

Managing Disks and Swap Space

Block Devices

Block devices under Linux are referenced by **special files** found in the **/dev** directory:

- hd[a-d]
 - IDE disks and ATAPI devices
 - sd[a-z]
 - SCSI/SATA disks
 - scd[0-7]
 - SCSI CDRoms
 - xd[a-d]
 - The original IBM XT disks
 - fd[0-7]
 - Floppy drives
 - st[0-7]
 - SCSI streamers that can rewind
 - nst[0-7]
 - SCSI streamers that cannot rewind
 - rmt8, rmt16, tape-d, tape-reset
 - QIC-80 devices
 - ram[0-15]
 - Virtual memory disks
 - loop[0-15]
 - loop devices used to access a filesystem in a file (such as an ISO file)
 - md[x]
 - Software **RAID** device
 - vg[x]
 - Volume Group
 - lv[x]
-

- Logical Volume

Partitions

Master Boot Record

This partition type, also known as **MBR**, **MS-DOS Partitions** or **BIOS partitions**, is the most common one on disks under 2 **tebibytes** in size. That limitation comes from the fact that it uses 32 bit pointers to refer to disk sectors. Most disk manufacturers use a sector size of 512 bytes. Taking these two points into account indicates that the maximum disk size permitted is $2^{32} * 512 \text{ bytes} = 2.2 * 10^{12} \text{ bytes} = 2\text{TiB}$.

<note important> Some disk manufacturers are now moving to 4096-byte sectors which effectively increases the maximum size permitted to 16 TiB.
</note>

Generally, a PC is equipped with two disk controllers each being able to manage two disks referred to respectively as the **Master** and **Slave**. Each disk is referred to differently :

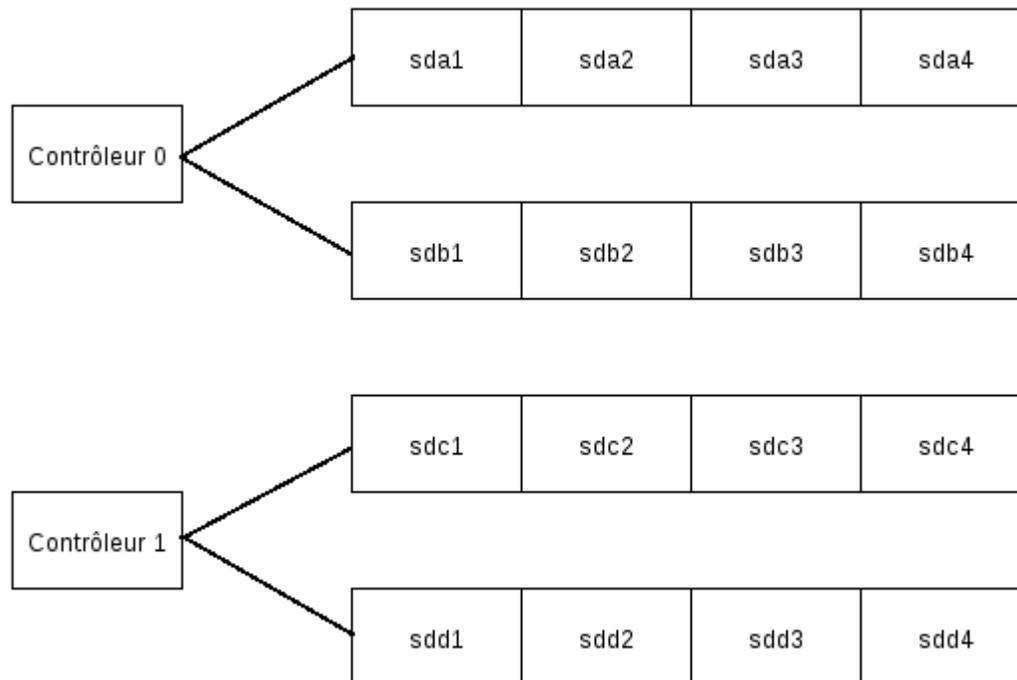
- Controller 0
 - Master
 - **hda** - IDE disk
 - **sda** - SATA/SCSI disk
 - Slave
 - **hdb** - IDE disk
 - **sdb** - SATA/SCSI disk
- Controller 1
 - Master
 - **hdc** - IDE disk
 - **sd** - SATA/SCSI disk
 - Slave
 - **hdd** - IDE disk
 - **sdd** - SATA/SCSI disk

