LINUX STORAGE · WITH THE WINDOWS EQUIVALENT BESIDE IT

Pooling disks and protecting files

Partitioning, LVM, software RAID, and POSIX permissions with ACLs — each term defined before it is used.

Three parts · every Linux idea mapped to what Windows calls it

THREE AREAS, AND WHAT WINDOWS CALLS EACH

The map

What you will learn	Linux tools	Windows equivalent
Making a disk usable, and pooling several	Partitioning, LVM	Basic and Dynamic disks, Storage Pools
Combining drives for size or safety	vgextend, mdadm software RAID	Storage Spaces: simple, mirror, parity
Controlling who may read and write	POSIX permissions, ACLs	NTFS permissions and Access Control Lists

Same problems, different vocabulary. Once the words are matched, the ideas are ones you already have.

How to read this deck	Blue boxes are definitions. Grey boxes are the Windows name. Code boxes are what you type. Read the definition first, every time.

FOUR WORDS USED ON EVERY SLIDE AFTER THIS ONE

Disk, partition, filesystem, mount

Disk	A physical storage device. Linux names them /dev/sda, /dev/sdb and so on. Raw space; cannot hold files on its own.
Partition	A marked-out region of a disk, recorded in a partition table. /dev/sdb1 is the first partition on /dev/sdb.
Filesystem	The structure written onto a partition or volume that organises files and folders. ext4 is the Linux default.
Mount point	The folder where a filesystem appears. /mnt/my_data is a folder; mounting attaches storage behind it.
Windows equivalent	Disk = Disk 0, Disk 1 in Disk Management. Partition = a volume. Filesystem = NTFS. Mount point = a drive letter such as D:

Windows hides the chain behind a drive letter. Linux shows every step — which is why it can be reshaped.

PART A

Partitioning and LVM

How Linux turns physical drives into a pool, and cuts resizable volumes from it. Windows: Basic and Dynamic disks, Storage Pools.

You cut your disk into fixed pieces

Example: a 500 GB disk



If C: fills up, you are stuck. You cannot take space from D: without deleting it and recreating both.

TWO KINDS OF PARTITION TABLE

MBR	Old. Maximum 2 TB per disk. Maximum 4 primary partitions.
GPT	Modern. No practical size limit. Required by Windows Server 2019 and 2022.

In Windows Server this is called a Basic Disk. On Linux: fdisk or parted, and the same fixed-size limitation.

Logical Volume Manager

DEFINITION

LVM

A layer between physical disks and filesystems. It gathers one or more disks into a pool, then lets you carve volumes from the pool and resize them while they are in use — without repartitioning or reformatting.

WINDOWS EQUIVALENT

Dynamic disks and Storage Pools. Both let a volume span disks and grow later; LVM is the Linux version of that idea.

The problem it solves

A plain partition is a fixed size. To make it bigger you must add a disk, copy everything across, and repartition. LVM removes all of that.

