4417/5417
System Administration

Lecture 6

File Systems

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What is a File System?

Methods and data structures that an operating system uses to keep track of files on a disk or a partition

Partition: A logical container created on a disk that houses a file system

A disk can have a single partition or many

If many, each is treated by the OS as a separate volume

A partition may be a simple volume or others (more later)

What is a File System?

4 main components

Namespace – way to name things

API – system calls to interact with file system

Security model – scheme for protecting, hiding, and sharing

Implementation – software to pull everything together

Modern OSes

FS agnostic approach

Does not matter what the FS is

CD, FAT, network, etc.

Modern File System requirements

Highly reliable

Manageable

Fault-tolerant

Windows Server 2008/2012 Storage Options

Storage systems

Basic disk

Traditional disk management techniques

Contains: primary and extended partitions and logical drives

Dynamic disk

Provides more flexibility

No restriction on number of volumes

Basic Disks

Partitioning

Blocks a group of tracks and sectors to be used by a particular file system

Formatting

Creates a table containing file and folder information for a specific file system in a partition

Volume

Logical designation of disk storage

Created out of one or more physical disk

Basic Disks

MBR and GPT Support

Master Boot Record (MBR)

Contains startup information about partitions and how to access the disk

Partition table

Contains information about each partition created

Globally Unique Identifier (GUID) Partition Table (GPT)

Newer way to partition disks

Part of Unified Extensible Firmware Interface (UEFI) approach

Basic Disks

GPT disks

   Store partition information in each partition using main and backup tables

GPT partition

   Can theoretically be up to 18 exabytes (Eighteen Billion Terabytes)

   One can convert an MBR disk to GPT and vice versa

Basic Disks

Primary and Extended Partitions on MBR Disks

Primary partition can boot an operating system

Active partition where computer will look for operating system startup files

Extended partition created from space that is not yet partitioned

Work-around for the four-partition limit of a basic disk

Basic Disks

Note that drives G:, H:, and I: are bordered in green. This shows that the fourth partition is an extended partition and G:, H:, and I: are the logical partitions within it. Windows Server 2008 and 2012 handles this 'under the hood,' referring to them as simple volumes also.

Volume	Layout	Type	File System	Status	Capacity	Free Space	%
	Simple	Basic	NTFS	Healthy (System, Active, Primary Partition)	350 MB	74 MB	21
(C:)	Simple	Basic	NTFS	Healthy (Boot, Page File, Crash Dump, Primary Partition)	29.66 GB	11.61 GB	39
D: (...	Simple	Basic	NTFS	Healthy (Primary Partition)	1000 MB	976 MB	98
E: (E:)	Simple	Basic	NTFS	Healthy (Primary Partition)	1000 MB	976 MB	98
F: (F:)	Simple	Basic	NTFS	Healthy (Primary Partition)	1000 MB	976 MB	98
G: (...	Simple	Basic	NTFS	Healthy (Logical Drive)	1000 MB	976 MB	98

Disk 0
Basic
30.00 GB
Online

350 MB NTFS
Healthy (System, Active, Primary Par

(C:)
29.66 GB NTFS
Healthy (Boot, Page File, Crash Dump, Primary Partition)

Disk 1
Basic
8.00 GB
Online

D: (D:)
1000 MB NT
Healthy (Prir

E: (E:)
1000 MB NT
Healthy (Prir

F: (F:)
1000 MB NT
Healthy (Prir

G: (G:)
1000 MB NT
Healthy (Lo

H: (H:)
1000 MB NT
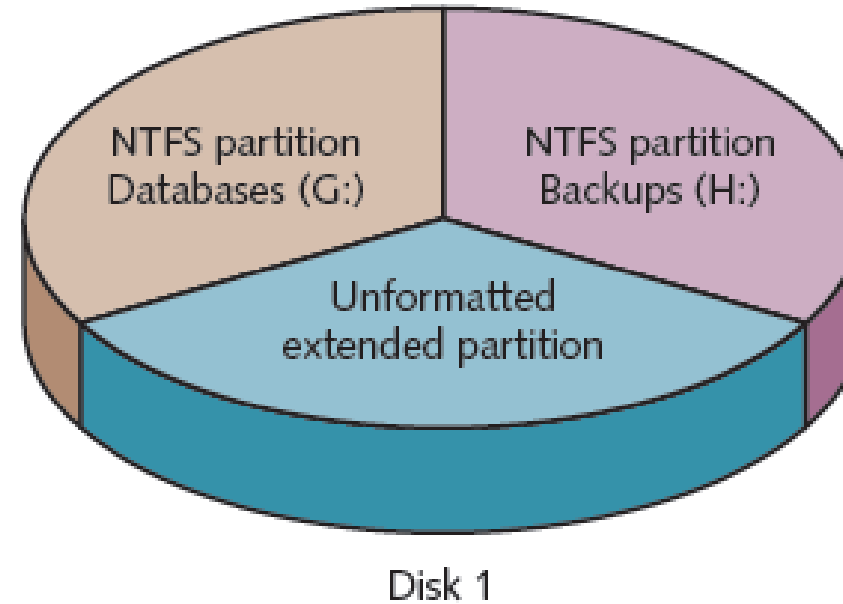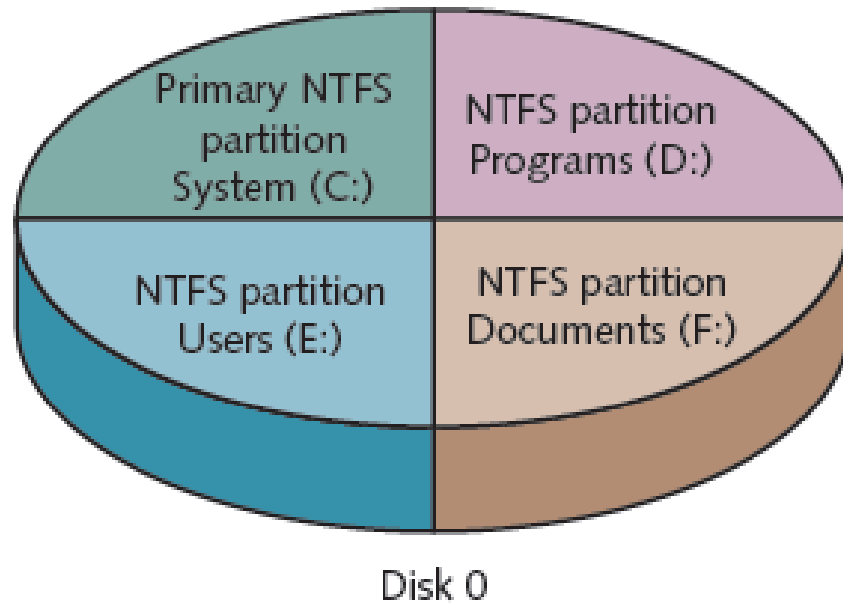Healthy (Log

I: (I:)
3.11 GB NTFS
Healthy (Logica

Disk 2
Basic
8.00 GB
Online

8.00 GB
Unallocated

Basic Disks

Partitions on two disk drives

Dynamic Disks

Volume and Stripe Sets

Volume set

Two or more partitions that are combined to look like one volume with a single drive letter

Stripe set

Two or more disks that are combined like a volume set, but that are striped for RAID level 0 or RAID level 5

Dynamic Disks

Simple Volume

Portion of a disk or an entire disk that is set up as a dynamic disk

Spanned volume

Stored on 2 to 32 dynamic disks that are treated as one volume

Striped volume

RAID-0

Main purpose to extend the life of hard disk drives by spreading data equally over two or more drives

