

<https://docs.google.com/spreadsheets/d/1mhhwpQTdQRQbexz6el-JJj5-2zqd7ivi8MpS0lCHtRU/edit#gid=0>

- a. Solution to CS must support bounded waiting, but not necessarily starvation
  - b. Solution to CS must be free from deadlocks
  - c. Solution to CS must ensure mutual exclusion to shared data structures.
  - d. None of the other options are true
- a
2. Which of the following is true in general about 16-bit (real) mode of x86-64 architectures?
- a. Both paging and segmentation are supported in real mode
  - b. Real mode is used during boot-up
  - c. Real mode can be used to access the entire RAM
  - d. Real mode does not support floating point operations
- b
3. Suppose you want to share a lot of data (> 500 MB) among multiple processes, but there is no strict requirement of synchronization. What is the best data structure for this requirement?
- a. Message queue
  - b. Pipe
  - c. Shared memory
  - d. None of the other options
- c
4. Which of the following is a disadvantage of hierarchical page table?
- a. Size of page table is too large
  - b. Not all page entries are present in the page table
  - c. Its hardware is much more complex to implement
  - d. It requires multiple memory accesses to access a single page frame
- d
5. Suppose a designer of a memory system finds that the size of page table is too large. Which of the following options are possible?
- a. Increase the size of page frames
  - b. Use multi-level page table
  - c. Use inverted page table
  - d. All the other options are possible
  - e. None of the other options are possible
- d

6. Suppose you have a two-level page table of the form 14|12|8. What is the size of the page frame, assuming that the memory is byte addressable?
- a. 512 bytes
  - b. 2 KB
  - c. 1 KB
  - d. 256 bytes
- d
7. Suppose you want to execute a shell script? Which of the permissions is NOT necessary for it to execute?
- a. All the options are necessary
  - b. Read
  - c. Write
  - d. Execute
- c
8. Which of the following permissions of a directory allows a user to make it the current working directory?
- a. Read
  - b. Write
  - c. Execute
  - d. Sticky
- c
9. Which of the following is true about a character device?
- a. A character device allows read, write and seek operations
  - b. A character device has a file in /dev directory
  - c. Operating on a character device does not go through Virtual File System
  - d. All of the other options are true
- a

#### 10. DO NOT USE

11. Which of the following latencies is equal to data access time from a hard disk?
- a. Rotational latency + seek latency
  - b. Rotational latency + seek latency + transfer latency
  - c. Seek latency + transfer latency
  - d. Rotational latency + transfer latency
- b
12. Which of the following leads to slow-down of file reads?
- a. Aging mechanical head
  - b. Fragmentation of files
  - c. Disk caches

- d. Excessive long-term usage of hard disk
- b

13. Suppose you write a single C program that prints integers from 1 to 100, and then computes their sum. Now, you run this program simultaneously from three different shells. How many processes (ignoring the shell processes) and how many additional threads (excluding the main thread) were created to run this C program?

- a. 1, 1
  - b. 3, 3
  - c. 1, 0
  - d. 3, 0
- d

14. Which of the following events are handled by the interrupt handler?

- a. Divide by zero
  - b. Overflow of a number
  - c. Cache miss
  - d. Access to a page frame residing in RAM
- b

15. Which of the following techniques do NOT utilize the principle of locality?

- a. Accessing data on disks
  - b. Accessing page frames
  - c. Load/Store instructions to get data
  - d. All of the above utilize locality
- c

16. In which of the following data sharing scheme is it possible to actually transfer data without using a system call?

- a. Pipe
  - b. Message Queue
  - c. Shared memory
  - d. Socket
- c

17. Which of the following is true about the current Linux process scheduler?

- a. It has a time complexity of  $O(\log n)$
- b. It gives more stress on throughput than on equitable access to resources
- c. It is much better suited for servers than for desktops