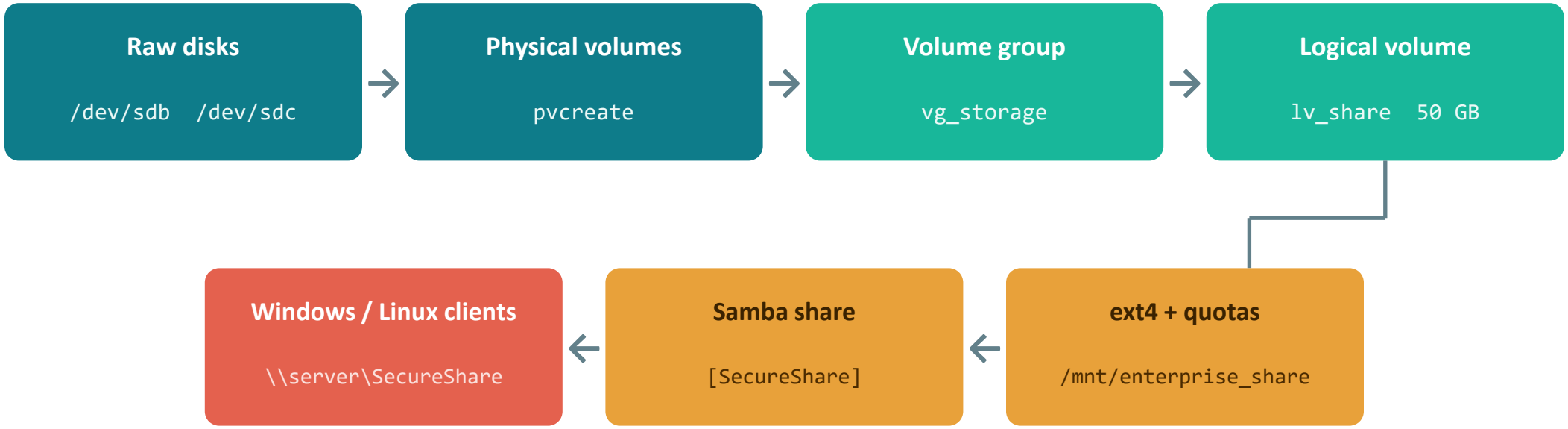
The cost

One extra layer to understand and to diagnose. Worth it on any server; unnecessary on a laptop.

THE WHOLE BUILD ON ONE SLIDE

The data flow

Read it left to right along the top, then down and back along the bottom.



Four layers of storage, then one layer of sharing. Every step below maps to one box on this slide.

PV, VG and LV

LOGICAL VOLUME (LV)

`my_data, 50 GB`

The virtual partition. This is what you format and mount.

VOLUME GROUP (VG)

`my_pool`

The pool. Its size is the sum of the physical volumes inside it.

PHYSICAL VOLUME (PV)

`/dev/sdb`

A disk or partition that has been initialised for LVM to use.

Read it bottom up	Physical volumes go into a volume group. Logical volumes come out of it. You build in that order and dismantle in reverse.
Windows equivalent	PV = a disk added to a pool. VG = the Storage Pool. LV = a virtual disk created from the pool.

HOW LINUX NAMES YOUR DISKS

Every device is a file in /dev

Linux represents hardware as special files inside the /dev directory. /dev/sdb and /dev/sdc are the names of storage devices — disks.

READING THE NAME

`/dev/sda`	the first disk — usually your operating system
`/dev/sdb`	the second disk
`/dev/sdb1`	the first partition on the second disk

SEE IT ON YOUR UBUNTU VM

```
lsblk
```

Lists every disk and partition as a tree, with sizes and mount points. Run it before any disk command, every time.

SIMPLE PRACTICAL EXAMPLE

Your VM has a second disk, /dev/sdb, and you want an LVM volume for student data. First make sure LVM is installed:

```
sudo apt update && sudo apt install lvm2      # installs the pv/vg/lv commands
```

Prepare the physical disk

DEFINITION

Initialise (pvcreate)

Write a small LVM label and metadata area onto the disk so that LVM recognises it as a physical volume. Nothing is pooled yet; the disk is only marked as available.

WINDOWS EQUIVALENT

Right-click a disk in Disk Management → Convert to Dynamic Disk, or adding a disk to a pool in Storage Spaces.

```
sudo pvcreate /dev/sdb
sudo pvs                    # physical volumes: size, and which group each belongs to
```

Whole disk or partition

You may give pvcreate a whole disk (/dev/sdb) or a partition (/dev/sdb1). Whole disk is simpler; partition is what you use if the disk also holds something else.

Destructive

Any existing data on that device is lost. Confirm with lsblk that it is the disk you mean, and that it is not the one your operating system lives on.

Create the pool

DEFINITION

Volume group (vgcreate)

A named collection of physical volumes treated as one continuous pool of space. All logical volumes are cut from a volume group, never directly from a disk.

WINDOWS EQUIVALENT

A Storage Pool. In Disk Management terms: the set of dynamic disks a spanned or striped volume may use.

```
sudo vgcreate my_pool /dev/sdb
sudo vgs                      # name, number of PVs, total size, free space
```

Naming

my_pool is the name you chose. Use something meaningful in production: vg_data, vg_backup. It appears in every path from here on.

Extents

Inside the group, space is tracked in fixed blocks called physical extents, 4 MB by default. Volume sizes are always a multiple of this.

