Foundations of Information Systems

Mock Exam

January 29, 2025

1. Simplify the following Boolean algebra expressions as much as possible.

   (a) $(a \vee a')'$

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

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

   (5+5+5)

2. Use a 7-bit floating-point representation where a floating point number has 1 sign bit followed by 3 exponent bits, and 3 bits for the significant. According to the IEEE standard, subnormal numbers have the exponent 000; the bias for a 3-bit exponent is $2^{3-1} - 1 = 3$. Answer the following questions:

   (a) Write out the bit pattern for the smallest positive normal number and determine its value in decimal.

   (b) Write out the bit pattern for the representation of -0.125. Note that the number may be subnormal!

   (c) Find three numbers a, b, and c where

   $$a \oplus (b \oplus c) \neq (a \oplus b) \oplus c$$

   when computed in this representation.

   (5+5+5)

3. Word processors can often do some spelling correction "on the fly". Construct a finite state transducer that does this in a very simple case: change a lower-case `i` to an upper-case `I` in sentences like

   ```
   i am done
   My dog and i go for a walk
   The exam i've written
   ```

   Specifically, change `i` to upper case if it is (i) the first letter in the string or preceded by ␣ (space) and (ii) followed by ␣ or `'` (apostrophe).

   Hint: Three states will suffice to perform this task. (10)

4. Consider a file system that may contain hard links (i.e., contain inodes with a reference count larger than one). Describe an algorithm that copies the contents of the entire file system onto another file system, preserving the hard links without creating duplicate data on the target file system.

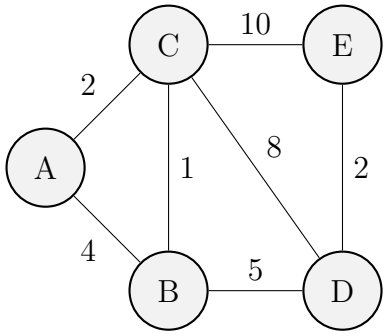
   Describe your algorithm in precise language or use Python-like pseudo-code. (10)

5. You receive the following Hamming-(8,4)-encoded message.

   01101101

   Extract the message, if possible, correcting single-bit errors as appropriate. The bit-order convention is the one used in class. Show all steps in your work. (5)

6. Consider the following router network:



   (a) Use Dijkstra's algorithm to compute the shortest path from router A to every other router in the network.

   (b) Suppose the link between C and E goes down. How does the network adjust to this damage and how does it affect the shortest path from A to E?

   (c) In general, which routing algorithm is faster to adjust to network damage? Link-state or distance-vector routing? Explain.

   (10+5+5)