CS2410

UNIVERSITY OF WARWICK

Second Year Examinations: January 2016

Operating Systems and Computer Networks

Time Allowed: 3 hours.

Answer **TWO** questions from **Section A** and **TWO** questions from **Section B.**

Use one answer book for your Section A answers and a separate answer book for your Section B answers.

Read carefully the instructions on the answer book and make sure the particulars required are entered on each answer book.

Approved calculators may be used.

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Section A Answer **TWO** questions from this section
(in a separate answer book to Section B).

1. (a) A process *p* is executing on a CPU. Explain all the possible state changes that can happen to *p* and the cause(s) behind each of them. [6]

(b) What is *context switching* with respect to scheduling? [2]

(c) Explain whether context switching happens when

(i) a process *blocks* while waiting to access a resource. [2]
(ii) a process *spinlocks* while waiting for a resource. [2]

(d) A variant of the producer-consumer problem is as follows: A producer process reads or writes to a database while a consumer process only reads from the database. Two or more consumers may access shared data while a producer needs to have exclusive access to the shared data. There are multiple producers and consumers in the system. All processes share the following data structure:

semaphore update;

All consumer processes share the following data structures:

semaphore mutex;
int num-of-consumers;

The semaphore *update* acts as a mutual-exclusion semaphore for producers, whereas the semaphore *mutex* is used to ensure mutual exclusion when the variable *num-of-consumers* is being updated. The variable *num-of-consumers* keeps track of the number of consumers currently reading the shared data. The initial values of the different data structures are: (1) *update* is set to 1, (2) *mutex* is set to 1 and (3) *num-of-consumers* is set to 0.

(i) Write pseudocode to illustrate the structure of the producer process [3]

(ii) Write pseudocode to illustrate the structure of the consumer process, making clear any assumption(s) you make. [7]

(iii) Explain a possible weakness of your solution. [3]

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2. Four processes, labelled P_1, P_2, P_3, P_4, exist in a computer system. They entered the system at times $t = 0, 0, 1, 1$ respectively. They have, respectively, the following actual CPU bursts: ⟨2, 1, 1⟩, ⟨1, 3⟩, ⟨1, 1, 3⟩, ⟨2, 3, 1⟩. They are to be scheduled using the *earliest deadline first* (EDF) algorithm.

   (a) Develop the schedule generated when a *preemptive* EDF is used on the process set using the actual CPU bursts. [5]

   (b) Calculate the *average waiting time* for the schedule in (a) above. [5]

   (c) Since we cannot schedule using actual CPU bursts, it is proposed to develop a schedule based on *predicted* CPU bursts. CPU bursts are to be predicted using *exponential averaging*, using only the most recent history information. Develop the schedule generated when a *non-preemptive* EDF is used on the process set using the predicted CPU bursts. You can assume that the first predicted burst always matches the actual burst. You can also assume that, in the case of a tie, the process with the smallest id has precedence. [10]

   (d) Calculate the *average waiting time* for the schedule developed in (d) above. [5]

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3. (a) Using a suitable example, explain how priority is assigned to processes in the Rate Monotonic Algorithm (RMA). [5]

   (b) Explain when a page fault occurs and how such a fault is handled. [5]

   (c) Compare and contrast the following two memory problems: *internal fragmentation* and *external* fragmentation. [5]

   (d) Explain the *best fit* and *first fit* algorithms for memory allocation. [5]

   (e) The following list describes holes currently available in memory, together with their respective sizes:

   $$\langle (B_1, 20), (B_2, 30), (B_3, 25), (B_4, 10), (B_5, 20), (B_6, 15) \rangle$$

   The kernel keeps track of the memory requests of different processes, as follows:

   $$\langle (P_1, 22), (P_2, 17), (P_3, 3), (P_4, 10), (P_5, 8), (P_6, 17) \rangle$$

   (i) Calculate the size of the holes left when the *first fit* algorithm is used for memory allocation. Justify your answer. [3]

   (ii) Show the memory allocation for each process when the *worst fit* algorithm is used. [2]

Section B Answer **TWO** questions from this section.
(in a separate answer book to Section A).