Carve out usable space

DEFINITION

Logical volume (lvcreate)

A block device carved from the volume group, of a size you choose. It behaves exactly like a partition — it can be formatted and mounted — but it can also be resized later without repartitioning.

WINDOWS EQUIVALENT

A virtual disk created from a Storage Pool, or a simple volume on a dynamic disk.

```
sudo lvcreate -n my_data -L 50G my_pool
sudo lvs                        # every logical volume, its group, and its size
```

`-n my_data`	The name of the new volume. Its device path becomes /dev/my_pool/my_data.
`-L 50G`	The size. It must fit inside the free space shown by vgs. Use -l 100%FREE to take everything that is left.

NOTE:But the LV doesn't yet contain a filesystem. You should create an ext4 filesystem.

Add a drive, grow the volume

```
sudo pvcreate /dev/sdc                          # 1. initialise the new drive
sudo vgextend my_pool /dev/sdc                  # 2. add it to the pool - the pool is now bigger
sudo lvextend -r -L +40G /dev/my_pool/my_data   # 3. grow the volume AND its filesystem
df -h /mnt/my_data                              # still mounted, now larger
```

vgextend	Adds a physical volume to an existing volume group. Free space in the group increases immediately.
lvextend -r	Grows the logical volume; -r also resizes the filesystem inside it. Without -r the volume grows but df shows no change.
-L +40G	The plus sign means grow BY 40 GB. Without the plus it means grow TO 40 GB. The difference has cost people data.
Windows equivalent	Add a drive to the pool, then Extend Volume in Disk Management. Same two steps.

The volume stayed mounted throughout. Users kept working. That is why LVM exists.

In-Class Practical: Create PV, VG & LV

Scenario: Your Ubuntu VM has a **10 GB additional virtual disk**. Your task is to use LVM to create a **4 GB logical volume** for student files.

LINUX STORAGE ADMINISTRATION

Building a Team File Server with Quotas and Samba

An end to end guide: from a blank disk to a shared network folder with storage limits for every user and team

Share: `\\server\enterprise_share`

What we will build

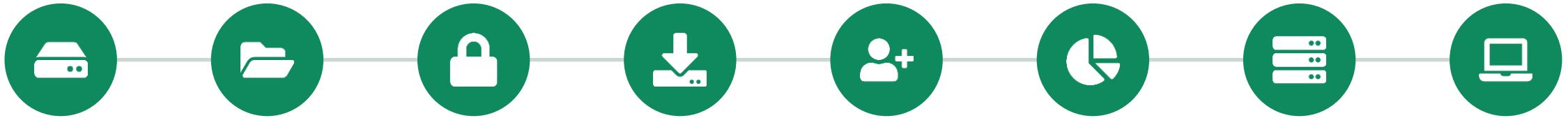
Samba share
`enterprise_share`

Team group
`smbgroup, limit 5 GB`

User alice
`limit 500 MB`

User bob
`limit 500 MB`

The Big Picture



Format
Step 1

Mount
Step 2

Team folder
Step 3

Install
Step 4

Users
Step 6

Quotas
Steps 5, 7 to 9

Samba
Steps 10 and 11

Clients
Steps 12 and 13

Our goal

A shared network folder for the team, stored on its own disk. Only team members can open it, everything they save belongs to the team, and both each person and the whole team have clear storage limits.

Staff connect from Windows, macOS, or Linux computers using Samba.

Key Terms: Storage

File System

Definition: The structure an operating system uses to organize, store, and find files on a disk.

In our setup: The new disk needs one before it can hold files.

ext4

Definition: The Fourth Extended File System, the default on most Linux systems. It recovers quickly after crashes and supports quotas.

In our setup: We format /dev/sdb1 as ext4.

Mount Point

Definition: An existing directory where a file system is attached to the Linux directory tree.

In our setup: The disk appears at /mnt/enterprise_share.

