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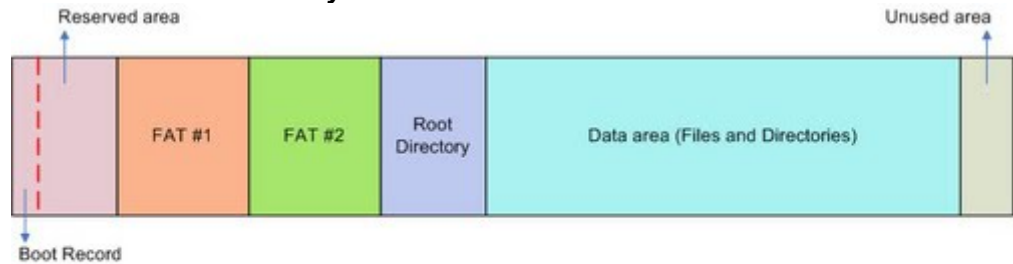
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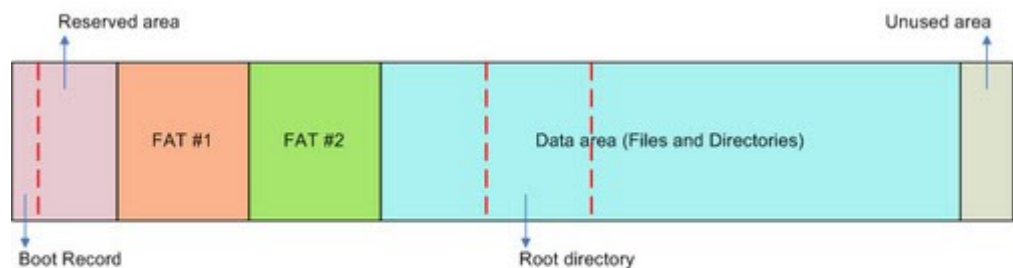
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Understanding file system

1. the structure of FAT file system



The structure of FAT16 file system



The structure of FAT32 file system

 by [iprinceps](#), <iprinceps@gmail.com>

- **The structure of FAT file system**

FAT16 and FAT32 are almost fundamentally same, but there are several differences between two file systems. The most significant difference is the existence of "Root directory area." In case of FAT16 file system, the "Root directory area" must be right after FAT #2 area. But, in FAT32 file system, there is no restriction of the location of "Root directory area", **because FAT32 file system considers root directory as one of common directories.**

- **Boot record**

This area means the first sector of a volume and the first sector of "Reserved area." In this area, there are assembly program code for booting a Windows operating system and several parameters of FAT file system. The second area is called "BIOS Parameter Block(BPB)." Even though this area is a small area which occupies just 1 sector, this area is in charge of the most important role. Because OS analyzes this area whenever OS tries to recognize a given volume. The format of boot record slightly different between FAT16 and FAT32.

- **Reserved area**

This area is reserved for the future. Normally, FAT16 allocates 1 sector for this area and FAT32 allocates 32 sectors for this area. In case of FAT16, if the size of reserved area is just 1 sector, FAT area is right after the boot record area because the boot record area uses 1 sector for itself. This area is not used in common FAT system, so programmers can use this area for their own purpose - save custom information, etc. But, FAT32 uses some sectors of the "Reserved area" for storing some information. Please pay attention to keep these sectors from a overwriting or a erasing.

- **FAT #1 and FAT #2 areas**

FAT area is the area has cluster management tables. Through FAT area

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programmer can grasp which cluster is empty and which cluster is connected to a certain file. If this area is damaged, FAT never work again - catastrophe! Fortunately, there is a copy of FAT area or more that is FAT #2 area and, of course, FAT #1 is the original. FAT #1 area and FAT #2 has exactly same data. For safe, file system has more than 1 FAT area and can have 3 or more.

- **Root directory area (only FAT16)**

In FAT16, the location of "Root directory" always right after FAT #2 area. (The location is fixed but the size can be variable.) This structure has an advantage that there is no need to search the location of root directory, however, there are some disadvantages - limited number of files, etc. Because of these drawbacks, the structure had been changed in FAT32. FAT32 just record the location of the root directory, so the location of the root directory is not concerned. Only weak point of this way is that the system is not able to know the location of the root directory if the boot record is destructed. Because of this problem, most of FAT32 codes put the root directory just after FAT #2 area. In this way, the system can find the root directory even though the boot record is seriously damaged.

