Foundations of Information Systems

Mock Exam

January 24, 2024

1. (a) Evaluate the following Boolean expression, showing all intermediate results in your computation:
$$(0 \wedge 1)' \vee (1 \wedge 1)' \tag{1}$$
   (b) State the two distributive laws of Boolean algebra.
   (c) Simplify the following Boolean expression:
$$(a' \wedge b \wedge c) \vee (a \wedge b' \wedge c') \vee (a \wedge b' \wedge c) \vee (a \wedge b \wedge c') \vee (a \wedge b \wedge c) \tag{2}$$

(5+5+5)

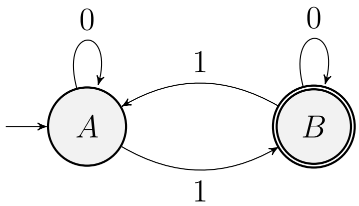
2. (a) Translate the following computation, written in decimal integer representation, term-by-term into binary. Use a 6-bit two's complement representation for the negative integers.
$$23 + (-28) = -5 \tag{3}$$
   (b) Translate the following binary rational number into decimal:
$$1011.101 \tag{4}$$

(5+5)

3. Which of the following expressions leads to unbounded growth of the relative rounding error when computed in finite-precision (IEEE) floating point? Identify the value of $x \neq 0$ near which the problem occurs. Rewrite the expression, if necessary, in a form that avoids this loss of accuracy.
   (a) $\dfrac{1 + (1+x)^2}{x}$
   (b) $\dfrac{2x - \sqrt{x^2+1}}{\sqrt{3}\,x - 1}$

(5+5)

4. (a) Write out a regular expression that recognizes strings that contain the substring `aa` anywhere within.
   (b) Describe which strings are recognized by the following finite state machine:



(c) Draw a finite state machine that checks if a given 7-bit input corresponds to a number digit (“0”, . . . , “9”) encoded in ASCII.

For reference, an ASCII table is enclosed. You may assume that the binary input stream consists of exactly 7 bits.

(5+5+5)

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	0 ^@ NUL NULL	1 ^A SOH START OF HEADING	2 ^B STX START OF TEXT	3 ^C ETX END OF TEXT	4 ^D EOT END OF TRANSM.	5 ^E ENQ ENQUIRY	6 ^F ACK ACKNOWL-EDGE	7 ^G BEL BELL	8 ^H BS BACKSP.	9 ^I HT CHARACT. TAB'TION	10 ^J LF LINE FEED	11 ^K VT LINE TAB'TION	12 ^L FF FORM FEED	13 ^M CR CARRIAGE RETURN	14 ^N SO SHIFT OUT	15 ^O SI SHIFT IN
1	16 ^P DLE DATALINK ESCAPE	17 ^Q DC1 DEVICE CONTROL1	18 ^R DC2 DEVICE CONTROL2	19 ^S DC3 DEVICE CONTROL3	20 ^T DC4 DEVICE CONTROL4	21 ^U NAK NEG.ACK-NOWLEDGE	22 ^V SYN SYNCHR. IDLE	23 ^W ETB END OF TRANS.	24 ^X CAN CANCEL	25 ^Y EM END OF MEDIUM	26 ^Z SUB SUBS-TITUTE	27 ^[ESC ESCAPE	28 ^\ FS INFO. SEP. 4	29 ^] GS INFO. SEP. 3	30 ^^ RS INFO. SEP. 2	31 ^_ US INFO. SEP. 1
2	32 SPACE	33 excl ! EXCLAM. MARK	34 quot " QUOT. MARK	35 num # NUMBER SIGN	36 dollar $ DOLLAR SIGN	37 percnt % PERCENT SIGN	38 amp & AMPER-SAND	39 apos ' APOS-TROPHE	40 lpar (LEFT PAREN.	41 rpar) RIGHT PAREN.	42 ast * ASTERISK	43 plus + PLUS SIGN	44 comma , COMMA	45 - HYPHEN-MINUS	46 period . FULL STOP	47 sol / SOLIDUS
3	48 0 DIGIT ZERO	49 1 DIGIT ONE	50 2 DIGIT TWO	51 3 DIGIT THREE	52 4 DIGIT FOUR	53 5 DIGIT FIVE	54 6 DIGIT SIX	55 7 DIGIT SEVEN	56 8 DIGIT EIGHT	57 9 DIGIT NINE	58 colon : COLON	59 semi ; SEMI-COLON	60 lt < LS.-THAN SIGN	61 equals = EQUALS SIGN	62 gt > GR.-THAN SIGN	63 quest ? QUEST-ION MARK
4	64 commat @ COMM'IAL AT	65 A	66 B	67 C	68 D	69 E	70 F	71 G	72 H	73 I	74 J	75 K	76 L	77 M	78 N	79 O
5	80 P	81 Q	82 R	83 S	84 T	85 U	86 V	87 W	88 X	89 Y	90 Z	91 lsqb [LEFT SQ. BRACKET	92 bsol \ REVERSE SOLIDUS	93 rsqb] RT. SQR. BRACKET	94 hat ^ CIRCUM'X ACCENT	95 lowbar _ LOW LINE
6	96 grave ` GRAVE ACCENT	97 a	98 b	99 c	100 d	101 e	102 f	103 g	104 h	105 i	106 j	107 k	108 l	109 m	110 n	111 o
7	112 p	113 q	114 r	115 s	116 t	117 u	118 v	119 w	120 x	121 y	122 z	123 { L. CURLY BRACKET	124 | VERTICAL LINE	125 } R. CURLY BRACKET	126 ~ TILDE	127 ^? DEL DELETE

ASCII code table including entity references, control codes and Unicode names (1.1) © Tom Gibara July 2014

5. Recall the “simple language” from class, which has non-negative integer variables, the statements `incr(X)` and `decr(X)`, as well as while loops of the form

```
while(X):
    loop body
```

Write code in simple language that takes as input two variables `X` and `Y` and yields a variable `Z` containing the sum of `X` and `Y`.

It is permitted to alter the values of `X` and `Y` as a result of this computation. (5)

6. (a) Process P_1 holds resource R_2 and needs resource R_1. Process P_2 holds resource R_1 and needs resource R_2. Draw a resource allocation graph. Is this a deadlock situation?

   (b) Now suppose that there are two copies of each resource, the second copy of R_1 is held by P_3, the second copy of R_2 is held by P_4. Is this a deadlock situation?

   (5+5)

7. The following questions refer to the $(7, 4)$-Hamming code, using the bit ordering convention adopted in class.

   (a) You receive transmissions of two $(7, 4)$-Hamming code words, 1000011 0101100, which encode one data byte. It is known that exactly one transmitted bit is wrong. Which bit is it, and what is the binary representation of the transmitted byte after the error is corrected?

   (b) What is the 7-bit codeword corresponding to the data word 0000?

   (c) Show that every codeword representing a data word different from 0000 contains at least three ones.

   (5+5+5)