

PC partitioning, OS2 LVM, GPT

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Principles of disk-partitioning as used on most personal computer systems, including the OS/2 Logical Volume Manager extensions and the GPT style partition tables (macOS, Windows)

FSYS - *software*

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Presentation contents

- Who am I
- Physical disk layout
- Partition-tables, MBR style
- Primary versus Logical partitions
- OS/2 Logical Volume Manager
- Brief overview of GPT partitioning
- Examples using DFSee ...

Who am I ?

Jan van Wijk

- Software Engineer, C, C++, Rexx, PHP, Assembly
- Founded FSYS Software in 2001 developing and supporting DFSee from version 4 to 15.x
- First OS/2 experience in 1987, developing parts of OS/2 1.0 EE (Query Manager, later DB2)
- Used to be a systems-integration architect at a large bank, 500 servers and 7500 workstations
- Developing embedded software for machine control and appliances from 2008 onwards

Home page: <https://www.dfsee.com/>

Why use partitions ?

- To keep things separate, like applications and data, operating system, swap-space
- To have different/multiple drive letters (PC)
- To use the full disk-size when the filesystem is limited in size (FAT 2GiB, HPFS 64 GiB)
- To use more than one OS (multi boot)
- Because most operating systems require partitioning data, even with a single partition (except on 'large floppy' removable media)

Partitioning methods

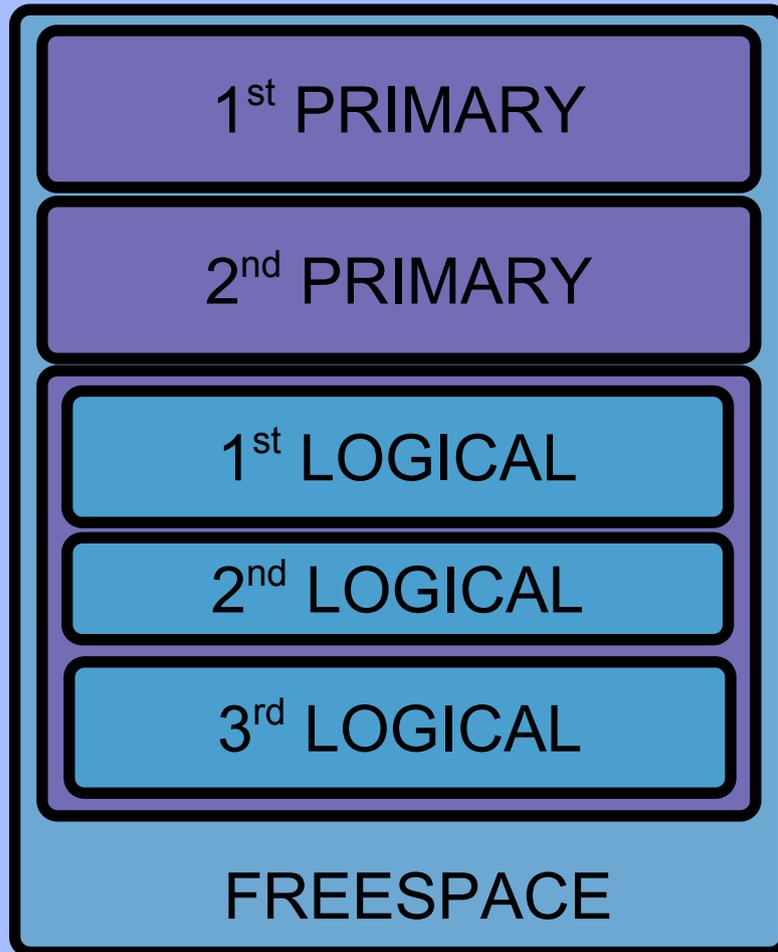
- On PC-systems, in almost all cases the classic MBR partition-tables will be used:
 - Allows dividing the disk in 4 PRIMARY areas
 - Allows subdividing one of these in LOGICAL areas
 - Include 'bootable' indicator and actual boot code
- Other alternatives, PC or others are:
 - Guid based Partition Tables (GPT) on Intel-MAC and newer Windows (incl 'Dynamic disk' variant)
 - Macintosh disk partitioning, for backward compatibility
 - Several Unix and Mainframe methods for partitioning

Classic PC partitioning

- Each disk has a Master Boot Record (MBR) with boot code and 4 partition table entries
- The system BIOS will boot using the code in the MBR on 1st (or a selectable) disk
(Or GPT boot program via UEFI style BIOS)
- The boot code in the active partition on that disk will be used to continue the booting process
This is either an OS, boot manager or both
- BIOS and OS may see disk order differently!

MBR partitioned disk

Partitioned disk



Primary partition

Primary partition

Extended partition
in this case containing 3
Logical partitions.