- **Data area (files and directories)**

Every files and directories are stored in this area. This area is read and written by the cluster, the logical unit, basis but other areas are based on the sector.

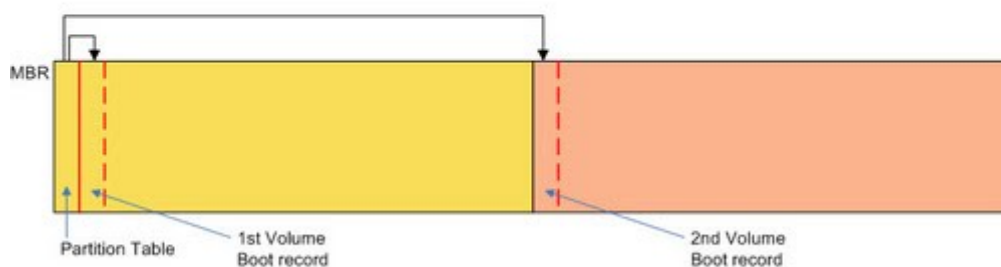
- **Unused area**

During FAT file system structurize the volume, there is always a surplus. This area is the surplus and can be used physically. But the size of this area is really small, the programmer usually don't use this area.

2. the boot record



The location of the boot record in case of the hard disk that has a single volume and no partition.



The location of the boot record in case of the hard disk that has two volumes and a partition.

by *iprinceps*, <iprinceps@gmail.com>

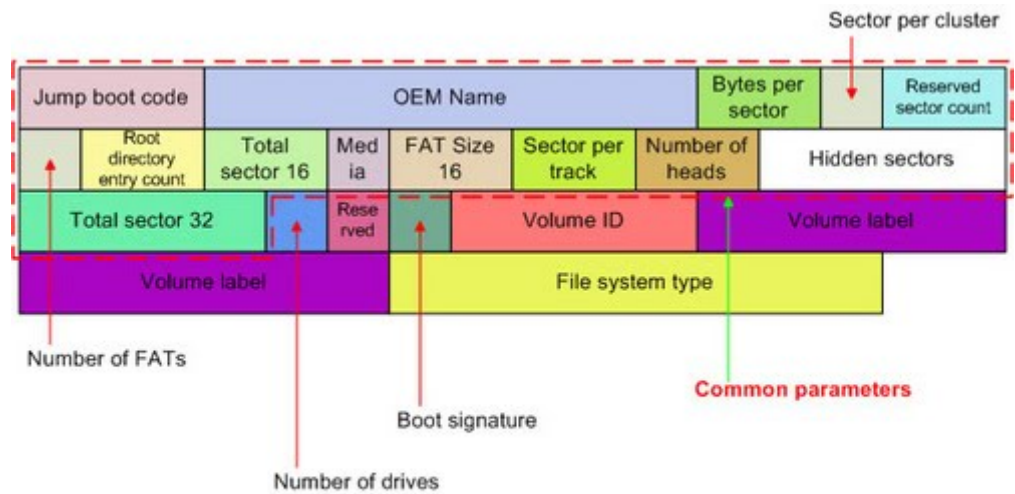
This area, called "BIOS Parameter Block(BPB)", has configuration parameters of its volume and the execution code for booting its volume. The location of the boot record is the first sector of its volume and the first sector of the "Reserved area" that is the first area of FAT file system areas. If the hard disk has two or more volumes, each volume has its own boot record. If there is only one volume because the hard disk is not partitioned, the boot record resides in the "Master boot record(MBR)" area.



The layout of the boot record of FAT16 and FAT32 file system

by *iprinceps*, <iprinceps@gmail.com>

From offset 0 to offset 32 of the boot record, there are common parameters of FAT16 and FAT32. Because parameters after offset 32 are different each other, two file systems are not compatible. Now, let's look into parameters for FAT16 file system.