Each disk can have three types of partitions:

- **Primary Partitions,**
 - Maximum of **4**. The **FAT** (*File Allocation Table*) is 64 bytes in length and 16 bytes are needed to code each partition,
- **Extended Partitions,**
 - Normally only one extended partition per disk. An Extended Partition contains Logical Drives.
- **Logical Drives.**

The 4 primary partitions are numbered 1 through 4:

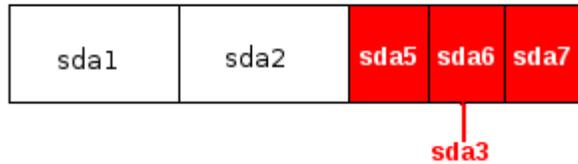
- **hda1, hda2, hda3** and **hda4** for the IDE Master on Controller 0,
- **sda1, sda2, sda3** and **sda4** for the **SCSI/SATA** Master on Controller 0.



;#;

;#;

An Extended Partition contains Logical Drives that start at **hda5** or **sda5** and takes the place of a Primary Partition, rendering it unusable:



<note important> Linux does not suffer from the same problem as Windows™ when using MBR. Linux does **not** have to be booted from a primary partition whereas Windows™ does. </note>

The total number of partitions on a disk is limited as follows:

- **IDE**,
 - Upto **63**,
- **SCSI**,
 - Upto **15**,
- Disks using the **libata** API,
 - Upto **15**.

<note important> These limits can be exceeded by using the **LVM** technology. </note>

Apple Partition Map

Also known as **APM**, this partition table type was used by Apple on its PowerPC based Macintoshes. Apple switched to GPT when it started to use Intel CPUs.

<note important> APM shares the same limitations as MBR concerning the maximum size of the disk. </note>

GUID Partition Table

Also known as **GPT**, this partition table type is defined in the **UEFI** (**U**nified **E**xtensible **F**irmware **I**nterface) definition.

Under GPT, there is no difference between primary, extended or logical partitions, instead GPT supports a fixed number of partitions which is **128** by

default

GPT uses 64-bit sector pointers and can therefore handle disks upto a size of $9.4 * 10^{21}$ bytes = 8ZiB (**zebibytes**)

Partitioning

Partitioning can be performed by several programs, some of which are partition-type dependant:

- **The libparted Tools,**
 - contain the **parted** text-mode program,
 - are at the heart of the **GParted** graphical program,
 - are compatible with MBR, APM and GPT partiton table types,
- **The fdisk Family,**
 - the **fdisk** program for MBR partition table types included in the **util-linux** or **util-linux-ng** packages,
 - the **cdfisk** program for MBR partition table types included in the **util-linux** or **util-linux-ng** packages,
- **GPT fdisk,**
 - a package that supplies the **gdisk** and **sgdisk** programs which are fdisk-like and cfdisk-like programs for GPT partiton types.

LAB #1 - Using fdisk

Partioning under Linux can be accomplished using the **fdisk** utility:

```
[root@centos ~]# fdisk /dev/sda
```

```
WARNING: DOS-compatible mode is deprecated. It's strongly recommended to
switch off the mode (command 'c') and change display units to
sectors (command 'u').
```

```
Command (m for help):
```

Hit the **m** key and to see a menu of the commands available:

```
Command (m for help): m
Command action
  a  toggle a bootable flag
  b  edit bsd disklabel
  c  toggle the dos compatibility flag
  d  delete a partition
  l  list known partition types
  m  print this menu
  n  add a new partition
  o  create a new empty DOS partition table
  p  print the partition table
  q  quit without saving changes
  s  create a new empty Sun disklabel
  t  change a partition's system id
  u  change display/entry units
  v  verify the partition table
  w  write table to disk and exit
  x  extra functionality (experts only)
```

```
Command (m for help):
```