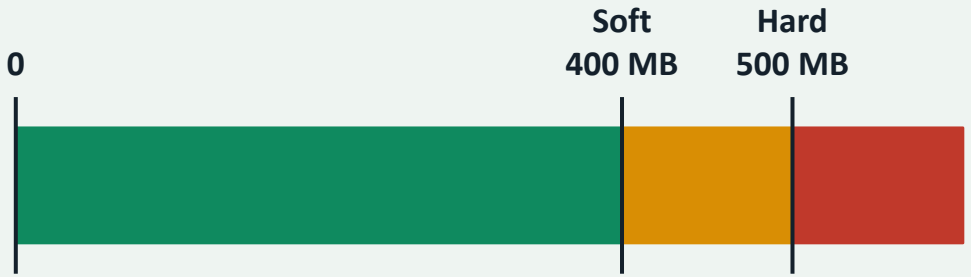
SGID Bit

Definition: Set Group ID, a special permission that makes new files in a directory inherit that directory's group.

In our setup: Every file saved in the share belongs to smbgroup.

Key Terms: Quotas

How limits work for one user



Normal use
Save freely.

Warning zone
Allowed only during the grace period.

Blocked
Nothing more can be saved.

Quota

Definition: A limit on how much disk space, or how many files, a user or group may use.

Soft limit

Definition: A warning level. A user may go above it, but only for a limited time.

Hard limit

Definition: The absolute maximum. The system refuses to save anything beyond it.

Grace period

Definition: How long someone may stay above the soft limit before it acts like a hard limit.

Key Terms: Network Sharing



SMB

Definition: Server Message Block, the network language Windows uses to share files and printers.

In our setup: Client computers talk to our server using SMB.



Samba

Definition: Free software that lets a Linux server share folders over SMB with Windows, macOS, and Linux computers.

In our setup: Samba publishes /mnt/enterprise_share on the network.



Share

Definition: A folder that is published on the network under a name that clients can connect to.

In our setup: Our share is named enterprise_share.



Client

Definition: A computer that connects to the server to use the share.

In our setup: Staff laptops running Windows, macOS, or Linux.

Find the Disk and Format It as ext4

What and why

A new disk cannot store files until it has a file system.

First we list the disks to find the right one. Here the new disk is sdb and its first partition is sdb1.

Then we format that partition as ext4.

Watch out: Formatting erases everything on the partition. Double check the name first.

Run these commands

```
# List disks and partitions
lsblk
# Format the partition as ext4
sudo mkfs.ext4 /dev/sdb
# Confirm the file system type
lsblk -f /dev/sdb
```

What each part means

`lsblk` Lists disks and their partitions.

`mkfs.ext4` Makes an ext4 file system.

`-f` Shows the file system type of each partition.

STEP 2 OF 13

Mount the Disk with Quota Support

What and why: We attach the disk to a folder so it can be used. Listing it in /etc/fstab mounts it at every startup, and adding usrquota and grpquota switches on quota support at the same time.

1. Create the mount point and open fstab

```
sudo mkdir -p /mnt/enterprise_share
sudo nano /etc/fstab
```

Tip: If you prefer, use the UUID shown by lsblk -f in place of /dev/sdb1.

2. Add this line at the end of /etc/fstab

/dev/sdb	/mnt/enterprise_share	ext4	defaults,usrquota,grpquota	0	2
Device	Mount point	Type	Options with quotas on	Dump	Check order

3. Mount everything listed in fstab

```
sudo systemctl daemon-reload
sudo mount -a
```

4. Check it is mounted with quotas

```
df -h /mnt/enterprise_share
mount | grep enterprise_share
```

STEP 3 OF 13

Create the Team Group and Shared Folder

What and why

We create a group for the team and hand the mounted folder to it.

Permission 2770 gives the owner and the group full access, blocks everyone else, and turns on the SGID bit so every new file belongs to smbgroup.

mkdir -p gives no error because the folder already exists from step 2.

Watch out: Do this after mounting. Mounting hides settings made on the empty folder.

Run these commands

```
sudo mkdir -p /mnt/enterprise_share
sudo groupadd smbgroup
sudo chown :smbgroup /mnt/enterprise_share
sudo chmod 2770 /mnt/enterprise_share
# Check the result
ls -ld /mnt/enterprise_share
```

What each part means

`groupadd` Creates the group smbgroup.

`chown :group` Changes only the folder's group.

`2` Turns on the SGID bit.

`7 7 0` Owner full, group full, others none.

`ls -ld` Shows the folder's own permissions.