The items of FAT16 boot record

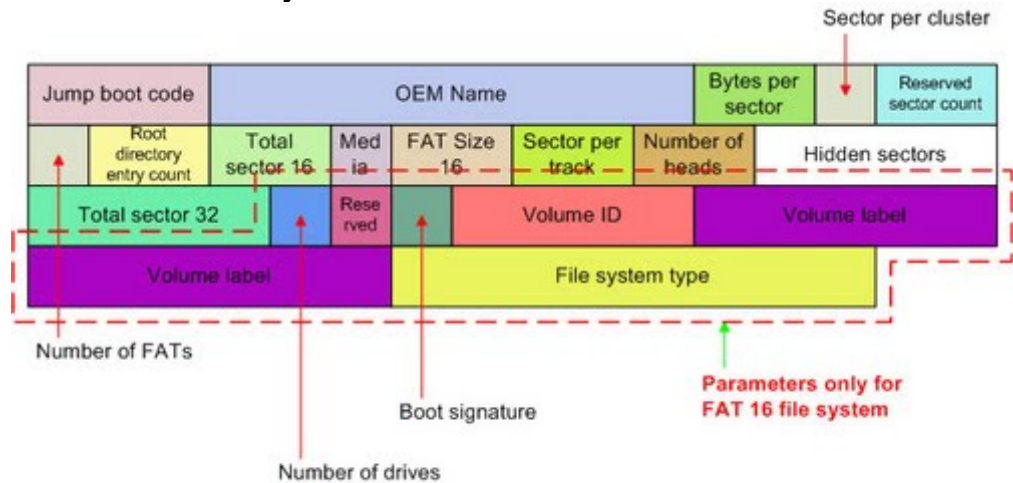
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- **Jump boot code:** The instruction that makes jump to the jump code. If a given volume is not for booting system, any data can be here.
- **OEM name:** Just string stands for OEM company. Any string can be here.
- **Bytes per sector:** This value is how many bytes does one sector has. The following values are only available - 512, 1024, 2048 and 4096. Usually, this field has 512 as its value.
- **Sector per cluster:** The number of sector each cluster has. This value must be greater than zero and be a multiple of two.
- **Reserved sector count:** This field has the number of the reserved sector. The size of the reserved area occupies one sector at least because the boot record is located at the first sector of the reserved area. So, this field have not to be zero. In FAT16, this field usually has one as its value compared to the field of FAT32 has 32. Sectors of the reserved area must be initialized by zero except the boot record and the sector that has some information.
- **Number of FATs:** This field has the number of FATs in a given volume. This value must be greater then one and 2 is recommended.
- **Root directory entry count:** (Only for FAT16) This field tells that how many entries (files and directories are the "entries") can reside in the root directory. This value is always an even number of the value of "Bytes per sector." For example, if the value of the bytes per sector is 512, this field can have values like 512, 1024, 2048, and so on. For maximizing compatibility, it is recommended that this value is 512. But, in case of FAT32, this field must be zero.
- **Total sector 16:** This value reflects total sectors of given volume. It is important that this value is NOT total sectors of the storage device BUT total sectors of the volume. If this field has a zero as its value, the "Total sector 32" field is not able to be zero. Even in case of FAT16, if the total number of sectors is greater than 0xFFFF, FAT16 uses the total sector 32 field. AND the value of this field in FAT32 must be a zero.
- **Media:** This field indicates that this volume resides in what kinds of media device. Usually, this value is 0xF8 that stands for the immovable disk. If the device is not floppy disk, 0xF8 is recommended.
 0xF0 - 1.44/2.88MB 3.5" floppy disk
 0xF9 - 720KB/1.2MB 3.5" floppy disk
 0xFD - 360KB 5.25" floppy disk
 0xFF - 320KB 5.25" floppy disk
 0xFC - 180KB 5.25" floppy disk
 0xFE - 160KB 5.25" floppy disk
 0xF8 - Any other devices
- **FAT size 16:** This field has the sector number of the FAT area. This value is not of the sum total of FAT #1 and FAT #2 area, but of the one FAT area (FAT #1 or FAT #2, because two area are same exactly). Only FAT12 and FAT16 uses this value and this value must be a zero for FAT32 file system.
- **Sector per track:** This item is for a kind of interrupt of x86 families - 0x13 interrupt. But this field is not used by windows now.
- **Number of heads:** This item is for a kind of interrupt of x86 families - 0x13 interrupt. But this field is not used by windows now.
- **Hidden sector:** This item is for a kind of interrupt of x86 families - 0x13 interrupt. This field stores the number of sector before the given volume. In volun

not partitioned, this field must be a zero. But this field is not used by windows now.

- **Total sector 32:** This value reflects total sectors of given volume. It is important that this value is NOT total sectors of the storage device bUT total sectors of the volume. If this field has a zero as its value, the "Total sector 16" field is not able to be zero. Precisely, FAT32 file system uses only this field.