<note important> To create a new partition you need to use the **n** command. </note>

Create the following partitions on your disk:

Partition	Type	Size
/dev/sda4	Extended	From the first available cylinder to the last available cylinder.
/dev/sda5	Logical	500 MB
/dev/sda6	Logical	200 MB
/dev/sda7	Logical	300 MB
/dev/sda8	Logical	500 MB
/dev/sda9	Logical	400 MB
/dev/sda10	Logical	500 MB

Partition	Type	Size
/dev/sda11	Logical	500 MB
/dev/sda12	Logical	200 MB

When you have finished, use the **p** command to see the resulting partition table:

```
Command (m for help): p
```

```
Disk /dev/sda: 21.5 GB, 21474836480 bytes
255 heads, 63 sectors/track, 2610 cylinders
Units = cylinders of 16065 * 512 = 8225280 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disk identifier: 0x00098187
```

```
   Device Boot      Start         End      Blocks   Id  System
/dev/sda1  *           1           13       102400    83  Linux
Partition 1 does not end on cylinder boundary.
/dev/sda2                13          651      5120000    83  Linux
Partition 2 does not end on cylinder boundary.
/dev/sda3                651          912      2096128    82  Linux swap / Solaris
Partition 3 does not end on cylinder boundary.
/dev/sda4                912         2610     13645273    5  Extended
/dev/sda5                912          976       520136+    83  Linux
/dev/sda6                977         1002       208813+    83  Linux
/dev/sda7               1003         1041       313236    83  Linux
/dev/sda8               1042         1106       522081    83  Linux
/dev/sda9               1107         1158       417658+    83  Linux
/dev/sda10              1159         1223       522081    83  Linux
/dev/sda11              1224         1288       522081    83  Linux
/dev/sda12              1289         1314       208813+    83  Linux
```

```
Command (m for help):
```

<note important> Each block contains 1,024 bytes. Each sector contains 512 bytes. When a partition contains an uneven number of sectors it is marked with a +. </note>

<note important> Note that the first three partitions show an error - **Partition X does not end on cylinder boundary.** </note>

This error seems to imply that the partitions overlap. In order to check if they really do, change the units used in the output from cylinders to sectors by using the **u** command :

```
Command (m for help): u
Changing display/entry units to sectors

Command (m for help): p

Disk /dev/sda: 21.5 GB, 21474836480 bytes
255 heads, 63 sectors/track, 2610 cylinders, total 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
Disk identifier: 0x00098187

   Device Boot      Start         End      Blocks   Id  System
/dev/sda1  *          2048       206847       102400   83   Linux
Partition 1 does not end on cylinder boundary.
/dev/sda2            206848     10446847       5120000   83   Linux
Partition 2 does not end on cylinder boundary.
/dev/sda3        10446848     14639103       2096128   82   Linux swap / Solaris
Partition 3 does not end on cylinder boundary.
/dev/sda4        14639104     41929649       13645273    5   Extended
/dev/sda5        14639167     15679439         520136+   83   Linux
/dev/sda6        15679503     16097129         208813+   83   Linux
/dev/sda7        16097193     16723664         313236   83   Linux
/dev/sda8        16723728     17767889         522081   83   Linux
/dev/sda9        17767953     18603269         417658+   83   Linux
/dev/sda10       18603333     19647494         522081   83   Linux
```

```
/dev/sda11    19647558    20691719    522081    83    Linux
/dev/sda12    20691783    21109409    208813+   83    Linux
```

```
Command (m for help):
```

<note important> Note that the first three partitions still show an error - **Partition X does not end on cylinder boundary**. However if you study the Start and End sectors of each partition you can see that they do not overlap. </note>

Write the partition table to disk using the **w** command and restart your virtual machine:

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

```
Calling ioctl() to re-read partition table.
```

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

Login and launch fdisk to check if your changes have been taken into account:

```
[trainee@centos ~]$ su -
Password:
[root@centos ~]# fdisk /dev/sda
```

```
WARNING: DOS-compatible mode is deprecated. It's strongly recommended to
switch off the mode (command 'c') and change display units to
sectors (command 'u').
```

```
Command (m for help): p
```

```
Disk /dev/sda: 21.5 GB, 21474836480 bytes
```

```
255 heads, 63 sectors/track, 2610 cylinders
Units = cylinders of 16065 * 512 = 8225280 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disk identifier: 0x00098187
```

Device	Boot	Start	End	Blocks	Id	System
/dev/sda1	*	1	13	102400	83	Linux
Partition 1 does not end on cylinder boundary.						
/dev/sda2		13	651	5120000	83	Linux
Partition 2 does not end on cylinder boundary.						
/dev/sda3		651	912	2096128	82	Linux swap / Solaris
Partition 3 does not end on cylinder boundary.						
/dev/sda4		912	2610	13645273	5	Extended
/dev/sda5		912	976	520136+	83	Linux
/dev/sda6		977	1002	208813+	83	Linux
/dev/sda7		1003	1041	313236	83	Linux
/dev/sda8		1042	1106	522081	83	Linux
/dev/sda9		1107	1158	417658+	83	Linux
/dev/sda10		1159	1223	522081	83	Linux
/dev/sda11		1224	1288	522081	83	Linux
/dev/sda12		1289	1314	208813+	83	Linux

```
Command (m for help):
```

Exit fdisk using the **q** command.

Journalized Filesystems

Presentation

A **journal** is part of a **journaled** or **journaling** filesystem. Its role is to keep track of any write operations in order to guarantee data integrity in the case of a system crash.

Red Hat Linux can use one of the following two filesystems:

- Ext3
- Ext4
- ReiserFS
- XFS
- JFS

<note important> Red Hat only supports EXT2/3/4 filesystems. You cannot create a journaling filesystem on a floppy disk. </note>

<note> You can compare filesystems by consulting [this page](#) </note>

Ext3

Ext3 is a journaling filesystem 100% compatible with the traditional Ext2 filesystem. The principal difference between the two is the addition of the journal.

The commands used to manage an Ext3 filesystem are :

Command	Description
mke2fs -j	Create a filesystem
mke2fs -t ext3	Create a filesystem
mkfs.ext3	Create a filesystem
fsck	Check/Repair a filesystem
e2fsck	Check/Repair a filesystem
tune2fs	Tune a filesystem
debugfs	Debug a filesystem
dump2fs	Obtain information about the filesystem

<note important> The fsck program is normally called automatically at boot every 6 months or 20 reboots whichever comes first. </note>

For more information concerning Ext3, please see [this page](#)

Ext4

The **Ext4** filesystem was first introduced with the **2.6.19** kernel. It became stable in the **2.6.28** kernel.

Ext4, although not an evolution of the Ext3 filesystem, is backward compatible with the latter.

The major characteristics of an Ext4 filesystem are:

- volume sizes of upto **1 024 pebiotets** (1 pebiotet (Pio) = 250 octets = 1024 Tio = 1125899906842624 octets),
- space allocation by using **extents**. An extent is a contiguous area of storage reserved for a file.

Extents were introduced with the **2.6.23** kernel.

The backward compatibility with Ext3 means that:

- you can mount an Ext3 filesystem as an Ext4 filesystem,
- you can mount an Ext4 filesystem as an Ext3 filesystem except when extents have been turned on.

The commands used to manage an Ext4 filesystem are :

Command	Description
mke2fs -t ext4	Create a filesystem
mkfs.ext4	Create a filesystem
fsck.ext4	Check/Repair a filesystem
e2fsck	Check/Repair a filesystem
tune4fs	Tune a filesystem
debugfs	Debug a filesystem
dump2fs	Obtain information about the filesystem

For more information concerning Ext4, please see [this page](#).

