The Linux user must exist and is cases sensitive. An equivalent samba user is **not** required.

Permissions will be the default for that Linux user.

This approach will ensure all files in the user's home directory that are created or edited by clients are owned by the correct server side Linux user.

If desired, `force create mode` and `force directory mode` may also be used.

5.4 The smb.conf From 5.1 Explained

<code>[global]</code>	Section header. Contains options that affect the server and all shares.
<code>log file = /var/log/samba/log.%m</code>	Log file location. %m is replaced with the name of the client.
<code>server role = standalone</code>	Sets server role. Standalone server, not part of a Windows Domain
<code>map to guest = bad user</code>	Attempts to login with an invalid username ¹¹ and password are treated as guest accesses.
<code>[shared]</code>	Start of share definition. “shared” is the share name.
<code>path = /srv/shared</code>	Server side path to shared directory. Must be an absolute path.
<code>read only = no</code>	Writes to the share are permitted ¹² .
<code>guest ok = yes</code>	Guest access to the share is permitted.
<code>force create mode = 666</code>	Force permissions for files created by clients. 666 grants read and write permissions to all users and groups.
<code>force directory mode = 777</code>	Force permissions for directories created by clients. 777 grants read, write and execute permissions to all users and groups ¹³ .

All other parameters will have their default values.

¹¹ Samba user not Linux user. Samba has its own user and password database.

¹² Subject to underlying file system permissions.

¹³ Without execute permission directories cannot be entered

6 A More Secure Samba Server

6.1 Configure Samba

11. Stop the samba server:

```
sudo systemctl stop smbd nmbd
```

12. If it does not exist, create a directory to share:

```
sudo mkdir -p /srv/shared
```

13. Open permissions on it:

```
sudo chmod 777 /srv/shared
```

14. Backup your current smb.conf:

```
sudo cp /etc/samba/smb.conf /etc/samba/smb.bak
```

15. Open /etc/samba/smb.conf in your preferred text editor. You will need to be root or use sudo.

16. Replace its contents with the following:

```
[global]
    log file = /var/log/samba/log.%m
    server role = standalone
    unix password sync = no

[shared]
    path = /srv/shared
    read only = no
```

See section 6.5 for a brief explanation of the above smb.conf.

17. Save and close.

18. Verify smb.conf:

```
testparm
```

19. Fix any errors and reverify.

20. Start the samba server:

```
sudo systemctl start smbd nmbd
```

6.2 Add Samba Users

Samba users must also be Linux users¹⁴ but it is not required that they have a home directory or the ability to login to Linux.

6.2.1 Add Linux User

All steps must be performed as root or with sudo. This step can be skipped if the Linux user already exists.

For a standard user with a home directory and the ability to login:

```
sudo adduser username
```

e.g.

```
sudo adduser sam
```

and follow prompts.

For a user without a home directory but with the ability to login:

```
sudo adduser -M username
```

e.g.

```
sudo adduser -M sybil
```

and follow prompts.

To disable login on a user:

```
sudo usermod -L username
```

e.g.

```
sudo usermod -L nobby
```

Do not disable users that need to login whether locally, via ssh, via SFTP, or via SSHFS.

¹⁴ This is a requirement of the default password backend.

6.2.2 Add The Samba User

User creation and management is done via `smbpasswd`. Most options require root or sudo though a user can change their own password.

The samba server must be running in order to add or modify a user.

If `unix password sync = yes` is present in `smb.conf` the Linux user's password will be updated to match the new samba password.

To create a user:

```
sudo smbpasswd username
```

e.g.

```
sudo smbpasswd sam
```

and follow prompts.

6.2.3 Users For Windows Clients

While not necessary, it can somewhat ease access from Windows clients if the created samba user has the same username and password as the user on the windows machine.

6.3 Client Access

6.3.1 Linux Command Line

Remote shares can be made available via the `mount` command this normally requires root privileges. For example:

```
sudo mount -t cifs -o user=sam,rw,file_mode=666,dir_mode=777  
//l-space/shared /mnt
```

Enter the samba user's password when prompted.

Remote shares may also be added to `/etc/fstab`. For example¹⁵:

```
//l-space/shared /mnt cifs  
defaults,nofail,_netdev,user=sam,password=bar,rw,file_mode=666,dir_mode=777 0 0
```

Permissions set in the above mount options are insecure as they will allow full access by all users on the client though files and directories will appear to be owned by root.

The meaning of the mount options are:

<code>user=sam</code>	Specify which remote samba user to connect as.
<code>password=bar</code>	Password for the above user
<code>rw</code>	Mount read/write.
<code>file_mode=666</code>	Override default file permissions.
<code>dir_mode=777</code>	Override default directory permissions.
<code>defaults</code>	Use default mount options
<code>nofail</code>	Allow boot to continue if the mount fails. Only useful; in <code>fstab</code> with the <code>auto</code> (and <code>defaults</code>) mount options.
<code>_netdev</code>	Flag to the system that the mount requires the network to be up.