EXTENDED CONTAINER

MBR partition table

Partition Table

Start	Entry-1
End	
Start	Entry-2
End	
Start	Entry-3
End	
Start	Entry-4
End	

MBR partition-table entry layout

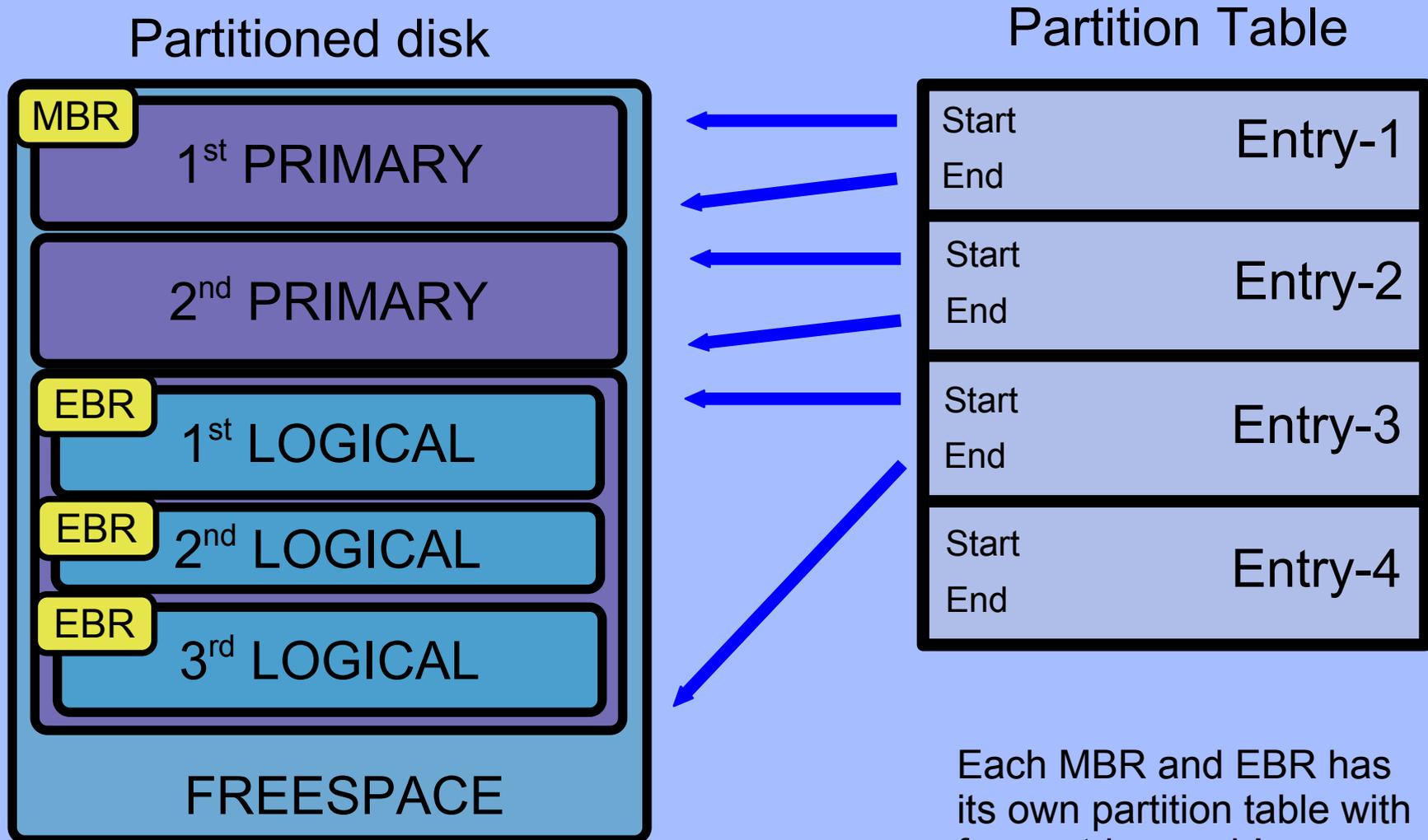
- 1 Flag Active/bootable indicator
- 3 CHS-start Start location as CHS
- 1 Type System-type
- 3 CHS-end End location as CHS
- 4 LBA-offset Linear offset (start)
- 4 LBA-size Size in sectors