STEP 4 OF 13

Install the Quota Tools and Samba

What and why

Two software packages are needed.

The quota tools switch quotas on, set limits, and produce reports.

Samba shares the folder on the network, and smbclient lets us test the share from the command line.

Run these commands

```
# Ubuntu or Debian
sudo apt update
sudo apt install quota samba smbclient
# Confirm both installed
quota --version
smbd --version
```

What each part means

`apt` The package manager that installs software.

`quota` The quota tools package.

`samba` The file sharing server.

`smbclient` A tool to test SMB shares.

STEP 5 OF 13

Switch on and Verify Quotas are On

What and why

Linux records usage and limits in two small database files inside the folder: aquota.user and aquota.group.

quotacheck scans the disk, counts current usage, and creates those files.

quotaon then starts enforcing the limits.

Watch out: Never delete aquota.user or aquota.group.

Run these commands

```
sudo quotacheck -ugm /mnt/enterprise_share
sudo quotaon -v /mnt/enterprise_share(turns disk quota)
sudo quotaon -p /mnt/enterprise_share
# Confirm the files exist
 sudo ls /mnt/enterprise_share
```

What each option means

.

`-p` Print which quotas were turned on.

`quotacheck -ugm`

STEP 6 OF 13

Create Users and Give Them Samba Access

What and why

Samba only lets in people who are Linux users and who also have a Samba password.

Samba keeps its own password list, separate from the Linux login password.

We create alice and bob, add them to smbgroup, and give each a Samba password.

Watch out: Always include -a with usermod, or the user loses other groups.

Run these commands

```
sudo useradd -m alice
sudo passwd alice
sudo usermod -aG smbgroup alice
sudo smbpasswd -a alice
# Repeat the four lines for bob
groups alice
sudo pdbedit -L
```

What each part means

`useradd -m` Create a user and a home folder.

`usermod -aG` Add (a) the user to a group (G).

`smbpasswd -a` Add the user to Samba with a password.

`pdbedit -L` List all Samba users.

STEP 7 OF 13

Set a Quota for Each User

What and why: A user quota limits the space taken by all files one person owns, including files saved through Samba. We give alice a 400 MB soft and 500 MB hard limit. Sizes are in kilobytes, so 400 MB is 400 × 1024 = 409600.

sudo	setquota	-u alice	409600	512000	0	0	/mnt/enterprise_share
	The command	For user alice	Soft space limit 400 MB	Hard space limit 500 MB	Soft file limit none	Hard file limit none	Which file system

Full commands for both users

```
sudo setquota -u alice 409600 512000 0 0 /mnt/enterprise_share
```

Zero means no limit. We only limit space here, not the number of files.

Handy alternatives

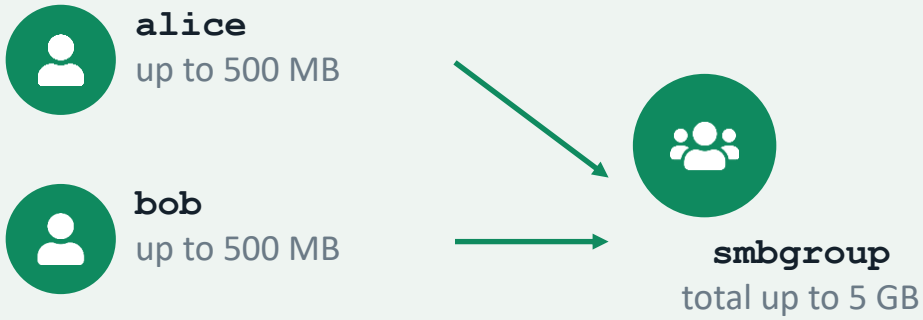
`sudo edquota -u alice`
Edit limits in a text editor.

`sudo edquota -p alice bob`
Copy alice’s limits to bob.

Set a Quota for the Group

What and why: A group quota limits the combined space of every file owned by the group. We give smbgroup a 4 GB soft and 5 GB hard limit (4 × 1048576 and 5 × 1048576 kilobytes).

