

Total: 15 marks

Duration: 25 mins

*open books and notes, no mobile phones, friends disconnected during exam***Be precise, no marks for vague answers. Make reasonable assumptions.**

Roll No:

Q1. Select the correct answer(s) for the following questions. No partial marks. (2×4)

- (i) Block usage bitmap structure is used to keep track of free blocks in the storage device. Assume that, if the i^{th} bit in block bitmap is 1, then the i^{th} block is in use. If a file system employs block bitmaps, for which of the following block usage scenarios, the corresponding bit in the block bitmap *must be* one?
- (a) The block is used to store any file inode.
 - (b) The block is used to store any directory inode.
 - (c) The block is used to store file content.
 - (d) The block is used to store contents of a directory.
 - (e) The block is used to store inode bitmap.

Ans: c, d

- (ii) If a file is read using `read(buf, K)` system call where K is the number of blocks to be read, the total number of disk block reads required to serve the request
- (a) is equal to K .
 - (b) is at least K .
 - (c) is at most K .
 - (d) can be more than K .
 - (e) can be less than K .

Ans: d, e

- (iii) Consider a flat directory organization with variable sized entries spanning K disk blocks, directly addressable from the inode. Which of the following statements are true for any given directory? Assume that inode is present in memory and there is no caching at any layer.
- (a) To create a new file inside the directory, at least K block reads are required.
 - (b) To rename an existing file inside the directory, at least K block reads are required.
 - (c) To delete a file inside the directory, at least K block reads are required.
 - (d) To delete the directory, at least K block reads are required.
 - (e) To rename the directory, at least K block reads are required.

Ans: {a, b, d} or {a, b}

- (iv) Which of the following statement(s) are true regarding file systems organized into multiple groups (like ext4)?
- (a) If a file inode is created in a group, only the inode bitmap of that group is updated.
 - (b) If the size of a file in a particular group expands, only the block bitmap of that group is updated.
 - (c) The superblock may be repeated across all groups for increased reliability.
 - (d) If a file inode belongs to a particular group, then all the data blocks of the file must be from the same group.
 - (e) Number of blocks provisioned to store inodes is same for all the groups.

Ans: a, c, e

Q2. (2 + 1 + 2 + 2 = 7)

Consider an indexed file allocation found in the UNIX operating system. The file block index structures contained in the inode are as follows: nine direct block addresses, five single-indirect block addresses, and two double-indirect block addresses. The file system block size is 4KB and block address is 32-bits.

- (i) What is the maximum file size supported by this file system?
- (ii) What is the maximum disk size supported by this file system?
- (iii) What is the actual disk usage to store four files of 5GB each (ignore the space usage for storing inodes)?
- (iv) If a user requests to read a single block from a file of size 1GB at a random file offset (4KB aligned), calculate the minimum and maximum size of disk read required to serve the request? Assume that, the disk inode corresponding to the file is present in memory.

Ans:

(i) Number of entries in each indirect block = $4KB / 32bits = 1024$

Max file size = $(9(DI) + 5 \times 1024(SI) + 2 \times 1024 \times 1024(DI)) \times 4KB$

(ii) $2^{32} \times 2^{12} = 16TB$

(iii) File of size 5 GB requires 1310720 data blocks. $1310720 = 9$ data blocks from direct pointers + $5 * 1024$ data blocks from SI + X data blocks from DI

$\Rightarrow X = 1310720 - 5120 = 1305591$

$\Rightarrow \# \text{ of SI blocks} = \left\lceil \frac{1305591}{1024} \right\rceil = 1275$

$\Rightarrow \# \text{ of DI blocks} = \left\lceil \frac{1275}{1024} \right\rceil = 2$

$\# \text{ of data blocks} = 9 + 5120 + 1305591 = 1310720$

$\# \text{ of indirect blocks} = 5 + 2 + 1275 = 1282$

Total = $1310720 + 1282 = 1312002$ blocks
= 5248008 KB

For four files, disk usage = $4 * 5248008$ KB

(iv) If the file offset corresponds to any direct block, then one (1) disk read is required.

The last block of the file will require a double indirect block access. Therefore, maximum three (3) disk reads are required.