There are FOUR such entries in each MBR or EBR, starting at byte offset 0x1BE

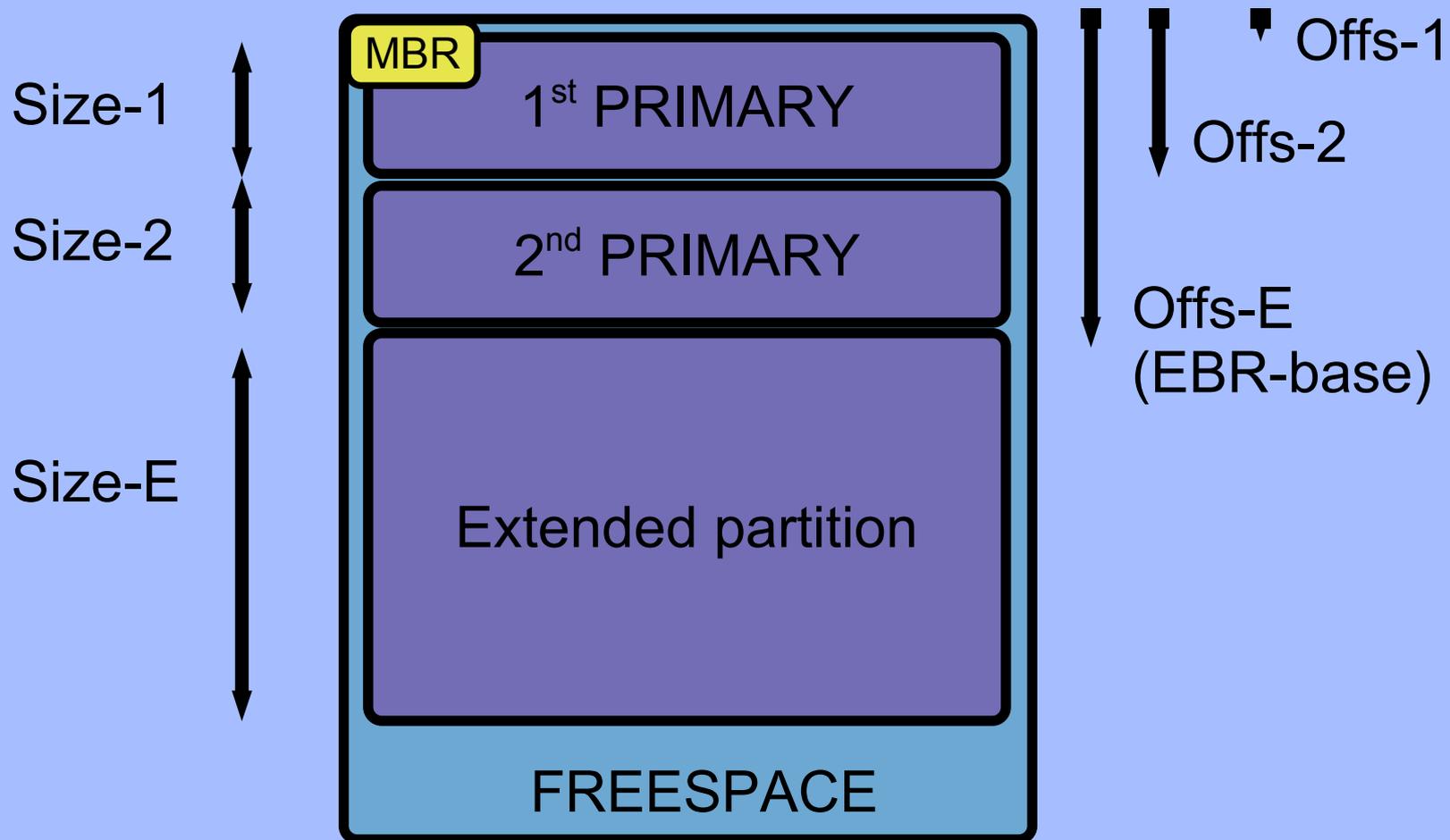
MBR partitioning properties

- A partition table has a maximum of 4 entries
 - MBR can hold 4 PRI, or 3 PRI and 1 extended
 - EBR usually holds 1 logical, and 1 'next' extended partition, forming an infinite linked list of logicals
- Partitions can be 'hidden' using a type value
 - One primary or multiple visible ones allowed by OS
 - Hiding logicals is usually not supported
 - Real visibility also depends on other OS specific settings, and availability of the right FS drivers
- BIOS boots primaries only (on some disks)
 - Boot manager allows boot from logical (OS2, Linux)