Also improves performance

Disk Management

Disk Management tool

Central location for viewing disk information

Perform tasks such as creating and deleting partitions and volumes

Dynamic Disks
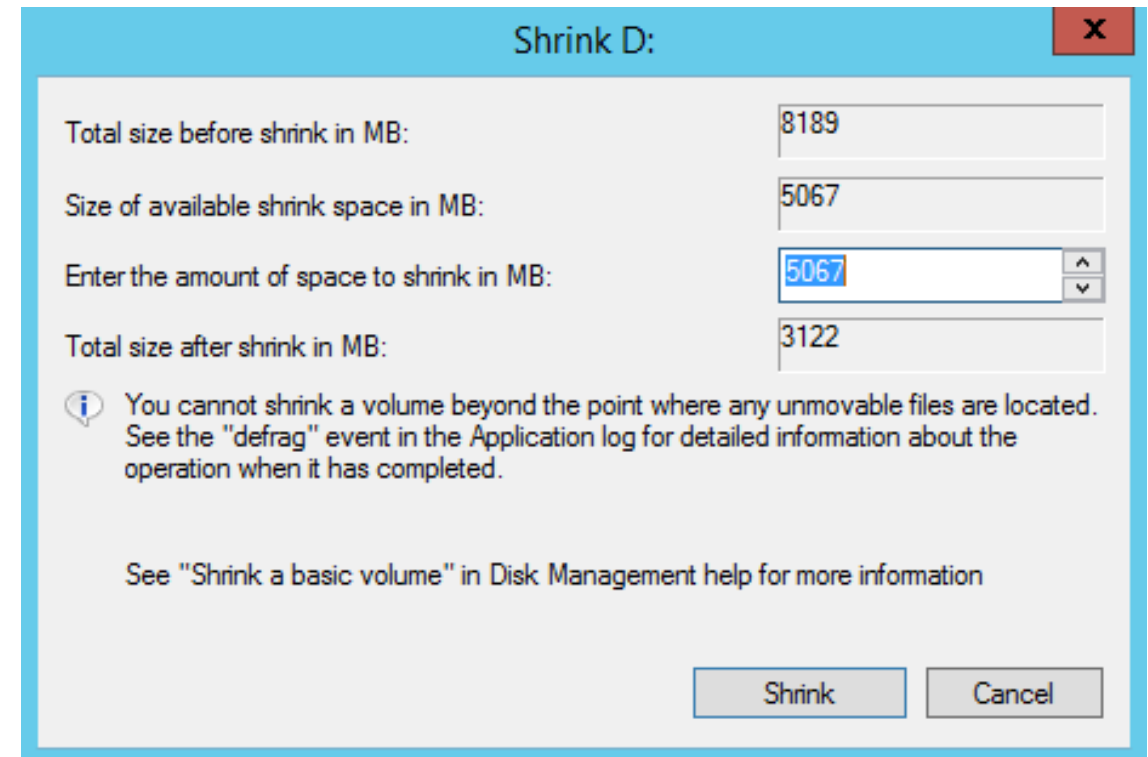
Note here that volume D: is a simple volume, volume E: spans Disk 1 and 2, volume F: spans Disk 1 and 3 and is a striped volume, volume G: spans Disk 3, 4 and 5 and is a RAID 5 volume, and volume H: spans Disks 2 and 3 and is a mirrored volume.
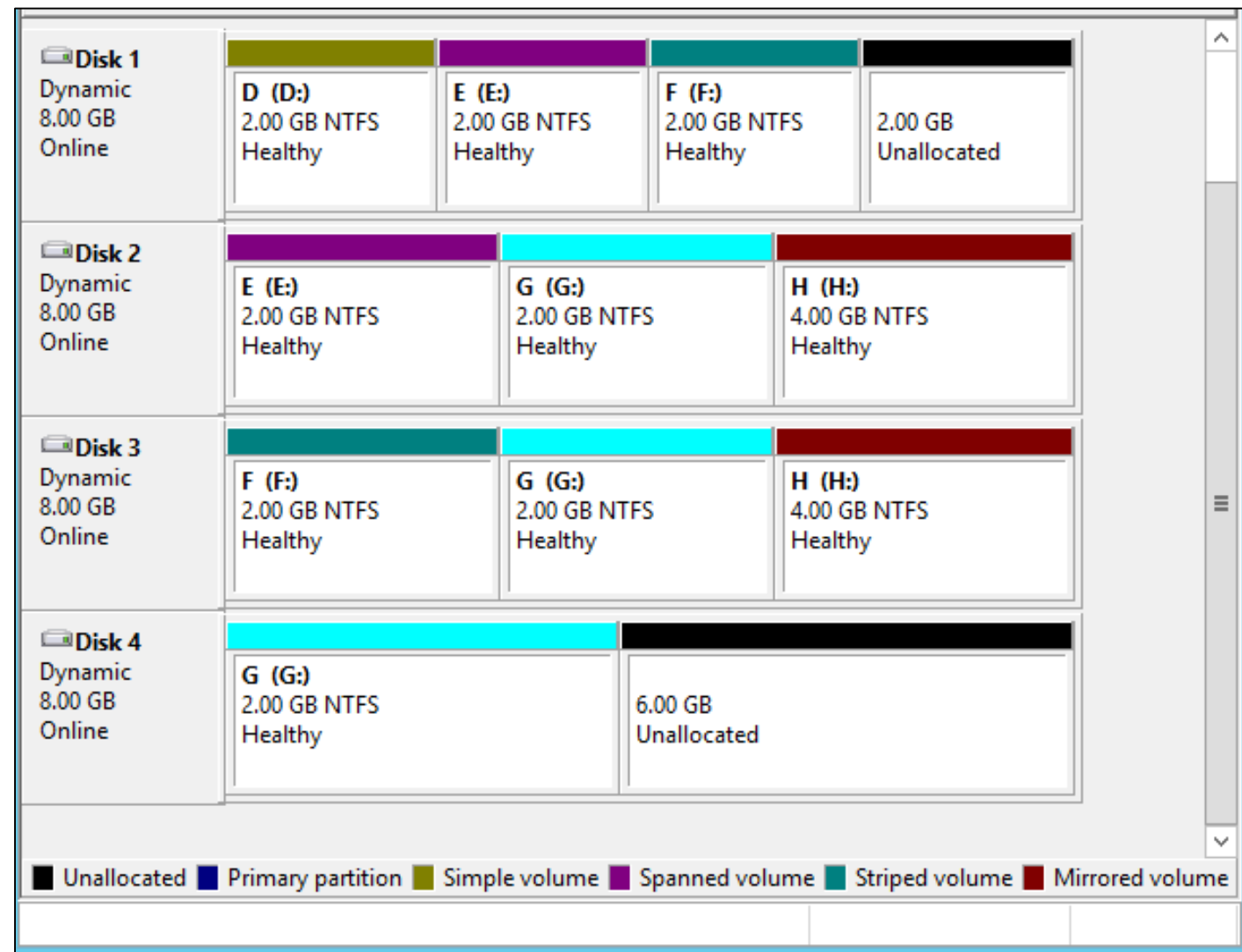
Dynamic Disks

Shrinking a Volume

Create a new partition when one is needed and you don't have extra disks

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Creating a Partition and Simple Volume

Partitions operate as separate storage units on a hard disk

Once a partition is formatted
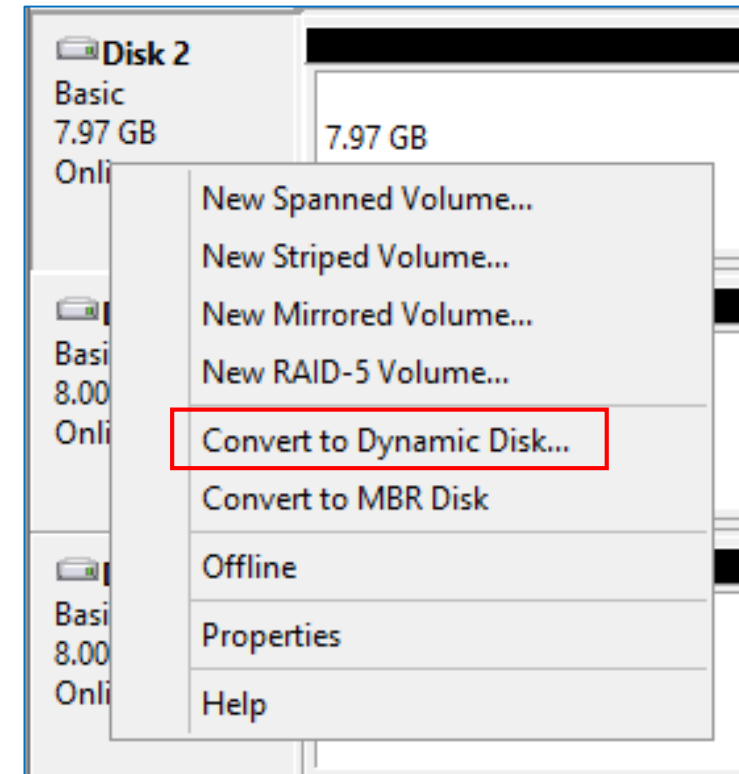
It is called a volume