For further mount options refer to the documentation for the `mount` and `mount.cifs` commands.

For further information on `/etc/fstab` please refer to its documentation or to my guide at <https://github.com/thagrol/Guides>.

`fstab` is readable by all users on a machine so the samba user's password is not secure. Use of a credentials file is preferred. See `man mount.cifs`.

¹⁵ An `fstab` entry must be on a single line. That may not be apparent here due to document formatting.

6.3.2 Linux Desktop

Mounts made via the command line or `/etc/fstab` will be available via the chosen mount point.

Most file managers can access shares by entering `smb://server/share` e.g.

`smb://l-space/shared` in the address field.

Network browsing may be functional but only if both the server and client have the SMB v1 protocol enabled.

Please refer to the documentation for your chosen file manager for more details.

6.3.3 Microsoft Windows

Shares can be accessed by entering `\\server\\share` e.g. `\\l-space\\shared` into the address field of File Explorer or This PC. Shares may be assigned a drive letter via “Map network drive”.

Network browsing may be functional but only if both the server and client have the SMB v1 protocol enabled or the server has `wsdd` installed (see 13.2.2). SMB v1 is disabled by default on Windows 10.

Please refer to the documentation for your version of Windows and to section 2.4.

6.4 Sharing Users Home Directories

It may be desirable to allow access to a user's home directory. Samba has built in support for this via the [homes] share.

- 1 Backup your smb.conf. You may wish to rename any existing backup first so it is not lost.
- 2 Open /etc/samba/smb.conf in your preferred text editor. You will need to be root or use sudo.
- 3 Add the following to the end of the file.

```
[homes]
comment = Home Directories
browseable = no
read only = no
valid users = %S
```

- 4 Save and close
- 5 Verify your new smb.conf:

```
testparm
```

- 6 Fix any errors and reverify.
- 7 Restart the samba server:

```
sudo systemctl restart smbd nmbd
```

No path = is required and a single share definition will function for all users that have a home directory.

valid users = %S ensures that only the user whose home directory it is can access it.

6.5 The smb.conf From 6.1 Explained

<code>[global]</code>	Section header. Contains options that affect the server and all shares.
<code>log file = /var/log/samba/log.%m</code>	Log file location. %m is replaced with the name of the client.
<code>server role = standalone</code>	Sets server role. Standalone server, not part of a Windows Domain
<code>unix password sync = no</code>	If the samba user's password changes do not update the Linux user's password to match.
<code>[shared]</code>	Start of share definition. "shared" is the share name.
<code>path = /srv/shared</code>	Server side path to shared directory. Must be an absolute path.
<code>read only = no</code>	Writes to the share are permitted ¹⁶ .

All other parameters will have their default values.

¹⁶ Subject to underlying file system permissions.

7 Better Support For Linux Clients – NFS

While the SMB/CIFS protocol has some support for Linux/Unix file ownership, permissions, and other file system features use of them is not recommended as they require the obsolete and very insecure v1. Most modern OS, servers, and clients will not use v1 unless explicitly instructed to do so.

NFS¹⁷ is Linux native with full support for Linux file system features.

Using both Samba and NFS on the same server directory is usually safe.

7.1 NFS And Users

Unlike with Samba/SMB/CIFS an NFS server does not require a separate user database nor does it require that any given user exist on both the client and server.

It does, however require that numeric user and group IDs are the same across all machines and that clients that do not have a particular user or group do not use the ID for a different user or group.

If user/group IDs are not consistent, file owner, group, and permissions will not be consistent across clients.

To illustrate:

Client device: Ankh

User: sam ID: 1001 Group: sam ID: 1001

User: sybil ID: 1002 Group: sybil ID: 1002

Client device: Morpork

User: sam ID: 1002 Group: sam ID: 1002

User: sybil ID: 1001 Group: sybil ID: 1001

While logged in to Ankh, sam creates a file that appears in `ls -l` as:

```
-rw-r--r-- 1 sam sam 1024 Jan 22 2021 laws.txt
```

Later sam views the same file whilst logged in to Morpork:

```
-rw-r--r-- 1 sybil sybil 1024 Jan 22 2021 laws.txt
```

Nothing has change on the file¹⁸ but as the IDs are not consistent the owner and group appear to have changed giving sybil permissions that only sam should have.

¹⁷ Network File System

¹⁸ The file system uses the numeric user and group IDs not the textual ones.

7.2 Quick, Dirty, And Somewhat Insecure

Quick because it's a minimal configuration. Dirty because it's a minimal configuration. Somewhat insecure because permissions on the exported directory are changed to allow full access by all users and the export definition allows access by all devices with access to your network. Normal Linux user, group, and permissions still apply.

That said, this may be good enough in some circumstances – where security is not required and all remote users and devices are trusted.