- d. It can easily handle hard deadlines
- a

18. Which of the following states does a process go to, if it blocks on a semaphore?

- a. Waiting
  - b. Ready
  - c. Running
  - d. New
- a

19. Which of the following states does a process go to, if it receives a semaphore signal, on which it was waiting?

- a. Waiting
  - b. Ready
  - c. Running
  - d. New
- b

20. Suppose a file has multiple hard links. What happens if one of the hard links is deleted?

- a. The file is actually removed from the hard disk, along with the other links
  - b. The file is removed from the hard disk, but the other links are not removed
  - c. The link is removed, but the file remains on the disk
  - d. You get an error message and nothing gets removed
- c

21. Why do Linux filesystems have a maximum file size?

- a. To avoid excess disk fragmentation
  - b. To save disk space
  - c. To limit the number of inode indirections
  - d. None of the above
- C

22.

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26. Consider the following (conceptual) page reference string

7,2,3,1,2,5,3,4,6,7,7,1,0,5,4,6,2,3,0,1

Assuming demand paging with three frames, and considering three different kinds of page replacement algorithms -- FIFO, optimal and MFU (most frequently used), which of the following correctly represents the number of page faults for each of the page replacement policies.

- a. MFU : 18, FIFO: 17, Optimal: 13
- b. MFU : 19, FIFO: 16, Optimal: 15

- c. MFU : 17, FIFO: 22, Optimal: 17
- d. None of the above is correct.

Option\_\_\_\_\_a\_\_\_\_\_

27. Which of the following is true about the interplay between virtual memory subsystem (MMU+kernel data structures) and VFS:

- a. MMU (and the kernel) translates virtual memory to real memory block which finally points to the data structures represented by VFS (e.g. inodes).
- b. MMU (and the kernel) takes care of page replacement policies while ignoring the data blocks represented by VFS structures and thus potentially causes starvation.
- c. MMU (and the kernel) relies on page faults to identify pages to import from the backing store and replace pages back to it (so as to make room for new pages). VFS uses this principle to also import file data blocks from the on disk file system and places them on pages allocated.
- d. None of the above

Option\_\_\_\_\_c\_\_\_\_\_

28. The memory ranges visible to Linux kernel modules are:

- a. Virtual address ranges.
- b. Corresponding to kernel address spaces.
- c. Use the same virtual memory management system (such as demand paging system) like the rest of the system does.
- d. The real addresses and not the virtual address, as the latter is only for application programs.
- e. A&B
- f. A&C
- g. None of the above

Option           f          

29. Which of the following is true about file system mounting:

- a. Only a recognized partition / file system can be mounted at a particular directory.
- b. You could mount swap partitions to specific directories.
- c. Devices that do not have file systems can also be mounted to the filesystem, e.g. devices like keyboard and mouse, as every device appears as a file in the filesystems.
- d. None of the above.

Sol: a

30. The following is true about the ``dirty'' bit in page descriptors:

- e. It is used to keep track of pages that may be replaced by data corresponding to any other process (that may have page faulted).
- f. It is used to keep track of pages that may be exchanged with pages in the swap memory.
- g. It is used to keep track of pages for a corresponding frame is allocated in the RAM.
- h. None of the above.

Sol.: b

33. The main reason why interrupts are often not disabled in interrupt handling is because:

- a. It is not supported by all CPU architectures.
- b. So as to allow a single interrupt handler to handle interrupts from various devices.
- c. For more system responsiveness, we require preemptive interrupt handling.
- d. Because disabling interrupts is often not an atomic operation.

Option           c

34. Which of the following is true for I/O schedulers:

- a. I/O schedulers take into consideration which process has gone into an I/O wait state and thus changes the process state accordingly.
- b. Other than (a) they also take into consideration the virtual memory address ranges the I/O devices may use and manages page replacement accordingly.
- c. I/O schedulers take into consideration which requests should be queued together based on their request identifiers (e.g. block numbers for disk blocks).
- d. I/O schedulers try to optimize the selection of which interrupt is to be handled in case of multiple interrupts arriving from various I/O devices (simultaneously).

Option\_\_\_\_\_c\_\_\_\_\_

35. The memory ranges visible to Interrupt handlers are:

- a. Virtual address ranges.
- b. Corresponding to kernel address spaces.
- c. Use the same virtual memory management system (such as demand paging system) like the rest of the system does.
- d. All the above.

