

# THE UNIVERSITY OF AUCKLAND

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EXAMINATION FOR BSc ETC 2004

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## COMPUTER SCIENCE

### Operating Systems

(Time allowed: **TWO** hours)

NOTE:

Attempt ALL questions.

Marks for the questions are shown and total **100**.

### Part A (30 marks)

#### Multiple choice questions

Circle the preferred choice on the **coloured answer sheet provided**. Each question is worth **1** mark.

1. If the relocation register has a value of 500, and the limit register has a value of 200, what is the range of logical memory addresses available to the process?
  - A) 500 - 699
  - B) 500 - 700
  - C) 1 - 200
  - D) 0 - 199
2. If the physical address generated was 300 and the relocation register was set to 100, what was the corresponding logical address?
  - A) 400
  - B) 200
  - C) 300
  - D) 399
3. In systems that support virtual memory,
  - A) physical memory is different from logical memory.
  - B) physical memory is the same as secondary storage.
  - C) virtual memory is different from logical memory.
  - D) virtual memory is the same as physical memory.

CONTINUED

4. What is the probability of a page fault, using demand paging, if the effective access time is 10 microseconds, the RAM access time is 250 nanoseconds, and the page fault time is 200 milliseconds? Assume that accessing the page table entry takes no time.
- A) 0.0049 %
  - B) 1 %
  - C) 0.00025 %
  - D) 0.5 %
5. Which of the following is not a benefit of virtual memory?
- A) speed up of process creation
  - B) increases in the effective access time of memory
  - C) the possibility of sharing memory between processes
  - D) the ability to address more memory than exists in RAM
6. Suppose we have the following page accesses: 1 2 3 4 2 3 4 1 2 1 1. Suppose that there are also three frames within our system. Using the FIFO replacement algorithm, what will be the final configuration of the three frames following the execution of the given reference string?
- A) 3, 1, 2
  - B) 4, 2, 1
  - C) 4, 1, 2
  - D) 1, 2, 3
7. Belady's Anomaly states that
- A) for some page replacement algorithms, the page-fault rate may decrease as the number of allocated frames increase.
  - B) giving more memory to a process will improve its performance.
  - C) for some page replacement algorithms, the page-fault rate may increase as the number of allocated frames increases.
  - D) as the number of allocated frames increases, the page-fault rate may decrease for all page replacement algorithms.
8. Given the reference string of page accesses: 1 2 3 4 2 3 4 1 2 1 1 and a system with three page frames, what is the final configuration of the three frames after the true LRU algorithm is applied?
- A) 1, 2, 3
  - B) 2, 1, 3
  - C) 4, 1, 2
  - D) 3, 4, 1
9. Which of the following is not a consideration when determining a system's page size?
- A) The desire to minimize I/O leads to larger page sizes.
  - B) Each process must have its own copy of the page table making large page sizes desirable.
  - C) Memory utilization is better with smaller page sizes.
  - D) Fragmentation is more severe with smaller page sizes.

10. Suppose that the operating system uses two internal tables to keep track of open files. Process one has two files open and process two has three files open. Two files are shared between the two processes. How many entries are in the per-process table of process one, the per-process table of process two, and the system-wide tables respectively?
- A) 2, 3, 1
  - B) 2, 3, 5
  - C) 5, 5, 5
  - D) 2, 3, 3
11. In the UNIX file system, the access control for a file is given as `r-- rw- r-x`. Which of the following is true?
- A) The group is allowed execute access and everyone else is allowed read access.
  - B) The owner is allowed read access only and everyone else is allowed read access.
  - C) The owner is allowed full access, while the group is allowed read and write access.
  - D) The owner is allowed full access and everyone else is allowed read access.
12. The UNIX file system uses which of the following consistency semantics?
- A) Processes are not allowed to share a current location pointer into the file.
  - B) Writes to a file by a process are visible immediately to other processes that have the file open at the same time.
  - C) Once a file is closed, the changes made to it are visible only in sessions starting later.
  - D) Writes to a file by a process are not visible immediately to other processes that have the file open at the same time.
13. Which of the following allocation methods ensures that only one access is needed to get a disk block using direct access?
- A) hashed allocation
  - B) linked allocation
  - C) contiguous allocation
  - D) indexed allocation
14. Programmed I/O (PIO) is characterized by
- A) watching status bits and feeding data into a controller register.
  - B) its speed and efficiency when used for large data transfers, such as with disk drives.
  - C) the use of a DMA controller.
  - D) the use of a special purpose processor for data transfer.
15. Which of the following is not a reason for buffering?
- A) the need to support data transfer between devices that are closely matched in speed
  - B) the need to cope with speed mismatches between the producer and consumer of a data stream
  - C) the need to adapt between devices that have different data-transfer sizes
  - D) the need to support copy semantics for application I/O