1. If not already done, install the NFS server per section 4.
2. If it does not exist, create a directory to export per section 5.1 steps 2 and 3.
3. Backup your current exports file:

```
sudo cp /etc/exports /etc/exports.bak
```

4. Open /etc/exports in your preferred text editor. You will need to be root or use sudo.
5. Add the following on a new line at the end of the file:

```
/srv/shared *(rw, sync, no_subtree_check)
```

6. Save and close.
7. Re-export all directories:

```
sudo exportfs -r
```

7.3 Client Access

7.3.1 Linux Command Line

Remote exports can be made available via the `mount` command this normally requires root privileges. For example:

```
sudo mount -t nfs l-space:/srv/shared /mnt
```

`l-space` is the name or IP address of the NFS server. `/srv/shared` is the same path as entered into `/etc/exports` on the server.

Remote exports may also be added to `/etc/fstab`. For example¹⁹:

```
//l-space/srv/shared /mnt nfs defaults,nofail,_netdev,rw, 0 0
```

The meaning of the mount options are:

<code>defaults</code>	Use default mount options
<code>nofail</code>	Allow boot to continue if the mount fails. Only useful; in <code>fstab</code> with the <code>auto</code> (and <code>defaults</code>) mount options.
<code>_netdev</code>	Flag to the system that the mount requires the network to be up.

For further mount options refer to the documentation for the `mount` and `mount.nfs` commands.

For further information on `/etc/fstab` please refer to its documentation or to my guide at <https://github.com/thagrol/Guides>.

7.3.2 Linux Desktop

Mounts made via the command line or `/etc/fstab` will be available via the chosen mount point.

Most file managers can access shares by entering `nfs://server/directory` e.g. `nfs://l-space/srv/shared` in the address field.

Please refer to the documentation for your chosen file manager for more details.

7.3.3 Microsoft Windows

Most versions of Windows have no native support for NFS²⁰. For those that do, please refer to the documentation for your version of Windows.

¹⁹ An `fstab` entry must be on a single line. That may not be apparent here due to document formatting.

²⁰ Third party drivers may exist however they are outside the scope of this guide.

7.4 Adding a User's Home Directory

It may be desirable to allow access to a user's home directory. As in 7.2, above, access is not permitted by any machine that can reach the server.

1. Backup your current exports file. You may wish to rename any existing backup first so it is not lost.

```
sudo cp /etc/exports /etc/exports.bak
```

2. Open /etc/exports in your preferred text editor. You will need to be root or use sudo.
3. Add the following on a new line at the end of the file:

```
/home/pi *(rw, sync, no_subtree_check)
```

4. Save and close.
5. Re-export all directories:

```
sudo exportfs -r
```

To export the home directories of all users simply export /home.

7.5 The Export File And Options Explained

Each line in /etc/exports defines an exported directory. The format is:

```
/path/to/directory      host(exports options)
```

For example:

```
/srv/shared *(rw, sync, no_subtree_check)
```

A full path must be used.

*	Allow access by all clients regardless of hostname or IP address. Safe as long as your server is not directly exposed to the internet.
rw	Allow writing by clients. Clients must still mount the export as rw.
sync	Reply to client write requests only after changes have been written to disc. May impact performance but prevents data loss or corruption if the server crashes.
no_subtree_check	Improves performance and reliability but has a minor security implication. See man exports.

8 Supporting Smart Devices As Clients

Most smart devices do not include support for SMB/CIFS and NFS instead preferring to use DLNA²¹²². Allowing DLNA clients requires installing and configuring additional software such as miniDLNA.

1. Install miniDLNA:

```
sudo apt update
sudo apt install -y minidlna
```

2. Backup your existing minidlna.conf:

```
sudo cp /etc/minidlna.conf /etc/minidlna.bak
```

3. Open /etc/exports in your preferred text editor. You will need to be root or use sudo.

4. Find the line starting media_dir=

5. Replace the path after “=” to the actual path to the directory you wish to share e.g.

```
media_dir=/srv/shared
```

6. Add any additional directories, one media_dir= definition per line.

7. Save and close.

8. Restart minidlna

```
sudo systemctl restart minidlna
```

Depending on the number of files, it may take miniDLNA some time to scan your media directories. Clients will not have access until this has completed.

21 **Digital Living Network Alliance**

22 Also known as UPnP.

9 Adding More Storage

Sooner or later you'll run out of free space and need to add additional storage.

9.1 Preparing The Storage

Unless you have a strong need to remove and directly connect the storage device (the drive) to a non Linux computer or device it's best to use a Linux file system such as ext4.

Bare drives are not usually supplied pre formatted so will need to be initialised and partitioned first.

All of the following procedures in this section are destructive and cannot be easily undone. Be certain you are operating on the correct device and partition. I cannot and will not accept responsibility for any damage or data loss that may occur.

