

Booting Multiple Operating Systems

Presentation to the Bowie Senior Computing Club

7/16/2015

Problem:

1. Our Computer Lab systems need to boot multiple operating systems [currently handle Win7, Win8]
2. We have a single-“**MBR**”-disk configuration
3. Want to keep our image-backup scheme for system maintenance [requires a large “Backup” partition]

Solution:

1. Utilize a multiple-partition configuration
2. Use a “**boot manager**” [we already do ---- “*just*” need to add more partitions!]

Result: eventual success,
but many lessons learned.

Formats (make “1”s & “0”s meaningful)

Three tiers:

- File formats: e.g. pictures can be stored in JPG, PNG, PDF, PDS, It's the job of “apps” (software programs) to understand / decode them. Note that it doesn't matter what kind of partition they're in.
- Partition formats: e.g. FAT16, FAT32, NTFS, Ext4, It's the job of operating systems to understand / decode these. If the OS supports a partition type, you can ignore the details – just copy, move, drag-and-drop,
- HDD primary structures (special concern is the boot partition): In order to load the OS, something other than the OS needs to control the HDD. This is the job of software in non-volatile memory that's not on the HDD. Two classes of this stuff: old style=**BIOS** which handles only **MBR** disks; new style=**UEFI** which handles MBR & **GPT** disks.

Utilities You May Need

- [GNU Partition Editor](#) (GPartEd): bootable partition utilities – best for controlling the “extended” partition
- [Partition Wizard](#): bootable partition utilities – best for moving / resizing partitions
- [EasyBCD](#): a Windows-based utility to control the Windows Boot Manager
- Windows Disk Management: >Control Panel >Admin Tools >Computer Management >Disk Management

Master Boot Record (MBR)

- The Master Boot Record is the first sector on every disk. It's small – just 512 bytes.
- The MBR contains the *partition table* for the disk and a small amount of executable code that examines the partition table, and identifies the partition with the operating system. The MBR then finds the system partition's starting location on the disk, loads that *boot sector* into memory, and transfers control to it.