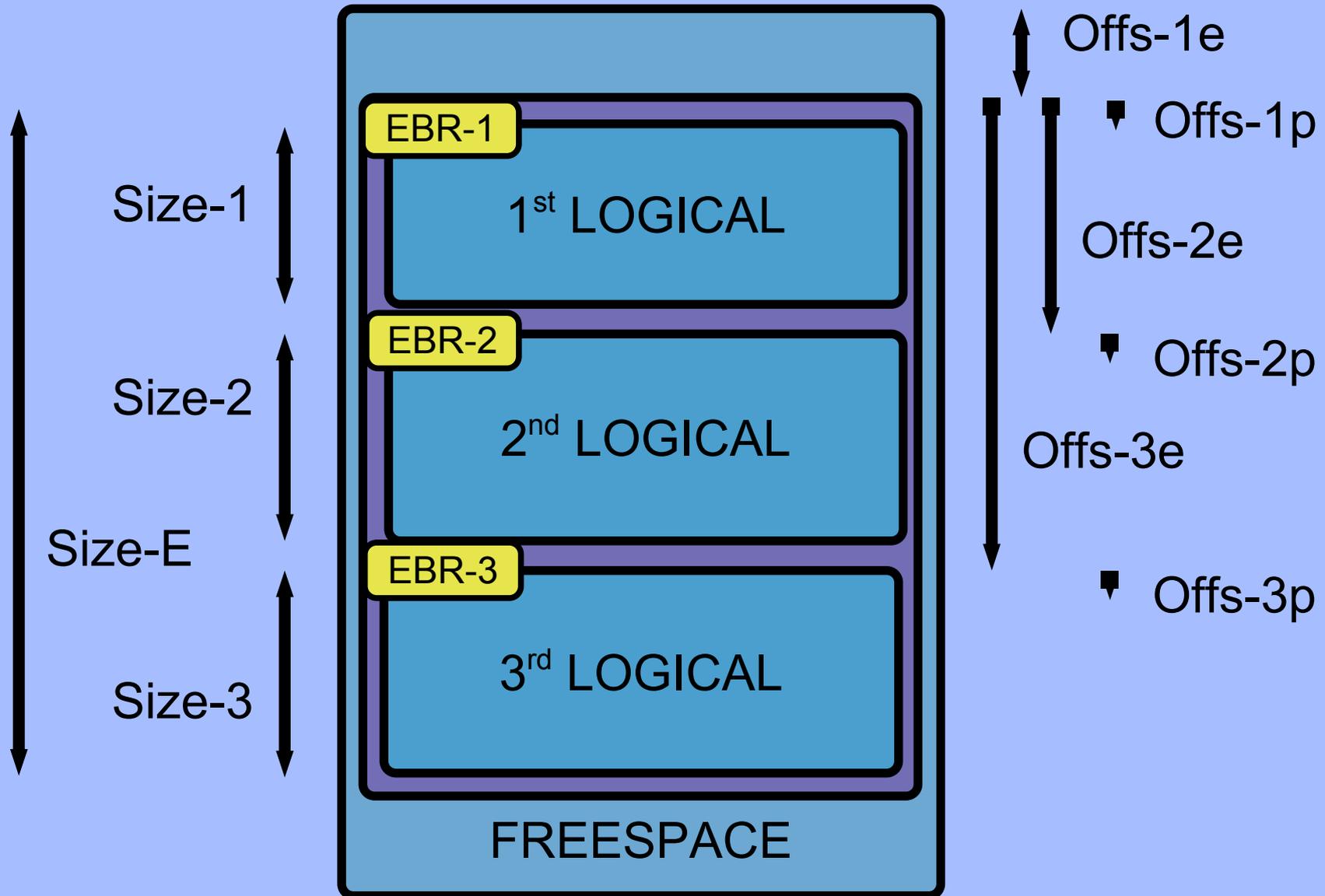
MBR-EBR placement



MBR table details



EBR table details



MBR/EBR table values

- Offs-1e Size-E = Extended container
- Offs-1p Size-1 = 1st logical partition
- Offs-2e Size-2 = 2nd extended
- Offs-2p Size-2 = 2nd logical partition
- Offs-3e Size-3 = 3rd extended
- Offs-3p Size-3 = 3rd logical partition