`setquota`	`-g smbgroup`	`4194304`	`5242880`	`0`	`0`	`/mnt/enterprise_share`
The command	For group smbgroup	Soft space limit 4 GB	Hard space limit 5 GB	Soft files none	Hard files none	Which file system



How the limits work together

Thanks to the SGID bit, every file saved in the share belongs to smbgroup, so all team work counts toward the 5 GB.

Each file counts toward its owner's quota and the group quota. Whichever limit is reached first stops the save.

STEP 9 OF 13

Set the Grace Period

What and why

The grace period decides how long someone may stay above their soft limit. We set 7 days for users and for groups.

Time is written in seconds: 7 × 24 × 60 × 60 = 604800.

`-t` Set grace times. First number is for space, second is for files.

What a user experiences

Day 0
alice passes 400 MB. She is warned but can keep saving.

Days 1 to 7
She can still save, but never past the 500 MB hard limit.

After day 7
No new saves until she deletes files and drops below 400 MB.

Run these commands

```
sudo setquota -u -t 604800 604800 /mnt/enterprise_share      # users
sudo setquota -g -t 604800 604800 /mnt/enterprise_share      # groups
```

STEP 10 OF 13

Publish the Folder with Samba

What and why: Samba reads its settings from /etc/samba/smb.conf. We add a section that names the share, points to our folder, and allows only smbgroup members in.

Add this to the end of the file

```
sudo nano /etc/samba/smb.conf

[enterprise_share]
   path = /mnt/enterprise_share
   valid users = @smbgroup
   read only = no
   browseable = yes
   force group = smbgroup
   create mask = 0660
   directory mask = 2770

# Check the file for mistakes
testparm
```

What each line means

`[enterprise_share]`	The share name clients will see.
`path`	The folder on the server being shared.
`valid users`	Who may connect. The @ means a group.
`read only = no`	Users can create and change files.
`browseable`	The share shows up when browsing.
`force group`	Saved files get group smbgroup.
`create mask`	New files: owner and group read and write.
`directory mask`	New folders keep SGID and stay private.
`testparm`	Checks smb.conf and reports errors.

Start Samba and Open the Firewall

What and why

Samba must be restarted to load the new share, and enabled so it starts after every reboot.

A firewall is a filter that blocks network traffic that is not allowed. We allow Samba through it on ports 139 and 445.

Watch out: On Red Hat systems, SELinux must also allow Samba to use the folder. See the notes.

Run these commands

```
# Ubuntu or Debian
sudo systemctl restart smbd
sudo systemctl enable smbd
sudo ufw allow samba
# Red Hat, Rocky, Fedora
sudo systemctl enable --now smb
sudo firewall-cmd --permanent --add-service=samba
sudo firewall-cmd --reload
# Check it is running
systemctl status smbd
```

What each part means

`restart` Stop and start Samba to load changes.

`enable` Start Samba automatically at boot.

`ufw / firewall-cmd` Firewall tools for each Linux family.

STEP 12 OF 13

Connect from Client Computers

What and why: Clients need the server's address. Find it with the command on the right. Our examples use 192.168.1.10.

```
hostname -I
```

Windows

1. Open File Explorer.

2. In the address bar, type the path below as one line and press Enter.

3. Sign in as alice with her Samba password.

```
\\192.168.1.10\
enterprise_share
```

To keep it, right click This PC and choose Map network drive.

macOS

1. Open Finder.

2. Choose Go, then Connect to Server.

3. Enter the address below as one line and sign in as alice.

```
smb://192.168.1.10/
enterprise_share
```

Tick Remember this password to reconnect easily.

Linux

1. Open a terminal.

2. Run the command below as one line.

3. Enter alice's Samba password, then use ls and put.

```
smbclient
//192.168.1.10/
enterprise_share -U alice
```

Type exit to leave the smbclient prompt.

Check Usage and Test the Limits

Check on the server

```
sudo repquota -us /mnt/enterprise_share
sudo repquota -gs /mnt/enterprise_share
ls -l /mnt/enterprise_share
```

`repquota` Usage report. -u users, -g groups.
`-s` Show sizes as MB and GB.
`ls -l` Shows each file's owner and group.