MBR = 1st 512 Bytes on the Disk

Offset(h)	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	
0000000000	33	C0	8E	D0	BC	00	7C	8E	C0	8E	D8	BE	00	7C	BF	00	3ÀŽĐ4.. ŽÀŽĐ%.. ¿.
0000000010	06	B9	00	02	FC	F3	A4	50	68	1C	06	CB	FB	B9	04	00	.²...üó«Ph...Ëû²..
0000000020	BD	BE	07	80	7E	00	00	7C	0B	0F	85	0E	01	83	C5	10	%%.€~...fÅ.
0000000030	E2	F1	CD	18	88	56	00	55	C6	46	11	05	C6	46	10	00	ãñí.ˆV.UÆF...ÆF..
0000000040	B4	41	BB	AA	55	CD	13	5D	72	0F	81	FB	55	AA	75	09	‘A»ˆUí.]r...ûUˆu.
0000000050	F7	C1	01	00	74	03	FE	46	10	66	60	80	7E	10	00	74	÷Á...t.þF.f`€~...t
0000000060	26	66	68	00	00	00	00	66	FF	76	08	68	00	00	68	00	&fh....fýv.h..h.
0000000070	7C	68	01	00	68	10	00	B4	42	8A	56	00	8B	F4	CD	13	h..h...‘BŠV.<óí.
0000000080	9F	83	C4	10	9E	EB	14	B8	01	02	BB	00	7C	8A	56	00	ŸfÄ.žě...».. ŠV.
0000000090	8A	76	01	8A	4E	02	8A	6E	03	CD	13	66	61	73	1C	FE	Šv.ŠN.Šn.í.fas.þ
00000000A0	4E	11	75	0C	80	7E	00	80	0F	84	8A	00	B2	80	EB	84	N.u.€~.€..„Š.ˆ€ë„
00000000B0	55	32	E4	8A	56	00	CD	13	5D	EB	9E	81	3E	FE	7D	55	U2äŠV.í.jěž.>þ)U
00000000C0	AA	75	6E	FF	76	00	E8	8D	00	75	17	FA	B0	D1	E6	64	ˆunýv.è...u.ú°Ñæð
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00000000E0	00	FB	B8	00	BB	CD	1A	66	23	C0	75	3B	66	81	FB	54	.û,...»í.f#Au;f.ûT
00000000F0	43	50	41	75	32	81	F9	02	01	72	2C	66	68	07	BB	00	CPAu2.û...r,fh.».
0000000100	00	66	68	00	02	00	00	66	68	08	00	00	00	66	53	66	.fh....fh....fSf
0000000110	53	66	55	66	68	00	00	00	00	66	68	00	7C	00	00	66	SfUfh....fh. ..f
0000000120	61	68	00	00	07	CD	1A	5A	32	F6	EA	00	7C	00	00	CD	ah...í.Z2ðè. ...í
0000000130	18	A0	B7	07	EB	08	A0	B6	07	EB	03	A0	B5	07	32	E4	. . .ë. ¶.ë. u.2ä
0000000140	05	00	07	8B	F0	AC	3C	00	74	09	BB	07	00	B4	0E	CD	...<ð-<.t.»...‘.í
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0000000160	24	02	C3	49	6E	76	61	6C	69	64	20	70	61	72	74	69	\$.ÄInvalid parti
0000000170	74	69	6F	6E	20	74	61	62	6C	65	00	45	72	72	6F	72	tion table.Error
0000000180	20	6C	6F	61	64	69	6E	67	20	6F	70	65	72	61	74	69	loading operati
0000000190	6E	67	20	73	79	73	74	65	6D	00	4D	69	73	73	69	6E	ng system.Missin
00000001A0	67	20	6F	70	65	72	61	74	69	6F	67	20	72	78	73	74	g operating syst
00000001B0	65	6D	00	00	00	63	7B	9A	94	45	9D	25	00	00	00	01	em...c{š“E.š....
00000001C0	01	00	DE	FE	3F	04	3F	00	00	00	86	39	01	00	80	19	←.pp?..?.... 9...C.
00000001D0	15	05	07	FE	FF	FF	00	40	01	00	00	50	2D	01	00	FE	...þÿÿ.©...P--þ
00000001E0	FF	FF	07	FE	FF	FF	00	90	2E	01	00	00	A6	0E	00	FE	ÿÿ.þÿÿ..... ...þ
00000001F0	FF	FF	0F	FE	FF	FF	FE	9F	D4	0F	02	C0	7F	47	55	AA	←.þÿÿþÿð.Ä.C.

Partition Table (MBR scheme)

- Has a 64-byte standard layout that is independent of the operating system.
- Each entry is 16 bytes long, thus a hard limit of 4 entries!
- Each entry starts at a fixed offset from the start of the MBR.
- Data include:
 - Boot indicator (Active?)
 - Start & end addr (head / cylinder / sector) – the size of these fields creates a limit on total disk size!
 - Partition type (e.g FAT16, FAT32, NTFS, EXT4, extended,...)