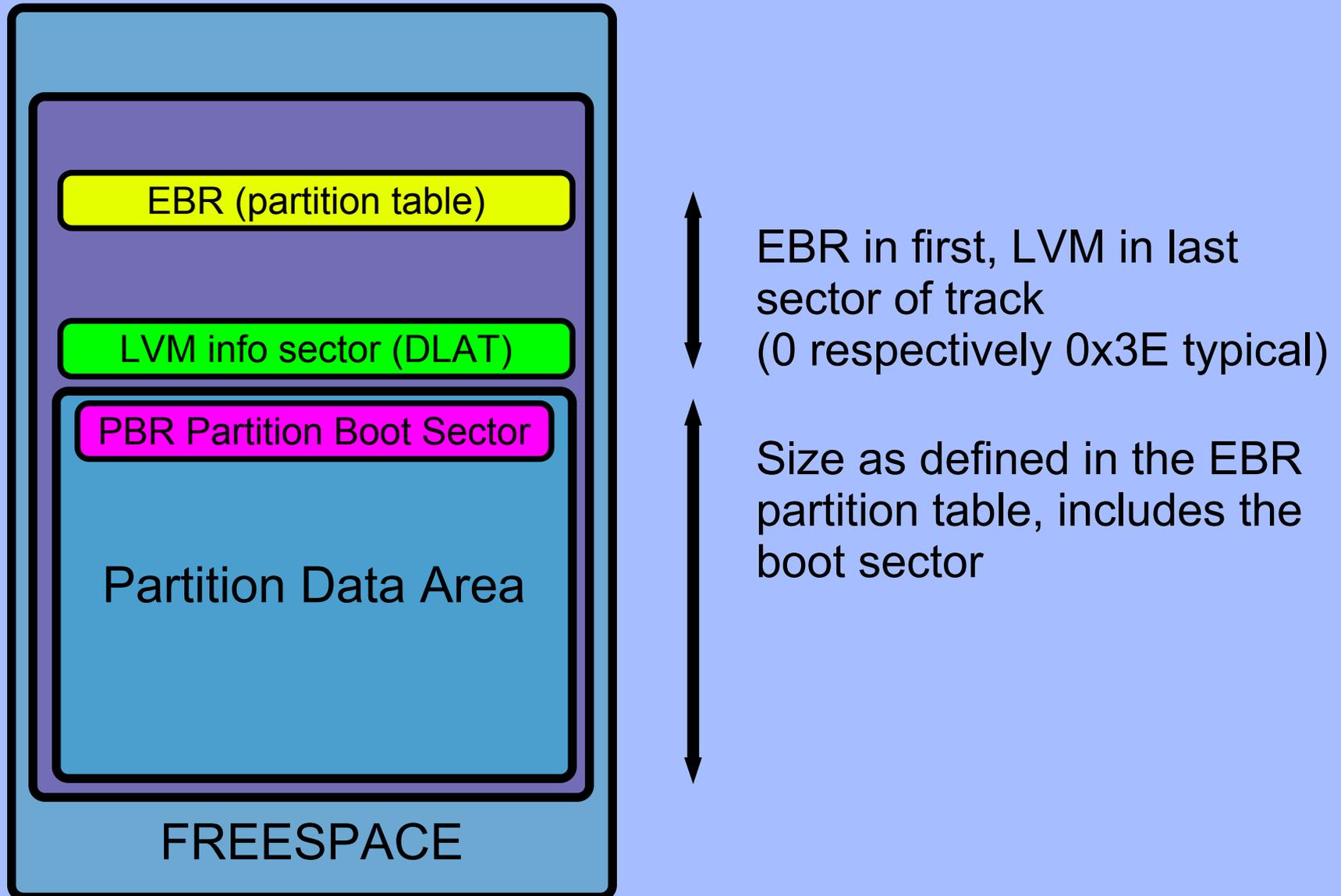
What does OS/2 LVM add ?

- The volume concept, where a volume is used to store a complete filesystem
- Volumes can have multiple partitions on any number of disks (disk spanning)
- 20-character descriptive names for disks, partitions and volumes
- Free assignment of drive letters

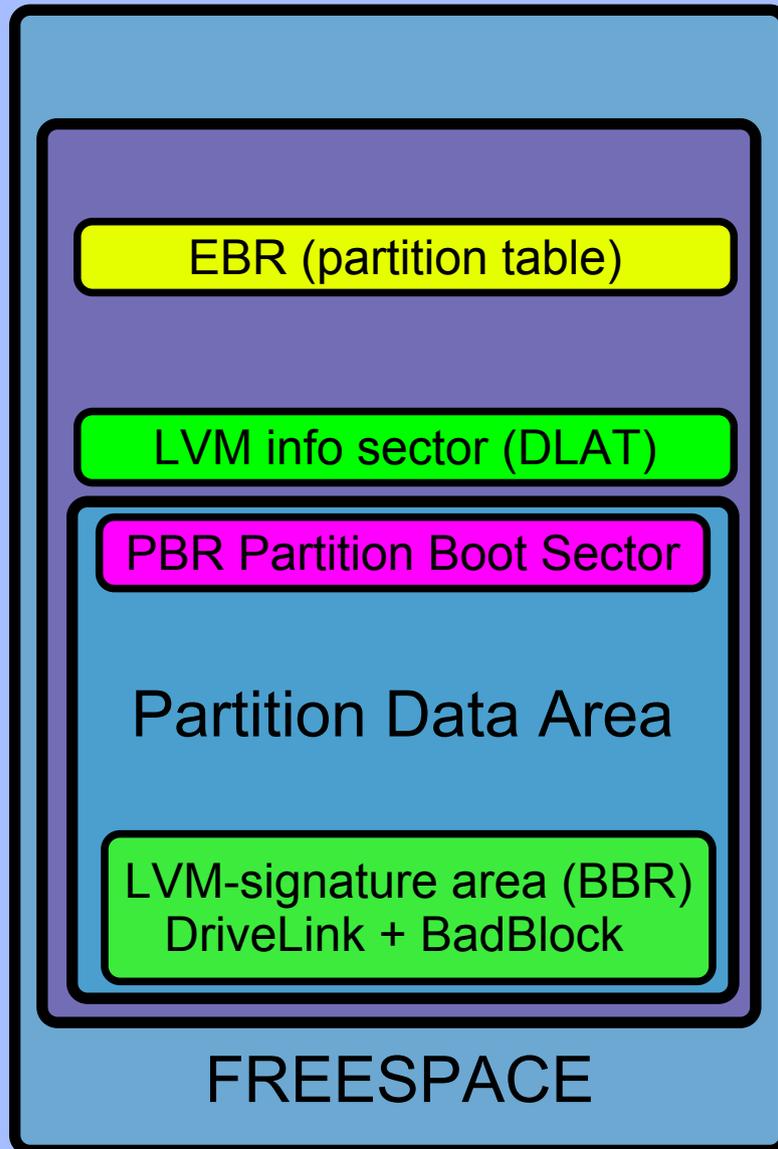
Why use LVM, advantages

- Dynamic expansion of volumes is possible by adding more partitions (OS2: JFS only)
- Can use one large volume on multiple disks
- Drive letter assignments do not change when partitions are added or removed
- LVM can handle bad-block relocation for the filesystem (OS2: non-bootable JFS only)