9.1.1 Desktop Users – Bare Drive

1. Connect the drive.
 2. Open gparted (Menu then System Tools or `sudo gparted` in a terminal)
 3. Enter your password if prompted.
 4. From the drop down select the correct device. With a single drive connected it should be `/dev/sda`.
 5. Open the “Device” menu.
 6. Select “Create partition table”
 7. Select partition type. Drives of 2TB or less can use either MS-DOS or GPT. Drives over 2TB must use GPT.
 8. Double check that you have selected the correct drive. Writing a new partition table to a device cannot be easily undone.
 9. Click “OK”
 10. Open the “Partition” menu.
 11. Select “New”
 12. Accept the default options to use the full size of the drive in a single ext4 partition.
 13. Click the green tick icon.
 14. Wait for the format to complete.
 15. Close gparted.
-

9.1.2 Desktop Users – Pre Formatted Drive

1. Connect the drive
2. If the drive has been automatically mounted, first unmount it via the file manager.
3. Open gparted (“Menu” then “System Tools” or `sudo gparted` in a terminal)
4. Enter your password if prompted.
5. From the drop down select the correct device. With a single drive connected it should be `/dev/sda`.
6. In the diagram or list find the correct partition. Most pre formatted drives only have one.
7. Right mouse click it.
8. In the menu open the “Format to” sub menu then select “ext4”.
9. Double check you have selected the correct drive and partition. Formatting the wrong one cannot easily be undone.
10. Click the green tick icon.
11. Wait for the format to complete.
12. Close gparted.

9.1.3 Command Line Users – Bare Drive

1. Connect the drive.

2. Find its device node²³:

```
lsblk
```

A single drive will likely be /dev/sda

3. Start fdisk

```
sudo fdisk /dev/sda
```

4. Create a new partition table:

```
o
```

or

```
g
```

For drives 2TB or less use o to create an MS-DOS partition table or g for a GPT partition table. Drives over 2TB must use g.

5. Create a new partition:

```
n
```

6. Accept the default options to all prompts.

7. View the changes:

```
p
```

8. If everything looks correct and you are certain that you are making changes to the correct drive, write the changes to disc:

```
w
```

You should now have a drive containing a single, unformatted partition. Proceed to 9.1.4

²³ The item in /dev that refers to the physical disc.

9.1.4 Command Line Users – Pre Formatted Drive

1. Connect the drive.
2. Find the device node for the desired partition.

```
lsblk
```

3. For a single drive with a single partition this will likely be /dev/sda1.
4. Format the partition. Note: be certain you are working with the correct partition as this cannot easily be undone.

```
sudo mkfs.ext4 /dev/sda1
```

9.2 Mounting The Drive²⁴

9.2.1 Using the Desktop's Automatic Mounting

Relying on the desktop to mount your drives/partitions, while possible, is not recommended for the following reasons:

- Mounting occurs only if the desktop is running and a user has logged in to it.
- Mounting occurs after the server software (NFS, Samba, miniDLNA) has started
- The mount point used is not guaranteed to be consistent across reboots.
- There is no control over which mount options are used.
- There is no control over which mount point is used.
- With the default permissions the mount point may not be accessible by other users.

The last point can be addressed by running `sudo chmod 766 /media/username` e.g. `sudo chmod 766 /media/pi`

No OS level configuration is required other than ensuring the OS boots to the desktop with automatic login enabled.

²⁴ In all but a few cases partitions get mounted not entire drives.

9.2.2 Using /etc/fstab

fstab provides much finer control over where a drive/partition is mounted and with what options. However getting it wrong can often result in a system that will not boot correctly. To aid recovery, have a second SD card with a clean OS install to hand before making changes.

A full, in depth discussion of fstab is outside the scope of this guide. The following are the steps required to mount an ext4 partition.

1. Connect the drive to your Pi
2. Find the PARTUUID and FSTYPE of the desired partition:

```
lsblk -o NAME,SIZE,TYPE,FSTYPE,MOUNTPOINT,PARTUUID
```

Output will be similar to this:

NAME	SIZE	TYPE	FSTYPE	MOUNTPOINT	PARTUUID
sda	960.5M	disk			
└─sda1	959.5M	part			83bd0d82-01
mmcblk0	14.9G	disk			
└─mmcblk0p1	256M	part	vfat	/boot	738a4d67-01
└─mmcblk0p2	14.6G	part	ext4	/	738a4d67-02

If you're unsure which item is the correct one, disconnect the drive, repeat the above command and compare the output.

3. Create a mount point²⁵ for the partition. For example:

```
sudo mkdir -p /srv/external
```

4. Backup your existing fstab:

```
sudo cp /etc/fstab /etc/fstab.bak
```

5. Open /etc/fstab in your preferred text editor. You will need to be root or use sudo.
6. On a new line at the end of the file add:

```
PARTUUID=83bd0d82-01 /srv/external ext4 defaults,rw,nofail 0 0
```

Replace “83bd0d82-01”, “/srv/external”, and “ext4” as required.