Option\_\_\_\_\_d\_\_\_\_\_

36. The advantage of using semaphores and mutexes over spin locks is as follows:

- a. Semaphores (and mutexes) are designed to yield the CPU to other processes whenever the caller attempts to enter the critical section but cannot.
- b. Semaphores (and mutexes) cannot be used within the kernel as they can go to sleep with the lock, leading to kernel deadlock state.
- c. One cannot disable the interrupts when semaphores (and mutexes) are used, while it may be done for spin locks.
- d. None of the above.

Option\_\_\_\_\_a\_\_\_\_\_

37. The main reason to store attributes of a files with the inodes (instead of managing centrally with a common data structures) is:

- a. To be able to keep attributes intact when the files are moved from one physical storage to another.
- b. To be able to maintain consistency across all files. The OS need not worry about the attributes.
- c. The attributes are actually stored in different data structures within the filesystem
- d. None of the above.

Option:\_\_\_\_\_a\_\_\_\_\_

38. Which kind of disk request scheduler is best suited for solid state drives:

- A. Shortest seek time first.
- B. First come first serve.
- C. Circular scan (C-SCAN).
- D. None of the above.

Option \_\_\_\_\_D\_\_\_\_\_

39. Which of the following is true for Non-Maskable Interrupts (NMIs):

- A. One cannot implement an interrupt handler for NMIs, the CPU handles them through built-in instructions.
- B. If a NMI and a regular interrupt arrive together, the regular interrupt generally has higher precedence.



- C. If a NMI and a regular interrupt arrive together, the NMI takes precedence over regular interrupt.
- D. A regular interrupt could take precedence over NMI by appropriately re-programming the Programmable Interrupt Controller (PIC).

Option\_\_\_\_\_C\_\_\_\_\_

40. The following is the difference between `pthread_mutex_lock()` and advisory locks (e.g. `flock()`):

- a. `Pthread_mutex_lock()` can be both blocking and non-blocking while `flock()` is always blocking.
- b. Advisory locks like `flock()` and `pthread_mutex()` work exactly the same way, they differ only in the arguments they use.
- c. `Pthread_mutex_lock()` can only be used in multithreaded programs, while `flock()` can be used in all cases.
- d. `Pthread_mutex_lock()` causes the calling thread to sleep, if some other process has acquired the lock, while `flock()` does not.
- e. None of the above.

Option\_\_\_\_\_d\_\_\_\_\_

41. Which of the following is true about library functions and processes.

- a. Just the way programs can run library routines, they may also deliberately or inadvertently corrupt the local and global variable of library functions.
- b. Library functions don't segfault as they use their own heap memory and do not use statically allocated variables, nor do they use dangling pointers.
- c. Pages containing library functions are treated like pages of other processes, as in they could be replaced by page eviction strategies, much like the pages of regular processes (say following a LFU strategy).
- d. You can load libraries in the main memory during boot-up by configuring appropriate `rc` scripts, so that they stay resident in RAM when process invoke the functions therein.

- e. Library functions have addresses that are mapped to code pages of all processes. Therefore, a malicious user could access the code, stack and data of other processes, using the access to library function addresses as conduit.
- f. None of the above.

Option\_\_\_\_\_f\_\_\_\_\_

42. Which of the following operations is well suited to be handled using DMA operations:

- a. Handling several quick keystrokes and mouse pointer movements in applications like computer games.
- b. Reading or writing data from the network card device -- e.g. while web browsing that involves exchanging millions of bits per second.
- c. Reading or writing to the sound card say when making audio calls over the Internet.
- d. Writing to a printer connected via USB (Universal Serial Bus).

Option\_\_\_\_\_b\_\_\_\_\_

43. Which of the following may be swapped out when page faults occur:

- a. Both process and library pages may be swapped to the swap space (backing store) to make room for other processes.
- b. Only process pages may be swapped, but not library pages, as they may be called by other processes.
- c. Pages containing files are usually not swapped out.
- d. Processes' and files' pages can all be swapped out.
- e. Kernel pages could be swapped out and recalled later.
- f. Kernel pages, but parts of the file system data structures, may not be swapped out.