Can be assigned a drive letter

Converting a Partitioned Basic Disk to a Dynamic Disk

Use Disk Management tool

Right-click on the Disk button

Select 'Convert to Dynamic Disk…'

Mounting a Drive

Mounted drive

    Appears as a folder
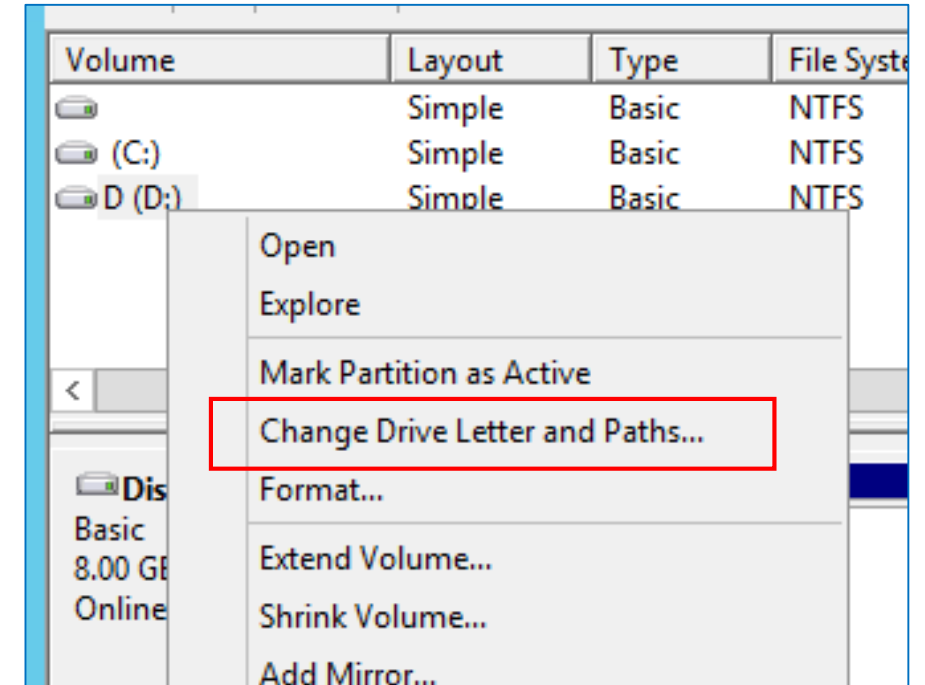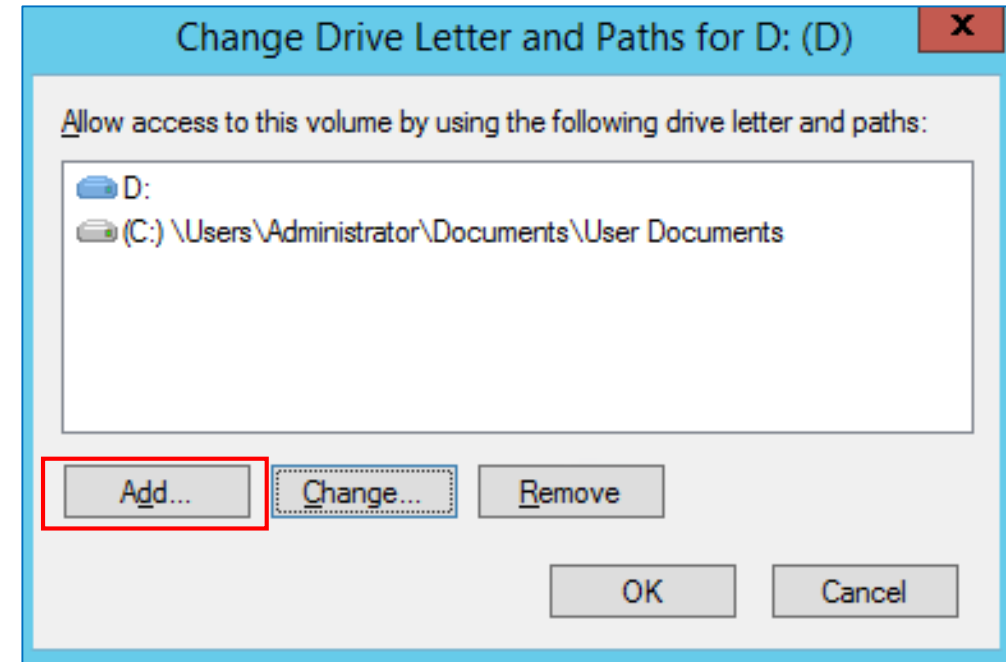
    Accessed through a path like any other folder

Can mount

    Basic or dynamic disk drive

    CD/DVD drive

    Removable drive

Mounting a Drive

Mounted drive

Appears as a folder

Accessed through a path like any other folder

Can mount

Basic or dynamic disk drive

CD/DVD drive

Removable drive

Change Drive Letter and Paths for D: (D)

Allow access to this volume by using the following drive letter and paths:

D:

(C:) \Users\Administrator\Documents\User Documents

Add...   Change...   Remove

OK   Cancel
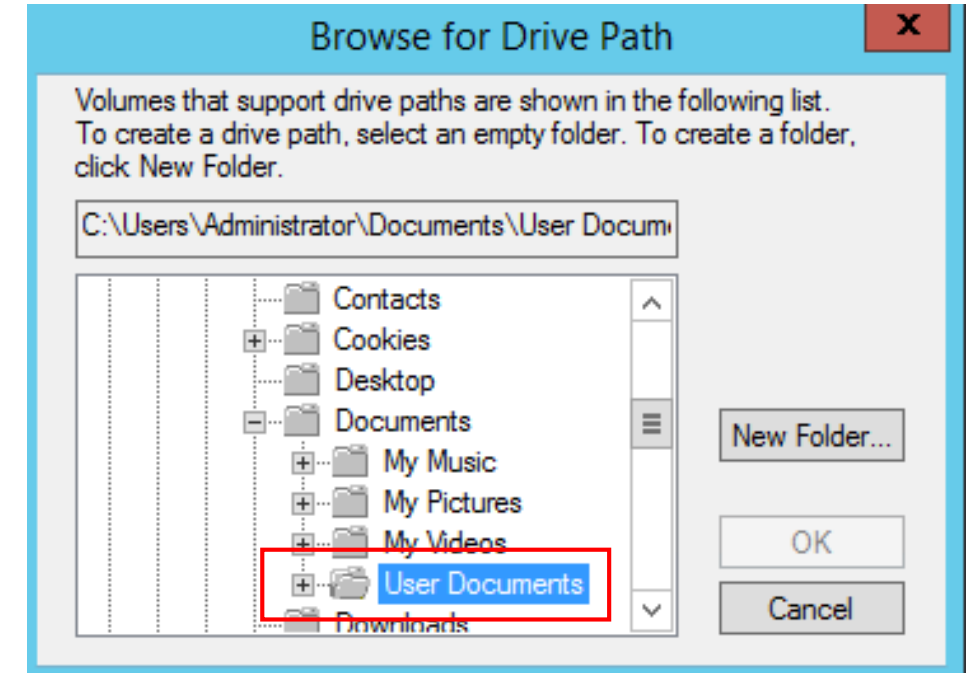
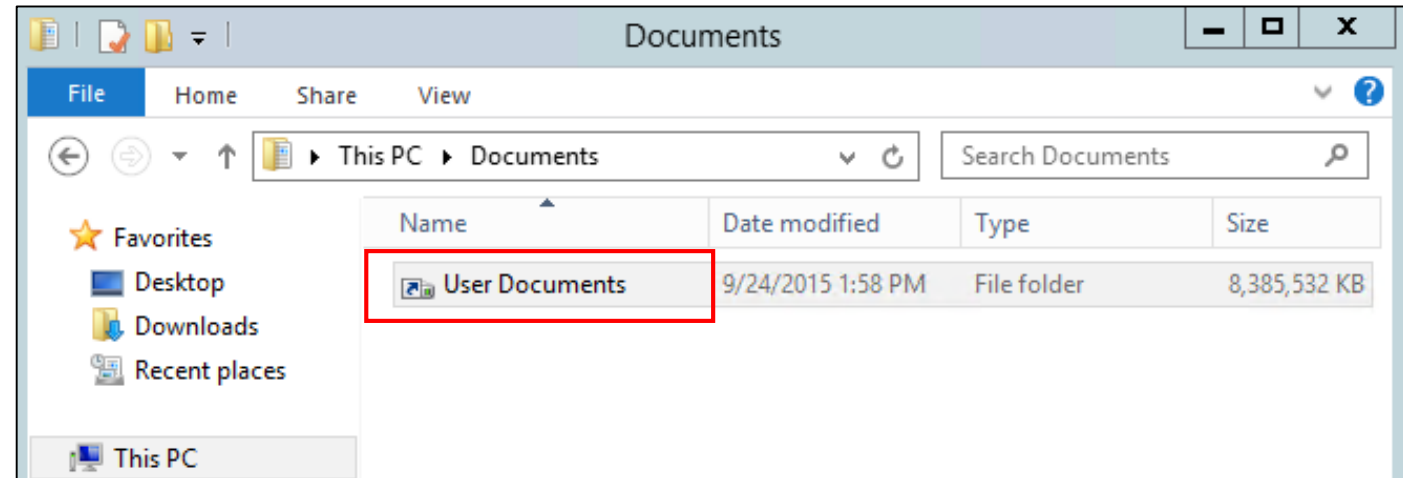# Mounting a Drive