7. Save and close

²⁵ A mount point is simply a directory somewhere in your file system. Preferably empty but it does not have to be. If it is not empty, its contents will be masked once something has been mounted n it.

8. Test the fstab entry:

```
sudo mount -a  
mountpoint /srv/external
```

The mount command should return nothing and the mountpoint command should indicate that /srv/external is a mount point. If not fix the error and retry.

Note: A malformed fstab will prevent your system from booting. Without the `nofail` option a failed mount will do the same. Power off your Pi, swap to your second SD card, boot from that and fix the broken fstab by mounting the first SD card in a USB card reader.

9.2.3 Other Methods

Other methods of mounting a partition include a systemd mount unit, a manual mount command, a mount command in `/etc/rc.local`, a mount command called from cron, etc. None of these are recommended.

Systemd mount units are automatically created from fstab during boot.

A manual mount command will result in an empty directory being shared/exported until a user logs in and performs the mount. This may also result in files being saved by clients onto the SD card instead of the external storage device.

A mount command in `rc.local` is non standard and should it fail will prevent execution of anything after it in `rc.local`.

A mount command called from cron is non standard.

While the non standard forms will allow the system to boot should a mount fail, using them will cause problems with future maintenance simply because they're not where they're expected to be.

10 Further Improving Security

10.1 Restricting Access To A Resource²⁶ To A Subset Of Users

NFS exports do not have explicit configuration options to deny or allow certain users as it has full support for Linux owner, group, and permissions.

10.1.1 Samba Guest Access

By default guest access is disabled. To enable it add the following to the [global] section of your smb.conf:

```
map to guest = Bad User
```

To disable either remove the above or change it to

```
map to guest = Never
```

Each share definition then needs to be configured to permit guest access. The default is to deny it. Add the following to the share definition to enable guest access:

```
guest ok = yes
```

Remove it or change it to the following to deny guest access:

```
guest ok = no
```

Refer to sections 5 and 6 for smb.conf examples.

In the event that a share should only be accessible by guest logins, include the following in the share definition:

```
guest ok = yes  
guest only = yes
```

Users who login with a valid username and password will be denied access to the share.

²⁶ A Samba share or NFS export.

10.1.2 Samba Invalid and Valid Users

The share specific parameters `invalid users` and `valid users` control which Samba users have access to the share.²⁷

Each is a space separated list of Samba user names which default to empty lists. If a user name appears in both lists, access to the share will be denied. An example (incomplete) `smb.conf`:

```
[Share1]
path = /srv/share1

[Share2]
path = /srv/share2
invalid users = nobby colon

[Share3]
path = /srv/share3
valid users = sam sybil

[Share4]
path = /srv/share4
invalid users = sybil
valid users = sam sybil
```

Share1 can be accessed by any non guest user.

Share2 can be accessed by any non guest user except for nobby and colon.

Share3 can be accessed only by sam and sybil.

Share4 can only be accessed by sam.

In the general case, if `valid users` is given but `invalid users` is not, only users in the list will have access; if `invalid users` is given but `valid users` is not, all users except those listed will have access; if both are given and a user appears in both lists that user will be denied access; if neither are given, all users will have access.

10.1.3 DLNA

DLNA has no concept of users so restriction by user name is not possible.

²⁷ If you want to deny access to a user to your entire server, delete or disable their account.

10.2 Restricting Access To A Resource²⁸ To A Subset Of Machines

10.2.1 Samba

Samba provides two parameters `hosts allow` and `hosts deny` to control access by machines. By default both lists are empty allowing access from all hosts.

Each is a comma, space, or tab separated list of hosts.

Hosts may be specified by hostname, IP address, an IP address prefix, or a subnet and netmask. IF a host appears in both lists, access will be granted.

The `EXCEPT` keyword may be used to exclude a host from a range. The `ALL`²⁹ keyword can be used with `hosts deny` to deny access from all hosts except those listed in `hosts allow`.

The loopback address (127.0.0.1) will always be allowed access unless explicitly denied.

An example (incomplete) `smb.conf`:

```
[Share1]
path = /srv/share1

[Share2]
path = /srv/share2
hosts deny = ankh, morpork

[Share3]
path = /srv/share3
hosts allow = 10.0.0. EXCEPT 10.0.0.1

[Share4]
path = /srv/share4
hosts deny = ALL
hosts allow = ankh, morpork
```

Share1 can be accessed from all hosts

Share2 can be accessed from any host except ankh and morpork.

Share3 can be accessed from all hosts with an IP address starting 10.0.0. but not from 10.0.0.1

Share4 can only be accessed from ankh and morpork.

²⁸ A Samba share or NFS export.

²⁹ 0.0.0.0/0 may also be used.