16. The FCFS (First Come First Served) algorithm for disk scheduling
- A) generally provides the fastest service.
  - B) is the simplest form of disk scheduling.
  - C) is intrinsically unfair.
  - D) None of the above.
17. Consider a disk queue holding requests to the following cylinders in the listed order: 98, 183, 57, 122, 200, 124, 65, 67. Using SSTF (Shortest Seek Time First) scheduling, what is the order that the requests are serviced assuming the disk head is at cylinder 65.
- A) 65 - 200 - 183 - 124 - 122 - 67 - 98 - 57
  - B) 65 - 57 - 98 - 67 - 122 - 124 - 183 - 200
  - C) 65 - 67 - 57 - 98 - 122 - 124 - 183 - 200
  - D) 65 - 67 - 57 - 98 - 122 - 124 - 200 - 183
18. Consider a disk queue holding requests to the following cylinders in the listed order: 98, 183, 57, 122, 200, 124, 65, 67. Using the SCAN scheduling algorithm, what is the order that the requests are serviced assuming the disk head is at cylinder 97 and moving towards 200?
- A) 200 - 67 - 65 - 57 - 98 - 122 - 124 - 183
  - B) 98 - 122 - 124 - 183 - 200 - 57 - 65 - 67
  - C) 122 - 124 - 183 - 200 - 67 - 65 - 57 - 98
  - D) 98 - 122 - 124 - 183 - 200 - 67 - 65 - 57
19. Which of the following is not one of the main approaches to naming schemes in a distributed file system?
- A) Files use a single global naming structure spanning all of the files in a system.
  - B) Files are named by some combination of their host name and local name.
  - C) Remote directories are attached to local directories thus giving the appearance of a coherent directory tree.
  - D) Files are named by some combination of their host name and a remote directory structure, generated by the system hosting the file, that is appended to the end of the host name.
20. With methods for verifying the validity of cached data, which of the following is true?
- A) In the server-initiated approach, the client records, for each server, the files that it caches.
  - B) The client-initiated approach can load down the network and server depending on the frequency of validity checks.
  - C) In the client-initiated approach, the server requests a consistent check of its local data with the client's master copy.
  - D) All of the above.
21. In a stateful file service,
- A) each file request is self-contained.
  - B) each request identifies the file and the position in the file in full.
  - C) a unique connection identifier is given to the client for accessing files.
  - D) the client does not need to perform an open operation on a file before accessing that file.

22. The enforcement of the global ordering requirement in a distributed environment is achieved through
- A) a virtual clock.
  - B) a time server shared among all clients and servers that computes the relative order of processes.
  - C) a logical clock.
  - D) a common clock.
23. Which of the following is an advantage of the Single-Coordinator approach of distributed concurrency control?
- A) The approach lacks vulnerability in that, if any site fails, the concurrency controller is not lost.
  - B) The scheme requires only three messages for handling lock requests and one message for handling unlock requests.
  - C) The scheme is simple to implement.
  - D) There is no bottleneck associated with the approach.
24. The wait-die deadlock prevention scheme
- A) cannot avoid starvation if a process is not assigned a new timestamp when rolled back.
  - B) is the same as the wound-wait scheme.
  - C) is based on a nonpreemptive technique.
  - D) is based on a preemptive technique.
25. In the UNIX operating system, a domain is associated with the
- A) procedure.
  - B) user.
  - C) process.
  - D) None of the above.
26. An access matrix may be implemented in which of the following ways?
- A) access list for objects
  - B) lock-key mechanism
  - C) global table
  - D) All of the above.
27. In the reacquisition scheme for implementing the revocation of capabilities,
- A) the capabilities point indirectly, not directly, to the objects.
  - B) capabilities are periodically deleted from each domain.
  - C) a key is defined when the capability is created.
  - D) a list of pointers is maintained with each object that point to all capabilities associated with that object.
28. Suppose a Linux process has 10 credits and is set to a priority of 5. After recrediting, how many credits will the process have?
- A) 10
  - B) 15
  - C) 50
  - D) 5
29. A character device

- A) sometimes offers random access to fixed blocks of data.
- B) does not offer random access to fixed blocks of data.
- C) is the main interface to all disk devices in a system.
- D) None of the above

30. In MULTICS, the protection domains are organized in a

- A) completely random structure.
- B) star structure.
- C) ring structure.
- D) linear structure.

### Part B (70 marks)

31.

- a) Explain how the LRU (Least Recently Used) page replacement algorithm is an approximation to the optimal page replacement algorithm. [2 marks]
- b) Describe a technique that can be used to efficiently approximate the LRU algorithm. [4 marks]

32. Message passing systems can be implemented in many different ways. Give reasons why a message passing system might be implemented in the following ways.

- a) With indirect communication, via a port or mailbox. [1 mark]
- b) With blocking write calls. [1 mark]
- c) With non-blocking write calls. [1 mark]

33.

- a) Calculate the Effective Access Time for memory access given a two-level page table with the following characteristics. Assume that all required memory positions are in physical memory, and that page table memory is accessible without memory translation.  
TLB hit ratio = 0.9  
RAM memory access time = 100ns  
TLB check time = 5ns  
Explain your working. [3 marks]
- b) Calculate the Effective Access Time for virtual memory access given the following characteristics. Ignore page table lookup time.  
Page fault rate = 0.2  
RAM memory access time = 100ns  
Page fault handling time = 10ms (1 ms = 1,000,000ns)  
Explain your working. [3 marks]

34.

