Foundations of Information Systems

Makeup Exam

April 10, 2024

1. Are the following identities true or false? If true, give a proof. If false, give a counterexample.

   (a) $a \vee (a \wedge b) = a$

   (b) $a \vee (a' \wedge b) = a \vee b$

   (5+5)

2. (a) What is the largest number you can represent in 6-bit two's complement binary representation? What is the smallest such number?

   (b) Convert the decimal number 9.5625 to binary.

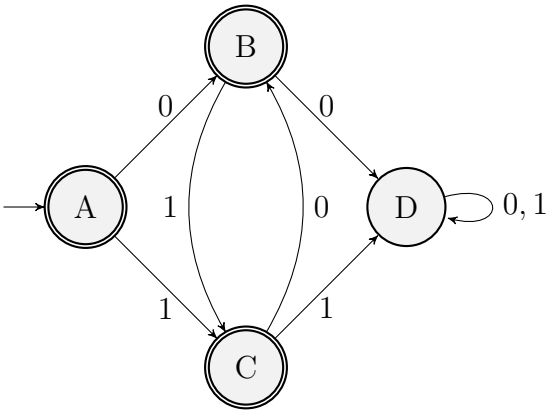
   (c) Compute

   $$(1.2 \cdot 10^{-2} - 7 \cdot 10^{2}) + 6.99 \cdot 10^{2}$$

   in *decimal* floating point arithmetic with 4 significant digits. Can you reduce the relative error by reordering the operations?

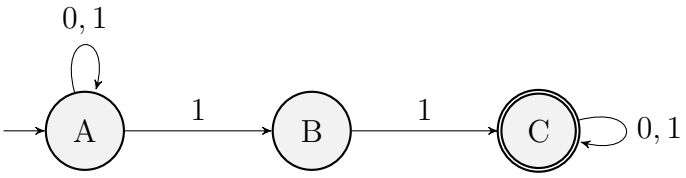
   (5+5+5)

3. (a) Which strings does the following finite state machine accept?



   (b) State a regular expression that is equivalent to the machine from part (a).

   (c) Convert the following non-deterministic finite state machine into a deterministic one.



(5+5+5)

4. (a) Encode the string 0110 as a Hamming-(8,4) encoded message. Your answer should have a clear indication of the bit ordering of the code word.

   (b) Can you design a code that can detect and correct a single-bit error for 16 bits of data in a message of 20 bits total length? Explain!

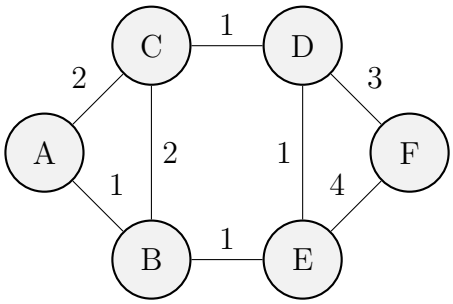
(5+5)

5. (a) Explain the difference between a soft link and a hard link in a file system.

   (b) What do you think if you find a USB drive with a Unix file system on it which contains a file named `Funny_Cat_Picture.jpg` which is a symbolic link to `/etc/passwd`?

(5+5)

6. Consider the following router network which uses distance vector routing.



   (a) State the optimal distance vector and routing table for router A. You do not need to compute anything as the network is simple enough to spot the answer directly.

   (b) Now suppose that router A is malicious and wants to intercept traffic destined for router F. Which routers can A prevent from communicating with F by advertising a false link? Assume that link costs must be positive integers.

(5+5)

7. You are given the following relational database schema of an online shop:

```
ITEM(ITEM_ID, DESCRIPTION)
CUSTOMER(CUSTOMER_ID, NAME, ADDRESS)
ORDER(CUSTOMER_ID, ITEM_ID)
```

   (a) Write a query, either using relational algebra or SQL, to find the names of all customers who bought a "Superbike" (`DESCRIPTION='Superbike'`).

(b) In a real online shop, an order can contain any number of items. Modify the given schema to represent such orders.

(5+5)