Mounted drive

Appears as a folder

Accessed through a path like any other folder

Can mount

Basic or dynamic disk drive

CD/DVD drive

Removable drive

Browse for Drive Path

Volumes that support drive paths are shown in the following list. To create a drive path, select an empty folder. To create a folder, click New Folder.

C:\Users\Administrator\Documents\User Docum

- Contacts
- Cookies
- Desktop
- Documents
  - My Music
  - My Pictures
  - My Videos
  - User Documents
- Downloads

New Folder...

OK

Cancel

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Mounting a Drive

Mounted drive

Appears as a folder

Accessed through a path like any other folder

Can mount

Basic or dynamic disk drive

CD/DVD drive

Removable drive

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Mounting a Drive

Home directory or home folder

Server folder that is associated with a user's account

Designated workspace for the user to store files

Principle of Least Privilege

Managing Disks

Using Disk Defragmenter

Fragmented

Data not stored contiguously

Defragmenting

Locates fragmented folders and files

Moves them to a location on the physical disk so they are in contiguous order

Managing Disks

Using **chkdsk**

    Start from command prompt
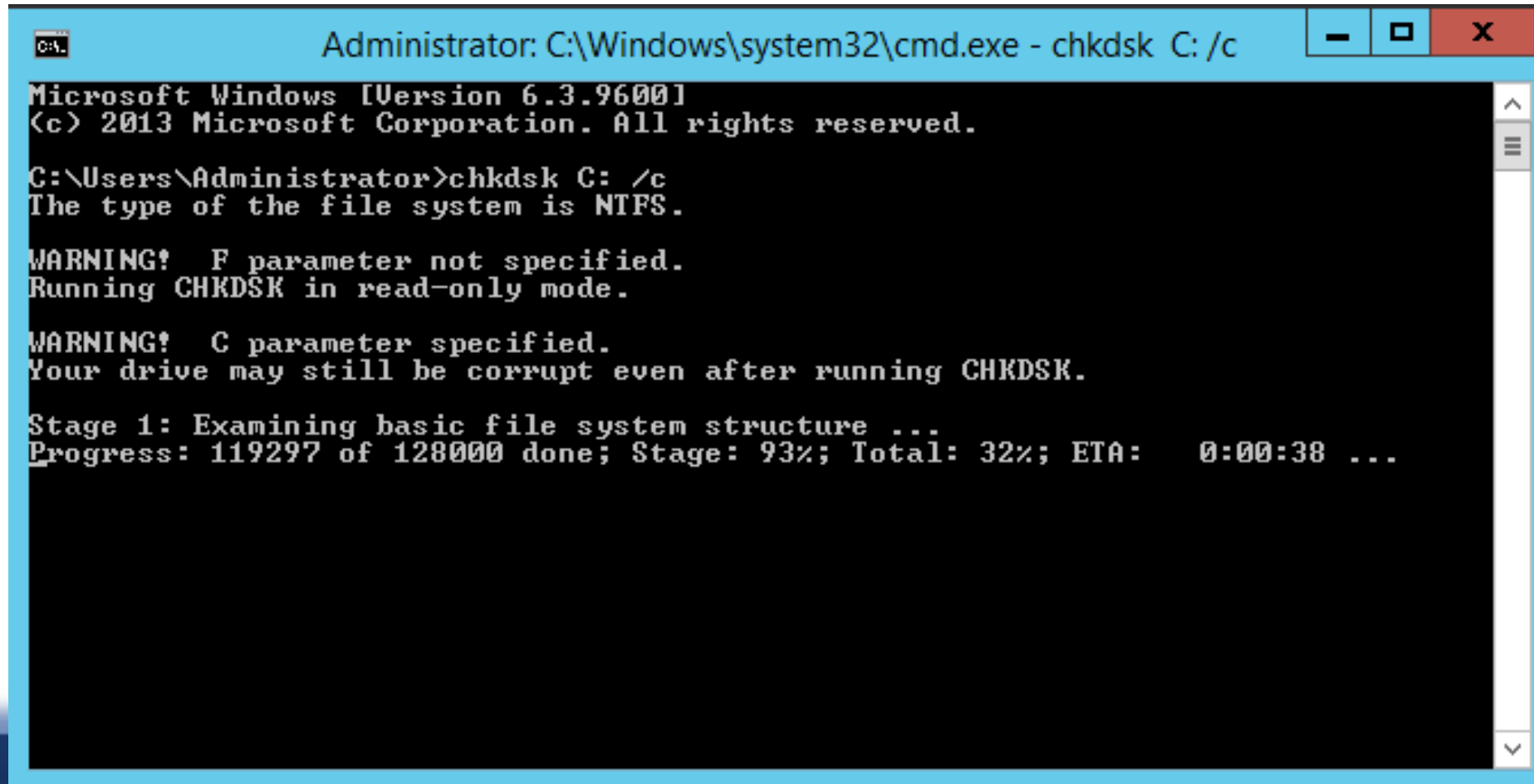
    May run automatically

Managing Disks

Switch/Parameter	Purpose
[*volume*] (such as C:)	Specifies that *chkdsk* only check the designated volume
[*filename*] (such as *.dll)	Enables a check of the specified file or files only
/c	Uses an abbreviated check of the folder structure
/f	Instructs *chkdsk* to fix errors that it finds
/i	Uses an abbreviated check of indexes
/L:size	Enables you to specify the size of the log file created by the disk check
/r	Searches for bad sectors, fixes problems, and recovers information (when not possible; use the Recover command on separate files)
/x	Dismounts or locks a volume before starting

chkdsk switch and parameter options

Managing Disks

End, Part One

RAID

Redundant Array of Inexpensive Disks – Lecture 6, continued

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Introduction to Fault Tolerance

Fault tolerance

Ability of a system to gracefully recover from hardware or software failure

Software-level RAID

Not meant as a replacement for performing regular backups of data

RAID Volumes

RAID (Redundant array of inexpensive disks)

Can be configured for any of three RAID levels:

Disk striping (RAID level 0)

Disk mirroring (RAID level 1)

Disk striping with parity (RAID level 5)

