

This question paper consists
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Number COMP221101

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School of Computing

January 2018

COMP2211

Operating Systems

Answer all three questions

Time allowed: 2 hours

Question 1

- (a) An operating system hides complicated details of the computer from its users and makes it much easier to use through well-defined interfaces. Describe and discuss examples of OS user interfaces. **[3 marks]**
- (b) The concept of interrupts is an essential part of modern operating systems and hardware. A keyboard, when connected to a computer, raises an interrupt whenever there is a key press. Explain the interrupt process in this example, in terms of both software and hardware. **[4 marks]**
- (c) Memory management is a crucial aspect of operating system functionality. A problem that needs to be addressed is that of memory fragmentation. Explain – with examples – how both internal and external memory fragmentation occur. **[3 marks]**
- (d) Consider the following bitmap, where shaded boxes represent allocated memory, and un-shaded boxes represent available memory:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
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Assume two memory allocation requests are processed by the system: firstly the system is asked to allocate 4 blocks of memory for *process A*. After this is successful, the system is asked to allocate two blocks of memory for another *process B*.

- (i) State which blocks from the above bitmap would be allocated to which process when using the **Best Fit** memory allocation algorithm. **[2 marks]**
- (ii) State which blocks from the above bitmap would be allocated to which process when using the **Worst Fit** memory allocation algorithm. **[2 marks]**
- (e) Page replacement happens when a requested page is not in memory, i.e. when there is a **page fault**. Let us assume that we have three frames, i.e. three pages can be in memory at any one time, and consider the sequence of page references: 9, 0, 1, 2, 0, 3, 0, 4.
- (i) Illustrate and state how many page faults would be caused by the given sequence of page references when using the **First-In-First-Out** page replacement algorithm and the **Least-Recently-Used** page replacement algorithm respectively. **[4 marks]**
- (ii) Compare the **First-In-First-Out** algorithm and **Least-Recently-Used** algorithm. **[2 marks]**

[question 1 total: 20 marks]

Question 2

- (a) A process is an instance of an executing program, containing the program code, data and execution state.
- (i) What operations must the operating system perform to create a process? **[3 marks]**
 - (ii) What is a context switch? Describe its operation. **[3 marks]**
- (b) Cooperating processes or threads require synchronisation when entering critical sections of their respective programs.
- (i) What is an atomic operation? **[1 mark]**
 - (ii) What is a critical section of a cooperating process? Why is synchronisation important when entering these sections? **[2 marks]**
 - (iii) Name and describe the three characteristics a synchronisation mechanism must have. **[3 marks]**
 - (iv) Describe two mechanisms for synchronisation that cooperating process may use to control access to critical sections. **[4 marks]**
- (c) The Hadoop's MapReduce is used to process large sets of data on a large number of collective servers. A job may have thousands of tasks, executed in parallel on the servers. However, the job is often slowed down due to the long-tail problem, i.e. a small amount of tasks make no or very slow progress. Clearly explain two of the main causes of the long-tail problem. Outline two mitigation strategies, and discuss their strengths and limitations. **[4 marks]**

[question 2 total: 20 marks]

Question 3

- (a) CPU scheduling provides low level of control over process execution. The choice of scheduling algorithms controls the decisions made by the dispatcher.

- (i) Describe the difference between scheduling for a normal operating system kernel and for a real-time operating system. **[4 marks]**

Consider the task set contained in the table below (assuming all tasks are initially released at the beginning). Will the task set be schedulable if EDF (Earliest Deadline First) scheduling is used? Explain your answer. **[5 marks]**

Task	Period (T)	Computation Time (C)	Deadline (D)
A	10	4	10
B	20	5	20
C	40	10	35

- (ii) In real-time scheduling there is a standard notation which includes: C for the worst-case computation time, T for the minimum time between task releases, as well as B, I, U, and R. Explain what B, I, U, and R refer to and how they might be used.

[6 marks]

- b) Computer security is the protection of computer systems from attacks to the systems and the services they provide. Explain what is an attack to the system, and describe two examples of security attacks. **[3 marks]**

- c) An encryption algorithm must provide the following property: given a ciphertext c , a computer can compute the message m such that $E_k(m) = c$ only if it possesses the key k , where E_k is a function for generating ciphertexts from messages. Explain why the algorithm ensures a degree of security. **[2 marks]**

[question 3 total: 20 marks]

[grand total: 60 marks]