



NANYANG JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATIONS

Higher 2

COMPUTING

9569/01

Paper 1 Written

12th September 2024

3 hours

READ THESE INSTRUCTIONS FIRST

An answer booklet will be provided with this question paper. You should follow the instructions on the front cover of the answer booklet. If you need additional answer paper ask the invigilator for a continuation booklet.

Answer **all** questions.

Approved calculators are allowed.

The number of marks is given in brackets [] at the end of each question or part question.

The total number of marks for this paper is 100.

This document consists of **9** printed pages and **1** blank page.

- 1 In packet switched networks, data that exceeds a threshold size has to be fragmented into multiple packets. This threshold is called the Maximum Transmission Unit (MTU). Such packets must be reassembled when received by the router.

The type of packet is indicated in the IP header with two Boolean flags, the Don't Fragment (DF) flag, and the More Fragments (MF) flag. The Fragment offset field of the IP header also stores an integer indicating the position of the data in the original packet. The rules for data reassembly are as follows:

- A packet must only have either the DF flag or MF flag set to True. A packet with both flags set to True is invalid and must be dropped.
- If a packet has the DF flag set to True and a Fragment offset value of 0, it is unfragmented and requires no reassembly. If the Fragment offset field is not 0, the packet is invalid and must be dropped.
- A packet with the MF flag set to True is a fragmented packet and requires reassembly. A Fragment offset value of 0 indicates that this is the first packet.
- A packet with both the MF and DF flags set to False is the last packet of a set of fragmented packets. The Fragment offset value must be greater than 0, otherwise the packet is invalid and must be dropped.

(a) Copy and complete the decision table below:

| Condition | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|--|---|---|---|---|---|---|---|---|
| DF flag = True | | | | | | | | |
| MF flag = True | | | | | | | | |
| Fragment offset is 0 | | | | | | | | |
| Action | | | | | | | | |
| Drop packet | | | | | | | | |
| Reassemble as first packet | | | | | | | | |
| Reassemble as subsequent packet | | | | | | | | |
| Pass to application without reassembly | | | | | | | | |

[4]

(b) Simplify your decision table to remove redundancies.

[2]

- 2 A procedure to process an array of numbers is defined as follows:

```

PROCEDURE P(arr_num)
  FOR pointer  $\leftarrow$  1 TO number_of_items - 1
    key  $\leftarrow$  arr_num[pointer]
    current_item  $\leftarrow$  pointer - 1
    WHILE (arr_num[current_item] > key) AND (current_item > -1) DO
      arr_num[current_item + 1]  $\leftarrow$  arr_num[current_item]
      current_item  $\leftarrow$  current_item - 1
    ENDWHILE
    arr_num[current_item + 1]  $\leftarrow$  key
  ENDFOR
ENDPROCEDURE

```

An array of numbers, containing 17, 11, 9, 21, 23, 15 is to be processed by procedure P.

- (a) List the contents of the array after the FOR loop has finished executing the iteration
pointer = 2. [1]
- (b) Name the algorithm that procedure P implements. [1]
- (c) Comment on the efficiency of procedure P if it is used when the elements of the array are
largely sorted. [2]
- (d) Rewrite procedure P as a recursive procedure that accepts two parameters: arr_num and
index_of_item. [5]

- 3** An airport uses a binary tree to manage landing time of international flights on its runways. Each node in the tree represents a plane with a unique flight number and its landing time in hours. A binary search tree (BST) is used to manage the schedule in such a way that for each node, all nodes in its left subtree have landing times less than the node's landing time, and all nodes in its right subtree have landing times greater than the node's landing time.
- (a)** The following flight details are inserted into a binary search tree (BST) in the order given:
 [FL555, 1200], [FL222, 1100], [FL777, 1400], [FL123, 0900], [FL678, 1000], [FL444, 1300],
 [FL333, 1500], [FL345, 0800], [FL111, 0930]
- (i)** Draw a diagram of the resulting BST. [5]
- (ii)** List the result of an in-order traversal of the BST from **(a)(i)**. [1]
- (iii)** State the time complexity of inserting a flight detail into the BST. [1]
- (b)** The airport also maintains a linked list for domestic flights in ascending order of the landing time. The linked list contains the following flight numbers:
 [FL999, 0830] → [FL888, 1030] → [FL777, 1130] → [FL666, 1230] → [FL555, 1330]
- (i)** Explain how [FL253, 0900] would be inserted into the above linked list. [3]
- (ii)** State the worst-case time complexity of inserting a flight detail into the above linked list. [1]
- (c)** **(i)** Explain whether it will be faster to insert a flight detail into the BST, or into an ordered linked list. [2]
- (ii)** Give one possible reason why the airport uses a linked list for domestic flights but a BST for international flights. [2]

- 4 A company is developing an application that allows clients to track daily expenses. The application will allow users to record expense data such as dates, categories, amounts, and descriptions among others.

(a) Explain an advantage of using Unicode over ASCII for the expense description. [2]

(b) Data needs to be validated and verified on entry.

(i) State **two** ways the dates can be validated on entry. [2]

(ii) State **one** way to ensure expense data is verified before submission. [1]

At a meeting, a suggestion was raised to store expense amounts as cents, using 8 digits. This will allow an expense amount between 0 and 99,999,999 to be stored.