- a) Draw a picture showing the relationships between a Unix program reading from a file, the process open file table, the system wide open file table, the inodes currently in memory and the on-disk inodes.

**[4 marks]**

- b) In Unix all devices and open communication channels look like files. What happens to open devices when a process forks? Explain your answer by referring to the process open file table.

**[2 marks]**

- c) Most file systems that maintain logs of changes to data only record information about changes to file metadata. Why is this? What are these logs used for?

**[2 marks]**

35.

- a) What is one possible output from the following Ruby program? Remember that in Ruby the `fork` system call returns `nil` in the child process.

```

$stdout.sync = true
puts "The first line"
childId = fork
if childId == nil
  puts "child"
else
  puts "parent"
end
anotherChildId = fork
if anotherChildId == nil
  puts "another child"
else
  puts "another parent"
end

```

**[3 marks]**

- b) When the code above was executed without the `$stdout.sync = true` statement it produced the following output. (The `sync` statement ensures that the output buffer is continually flushed to the operating system.)

```

The first line
child
another child
The first line
child
another parent
The first line
parent
another child
The first line
parent
another parent

```

Explain how this occurred.

**[2 marks]**

- c) How many processes were created by the code in part a)? Do not count the original parent process. [1 mark]
- d) Why is there more than one possible output from the program in part a)? [1 mark]
- 36.
- a) When a parent process terminates in Unix what normally happens to its children? [2 marks]
- b) There is a `detach` method that a Ruby process can call in Unix that means that the parent is not interested in collecting the termination status of its child. Why is such a method useful? [1 mark]
- 37.
- a) Explain why locks, semaphores and monitors are difficult to use in a distributed system. [1 mark]
- b) Describe one method that is used to provide exclusive access to a resource in a distributed system. Mention how requests are made for the resource and how the resource is allocated. Also explain any problems the scheme suffers from. [5 marks]
- 38.
- a) Describe the contents of a typical file control block. [3 marks]
- b) Name two file systems that allow more than one data stream to be associated with a file. [1 mark]
- c) Give a reason why it is useful to have more than one data stream associated with a file. [1 mark]
- d) What is the greatest problem with having more than data stream associated with a file? [1 mark]
- 39.
- a) Briefly describe how a process accesses a file on another machine using NFS. [3 marks]
- b) Administering a large NFS installation has several problems, describe two of them. [4 marks]
- c) How does AFS overcome the problems you described in part b). [4 marks]
40. There are two main methods to implement waiting for I/O: devices can be repeatedly polled until the I/O is complete or an interrupt handler can be called when the I/O is complete.
- a) Explain the advantages of each method. [4 marks]
- b) Describe a situation where the first method would be the best choice and another situation where the second method would be the best choice. [2 marks]



41. Given this access matrix, answer the following questions.

Domain	F1	F2	F3	D1	D2	D3
D1		Owner Read *	Read * Owner Write *	Control		Switch Control
D2		Write	Write	Switch	Control	
D3	Owner Execute				Switch	

- a) Describe two different ways that a process executing in domain D1 could write to F2. **[2 marks]**
- b) Which domains can directly remove the “Execute” permission that domain D3 has on F1? **[2 marks]**
- c) This system is completely open, in the sense that a process in any domain can access all resources. Explain how. **[2 marks]**
- d) Briefly describe one method that could be used to efficiently represent this access matrix in an operating system. **[2 marks]**

## ANSWER SHEET

ID: \_\_\_\_\_

**Part A**

Circle the preferred answer.

If you make a mistake, mark a cross through your wrong choice and circle your next alternative.

- |     |   |   |   |   |
|-----|---|---|---|---|
| 1.  | A | B | C | D |
| 2.  | A | B | C | D |
| 3.  | A | B | C | D |
| 4.  | A | B | C | D |
| 5.  | A | B | C | D |
| 6.  | A | B | C | D |
| 7.  | A | B | C | D |
| 8.  | A | B | C | D |
| 9.  | A | B | C | D |
| 10. | A | B | C | D |
| 11. | A | B | C | D |
| 12. | A | B | C | D |
| 13. | A | B | C | D |
| 14. | A | B | C | D |
| 15. | A | B | C | D |
| 16. | A | B | C | D |
| 17. | A | B | C | D |
| 18. | A | B | C | D |
| 19. | A | B | C | D |
| 20. | A | B | C | D |
| 21. | A | B | C | D |
| 22. | A | B | C | D |
| 23. | A | B | C | D |
| 24. | A | B | C | D |
| 25. | A | B | C | D |
| 26. | A | B | C | D |
| 27. | A | B | C | D |
| 28. | A | B | C | D |
| 29. | A | B | C | D |
| 30. | A | B | C | D |

TIE THIS ANSWER SHEET TO YOUR SCRIPT BOOK

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