10.2.2NFS

The host portion of an NFS export controls which machines can access it and can be specified in one of the following ways:

- hostname e.g. ankh or morpork.disc
- Wildcards:
 - * matches zero or more characters
 - ? matches exactly one characters
 - [square brackets] indicate lists of characters to match against e.g. [abc]
- IP address e.g. 10.0.0.1
- IP networks e.g. 10.0.0.0/255.255.255.0 or 192.168.0.0/24

An example exports file:

/srv/1	ankh(rw)
/srv/2	*(rw)
/srv/3	*.disc(rw)
/srv/4	clacks[123](rw)
/srv/5	10.0.0.1(rw)
/srv/6	192.168.0.0/24(rw)

/srv/1 can only be accessed from ankh.

/srv/2 can be accessed from any machine.

/srv/3 can only be accessed from any machine with a hostname in the .disc domain including any subdomains it may have.

/srv/4 can only be accessed from clacks1, clacks2, and clacks3.

/srv/5 can only be accessed from a machine with an IP address of 10.0.0.1.

/srv/6 can be accessed from any machine with an IP address in the 192.168.0.0/24 subnet.

10.2.3DLNA

DLNA does not support restricting access to specific hosts.

11 User Management

11.1 Samba

Samba requires both a Samba specific user and a corresponding Linux user. The Linux user is created and managed via the normal Linux tools (adduser and usermod), the Samba user is created and managed by smbpasswd.

Normal (i.e. non root) user are only able to change their password. All other options require root or sudo.

If the [global] parameter `unix password sync = yes` is in force the matching Linux user's password will be updated to match the new Samba password. No other changes are propagated.

To add a user:

```
sudo smbpasswd -a username
```

for example

```
sudo passwd -a sam
```

To delete a user:

```
sudo smbpasswd -x username
```

for example

```
sudo smbpasswd -x nobby
```

To disable but not delete a user:

```
sudo smbpasswd -d username
```

for example

```
sudo smbpasswd -d sam
```

To change a user's password:

```
sudo smbpasswd username
```

for example

```
sudo smbpasswd colon
```

To change your own password:

```
smbpasswd
```

11.2 NFS And sftp/sshfs

NFS user management is done with the normal Linux user management tools with one caveat: the numeric user and group IDs for a user/group must be the same across all clients and the server or if the user/group does not exist on a machine that the numeric ID must be unused.

Linux users for Samba, sftp, and sshfs are managed with the same tools without the requirement on numeric IDs.

See also 7.1

Adding or changing a user requires root or sudo. See 6.2.1 and the man pages for `adduser` and `usermod`.

Users can change their own passwords with `passwd`. This will not update the password for the corresponding Samba user should one exist.

Root (or users with appropriate sudo rights) can update the password of any user via

```
passwd username
```

for example:

```
passwd sybil
```

or

```
sudo passwd sybil
```

11.3 DLNA

DLNA has no concept of users so user management is neither needed nor possible.

12 Advanced Usage

12.1 Access From The Internet

Use a VPN. Directly exposing Samba, NFS and/or DLNA is not safe. Detailed instructions on setting up a VPN are outside the scope of this guide however [pivpn](https://pivpn.io/)³⁰, [openvpn](https://en.wikipedia.org/wiki/OpenVPN)³¹, and [wireguard](https://en.wikipedia.org/wiki/WireGuard)³² may be of interest.

sftp and sshfs may be used over the internet but you should be aware of and take steps to mitigate the security issues, particularly those relating to the well know default user name and password on Raspberry Pi OS.

Port forward port 22³³ on your router to port 22 on your NAS.

12.2 Download Only Access From Web Browsers

This is quick and easy but insecure. Data transfers are not encrypted, no login is required, and all file access on the server is done as the user starting the process. As such starting it as root is not recommended as, while files cannot be changed, files that should not be accessible to normal users may be accessed.

The following command will start python's http.server module which will allow access to the current directory and its sub directories:

```
python3 -m http.server
```

To use a specific directory:

```
cd /path/to/directory ; python3 -m http.server
```

e.g.

```
cd /srv/shared ; python3 -m http.server
```

This can be started at boot using any of the normal methods.

Clients can connect via the URL <http://server:8000/> e.g. <http://l-space:8000/>

³⁰ <https://pivpn.io/>

³¹ <https://en.wikipedia.org/wiki/OpenVPN>

³² <https://en.wikipedia.org/wiki/WireGuard>

³³ Some routers allow different ports on the internal and external sides. Using a non standard port on the outside of your router is not a substitute for proper security measures.

12.3 A Resource With Read Only Access To All And Write Access to Some Users

NFS handles this natively using the underlying file system properties. For Samba define a share as read only then add the write list parameter with the names of the Samba user who should be able to write tot he share. For example:

```
[shared]
    path = /srv/shared
    read only = yes
    write list = sam, sybil
```

Users sam and sybil will be able to write to the share. All other users will not. This includes guest logins should those be enabled.