Striping

Spread data over multiple disks or volume

Disk mirroring

Creating a mirror image of all data on an original disk

RAID Volumes

Ability to survive a hard drive failure

RAID does NOT replace backups

May increase disk subsystem access time

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RAID Volumes

RAID

Set of standards for lengthening disk life, preventing data loss, and enabling relatively uninterrupted access to data
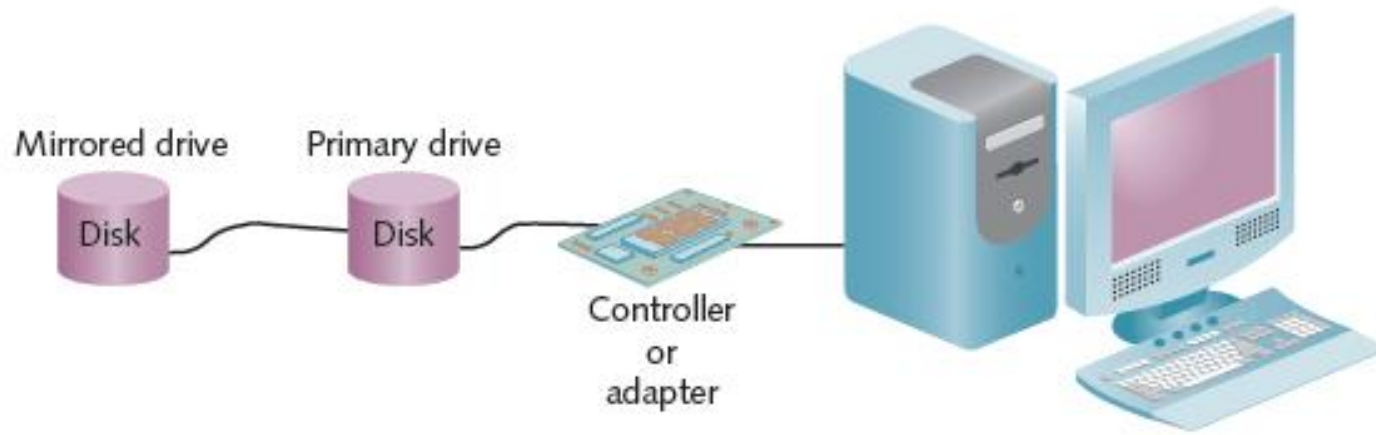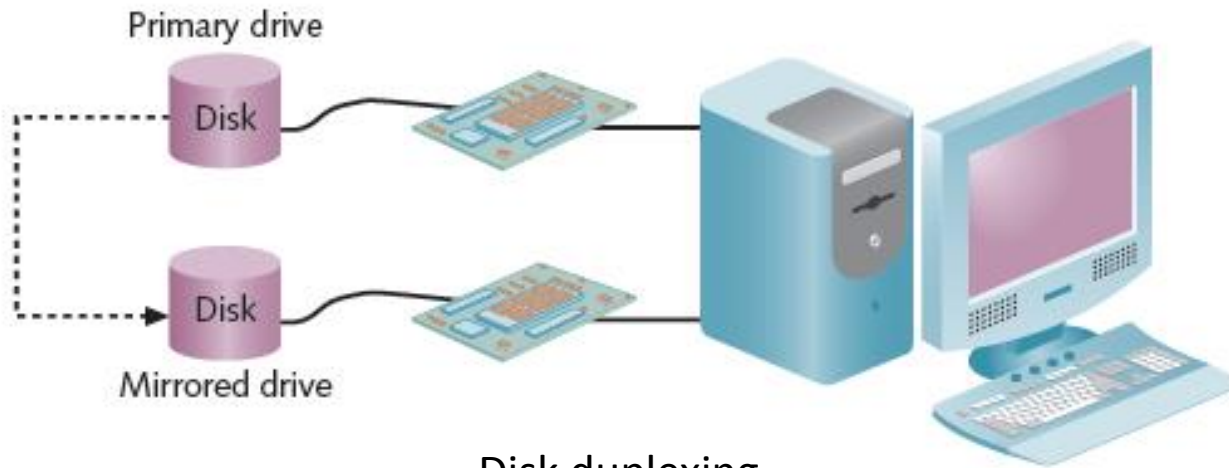
6 Levels

Striping

Mirroring

Duplexing

Windows Server 2008/2012 supports RAID levels 0, 1, and 5
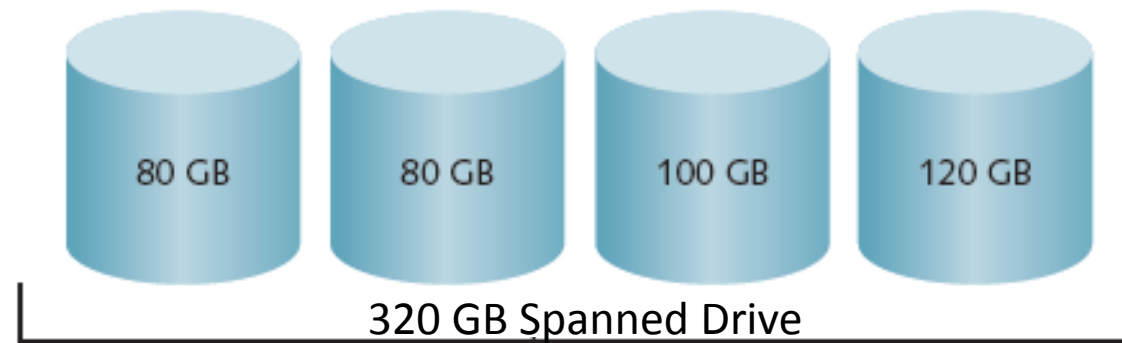
Disk mirroring

Disk duplexing

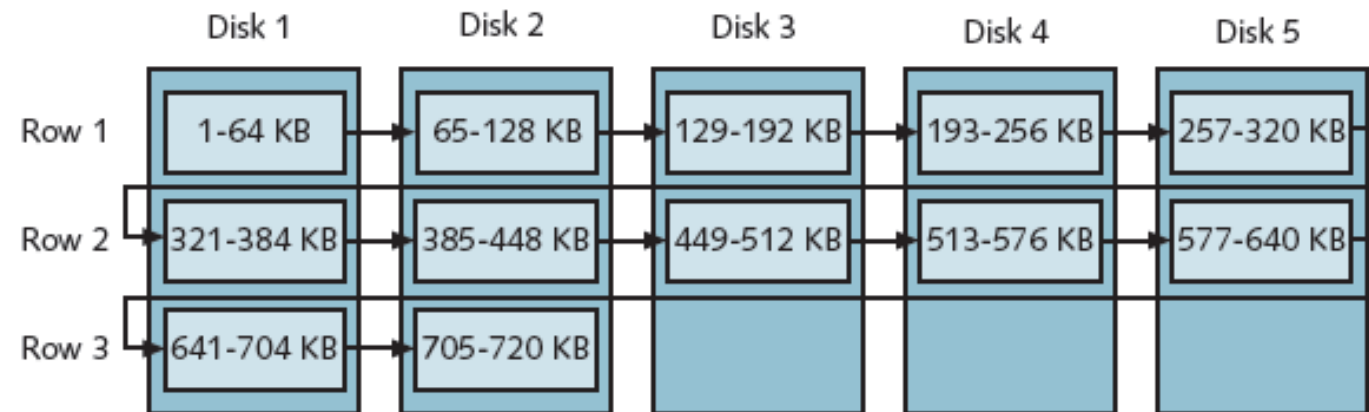**Figure 7-4** Creating one spanned volume from four disks

Figure 7-5 Disks in a striped volume

RAID Controllers

Parity computation is CPU intensive

SW RAID available on both MS and Linux = weak

MB RAID OK for home use, not good for servers

Quality of RAID card directly = to RAID performance

$1,500 or more

Using a Striped Volume (RAID-0)

Reasons for using a RAID level 0

- Reduce the wear on multiple disk drives by equally spreading the load

- Increase disk performance compared with other methods for configuring dynamic disk volumes

RAID

RAID 0

NO data protection

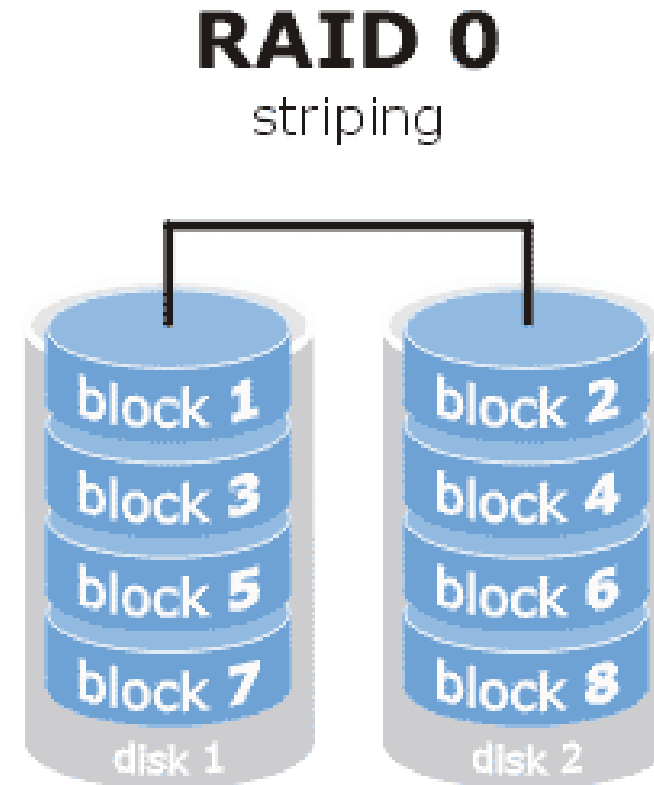Used for increased speed

Subject to higher failure rates

Used on static servers

    e.g., web servers

Using a Mirrored Volume (RAID-1)