<note important> When an ext2/ext3/ext4 filesystem is formatted by default 5% is reserved for root. Reserved space is supposed to reduce fragmentation and allow root to login in case the filesystem becomes 100% used. You can use tune2fs to reduce the amount of reserved space as follows **tune2fs -m n /dev/sdXY** where n is the new percentage to reserve. </note>

ReiserFS

The principal advantage of ReiserFS is that it is much more efficient than Ext3 at storing files of a size of a couple of KB. This can lead to a 10% disk space gain when compared to Ext3.

The commands used to manage an ReiserFS filesystem are :

Command	Description
mkreiserfs	Create a filesystem
mkfs.reiserfs	Create a filesystem
reiserfsck	Check/Repair a filesystem
reiserfstune	Tune a filesystem
debugreiserfs	Debug a filesystem
debugreiserfs	Obtain information about the filesystem

For more information concerning ReiserFS , please see [this page](#).

XFS

XFS is a 64-bit journaling filesystem created by SGI for its IRIX operating system. XFS was introduced into Linux in the 2.6.xx kernels.

The commands used to manage an XFS filesystem are :

Command	Description
mkfs.xfs	Create a filesystem
xfs_check / xfs_repair	Check/Repair a filesystem
xfs_admin	Tune a filesystem

Command	Description
xfs_db	Debug a filesystem
xfs_info	Obtain information about the filesystem. Requires the filesystem to be mounted.

For more information concerning XFS, please see [this page](#).

Swap Space

Swap Size

The following table gives the recommended swap size as a function of the quantity of RAM in the system:

RAM	Swap Size
4 GB or less	2 GB
4 GB to 16 GB	4 GB
16 GB to 64 GB	8 GB
64 GB to 256 GB	16 GB

Swap Partitions

A swap partition can be created on:

- a Disk Partition,
- a Software RAID device,
- a Logical Volume.

The swapon Command

To see a list of the current swap devices, use the **swapon** command with the **-s** switch.

```
[root@centos ~]# swapon -s
Filename                Type          Size    Used    Priority
/dev/sda3                partition    2096120  0      -1
```

<note important> Note that in the above example the swap is not being used. There is also a notion of swap priority which we will detail later. </note>

Command Line Switches

The switches associated with this command are:

```
[root@centos ~]# swapon --help

Usage:
  swapon -a [-e] [-v] [-f]           enable all swaps from /etc/fstab
  swapon [-p priority] [-v] [-f] <special>  enable given swap
  swapon -s                          display swap usage summary
  swapon -h                          display help
  swapon -V                          display version

The <special> parameter:
  {-L label | LABEL=label}          LABEL of device to be used
  {-U uuid | UUID=uuid}            UUID of device to be used
  <device>                          name of device to be used
  <file>                             name of file to be used
```

<note important> Note that the **-p** switch is used to set the swap priority. </note>

La Commande swapoff

In our case the swap partition is **/dev/sda3**. To turn off the swap, use the following command:

```
[root@centos ~]# swapoff /dev/sda3
[root@centos ~]# swapon -s
Filename                Type          Size      Used      Priority
```

To turn the swap back on, use the **swapon** command:

```
[root@centos ~]# swapon /dev/sda3
[root@centos ~]# swapon -s
Filename                Type          Size      Used      Priority
/dev/sda3               partition    2096120    0        -1
```

Command Line Switches

The switches associated with the swapoff command are:

```
[root@centos ~]# swapoff --help
```

Usage:

```
swapoff -a [-v]           disable all swaps
swapoff [-v] <special>   disable given swap
swapoff -h                display help
swapoff -V                display version
```

The <special> parameter:

```
{-L label | LABEL=label} LABEL of device to be used
{-U uuid | UUID=uuid}    UUID of device to be used
<device>                 name of device to be used
<file>                   name of file to be used
```