3. Boot record items only for FAT16

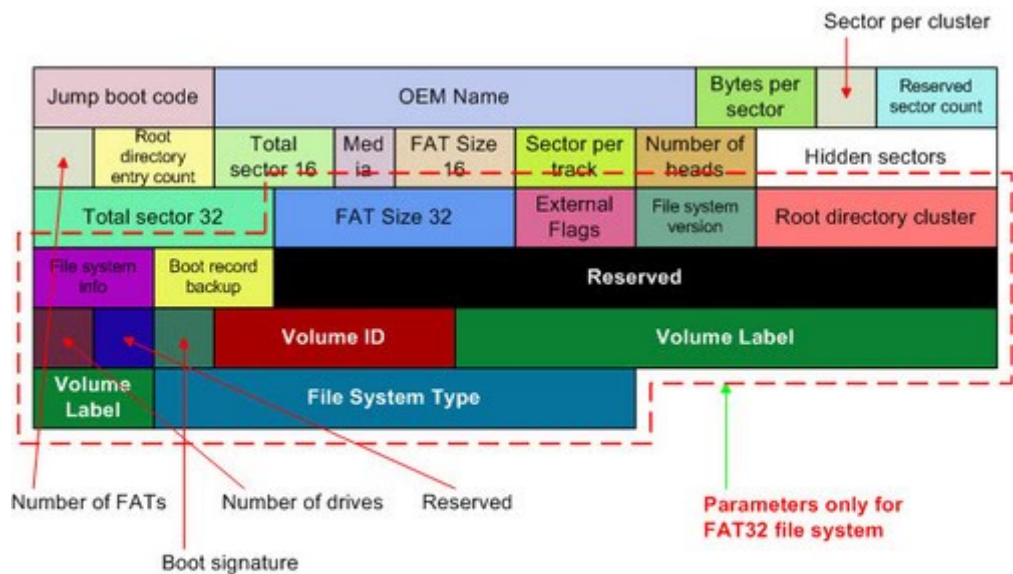


The items of FAT16 boot record

by *i princeps*, <i princeps@gmail.com>

- **Drive number:** This field is for the 0x13 interrupt signal of x86 family. This value configures the drive value defined by INT 0x13. If the drive is the floppy disk drive, this value is 0x0. If another devices, this value should be 0x80. But Windows OS does not use this value any more.
- **Reserved:** This field is only for Windows NT family and should be a zero. This field is only for FAT16 file system.
- **Boot signature:** Extended boot signature. This value always has to be '0x29'. '0x29' means that this field is not the end of the boot record and the boot record has 3 more fields after this field. This field is only for FAT16 file system.
- **Volume ID:** Volume serial numbers. The file system writes its own serial number. This field is only for FAT16 file system.
- **Volume label:** Volume label. This field has the label of the volume. The string stored this field is the the name of the disk drive by Windows. There are two field for the volume label. One is here, and the other is on the root directory that is the "Label entry". If you want to change the volume label, you should change the value of two fields. And if you do not create the "Label entry", this field must be "NO NAME". This field is only for FAT16 file system.
- **File system type:** This field can have one of the following values - "FAT12", "FAT16", and "FAT". But this field has no mean - this is just string. Windows does not use this field any more.

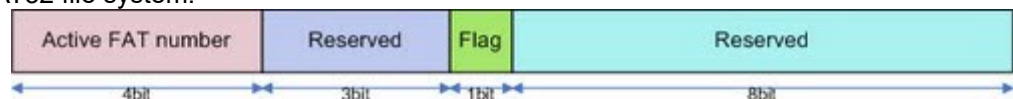
4. Boot record items only for FAT 32



The items of FAT32 boot record

by *iprinceps*, <iprinceps@gmail.com>

- **FAT size 32:** This field has the number of sectors of FAT area. The programmer should write the value of one FAT area's counts of sectors, for example, just FAT #1. This field is only for FAT32 file system.
- **External flags:** This field stores several configuration parameters. This field is only for FAT32 file system.



Active FAT number: The number of FAT that the user want to activate. This field available only when the value of Flag is '1'.

Reserved: NOT used. This field is reserved for the future.