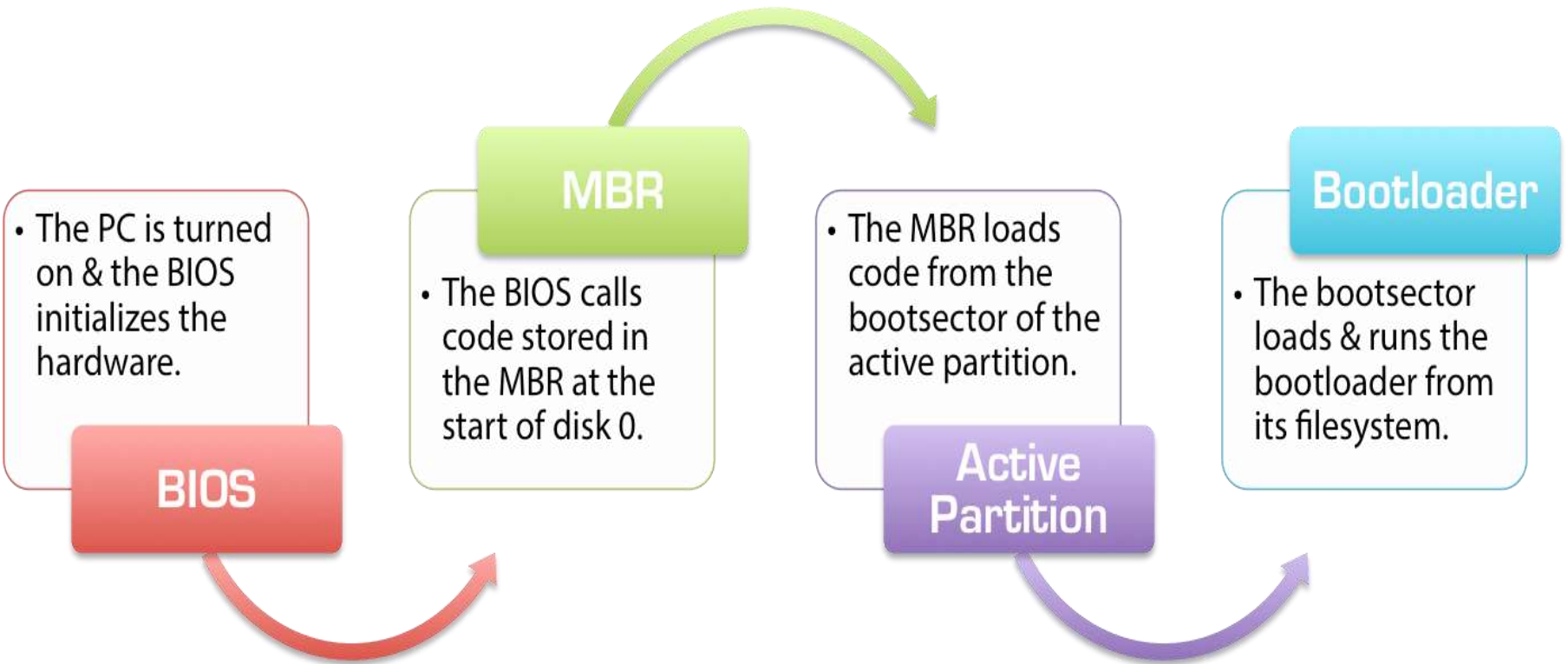
“The MBR Rules”

- Only 4 **primary** partitions per hard disk. These can be bootable.
- Of the primary partitions, only one can be marked **active**. That’s the one that actually gets booted.
- One extended partition can be added in place of a primary partition. Extended partitions hold only **logical** partitions.
- Logical partition can not be booted!

But... are these
“Hard & Fast” or “Squishy”?

BIOS Sequence

- Wait for “Power good”, POST, video card initialized, display startup screen, initialize other devices, more diagnostics (beyond POST), display system status, accept user re-configurations, ...
- Look for boot disks. Order can be set in BIOS (maybe just “HDD or more specifically HDD#2).
- Having identified its target boot drive, the BIOS looks at the [master boot record](#) (the first sector on the disk). Code in the MBR is executed, the partition table is analyzed, the **active** partition is identified & its 1st sector is loaded into memory. Finally a JUMP is made to it.
- This sector may be the boot record of the operating system, or optionally a **boot manager** could be used. A boot manager analyzes the primary partition(s) on the disk and then presents a menu to you and asks which operating system you want to use.