The /etc/fstab file

For each swap partition, there must be an entry in the **/etc/fstab** file:

```
[root@centos ~]# cat /etc/fstab

#
# /etc/fstab
# Created by anaconda on Fri Oct 25 09:32:46 2013
#
# Accessible filesystems, by reference, are maintained under '/dev/disk'
# See man pages fstab(5), findfs(8), mount(8) and/or blkid(8) for more info
#
UUID=c7b1d3e8-6471-4cba-947b-430db974e774 /          ext4    defaults    1 1
UUID=d8988475-7dc7-4a61-8081-6153b7c9551b /boot      ext4    defaults    1 2
UUID=a1d6a043-6f10-4f60-bb9c-aaaac9632c57 swap       swap    defaults    0 0
tmpfs          /dev/shm          tmpfs    defaults    0 0
devpts         /dev/pts          devpts   gid=5,mode=620 0 0
sysfs         /sys              sysfs    defaults    0 0
proc          /proc             proc     defaults    0 0
```

Each line in this file has 6 fields :

Field 1	Field 2	Field 3	Field 4	Field 5	Field 6
Special file or UUID or Virtual File System	Mount Point	Filesystem Type	Comma separated list of options	Used by the dump command (1 = dump, 0 or empty = do not dump)	The order in which the <i>fsck</i> command checks the disks/partitions at boot time

The **UUID** (*Universally Unique Identifier*) is a randomly generated 128 bit string that is automatically generated by the system when a filesystem is created on the partition.

<note> Please see the manual for the **mount** command to document yourself on the different options available in field 4. </note>

Swap Files

You can also use a file as swap space. Create a swap file of 256 MB using the dd command:

```
[root@centos ~]# dd if=/dev/zero of=/swap bs=1024k count=256
256+0 records in
256+0 records out
268435456 bytes (268 MB) copied, 5.62261 s, 47.7 MB/s
```

To set up this file as swap space you need to use the following command:

```
[root@centos ~]# mkswap /swap
mkswap: /swap: warning: don't erase bootbits sectors
on whole disk. Use -f to force.
Setting up swappiness version 1, size = 262140 KiB
no label, UUID=77dc521a-e239-4be2-8764-ab5b31fde1ed
```

Now activate the swap file with a priority of 3:

```
[root@centos ~]# swapon -p3 /swap
```

Pour visualiser les espaces swap, saisissez la commande suivante :

```
[root@centos ~]# swapon -s
Filename                Type              Size    Used    Priority
/dev/sda3                partition        2096120    0    -1
/swap                   file             262136     0     3
```

<note important> The swap file has a priority of 3. This means it will be used in preference to the swap partition that has a lower priority. </note>

In order to activate the swap file at boot time, you need to edit the **/etc/fstab** file:

[fstab](#)

```
#
# /etc/fstab
```

```
# Created by anaconda on Fri Oct 25 09:32:46 2013
#
# Accessible filesystems, by reference, are maintained under '/dev/disk'
# See man pages fstab(5), findfs(8), mount(8) and/or blkid(8) for more info
#
UUID=c7b1d3e8-6471-4cba-947b-430db974e774 /                ext4    defaults    1 1
UUID=d8988475-7dc7-4a61-8081-6153b7c9551b /boot            ext4    defaults    1 2
UUID=a1d6a043-6f10-4f60-bb9c-aaaac9632c57 swap             swap    defaults    0 0
/swap                                swap      swap        defaults    0 0
tmpfs                                /dev/shm  tmpfs       defaults    0 0
devpts                                /dev/pts  devpts      gid=5,mode=620 0 0
sysfs                                  /sys      sysfs       defaults    0 0
proc                                   /proc     proc        defaults    0 0
```

<note important> Do not modify your /etc/fstab file since you are going to delete the swap file. </note>

Now turn off the swap file:

```
[root@centos ~]# swapoff /swap
[root@centos ~]# swapon -s
Filename                Type          Size      Used      Priority
/dev/sda3                partition    2096120   0         -1
```

Now delete the swap file:

```
[root@centos ~]# rm /swap
rm: remove regular file `/swap'? y
```

~~DISCUSSION:off~~

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