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COMPUTER SCIENCE

9608/31

Paper 3 Advanced Theory

May/June 2021

1 hour 30 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use an HB pencil for any diagrams, graphs or rough working.
- Calculators must **not** be used in this paper.

INFORMATION

- The total mark for this paper is 75.
- The number of marks for each question or part question is shown in brackets [].
- No marks will be awarded for using brand names of software packages or hardware.

This document has **16** pages. Any blank pages are indicated.

2

- 1 In a particular computer system, two real numbers, **A** and **B**, are stored using floating-point representation with:

- 12 bits for the mantissa
- 4 bits for the exponent
- two's complement form for both mantissa and exponent.

Number A

Mantissa

Exponent

1	1	0	0	0	0	0	0	0	0	0	0
---	---	---	---	---	---	---	---	---	---	---	---

0	0	1	0
---	---	---	---

Number B

Mantissa

Exponent

0	1	1	1	0	0	0	0	0	0	0	0
---	---	---	---	---	---	---	---	---	---	---	---

1	1	1	1
---	---	---	---

- (a) (i) Identify whether each number is positive or negative. Justify your answer.

Number A

.....

Number B

.....

[2]

- (ii) Convert the binary values of the **mantissa** and the **exponent** for each number to their separate denary values.

A mantissa

.....

A exponent

.....

B mantissa

.....

B exponent

.....

[4]

(iii) Calculate the denary value of each floating-point number using your values from part (a)(ii).

Number A

.....

.....

Number B

.....

.....

[2]

(b) State which number, **A** or **B**, is stored in normalised floating-point form. Justify your answer.

Number

Justification

.....

.....

.....

.....

[3]

4

2 The TCP/IP protocol suite can be viewed as a stack with **four** layers.

(a) Write the correct descriptions for the **two** layers **and** the correct layers for the **two** descriptions given in the following table.

Layer	Description
Application	
	Handles forwarding of packets
Internet/ Network	
	Handles how data is physically sent

[4]

(b) (i) Explain why communication protocols are necessary.

.....

 [2]

(ii) Identify **and** describe **one other** communication protocol. State its purpose.

Protocol

Description

.....

Purpose

..... [3]

5

- 3** Describe, with the aid of a diagram for each one, the bus and star network topologies.

Bus

Description

.....

.....

.....

.....

.....

Star

Description

.....

.....

.....

.....

.....

[6]

6

- 4 (a) The truth table for a logic circuit with four inputs is shown.

INPUT				OUTPUT
P	Q	R	S	X
0	0	0	0	1
0	0	0	1	0
0	0	1	0	1
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	0
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	0
1	1	0	0	0
1	1	0	1	1
1	1	1	0	0
1	1	1	1	1

- (i) Write the Boolean expression for the truth table as a sum-of-products.

X = [2]

- (ii) Complete the Karnaugh Map (K-map) for the truth table.

		PQ			
		00	01	11	10
RS	00				
	01				
	11				
	10				

[2]

7

(iii) The K-map can be used to simplify the expression in **part (a)(i)**.

Draw loops around appropriate groups of 1s in the table in **part (a)(ii)** to produce an optimal sum-of-products. [2]

(iv) Write the simplified sum-of-products expression for your answer to **part (a)(iii)**.

X = [2]

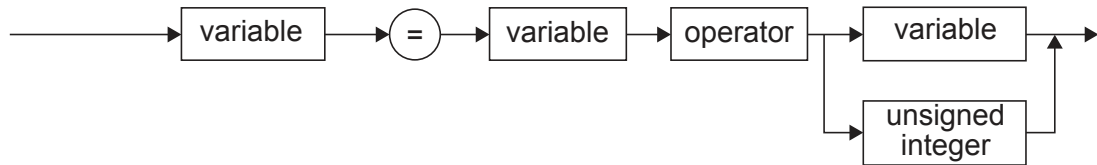
(b) Simplify your expression for **X** in **part (a)(i)** using Boolean algebra. Show your working.

.....
.....
..... [2]

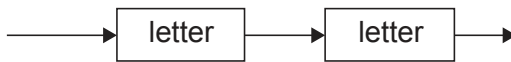
5 The following syntax diagrams for a programming language show the syntax of:

- an assignment statement
- a variable
- an unsigned integer
- a digit
- a letter
- an operator

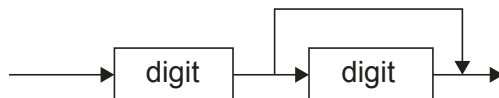
assignment statement



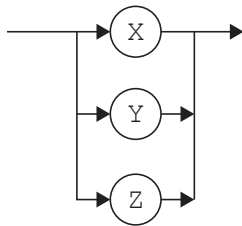
variable



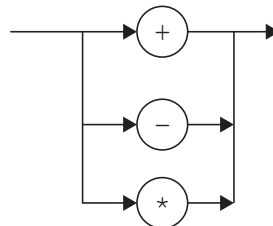
unsigned integer



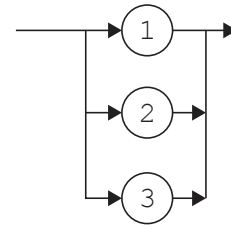
letter



operator



digit



(a) Give reasons why each of these statements is **invalid**.