Disk mirroring

Creating a shadow copy of data on a backup disk

RAID level 1

Only dynamic disks

Can be a slight performance degradation for disk writes

Well suited for situations in which data is mission-critical and must not be lost under any circumstances

RAID

RAID 1

Disk Mirroring

Data duplicated on 2 drives

Lose 50% of purchased storage

Simple

RAID 1
mirroring

block 1 = block 1
block 2 = block 2
block 3 = block 3
block 4 = block 4
disk 1   disk 2
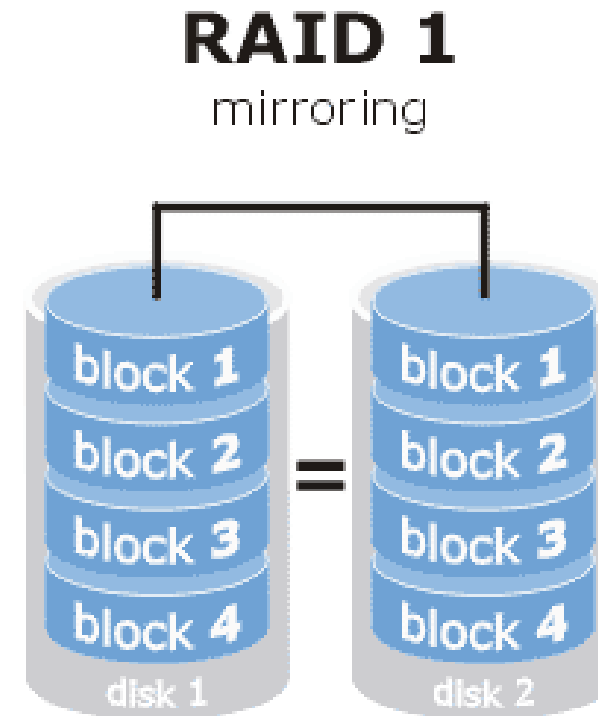
Using a RAID-5 Volume

RAID-5 volume

    Requires a minimum of three disk drives

Performance is not as fast as with a striped volume (Read can be faster; write slower)

Amount of storage space used

    Based on the formula 1/n where n is the number of physical disks in the volume

Using a RAID-5 Volume

Available storage – example

A RAID-5 volume with consisting of five 100GB disks would have

- (5 -1) * 100 GB =
- 4 * 100 GB =
- 400 GB available for storage

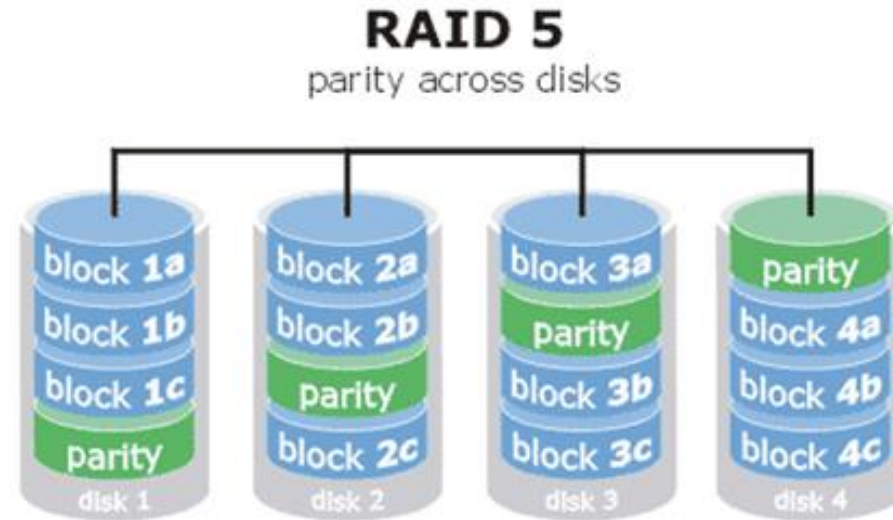The remaining 100 GB would be used to store the parity information

RAID

RAID 5

Disk stripping with parity

Data is written across all drives in stripes

Read performance increased

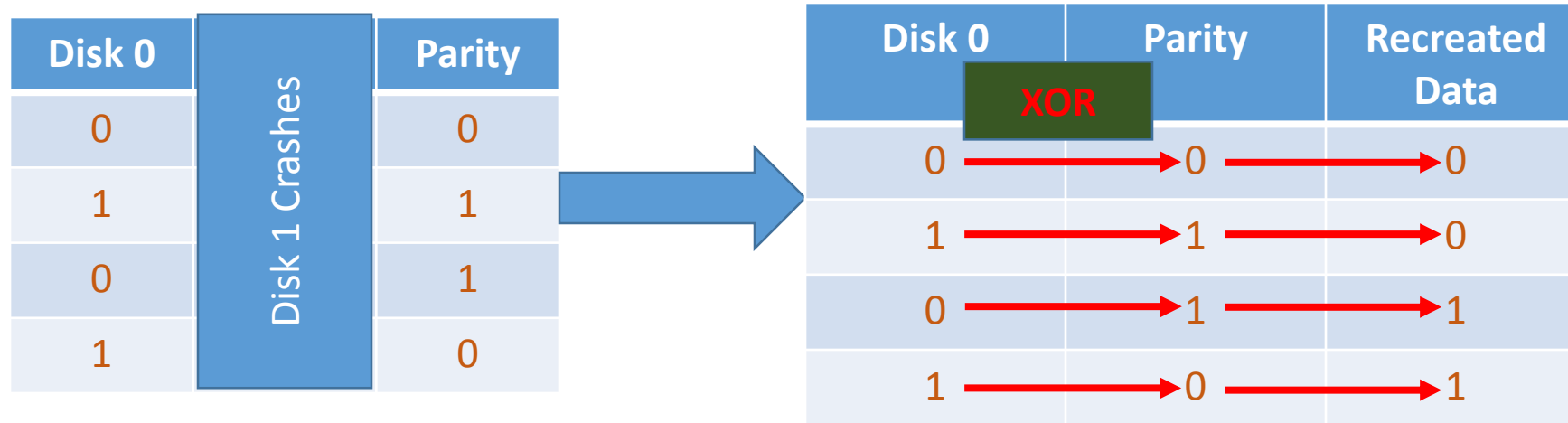Loose 1 disk to parity

RAID 5
parity across disks

How Does Parity Allow for Recreation of Lost Disk?

The parity block is the result of an XOR operation, bit-wise, on the data from the other disks. For example:

How Does Parity Allow for Recreation of Lost Disk?

Disk 0	Disk 1 Crashes	Parity
0		0
1		1
0		1
1		0

Disk 0	Parity	Recreated Data
	XOR	
0 →	0 →	0
1 →	1 →	0
0 →	1 →	1
1 →	0 →	1

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Software RAID vs. Hardware RAID

Software RAID

   Implements fault tolerance through the server's operating system

Hardware RAID

   Implemented through the server hardware

   Independent of the operating system

   More expensive than software RAID

   Offers many advantages over software RAID

Windows Server 2008/2012 Storage Features

Management of Storage Area Networks

Using multiple paths to storage for fault tolerance

For medium to large networks

Storage Manager for SANs and LUNs

Storage Area Network (SAN)

Grouping of storage devices that forms a subnet

Uses FiberChannel or iSCSI technology

Storage Manager for SANs

Manage logical unit numbers for Small Computer System Interface drives

32- or 64-bit computer adapter that transports data between one or more attached devices

Logical unit number (LUN)

Identifies a physical SCSI drive or logical SCSI targets

Storage Manager for SANs and LUNs

Types of LUNs

Simple

Spanned

Striped

Mirrored

Striped with parity

Virtual Disk Service (VDS)

Enables management of disk volumes in SANs through one interface at a server

Storage Manager for SANs

Three windows of operation

Disk Quotas

Only available on NTFS partitions

Limiting user space

Think 'Z' drive

Easy to create, not much flexibility

File Server Resource Manager

Central admin file sharing

Hides shares from users without permission for them

Tunes server for file server role

Configs Client-side caching

Off-line files

Advance Quota management

File screen filtering (ex., no *.mp3)