Option\_\_\_\_\_d\_\_\_\_\_

44. Consider the following demand-paging system with the following time-measurement utilizations:

CPU Utilization: 10%

Swap space: 88%

I/O operations: 2%

I.e. 10% of the time the CPU is utilized, 88% of the time the swap space is being used and only 2% of the times the I/O operations are executing.

Which of the following do you think can optimize CPU utilization:

- a. Install a faster CPU.
- b. Increase swap space.
- c. Increase main memory.
- d. Install a faster disk.

Option: \_\_\_\_\_ **c** \_\_\_\_\_

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22. NTFS/FAT32 etc differ from VFS in that:

- a. They do not use a unified structure to take care of various files, directories devices etc.
- b. It is much easier to add a new device and add device drivers for it in VFS. They appear as files.
- c. In VFS the devices can be accessed as memory mapped while in other filesystems, one need to only use I/O instructions.
- d. a&b
- e. a&c
- f. b&c
- g. A&b&c
- h. None of the above.

Option: \_\_\_\_\_ **d** \_\_\_\_\_

23. Shared library (aka dynamically linked library) are able to have multiple address ranges because:

- a. Paging allows them to be mapped to different virtual address ranges. In other words multiple virtual addresses map to the same physical address.
- b. Because of the OS symbol table which allows mapping multiple address range to a single address range.
- c. Because they aren't really processes per se, only pages with executable permissions.
- d. A&B.
- e. A&C
- f. None of the above.

Option: \_\_\_\_\_ e \_\_\_\_\_

24. Opening the file from two different terminals simultaneously, using your favourite editor (e.g. 'vi', 'naon' etc.), results in a warning message at either one (or both) the terminals. How do you think file locks work in achieving this sort of warnings:

- a. Advisory locks can detect if a file is already open. Any subsequent attempts to open the file result in the warning message to the one that is trying to acquire and already acquired lock.
- b. Mandatory locks, and not advisory locks, can detect if a file is already open. Any subsequent attempts to open the file result in the warning message to the one that is trying to acquire and already acquired lock.
- c. Most text editors mediate the process of file opening using a semaphore. The semaphore reports a warning message if more than one process attempts to open a file simultaneously.
- d. Locks have no role in generating such alerts/warning messages. The messages are generated upon reading the reference count of the file before opening.
- e. None of the above

Option \_\_\_\_\_ d \_\_\_\_\_

25. Socketpair() differs from socket() in which of the following ways:

- a. A program that uses Socketpair, unlike sockets, does not need to take care of manually (programmatically) managing socket descriptors.

- b. Socketpairs provide bi-directional communication while sockets only provide uni-directional communication.
- c. Socketpair can be used for byte oriented, fixed size messages while sockets are agnostic to such message length boundaries.
- d. None of the above.

Option\_\_\_\_\_d\_\_\_\_\_

26. Which of the following are true about the default current Linux process scheduler?

- i. It has a time complexity of  $O(\log n)$
  - j. It gives more stress on equitable access to resources than on throughput.
  - k. It is much better suited for servers than for desktops.
  - l. It can easily handle hard deadlines.
  - m. a&b.
  - n. c&d.
  - o. a&b&d
  - p. None of the above.
- (e)

27. Which of the following states does a process go to when coming out of a blocked/sleeping state ?

- q. Waiting
  - r. Ready
  - s. Running
  - t. New
- (b)

28. Suppose a file has a hard link. Which of the following is true about it?

- u. If the link is deleted then the file is actually removed from the hard disk, along with the other possible links to it (either hard or soft).
  - v. The file is removed from the disk, but the other links are not.
  - w. The link is removed, but the file that it points to remains on the disk.
  - x. None of the above.
- b

29. Why do UNIX filesystems (e.g. UFS, ext2/ext3/ext4) have a maximum file size?

- y. To avoid excess disk fragmentation
  - z. To save disk space
  - aa. To limit the number of inode indirections
  - bb. None of the above
- c

30.. Consider the following (conceptual) page reference string  
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Assuming demand paging with three frames, and considering three different kinds of page replacement algorithms -- FIFO, optimal and MFU (most frequently used), which of the following correctly represents the number of page faults for each of the page replacement policies.