LVM compatibility volume



LVM volume, usually JFS



EBR in first, LVM in last sector of track
(0 respectively 0x3E typical)

Size as defined in the EBR partition table, includes the bootsector and LVM cylinder

Nett partition size as seen by the filesystem up to 1 cylinder LESS than seen in partition table!

LVM-info structure layout

- Used by compatibility and LVM (JFS) volumes
- IBM name: Drive Letter Assignment Table
- Generic info in each DLAT sector:
 - Disk geometry, disk name and disk-id value
 - Boot-disk-id, sector CRC-value and install flags
- Partition specific information (max 4 entries):
 - Start PSN of partition and size in sectors
 - Volume-id and Partition-id values
 - On-BM-menu flag and installable flag
 - Volume and Partitions names (20-character max)
 - Assigned drive letter, if any (zero if hidden)

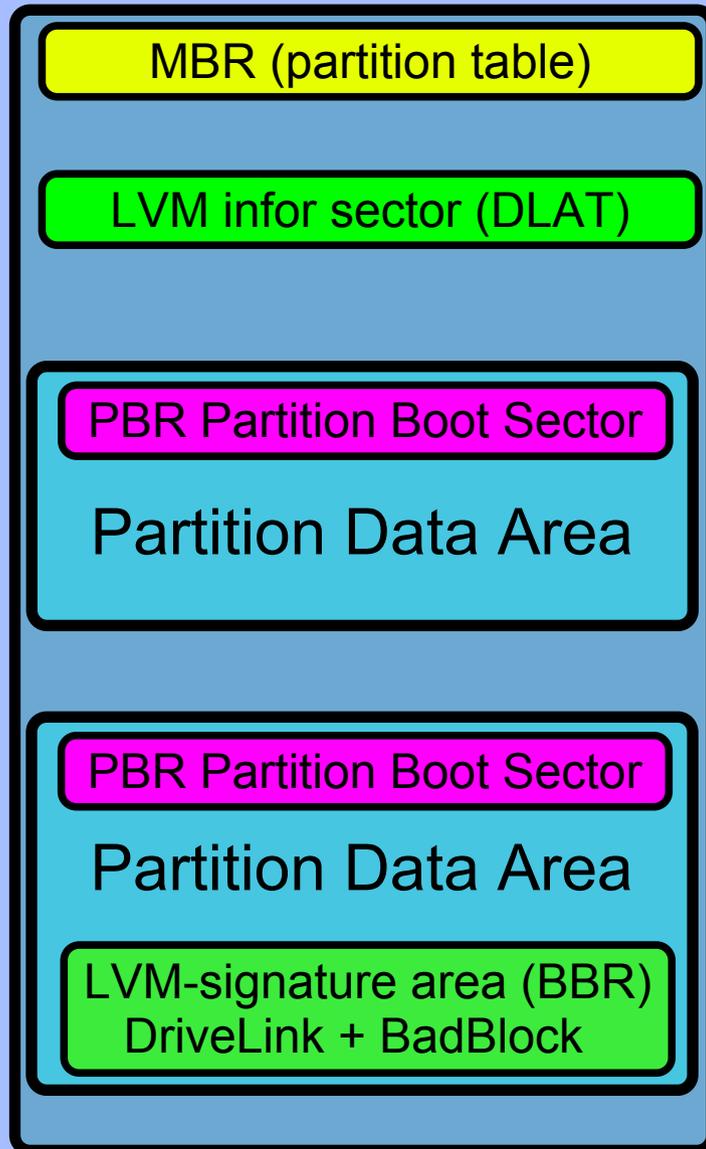
LVM-signature structure layout

- Used by LVM type 0x35 (JFS) volumes only
- Partition specific information (always 1):
 - Start PSN, last PSN and partition size in sectors
 - Boot-disk-id and sector CRC-value
 - Volume-id and Partition-id values
 - Volume and Partitions names (20-character max)
 - Assigned drive letter, if any (zero if hidden)
 - Fake-EBR sector PSN, describes whole volume
 - Partition comment-string (not used by LVM yet)
 - LVM major and minor version number
 - Disk name, 20 character description
 - Sequence and aggregate information (multi-part-vols)