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Distributed File System

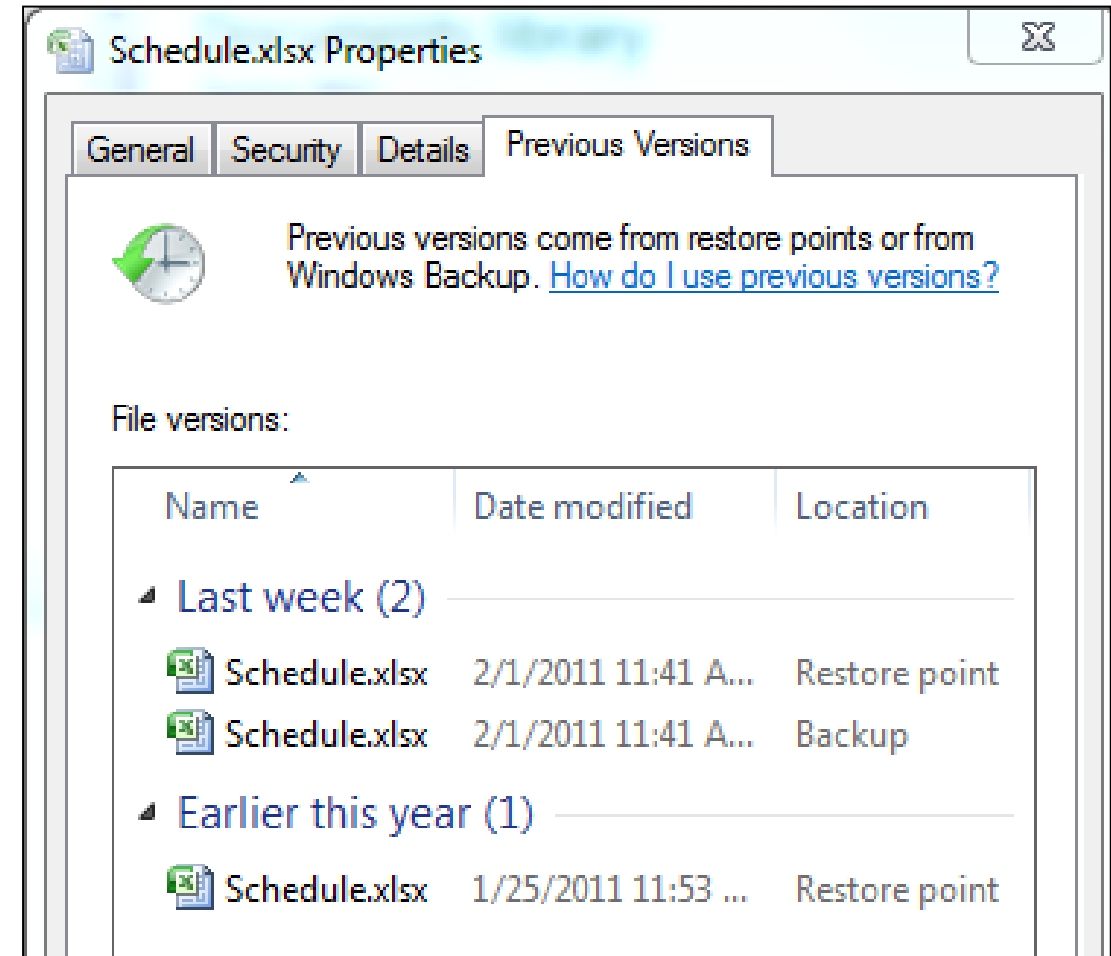Looks like one 'share' but exists on different servers

Data redundancy

Data replication

Data consolidation

Volume Shadow Copy

Real time snapshot of data

On clients, it is seen as 'previous versions'

End, part 2

Linux File Systems

Lecture 6 - Continued

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Linux Tree

/ - root directory, 'start' of entire file system

/bin – command binaries

/boot – boot loader

/dev – essential devices

/etc – config files

/home – user dirs

/media – mount point for removable media

Linux Tree

/mnt – temp mount points

/proc – virtual filesystem

/sbin – system binaries

/tmp – temp files

/usr – multi-user apps

fdisk

fdisk -l

Lists all available disks

File Edit View Search Terminal Help

```
Disk /dev/sda: 20 GiB, 21474836480 bytes, 41943040 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0x0009c787

Device     Boot     Start       End  Sectors   Size Id Type
/dev/sda1  *          2048  39845887 39843840   19G 83 Linux
/dev/sda2          39847934  41940991  2093058 1022M  5 Extended
/dev/sda5          39847936  41940991  2093056 1022M 82 Linux swap / Solaris


Disk /dev/sdb: 29.8 GiB, 32015679488 bytes, 62530624 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0x00000000

Device     Boot Start       End  Sectors   Size Id Type
/dev/sdb1          32  62530623 62530592 29.8G  c W95 FAT32 (LBA)
jack@topaz:~$
```

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Creating a Partition/Preparing for use

Creating a partition:

`fdisk /dev/sdb1`

```
jack@topaz:~$ sudo fdisk /dev/sdb1

Welcome to fdisk (util-linux 2.26.2).
Changes will remain in memory only, until you decide to write them.
Be careful before using the write command.


Command (m for help): p
Disk /dev/sdb1: 29.8 GiB, 32015663104 bytes, 62530592 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0x00000000
```

Creating a Partition/ Preparing for use

Creating a partition:

`fdisk /dev/sdb1`

File Edit View Search Terminal Help

DOS (MBR)
```
a    toggle a bootable flag
b    edit nested BSD disklabel
c    toggle the dos compatibility flag
```

Generic
```
d    delete a partition
l    list known partition types
n    add a new partition
p    print the partition table
t    change a partition type
v    verify the partition table
```

Misc
```
m    print this menu
u    change display/entry units
x    extra functionality (experts only)
```

Script
```
I    load disk layout from sfdisk script file
O    dump disk layout to sfdisk script file
```

Save & Exit
```
w    write table to disk and exit
q    quit without saving changes
```

Create a new label
```
g    create a new empty GPT partition table
G    create a new empty SGI (IRIX) partition table
o    create a new empty DOS partition table
s    create a new empty Sun partition table
```

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Creating a Partition/ Preparing for use

Making a filesystem

`mkfs`

Linux Filesystems

ext2
ext3
ext4
ReiserFS
JFS
XFS
Btrfs

FAT
NTFS
HFS & HFS+ (Apple)
ISO-9660 (CD-R)

mount

Command used to attach other file systems to the tree

`sudo mount /dev/sda4 /users`

Mounts the device at /sda4 to /users

We can now cd /users

`umount` to release file system

Linux Partition Schemes

hda = IDE drive (block device)

   hda1 = 1st partition on hard drive 1

sda = sata or usb drive

`ls -l`

List and inspect files

```
teacher@teacher-VirtualBox:~$ ls -l
total 36
drwxr-xr-x 2 teacher teacher 4096 2011-01-25 13:09 Desktop
drwxr-xr-x 2 teacher teacher 4096 2011-01-25 13:09 Documents
```

Type and mode

Permissions

owner, group, other (world)

Link count

Owner and group owner

File size in bytes

Last date of modification

chmod

Used to change permissions

Broken into

    read

    write

    execute

3 binary digits for each

chmod 711 myprog gives all permissions to owner and execute to everyone else
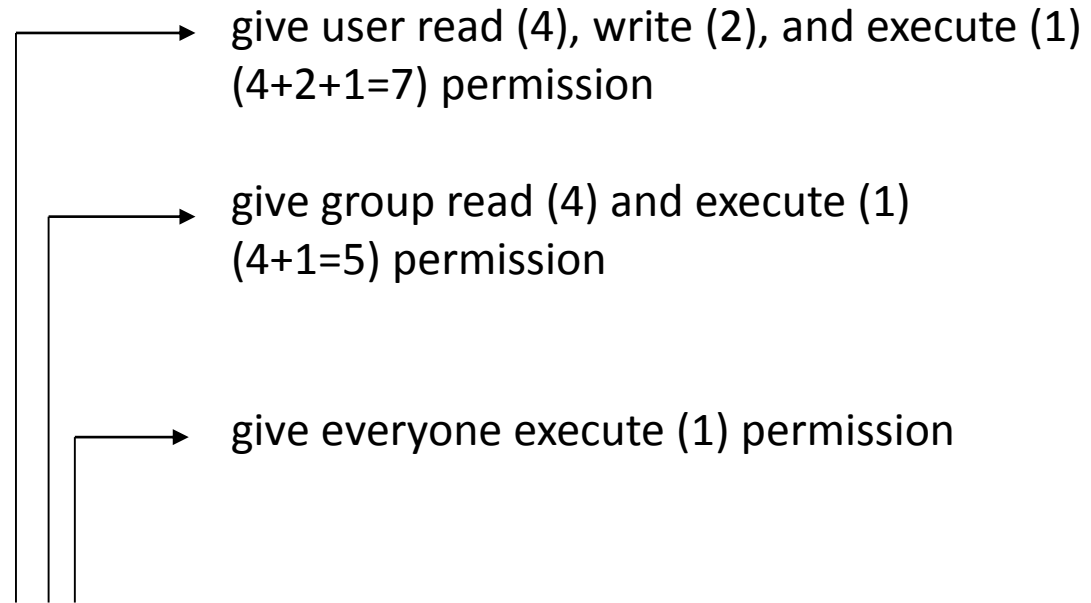