Boot Managers

NTLDR

- NTLDR is the default bootloader for Windows NT, 2000, and XP.
- BOOT.INI on the active partition contains the list of operating systems and their locations.
- NTDETECT.COM is a helper program that runs to detect hardware and identify devices.

BOOTMGR

- BOOTMGR is the new Windows and is used on Windows Vista, 7, 8, and 10.
- The list of operating systems is now read from the BCD file in the BOOT directory on the active partition.
- BOOTMGR is self-contained, and does not need any helper programs or routines.

GRUB(2)

- GRUB is the most-popular bootloader for Linux, though it can boot numerous other OSes as well.
- Its boot settings are stored in a file usually called grub.cfg (GRUB2) or menu.lst (GRUB).
- GRUB is a modular bootloader, that can load additional modules from disk.

So What's the Problem...

- Our current computers have MBR disks (allowing 4 primary/bootable partitions)
- We need 4 operating systems. Seems OK, but.....
- Dell uses 2 of the 4 partitions for “other stuff”!!!
 - Extended Diagnostics: During BIOS execution, you can request either BIOS-based diagnostics, or much more extensive disk-based diagnostics resident in a separate partition. This partition is “hidden”. It can be seen – but not deleted – by “Disk Management”.
 - RECOVERY: Given its name & size, this looks like it holds the data for making “recovery media”. And maybe it does – but Dell made it the Active partition!!!!

GPT versus MBR

GUID Partition Table (GPT) is the next generation partitioning scheme developed to lift restrictions of the old MBR. It's benefits include:

- Up to 128 primary partitions for the Windows implementation (only 4 in MBR);
- The maximum allowed partition size is 18 exabytes [10^{18}] (only 2 terabytes [10^{12}] in MBR);
- More reliable thanks to replication and cyclic redundancy check (CRC) protection of the partition table;
- A well defined and fully self-identifying partition format (data critical to the platform operation is located in partitions, but not in un-partitioned or hidden sectors as this is the case with MBR).

GPT Experience

- Used a partition utility to convert an MBR disk to a GPT disk. Win7 & 8 could read/write the new disk!!
- But.. the GPT disk was ~~GREEK~~ to BIOS!! The disk is absolutely not bootable by BIOS, and there is no upgrade-to-UEFI option from Dell.

So we're stuck with BIOS & MBR. Time to find out just how Squishy those rules are.

After Much Trial-and-Error

Eventually was able to configure the disk like this. RECOVERY is still the “active” partition. The green represents the “Extended” partition.

[Linux]

Ext4 Swap



Installation Sequence

1. Leave the 2 Dell partitions alone
2. Add Win7 (primary). Only one partition slot left.
3. Add an “Extended” partition. Make it the-rest-of-the-disk.
4. Within the Extended partition, add Win8, Win10 & XTRA.
5. Install Linux. Let it create the Ext4 & Swap partitions. These can either be “logical” (within Extended) or primary (Extended is shrunk and then partitions are added outside it).

Back to Those Rules...

- Only 4 primary partitions per hard disk.
- Of the primary partitions, only one can be marked active. That's the one that actually gets booted.
- One extended partition can be added in place of a primary partition. Extended partitions hold only logical partitions which cannot be booted!



All were violated!

Only 4 primary partitions (?)

Apparently Linux does their partitioning very differently. The Ext4 & Swap partitions aren't recognized by Windows Disk Manager. Partition tools like GPartEd & Partition Wizard handle all types, but even they were stopped by this rule. However, the Linux installer was not!.

Linux doesn't abide
by this rule.

Active Partition Gets Booted (?)

RECOVERY is the active partition. It holds no operating system, but:

- It does hold the Boot Manager; and
- The MBR processing does in fact jump to the active partition

Marking a partition “active” means that its boot record gets executed after MBR processing. This active partition isn’t necessarily an operating system.

Logical Partitions Can't Be Booted (?)

Well, when called from a boot manager...

...yes they can!

Questions?

And now it's time to play with the systems!

All FOUR of them!