(c) State the minimum number of bytes required to store the expense amount, using the following data types:

(i) integer, [1]

(ii) ASCII string. [1]

(d) State **one** advantage and **one** disadvantage of storing the expense amount as a string. [2]

(e) During the testing phase of the application, an error popped up on the screen with the following pair of hexadecimal codes, separated by a colon:

BFF1 : 1AF0

Represent the hexadecimal code

(i) to the left side of the colon as a decimal value, [1]

(ii) to the right side of the colon as a binary value. [1]

5 NVT Inc. is an IT company that works on two types of projects:

- software projects,
- installation of local area networks.

All projects undertaken by NVT Inc. will have the following information documented:

- project ID,
- project start date,
- project leader.

A software project can either be

- a bespoke software project for a client, or
- an off-the-shelf software project.

All software projects will have the following information documented:

- programming language used,
- software development budget, and
- state of testing: not started, in progress, or completed.

All software projects will have a base development budget of S\$50,000.

Besides the information documented for all software projects, bespoke software projects will have the following additional information documented:

- client's name,
- delivery date,
- annual maintenance fee.

Due to the complexity of bespoke software development, the development budget is calculated to be 150% of the base development budget.

In addition, the annual maintenance fee for the bespoke software is calculated as 10% of the bespoke software development budget.

On the other hand, all off-the-shelf software development projects will have the following additional information documented:

- project title,
- anticipated retail price,
- sales forecast for the first year of sales, expressed as the number of purchases or subscribers.

The sales forecast is typically derived from market analysis of the sales / subscription rates of similar software in the market.

The anticipated retail price is then calculated as

$$120\% \times \frac{\text{base development budget}}{\text{total purchase or subscription}}$$

All projects for the installation of local area networks will have the following information documented:

- client company,
- installation cost,
- manpower cost.

The manpower cost is calculated as 20% of the installation cost.

NVT Inc. wishes to implement a documentation system of their project management structure using object-oriented programming.

- (a) Draw the class diagram for a possible object-oriented implementation of the documentation system. Your design should include all relevant attributes and methods, as well as demonstrate appropriate inheritance and polymorphism. [12]
- (b) Explain the difference between a class and an object. [2]
- (c) (i) State what is meant by encapsulation. [1]
- (ii) Explain how encapsulation allows you to achieve data and information hiding in your design. [2]
- (d) (i) Explain the purpose of inheritance in object-oriented programming. [1]
- (ii) Describe the advantages inheritance provides to your design of NVT's documentation system. [3]
- (e) (i) State the purpose of polymorphism. [1]
- (ii) Explain the advantages polymorphism provides in software development, citing one relevant example from your design in (a). [2]

- 6 Toppee, an online retailer, uses a relational database to store customer sales information. The relational database tracks customers and their shopping carts.

- each shopping cart comprises one or more types of items,
- each item in a cart has a quantity,
- each cart is associated with one customer only.

The relational database contains the following tables:

Customer (CustID, CustName, ContactNumber, Email)

Item (ItemID, ItemName, Description, Price)

Cart (CartID, CustID, ItemID, Quantity)

- (a) Explain, giving an example, whether the **Cart** table is in third normal form (3NF). [3]

A table description can be expressed as:

TableName (Attribute1, Attribute2, Attribute3, ...)

The primary key is indicated by underlining one or more attributes.

- (b) Write table descriptions for two tables to hold the data from the **Cart** table each of which are in third normal form (3NF). [3]
- (c) Draw an entity-relationship (ER) diagram showing the three given tables and the relationships between them. [3]

Toppee wishes to modify the table design to allow the use of vouchers. Each voucher comprises an id, and additional data about how it is applied. Each cart is allowed to use up to one voucher.

- (d) Describe a change to be made to the existing three-table design to enable the use of vouchers. [2]
- (e) Write an SQL query for the given tables to output the total price of items in the cart of the customer with id 6. [5]

Toppee's shopping application and database are run on different machines. The shopping application accesses the database over the internet when updating customer shopping carts.

- (f) (i) State one vulnerability which may result in customer's personal data being compromised. Describe one measure that Toppee can implement to mitigate this vulnerability. [2]
- (ii) Explain how the use of digital certificates can improve the security of the shopping experience for Toppee's customers. [3]
- (g) Besides Protection Obligation, name two other relevant PDPA obligations. For each obligation, suggest one measure Toppee can implement to meet it. [4]

- 7** A software development company is tasked to develop a new banking application for ordinary users to manage their personal finances. The company decides to develop a web application that can be accessed through a web browser rather than a native application. The application will allow users to store financial transactions, track their net worth, and manage information that can be used to determine their creditworthiness.

- (a)** Describe two differences between web applications and native applications. [2]
- (b)** Discuss whether the company's decision to create a web application instead of a native application is justified. [2]
- (c)** State one relevant usability principle and explain how applying it can improve the user experience of the banking application. [2]

The company is under pressure to meet a tight deadline for the new online banking application. To expedite the development process, the company decides to reuse a portion of code from a previous project without conducting rigorous security testing for security vulnerabilities that could potentially expose customer financial data.

- (d)** Discuss whether the software development company's actions are aligned with the code of ethics for computing professionals. [4]

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