read   write   execute
4+2+1

Propriétaire

read   execute
4+1

Groupe

read   execute
4+1

Public

755

read = lire
write = écrire
execute = executer
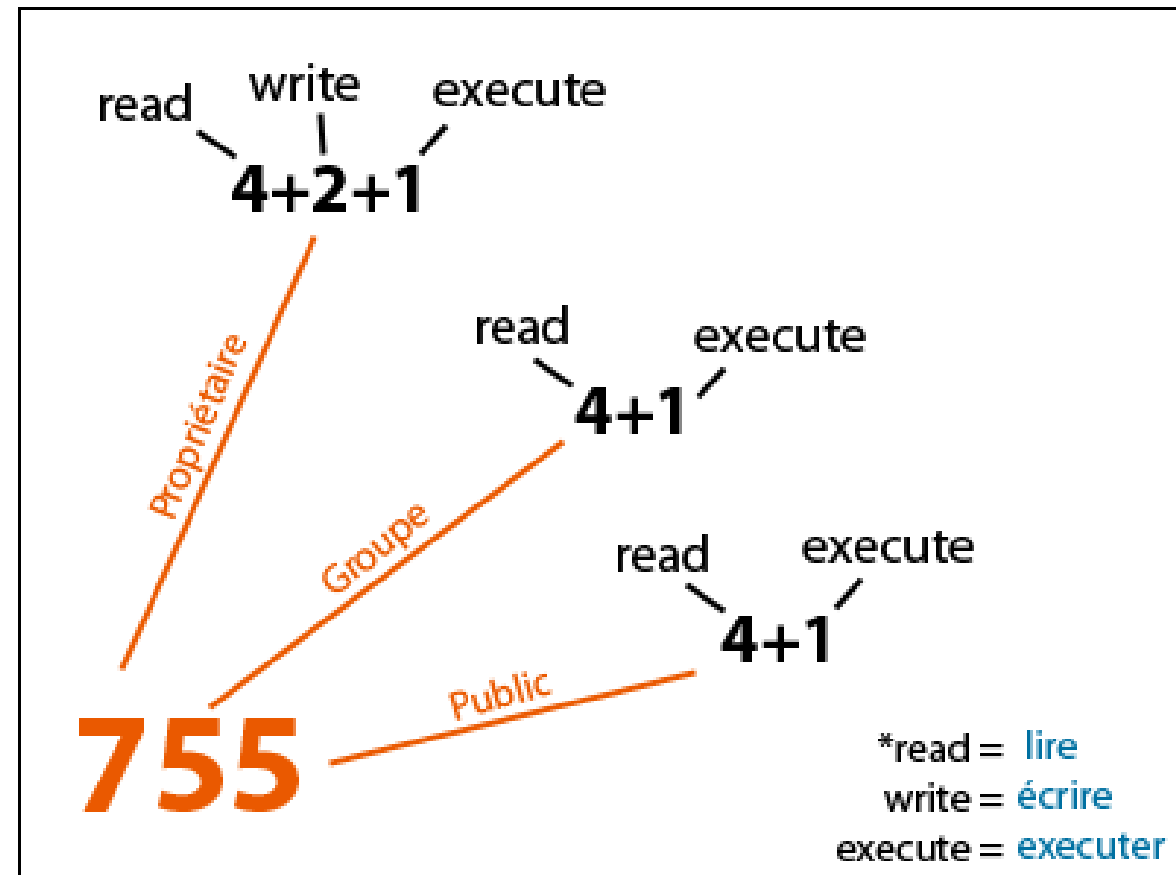
Octal Permissions

Octal value	equation	Permissions
0	0	none
1	1	execute
2	2	write
3	1+2	write and execute
4	4	read
5	4+1	read and execute
6	4+2	read and write
7	4+2+1	read, write, and execute

chmod Examples

using octal permissions

give user read (4), write (2), and execute (1) (4+2+1=7) permission

give group read (4) and execute (1) (4+1=5) permission

give everyone execute (1) permission

- chmod 751 myfile

myfile permissions would show as -rwxr-x--x

directory

other

user

group
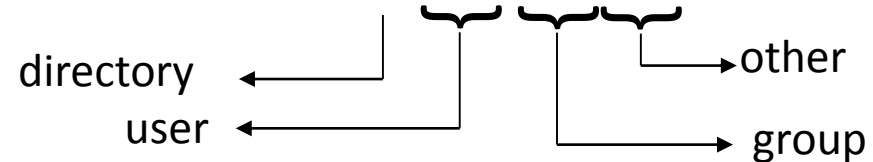
chmod [*options*] *mode file*

Changes the access mode for a given file; only the owner of the file or the SuperUser can change its access mode.

Options

-R recursively

Can use octal permission numbers

r – 4 : read permission

w – 2 : write permission

x – 1 : execute permission*

*For directories execute permission allows users to access a directory without reading it. This is important for creating html directories, allowing web users to view web content within a directory, but not be able to read the directory itself.

chmod [*options*] *mode file*

Class of user:

u	User (you)
g	Group
o	Other (all others)
a	All u, g, and o

Permission Values:

r	Read
w	Write
x	Execute

Operations:

+ add permission

- remove permission

= set permission (replacing existing)

chmod Examples

<table>
<tr><td colspan="2" style="writing-mode: vertical">Using options</td></tr>
</table>

permission	meaning
u=rwx,g=rw,o=r	user has read, write, and execute; group has read and write, others have read
g-w,o-r	remove write permission from group, remove read permission from other (leave all other permissions alone)
o+r	add write permission to others
a-w	remove write permissions for all (user, group, and others)

Review Questions

What RAID level uses disk mirroring?

RAID-1

Review Questions

What kind of drive is indicated by a sda partition?

SATA or thumbdrive

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Review Questions

You are consulting for an organization that has chosen to use disk striping as a way to extend the life of their four hard disks. Now one of the disks has failed and they call you for help. What do you advise them?

Take the failed disk offline and let the other three disks rebuild the data from the failed disk automatically

Download the failed disk's folder header information to the 2nd disk in the series & let it rebuild the data that was on the failed disk

Install a new disk & download the backup cache from the failed disk to restore files to the new disk

Install a new disk and perform a full restore on all four disks

Review Questions

You've spent some time archiving old files to DVDs and then deleting those files as a way to free up some disk space. After you finish, you notice that the server seems to run slower. What should you do?

Perform a full backup. Reformat the disk and then perform a recovery from your backup

Start the Disk Defragmenter to defrag your disks

Use the Disk Check tool to retrieve contiguous disk space

Use Device Manager to perform a disk verification

Review Questions

What operator is used with RAID parity to restore data lost when a disk crashes?

OR
NOR
XOR
NAND

Review Questions

What permissions would the following file have after running chmod 740 musers.sh?

User –   read, write, execute

Group – read

Other –   none

Review Questions

Which Linux directory houses command binary files?

/

/sbin

/usr/bin

/bin

Review Questions

You have configured a RAID-5 volume using five 250 GB disks. How much disk space is actually available for storage of folders and files?

875 GB

1000 GB

934.5 GB

1993.75 GB

Next Up

Network Services – SSH & RDP (Read PSA - Chapter 27)

DNS/DHCP (U&L - pp 552-596)

References

- http://tldp.org/LDP/Linux-Filesystem-Hierarchy/html/index.html
- Unix and Linux Handbook
- Windows Server 2008 Unleashed
- Windows Server 2012 Unleashed

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