12.4 Samba – Enable Printing

This does not configure the printing subsystem of the OS on your NAS³⁴. It simply enables the relevant Samba shares and features.

1. Add the following share definitions to your smb.conf:

```
[printers]
    comment = All Printers
    browseable = no
    path = /var/spool/samba
    printable = yes
    guest ok = no
    read only = yes
    create mask = 0700

[print$]
    comment = Printer Drivers
    path = /var/lib/samba/printers
    browseable = yes
    read only = yes
    guest ok = no
```

2. Restart Samba:

```
sudo systemctl restart smbd nmbd
```

³⁴ That's outside the scope of this guide.

12.5 Samba – Fully Disable Printing

To fully disable printing support in Samba:

1. Removes the share definitions listed in 12.4
2. Add the following to the [global] section of your smb.conf:

```
load printers = no
printing = bsd
printcap name = /dev/null
disable spoolss = yes
```

3. Restart Samba:

```
sudo systemctl restart smbd nmbd
```

12.6 Samba – Additional smb.conf Parameters

For a comprehensive list see <https://www.samba.org/samba/docs/current/man-html/smb.conf.5.html>

12.6.1[global] Parameters

log file =	Log file location.
server role =	Sets server role. One of auto, standalone, member server, classic primary domain controller, classic backup domain controller, or active directory domain controller. Default: auto.
map to guest =	When to map a failed login to a guest login. One of never, bad user, bad password, or bad uid. Default: never
guest account =	Linux user to use for all guest access. Default: nobody
server string =	Text shown to clients when browsing the network. %v is replaced by the samba version number, %h is replaced by the server's hostname. Default: Samba %v
workgroup =	Workgroup the server will belong to. Default: WORKGROUP

12.6.2[share] Parameters

<code>path =</code>	Server side path to shared directory. Must be an absolute path. No default and must be specified.
<code>comment =</code>	Text sent to client when browsing the network. No default.
<code>read only =</code>	Whether writes to the share are denied ³⁵ . yes or no Default: yes
<code>guest ok =</code>	Whether guest access to the share is permitted. yes or no. Default: no
<code>guest only =</code>	Whether a share is restricted to guest logins only. yes or no. No effect if guest access is not permitted. Default: no
<code>force create mode =</code>	Force permissions for files created by clients. Standard Linux octal bit mask. Default: 0000
<code>force directory mode =</code>	Force permissions for directories created by clients. Standard Linux octal bit mask. Default: 0000
<code>create mode =</code>	Permissions for files created by clients. Standard Linux octal bit mask. Permissions not set here will not be present on the file unless set in <code>force create mode</code> . Default: 0744
<code>directory mode =</code>	Permissions for directories created by clients. Standard Linux octal bit mask. Permissions not set here will not be present on the directory unless set in <code>force directory mode</code> . Default: 0755
<code>hosts deny =</code>	See 10.2.1
<code>hosts allow =</code>	
<code>invalid users =</code>	See 10.1.2
<code>valid users =</code>	
<code>write list =</code>	See 12.3
<code>hide files =</code>	List of files and/or directories that are not visible but are still accessible. Clients see the DOS “hidden” attribute is set. “/” is used as a separator so cannot be used as part of a file or directory name. “*” and “?” wildcards are permitted. Names are case sensitive. No default. May impact performance. Example: <code>hide files = /.*/foo/ba?/</code>

³⁵ Subject to underlying file system permissions.

12.7 Samba – Unix Extensions

When both client and server are using SMB/CIFS protocol v1, Samba can implement the CIFS UNIX extensions. However, v1 is old, insecure, and deprecated and should not be used.

They are also only useful with Linux and UNIX clients.

If you must use them:

1. Add the following to the [global] section of your smb.conf:

```
unix extensions = yes
server min protocol = NT11
```

2. Restart samba.
3. Remount the share on the client using the vers=1.0 mount option.

12.8 NFS – Different Export Options For Different Clients

Each exported directory in /etc/exports can have multiple sets of options for different hosts. Each host(options) group must be separated from the next by a space and be on the same line.

For example:

```
/srv/shared *(ro) ankh(rw)
```

All clients have read only access except ankh which has read/write access.

12.9 NFS – Export Options

For a comprehensive list see `man exports`.