$X = XY + 21$

.....

$YZ := YZ * 3$

.....

$XY = XY - 5$

.....

[3]

9

(b) Complete the Backus-Naur Form (BNF) for the syntax diagrams shown.

<letter> has been completed for you.

<letter> ::= X|Y|Z

<assignment_statement> ::=

.....

<variable> ::=

.....

<digit> ::=

.....

<unsigned_integer> ::=

.....

<operator> ::=

.....

[5]

(c) The syntax of a **variable** is changed to allow one or two letters followed by zero, one or two digits.

(i) Draw an updated syntax diagram for the **variable**.

[3]

(ii) Give the BNF for the revised **variable**.

.....

.....

.....

.....

..... [3]

6 Encryption is used to provide security when messages are transferred over a communication link.

- (a) (i) Explain the way in which asymmetric key cryptography is used to encrypt a message being sent from one computer user to another over the Internet.

.....

.....

.....

.....

.....

.....

.....

..... [4]

- (ii) State **two** benefits of using asymmetric key cryptography.

1

.....

2

..... [2]

- (b) (i) Explain the way in which Transport Layer Security (TLS) provides communication security over a computer network.

.....

.....

.....

.....

.....

.....

.....

..... [4]

11

(ii) State **two** situations where the use of TLS would be appropriate.

1

.....

2

.....

[2]

12

- 7 Four shipping containers are used to store goods on the dockside at a port. The temperature inside each container should be kept between 5 and 8 degrees Celsius inclusive. Each container has a temperature sensor.

A computer system is programmed to control each container's temperature by:

- turning on the heater and turning off the air conditioning unit when the temperature falls below 5 degrees
- turning off the heater and turning on the air conditioning unit when the temperature rises above 8 degrees.

- (a) (i) State the name given to the type of system described.

..... [1]

- (ii) Justify your answer to **part (i)**.

.....

 [2]

- (b) The computer system stores the temperature readings for the four sensors in two's complement form and in four eight-bit memory locations with addresses 301 to 304.

301	0	0	0	0	1	0	0	1	Container 1
302	0	0	0	0	0	1	1	1	Container 2
303	0	0	0	0	0	1	1	0	Container 3
304	1	1	1	1	1	1	1	0	Container 4

State the container number(s) where the temperature is out of range **and** give the value(s) of these temperature(s) in denary.

.....

 [2]

13

(c) The status of the heaters and the air conditioning units is shown at location 300.

A value of 1 means that the device is on and a value of 0 (zero) means that the device is off.

The status of the heaters is shown in the most significant four bits; the status of the air conditioning units is shown in the least significant four bits.

The pattern of bits at location 300 shows that the heater for container 4 is on and the air conditioning unit for container 1 is on.

Container number							
1 2 3 4				1 2 3 4			
300	0	0	0	1	1	0	0
Heater				Air conditioning			

Show the pattern of bits when the heater is on for containers 1 and 2 and no air conditioning units are on.

300							
-----	--	--	--	--	--	--	--

[1]

- (d) The following table shows assembly language instructions for the container computer system that has one general purpose register, the Accumulator (ACC).

Instruction			Explanation
Label	Op code	Operand	
	LDM	&n	Load the hexadecimal number n to ACC
	LDD	<address>	Load the contents of the location at the given address to ACC
	STO	<address>	Store the contents of ACC at the given address
	AND	&n	Bitwise AND operation of the contents of ACC with the hexadecimal number n
	LSL	#n	Bits in ACC are shifted denary number n places to the left. Zeros are introduced at the right hand end
	CMP	&n	Compare the contents of ACC with the hexadecimal number n
	JPE	<address>	Following a compare instruction, jump to <address> or <label> if the compare was True
<label>:	<op code>	<operand>	Labels an instruction

If the bit for a container's heater and the bit for the same container's air conditioning unit are both set to 1, a routine at label ERROR is executed. This routine has not been provided.

- (i) These assembly language instructions check for an error in the container 1 system.

```
LDD 300
AND &88
CMP &88
JPE ERROR
```

Explain the purpose of each instruction.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(ii) Write the assembly language instructions to check for an error in the container 4 system.

.....

.....

.....

.....

.....

..... [3]

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