Flag: If this field has '0', changes affect all FAT areas. And if '1', changes only affect the FAT area that indicated by Active FAT number field.

by *iprinceps*, <iprinceps@gmail.com>

- **File system version:** This field is the version of FAT32. Upper byte is a major number of the version and lower one is a minor number. Windows stop trying to recognize this partition if the version of this field is higher than the value that Windows can recognize. But, all FAT version set this field as a '0x00' and the version has never increased. So, you should write '0x00' to this field. This field is only for FAT32 file system.
- **Root directory cluster:** This field has the number of the root directory's clusters. In contrast to FAT16 file system, FAT32 has nothing to do with the location of the root directory. So, FAT32 file system writes the starting location of the root directory to this field. Normally, this has '2' as its value because the file system easily can find the location of the root directory even though the value of this field is damaged. This field is only for FAT32 file system.
- **File system information:** This value points the location of the FSInfo structure. Normally, FSInfo structure is located at the first sector of the volume. This field is only for FAT32 file system.
- **Boot record backup sector:** Because the boot record is really really important, it is wise that making a backup of the boot record. This field has the location of that backup boot sector. The location of a backup is not restricted but usually located at 6th sector. This field is only for FAT32 file system.
- **Reserved:** This field is reserved for the future and should be filled by a zero. This field is only for FAT32 file system.
- **Drive number:** This field is for 0x13 interrupt. But Windows does not use this field any more, so this field has no effect. This field is only for FAT32 file system.
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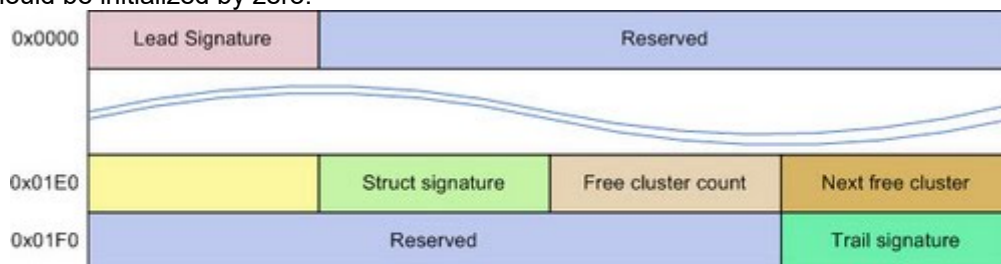
5. the end of the boot record

In implementing the boot record in your system, the last thing is the end signature of the FAT16/32 file system. The location, where the offset 511 ~ 512 of all FAT16/32 file system, should have the value of 0xAA55 - the end signature of the boot record.

Almost documents about FAT file system say, "The location of the end signature is the last part of the boot record area." This is not false, but not always true. Because the previous sentence is true just when the size of the boot record is 512 bytes. So, even though the size of the boot record is greater than 512 bytes, the end signature always locate at offset 511 ~ 512.

6. the file system information (FSInfo)

Generally, purposes of the "Reserved" area of FAT file system are the storage for the boot record and for the backup of the boot record. FAT16 and FAT32 file system should have the boot record at the first sector of the reserved area. In case of Windows FAT32 file system, it backups the boot record at 6th sector of the reserved area and saves FSInfo(File system information) at the second sector. If the boot record at the first sector is damaged, the programmer can recover the boot record by the backup at 6th sector. Because the location of FSInfo and the backup is not fixed, the programmer can change the location of fields by changing pertinent details of the boot record. The others should be initialized by zero.



The items of the FSInfo struct

by *iprinceps*, <*iprinceps@gmail.com*>

FSInfo is really simple structure.

- **Lead signature:** This field indicates that this sector has FSInfo structure. This value always should be "0x41615252" and never changed.
- **Reserved:** This field is reserved for the future and should be initialized by zero. Because this area is not used, the programmer can use this field for their own purpose.
- **Struct signature:** This field also indicates that this sector has FSInfo structure and always should have "0x61417272".
- **Free cluster count:** This item has the number of free cluster in volume. If this field is "0xFFFFFFFF", the file system does not count the number of free cluster in volume. So, the programmer should check free clusters. And this value is not always correct, so the programmer just use this field just for reference.
- **Next free cluster:** This value helps the programmer find a free cluster quickly. So, this field has the location of the cluster located most recently. If this field is "0xFFFFFFFF", the file system does not know where is free cluster. So, the programmer should find a free cluster from the first sector.
- **Trail signature:** This field, yes, also indicates that this sector has FSInfo structure and should be "0xAA550000".

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