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- f. MFU : 19, FIFO: 16, Optimal: 15
- g. MFU : 17, FIFO: 22, Optimal: 17
- h. None of the above is correct.

Option\_\_\_\_\_a\_\_\_\_\_

31. Which of the following is true about the interplay between virtual memory subsystem (MMU+kernel data structures) and VFS:

- a. MMU (and the kernel) translates virtual memory to real memory block which finally points to the data structures represented by VFS (e.g. inodes).
- b. MMU (and the kernel) takes care of page replacement policies while ignoring the data blocks represented by VFS structures and thus potentially causes starvation.
- c. MMU (and the kernel) relies on page faults to identify pages to import from the backing store and replace pages back to it (so as to make room for new pages). VFS uses this principle to also import file data blocks from the on disk file system and places them on pages allocated.
- d. None of the above

Option\_\_\_\_\_c\_\_\_\_\_

32. The memory ranges not visible to Linux Modules are:

- a. Virtual address ranges visible to processes.
- b. The kernel address ranges.
- c. The same addresses that are assigned to the pages corresponding to file data blocks, that likely have been brought into the RAM via the VFS framework.

d. A&B

e. A&C

f. B&C

g. None of the above

Option           e          

33. Which of the following is not true about file system mounting:

- a. Only a recognized partition / file system can be mounted at a particular directory.
- b. You can mount swap partitions to specific directories.
- c. Devices that do not have file systems cannot also be mounted to the filesystem, e.g. devices like keyboard and mouse.
- d. Pseudo filesystems can also be mounted on specific directory locations
- cc. None of the above.

Sol: b

34. The following is true about the ``dirty'' bit in page descriptors:

- dd. It is used to keep track of pages that may be replaced by data corresponding to any other process (that may have page faulted).
- ee. It is used to keep track of pages that may be exchanged with pages in the swap memory.
- ff. It is used to keep track of pages for a corresponding frame is allocated in the RAM.
- gg. None of the above.

Sol.: b

35. Which of the following programs is a good candidate for setuid and setgid:

- a. `adduser' / `useradd' programs that add individual users.
- b. `Vi' (the Vi editor, as it is accessed by several users).
- c. `sh', the shell.
- d. `apt' / `pkg' / `yum' / `pacman', i.e. programs that are used to install binary packages in Linux/FreeBSD.
- e. `passwd' program that changes the login password of a user and involves updating the /etc/shadow file (whose owner is root).

(e)

36. The main reason why interrupts are often not disabled in interrupt handling is because:

- a. It is not supported by all CPU architectures.
- b. So as to allow a single interrupt handler to handle interrupts from various devices.
- c. For more system responsiveness, we require preemptive interrupt handling.
- d. Because disabling interrupts is often not an atomic operation.

Option\_\_\_\_\_c\_\_\_\_\_

37. Which of the following is true for I/O schedulers:

- a. I/O schedulers take into consideration which process has gone into an I/O wait state and thus changes the process state accordingly.
- b. Other than (a) they also take into consideration the virtual memory address ranges the I/O devices may use and manage page replacement accordingly.
- c. I/O schedulers take into consideration which requests should be queued together based on their request identifiers (e.g. block numbers for disk blocks).
- d. I/O schedulers try to optimize the selection of which interrupt is to be handled in case of multiple interrupts arriving from various I/O devices (simultaneously).

Option\_\_\_\_\_c\_\_\_\_\_

38. The memory ranges visible to interrupt handlers are:

- a. Virtual address ranges.
- b. Corresponding to kernel address spaces.
- c. Use the same virtual memory management system (such as demand paging system) like the rest of the system does.
- d. All the above.

Option\_\_\_\_\_d\_\_\_\_\_

39. The advantage of using semaphores and mutexes over spin locks is as follows:

- a. Semaphores (and mutexes) are designed to yield the CPU to other processes whenever the caller attempts to enter the critical section but cannot.



