# Section12: File Management

For Exam: Your answers will be penalized if you describe the disk blocks used to maintain file contents as “Memory”.

## Question 1

Describe the purpose of the File Descriptor.

### Answer

File descriptors are a resource created and managed by the operating system. File descriptors are a data structure created by system calls that create new files or open existing files. The file descriptor is used by system calls that manipulate the contents of a file i.e. read, write, seek, etc. The file descriptor maintains state information about the open file e.g. the stream index (position) of the next read or write operation on the open file.

## Question 2

1. Describe the purpose of the File Allocation Table.
2. Describe the purpose of the Unallocated Block List.

### Answer

1. The FAT is the data structure used to maintain the association between a file and the blocks allocated to storing the file’s contents including the ordering of the blocks.
2. The UBL is the list (set) of blocks that are currently not allocated to any file. It is the file system’s free space.

## Question 3

1. How are file systems allocated in a drive?
2. What determines the size of a file system?
3. What is the root file system?
4. What is a child file system?
5. What does it mean to *mount* a child file system?

### Answer

1. A file system is allocated to a partition. That is, the blocks contained in a partition are allocated to the file system installed in the partition.
2. A file system’s size is determined by the number of blocks allocated to the partition.
3. The root (aka the boot filesystem) file system is the single file system that is activated when the system boots. The root FS maintains the executables, libraries, and data files needed to load and execute the Operating System.
4. Child file systems are separate file systems which have been created by the administrators to organize data other than the operating system. For example, it is common to place the user’s home directories in a separate file system. Or to put database or other application data files in a separate file system.
5. Multiple file systems can be arranged in a tree with the root FS as the tree’s root and zero or more FS mounted at mount points in a mounted FS. Normally, all child FS are mounted in the root FS.

## Question 4

1. What purpose does the ‘free block bitmap’ serve?
2. What is the formula for calculating the size of the free block bitmap?
3. How large of an array (in bytes) will be needed to maintain a 1 Gig disk (1073741824) with 512-byte blocks?

### Answer

1. The free block bitmap is a technique for maintaining the unallocated blocks in a file system i.e. identifying the blocks not yet allocated to a file. The bitmap is a logical array of N bits (0|1) that represent whether block i is allocated or free (where N is the number of FS blocks).
2. 262144

## Question 5

1. What is a File System Extent?
2. What is the relationship between an extent and a file?
3. Why are large extents desired from the file allocation method?

### Answer

1. An Extent is a range of contiguous (adjacent) disk blocks that has been allocated to a file or found in the file system’s free list.
2. A file can be allocated as one or extents where extent sizes range from a single block to an extent that encompass the entire file.
3. Large extents are encouraged because as sets of contiguous blocks, an extent can be more efficiently retrieved from a HDD drive (not applicable to SSD).

## Question 6

1. Describe Contiguous File Allocation.
2. What are the two disadvantages of contiguous allocation?
3. What information is maintained in the FAT for contiguous allocation?

### Answer

1. Each file is allocated (laid out in) a contiguous range of drive blocks i.e. in a single extent.
2. 1) External fragmentation becomes a problem when the disk fills with many small regions of unallocated extents. 2) Extending a file requires moving the file from its current extent to another larger extent.
3. The FAT maintains the index of the first block and the number of blocks allocated to the file / extent.

## Question 7

1. Describe Chained File Allocation.
2. What two disadvantage does chained allocation offer?
3. What information is maintained in the FAT for chained allocation?

### Answer

1. The blocks allocated to a file maintain as a ‘linked list’ i.e. each block maintains the index of the next block in the file. Each block maintains the index of the next block.
2. The use of a pointer in each block 1) reduces the space available in the block for file data and 2) causes the amount of data stored in the block to be something other than a power of two.
3. The FAT maintains the index of the first block and the number of blocks in the chain. Optionally, an end of chain / file marker can mark the last block in the chain.

## Question 8

1. Describe the purpose of the ‘Inode’.
2. What information is maintained in the FAT for Indexed Allocation with Inodes?
3. How is inode overflow handled in the Linux filesystem?

### Answer

1. The Inode (Index Node or Index Block) is a disk block that maintains an ordered list of block numbers (addresses). The blocks in the list contain the file’s contents.
2. The FAT contains the file name and block address of the file’s inode.
3. When the size of the file exceeds the number of direct block addresses in the root inode, the root node maintains pointers to indirect address blocks which is a block containing file block addresses. Indirect address blocks can be nested like trees allowing for very large file sizes. See Slide 44 “Linux Nested Block Structure”.

## Question 9

What is the reason for file system consistency checks?

### Answer

For reasons of efficiency, the file system’s metadata structures (FAT and Unallocated Block List) are cached in memory disk blocks. This information needs to written to disk before the system is shut down and the contents of the in-memory cache are lost.

If the system loses power, or otherwise crashes, the cached state of the file system will be lost. For this reason, the operating system frequently flushes (writes) these caches to disk. However, if a change to the file system is made and the system crashes before the flush, the on-disk image of the files system may be corrupted.

The file system consistency check is a system utility the scans the entire file system and locates any unattached disk blocks i.e. blocks not allocated to a file and not maintained in the free block list. The utility usually reattaches these lost blocks to the free block list.

## Question 10

What is the purpose of a Journaled File System?

What problem does a JFS solve?

### Answer

A Journaled file system maintains a journal file that the OS uses to record changes to the file system’s metadata and optionally changes to data blocks. The journal file is persistently maintained on disk as another type of file system metadata. Its purpose is to record changes to the file system more efficiently (with fewer I/O operations) than updating the metadata data structures (FAT and Unallocated Blocks) each time a change is made to the file system. In the event of a system crash, the changes recorded in the journal file can be played back to recover the state of the file system just prior to the crash.

A JFS is used to reduce amount of time needed to perform a file system consistency check needed to recover the file system after a system crash.