LVM features linked to signature

- The LVMsig sector can link to multiple features which will be located in the same (last) cylinder
- For the Warp 4.5 LVM only two are defined:
 - Bad Block Relocation data (BBR)
An area of sectors set apart to be replacements for sectors detected as 'bad', managed by LVM
 - Drive Link data (DL)
Listing all partitions (by partition-id) that are part of the same volume, and also their ordering

LVM info for primary partitions



MBR in very first sector (0)

LVM info for up to 4 primaries
in last sector 1st track (typical 0x3E)

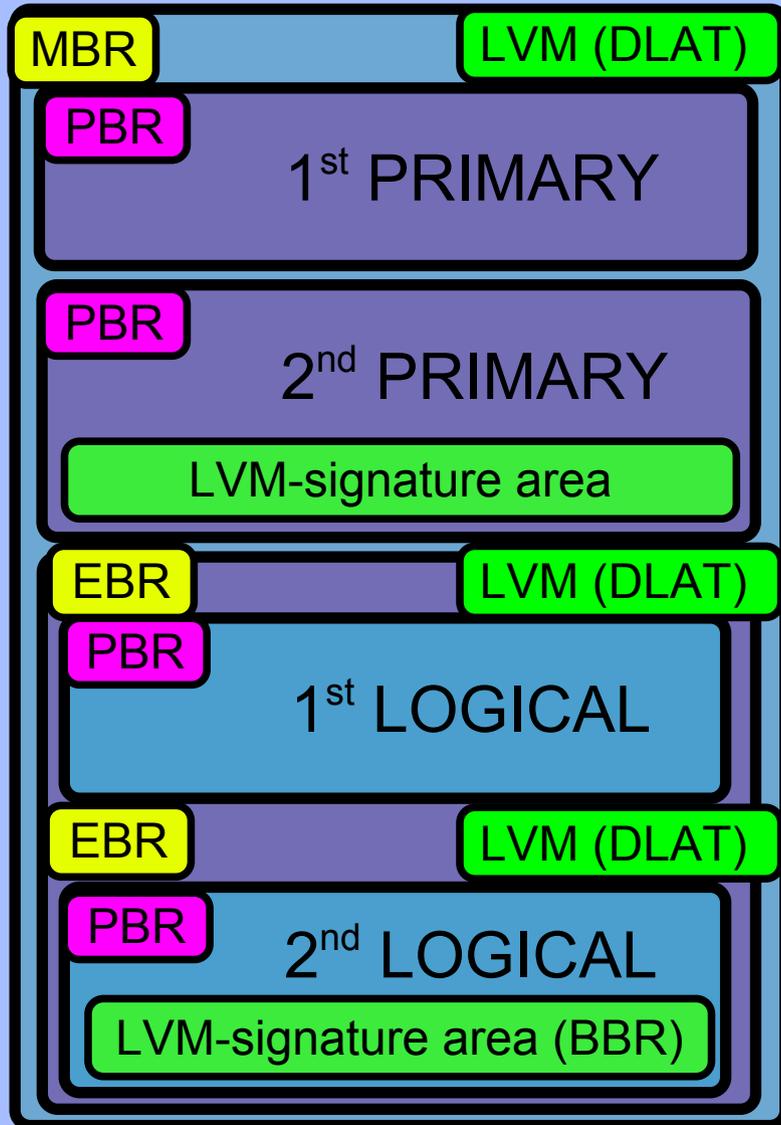


Primary Compatibility Volume.
Size as defined in MBR table
includes boot sector



Primary LVM (JFS) Volume.
Size as defined in MBR table
includes boot sector AND the
LVM signature area

MBR-EBR-LVM placement



First track, MBR (0) and LVM (0x3e)

Primary Compatibility partition

Primary LVM-JFS partition (classic)

Logical Compatibility partition

Logical LVM-JFS partition (classic)

CHS addressing, background

- CHS values were present in the tables because they are exactly in the format required by the standard programming interface of these days being the 'interrupt 13' calls in DOS/BIOS
- The specific fields are sized to fit in 3 bytes, taking up minimum CPU-register space.
- This choice has led to limits and restrictions in CHS style addressing that still causes problems today (backward compatibility)

CHS value field layout

- hhhhhhhh CCssssss cccccccc
- C = Cylinder, 10 bits range 0 .. 1023
- H = Heads, 8 bits range 0 .. 254
- S = Sectors, 6 bits range 1 .. 63
- Head value 255 normally not used (DOS/BIOS bug)
- Sector value 0 is illegal, numbering is 1-based (cylinder and head are both zero-based)
- CHS values are NOT really used anymore, but are often CHECKED by partitioning tools

CHS related limits

- The values and ranges specified in the last slides lead to the dreaded '1024 cylinder' limit
- To maximize the addressable size with this limit, many systems use 'translation' to maximize the number of heads and sectors (255, 63) in order to minimize the number of cylinders leading to a cylinder size of 7.8 MiB, and a disk size that is directly addressable of almost 8 GiB
- Sectors beyond the limit can't be represented by CHS fields, and are replaced by DUMMY values