- b. Semaphores (and mutexes) cannot be used within the kernel as they can go to sleep with the lock, leading to kernel deadlock state.
- c. One cannot disable the interrupts when semaphores (and mutexes) are used, while it may be done for spin locks.
- d. None of the above.

Option\_\_\_\_\_a\_\_\_\_\_

40. The main reason to store attributes of a files with the inodes (instead of managing centrally with a common data structures) is:

- a. To be able to keep attributes intact when the files are moved from one physical storage to another.
- b. To be able to maintain consistency across all files. The OS need not worry about the attributes.
- c. The attributes are actually stored in different data structures within the filesystem
- d. None of the above.

Option:\_\_\_\_\_a\_\_\_\_\_

41. Which of the following is true for Non-Maskable Interrupts (NMIs):

- a. One cannot implement an interrupt handler for NMIs, the CPU handles them through built-in instructions.
- b. If a NMI and a regular interrupt arrive together, the regular interrupt generally has higher precedence.
- c. If a NMI and a regular interrupt arrive together, the NMI takes precedence over regular interrupt.
- d. A regular interrupt could take precedence over NMI by appropriately re-programming the Programmable Interrupt Controller (PIC).

Option\_\_\_\_\_C\_\_\_\_\_

42. The following is the difference between pthread\_mutex\_lock() and advisory locks (e.g. flock()):

- a. Pthread\_mutex\_lock() can be both blocking and non-blocking while flock() is always blocking.

- b. Advisory locks like flock() and pthread\_mutex() work exactly the same way, they differ only in the arguments they use.
- c. Pthread\_mutex\_lock() can only be used in multithreaded programs, while flock() can be used in all cases.
- d. Pthread\_mutex\_lock() causes the calling thread to sleep, if some other process has acquired the lock, while flock() does not.
- e. None of the above.

Option\_\_\_\_\_c\_\_\_\_\_

43. Which of the following is true about library functions and processes.

- g. Just the way programs can run library routines, they may also deliberately or inadvertently corrupt the local and global variable of library functions.
- h. Library functions don't segfault as they use their own heap memory and do not use statically allocated variables, nor do they use dangling pointers.
- i. Pages containing library functions are treated like pages of other processes, as in they could be replaced by page eviction strategies, much like the pages of regular processes (say following a LFU strategy).
- j. You can load libraries in the main memory during boot-up by configuring appropriate rc scripts, so that they stay resident in RAM when process invoke the functions therein.
- k. Library functions have addresses that are mapped to code pages of all processes. Therefore, a malicious user could access the code, stack and data of other processes, using the access to library function addresses as conduit.
- l. None of the above.

Option\_\_\_\_\_f\_\_\_\_\_

44. Which of the following operations is not well suited to be handled using DMA operations:

- a. Handling several quick keystrokes and mouse pointer movements in applications like computer games.
- b. Reading or writing data from the network card device -- e.g. while web browsing that involves exchanging millions of bits per second.
- c. Writing to a USB (Universal Serial Bus) external hard drive.
- d. None of the above.

Option\_\_\_\_\_a\_\_\_\_\_

45. Which of the following may be not swapped out when page faults occur:

- a. Both process and library pages to make room for other (newer) processes.
- b. Pages corresponding to addresses memory mapped I/O devices.
- c. Pages containing data files.
- d. None of the above.

Option\_\_\_\_\_b\_\_\_\_\_

46. Consider the following demand-paging system with the following time-measurement utilizations:

CPU operation times: 60%

Memory read write times: 20%

Swap space read and write times: 10%

Time spent doing I/O operations: %10

Which of the following do you think is likely to maximally optimize the system's performance:

- a. The performance could be optimized by adding more RAM.
- b. The performance could be optimized by adding more swap space..
- c. The system could be optimized by increasing higher CPU core count and clock speeds. .
- d. The system could be optimized by having a hard drive with lower access time compared to what is being used.
- e. None of the above.

Option: \_\_\_\_\_c\_\_\_\_\_