<code>ro</code>	Default. Only allow reading.
<code>rw</code>	Allow both reading and writing
<code>sync</code>	Default. Only reply to clients after changes have been written to disc.
<code>async</code>	Reply to client write requests only after changes have been written to disc. May impact performance but prevents data loss or corruption if the server crashes.
<code>no_subtree_check</code>	Default. Improves performance and reliability but has a minor security implication. See <code>man exports</code> .
<code>subtree_check</code>	Opposite of <code>no_subtree_check</code> . “tends to cause more problems than it is worth.” ³⁶
<code>mountpoint=path</code> <code>mp=path</code>	Only export the directory if <code>path</code> is a mount point. If <code>path</code> is not given, the path of the export must be a mount point.
<code>root_squash</code>	Map all access as root (UID 0, GID 0) to the anonymous user instead (usually nobody and nogroup).
<code>no_root_squash</code>	Turn off <code>root_squash</code> . Normally only really needed for network booted clients.
<code>all_squash</code>	Map all UIDs/GIDs to the anonymous ones.
<code>anonuid</code>	UID to use when squashing
<code>anongid</code>	GID to use when squashing

³⁶ Source: `man exports`

13 Troubleshooting

13.1 Basics

- Check the server is switched on.
- Check all network hardware (routers, switches, Wi-Fi access points, etc.) are switched on and working.
- Check the server is connected to the network.
- Check the server has an IP address for the Ethernet or Wi-Fi interface in use.
- Check the server software (smbd, nmbd, etc.) is running.
- Check the client is connected to the same network as the server.
- Check the client has an IP address for the Ethernet or Wi-Fi interface in use.
- Check the client can ping the server using the server's IP address.
- Check the client can ping the server using the server's hostname.

If any of the above fail, troubleshoot your network issues and come back to NAS issues once your network is functioning. General network troubleshooting is outside the scope of this guide.

13.2 Samba Shares Not Showing In Windows Explorer

Browsing Samba shares and/or servers in windows explorer requires either that both Windows and the server have v1 of the protocol enabled or that the Samba server have wsdd³⁷ installed. Recent version of Windows and Samba do not have v1 enabled by default.

Shares can still be accessed by \\servername\share e.g. \\morpork\shades.

13.2.1 Enabling SMB v1

Enabling SMBv1 is not recommended as there are serious security issues with it.

To enable SMBv1 on the server:

1. Add the following to the [global] section of your smb.conf:

```
server min protocol = NT1
```

2. Restart Samba:

```
sudo systemctl restart smbd nmbd
```

To enable SMBv1 on Windows clients:

1. Open Control Panel
2. Open Programs and Features
3. Click Turn Windows features on or off
4. Find and tick SMB 1.0/CIFS File Sharing Support
5. Click OK

37 Web Service Discovery Daemon

13.2.2 Installing wsdd

wsdd can be found at <https://github.com/christgau/wsdd>. Installation on Raspberry Pi OS is as follows:

Ensure you have python 3.7 or later installed. Raspberry Pi OS Buster and later this will be the case.

1. Install git

```
sudo apt update  
sudo apt install -y git
```

2. Clone the wsdd repository:

```
git clone https://github.com/christgau/wsdd
```

3. Copy the script:

```
sudo cp wsdd/src/wsdd.py /usr/bin/wsdd
```

4. Ensure it is executable:

```
sudo chmod a+x /usr/bin/wsdd
```

5. Copy the systemd service:

```
sudo cp wsdd/etc/systemd/wsdd.service /etc/systemd/system
```

6. Open /etc/systemd/system/wsdd.service in your preferred text editor. You will need to be root or use sudo.

7. Replace Group=nobody with Group=nogroup

8. Save and close

9. Enable the service:

```
sudo systemctl enable wsdd
```

10. Start the service:

```
sudo systemctl start wsdd
```

If desired, the directory created in step 2 can now be removed and git uninstalled.

13.3 Problems Writing to a Resource

In order to write to a Samba share, NFS export, or SFTP server all of the following must be true:

- The client must have mounted the resource read/write.
- The local user on the client must have write permission on the mounted resource.
- The Samba share, NFS export or SFTP server must allow writing by the user who has logged in.
- The Linux user on the server must have write permission to both the file and the directory containing it.
- The driver for the file system in use on the server must allow writing. Drivers for some non-Linux file systems do not.
- The disc partition must be mounted read/write on the server.

Clients cannot override server permissions.³⁸

13.4 Samba Reports The Wrong Amount Of Free Space To Clients

This is most likely when your server shares a directory whose subdirectories are mount points. Share the mount points rather than the directory containing them.

13.5 Unable To Upload Large Files

Assuming there is sufficient free space and no disc space quotas have been set up, check the file system in use on the server can handle files of the required size. FAT32 has a maximum file size of 4GB. NTFS, ext4, and exFAT for practical purposes have no upper limit³⁹.

13.6 Some Clients Can Connect Others Cannot

Perform basic network troubleshooting (see 13.1) then check the following:

- For Samba, check the `hosts allow =`, `hosts deny =`, `invalid users=`, and `valid users =` share settings
- For NFS, check the client name/IP section of the export settings.

³⁸ NFS clients of servers exporting Linux native file systems may be able to change permissions and ownership subject to the usual rules.

³⁹ They do, in fact, have an upper limit but it's several orders of magnitude bigger than the biggest available HDDs.