CHS, dummy standards

- IBM/DFSee style:
 - Use maximum valid values for all fields
 - Typical values on 255/63 geo : C:1023 H:254 S:63
- PowerQuest (partition magic) style:
 - Use maximum value for Cylinder only, rest real value
 - Typical start on 255/63 geo : C:1023 H:0 S:1
 - Typical end on 255/63 geo : C:1023 H:254 S:63
- Microsoft style:
 - Use maximum (invalid) values for all fields
 - Typical values on 255/63 geo : C:1023 H:255 S:63
 - This leads to a combined CHS value of 0xFFFFFFFF

CHS, warnings and errors

- Using dummy values that do NOT conform to the 'dummy style' of your tools will lead to errors or warnings, and sometimes prevent you from making any changes, until corrected
 - DFSee: use 'FIXCHS' with the '-c:style' option
- Using incorrect CHS values WITHIN the limits is always considered an error, and most tools will not allow any changes to be made
 - A cause for this is a change in used geometry
 - DFSee: use 'FIXCHS' to update the CHS values, or 'GEO cc hh ss' to change used geometry

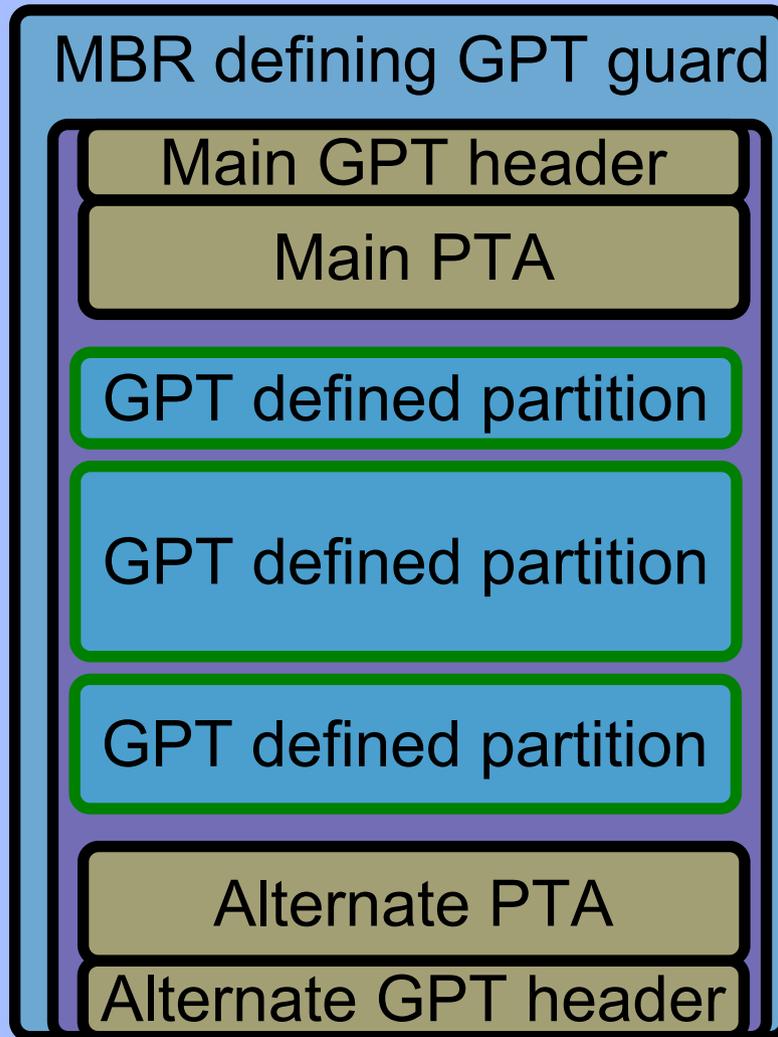
GUID Partition Tables (GPT)

- Uses (16-byte) GUID strings to identify each Disk, each Partition, and the partition types
- Allowing disks and partitions larger than 2TB (64 bit sector numbers, PSN)
- Embedded in an MBR-style 'guard' partition spanning the whole disk, for MBR tools.
- DFSee has full support for GPT style partitioning tables, including an interactive table editor (PTE) and of course in the 'CR' command and menu

GPT header and PT-Array

- The GPT header and Partition-Table-Array are duplicated at the end of the disk to support a full recovery from disk damage (reversed order)
- Header has info on PTA position and size, Header/PTA CRC's, disk size, disk GUID, version/signatures and alternate location
- Array entry has partition type (GUID), size and position info, some extra flags and a descriptive (unicode) name for the partition

GPT Partitioned disk



1 sector, guard starting at 2nd!

Main GPT header (1 sector) and main Partition Table Array (PTA)
Size 1 KiB .. 1 MiB (typical 16 KiB)

GPT defined partitions, often at 1 MiB boundaries (0x800)

Start and size in 64-bit values

Backup copy of the GPT database

PC partitioning, OS2 LVM, GPT

Questions ?

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