4. (a) (i) Explain the term *bandwidth,* and differentiate between *baseband* and *bandpass* signals. Use diagrams to illustrate your answer. [4]

(ii) What maximum sampling period (in μs) is necessary for all information to be captured in a digitised 4 kHz telephone channel? [2]

(b) (i) With the aid of diagrams, explain the terms (1) *Frequency Division Multiplexing* (FDM) and (2) *Time Division Multiplexing* (TDM). [4]

(ii) Explain the term *Asymmetric Digital Subscriber Line* (ADSL). [4]

(iii) How are FDM and TDM utilised in the GSM mobile phone system? [3]

(c) (i) Give two advantages and one disadvantage of using a *packet-switching* network over a *circuit-switching* network. [3]

(ii) Three packet-switching networks each contain *n* nodes. The first network has a star topology with a central switch node, the second is a bi-directional ring, and the third is fully interconnected, with a wire from each node to every other node. What are the best-, average-, and worst-case transmission paths in hops? [3]

(d) Chip sequences used in Code Division Multiple Access (CDMA) are pair-wise orthogonal. In other words, the normalised inner product (S•T) of any two distinct sequences, S and T, is zero.

$$S \cdot T \equiv \frac{1}{m} \sum_{i=1}^{m} S_i T_i = 0$$

What can you conclude about the number of corresponding chips that must match in any two distinct chip sequences? [2]

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5. (a) (i) Describe the operation of the MAC protocol used in classic Ethernet, and explain the purpose and operation of the binary exponential back-off algorithm. [6]

(ii) Why is it not possible to use the MAC protocol used in Ethernet for a wireless local area network? [2]

(b) A 100 Mbps CSMA/CD local area network (not Ethernet) has equally spaced nodes and a total length of 2km.The signal propagation speed in the cable is 2×10^8 m/s. There are no repeaters.

(i) If two stations start to transmit at exactly the same time, what will be the mean time for them to detect a collision? [3]

(ii) Given the above parameters, what minimum frame length (in bits) is required for correct operation of the CSMA/CD protocol? [3]

(c) (i) Describe the basic architecture of a Bluetooth personal area network and briefly explain how Bluetooth-enabled devices communicate with each other. [4]

(ii) Why does a Bluetooth frame contain redundant information and how is the redundancy utilised? [2]

(iii) Bluetooth uses frequency hopping spread spectrum with a hop rate of 1600 hops/s. What is the length of a time slot in bits, given that the bandwidth is 1 MHz and information is coded at the rate of 1 bit/Hz? [2]

(iv) In each slot of the Bluetooth system described in (c)(iii) above, 259 μs is needed for hopping and control mechanisms. Packets can be of 1, 3 or 5 slots in length. How long does the frame last in each type of packet? [3]

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6. (a) (i) Explain the term *protocol*, and describe the purpose and operation of a 'layered protocol' structure. [4]

(ii) A system has an *n*-layer protocol hierarchy. Applications generate messages of length *M* bytes. At each of the layers, an *h*-byte header is added. What fraction of the network bandwidth is filled with headers? [2]

(b) (i) Describe the TCP/IP Reference Model and briefly mention the purpose of each layer. [5]

(ii) Explain the term *jitter*, and state one application for which it is important to minimise jitter. [3]

(iii) Describe how TCP segment flow is controlled using a sliding window. [4]

(iv) In TCP, why is efficiency reduced if an application is producing too little data at a time for TCP transmission, or an application is consuming too little of the data received. Suggest solutions that can be employed to reduce these inefficiencies. [4]

(v) The round-trip time between two hosts has been found to be 64ms. If the bit rate of the link between the hosts is 480 kbps, what minimum TCP window size (in bytes) is required such that, when data is continually being sent, the buffers will not overflow? [3]

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