Test the hard limit

From a client, sign in as alice and copy in a file larger than 500 MB. Or run this on the server:

```
sudo -u alice dd if=/dev/zero \
  of=/mnt/enterprise_share/test.img bs=1M count=600
# Expected: Disk quota exceeded
```

Example report (simplified)

Name	Used	Soft	Hard	Grace
alice	120M	400M	500M	
bob	460M	400M	500M	6 days
smbgroup	580M	4096M	5120M	

Signs that everything works

Files saved from a client show owner alice and group smbgroup in ls -l.

bob is over his soft limit, so a grace countdown appears.

The large copy fails. Windows reports there is not enough space. Delete test files afterwards.

How It All Works Together

What happens when alice saves report.docx from her Windows laptop



1. Client

alice opens the team share and saves report.docx.



2. Samba

Checks her Samba password and that she is in smbgroup.



3. Linux user

Samba writes the file as the Linux user alice.



4. ext4 + SGID

The file is stored on the disk with group smbgroup.



5. Quotas

Checks alice's 500 MB and the team's 5 GB. If either is full, the save fails.

The key idea: Samba turns every network user into a real Linux user, so the permissions, the SGID bit, and the quotas we set on the server all apply automatically to files saved from any computer.

IN-CLASS TASK

20 MIN · PAIRS · LINUX

Mukono Teachers' SACCO needs a finance share

A real request, from a real kind of organisation. You have one Ubuntu server and one spare disk. Make the following true.

1. **It must be able to grow**
   Loan files and scanned IDs accumulate for years. Adding a disk later must not mean copying everything and starting again.

2. **Only Finance may open it**
   Amina and Joseph are Finance. Nobody else in the SACCO — not the loans desk, not the front office — may see inside.

3. **Every person has a ceiling**
   One member scanning 400 MB of passport photos must not fill the disk for everyone. 500 MB each.

4. **The regulator's auditor reads, never writes**
   Okello comes from UMRA twice a year. He must open every file. He must never change one, and he must not be made

5. **Staff reach it from their own laptops**
   Finance work on Windows laptops. The folder must appear as a network drive, with a username and password.

6. **It survives a power cut**
   UMEME will cut the power. When the server comes back, the share must be there without anyone touching it.

HAND IN

Five screenshots — stages 1, 2+3, 5, 8, and Amina being stopped — with your hostname visible in each. Then two questions from me, answered out loud.

Summary: The Full Checklist

Step	Goal	Key command
1	Format the disk	`sudo mkfs.ext4 /dev/sdb1`
2	Mount with quotas	`fstab: defaults,usrquota,grpquota  then  sudo mount -a`
3	Team group and folder	`sudo groupadd smbgroup ; sudo chmod 2770 /mnt/enterprise_share`
4	Install software	`sudo apt install quota samba smbclient`
5	Switch quotas on	`sudo quotacheck -cugm /mnt/enterprise_share ; sudo quotaon -v ...`
6	Users and Samba access	`sudo usermod -aG smbgroup alice ; sudo smbpasswd -a alice`
7	User quota	`sudo setquota -u alice 409600 512000 0 0 /mnt/enterprise_share`
8	Group quota	`sudo setquota -g smbgroup 4194304 5242880 0 0 /mnt/enterprise_share`
9	Grace period	`sudo setquota -u -t 604800 604800 /mnt/enterprise_share`
10	Publish the share	`[enterprise_share] in /etc/samba/smb.conf ; testparm`
11	Start and allow	`sudo systemctl restart smbd ; sudo ufw allow samba`
12	Connect	`\\192.168.1.10\enterprise_share`
13	Check and test	`sudo repquota -us /mnt/enterprise_share`

Six layers, one command each

Layer	Command	Windows name
Disk	`lsblk  (identify it)`	Disk 1 in Disk Management
Physical volume	`pvcreate /dev/sdb`	Disk added to a pool
Volume group	`vgcreate my_pool /dev/sdb`	Storage Pool
Logical volume	`lvcreate -n my_data -L 50G my_pool`	Virtual disk / volume
Filesystem	`mkfs.ext4 /dev/my_pool/my_data`	Format as NTFS
Mount point	`mount /dev/my_pool/my_data /mnt/my_data`	Drive letter

lsblk shows the whole chain as a tree. Run it after every step and watch the tree grow.